Executive Summary

On March 16, 2021, a Class A tour bus (hereafter “the Bus”), plate number KAA-0853, belonging to Tenglong Transportation Ltd. was on its way back to New Taipei City from a 2-day tour to Hualien County. At 16:19, the Bus hit a mountainside retaining wall on the other side of the road at the 114.7 km marker on northbound Provincial Highway No.9. The accident caused damage to the Bus body, 6 passengers were killed, and 39 people were injured, including the driver of the Bus (hereafter “the Driver”) and passengers.

According to the Transportation Occurrence Investigation Act of the Republic of China (ROC), the Taiwan Transportation Safety Board (TTSB), an independent transportation occurrence investigation agency. The investigation team members also included the Ministry of Transportation and Communications (MOTC); Directorate General of Highways; Tourism Bureau; Vehicle Safety Certification Center (VSCC), Tenglong Transportation Ltd.; Good Vision Travel Agency Ltd.; Mingsheng Industry Ltd.; Master Transportation Bus Manufacturing Co., Ltd.; and Richin Tech Ltd.

The Final Report of the occurrence investigation was approved by TTSB’s 44th Board Meeting on 4 November 2022.

On the basis of comprehensive factual information and analyses, the following 38 investigation findings and 22 safety recommendations were proposed.

Findings Related to Probable Causes:

1. The Driver was driving on a downhill road in high gear and frequently used the Bus’s hydraulic retarder to control the speed of the vehicle. When the Bus speed did not decrease as expected, the Driver start to apply the brakes.

However, the Driver had chronic sensory neuropathy, motor neuropathy, and ulcer wounds in his feet caused by diabetes, which may have resulted in him having lower tactile sensitivity in his feet and a slower response and may have prevented him from braking effectively. When attempting to shift to a lower gear, the Driver accidentally shifted to the neutral gear because the Bus speed remained too high. Additionally, the Driver was too late in applying the brakes to slow down. These factors caused the Bus to lose control, cross into the opposite lane, and hit the retaining wall on the side of the road.

2. When the left front side of the Bus hit the retaining wall, the seat anchorages were unable to withstand the impact energy, with some of the seat anchorages failing and detaching from the floor of the Bus. After the Bus hit the retaining wall, it continued to scrape along the wall to its left. Although the Bus speed decreases, the angular velocity increases due to the inertial force. When the body structure near the safety door hit the corner of the retaining wall, the structure of the area, which was poorly welded, could not withstand the load, resulting in the body of the Bus becoming distorted and fractured at the point of impact. At this time, the Bus still had kinetic energy, and the corner of the retaining wall was crushing the left side of the body of the Bus and damaging the other parts of the Bus. The damage to the skin of the Bus led to the seats that had detached from the floor being thrown out of the Bus.

Findings related to the risks:

Dynamic driving simulation

1. Large vehicle dynamics simulation software and vehicle collision analysis software were used to estimate the movements of the Bus before the accident and to simulate its collision with the retaining wall. The simulation results revealed that the Bus passed the accident road curve at 1619:36 hours at a speed of about 58.9 km/h. The right side of the vehicle lifted, which caused

it to lose its right lateral force. This caused the Bus to cross the lane divider over to the opposite lane. The Bus was tilted sideways, and the left front chassis scraped the ground before the left front side collided with the retaining wall at a speed of about 53.3 km/h at 1619:38 hours.

Education and training

2. Professional bus drivers are required to complete a 6-hour regular training course every 3 years. Although the course content covers various safe driving scenarios, the Driver was not sufficiently aware of his unsafe downhill braking practices, indicating that the Driver did not implement the safe driving practices he learned in the driver education and training.

The Driver's physical health and the physical examination system

3. The Driver had had diabetes for more than 10 years. The Driver continues to use insulin but had poor blood sugar control for a long time; this caused him to experience chronic sensory neuropathy, motor neuropathy, and ulcer wounds in his feet, which resulted in him having less tactile sensitivity and slower reaction when stepping the pedals with his feet. The Driver had experienced a lack of sensation when he stepped on the brakes and clutched the pedals before, after, and during the accident, which may have affected the Driver's ability to operate the Bus safely.

4. The Driver obtained satisfactory results in his most recent professional driver physical examination before the accident. However, the examination does not include an assessment of diabetic complications or glucose control and, therefore, fails to address their potential impact on driving ability.

5. The qualification standards for the physical examination of professional drivers in the commercial automobile business in Taiwan do not stipulate that professional drivers under the age of 60 must not have diabetes or any

conditions that may result in poor glucose control. Compared with those of other countries, such as Canada, the United States, and the United Kingdom, the comprehensive physical examination and assessment system for professional drivers with diabetes in Taiwan is lacking. This may negatively affect the ability to control for safety risks resulting from driving ability being undermined by acute or chronic complications related to diabetes.

Frame welding

6. Many parts of the frame of the Bus exhibited signs of poor welding, such as unfilled weld runs, incomplete fusion of weld runs, and unremoved slag on the surface of weld runs. The damaged frame was severely deformed after the collision, exhibiting rapid damage characteristics. Some parts of the weld runs even had lean-break fractures, without any sign of deformation caused by the impact.

7. The metallographic structure of the frame of the Bus was normal; the chemical composition and tensile strength met the standards, and the hardness distribution was normal (weld run > heat affected zone > base material). Although the core structure of the weld run at the site of the fracture was normal, the galvanized layer was attached to the fracture surface, substances were found attached to the surface, and the hardness distribution was abnormal (heat affected zone > base material > weld run); these were all abnormal observations for a welded part.

8. According to the finite element damage analysis simulation results, when the Bus collided with the retaining wall, the poorly welded area near the safety door was either deformed or fractured. In such situations, the weaker the welding strength is, the more serious the damage is to the vehicle body, and the greater the speed is, the greater the damage is to the vehicle body.

9. The six principal view diagram of the body of the Bus indicated welding methods to be used only for the lap joints between each side of the frame; it did not include an instruction requiring welding technicians to apply full-circumference welding to any joints whose welding methods are not specified on the diagram. Therefore, on-site welding technicians may have considered it unnecessary to perform full-circumference welding on joints whose welding methods are not specified on the six principal view diagrams of the Bus.

10. At Mingsheng Industry's vehicle manufacturing factory, welding operations rely on the expertise and experience of welding technicians. Its failure to provide a set of vehicle frame welding standards or specifications for welding technicians to follow may result in inconsistent welding quality at different parts of a frame, which may undermine the overall quality of the finished frame.

11. Taiwan does not require car manufacturers to formulate standards or specifications for welding quality inspection, welding inspection methods, welding defect identification methods, or welding defect improvement methods. The lack of standards or specifications for vehicle body welding quality inspection may lead to inconsistent standards being applied when Class B welding technicians conduct such quality inspections and may prevent the condition and quality of vehicle frame welding from being effectively verified.

12. In the accident, the frame of the Bus was poorly welded, which resulted in the structural strength of the vehicle body being below the standards applied in the structural strength inspection for large passenger vehicles, and thus the structural strength of the Bus may have been insufficient to withstand the damage caused by certain levels of collisions.

13. Computer software simulations conducted by a technical service to test the strength of the body structure of a bus are based on the assumption that the welding at the joints of the vehicle frame will not be damaged. However, the Bus had several defects and flaws, including poor welding. This indicates that the actual status of the Bus may not be adequate to pass such structural strength tests for large passenger vehicles.

14. Technical services may be unable to check the quality of vehicle frame welding when conducting physical vehicle inspections. Alternatively, inspectors may only visually check welding quality; for places that are not visible, the welder of the vehicle frame manufacturer may be required to confirm the quality themselves. Such an inspection practice may fail to reveal the actual quality of the vehicle frame.

15. Physical vehicle inspections are conducted only on one vehicle as a sample for each vehicle model. Even if the inspection body thoroughly confirms that the number of frame components, materials, and welding methods are consistent with the inspection report and the computer simulation result, the construction quality of other vehicles of the same model cannot be ensured in this inspection practice.

16. The VSCC's vehicle safety type approval involves only written review, which may fail to reveal situations where the vehicle frame welding is not properly performed, where the actual status of a vehicle does not meet the structural strength testing standards for large passenger vehicle, or where the technical services may be unable to effectively inspect the condition of vehicle frame welding.

17. The VSCC's examination of conformity of production (COP) on high-volume vehicle models involves only written reviews and on-site document reviews, which may fail to address flaws and defects present in vehicle

welding.

Seat installation and testing

18. Based on the static test conditions outlined in section 5.2.2 under item 49-1 of the vehicle safety testing directions, the seat anchorages of the Bus were detached and failed when approaching 55.5% of the required minimum breaking strength specified by the regulations, indicating the anchoring methods and strength of the anchorages in the Bus did not meet the regulatory requirements.

19. On the basis of the dynamic tests outlined in section 5.1.3 under item 49-1 of the vehicle safety testing directions, angle and acceleration waveforms similar to those of the impact conditions of the Bus were used to simulate the movement of the seats. The test results revealed that the seat anchors of the Bus were unable to withstand the impact; the seat anchor device failed and was detached from the floor.

20. The seats of the Bus complied with the requirements of section 5.2.1 of item 49-1 of the vehicle safety testing directions for seat strength but failed to pass the static test for seat anchorages outlined in section 5.2.2 of the same testing directions, indicating that the seat anchorages of the Bus may be different from the anchorages used in the test. This also indicates that the specifications regarding seat anchorages in items 49-1 and 48-2 of the vehicle safety testing directions may be incompatible.

21. Current laws and regulations do not include any specifications regarding the torque requirements of seat anchors for buses nor do they stipulate an inspection cycle for seat anchors after vehicles have begun to be used. Because relevant laws and regulations have not been implemented, ensuring a consistent quality standard for the locking strength of the bus seat anchor

devices throughout Taiwan is difficult.

Road environment

22. The design speed of the section of the road on which the accident occurred is 30 km/h. The Directorate General of Highways adjusted the speed limit for this section of road to 40 km/h in accordance with the requirements of the Institute of Transportation of the Ministry of Transportation and Communications and those stipulated in its internal documents. Although the adjustment to the speed limit for this section of the road was approved after discussion with various units at the meeting described in section 1.8.3, the horizontal curve radius at the accident location is 35 meters, which does not meet the specifications for a speed limit of 40 km/h. This road section does not belong to the higher standard road section outlined in the aforementioned documents. Therefore, the speed limit does not conform to the required safe design conditions, which increases the driving risk.

23. The horizontal curve radius at the accident location and the widening of the curve do not meet the safe range required by the design specifications for a speed limit of 40 km/h. In addition, the dangerous descent sign and the dividing line, and reflectors on the road surface were incomplete or worn.

24. The relevant regulations in Taiwan do not specify how the ends of retaining walls should be finished. This has led to design and construction personnel only smoothing the exterior of the retaining wall, that is, the side facing the road, and not the obstacles created at the ends of such walls, which may pose a risk to traffic safety.

Seat belts

25. The Driver, the tour escort, and at least 11 passengers were not wearing seat belts; a salesperson who was not a part of the tour group was standing in the

aisle. Therefore, at least 14 people on the bus were not wearing seat belts. Not wearing seat belts can increase the likelihood of injury and the severity of injury during an accident. During the accident, the Driver and the tour escort sat in the front seats without wearing seat belts, and the salesperson stood in the aisle. This was a violation of the relevant provisions of the Road Traffic Safety Regulations.

Other investigation findings:

1. The Driver had a valid professional bus driver's license and a tour bus driver professional practice registration certificate issued by the Directorate General of Highways. He had completed preservice courses and regular training for tour bus drivers in accordance with the relevant regulations.

2. There was no evidence showing that the Driver was operating the bus under the influence of fatigue or alcohol.

3. The frequency and content of training provided by Tenglong Transportation Ltd. to its drivers are in accordance with the legal requirements.

4. During the accident, the air pressure brake and the hydraulic retarder of the Bus were functioning normally. The engine and gearbox of the Bus did not overheat, and the hydraulic retarder was operational.

5. According to the driving movement simulation results, the tire marks on the ground at the accident site, and the tires of the Bus, the Driver failed to brake effectively between 1619:19 and 1619:38.

6. When a simulation was completed with a vehicle frame with completely aligned welding runs, the tensile strength was able to reach 97% of the specified value, indicating that the strength of normal weld runs is close to that of the base material of the vehicle structure.

7. Although a winding road sign has been placed in the winding road area near the Xin'ao Tunnel exit, and a left turn ahead sign has been installed at the 117K+200 marker on the Provincial Highway No.9, no sign has been placed to warn drivers of the curved road area with poor conditions that lie between the other sections of the Provincial Highway No.9 and the accident location.

8. The Bus was carrying a total of 45 people, and 6 passengers (13.3%) were killed. In addition, 10 passengers (22.2%) were seriously injured, and 4 individuals, (1 tour escort and 3 passengers; 8.9%) were moderately injured. A total of 25 individuals (the Driver, the salesperson, and 23 passengers; 55.6%) were slightly injured.

9. The 6 passengers who were killed and 10 passengers who were seriously injured were sitting in the rear section of the Bus at the time of the accident. The left rear section of the vehicle body struck the mountainside retaining wall, damaging the structure in the area between the left-side safety door and the 10th row of seats. Without the complete protection of the vehicle body, at least 12 of the dead and seriously injured passengers and the passengers' seats in the eighth and ninth rows on the left were thrown out of the Bus through the opening of the left rear section of the vehicle body. This is believed to be the reason for the death or serious injury of the 16 passengers.

10. The tour escort agreed to allow the salesperson, who was not part of the tour group, to board the bus during the trip, which is a violation of the Regulations Governing Travel Agencies that indicate tour buses are only allowed to carry tourists from the tour groups they have been hired to carry and are not allowed to pick up other passengers along the way.

11. Although the Tourism Bureau of the Ministry of Transportation and Communications has established an inspection mechanism for the practice of travel agencies, current road inspection operations are unable to effectively

detect situations in which salespeople who are not part of tour groups sell goods on tourist bus while it's on the road.

Safety Recommendations

To Mingsheng Industry Ltd.

1. Construction-related standards or specifications for the practice of vehicle frame welding and the inspection of welding quality must be formulated for welding personnel and quality inspection personnel to follow such that the quality of vehicle body construction is improved.
2. Seats must be properly installed using a seat installation method that has passed a vehicle safety testing directions review, and a seat installation quality inspection mechanism must be established.

To the Ministry of Transportation and Communications (MOTC)

1. Regulations related to vehicle safety inspection must be revised, bus manufacturers must be required to formulate relevant construction standards or specifications for bus frame welding and welding quality inspection, and welding and quality inspection records and traceability procedures must be established to ensure the construction quality of the vehicle body meets safety standards.
2. The vehicle safety type approval mechanism must be strengthened, and methods that allow for the detection of the following situations must be developed to ensure that the vehicle bodies of buses have the required strength and meet the requirements of relevant legislation.
    - The welding of the vehicle body frame has not been properly completed
    - The strength of the body structure does not meet vehicle safety testing directions

- The technical service has failed to effectively verify the welding conditions of the vehicle frame

3. Items 48 and 49 of the vehicle safety testing directions must be reevaluated, and the test specifications for seat anchorages must be clarified to ensure the seat anchorages in actual vehicles are the same as those that have passed inspection. Content in the two testing items concerning seat anchorages must be verified as compatible.

4. For tourist buses that must comply with items 48 and 49 of the vehicle safety testing directions, standards, and methods for verifying the strength of seat anchor devices on in-service vehicles must be established to ensure that the vehicle seat anchor devices have appropriate strength.

5. Regulations regarding the construction of roadside retaining walls, protection slopes, and similar features must be re-evaluated. The external aspects of the features must be considered, and the safety margin must be increased to reduce damage caused by the collision of a vehicle that is out of control.

6. Laws requiring bus passengers to fasten their seat belts should be further promoted and implemented.

7. Revise the regulation regarding the rear seat passengers must wear seat belts when the tourist bus transportation enterprise performs travel-related business. This should apply to travel on all roads in addition to highways and expressways.

8. The seat strength testing standards must be reviewed, and the dynamic and static testing methods and standards must be established to prevent passenger seats from detaching from the vehicle body when the strength meets the testing standards.

9. The examination of COP for seat installation must be strengthened, seat installation procedures and inspection operations must be established, installation records and traceability procedures must be established, and the inspection results must be verified as consistent with the actual vehicle installation status, and the examination of COP for seat quality of the VSCC must be improved.

To the Directorate General of Highways of the Ministry of Transportation and Communications

1. Evaluate the increase in the number of regular training hours and real vehicle driving training for drivers in tourist bus transportation enterprise. Alternatively, consider adding simulator training courses to evaluate the drivers' operation quality under special terrain and weather conditions to improve drivers' safe driving skills.

2. Regulations and guidelines regarding professional drivers' physical examinations, including assessments of diabetes and poor glucose control, should be reviewed and strengthened, and the feasibility of including such assessments in the medical examinations for professional drivers under the age of 60 should be considered.

3. Collaboration with the Tourism Bureau of the Ministry of Transportation and Communications to discuss and implement effective improvement strategies for safety issues related to salespeople selling goods on tour buses should be employed.

4. The appropriateness of the design speeds and speed limits of highways under the Directorate General of Highways's jurisdiction should be reviewed. If the directorate general sees a need to implement a speed limit higher than the design speed, all types of vehicles must be verified as capable of operating

safely within the speed limit. If this is not possible, the geometric conditions of the road or traffic engineering features must be improved to ensure safety.

5. The external characteristics or installation positions of retaining walls, protection slopes, and other features of the same nature on the sides of the roads that are under the jurisdiction of the Directorate General of Highways must be checked, and the ends of retaining walls that may affect traffic safety must be smoothed to prevent serious injuries related to uncontrolled vehicle collisions.

To the Vehicle Safety Certification Center (VSCC)

1. Appropriate supervision and assistance should be provided to bus manufacturers to ensure that appropriate construction-related standards or specifications for vehicle body frame welding and welding quality inspection are formulated for welding personnel and quality inspection personnel to follow. Additionally, welding and quality inspection records and traceability procedures should be established to facilitate vehicle safety type approval for large passenger vehicles.

2. The examination of COP mechanisms should be strengthened, and on-site inspections must include checks on the actual conditions of vehicle body frame welding to improve the construction quality of vehicle bodies.

3. When seat manufacturers apply for inspections under items 48 (i.e., safety belt anchorage) and 49 (i.e., seats) of the vehicle safety testing directions, the manufacturers should be asked to provide detailed information on the seat specifications and anchoring methods, and the inspectors should ensure that the submitted information is consistent with the actual status during the inspection.

To Richin Tech Ltd.

1. Ensure the joints for both the setting of the body frame and the body frame of the actual vehicle are the same when conducting the structural strength test of the bus frame. In addition, the methods used to inspect the welding conditions of the actual vehicle frame should be improved.

To the Tourism Bureau of the Ministry of Transportation and Communications

1. Collaboration with the Directorate General of Highways of the Ministry of Transportation and Communications should be employed to discuss effective strategies for improving safety concerns related to salespeople selling goods on tour buses. In addition, travel agencies should be asked to strengthen their efforts in ensuring passenger compliance with the requirement to fasten their seat belts during travel.

To Good Vision Travel Agency Ltd.

1. The safety publicity and education training for tour guides and tour escorts should be strengthened. Carry out the regulations on wearing seat belts properly during travel.