Case ID: 090318-01

Accident Narrative

At about 09:00 on Wednesday, 18 March 2009, the double decker intercity bus, service between Bangkok and Mae Sot, lost control on a wet pavement surface while traveling on Highway No. 32 at KM. 42+600, Bang Pahan, Ayutthaya (**Figure 3-1**). It fell into a roadside slope and overturned. Four passengers out of a total of 37 on board died instantly. Another 7 and 26 suffered serious and light injuries, respectively.

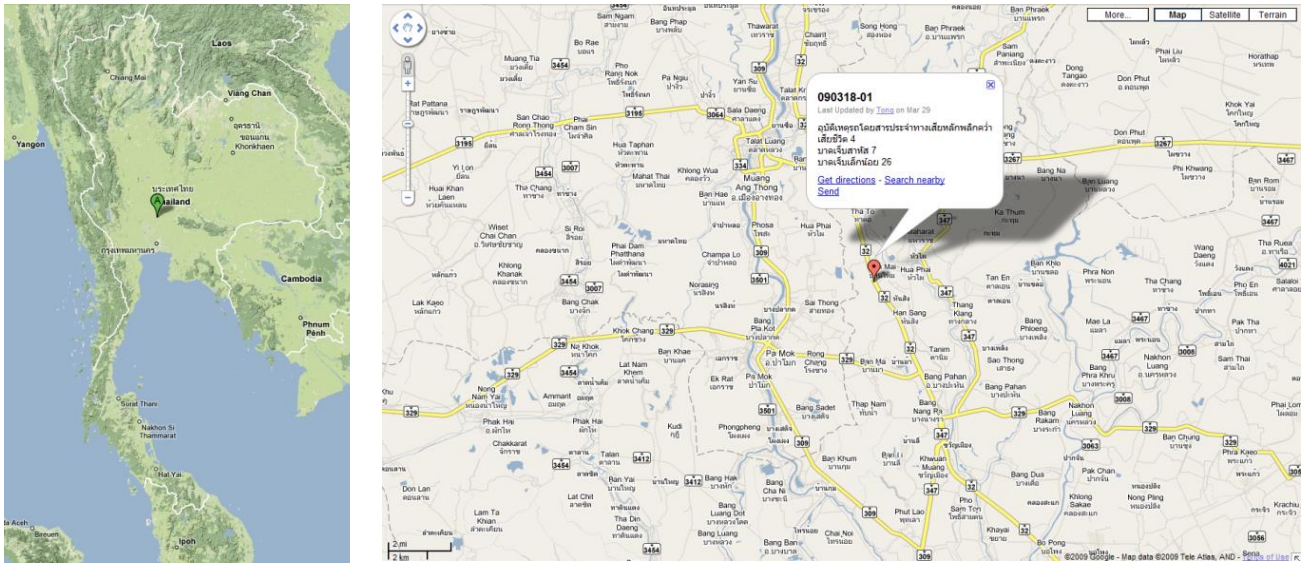

Figure 3-1: Crash Location

This morning trip started from Mo Chit 2, Bangkok bus terminal station, at about 08:15. It traveled on Highway No.1 and turned right into Highway No.32 in Bang Pa-in, Ayutthaya, planning to arrive in Mae Sot at 17:00. The bus route is shown in **Figure 3-2**. It was slightly raining and the windshield wiper was on. The bus started losing its control at KM.42+600 and swung left from the middle lane. The bus swayed two or three times, according to the witness passengers. The bus turned on its right immediately after departing the roadway, causing the subsequent injuries as mentioned.

Figure 3-2: Bus Route

Vehicle Information

The double deck bus was locally assembled in Thailand. The body structure was emulated while the structure and engine were imported. There are eight wheels on three axles. The original dimensions were 4.0 m. high, 2.5 m. wide, and 12.0 m. long. It was white-gray-orange in color. According to the service provider, it is a first class VIP public bus running in the Northern corridor between Bangkok and Mae Sot, Tak. **Table 3-1** shows the details of the tires information

Table 3-1: Tires Detail

Location	Damage	Manufacture	Tire Name	Year	Size	Tread Depth (mm)	Pressure (psi)
1L	No	Michelin	XZA2	4008	295/80 R22.5	13	135
1R	No	Michelin	XZA2	4008	295/80 R22.5	11	135
$2L_{in}$	No	Michelin	XZA2	0208	295/80 R22.5	9	135
$2L_{out}$	No	Michelin	XZA2	0208	295/80 R22.5	10	N/A
$2R_{in}$	No	Michelin	XZA2	4008	295/80 R22.5	9	138
$2R_{out}$	No	Michelin	XZA2	4008	295/80 R22.5	10	N/A
3L	No	Michelin	XZA2	0208	295/80 R22.5	7	133
3R	No	Michelin	XZA2	0208	295/80 R22.5	8	135

From **Figure 3-3**, it can be seen that the lower deck is arranged into 5 parts including the driver cab, staff room, occupants compartment, luggage room, and engine box. Six set of passenger seats are installed in the occupants compartment, four on the right and two on the left. On the upper deck, the seating configuration of the bus consists of 12 rows. There are the seats only on the right side on the first, sixth and seventh rows, leaving space for the staircase on the left. The twelfth rows comprises of five seats connected to each other. Each set on the other rows are all individual but attached as a pair. The space between the seats is 85 cm. The seats are connected to the bus body by a pair of steel hooks, one attached to the floor while another one is attached to a side bar (**Figure 3-4**). However, only

the last row and three sets on the lower deck have seats installed on the bus floor by connecting bolts. All seats are equipped with a lap seatbelt. However, all of them were hidden and fasten at the back of the seats (**Figure 3-5**).

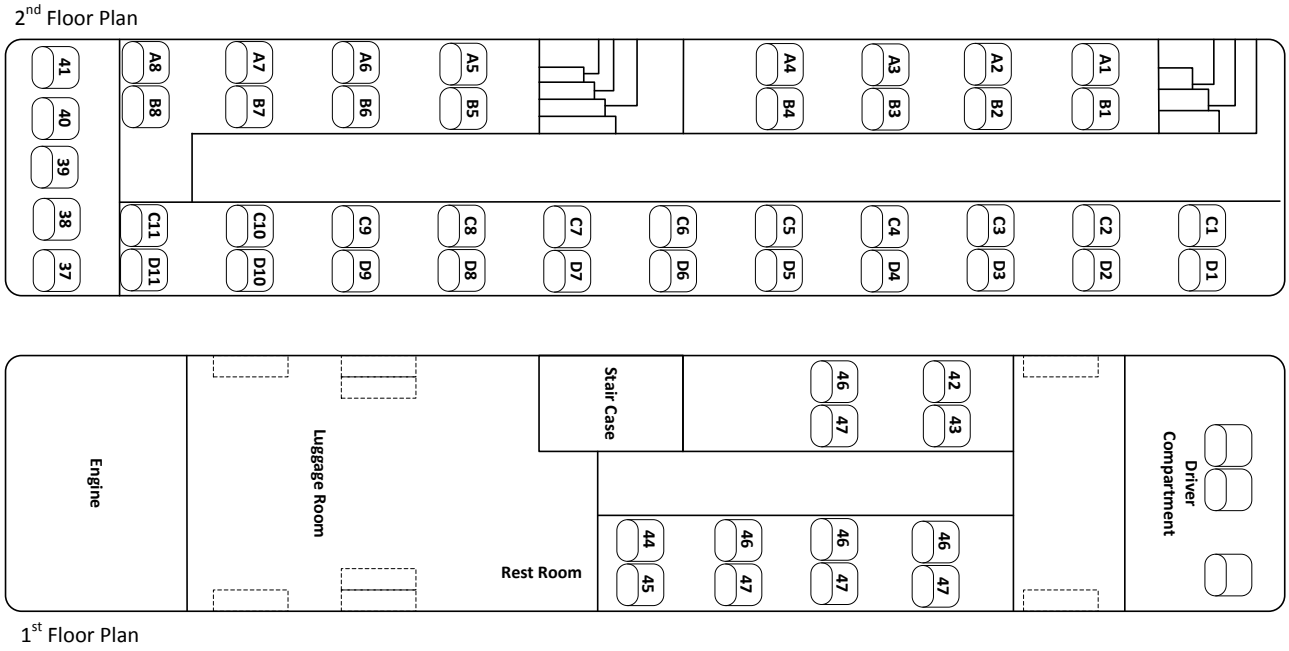

Figure 3-3: Seating Configuration

Figure 3-4: Seat Installation

Figure 3-5: Seatbelt

Bus Damage

There was no major intrusion from the collision in this single vehicle crash (**Figure 3-6**). Since the bus stopped on its left side, there were scratch marks, mud, and grass entirely on this side. Almost all windows, except between second and third pillars, were shattered including the front windshield. The rear mirror on the left side was damaged.

Figure 3-6: Bus Damage on Left Side

The interior damages showed a little deformation on the cabin luggage between the second and fourth and eighth and ninth rows (**Figure 3-7**). All passenger seats were intact.

Figure 3-7: interior Damage

Driver Information

The bus driver was a 42 year old male. He was employed by the Transport Company Limited. He had about ten years of driving public transport bus experience and had been using this bus for seven months. He regularly drove only this route with15 trips per month. There were two drivers switching at the middle of the trip in Nakhonsawan. On that night trip, he drove from Mae Sot to Nakhonsawan, and arrived in Bangkok at about 03:30. For this trip, he left Mo Chit at about 08:15.

Highway Information

The crash occurred on Highway No.32 (unofficially called “Asia Route”) at KM. 42+600 in Bang Pahan, Ayutthaya. Highway No.32, 151 km long, serves as a Northern corridor, starting from Highway No.1 at Bang Pa-In, Ayutthaya running through the provinces of Ayutthaya, Ang thong, Singburi, and connecting again at Manorom, Chainat (**Figure 3-8**).

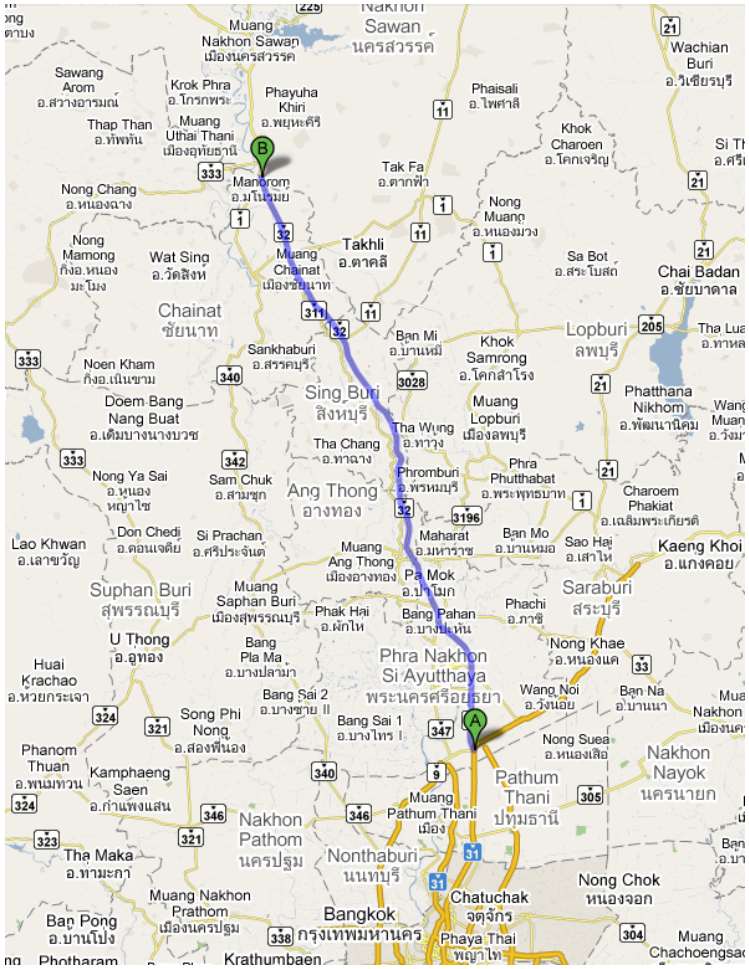

Figure 3-8: Highway No.32

In the area of the crash, the road is an eight lane divided road without frontage. It is separated by a concrete barrier. There is a 3.6 m. wide lane and a 2.7 m. wide shoulder in each direction. The crown slope is 3% on the traveling lane and 2% on the shoulder. The coefficient of friction of the wet asphaltic concrete pavement measured at the scene was 0.48. About 100 m. before, a reverse curve is applied to detour the traffic from the office building in the middle of the road.

The grassy roadside is about 20 m. wide and plenty of Sedges are located along it, at a distance of 11 m. from the traveling lane. The roadside slope at the bus rest position was measured to be 1V:6H.

Physical Evidence

A set of wheel tracks were obviously seen, started from the third lane (counted from the median) and ended at the outer shoulder. The details of the tire marks are shown in **Figure 3-9** and **Table 3-2**. It was clearly shown that the bus started to yaw, or slide, in between the second and third lane. However, there was not enough space for the bus to recover on the traveling lane. The debris on the roadside, next to the shoulder, showed that the bus

overturned on the left side immediately after moving out of the road leaving no wheel tracks in this area. The bus finally stopped on the roadside ditch on its left side.

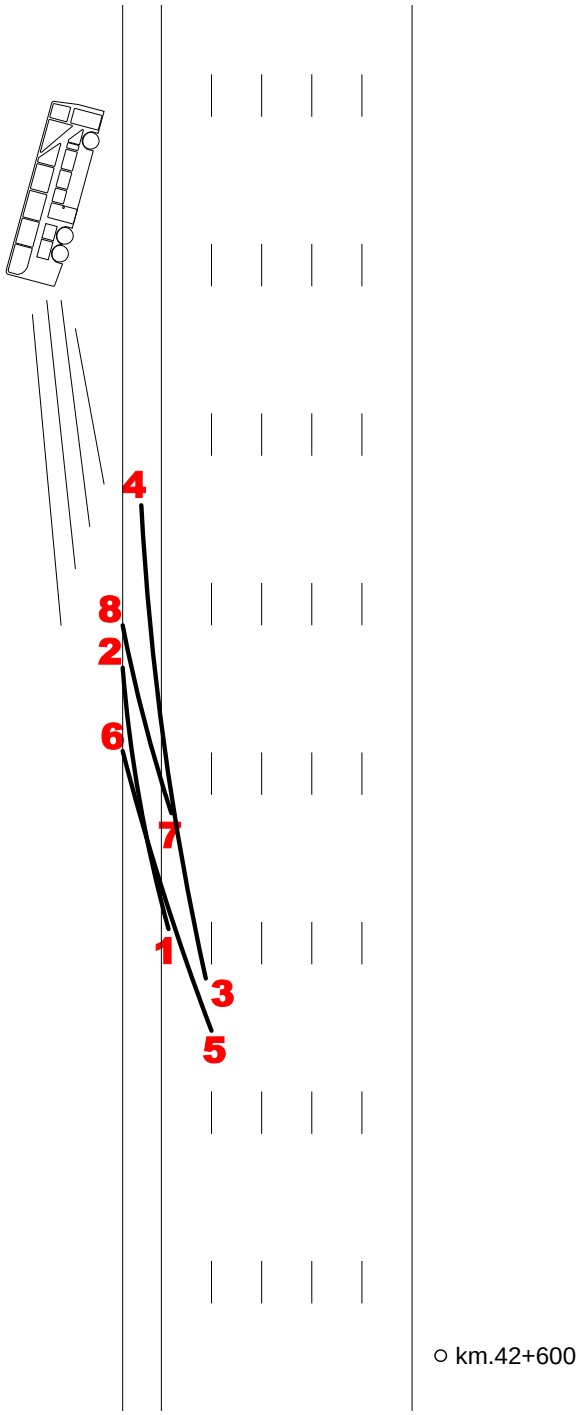

Figure 3-9: Bus Tire Marks

Table 3-2: Tire Mark

Tire	Number		Length (m)
	Start	End	
Front Left	1	2	18.8
Front Right	3	4	33.8
Rear Left	5	6	20.7
Rear Right	7	8	13.7

Injury Information

Four passengers were found dead in the wrecked bus, two males and two females. The legs and arms of one dead passenger were separated from the body. Other 7 serious injuries and 26 light injuries were hospitalized at Bang Pahan Hospital and Ayutthaya Hospital. **Table 3-3** below shows details of the occupants' injuries in this crash.

Table 3-3: Summary of Occupants Injury

Person	Gender	Age	Level of Injury	Injury	ICD 10
1	Female	12	Fatal	Fracture of mandible	S02.6
				Fracture of rib	S22.3
				Fracture of femur	S72.0
				Open wound of thigh	S71.1
				Open wound of lower back	S31.0
				Open wound of forearm	S51.1
2	Female	40	Fatal	N/A	N/A
3	Female	65	Fatal	N/A	N/A
4	Male	35	Fatal	N/A	N/A
5	Female	36	Serious	Fracture of humerus	S42.2
6	Male	18	Serious	Injury to the intra-abdominal organ	S36.9
7	Male	29	Serious	Fracture of lumbar vertebra	S32.0
8	Female	40	Serious	Fracture of forearm	S52.9
9	Female	40	Serious	Fracture of femur	S72.0
				Fracture of elbow	S52.9
10	Male	41	Serious	Fracture of femur	S72.0
11	Female	25	Serious	Superficial injury to the eyelid	S00.8
12	Female	22	Serious	Fracture of femur	S72.0
13	Male	37	Serious	Fracture of 6th cervical vertebra	S12.2
14	Male	39	Serious	Fracture of vault of skull	S02.0
19	Female	63	Serious	Crushing injury to the head	S07.9
24	Female	40	Serious	Fracture of lower end of radius	S52.5
25	Female	35	Serious	Injury to the muscles of unspecified body region	T14.6
28 (Driver)	Male	41	Slight	Crushing injury to the unspecified body region	T14.7
15	Male	20	Slight	Crushing injury to the chest	S28.0
16	Female	28	Slight	Open wound of unspecified body region	T14.1
17	Female	10	Slight	Open wound of lower leg	S81.8
18	Male	33	Slight	Injury to the muscles of unspecified body region	T14.6
20	Male	37	Slight	Injury to the muscles of unspecified body region	T14.6
21	Female	30	Slight	Crushing injury to the unspecified body region	T14.7
22	Male	54	Slight	Open wound of unspecified body region	T14.1
23	Female	35	Slight	Injury to the muscles of unspecified body region	T14.6
26	Male	30	Slight	Crushing injury to the unspecified body region	T14.7
27	Female	31	Slight	Open wound of lower back	S31.0
29	Female	10	Slight	Crushing injury to the unspecified body region	T14.7
30	Male	30	Slight	Crushing injury to the unspecified body region	T14.7
31	Male	1	Slight	Crushing injury to the unspecified body region	T14.7
32	Male	37	Slight	Injury to the muscles of unspecified body region	T14.6
33	Female	29	Slight	Open wound of unspecified body region	T14.1
34	Male	33	Slight	Open wound of lower back	S31.0
35	Female	4	Slight	Crushing injury to the unspecified body region	T14.7
36	Male	37	Slight	Injury to the muscles of unspecified body region	T14.6
37	Male	31	Slight	Superficial injury to the ear	S00.4

Accident Contributing Factors

Leaving the Roadway

The coefficient of friction plays an important role in road safety. It was found that the crash risk on a road where the coefficient of friction is less than 0.45 is 20 times higher than on a road where the friction is higher than 0.6 (TD, 1994). The risk will increase by 300 times if the friction is lower than 0.30. One study from Viner et al concludes that low friction by water is the most potentially dangerous driving condition, especially if combined with poor road geometry (Viner et. al, 2005). In this crash, the coefficient of friction is reduced to only 0.48. It was two times lower than on dry surface (0.80). In addition, the crash occurred on the reverse curve where the office building is in the middle of the road.

To understand the effect of low surface friction, a simple calculation of stopping sight distance is determined to compare between measured wet surface and normal dry surface at the crash scene as shown below.

$$SSD = 0.278vt + \frac{v^2}{254(f \pm G)}$$

where;

SSD	=	required stopping sight distance (m)
v	=	speed (km/hr)
t	=	perception reaction time (s)
f	=	coefficient of friction
G	=	grade

If the bus driver was travelling at 80 km/hr as he mentioned, the SSD for the dry surface is 76 m , increasing to 97 m for the wet surface (assuming a 2 second perception reaction time). It needs an extra 21 m to stop on the wet surface. Drivers have difficulty to recognize this additional distance, or a 28% increase, while driving on a wet surface. The situation becomes worse when the visibility is clear as the driver then keeps driving at a high speed. The statistics confirm that about 40% of speeding related crashes happened on wet roads (LTNZ, 2004).

Referring to the date of the crash, there were two more crashes which occurred between a police pickup –rescue team pickup and an EMS van – stopped truck. They were in a hurry to reach the crash scene but there was still water remaining on the road surface. These two crashes caused injuries to 3 policemen and 4 nurses.

Rollover

A roadside slope at the crash scene is desirable according to the recommendations by AASHTO in the 2002 Roadside Design Guide. The side slope is measured as 1:6, together with a 90 km/hr design speed and 48,524 vehicles per day of 2007 Average Annual Daily Traffic (AADT), the clear zone distance required is 6.5 – 7.5 m.

Vehicle dynamic is likely to be an important factor in this crash. In Thailand, a static measure to determine the Static Stability Factors (SSF) has not yet been performed. The theory of SSF defines that the vehicle rollovers if the sum of the lateral forces on the tires, divided by the weight of the vehicle, is greater than T/2H for a sufficient length of time (Gillespie, 1992). SSF is defined as the track width divided by twice the center of gravity height, meaning that SSF = T/2H (TRR, 2002) (**Figure 3-10**).

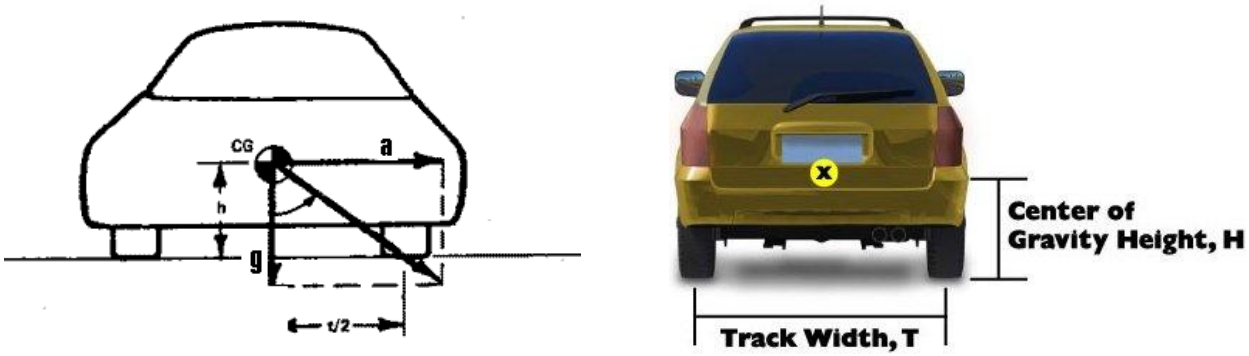

Figure 3-10: Static Stability Factors

Source: Virginia Polytechnic Institute and State University and National Highway Traffic Safety Administration

All of the cars in the United States are rated by using stars for the chance of rollover (**Figure 3-11**). Normally, the SSF of cars, vans, pickup, or SUVs are between 1.00 – 1.50. The bus, however, is calculated to be equal to 0.80 approximately. By applying the idea of statistical model used in medium cars, it is shown that a bus has a roll over risk 8 times higher than a car.

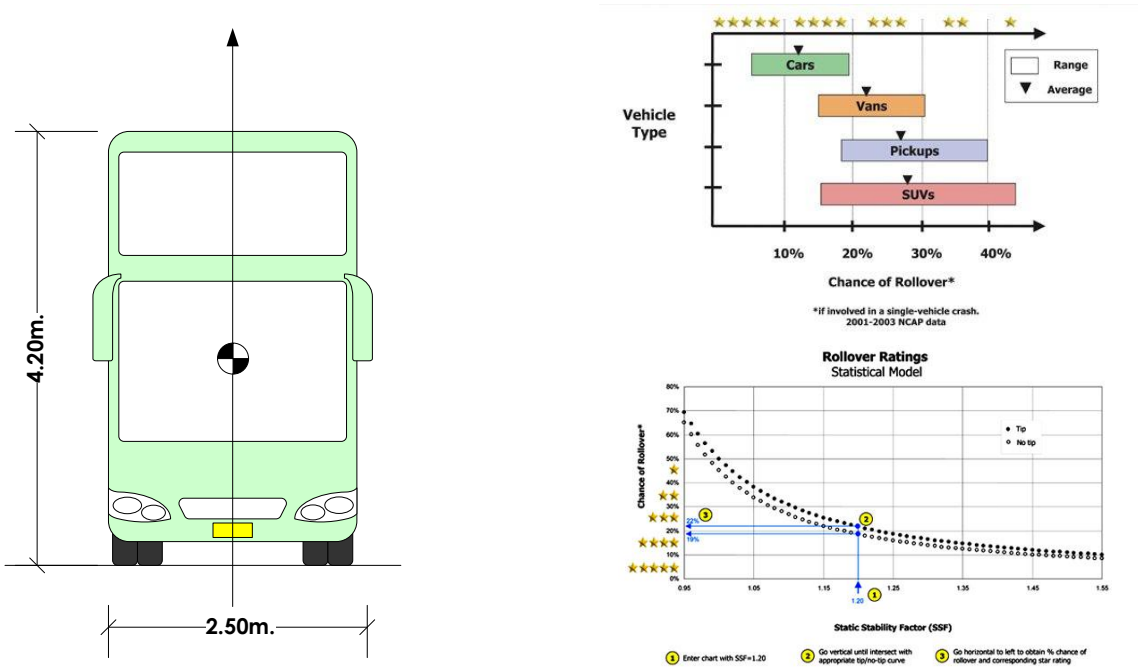

Figure 3-11: High Rollover Risk Bus

Occupant Restraint System

The most harmful event in vehicular collision is that of occupants hitting interior objects with other occupants. In this case, even though all passenger seats are equipped with the lap seatbelts they are fastened and kept hidden in the back of the seat. None of the occupants were using them. All four fatalities were found dead under the bus wreckage. One suffered severe cutting to the arms and legs.

Significant Factors

TARC determined that the probable cause of the 090318-01 crash occurrence was the loss of control of the vehicle due to wet surface as supported by the above mentioned evidences. The crash consequences were increased by the vehicle rolling over and the lack of a sufficient roadside protection.