Safety Issues of Bus Transport in Thailand – A Lesson Learnt From an In-Depth Accident Investigation

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Abstract – Bus is generally believed to be one of the safest modes of transport in developed countries. However Thailand's statistics shows that there were about 3,600 bus accidents recorded each year during 2000-2008. Each serious bus accident always raises questions among general public on Thailand bus safety and this may inevitably make people less confident on the safety of the public transport mode. Recently a number of in-depth investigations of serious bus accidents have been conducted by The Road Accident Investigation Units to identify causes and contributing factors such that relevant countermeasures have been proposed to prevent the reoccurrence of such serious accidents. It is the objective of this paper to illustrate the safety issues and/or causes of bus transport in Thailand obtained from our recent in-depth investigations. Among other issues it was found that bus standard, safety precautions and practices in case of fire, and regulation relating to the readiness of bus drivers need to be promptly reviewed. Suitability of the operation of double deck tour bus and full trailer on mountainous road needs to be addressed.

Keywords – Bus transport, Bus safety, Bus accident, Accident investigation, Double deck bus

1. INTRODUCTION

In developed countries bus travel is considered to be one of the safest mode of transport. In European Union countries rail and air travel are the safest modes per distance travelled, followed by bus. The passengers of trains, buses/coaches and planes within the EU have the lowest risk per passenger kilometer. As shown in Table 1 and 2, the fatality risk of bus/coach was 0.07 deaths per 100 person-kilometers and 2 deaths per 100 million person travel hours.

However the situation in developing countries particular in Thailand may be different --- headlines on serious bus accidents appear frequently in local newspapers and televisions. Large buses (bus ≥ six wheels) in Thailand involved in accidents during the past 9 years from 2000 to 2008 were in the order of 3,600 vehicles per year (Table 3).

Geographically about 57 % of accidents occurred in Bangkok Metropolitan Area and the rest of 47% occurred in other provinces of the Country. General speaking, the

Table 1 Deaths per 100 person-kilometers

Road (Total)	0.95
Motorcycle/moped	13.8
Foot	6.4
Cycle	5.4
Car	0.7
Bus/coach	0.07
Ferry	0.25
Air (Aviation)	0.035
Rail	0.035

Source: European Transport Safety Council (2003)

Table 2 Deaths per 100 million person travel hours

Road (Total)	28
Motorcycle/moped	440
Foot	75
Cycle	25
Car	25
Bus/coach	2
Ferry	16
Air (Aviation)	8
Rail	2

Source: European Transport Safety Council (2003)

Table 3 Number of larger buses and coaches involving in accidents.

Year	Number
2000	3,533
2001	3,618
2002	3,823
2003	4,509
2004	4,433
2005	3,904
2006	3,373
2007	2,961
2008	2,534

Source: Royal Thai Police

frequencies of accidents in BMA are quite high with less severity, compared to the accidents in other regional provinces which are lower in terms of frequency with more severity.

Further analysis of bus crash data on the road network under the jurisdiction of the Department of Highways showed that, on average, one bus accident resulted in 0.42 fatalities, 0.9 severe injuries and 2.69 minor injuries. Using these average figures bus accidents costs around 7 to 8 billion Baht per year or about 2 million Baht per accident to Thailand (PSU, 2007). About 34 Baht is 1 US$.

Although by average the number of fatality per bus accident is only about 0.42, however, bus accidents has always been received public attention and some accidents cause enormous losses. For example, in 2007, two bus accidents caused 17 and 30 on-scene deaths with 35 and 31 injuries respectively. This kind of tragedies poses questions on the safety of bus and coach transport in Thailand. Those serious accidents should be prevented from reoccurrence. The root causes of accidents have to be discovered, corrective measures proposed and appropriate actions taken.

This paper consists of seven sections. First is the introduction and followed by the necessity of in-depth investigation of bus accidents in second section. The general process used for the in-depth investigation is briefly described in section three. Section four will provide an example of accident investigation. Section five summarizes some bus accident investigations since 2006 in Thailand and their causes and/or contributing factors. Section six will highlight the safety-related issues required actions from the responsible parties; and followed by the conclusion in section seven.

2. THE NECESSITY OF IN-DEPTH INVESTIGATION

Various parties are involved and rushing to the accident site when accident happened and they have their own duties to perform. Such as:

– Police: Providing safety at the accident site, assistance to injured persons; investigate who is to be blamed and document of proofs and witness testimonies.

– Road authority: Recover the accident site to be ready for traffic use.

– Medical personnel and rescue unit: Provide emergency medical service (EMS) to injured persons. Delivery of injured persons to hospitals.

– Insurance company: To settle the insurance claim.

To find out what, where, when, who and why accident occurred, the level of detail about accident circumstances in these parties' report, due to their restrictions, are not enough to provide a detailed insight into the causes and preventive measures of road accident. Thus the independent in-depth investigation is required and one of the purposes of such investigation is **to prevent the reoccurrence of serious accidents** (such as bus/coach crashes). For this purpose **even the investigation based on single or very few cases can recommend a preventive measure and actions taken**. (Expert Group in Accidents in Transport Sector, EU, 2006)

3. IN-DEPTH TRAFFIC ACCIDENT INVESTIGATION PROCEDURE

Traffic Accident Investigation can be defined as (River R.W., 1995)

"the thorough examination of all elements contributing to the accident, resulting in a well-founded explanation of the series of events which occurred based upon the factual data"

The objectives of the traffic accident investigation are to determine:

a. WHAT happened
b. WHERE the accident occurred
c. WHEN the accident occurred
d. WHO is involved
e. WHY the accident occurred, (determine what are the contributing factors) e.g., violation of law, road defects and environment, vehicle component failures, etc.

And the more important objective is to provide safety recommendations, the implementation of which by responsible parties would minimize the potential for a recurrence of the type of accident under investigation.

To perform such tasks the independent Traffic Accident Investigation Unit must be established. The procedures of investigation is a well-established process to guarantee that all factual data are collected and analyzed in a systematic way as stated by Van Kerk (2001) as followed :

"Each accident is different; the method of investigating an accident is not. Whether the vehicle is a total disaster or only has minor damage, the method by which the investigation must be done has to be exactly the same each and every time"

The general procedures of investigation include (River R.W., 1995, OTP, 2007):

a. Monitoring of traffic situations and accident notification.
b. Procedures just after the accident being notified to the Investigation Unit.
c. Procedures at accident site.
d. Additional data collection.
e. Analysis and accident reconstruction.
f. Reporting (with recommendation).

Since 2006 a number of bus/coach accidents were investigated following the above procedures in Thailand, some of which are summarized in the next section of this paper.

4. AN EXAMPLE OF BUS/COACH ACCIDENTS IN-DEPTH INVESTIGATION: ROLLOVER OF DOUBLE-DECK TOUR BUS.

Tour bus usually operates on non-fixed routes. It operates like a chartered bus --- the schedule or time of operation or route depends on its passengers. At first glance the bus is of luxury type: the first floor can be designed as a recreation lounge while most passenger seats are on the upper deck. The typical dimensions of double-deck bus are 2.50 m. wide,

12.00 m. long and 4.50 m. high. It weighs about 17 ton and the engine power rating is about 275-320 horsepower (Figure 1). Accidents of the double tour buses occur quite frequently particularly in Northern Thailand where more highways are in mountainous area which steep grades and sharp curves are quite common.

Figure 1 - Typical double deck bus which is about 2.5 m. wide, 12.0 m. long and 4.5 m. high.

Figure 2 – Bus rolled with its right side on ground. The roof, upper floor passenger cabin and all seats were thrown away during rollover.

On January 19, 2007, a double deck tour bus travelled on mountainous highway from Chiang Rai to Chiang Mai. At 1100 AM Driver was unable to control his bus speed as it approached a sharp reverse curve and bridge. It went straight, hitting the concrete barrier at high speed, rollover, and finally rested in the stream bed. The roof, passengers and all 44-upper deck seats were totally ejected from its upper floor resulting in 17-deaths at scene and 35 injuries (Figure 2). From the in-depth investigation the causes and contributing factors were:

Human Factors: Driver not familiar with the route, Improper use of gear and pumping to much brake. Speed too high

Vehicle Factors: Strength of bus superstructures not adequate to protect passengers during rollover accidents. Passenger seats thrown away during the accident.

Road Factors: Lower design standard resulted in steep grade and winding road

This accident has raised several questions on the operation of tour bus and the strength of the bus body itself. The more important are:

– Tour bus is operated as a chartered bus, which the route and time of operation depends largely by the tour group or passengers. There is a possibility that bus driver will drive on the route which he is not familiar with (especially on the mountainous roads where special precautions are required) and drives without adequate rest.

– The structural integrity of the super-structure joints is not adequate to protect passenger during rollover. In Figure 2 the roof and its supporting columns disappeared, there was no survival space for passengers.

– Passengers are very often were ejected from the bus leading to serious injuries.

– Passenger seats which should be firmly attached to the bus floor at all times are loosen and not in place.

The existing regulation of the Department Land Transport (DLT) states very simply that, to register and use as public bus, the bus should be stable and strong and is certified by a mechanical engineer. At present there is no prescribed test to quantify the stability and strength of the public bus. Bus manufactures in Thailand can produce buses of various standards and qualities in accordance with customer needs. From the outside buses used today may look the same but in fact their strength and stability do vary.

The following recommendations had been proposed to prevent the reoccurrence of double–deck-tour-bus rollover accident:

– Introduce the measure on restriction or ban of double deck bus on steep grade and winding routes.

– Providing survival space for passengers via quality control of the strength of bus superstructures. The regulation should specify that, in order to register, the bus should pass a specified test (the UN-ECE Regulation 66 as an example), or the certification of bus manufacturers by the DLT should be adopted.

– Avoid the ejection of passengers from the bus by means of safety belts or laminated side windows.

– Avoid the loosening of passenger seats by firmly secured them to the bus floor.

Regarding to the above recommendations the highway authorities are now considering how to assess the suitability of highways for double deck bus and truck-trailer operation. DLT and academics are also studying on the integrity of bus superstructures.

5. BUS/COACH ACCIDENT INVESTIGATION IN THAILAND

Since 2006 Five Road Accident Investigation Units have been initiated --- under the collaboration between the Office of Transport and Traffic Policy and Planning, Ministry of Transport and Communications, and five Universities: Chiang Mai University, Khon Kaen University, Suranaree University of Technology, King Mongkut's University of Technology Thonburi and Prince of Songkla University. Each Road Accident Investigation Unit will handle the investigation of accidents under the specified region in the country. RAIU-CMU, RAIU-KKU, RAIU-SUT, RAIU-KMUTT and RAIU-PSU will be in charge of the accident investigation in the North, Upper Northeast, Lower Northeast, Central and Southern Region respectively. In fact the in-depth investigations so far are not considered as the comprehensive type, they are special investigations from time to time of serious accidents, accidents that are of public interest such as bus or coach accidents, school bus accidents, and heavy truck accidents, etc. Since their inceptions at least 19 bus/coach accident investigations were conducted as summarized in Table 4. Most of these investigations were conducted by the RAIU at Chiang Mai University, unless other stated.

Accident happens due to human error, vehicle defect, road and environment or a combination of these three main factors. In many cases it was found that more than one factor were involved. On the other hand, just one factor can also lead to serious accident. Table 5 regroups causes and contributing factors of the 19 accidents into human factor, vehicle factor and road/environment factor.

6. SAFETY ISSUES OF BUS TRANSPORT

Table 4 and 5 list the causes and contributing factors involved in serious bus accidents in Thailand. The investigation proved that these are causes and contributing factors in real-life situations and leading to (mass) fatal and serious injuries. Some of the factors will be explained as follows.

Human Factors:

1) Driver not familiar with the bus or the route. As a result he descended the steep grade and sharp curve at too high speed, or improper use of gear and pumping brake too often leading to brake failure.

2) Speed too high. Driver be in a hurry, bad temper or drunk driving.

3) Driver not competent as a professional one.

Vehicle Factors:

1) Lack of proper bus maintenance system and/or inspection system before use. In many cases driver failed to control his bus due to brake failure or blow off tires.

2) The strength of bus superstructures is not adequate to protect passengers during rollover.

3) The restraint of passenger seat with bus floor is not adequate. The restraint devices of passengers with the seats (seat belt) in many cases not available. Passengers were ejected from the bus.

4) No protective devices in case of the transmission shaft broke and came to contact with the ground. As this can cause flames and fire. In case of fire it will be fatal if the emergency door and fire extinguisher cannot function properly. Overcrowded bus made evacuation of passengers very difficult. In addition most materials inside the bus cabin are vulnerable in case of fire.

Road Factors:

1) Low design standard resulted in steep grade and winding road. In mountainous area some roads are not suitable for the operation of double deck bus.

2) Too many conflict points at unsignalised intersection where sight distances are restricted. Even small bicycle or motorcycle cutting in front of the bus can lead to fatal accident.

3) Lack of appropriate warning signs such as “steep grade – use low gear” sign or “sharp curve” sign.

4) Trees on the side slope and in the median are hazardous objects; they cause serious damage to the loss of control bus and its passengers. Trees should be removed from the clear zone or shielded.

With regards to the aforementioned safety issues the parties concerned are now recognized the problems and some countermeasures are under considerations. The Department of Land Transport now has a plan to introduce the following short, medium and longer term solutions, namely :

Short-term measures:

Increase of bus inspection frequency by DLT from 1 to 2 times a year. Installation of automated inspection equipments at DLT offices. Installation of automated door control system. Use of safety glasses for the side window. VDO on bus – how to use safety equipments on board.

Medium-term measures:

Prepare a standard for installing passenger seats and seat belt anchors. Installation of safety belts on all passenger seats. Issuing the structural standards of buses. Feasibility study of driver’s (and driving) performance recording machine.

Long-term measures:

Limitation of bus and truck age. Construction of bus test tracks. Construction of facilities for bus stability test or tilt test. Study on standardization of bus – manufacturing plants.

7. CONCLUSION

To understand the cause (s) and contributing factor (s) of an accident all elements contributing to the accident (human, vehicle, road and environment) has to be investigated thoroughly. In-depth investigation of even a single or very few cases of serious accidents can provide recommendation and preventive actions that can be taken to prevent the reoccurrence of such accidents (such as bus/coach crashes). Investigation of 19 cases of bus accidents in Thailand confirms that even human error that at first glance may be a minor one, e.g. bus driver does not familiar with the route, can finally lead to fatal accidents. Bus speed too high is also common in Thailand. Several concerns on the integrity of bus superstructures, seats and passenger restraints, precautions in case of bus caught fire, bus brake system and its maintenance standards and cares need to be addressed urgently. Besides the bus itself, restriction or ban of double deck tour bus on some steep grade and winding roads should be studied and imposed.

8. ACKNOWLEDGEMENT

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10. BIOGRAPHY

Mr. Lamduan Srisakda

was born in Thailand, in 1949. He received the M.Eng in Transportation Systems from Asian Institute of Technology in 1974 and a diploma in traffic management and safety from Road Directorate, Denmark, in 1980.His interest in transport safety has begun since 1982. During the past 10 years his interests are mainly in the field of road safety audit, blackspot treatments, accident modeling, accident investigation and reconstruction.

Table 4 Summary of bus accidents investigated by the RAIU

Date Time	What happened	Severity	Causes and contributing factors
21-06-06[b]	At 4-leg intersection where a minor road intersects 6-lane divided highway, a modified pickup truck (used as school bus) with 21 students on board stopped in the median opening waiting to cross the 3-lane highway. Bus driver decided to cut across as a 10-wheeled truck were approaching the intersection. Truck driver used the horn to warn that the truck was coming. Finally the bus was hit on its left side, from the front to the cab.	2-deaths at hospital 5-serious injuries 15- slightly injuries	-School bus driver used mobile phone while trying to cross the intersection. - Sight distances between the approaching truck and the vehicles in the intersection were restricted due to the crest curve. - A modified pickup as currently used as a schoolbus is not a safer bus.
16-07-06[a] 1030	Flat-bed 10-wheeled truck carrying a backhoe approached the 3-leg intersection from a minor road. A 28-seat air-conditioned bus entered intersection on the main road at high speed. The truck struck at right angle to the left side of the bus and tore down almost the whole left-portion of the bus.	4-deaths on scene 8-deaths at hospital 20-injuries	- Truck driver not competent and nor familiar with the truck. - Truck in poor condition. Brake failure. - Too many conflict points at the 3-leg intersection where side distances were restricted.
……..[b] 2030	On two-lane two-way highway 18-wheeled fully loaded trailer suddenly loss of control (jackknifed), the tractor unit was pushed onto the opposite lane in front of the incoming 10-seat passenger van with 14 persons on board.	12-deaths on scene 5-injuries	- Brake of the trailer unit not function and badly worn tires. - Passenger van were overloaded and no seat belts. -For the route with high percentage of heavy trucks and trailers two-lane two-way road is vulnerable to serious accidents
27-07-06 0600	A 34-seat bus with 9 persons on board descended a wet steep slope. Driver loss control of the bus as he approached a sharp left-hand curve. Bus hit the trees on the right of the curve and finally rest with its left side down on the carriageway.	1-death on scene 8- injuries	- Approaching speed to the curve too high. - Driver not familiar with this bus. - Low standard of road alignment requires slow speeds. - No road sign to warn driver about steep grade and use of low gear
21-08-06 1015	A foreigner drove a compact car along a long left-turn bend of 2-lane highway. He veered into the opposite lane and collided head on with the 40-seat bus. Bus loss of control, went straight, hit 3 guideposts and 3 trees on the side slope, rolled on its left side and finally rest in the rice field.	1-death on scene 13-slightly injuries	- Speed of the car was too high. - Trees in the clear zone caused more damages to the front of the bus. - Passenger section of the bus was still intact and having seat belts could possibly minimize injuries.
20-08-06 0400	A tour bus with 33 students on board struck the rear of a 10-wheel truck while trying to overtake. Bus loss of control and finally rest in the depressed median with its left side down.	3-students died at the site. 30-injuries	- Driver's fatigue. He was on duty one day and two nights without adequate sleep. - Driving too fast. - No restraining devices to secure passengers to the seats. All three deaths were thrown out of the bus.

Table 4 Summary of bus accidents investigated by the RAIU (Cont.)

Date Time	What happened	Severity	Causes and contributing factors
24-11-06[c] 0540	A driver of 24-seat long distance bus tried to avoid hitting pedestrian. Abrupt lane change led to loss control of his bus. The bus also hit some trees and rolled on its right side until it rest against another tree in the roadside.	2-deaths on scene 17-injuries	- An unauthorized sign placed on a shoulder may cause the pedestrian to walk on the traffic lane. - Higher speed (95 – 110 kph) of the bus on the highway passing through rural community. At high speed bus cannot stop even though the driver can notice the pedestrian at 90 metres ahead. - Trees close to the shoulder are hazardous objects. - Passenger seats not firmly fixed to the bus floor.
9-12-06	On 3-lane mountainous section of Mae Sod – Tak highway, a fully loaded 18-wheel full trailer descended a steep and winding slope, encroaching into the middle lane. Its trailer swung to the far right lane and torn down the right part of the opposing uphill bus.	12- deaths (10-on scene) 25-injuries	- Truck trailer travelled downhill with too high speed although warning signs being installed. - Because of steep grades and sharp curves this section of the highway is not safe for truck trailer operation.
19-01-07 1100	A double deck tour bus travelled on mountainous highway from Chiang Rai to Chiang Mai. Driver was unable to control bus speed as the bus approached a sharp reverse curve. It went straight, hitting the concrete barrier, rollover, and finally rest in the stream bed. The roof, passengers and all 44- upper deck seats were totally ejected from its upper floor.	17-deaths 35-injuries	- Driver not familiar with the route. - The incorrect use of gear and pumping too much brake. - Double deck bus's superstructures not strong enough. - The current practice of fixing passenger's seat to the bus floor needs to be critically reviewed.
21-02-07	A 42-seat double deck tour bus descended steep grade and negotiated a sharp left-hand curve. The bus collided with guardrail, hitting head-on the opposing uphill pickup. The bus rollover and finally rest on its left side across the carriageway.	21-injuries	- Driver not familiar with the route. - Steep grade (-10.6%) and sharp curve (radius = 53.8 metres) road is not safe for double deck bus, unless using slow speed with a lower gear.
	A Yasothorn – Bangkok bus packed with passengers had to continue this trip with its brake locked. Engine and transmission shaft had to run at higher load causing temperature to rise and finally the transmission shaft broke until the shaft came to contact with the road and produced flames. Bus caught on fire starting from the back to the whole bus. Driver cannot stop his bus due to brake failure together with high (1:2) side slope of the road. Even when driver can stop the overcrowded passengers cannot get out—there was only one exit door at the front. Passengers were trapped in the burning bus[b].	29-deaths on scene 31- injuries	- Bus owner ordered the bus driver to continue his trip with his brake failed and locked. - No protective devices in case of the transmission shaft broke and came to contact with the ground. - The emergency door and fire extinguisher cannot function. - Most materials inside the bus cabin are vulnerable in case of fire. - Overcrowded bus made evacuation of passengers very difficult.

Table 4 Summary of bus accidents investigated by the RAIU (Cont.)

Date Time	What happened	Severity	Causes and contributing factors
13-12-07 1130	A motorcycle suddenly turned right in front of the incoming 24-seat VIP bus. Bus driver abruptly steered his bus to the right to avoid hitting the motorcycle. Driver loss of control of his bus. The bus veered into the opposing lanes, toppling onto it left side, hitting another motorcycle, a pickup and a minibus. Finally it rest on the roadside with the pickup crushed under it.	2-deaths on scene. 18- injuries	- MC driver was under the influence of alcohol. - The accident site (3-leg where a 2-lane local road joins a high speed 6-lane divided highway) is a dangerous site.
13-03-08 0100	On 4-lane divided highway a 32-seat Bangkok-Phayao bus followed a slow 18-wheeled full trailer. Two rear axle tires of the trailer blew off, the trailer unit suddenly swung to the right and the bus hit the trailer unit while trying to overtake. Bus driver tried to avoid hitting the tractor unit which blocked the right lane by swerving his bus into the median, finally the bus rest at a tree in the median.	11-seriously injuries	- Poor condition of the trailer unit's tires was the main factor. The full trailer ran at nighttime at slow speed due to its two rear-axle tires blew off without any warning signals to notify other vehicles. The rest two tires could not sustain heavy loads then subsequently caused second blowout.
30-03-08	A 39-seat tourist bus 21 persons on board descended the steep and winding section of mountainous road. Bus driver failed to slow down along a critical downgrade (-11%) section. Driver lost of control of his bus as it approached a very sharp right-hand bend. The bus went straight heading to a deep ravine. At 20 metres down from the road surface the bus came to rest against a tree.	1-death on scene. (bus driver) 2- serious injuries 18-slight injuries	- Brake failure. Driver fail to shift to lower gear when travelling down a steep road section. - Driver not familiar with the bus he operated.
08-04-08	A driver of 28-seat bus (41 passengers on board) negotiated a sharp right-hand curve, with gentle downward slope. He realized that the left wheels were going to leave the left paved shoulder. He abruptly turned the steering wheel to the right. The bus veered across the road. Finally the right wheels went into the right side slope, rolled over. The bus rest upside down in the roadside.	6-serious injuries. 35-slightly injuries.	- Driver is not competent. - The curve is quite sharp---originally designed for 40 kph speed. Lane widening at later date make it look safe. But it is dangerous if the approach speeds are high. No warning about the sharpness of the curve. - Bus structures not strong.
09-04-08	A 30 seat (modified) bus climbed a very steep slope (grade +10%) . Driver failed to shift from the 2nd gear to 1st gear. The engine stopped and the bus moved backward down slope. Driver tried to avoid hitting a car behind him by steering the bus to the right until it moved in the rugged roadside. As driver steered his bus back on the road he lost control of his bus, it rolled and rest across the road on its right side.	1-death on scene 1- death at hospital. 2- serious injuries.	- The available horsepower of the bus engine is not adequate for the operation on such steep terrain. In fact the rated power of 115HP should be able to climb this slope with the 2nd gear. - No any devices to hold passengers with the seats in case of bus rollover.

Table 4 Summary of bus accidents investigated by the RAIU (Cont.)

Date Time	What happened	Severity	Causes and contributing factors
12-04-08	A crowded (during Songkran Festival) 44-seat bus with about 88 passengers on board descended a gentle slope but winding highway under reconstruction. By pumping his pneumatic assisted brake driver realized that he could not control the speed of his bus. He tried to steer his bus on course. He succeeded at the first right-hand curve but failed on the second one which was a sharper left-hand curve. The bus rolled, with its right side on the road. It slid further until it rest on the edge of the 20- meter high embankment.	7-serious injuries. 30- slight injuries.	- Brake failure. Although this bus is a new one (5 months old). There is only one system of brake. No secondary or exhaust brake available on this type of the bus. - Overloading with standing passengers.
17-04-08 2330	During Songkran Festival, on a 4-lane divided highway a 45-seat tour bus from Phayao to Bangkok hurriedly overtook two vehicles by using the 2.50 metre wide paved left shoulder. Its left wheels fell on the left sideslope. Driver tried to steer the bus back on the traffic lanes; Due to its high speed and greater weight he lost control his bus. The bus veered to the right and left and finally rest on its left side in the median.	7-deaths on scene 2-deaths at hospital. 37-injuries.	- Driver not well-prepared to drive. Be in bad temper, impolite and drive fast along the way. -Reckless driving. - Some passengers said that they tried to contact the police to stop this bus but they were too late.
05-05-08 1300	A 57-seat tour bus descended a steep slope and winding section of Mae Sod – Tak highway (which has two lanes in uphill direction and one lane downhill). As the bus was in a sharp left-hand curve the driver loss control of his bus. The bus veered to the right side crossing two opposite lanes and hit the concrete barrier, scraped along it for 10 metres before rolling over the barrier, hit the electric pole and finally rest upside down on the deep sideslope.	3-deaths on scene 44-injuries.	- The route itself is not suitable for heavy buses and trucks. It requires special cautions regarding the speed and using low gears. - Driver is not a professional one although he owns a bus driving license. He was a general worker. He was hired just to drive this tour bus and for this trip. Driver not familiar with this mountainous road.

[a] = conducted by RAIU KhonKaen University
[b] = conducted by RAIU Suranaree University of Technology
[c] = conducted by RAIU Prince of Songkhla University

Table 5 Summary of causes and contributing factors to serious bus accidents (19 cases) investigated by RAIU.

Human	Vehicle	Road and Environment
- Speed too high - Not familiar with the bus. - Not familiar with the route. - Driver fatigue. - Improper use of gear and pumping to much brake. - Drunk driving - Fail to give proper signal. - Driver not competent. - Driver not well-prepared. - Use left shoulder for overtaking. - Abruptly turn the steering wheel to avoid an accident led to another accident. - Use mobile phone while driving. - Continue his trip in spite of brake failed and locked.	- Strength of bus superstructures not adequate to protect passenger during rollover accidents. - No seat belt for bus passenger. - Passengers' seats thrown away during accident. - Tires in poor condition. - Brake failure. - Bus engine not well maintained. - Use of modified truck as a school bus or ordinary bus. - No protective devices in case of the transmission shaft broke and came to contact with the ground. - The emergency door and fire extinguisher cannot function. Most materials inside the bus cabin are vulnerable in case of fire. - Overcrowded bus made evacuation of passengers very difficult.	- Low design standard resulted in steep grade and winding road. Or the road not suitable for double deck bus and full trailer. - Lack of appropriate warning signs. - Trees in the clear zone. - Restricted sight distance at intersection. - Too many conflict points at unsignalised intersection.