

Accident Narrative

At about 03:45 on Tuesday, 23 July 2013, a double decker passenger bus caught fire after colliding with a truck in one of the Thailand's busiest highway, killing 19 people and injuring 18. The overnight bus departed from Roi Et and had been heading for Bangkok on the Mittraphab highway - west bound, around km 18+900, in Khaeng Khoi district in the central province of Saraburi (Figure 1).

According to the bus schedule, the bus departed from RoiET at 9:30 pm and stopped in Maha Sarakham to pickup some additional passenger at about 10 pm. One of the passenger in the bus informed TARC team during the interview that the bus was not travelling fast and most of the passenger were sleeping before the accident. After the crash, the bus caught fire and according to one witness, it took 10 until the bus was completely burn. Bus rotated left to the edge of the highway and truck rotated left and rest with the drivers compartment in the median (Figure 2). After the initial crash, a pickup hit the piled-up truck, injuring 3 people.

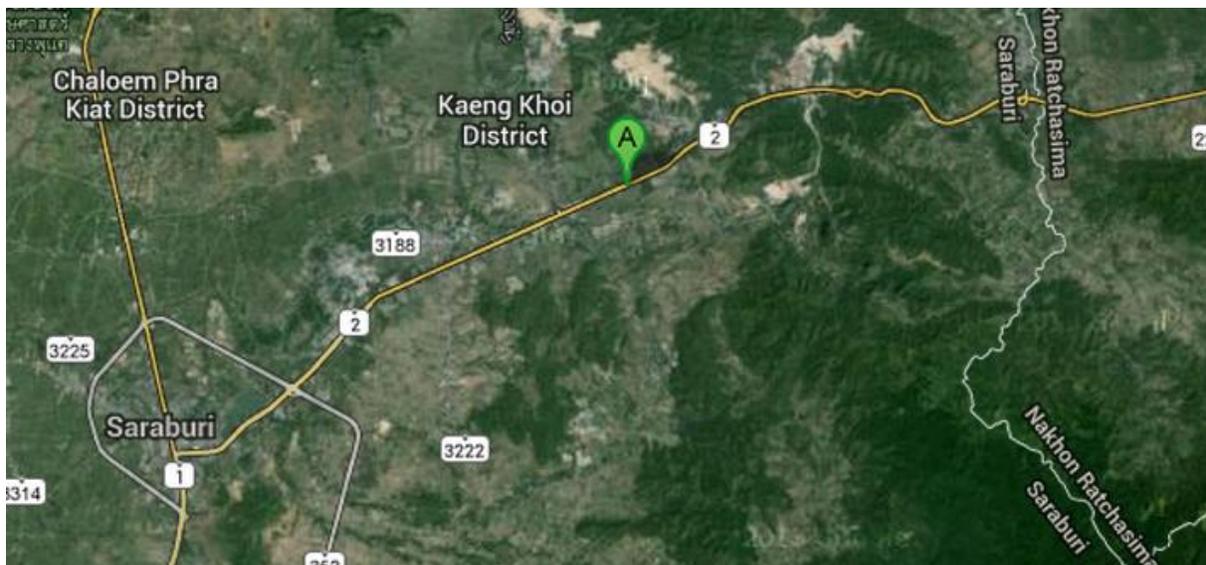


Figure 1 Location of Crash site

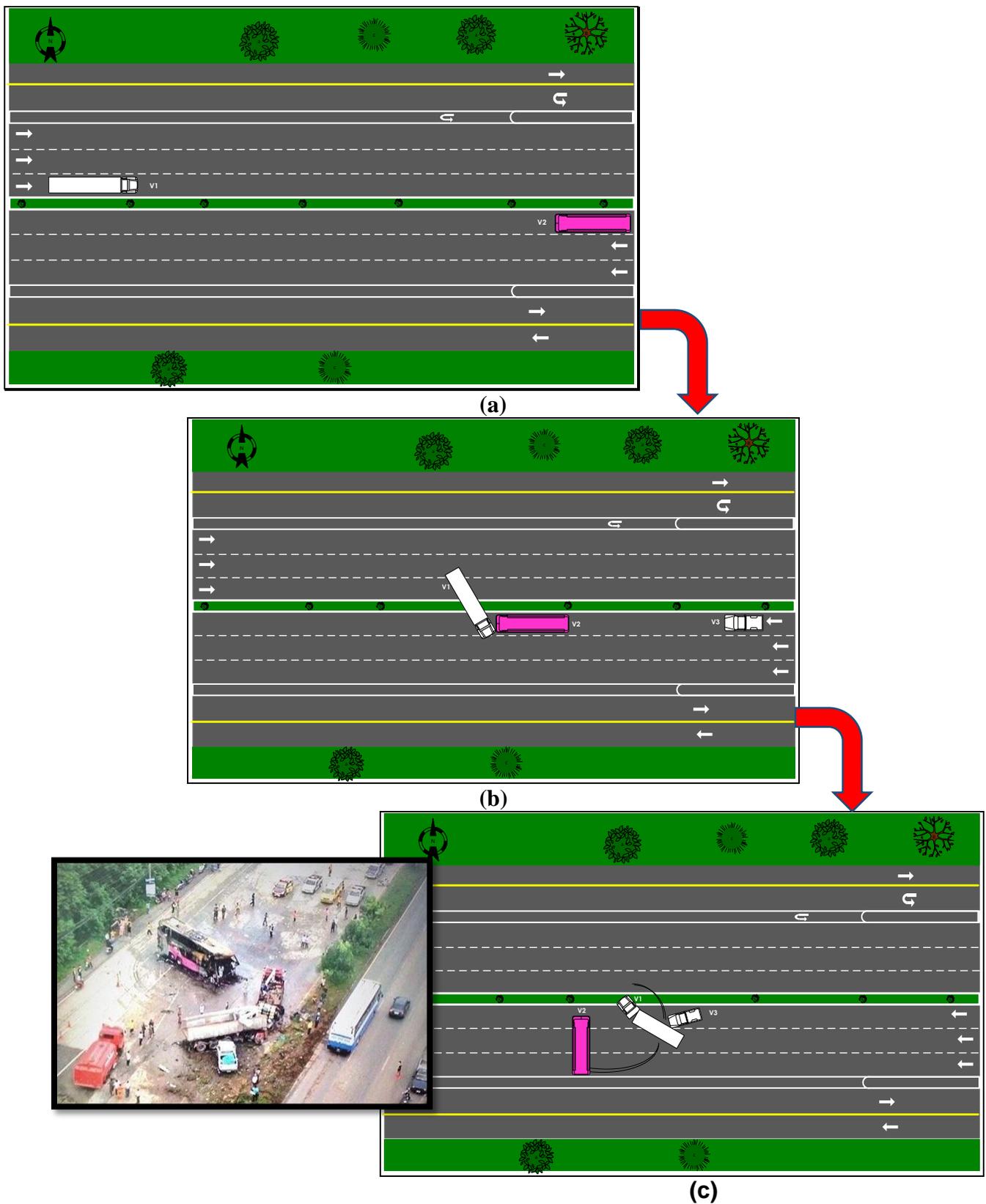


Figure 2 Schematic of Accident Scene, (a) before Collision, (b) during Collision (POI) and (c) after Collision (POR)

Vehicle Information

Truck (V1)

The truck involved in this crash was HINO 500, 22 wheeled, NGV fuel engine (modified), white in color. The truck belongs to JL transport co. The dimension of the truck is shown in the Figure 3.



Figure 3 Truck Dimension

Table 1 Details of the Tires of V1

10	Damage	Manufacture	Tire Name	Year	Size	Load Index & Speed Symbol	Tread Depth(mm)
1R	No	Michelin	XZA2+ Energy	0313	295/80R2 2.5	Single 3350kg Dual 3150kg	13.5
1L	Yes						13.6
2R	No		XZY3	N/A	11R22.5	Single 3150kg Dual 2900kg	16.3
2L							11.0
3R		10.7					
3L		13.1					
4R		Firestone	FS495	N/A	N/A	N/A	0.5
4L		Otani	Performa X	2212	10R20	Single 3075kg Dual 2725kg	0.0
5R	No	Bridgestone	M84	N/A	11R22.5	Single 3000kg Dual 2725kg	11.5
5L							5.1
6R		Michelin	XZY3	N/A	11R22.5	Single 3150kg Dual 2900kg	6.3
6L							9.2

Damages

Truck had a massive damages on its frontal part. The driver's compartment was crushed and detached from the chassis due to the impact as seen in Figure 4. It was observed that the front left chassis of the truck was deformed, assuming that it was hit by bus from left side. Similarly, some damages can be seen on the NGV fuel system and the frontal tires. Also, there was a minor damage on the front of the trailer. After the initial crash, truck was again hit by a pickup at the right of trailer, making a little damage. The speed of the truck before crash was 78 km/hr.



Figure 4 Damages of the Bus

Bus (V2)

The bus was a double decker passenger bus, designed in 3 axles with 8 wheels. The chassis was Volvo B12B, 12 000 cc, 420 hp, electronically controlled 12.1-litre diesel engine, manual transmission but the body frame was locally designed and built up by Cherdchai Company in Thailand. This bus belongs to “The Transport Company” which is a semi government run bus company that provides services to most parts of Thailand. It is a VIP intercity bus having a 1+2 seating position (Figure 5, Figure 6 Seat position and Location of Safety Equipment’s), onboard toilets and air conditioned. There were a total of 32 passenger seats, 6 seats in lower deck and 26 seats in upper deck. There were two driver seats in the front of lower deck and a stewardess at the back of upper deck.



(a)



(b)

Figure 5 original Structure of the Bus (a), Seat Position (b)

Table 2 Details of Tires of V2

Location	Damage	Manufacture	Tire Name	Year	Size	Load Index & Speed Symbol	Tread Depth(mm)
1R	Yes	BURNED					
1L							
2R	No	Michelin	XZA2+ Energy	3012	295/80R2	Single 3350kg Dual 3150kg	4.3
2L				N/A			2.5
3R				2212			5.1
3L							6.2

Safety Equipments of the bus

The bus had several safety components installed inside it. There were 2 main hydraulic doors, one in front left (Figure 7) and another in middle left of lower deck, while 2 emergency door, one in back right of upper deck and another in back right of lower deck (Figure 6Figure 8). Likewise, there was one driver door in the front right of lower deck. There were 3 tempered glass emergency windows, one in right front of lower deck and others in the middle- both left and right side of the upper deck. Lap seat belt were equipped on every seats. Also there were 6 emergency hammer: 2 in lower deck, 4 in upper deck and 4 fire extinguisher: 1 in lower deck, 3 in upper deck as shown in Figure 10.



Figure 6 Seat position and Location of Safety Equipment's



Figure 7 Front left Door of the bus



Figure 8 Location of Tempered Windows and Emergency Door



Figure 9 Seat belt and the location of Hammer



Figure 10 Location of Fire Extinguisher

Damages of the bus

The bus was 4.2 meters height in original, 12.0 meters in length and 2.4 meters in width. The bus sustained frontal crush and the right frontal corner showed a massive damages, intruding the front bumper and the frame inside the driver's compartment (Figure 12). However, the major measurable deformation was noticed on the front left axles with the maximum deformation at left corner (Figure 11). Some passenger seat were dislodged from the floor and the seat covers, carpet, front tires, ceiling material, blankets, drapes etc. were burnt completely due to the fire (Figure 13). All the windows were broken and the doors were open due to the failure of hydraulic pressure. Also, we can see from the Figure 14 , the batteries which were placed beneath the driver's seat were short circuited and damaged. The fuel tank near by the electric circuit was ejected out after the blast. According to the bus "The transport Company", the speed of the bus from GPS was 79 km/hr before the crash.

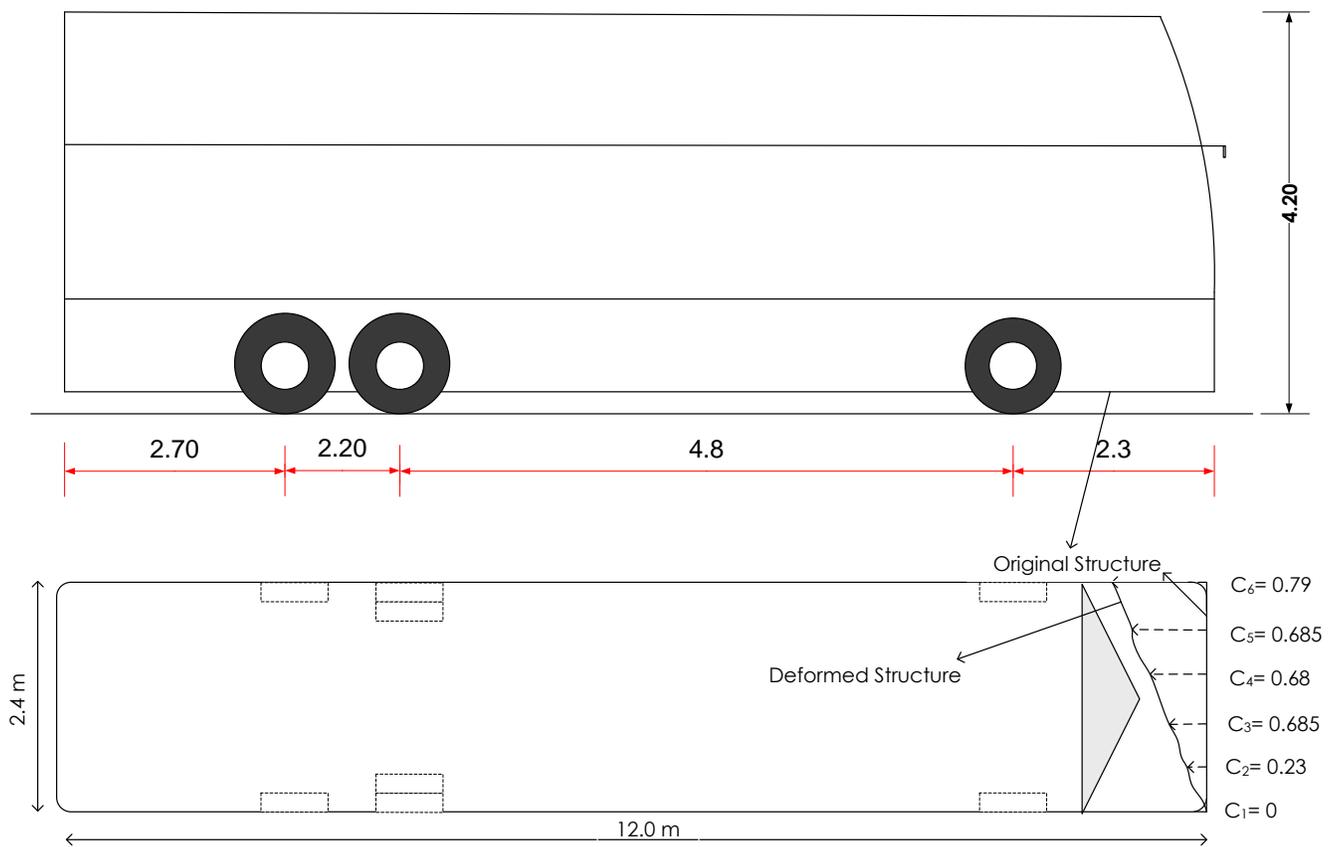


Figure 11 Crush Deformation of the Bus



Figure 12 Damages of the Bus



Figure 13 Damages inside the Bus



Figure 14 Location of the Batteries

Highway Information

The accident occurred on the Mittraphab road, highway no. 2 in Saraburi province, at 14°36'28.39" N, 101°04'02.26" E. It is the first highway in Thailand to use both asphalt and concrete. It is the main road that connects Isan (northeastern Thailand) across the Dong Phaya Yen Range with Saraburi with the total of 508 km. It passes through the provinces of Nakhon Ratchasima, Khon Kaen, Udon Thani, and ends in Nong Khai. The accident occurred at around km 18+900, downhill section and has 4 % gradient, raised median, 3 lane meging with 2 lane frontage road in each direction. The width of the lane is 3.50 meteres, 2% slope, and the right of way is 60 meteres. The details of the pavement and the cross section of the highway at accident site is shown in Figure 15.

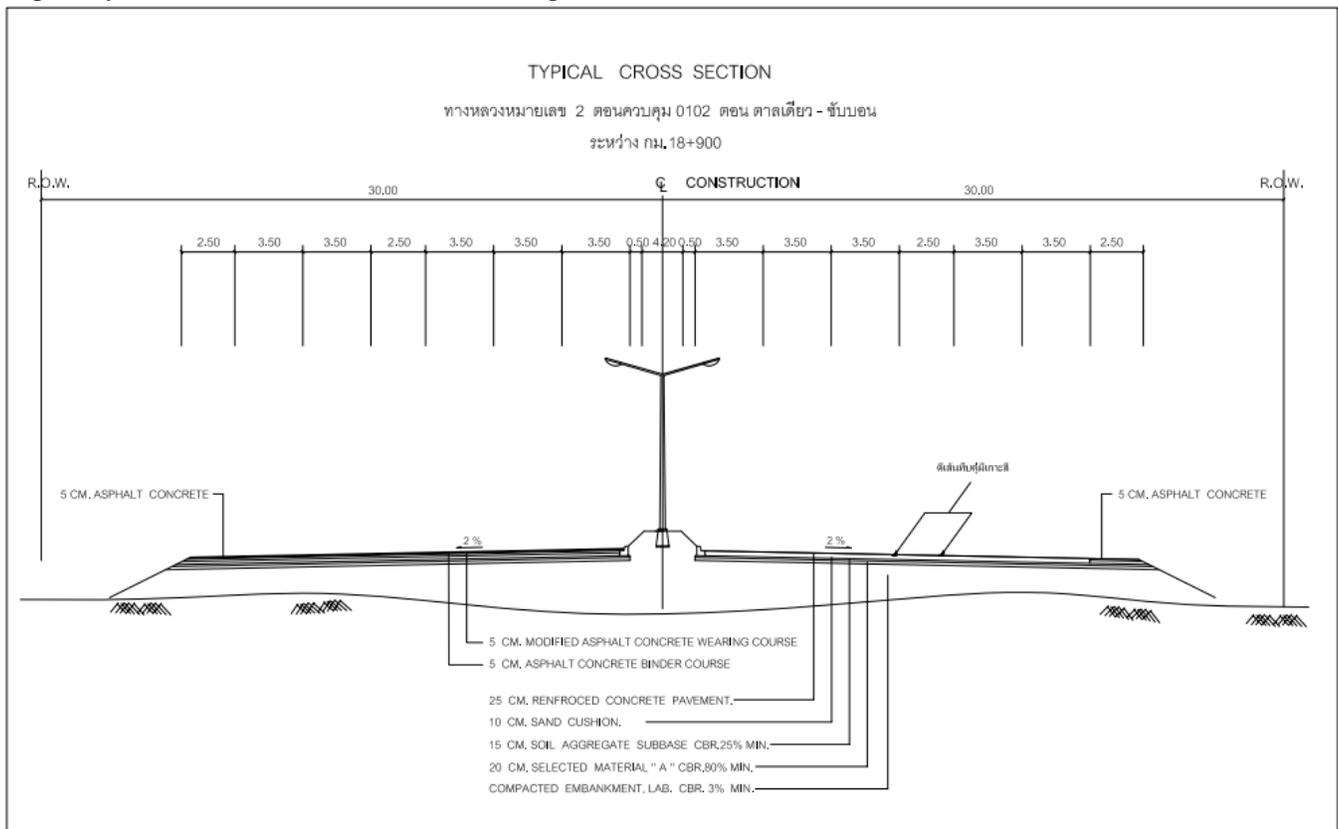


Figure 15 Cross-section of the Mittraphab Highway at km 18+900

Physical Evidence

TARC investigated the accident site and apparently found a barren patch in the median of the highway (Figure 16), which clearly shows that the truck crossed the median to the opposite direction. Also, the presence of yaw marks in the travel lane indicates that the bus rotated clockwise after it get hit by a truck.



Figure 16 Sequences of the Accident Provided with Evidences (Yaw Marks and Barren Lawn)

Driver Information

The truck driver, 29 years old male was an employee of TJJ Transport Ltd. He has been working in this company since one year, however he made his driver license in 2005 and has 5 or 6 years' driving experience in the former company he used to work. The medical report showed that the alcohol content in his blood was only 5 %, which is not significant for the accident. The truck driver summarized the event prior to the collision as - the truck started its journey from Rattana-thibeth road, Nothanburi at 1 am to kaeng Koi quarry, Saraburi in order to

collect the gravel. He said that he had an one hour sleep at Samkhok, Pathumthani and continued his journey to the quarry. While the Truck (V1) was moving in the inner lane of eastbound approach (uphill); he was feeling drowsy and sudenly the truck lost its control and deviate across median, approaching to opposite directional flow and colliding with the bus (V2) in westbound approach (downhill).

Similarly, there were two drivers in bus, named as driver 1 and driver 2 as shown in Figure 19. Driver 1, 43 years old male was driving the bus. As per the bus schedule, he started his trip from Roi Et and after picking up some passangers from Maha Sarakham, he resumed his journey to Mochit. Driver 2, 51 years old male was sleeping in the compartment. He had an experience of 10 years and was familiar to this route.

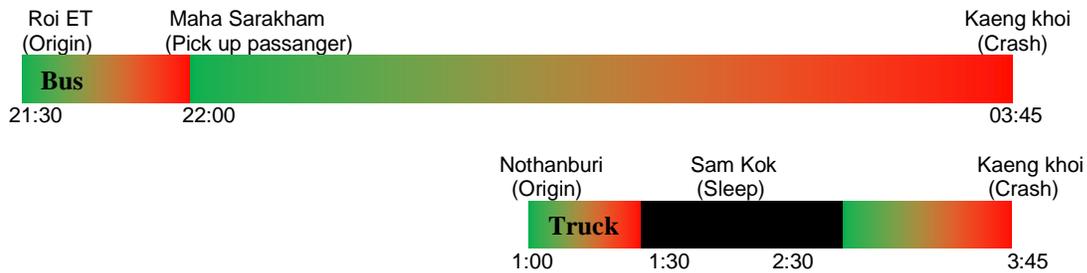


Figure 17 Bus and Truck Driving Hours before Crash

Injury Information

There were 36 occupants including 2 drivers on board at the time of crash. Altogether 19 occupants died inside the bus, while the remaining were severely injured. The seating position of the occupant inside the bus are shown in Figure 18. As seen in figure, 8 occupants were sitting in the lower deck, while 27 occupants were sitting in the upper deck of the bus. The injury information of the occupants was collected from two hospitals: Kang koi Hospital and Saraburi Hospital, while the fatality information was collected from the Institute of Forensic medicine, Bangkok.

TARC performed an in-depth study of the casualties by classifying them according to the level of injury, seat positions, and cause of death (due to impact or fire). Figure 18 shows the casualties according to the seating position and level of injury. As we can see, most of the occupant seating in the front in both upper and lower deck has more fatality than the occupant seating in the back. The fatality was due to the impact and the fire. According to the report from Institute of Forensic Medicine, 10 out of 19 occupants died before the bus catches fire and the rest of them died because of the respiration failure due to smoke. The details of the fatality and injury according to the seating position are presented in Figure 19. Similarly, the summary of the injury information based on ICD code are presented in

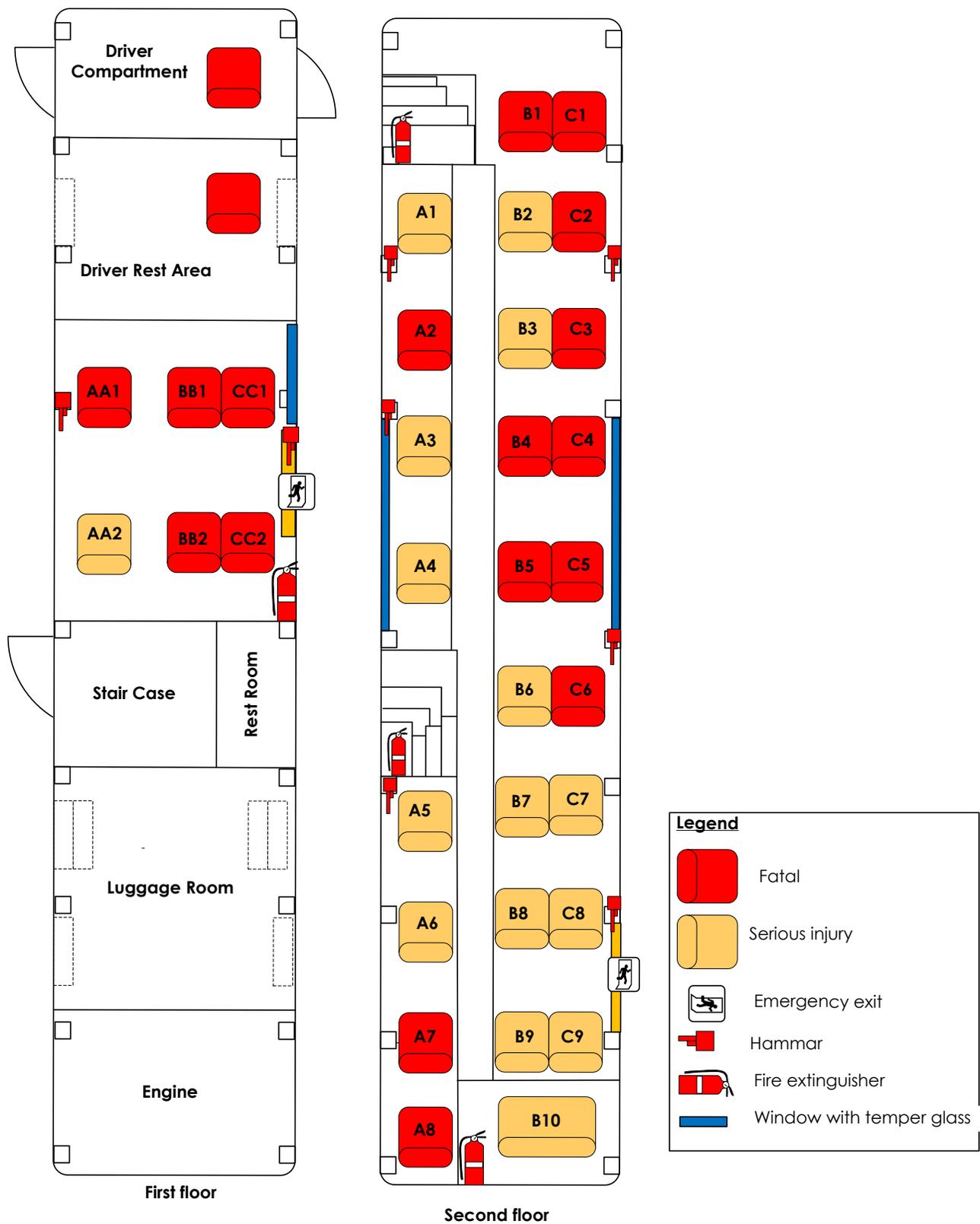
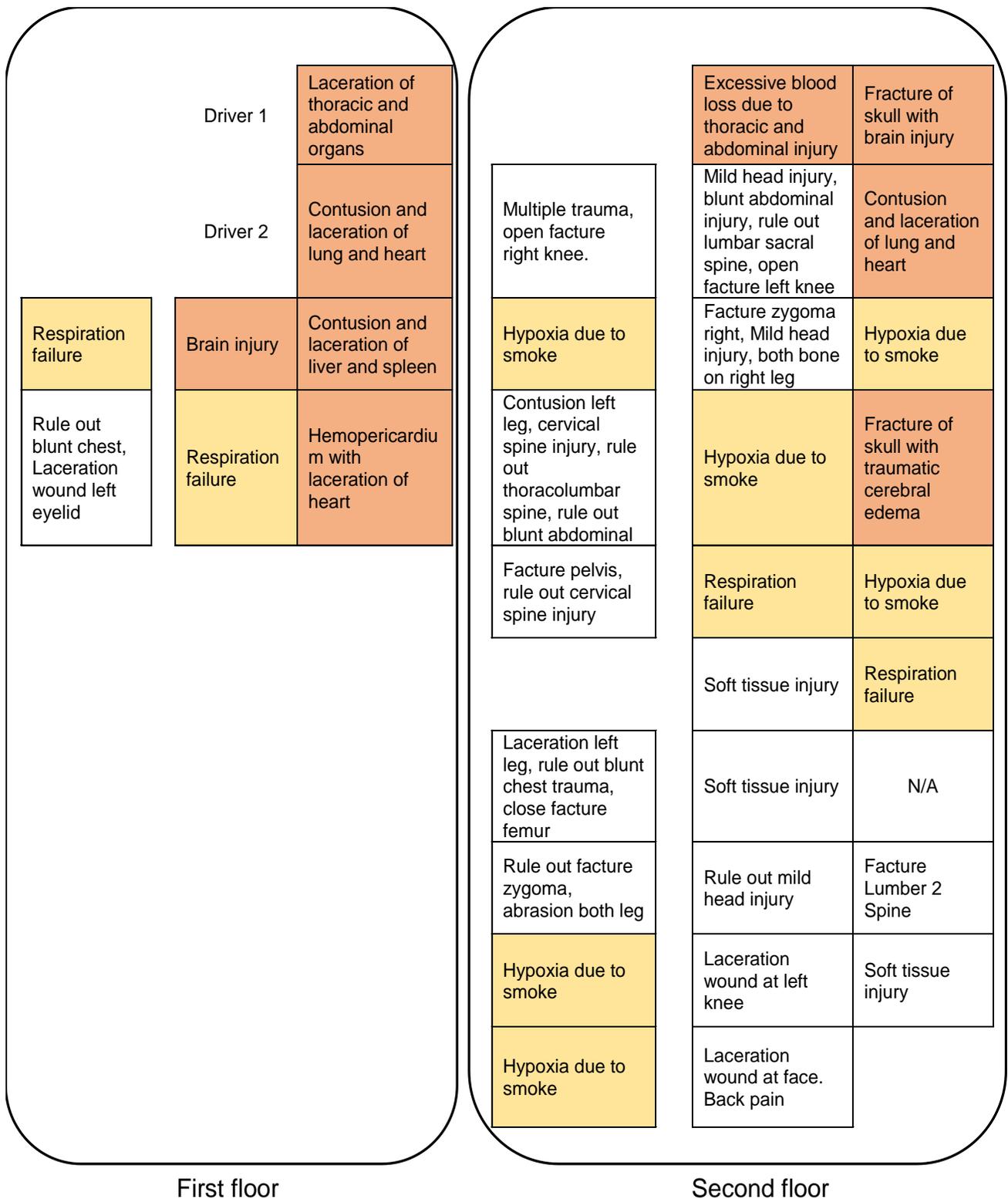


Figure 18 Seating position and the Injury Level



Fatal (before burning)
 Fatal (after burning)
 Injured

Figure 19 Cause of Fatality and their Seating Position

Table 3 Summary of Occupant's injury Based on ICD 10 code

First Floor			
Position	Diagnosis	ICD-10	Description
AA 1	Respiratory Failure	J96.9	Respiratory failure, unspecified
AA 2	Rule Out Blunt Chest, Laceration Wound Left Eyelid	S20.2 S01.1	Contusion of thorax (R/O) Open wound of eyelid and periocular area
BB 1	Brain Injury	S06.9	Intracranial injury, unspecified
BB 2	Respiratory Failure	J96.9	Respiratory failure, unspecified
CC 1	Contusion and Laceration of Liver Contusion and Laceration of Spleen	S36.1 S36.0	Injury of liver or gallbladder, Injury of spleen
CC 2	Haemopericardium with Contusion and	S26.0	Injury of heart with haemopericardium
Second Floor			
Position	Diagnosis	ICD-10	Description
A 1	Multiple Trauma	T94.0	Sequelae of injuries involving multiple body regions
A 2	Hypoxia due to Smoke	X09	Exposure to unspecified smoke, fire and flames
A 3	Contusion Left Leg, C-Spine Injury, Rule Out T-L Spine, Rule Out Blunt Abdomen	T13.0 S24.1 T09.3 S39.9	Superficial injury of lower limb, level unspecified Other and unspecified injuries of thoracic spinal cord Injury of spinal cord, level unspecified (R/O) Unspecified injury of abdomen, lower back and pelvis
A 4	Fracture Pelvis	S32.8	Fracture of other and unspecified parts of lumbar spine
A 5	Laceration Left Leg, Rule Out Blunt Chest Trauma, Close Fracture Femur	T13.1 S27.9 S72.90	Open wound of lower limb, level unspecified, Injury of unspecified intrathoracic organ (R/O), Closed Fracture of femur, part unspecified
A 6	Rule Out Fracture Zygoma, Abrasion Both Leg	S02.4 T13.0	Fracture of malar and maxillary bones (R/O), Superficial injury of lower limb, level unspecified
A 7	Hypoxia due to Smoke	X09	Exposure to unspecified smoke, fire and flames
A 8	Hypoxia due to Smoke	X09	Exposure to unspecified smoke, fire and flames
B 1	Severe Blood Loss due to Thoracic and	T79.4	Traumatic shock
B 2	Mild Head Injury, Blunt Abdominal Injury, Rule Out L-S Spine	S09.9 S39.9 T09.3	Unspecified injury of head Unspecified injury of abdomen, lower back and pelvis Injury of spinal cord, level unspecified (R/O)
B 3	Fracture Zygoma Right, Mild Head Injury, Fracture of Both Bone Right Leg	S02.4 S09.9 S82.9	Fracture of malar and maxillary bones Unspecified injury of head Fracture of lower leg, part unspecified
B 4	Hypoxia due to Smoke	X09	Exposure to unspecified smoke, fire and flames
B 5	Respiratory Failure	J96.9	Respiratory failure, unspecified
B 6	Soft Tissue Injury	T14.6	Injury of muscles and tendons of unspecified body region
B 7	Soft Tissue Injury	T14.6	Injury of muscles and tendons of unspecified body region
B 8	Rule Out Mild Head Injury	S09.9	Unspecified injury of head (R/O)
B 9	Laceration Wound Left Knee	S81.0	Open wound of knee
C 1	Fracture of Skull, Brain Injury	S02.9 S06.9	Fracture of skull and facial bones, part unspecified Intracranial injury, unspecified
C 2	Contusion and Laceration of Lung Contusion and Laceration of Heart	S27.3 S26.9	Other injuries of lung Injury of heart, unspecified
C 3	Hypoxia due to Smoke	X09	Exposure to unspecified smoke, fire and flames
C 4	Fracture of Skull, Traumatic Cerebral Edema	S02.9 S06.1	Fracture of skull and facial bones, part unspecified Traumatic cerebral edema
C 5	Hypoxia due to Smoke	X09	Exposure to unspecified smoke, fire and flames
C 6	Respiratory Failure	J96.9	Respiratory failure, unspecified
C 7			
C 8	Fracture L2 Spine	S32.0	Fracture of lumbar vertebra
C 9	Soft Tissue Injury	T14.6	Injury of muscles and tendons of unspecified body region
Others			
Position	Diagnosis	ICD-10	Description
Driver 1	Laceration of Thoracic Organs Laceration of Abdominal Organs	S27.9 S39.9	Injury of unspecified intrathoracic organ Unspecified injury of abdomen, lower back and pelvis
Driver 2	Contusion and Laceration of Brain, Fracture of Skull	S06.9 S02.9	Intracranial injury, unspecified Fracture of skull and facial bones, part unspecified
Airbus	Laceration Wound at Face, Back Pain	S01.8 M54.5	Open wound of other parts of head Low back pain
N/A	Tension Head	G44.2	Tension-type headache
N/A	Laceration Wound at Face, Back Pain	S01.8 M54.5	Open wound of other parts of head Low back pain

Accident Contributing Factors

Human Factor

From the truck driver's information, he started his journey from Rattana-thibeth Road, Nothanburi and taking one hour sleep in Sam Khok, he resumed his journey. It signifies that the driver might not have slept properly and was feeling sleepy at the time of crash, which can be considered as an important accident contributing factor for the accident. Drowsiness reduces reaction time which is a critical element of safe driving. It also reduces vigilance, alertness and concentration and the ability to perform attention-based activities such as driving is impaired.

Highway Condition Factor

TARC investigated the crash site, its highway and environmental condition to find out if they have any significant effect on the accident. The wet surface could be one of the factors contributing an accident. According to the witness, during the crash, there was a raw drizzling rain and the road surface was wet (Figure 20). Wet roads have lower level of friction and skidding/loss of control can occur when the forces generated in acceleration, braking or cornering exceed the level of grip available. Similarly, another contributing factor could be the low curb height of the median due to pavement overlaying. The use of curb in high-speed roadways can be dangerous because of their potential to cause drivers to lose control and crash. The vertical curb have some stability to redirect errant vehicles since the impacting wheel is steered by the curb in a direction parallel to the travel way. If the impact velocity and angle are modest, this steering action is all that may be required to prevent the vehicle from leaving the roadway. If the speed and encroachment angle are higher, then the steering action of the curb alone is not sufficient to redirect the vehicle, leaving it from roadway or rollover. Also, the highway in this case has no shoulder between right edges of the road and curb (Figure 21). This can cause the tires of the vehicle has high chance to get over the curb, esp. if the height of the curb is too low. All these factors coupled together might have made a situation for the truck to cross over the median and collide.



Figure 20 Wet pavement Surface seen at the Crash Site



Figure 21 Low Height Median Curb and No Shoulder between Right lane and Median

Injury Contributing Factors

Human factors

All the seat in the bus was equipped with lap seat belt. Use of seat belts mitigate impacts to a motorist due to crash, thereby reducing the severity of injuries. Seat belts also prevents occupant from being ejected during a crash. However, none of the occupant used seat belt during the crash, increasing the chance of getting injured by the sudden impacts. Similarly, as we can see, that the bus has several safety equipment's like fire extinguisher, hammer, windows with temper glass and emergency exit. It was likely to be seen that none of these safety measures has been adopted by the occupant during the crash, indicating that the occupants had inadequate information about the safety equipment to be used during emergency situation.

Vehicle factors

The design of fuel tank near the electric circuit was observed in the bus. The source of ignition of the fuel tank could be the short circuit nearby, making an explosion and leading to the fire spreading all over. As seen in Figure 22, the presence of thick seat covers, carpet, ceiling material, blankets and drapes inside the bus can be the another contributing factor for the severity of injuries. These materials can be burn easily and produce excessive smoke when caught with fire. The smoke of these burning cloths and foams can be dangerous for human, which may cause respiratory failure due to choking. From the autopsy report, 10 occupant died

due to the respiratory failure, which might be only due to the smoke from these flammable materials inside the bus.



Figure 22 Flammable Materials Inside the bus

Significant Factors

TARC determined that the probable cause of the 130724-01 crash occurrence was due to drowsiness of the truck driver followed poor highway conditions like median with low curb height, poor visibility due to rain during night time, wet pavement surface as supported by the mentioned evidences. Similarly, TARC also determined the probable cause of injury of the same case. Sitting in position without any safety protection, inadequate information about the safety equipment, presence of flammable materials inside the bus and improper design of electric circuit and fuel tank played a key role to increases the injuries level of the occupant both in lower and upper deck.