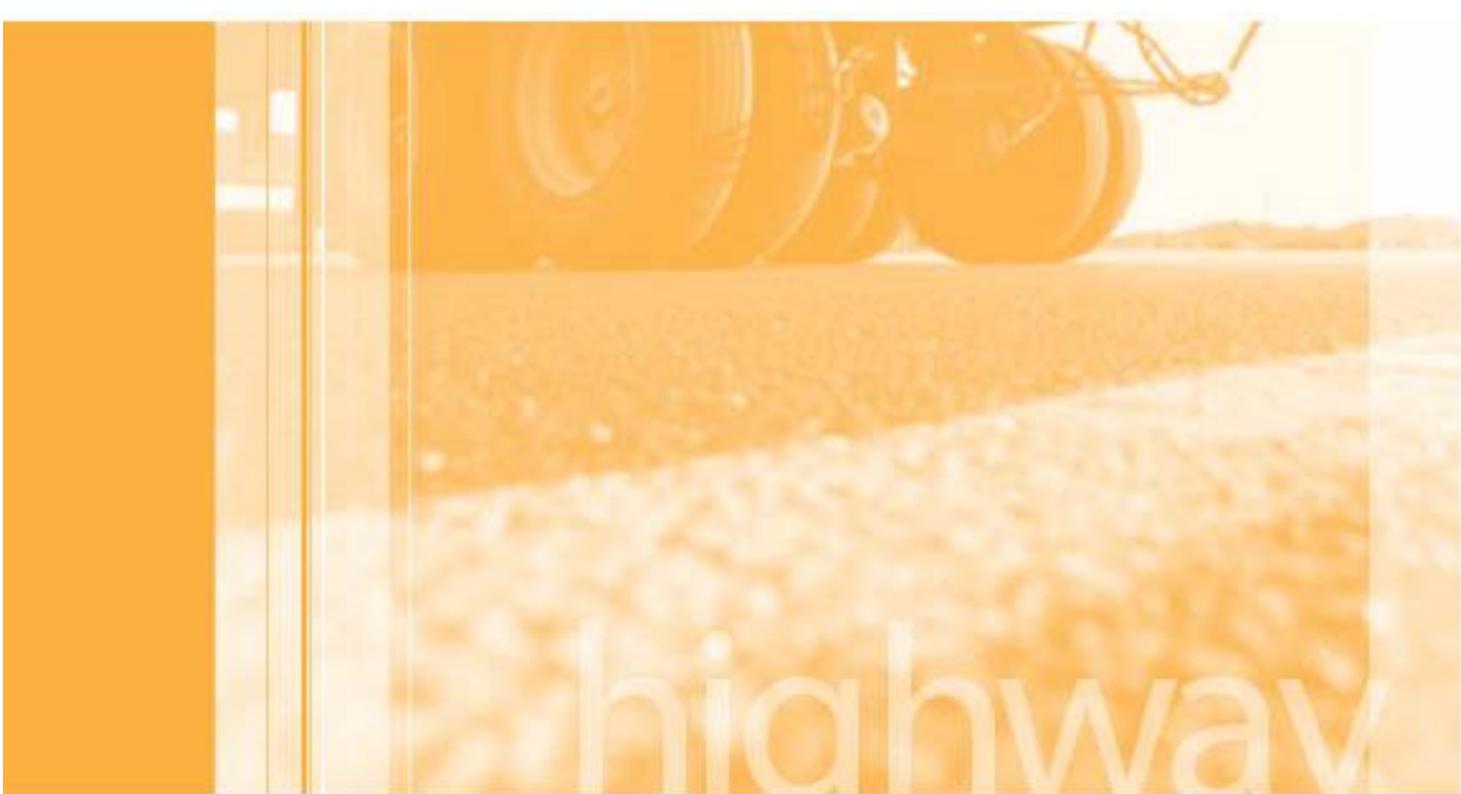


Amphibious Passenger Vehicle *DUCK 6*
Lane Crossover Collision With Motorcoach
on State Route 99, Aurora Bridge
Seattle, Washington
September 24, 2015



Accident Report

NTSB/HAR-16/02
PB2017-100408



**National
Transportation
Safety Board**

NTSB/HAR-16/02
PB2017-100408
Notation 8737A
Adopted November 15, 2016

Highway Accident Report

Amphibious Passenger Vehicle *DUCK 6*
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Seattle, Washington
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**National
Transportation
Safety Board**

490 L'Enfant Plaza, S.W.
Washington, D.C. 20594

National Transportation Safety Board. 2016. *Amphibious Passenger Vehicle DUCK 6 Lane Crossover Collision With Motorcoach on State Route 99, Aurora Bridge, Seattle, Washington, September 24, 2015.* Highway Accident Report NTSB/HAR-16/02. Washington, DC.

Abstract: On September 24, 2015, the 2005 *DUCK 6* amphibious passenger vehicle (APV) was traveling north on the Washington State Route 99 Aurora Bridge in Seattle, Washington. At the same time, a 2009 Motor Coach Industries motorcoach was traveling south in the center lane. The *DUCK 6* driver heard a loud noise at the left front of the APV; the vehicle drifted to the right and then veered left suddenly; the driver lost control of the vehicle. The APV crossed the center line into the southbound lanes and struck the motorcoach. Three other vehicles were damaged. As a result of this crash, five motorcoach passengers died. Seventy-one motorcoach and APV occupants reported injuries ranging from minor to serious.

The report addresses the following safety issues: failure by an unregistered vehicle manufacturer to properly remedy a defective safety-related motor vehicle part under the federal recall process, lack of adequate oversight of APV maintenance and failure to conduct effective safety repairs as recommended in service bulletins, lack of adequate occupant protection in APVs used in commercial passenger tours, and risk management in APV operations. As a result of the investigation, the National Transportation Safety Board makes safety recommendations to the National Highway Traffic Safety Administration, the US Coast Guard, Ride the Ducks International, Ride the Ducks of Seattle, and the Passenger Vessel Association.

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Acronyms and Abbreviations

AASHTO	American Association of State Highway and Transportation Officials
AAWPP	assumed average weight per person
ABS	antilock braking system
ACM	airbag control module
APV	amphibious passenger vehicle
BDT	Boston Duck Tours
Bellair Charters	CWA Inc. dba Bellair Charters Hesselgrave South
CAMI	Civil Aerospace Medical Institute
CDL	commercial driver's license
<i>CFR</i>	<i>Code of Federal Regulations</i>
CMV	commercial motor vehicle
CR	compliance review
DUKW	D=1942; U=utility amphibious; K=all-wheel drive; W=two powered rear axles
DVIR	driver vehicle inspection report
ECM	engine control module
EOC	City of Seattle Emergency Operations Center
FMCSA	Federal Motor Carrier Safety Administration
<i>FMVSSs</i>	<i>Federal Motor Vehicle Safety Standards</i>
GAWR	gross axle weight rating
GPS	global positioning system
GVWR	gross vehicle weight rating
IVD	incomplete vehicle document
NDR	National Driver Register
NHTSA	National Highway Traffic Safety Administration
non-OTRB	non-over-the-road bus
NSCC	North Seattle Community College
NTSB	National Transportation Safety Board
NVIC	Navigation and Vessel Inspection Circular
OTRB	over-the-road bus

PDPS	Problem Driver Pointer System (NDR)
PVA	Passenger Vessel Association
RTDI	Ride the Ducks International
RTD Seattle	Ride the Ducks of Seattle
SFD	Seattle Fire Department
SPD	Seattle Police Department
SR-99	State Route 99
SUV	sport utility vehicle
<i>USC</i>	<i>United States Code</i>
USDOT	US Department of Transportation
VIN	vehicle identification number
WUTC	State of Washington Utilities and Transportation Commission

Executive Summary

Investigation Synopsis

On Thursday, September 24, 2015, about 11:11 a.m. Pacific daylight time, the 2005 *DUCK 6* amphibious passenger vehicle (APV) was traveling north on the Washington State Route 99 Aurora Bridge in Seattle, Washington. At the same time, a 2009 Motor Coach Industries motorcoach was traveling south in the center lane. The *DUCK 6* driver heard a loud noise at the left front of the APV; the vehicle drifted to the right and then veered left suddenly; the driver lost control of the vehicle. The APV crossed the center line into the southbound lanes of oncoming traffic and struck the motorcoach.

Three other vehicles were damaged during the crash event: a southbound 2011 Ram Trucks pickup truck and two northbound vehicles—a 2006 Toyota Highlander sport utility vehicle and a 2007 Toyota Tundra pickup truck. As a result of this crash, five motorcoach passengers died. Seventy-one motorcoach and APV occupants reported injuries ranging from minor to serious.

Probable Cause

The National Transportation Safety Board determines that the probable cause of the Seattle, Washington, crash was the mechanical failure, due to improper manufacturing by Ride the Ducks International (vehicle manufacturer) and inadequate maintenance by Ride the Ducks of Seattle (operator), of the left front axle housing of the stretch amphibious passenger vehicle (APV) *DUCK 6*, which resulted in loss of vehicle control. Contributing to the severity of the motorcoach occupant injuries was the APV's structural incompatibility with the motorcoach, causing intrusion into the motorcoach sidewall, windows, and interior passenger compartment. Contributing to the severity of the APV passenger injuries were the lack of occupant crash protections and the high impact forces.

Safety Issues

The crash investigation focused on the following safety issues:

- Failure by an unregistered vehicle manufacturer to properly remedy a defective safety-related motor vehicle part under the federal recall process,
- Lack of adequate oversight of APV maintenance and failure to conduct effective safety repairs as recommended in service bulletins,
- Lack of adequate occupant protection in APVs used in commercial passenger tours, and
- Risk management in APV operations.

Recommendations

As a result of this investigation, the National Transportation Safety Board makes safety recommendations to the National Highway Traffic Safety Administration, the US Coast Guard, Ride the Ducks International, Ride the Ducks of Seattle, and the Passenger Vessel Association.

1 Factual Information

1.1 Crash Narrative

1.1.1 Precollision

DUCK 6. On the morning of Thursday, September 24, 2015, the 2005 *DUCK 6*, a stretch amphibious passenger vehicle (APV), sometimes referred to as a DUKW, was prepared for its first passenger tour of the day in Seattle, Washington.

Many APVs are DUKWs that have been modified for use as land and water sightseeing vehicles and are colloquially referred to as “ducks.” A DUKW is a 2.5-ton, six-wheel-drive amphibious truck that was originally produced for military use in World War II to transport goods and troops over land and water.¹ Two other types of APVs are of note in this report: a “stretch” APV, such as the *DUCK 6*, which is a DUKW that has been significantly extended and modified for tourism purposes, and a “truck duck,” which is generally a newly manufactured amphibious vehicle built to resemble a DUKW, also used for tourism purposes.² There are currently 142 fleet, truck, and stretch APVs operating in the United States; 46 of these are stretch APVs.³

The *DUCK 6* was part of a fleet operated by Ride the Ducks of Seattle (RTD Seattle), doing business as Seattle Duck Tours, to conduct tour operations in the Seattle area. The *DUCK 6* driver/captain began his work shift on September 24 at 9:08 a.m. at the RTD Seattle company terminal.⁴ He conducted the pretrip inspections of the *DUCK 6* detailed in the driver vehicle inspection report (DVIR), as required by the US Department of Transportation (USDOT) and the US Coast Guard.⁵

About 10:35 a.m., the *DUCK 6* driver completed the loading of 36 passengers onto the APV at the Seattle Center at 5th Avenue and Broad Street, where he conducted the predeparture safety briefing required by the Coast Guard.⁶ He then left the Seattle Center for the road portion of the *DUCK 6* tour. The *DUCK 6* traveled along the waterfront and through Pioneer Square and

¹ The acronym DUKW came from General Motors Corporation nomenclature in which the “D” indicated the first year of manufacture (1942), the “U” indicated a utility amphibious vehicle, the “K” indicated all-wheel drive, and the “W” indicated two powered rear axles.

² In this report, the accident stretch APV is interchangeably referred to as the “*DUCK 6*,” the “APV,” and the “stretch APV.”

³ (a) See www.passengervessel.com/SitePages/maritrends.html, accessed August 12, 2016. (b) A fleet APV is an original, nonmodified amphibious vehicle from the World War II era.

⁴ Throughout this report, times are reported in Pacific daylight time unless otherwise indicated.

⁵ In his statement to police, the *DUCK 6* driver stated that the vehicle pretrip inspection did not reveal any defects, and he believed that the vehicle was in good operating condition.

⁶ The Coast Guard regulation at 46 *Code of Federal Regulations (CFR)* 185.506 “Passenger safety orientation,” requires the driver of a small passenger vessel, such as the *DUCK 6*, to provide a safety briefing to passengers before getting under way. The briefing should include statements on removing egress obstructions, such as windows or curtains; on no smoking at any time on the vessel; and on passengers remaining seated for the duration of the voyage, unless otherwise directed by the master.

the downtown shopping district before heading north on Washington State Route 99 (SR-99) toward the George Washington Memorial Bridge, locally known as the Aurora Bridge.

Motorcoach. Also on the morning of September 24, a charter tour of the Seattle area, conducted using two motorcoaches, began for a group of college students and chaperones from the North Seattle Community College (NSCC). NSCC had contracted with the motor carrier Bellair Charters to provide this trip.⁷ The two motorcoaches arrived at the NSCC campus at 9:45 a.m. to pick up passengers; they departed about 10:15 a.m., heading to downtown Seattle. The lead motorcoach was a 2009 Motor Coach Industries motorcoach; it was occupied by a driver and 49 passengers.

1.1.2 The Crash

About 11:11 a.m., the *DUCK 6* was traveling north on SR-99 on the Aurora Bridge above Lake Union. About the same time, the Bellair Charters motorcoaches were traveling southbound on the bridge in the center lane. According to the *DUCK 6* driver, traffic was light.

In his statement to police, the driver said that as the *DUCK 6* traveled northbound across the south end of the Aurora Bridge, just after he drove over the bridge's second expansion joint, he heard a loud and unusual "clunk, clunk" noise from the area of the left front axle.⁸ He said the vehicle "all of a sudden just did an uncommanded drift to the right and the steering felt really loose." Almost immediately, the driver lost control of the *DUCK 6* as it abruptly veered sharply to the left. He attempted to countersteer to the right; however, the steering wheel would not turn. The driver said it felt "locked." He applied the brakes, using an action he described as "standing" on the brakes. The vehicle would not slow down and continued across the left northbound lane. The *DUCK 6* then crossed the center line into the southbound lanes of oncoming traffic and struck the lead Bellair Charters motorcoach, which was traveling in the center lane southbound. (See figures 1 and 2.)

⁷ The motorcoach was owned and operated by CWA Inc. doing business as Bellair Charters Hesselgrave South (Bellair Charters).

⁸ An expansion joint is an assembly joining a mid-structure separation of bridge sections to safely relieve stress and absorb structural movement while allowing for continuous traffic flow across the joint. Stress and movement of a bridge structure are typically caused by temperature changes, loading and unloading of the structure due to traffic, sway (caused by the wind), and seismic events.



Figure 1. Crash location on SR-99 Aurora Bridge.



Figure 2. Crash scene on SR-99 Aurora Bridge. (Source: Television station KING 5 Seattle, published September 25, 2015)

Video and postcrash roadway evidence indicated that the motorcoach began to move toward the right lane immediately before being struck by the *DUCK 6*, consistent with driver steering input to avoid the crash.⁹ The impact occurred approximately 865 feet north of the southern bridge abutment. (See figure 3.)



Figure 3. Still image from crash motorcoach's windshield-mounted video camera, showing the *DUCK 6* entering the southbound lanes about 0.4 second before impact.

At impact, the approach headings of the *DUCK 6* and the motorcoach had an offset of about 21 degrees. Following the initial contact, the front of the APV breached the driver (left) side of the motorcoach sidewall, creating an approximately 19-foot-long opening. (See figure 4.)

⁹ The Bellair Charters motorcoaches were equipped with a camera system mounted on the windshield in a forward-facing position. The video recorder associated with the camera on the trailing motorcoach captured the crash. (See section 1.4.2 for more information on the camera system.)



Figure 4. Crash scene, facing southbound. (Source: Seattle Police Department)

Three other vehicles were involved in the crash event: a southbound 2011 Ram Trucks pickup truck; and two northbound vehicles, a 2006 Toyota Highlander sport utility vehicle (SUV) and a 2007 Toyota Tundra pickup truck. As the *DUCK 6* struck the motorcoach, the Ram pickup truck struck the passenger side of the *DUCK 6*. It remained in contact as the *DUCK 6* rotated, and it was redirected into the northbound lanes. The Ram truck, now in the northbound lanes, struck the northbound Toyota Tundra, which was traveling in the right northbound lane. The *DUCK 6*, still in contact with the motorcoach, rotated counterclockwise, swayed onto its left wheels as it separated from the motorcoach, and rolled onto the Toyota Highlander briefly before coming to rest in an upright position. (See figures 5 and 6.) (See appendix A for additional information on this National Transportation Safety Board [NTSB] investigation.)



Figure 5. Southbound SR-99 crash scene as photographed from the northbound lanes. (Source: Seattle Police Department)

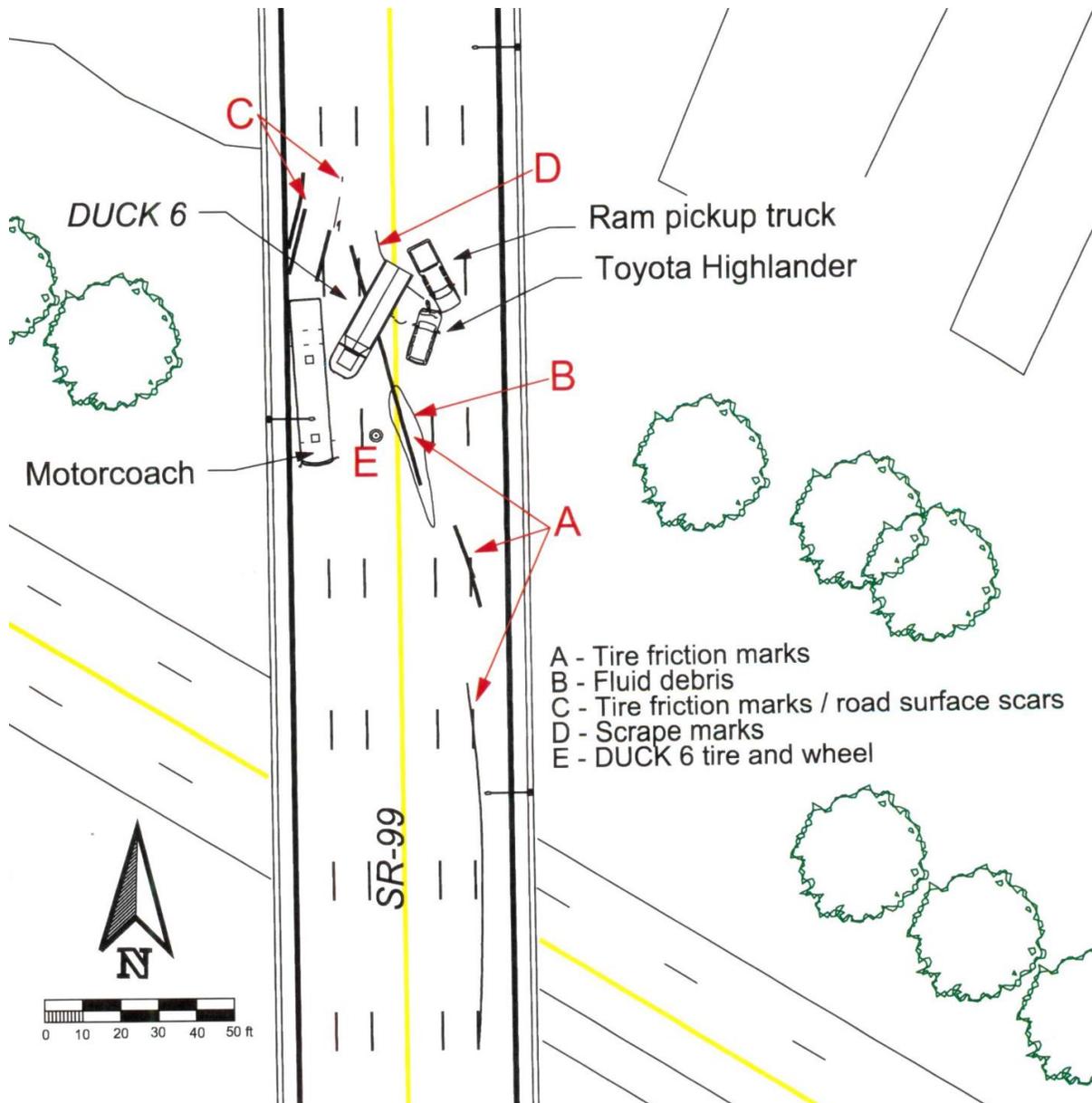


Figure 6. Crash scene diagram.

1.2 Injuries

As a result of this crash, five motorcoach passengers died. Sixty-nine passengers of the motorcoach and the *DUCK 6* reported injuries ranging from serious to minor. The *DUCK 6* driver was seriously injured, and the motorcoach driver sustained a minor injury. The occupants of the Ram pickup truck and the Toyota Tundra and Highlander reported no injuries. Table 1 provides a summary of the injuries resulting from this crash.

Table 1. Injuries.

Injury Severity ^a	Fatal	Serious	Minor	None	Unknown	Total
DUCK 6 Driver	0	1	0	0	0	1
DUCK 6 Passengers	0	16	20	0	0	36
Motorcoach Driver	0	0	1	0	0	1
Motorcoach Passengers	5	13	20	1	10	49
Occupants of three passenger vehicles	0	0	0	4	0	4
Total	5	30	41	5	10	91

^a Although 49 *CFR* Part 830 pertains to the reporting of aircraft accidents and incidents to the NTSB, section 830.2 defines fatal injury as “any injury which results in death within 30 days of the accident” and serious injury as “any injury which: (1) requires hospitalization for more than 48 hours, commencing within 7 days from the date the injury was received; (2) results in a fracture of any bone (except simple fractures of fingers, toes, or nose); (3) causes severe hemorrhages, nerve, or tendon damage; (4) involves any internal organ; or (5) involves second- or third-degree burns, or any burn affecting more than 5 percent of the body surface.”

1.2.1 Motorcoach

According to the King County medical examiner, all five of the motorcoach passengers died from significant head trauma and multiple blunt force trauma injuries to their torsos and extremities. These five passengers had been seated in rows 4 through 10 on the driver side of the motorcoach.

Of the 13 seriously injured motorcoach passengers, 6 were seated on the driver side of the motorcoach and sustained left extremity and torso injuries, including fractures and internal organ contusions and lacerations, as well as head trauma. Passengers’ minor injuries consisted of abrasions, contusions, and lacerations. Two passengers were ejected, and two other passengers were partially ejected from the motorcoach.¹⁰

1.2.2 DUCK 6

Of the 37 *DUCK 6* occupants, none were fatally injured. Eleven passengers were completely ejected from the vehicle during the collision sequence: 4 from the passenger side, 2 from the rear, and 5 from the driver side. Seven of the ejected passengers were seriously injured; they sustained pelvic, shoulder area, rib, and extremity fractures, as well as concussions. A few passengers reported that they were standing up when the *DUCK 6* moved left into oncoming traffic and struck the motorcoach. Passengers with minor injuries sustained lacerations, abrasions, and contusions (particularly to the shin area). (See figure 7 for *DUCK 6* occupant seating locations and injury classifications.)

¹⁰ Due to limited availability of information on the seating positions of the motorcoach passengers, a motorcoach seating chart is not included in this report.

Seattle, WA

INJURY LEGEND		
F = FEMALE	M = MALE	# = AGE
M = MINOR	S = SERIOUS	E = EJECTED
SAMPLE		
INJURY LEVEL	↓	
AGE	↓	
GENDER	↓	
	F	14
		M

Source: NTSB

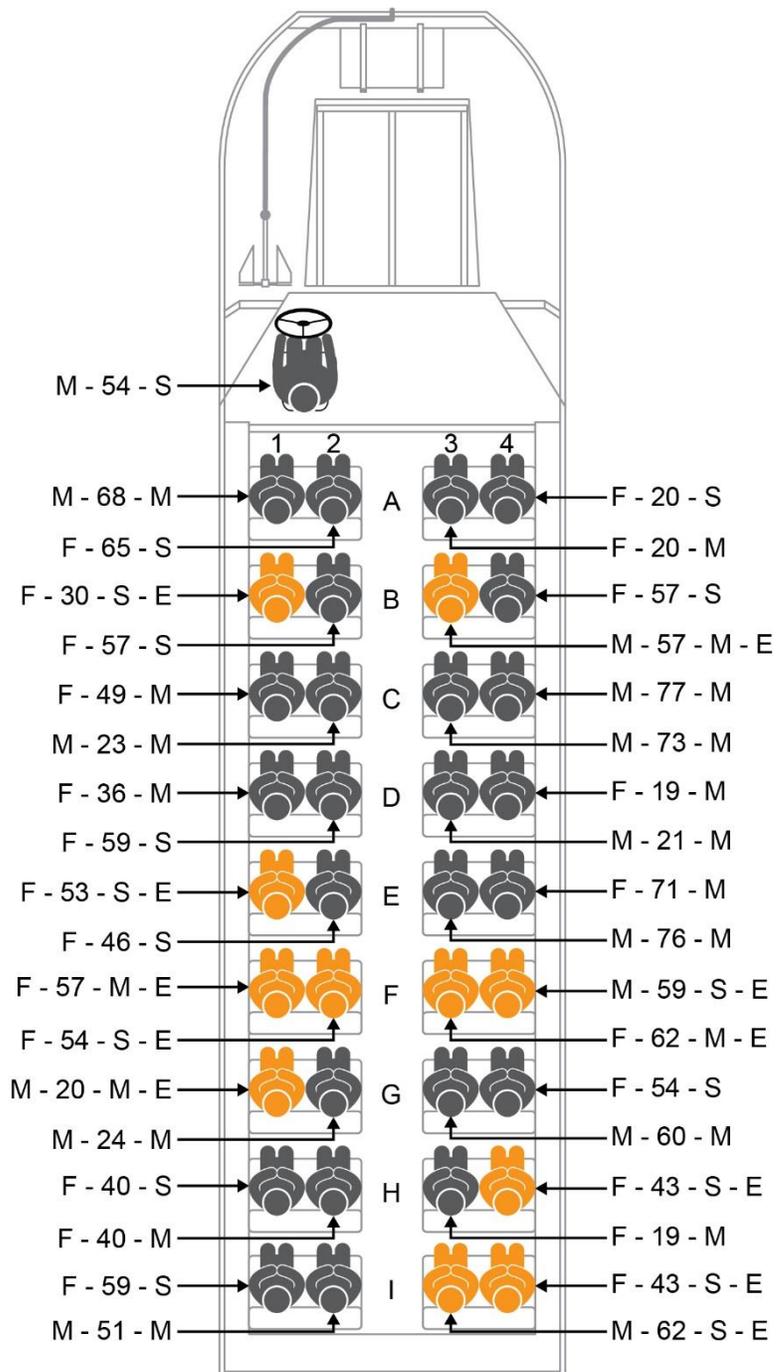


Figure 7. DUCK 6 occupant seating chart, which provides injury, demographic, and ejection information. (Images in yellow/orange indicate those passengers who were ejected from the vehicle.)

1.3 Emergency Response

The City of Seattle Police 911 Center received notice of the crash at 11:11 a.m.¹¹ More 911 calls were transferred to the Seattle Fire Department (SFD) Fire Alarm Center. Dispatchers declared the crash a multiple casualty incident at 11:13 a.m. The SFD incident commander arrived on scene at 11:15 a.m. and immediately began triage operations. Also by 11:15 a.m., the SFD Disaster Medical Control Center was established for patient transfer to area hospitals.¹² Additional units began arriving at 11:18 a.m. The first Seattle Police Department (SPD) unit arrived on scene at 11:21 a.m., followed by five more SPD units within the next 10 minutes, including the first SPD incident commander. A unified command structure was established, and the SFD took the lead in the initial rescue portion of the event.¹³

Postcrash, some *DUCK 6* passengers were able to exit the vehicle on their own, using the rear exit staircase, after the driver had lowered it. Many of the motorcoach passengers who were able to exit that vehicle without assistance exited through the partially open front loading door or, because the aisle was blocked by debris, through the right-side emergency windows.¹⁴

When emergency responders arrived, both the north and south side entry points of the Aurora Bridge were designated as corridors for patient transport, and all lanes of SR-99 were closed to traffic. Emergency responders extricated the injured from both vehicles. In total, 67 people were transported to 7 area hospitals. Additional injured persons later arrived on their own for medical examination at two additional hospitals.

Five emergency service agencies responded to the scene: the SPD, SFD, American Medical Response Ambulance Service, Shoreline Fire Department, and Seattle Department of Transportation. The SFD dispatched four basic life support and seven advanced life support units in addition to its medical ambulance bus. The American Medical Response Ambulance Service sent 36 basic life support ambulance units to the scene, and the Shoreline Fire Department dispatched 2 medic units and transported 1 patient. The SPD assigned a total of 124 units for the duration of the event. On the day of the crash, the SFD had just finished an emergency response practice drill near the crash site. As a result, the SFD could send multiple additional units and supervisors to the multiple casualty incident.

¹¹ This 911 center is the primary answering point for all police, fire, and medical emergencies within the city limits. Any calls for a fire or medical emergency are then transferred to the fire alarm center.

¹² The Disaster Medical Control Center designates Harborview Medical Center as responsible for providing coordinated distribution of patients (with the SFD) to area hospitals based on patient needs and hospital capabilities. The Northwest Healthcare Response Network also initiated its disaster plan using the WATrac System. The WATrac System is an online disaster management program to track resources, locate available trauma care facilities, notify partners of emergency events, and track patients.

¹³ Upon completion of rescue operations at 12:55 p.m., command was transferred to the SPD for the investigation phase of the event.

¹⁴ The motorcoach's front loading door could only partially open because it was obstructed by the pedestrian railing on top of the short barrier wall. Those motorcoach passengers who exited via the emergency windows came out onto this pedestrian railing.

The City of Seattle Emergency Operations Center (EOC) was activated within minutes of designation of the multiple casualty incident to support the SFD and SPD on scene. The EOC is the city's command center for coordinated leadership and direction; the facility is equipped with communications systems and staffed to help manage resources and facilitate interagency coordination. The EOC accommodated personnel from 23 federal, state, and local agencies during this response.

1.4 Vehicles

1.4.1 DUCK 6

General. The *DUCK 6* was 1 of 56 APVs that were termed “stretch ducks” by their manufacturer, Ride the Ducks International (RTDI) of Branson, Missouri.¹⁵ The *DUCK 6*, manufactured in 2005 to carry up to 37 occupants on combined road and water tours, consisted of a 1945 General Motors chassis cut in the center and lengthened by 15 inches of added frame material; a 1992 General Motors engine; and a 2005 hull constructed of 10-gauge steel at its bottom and 12-gauge steel at its sides, reinforced by interior framing and exterior reinforcement ribs.¹⁶ (See figure 8.) RTDI sold the *DUCK 6* to RTD Seattle, and RTD Seattle has an operational licensee agreement with RTDI.

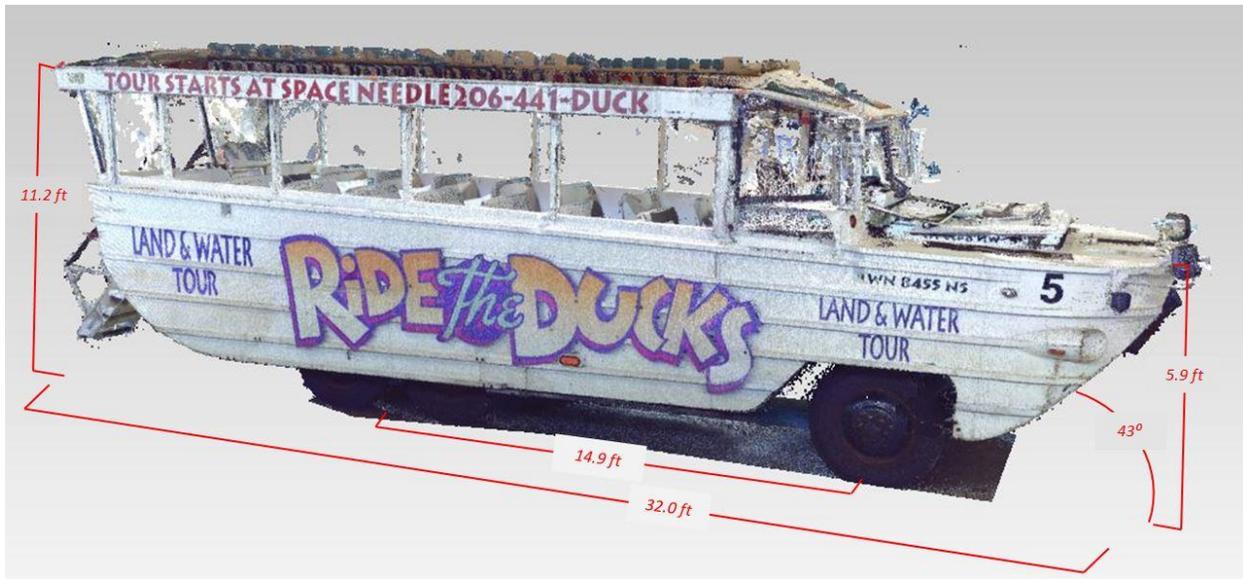


Figure 8. Colorized 3D scan image of an exemplar RTD Seattle stretch APV with measurements.

¹⁵ Before 2005, these stretch APVs were manufactured by Amphibious Vehicle Manufacturing. This company merged into RTDI in 2005. RTDI manufactured two types of vehicles, a stretch APV and a truck duck APV. The truck duck APV was RTDI's patented new-design APV based on a heavier-duty military chassis; the Coast Guard considers it to be a new construction vehicle. RTDI manufactured its last APV in 2008 and contracted the right of construction of new RTDI APVs to Chance Rides Manufacturing of Wichita, Kansas.

¹⁶ Although the appearance of the stretch APV may seem similar to the original 1945 model, most engineering systems were updated from the original design, and some new systems and equipment were added.

The *DUCK 6* had six wheels—two on the steer axle and two on each of the axles comprising the rear tandem axle assembly.¹⁷ The engine output shaft was connected to an Allison AT-545 automatic transmission. The transmission was connected to a single-speed GMC Truck & Coach full-time four-wheel drive transfer case that was then connected to differentials at the steer and lead tandem axles. A conventional (automotive-style) power-assisted hydraulic steering system was used to steer the *DUCK 6* on the road. Per RTDI technical data, the maximum speed attainable by the stretch APV was 55 mph.

The *DUCK 6* passenger cabin had nine rows of bench seats on each side of the vehicle, divided by a center aisle (each seat accommodated two passengers). Maximum passenger capacity was 36.

The *DUCK 6* was not equipped with fixed passenger windows. Five openings on each side of the vehicle were fitted with transparent plastic curtains that were separated by canopy roof stanchions (welded steel tubular framing). The curtains were automated with electric motors, which rolled the curtain windows up into an attachment on the roof.¹⁸ (On the day of the crash, the plastic window “curtains” were in their rolled-up positions, which left the window spaces open.) The first four openings on each side of the *DUCK 6* measured 55.25 inches wide by 33.25 inches high. The fifth opening at the rear measured 24.5 inches wide by 33.25 inches high.¹⁹ During the crash sequence, passengers were ejected through the open spaces between the sidewall and the roof canopy.

RTDI did not provide a manufacturer-required gross vehicle weight rating (GVWR) for the *DUCK 6*.²⁰ According to National Highway Traffic Safety Administration (NHTSA) requirements, manufacturers of motor vehicles must provide a GVWR for each vehicle; it is the maximum weight a vehicle is designed to carry when loaded, including the weight of the vehicle itself plus fuel, passengers, and cargo (49 *CFR* 571.3). Under NHTSA’s certification regulation (49 *CFR* Part 567), to compute the passenger portion of the GVWR, a calculation of 150 pounds multiplied by the number of the vehicle’s designated seating positions is used.

¹⁷ The on-road drive arrangement had been modified from the original DUKW six-wheel drive (6x6) to a four-wheel drive (6x4) system.

¹⁸ During inclement weather, roller curtains of clear plastic sheeting could be electrically lowered to enclose the otherwise open-sided cabin. In the event of an emergency requiring an over-the-side evacuation while the curtains were down, each roller curtain was fitted with a manually operated release mechanism that used gravity to quickly drop the curtain outward. Coast Guard guidance concerning APVs states that “Canopies and canopy supports can impede the egress of passengers. Again, the primary egress on these vehicles is over the side. Canopy supports should be positioned to allow the majority of passengers’ unobstructed egress.” (See Coast Guard NVIC 1-01, *Inspection of Amphibious Passenger-Carrying Vehicles*, Enc. 1, Section IV. C, p. 23, December 11, 2000.)

¹⁹ There was a rear opening on either side of the rear loading staircase covered by heavy plastic sheeting measuring 32.5 inches wide by 45 inches high on the passenger side and 27.5 inches wide by 45 inches high on the driver side.

²⁰ A newly manufactured motor vehicle must bear a Federal Motor Vehicle Safety Standard certification label. This label includes the vehicle’s GVWR and gross axle weight rating.

Postcrash, RTDI provided NTSB investigators with technical data specific to the *DUCK 6* showing that the APV had a curb weight of 19,680 pounds and a gross weight of 26,710 pounds.²¹ To calculate this gross weight, RTDI used the Coast Guard's new standard for assumed average weight per person (AAWPP) of 185 pounds per passenger (185 pounds x 38 occupants) for a payload of 7,030 pounds.²² (Using NHTSA's AAWPP of 150 pounds, multiplied by 38 designated seating positions, the GVWR could have been at least 25,380 pounds.)

Following the crash, the Seattle Commercial Vehicle Enforcement Squad weighed an RTD Seattle stretch APV (without passengers or cargo); this exemplar vehicle's weight was 19,300 pounds. Using this exemplar vehicle weight plus the Coast Guard AAWPP calculation for 37 occupants, the exemplar APV would have had a gross weight of 26,145 pounds (without cargo).²³

Damage. The *DUCK 6* sustained collision damage to its entire front end, or bow, with more severe damage to the left side. The windshield was intact, and the hull was pierced in three locations. The vehicle also had scrapes to its side, paint transfer marks, and several sheared-off bolts, which caused hull separation.

In the vehicle interior, the seat frames were made of tubular metal and attached to the floor and sidewall with bolts. Postcrash, the majority of the tubular floor posts were bent forward due to the seatbacks and seat frames being deformed forward with visible scuffing to the rear seatbacks. All the seatbacks, except those in row 9, were bent forward and deformed down; several seatbacks were almost flat against the seat pan (bottom horizontal cushion). The seat pan in row 7 was attached to the seat frame by toggle clamps, which detached during the crash, allowing the entire seat to fold forward.²⁴

The steering wheel was crushed and deformed with a portion bent toward the dashboard. Steering components had disconnected from the left front wheel and hub assembly, with the drag link separated from the steering arm and a broken bracket at the link and arm connection. The entire left front wheel, brake, and hub assembly was separated from the axle.

The *DUCK 6* was originally equipped with drum brakes with a single reservoir. RTDI modified the APV so that it had hydraulic disc brakes on the three axles with a dual reservoir, but

²¹ Curb weight is the actual weight of the vehicle with a full tank of fuel and other fluids needed for travel but no occupants or cargo.

²² (a) Title 46 *CFR* 170.090(d). (b) The *DUCK 6*'s Certificate of Inspection and Stability test results in the Coast Guard Vessel Critical Profile dated July 15, 2011, showed that, based on a stability review, the *DUCK 6* complied with the amended AAWPP regulations that went into effect on December 1, 2011. The AAWPP standards govern the maximum weight and number of passengers that may be safely permitted on board a vessel, as well as other stability regulations. (The Coast Guard final rule published on December 14, 2010, became effective on March 14, 2011, except for the new AAWPP, which became effective on December 1, 2011.)

²³ Using NHTSA's AAWPP would have resulted in a gross weight of approximately 24,850 pounds.

²⁴ The inside toggle clamp partially separated from the cross-member frame while the outside toggle clamp remained attached. However, the cross-member was bowed outward. First responders cut the floor attachment points in the first and second seat rows on both sides to make room for extrication of injured passengers.

it did not install an antilock braking system (ABS).²⁵ The left front hydraulic brake line was severed at the caliper. The master cylinder was undamaged by the accident, the front brake fluid reservoir was empty, and the rear reservoir was approximately one-third full.

On its front axle, the rubber boot covering the left-side front axle housing was ripped in half when the wheel separated from the axle housing.²⁶ The left front axle housing had fractured in a tapered area of the housing near where it connected to the steering knuckle. One end remained with the left front wheel and hub assembly, and the opposite end remained inside the axle housing. On the bottom of the housing, in the tapered area, the axle had been modified with a small metal tab, measuring approximately 1 inch by 2 inches, welded to span the taper. The tab had separated from the outboard weld on the left side, and the inboard weld held the tab to the housing. The right-side tab front axle housing remained intact. (See figure 9.)

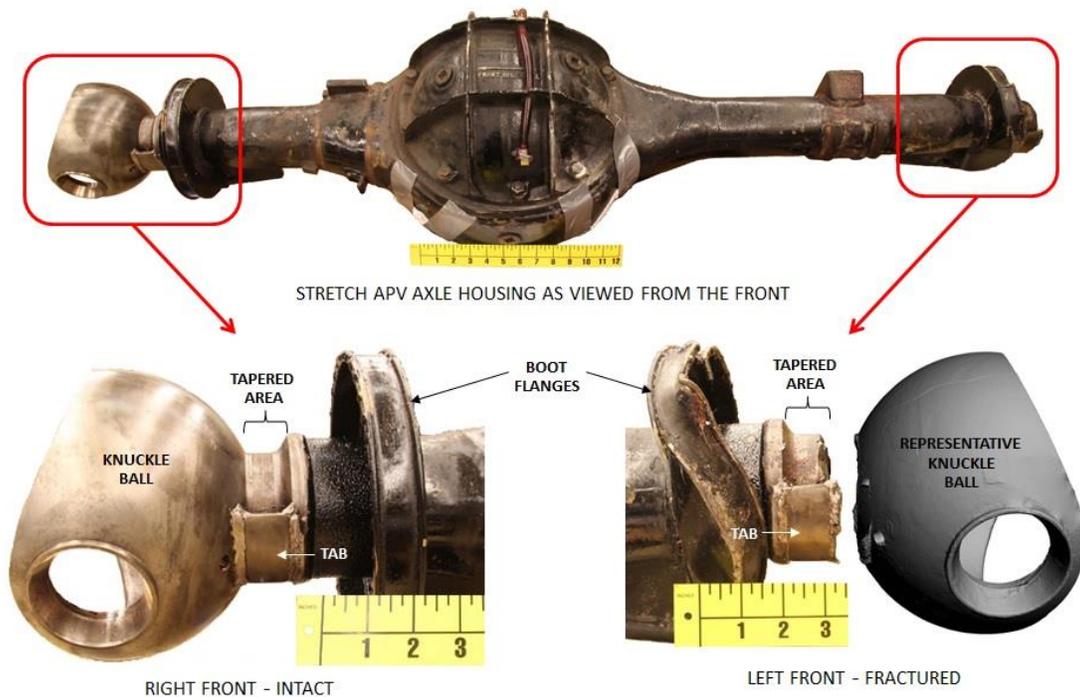


Figure 9. Top image shows front axle of the *DUCK 6* (as viewed from the front of the vehicle and looking rearward) with the two axle housings in their postcrash condition. Bottom images show the two axle housings (intact right housing is on the left and fractured left housing is on the right) in greater detail. (A “representative knuckle ball” image is used to indicate the damaged left knuckle ball.)

²⁵ The purpose of ABS is to help maintain directional stability and control during braking and possibly reduce stopping distances on some road surfaces, especially wet roads. ABS may prevent crashes involving loss of control. Federal Motor Vehicle Safety Standard 105, effective March 1, 1999, requires buses with a GVWR greater than 10,000 pounds to be equipped with ABS and to meet additional stopping distance requirements.

²⁶ The boot was attached with hose clamps to a metal flange welded onto the front axle housing approximately 6–8 inches from the end of the knuckle ball. The opposite end was connected to the inside of the steering knuckle. This design created a waterproof seal, and the area was filled with approximately 2.5 gallons of gear oil.

NTSB Materials Laboratory Examination and Finite Element Modeling Study. Postcrash, the NTSB laboratory in Washington, DC, examined the *DUCK 6* axle housing. Where the left front axle housing fractured (tapered area adjacent to the knuckle ball), the separated knuckle fracture surface had visible progressive crack arrest marks and ratchet marks consistent with fatigue cracking. (See figure 10.) The fatigue cracking emanated from a band of regular, concentric circumferential markings on the axle housing surface, consistent with single-point tooling marks from machining.²⁷ Under scanning electron microscope examination, numerous very fine ratchet marks and striations were observed, consistent with diffuse-origin fatigue crack initiation.



Figure 10. Mating fracture surfaces of the separated left side of the front axle housing. The images on the left show the fracture surface of the front axle housing in the taper area. The images on the right show the mating fracture surface on the knuckle ball of the front axle housing. The fatigue cracking initiation region is indicated on each fracture surface. The tab that separated at the outboard weld is also shown.

²⁷ Ratchet marks are slight vertical steps in the fracture that link slightly offset planes of fatigue cracking at a fatigue origin area. Ratchet marks generally are aligned in the direction of cracking and taper off as distance from the origin is increased and a unified crack front is produced.

The fracture surface of the separated outboard weld on the left side of the tab had large areas of smooth, unfused weld material, consistent with incomplete fusion, where it had detached from the knuckle. The weld material had an inconsistent width along the length of the tab, and portions of the machined tab surface were visible, consistent with inadequate weld joint penetration. Incomplete fusion and inadequate joint penetration are weld discontinuities that should have been identified during post-weld inspection. The areas of the outboard weld that had fractured within the weld material were consistent with overstress separation.

The NTSB laboratory used finite element modeling to examine local stresses in the axle housing assembly that fractured. The original axle housing, as well as modified versions with welded tabs, were studied. The laboratory constructed 3-D finite element models of the axle housing assembly based on laser scans and measurements. Loads and boundary conditions simulating in-service conditions were applied to the model. The finite element study focused on the local stresses in the region of the axle housing transitioning to the knuckle, as well as the stresses in the welded tab used as a stiffening modification.

The study found that a stress concentration existed in the transition region between the knuckle ball and the tapered area of the original, unmodified axle when loaded, and a new stress concentration was created at the welded interface for the axle with welded tabs. Figure 11 (left side) provides a close-up view of the Mises stress distribution in the vicinity of the transition region on the left side of the loaded axle housing, without the welded tab modification.²⁸ The image shows that the peak stress occurred in the transition region, and the magnitudes of the peak stresses on the top and bottom of the axle housing were found to be approximately the same (the bottom in tension and the top in compression, as expected for a bending load).

The right side of figure 11 depicts the contours of the Mises stress on the cross section in the area including the welded tab and the transition region of the axle housing. The results showed that stresses were still higher in the transition region than away from it, although their magnitudes decreased from the case without the welded tab plate. At the same time, a new set of local stress concentrations was introduced by the welded tab plate at the tips of the unfused regions at the welded interfaces.

²⁸ Mises stress is a stress measure calculated with individual stress components. It is commonly used in determining whether a material will yield when subjected to complex loading conditions.

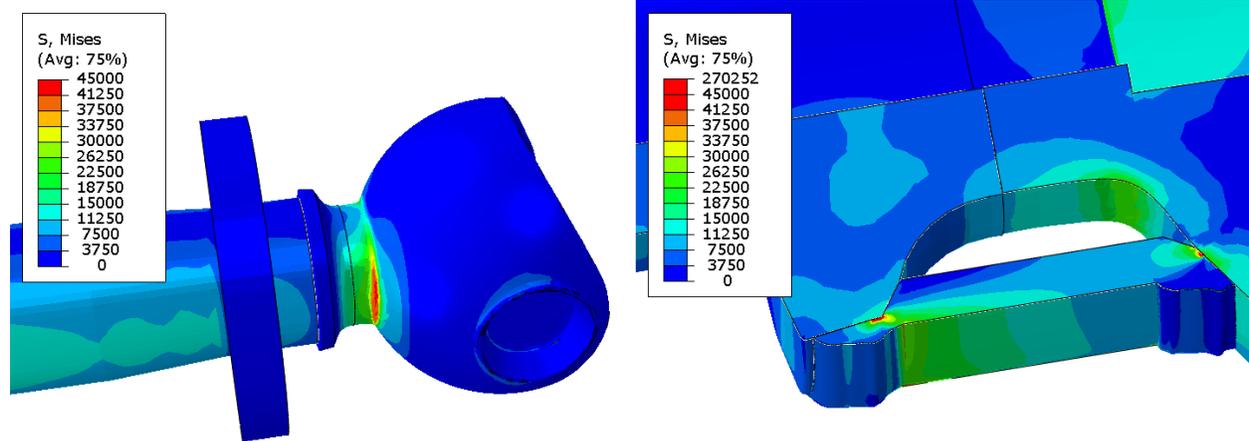


Figure 11. Mises stress distribution images. The left image depicts the Mises stress distribution in the vicinity of the left front axle transition region, rotated to show the bottom of the axle housing. The right image depicts a cross section, zoomed-in view of the Mises stress distribution in the vicinity of both the left front axle transition region and the tab modification welded to the bottom of the axle housing.

Maintenance, Inspections, and Service Bulletins. Postcrash, NTSB investigators examined RTD Seattle maintenance records from September 2014 through September 20, 2015. The company provided documentation for a variety of regularly scheduled preventative maintenance activities and repairs.²⁹ RTD Seattle has 13 full-time mechanics responsible for all maintenance operations on its APV fleet. The annual inspection of the *DUCK 6* was completed on November 25, 2014, and the only repairs noted were the replacement of the left front leaf spring hanger pins and U-bolts.³⁰

RTD Seattle also provided investigators with a maintenance binder that contained service bulletins issued by RTDI (the vehicle manufacturer) between July 22, 2004, and June 15, 2015. RTDI sent these periodic service bulletin updates to all RTDI company-owned operators, franchisees, and licensees.³¹ The terms of the licensee agreement between RTD Seattle and RTDI did not provide for RTDI to conduct inspections to determine whether the work detailed in its service bulletins had been completed. RTD Seattle had completed the work called for in 15 of the 74 RTDI bulletins.

²⁹ Per RTD Seattle policy, major maintenance actions were to be performed at 250-hour intervals and included the wheels, brakes, steering, suspension, lubrication, drive axles, struts, and drive shafts. Per the RTD Seattle annual inspection form (work order #5710), “DUKWs are subject to a variety of stresses, strains, vibrations, and detrimental environments” that would “soon render the DUKW inoperable if inspections were not conducted on a regular basis,” and “constant vigilance enables our fleet to be operated safely until the next scheduled inspection.”

³⁰ As its primary function, a U-bolt provides the force required to clamp the leaf spring and related components firmly together. Hanger pins are used to connect the leaf spring ends to the spring hangers.

³¹ RTDI staff also provides to all operators, franchisees, and licensees (1) biweekly maintenance conference calls on newly issued service bulletins and (2) maintenance and service information via an internal website, called *Duck Central*.

One service bulletin, SB-00-14-13, issued in October 2013, outlined a repair modification to avoid axle fractures; the bulletin stated that the repair was to be performed “as soon as practical and prior to operating in 2014.” The bulletin recommended welding a “collar” of two reinforcing metal half pipes to the tapered section of the front axle housing to strengthen it, specifically at the location where the steering knuckle met the axle housing (further discussed below). (See figure 12 for an image of a collar assembly from the service bulletin.) The bulletin recommended that until the service bulletin work could be completed, the wheels of each stretch APV should be visually inspected on a daily basis for signs of vertical canting (tilting). The axle fracture that occurred on the *DUCK 6* before its collision with the motorcoach took place at the section of tapered axle housing addressed in SB-00-14-13.

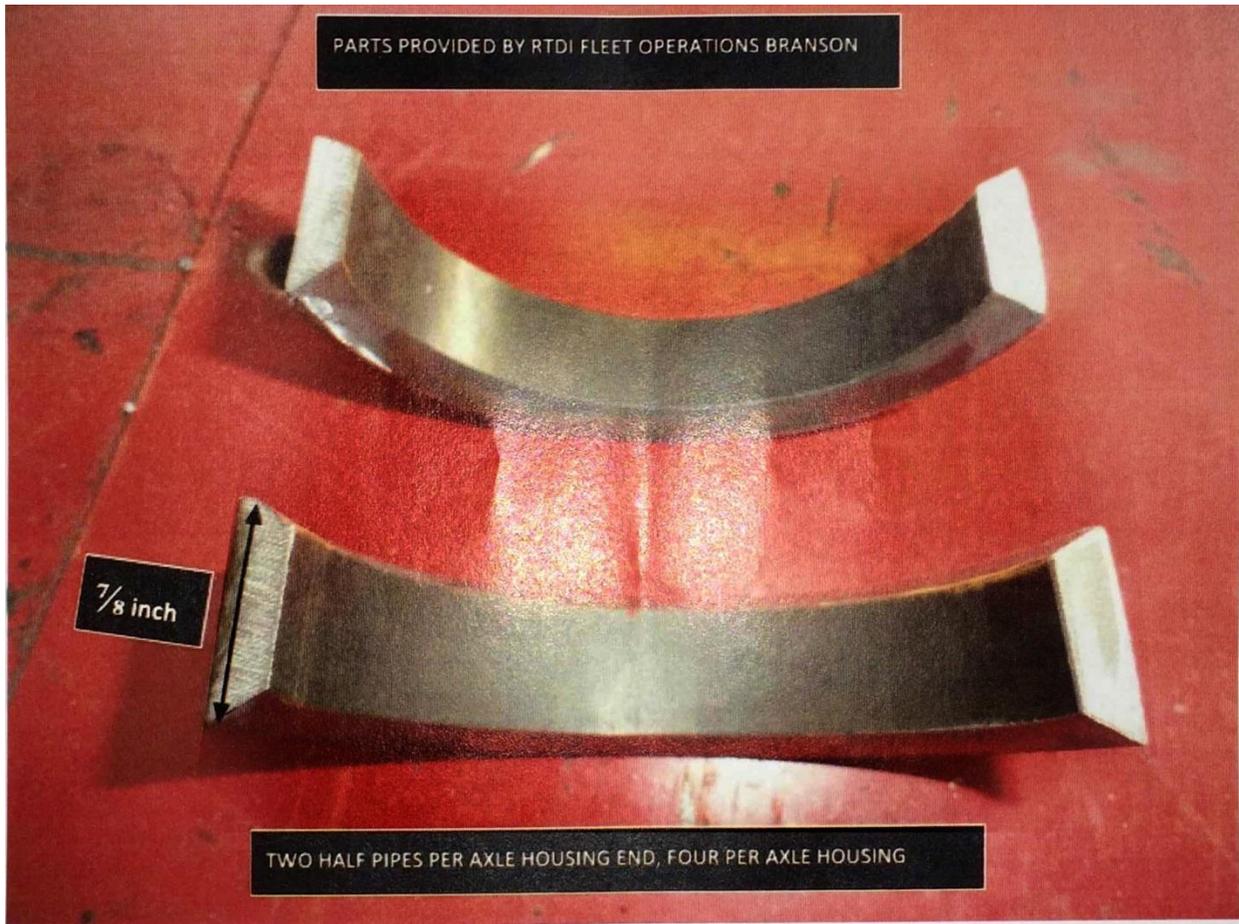


Figure 12. Image of collar assembly for recommended repair provided in SB-00-14-13 from RTDI.

Postcrash, NTSB investigators spoke with five mechanics at the RTD Seattle maintenance facility regarding SB-00-14-13; they stated that none of them had any knowledge of the service bulletin before the crash, and none had seen an axle with the modification.³² NTSB investigators

³² Stretch APVs are built with a waterproof rubber bellows-style boot on each side of the front axle housing that covers the axle housing. The boots are replaced only when they begin leaking or are damaged, approximately every 12–18 months. Only during this replacement would the axle housing area be accessible for inspection.

examined RTD Seattle's inventory of spare front axle housings and found that none had either the collar weld modification called for in 2013 via SB-00-14-13 or the earlier tab weld modification found on the *DUCK 6* front axle (discussed below).³³

RTDI told NTSB investigators that in the early 2000s, it was aware of the following front axle fracture events:

- On July 8, 2003, a stretch APV in Branson, Missouri, was observed to have a broken steering axle housing where it connected to the knuckle on the right side. This APV had previously been involved in an incident in which it had run over a retaining wall. RTDI believed that the broken axle housing was related to this incident.
- Between 2003 and 2004, RTDI became aware of two more of its stretch APVs that had fractured left axle housings at the tapered area. (These fractures were discovered during routine vehicle inspections because the left front wheels were canted inward at the top.)

As a result of these 2003 and 2004 axle housing fractures, RTDI developed a modification in which a small section of pipe (termed a "tab") was welded to bridge the gap between the bottom of the knuckle ball and the axle housing. This modification was to be implemented on all stretch APVs manufactured after fall 2004. RTDI did not issue a service or maintenance bulletin regarding this modification process. The *DUCK 6* was manufactured in January 2005, and it had the 2004 welded tab modification before it became part of the RTD Seattle fleet.

RTDI documented no axle fractures between 2004 and 2013. In 2013, two stretch APVs at the Branson, Missouri, location were found to have fractured axle housings. RTDI provided the following details regarding the 2013 axle fractures:

- On July 27, 2013, a stretch APV was found to have a broken left front axle housing. This vehicle had been overturned in a tornado the previous year, and RTDI used a crane to return it to an upright position. RTDI suspected that the fracture may have started during the process of lifting and up-righting the stretch APV.
- On August 10, 2013, a stretch APV was found to have a fractured left front axle housing. RTDI noted that this vehicle had the 2004 tab weld modification. This 2013 fracture event prompted RTDI to develop the collar weld modification to strengthen the axle and to issue service bulletin SB-00-14-13 to all its APV operators.

Postcrash, the NTSB examined all ten of RTD Seattle's stretch APVs to determine if they had the 2004 tab weld or 2013 collar weld modifications. None of the stretch APVs had the 2013 collar weld repair as outlined in SB-00-14-13. RTD Seattle provided no explanation as to why this service bulletin repair had not been completed. With respect to the earlier 2004 modification, the *DUCK 6* and three other stretch APVs had the 2004 tab modification in place; however, investigators noted areas of concern with some of the welds, and several of the tab welds had

³³ RTD Seattle obtained the spare axle housings from Boston Duck Tours, another operator that has a licensee agreement with RTDI.

cracks in them.³⁴ Four of the six welds on the other three stretch APVs (two welds per vehicle) had visible cracks.

During the crash investigation, RTDI told NTSB investigators that the company did not perform engineering analyses or tests to determine the effectiveness of either the 2004 or 2013 modification.

Other Mechanical Systems. NTSB investigators performed functional checks of the *DUCK 6* braking, suspension, and electrical systems, as well as examinations of the wheels and tires. Other than the damage to the steering and left front wheel hub and brake previously described in section 1.4.1, investigators found no evidence of precrash vehicle damage or defects to the remaining tires, rims, or brakes.

Inspections. The *DUCK 6* had undergone a Coast Guard inspection and received a Certificate of Inspection on January 25, 2015.³⁵ Officers of the Seattle Commercial Vehicle Enforcement Squad performed a roadside inspection of the *DUCK 6* on August 24, 2015. Aside from an “over licensed capacity” violation of local rules and regulations (49 *CFR* 392.2) regarding the vehicle’s registered weight, no vehicle defects were reported.³⁶

Seat Belts. The driver’s station of the *DUCK 6* had a bucket-style seat at the left side of the passenger cabin. It was equipped with a two-point (lap-only) seat belt. During an interview with NTSB investigators, the driver stated that he was wearing his lap belt at the time of the crash.³⁷ Postcrash examination of the driver’s seat revealed evidence consistent with seat belt use at the time of the crash. The *DUCK 6*’s passenger seats were not equipped with seat belts.

Cameras. Each RTD Seattle APV was equipped with two cameras: one on the front of the vehicle and one on its rear.³⁸ The camera viewing screen was mounted directly to the right of the driver’s station, at the bottom of the windshield. The Washington Utilities and Transportation Commission (WUTC) verified that the cameras on each vehicle were operational. RTD Seattle provided the WUTC with a diagram of the driver’s view from each mirror and camera. The

³⁴ Two of three stretch APVs had the tab weld modification on the housing bottom, and one had the tab modification welded on the top of the housing.

³⁵ A Certificate of Inspection is required by law (46 *United States Code [USC]* 3309) and an approved stability letter is required by regulation (46 *CFR* Part 170) before a small passenger vessel may carry more than six passengers, including at least one for-hire passenger (paying customer).

³⁶ Title 49 *CFR* 392.2, “Applicable operating rules,” states that “Every commercial motor vehicle must be operated in accordance with the laws, ordinances, and regulations of the jurisdiction in which it is being operated. However, if a regulation of the Federal Motor Carrier Safety Administration imposes a higher standard of care than that law, ordinance, or regulation, the Federal Motor Carrier Safety Administration regulation must be complied with.”

³⁷ Washington State has a primary enforcement seat belt use law (RCW 46.61.688: Safety belts, use required), which states that “every person sixteen years of age or older operating or riding in a motor vehicle shall wear the safety belt assembly in a properly adjusted and securely fastened manner.” According to the Governors Highway Safety Association, primary seat belt laws allow law enforcement to stop a vehicle and issue a citation when the officer observes an unbelted driver or passenger. (See www.ghsa.org/html/issues/occprotection/index.html.)

³⁸ In 2011, an APV operated by RTD Seattle was in a crash involving a motorcycle in downtown Seattle. The motorcycle and the APV were stopped at a traffic light; the motorcycle was in front of the APV. When the RTD Seattle driver saw the light turn green, he accelerated faster than the motorcyclist. He ran over the motorcycle and its motorcyclist, dragging both for several blocks. The motorcyclist was seriously injured. Following this event, RTD Seattle installed the camera systems on its vehicles.

company's pretrip inspection procedures directed the drivers to check and ensure that the mirrors and cameras are positioned for proper visibility. The cameras were not equipped to record.

1.4.2 Motorcoach

General. The 2009 Motor Coach Industries J4500 56-passenger, 45-foot-long motorcoach was equipped with a Detroit Diesel engine and an Allison B500 automatic transmission. The motorcoach was also equipped with Meritor WABCO six-wheel air-operated antilock disc brakes. It had a GVWR of 54,000 pounds.

Damage. The *DUCK 6* initially struck the left front (driver side) of the motorcoach. Damage began at the motorcoach's front lower left corner and extended upward toward the rear. The roofline upper supporting rails were damaged, the motorcoach body was bowed inward from impact, and the interior roof was deformed from contact by the APV bow as it rotated up into the motorcoach. The motorcoach's right side had minor contact damage near the front corner and door area from scraping against a barrier and a pedestrian railing.

Passenger compartment intrusion began at the left front corner at the driver's seat footwell area and extended along the left sidewall and windows for approximately 19 feet laterally, at a height of about 6 feet. Maximum intrusion, of about 2 feet, occurred between motorcoach rows 5 and 6. (See figure 13.) The motorcoach floor buckled vertically about 18 inches between rows 3 and 4. The driver's seat was deformed due to the floorboard's buckling upward.



Figure 13. Colorized 3D postcrash scan of motorcoach.

The passenger seat frames and anchorages on both sides of the motorcoach were deformed. Several seats on the driver side were torn out by the impact from the *DUCK 6*, and rows 4–7 were displaced and damaged.³⁹ The driver-side panel was displaced vertically and laterally to the right,

³⁹ First responders removed the passenger seats from rows 8 and 9 during patient extrication.

and the passenger-side stairwell panel was displaced slightly forward. Both windshield windows and the front passenger door glazing were broken out.

Vehicle Systems, Inspections, and Maintenance. NTSB investigators performed functional checks of multiple vehicle systems. Investigators examined the steering, suspension, braking, and electrical systems, as well as the wheels and tires. No evidence of preexisting vehicle damage or defects was found.

The accident motorcoach had an annual inspection on August 28, 2015, and no defects were found. Bellair Charters provided investigators with its DVIRs for the 3 months before the crash, and no major maintenance issues were noted. Bellair Charters had performed all routine maintenance and repairs in-house at its terminal locations.

Restraints. The driver seat was an air-ride bucket seat with a two-point (lap-only) restraint. Examination of the driver's lap belt showed evidence consistent with belt use at the time of the crash. None of the two-person passenger seats in the 14 rows of seating were equipped with seat belts. The passenger seats were equipped with adjustable headrests.

Event Data Recorders. The motorcoach engine was electronically controlled by a DDEC VI motor control module and a common powertrain controller; when combined, these devices are known as an engine control module (ECM). Postcrash, NTSB investigators extracted data from the ECM, including a relevant last stop recording that provided vehicle parameters, including speed and brake application.

A Rosco DV101E dual-vision camera system was mounted on the motorcoach windshield. The camera system recorded two channels of video, one acquired by a forward-facing and one by an inward-facing camera. The video recordings had 640x480 resolution and a frame rate of 7.5 frames per second. The unit also included a three-axis accelerometer and a global positioning system (GPS) receiver that was used to update the device's clock time and supply geotagging information for the recorded videos.

The video contained GPS information for the entire trip on September 28, 2015. The NTSB extracted the crash-related last 1 minute 15 seconds of video and GPS data, from 11:09:24 to 11:10:38, which included the crash segment. The GPS data appeared to update once per second and to be synchronized to local time. Per the video data, by 11:10:09, the motorcoach had turned southbound onto the Aurora Bridge and, while traversing the bridge, increased its speed steadily. The last recorded data point, at 11:10:38, showed the motorcoach traveling at 43 mph. (The posted speed limit was 40 mph.) The camera also captured the *DUCK 6*'s movements from the time it began to leave the center northbound lane until shortly before it struck the motorcoach.

1.4.3 Other Vehicles Involved in the Crash

Damage. The Ram pickup truck had damage to its right front fender and headlamp assembly. Damage, including tears, scrapes, and dents, progressed rearward to the taillight area. The front axle and suspension were dislodged from the vehicle frame, the left tire was canted outward, and the front differential was disengaged from the driveline. The Toyota Highlander SUV had damage to its entire front end, including the left headlight, grill, bumper, and hood. The

radiator was pushed back into the engine compartment. The Toyota Tundra pickup truck had damage to its left-side rear passenger doors.

Seat Belts. The Ram pickup truck and the Toyota Highlander and Tundra were equipped with three-point (lap/shoulder) restraints at all seating positions. The Ram driver lap/shoulder belt and the Toyota Highlander driver and front passenger lap/shoulder belts showed evidence consistent with use at the time of the crash.

Event Data Recorders. An airbag control module (ACM) is part of an automobile's supplemental restraint system, which creates a recording when a triggering event occurs.⁴⁰ The SPD downloaded the Ram pickup truck's ACM. Its precrash data indicated that, 5 seconds before the triggered event, the Ram pickup truck had been traveling 55 mph. ACM system data indicated that the airbags did not deploy. Precrash data from the Toyota Highlander's ACM indicated that, 4.2 seconds before the triggered event, the vehicle had been traveling 50 mph. ACM system data indicated that the airbags deployed.

1.5 Driver Factors

1.5.1 *DUCK 6* Driver

Licensing, History, and Training. For the land portion of the amphibious tours, the APV driver must hold a commercial driver's license (CDL) with a passenger endorsement. For the water portion, the operator must hold the appropriate Coast Guard master's license.

The 54-year-old *DUCK 6* driver possessed a Washington class "C" CDL with a passenger endorsement and an air brake restriction. The CDL was issued in March 2015 with an expiration date in February 2017. A search of the National Driver Register (NDR) Problem Driver Pointer System (PDPS) found no revocations or suspensions for this driver.⁴¹ RTD Seattle hired the driver in February 2015, and he obtained his CDL through RTD Seattle's in-house CDL training.

The *DUCK 6* driver also held a merchant mariner credential issued by the Coast Guard in March 2015, with an expiration in March 2020.⁴² This credential permitted the driver to serve as a "limited master" of self-propelled vehicles, not including auxiliary sail, of less than 25 gross register tons, limited to DUKW vessel vehicles owned and operated by RTD Seattle.

Medical Certification and Toxicology. The *DUCK 6* driver had a current USDOT medical certificate, issued in February 2015. The driver reported no injury or illness and no medication use on his medical examination form, and the examining physician noted no issues with the driver's health or vision. The driver was qualified for 2 years.

⁴⁰ Depending on the vehicle, the module may be capable of recording data when triggered by an airbag event known as a deployment or non-deployment.

⁴¹ The PDPS is a repository of information on problem drivers provided by all 51 US jurisdictions. Based on information from an NDR search, the PDPS will "point" the inquiring jurisdiction to the state of record, where driver status and history information is stored. (See www.aamva.org/PDPS, accessed July 18, 2016.)

⁴² The APV was considered to be and served as a watercraft under Coast Guard oversight.

The Coast Guard also required that the *DUCK 6* driver have a medical certificate (separate from the Federal Motor Carrier Safety Administration [FMCSA] USDOT medical certificate). The driver had undergone a Coast Guard physical in February 2015, and he indicated that he was not taking any prescription or over-the-counter medications and did not have any health issues. No issues were noted on the Coast Guard physical examination form.

Postcrash, the driver was transported to Northwest Hospital, where blood and urine were collected for diagnostic purposes. Toxicological screening of the blood for alcohol was negative, and the urine screening was negative for specific drug substances.⁴³ The NTSB sent the remaining blood sample to the Civil Aerospace Medical Institute (CAMI), where no alcohol or other drugs were detected in the forensic toxicology analysis.⁴⁴

Driver's Precrash Activities. The *DUCK 6* driver told NTSB investigators that he made his usual pretrip inspection of the vehicle before departing the garage. He described the inspection and said he found no issues with the vehicle. Before leaving the downtown location with passengers, he gave a pretrip briefing. He recalled that the vehicle and the tour seemed "normal."

Using the records from the *DUCK 6* driver's personal and RTD Seattle-issued cell phone, the driver's timecards, and the NTSB's interview of the driver, investigators developed a table of driver activities leading up to the crash. The cell phone records showed that the *DUCK 6* driver did not make any phone calls during the crash trip. Based on the obtained information, NTSB investigators determined that he had over 8 hours available in which to rest on September 22 and over 9 hours on the night before the crash. (See table 2.)

Table 2. *DUCK 6* driver's precrash activities, September 22–24, 2015.

Time	Event	Source
Tuesday, September 22		
~8-9:00 a.m.	Awakens (estimated)	Interview
7:00 p.m.	Cell phone logs end of outgoing call ^a	Cell records
8:27 p.m.	Cell phone logs sent text message	Cell records
10:15 p.m.	Goes to bed (estimated)	Interview
11:25 p.m.	Cell phone logs incoming text message	Cell records
Wednesday, September 23		
~8-9:00 a.m.	Awakens (estimated)	Interview
2:30 p.m.	Cell phone logs incoming call	Cell records
2:32 p.m.	Cell phone logs incoming text message	Cell records
3:17 p.m.	Cell phone logs end of outgoing call	Cell records
~10:15 p.m.	Goes to bed (estimated)	Interview

⁴³ The urine was screened for methadone, benzodiazepines, cocaine, amphetamines, THC (the active chemical in marijuana), opiates, barbiturates, antidepressants, and TCA (tricyclic antidepressants).

⁴⁴ CAMI analyzed the sample for ethanol, amphetamines, opiates, marijuana, cocaine, phencyclidine, benzodiazepines, barbiturates, antidepressants, and antihistamines.

Thursday, September 24		
7:30 a.m.	Awakens	Interview
8:24 a.m.	Cell phone logs outgoing call on work cell phone	Cell records
9:08 a.m.	Clocks in for work	Timecard
~9:15 a.m.	Begins pretrip inspection	Interview
10:00 a.m.	Arrives at ticket booth downtown	Interview
10:17 a.m.	Cell phone logs incoming call on work phone	Cell records
10:30 a.m.	Scheduled departure time	Interview
~10:35 a.m.	Gives safety briefing and begins tour	Interview
11:11 a.m.	Crash	-----
<small>^a Cell phone calls and texts listed include only the first or last call or text message of each day.</small>		

Driver's Tour-Related Activities. The *DUCK 6* was equipped with an audio system through which the driver could make announcements to the passengers and play music. According to the driver's statement to the SPD, he had activated the music just before driving onto the Aurora Bridge, and he was not manipulating the system controls or making an announcement at the time of the crash.

1.5.2 Motorcoach Driver

The motorcoach driver was a 68-year-old male holding a current Washington class "A" CDL with a "P" passenger, tank, and double/triple endorsement. His CDL was issued in May 2011 with a May 2016 expiration. His record with the Washington Department of Motor Vehicles indicated that he had no citations or accidents in the previous 10 years, and the NDR PDPS for this driver showed no revocations or suspensions.

His most recent medical examination for CDL fitness determination was completed in January 2015; it was valid for 1 year from issuance. The shorter-than-usual expiration was due to the driver's hypertension and sleep apnea (for which he was being treated). The USDOT requires that all commercial drivers involved in a crash undergo postcrash toxicological testing. For the motorcoach driver, the test results were negative for alcohol and all other drugs for which he was tested.⁴⁵

At the time of the crash, the motorcoach was operating as part of a two-bus charter for the NSCC, taking students to points of interest in the Seattle area. When interviewed by police on scene, the driver said that, just before the crash, he had been coming from Gasworks Park and had merged onto the Aurora Bridge southbound. He was in the center lane traveling at an estimated speed of 35 mph. He said he first noticed the *DUCK 6* as it crossed the center (yellow) line. The motorcoach driver steered to the right and applied his brakes, but he could not avoid the oncoming APV and subsequent collision. The driver declined to be interviewed by the NTSB. Using

⁴⁵ The urine sample was tested for marijuana, cocaine, PCP, opiates, and amphetamines. A breath sample was collected and analyzed for breath alcohol content.

information from the driver's logbook, a recorded interview with police, and cell phone records, investigators developed a table of precrash activities for the driver.⁴⁶ (See table 3.)

Table 3. Motorcoach driver's precrash activities, September 22–24, 2015.

Time	Event	Source
Tuesday, September 22		
9:54 a.m.	Cell phone logs incoming call ^a	Cell records
11:30 a.m.	On-duty, not driving, in Ferndale, WA	Logbook
12:30 p.m.	Driving	Logbook
1:45 p.m.	On-duty, not driving, at Smokey Pt. rest stop	Logbook
2:00 p.m.	Driving	Logbook
4:00 p.m.	On-duty, not driving, at Gig Harbor	Logbook
4:15 p.m.	Driving	Logbook
5:00 p.m.	On-duty, not driving, at Federal Way	Logbook
5:45 p.m.	Off-duty	Logbook
5:53 p.m.	Cell phone logs end of outgoing call	Cell records
Wednesday, September 23		
10:08 a.m.	Cell phone logs outgoing call	Cell records
8:37 p.m.	Cell phone logs sent text message	Cell records
9:08 p.m.	Cell phone logs end of outgoing call	Cell records
Thursday, September 24		
8:02 a.m.	Checks voicemail (first call activity of day)	Cell records
8:15 a.m.	On-duty, not driving, at Federal Way	Logbook
8:30 a.m.	Driving	Logbook
9:30 a.m.	Off-duty at NSCC	Logbook
9:45 a.m.	NSCC pickup time	Interview
10:15 a.m.	On-duty, not driving	Logbook
10:45 a.m.	On-duty, not driving, ends; no new duty status	Logbook
11:11 a.m.	Crash	-----
^a Cell phone calls and texts listed include only the first or last call or text message of each day.		

⁴⁶ The driver's logbook was up to date and showed no evidence of hour-of-service or false record-of-duty status violations in the 7 days before or on the day of the crash. The driver had been on duty for 32.5 hours in the previous 8 days.

1.6 Motor Carrier Factors

1.6.1 Ride the Ducks of Seattle

General. RTD Seattle began operating in 1997 and is registered with the WUTC as an “excursion service carrier of passengers.”⁴⁷ Although RTD Seattle engages only in intrastate operations and as such does not require federal interstate operating authority, it has an FMCSA USDOT number (1905507).⁴⁸

RTD Seattle operates a fleet of 20 DUKW vehicles, 10 of which are stretch APVs purchased from RTDI. It employs 51 drivers and leases a terminal and maintenance shop in Seattle, where it has offices, conducts employee training, and performs vehicle maintenance. All RTD Seattle vehicles are housed at this location. The company operates under a license from RTDI of Branson, Missouri.

Driver Training Program. RTD Seattle provides three types of training: initial training, consisting of 240 hours over 6 weeks for newly hired applicants; annual recurrent training, consisting of 18–24 hours of classroom courses, use of a driving simulator, and emergency drills on land and water; and return-to-duty training, consisting of 8–16 hours of training, which is provided when a driver returns after having been inactive or on a leave of absence.

WUTC Oversight. The WUTC provides primary oversight of RTD Seattle, due to the carrier’s intrastate, rather than interstate, operating authority. The WUTC is authorized to administer and enforce state laws and rules relating to passenger transportation companies. The WUTC activities include inspecting equipment, drivers, records, files, accounts, books, and documents. The WUTC has the authority to place vehicles and drivers out of service.⁴⁹ The WUTC has conducted four compliance reviews (CR) of RTD Seattle since 1999, when the company received operating authority as an excursion service carrier. The WUTC gave RTD Seattle satisfactory ratings in 2003, 2006, 2010, and 2013.

Postcrash WUTC and FMCSA Compliance Reviews. The WUTC initiated a postcrash CR, which identified 1 acute and 6 critical violations of the regulations and 131 non-pattern

⁴⁷ (a) The company is registered with state of Washington certificate ES-00146 under Revised Code of Washington RCW 81.70.270. (b) Excursion service carriers are defined by the state of Washington as: every person engaged in the transportation of persons for compensation over any public highway in this state from points of origin within the incorporated limits of any city or town or area, to any other location within the state of Washington and returning to that origin. The service must not pick up or drop off passengers after leaving and before returning to the area of origin. The excursions may be regularly scheduled.

⁴⁸ As an intrastate carrier, RTD Seattle is subject to FMCSA oversight under 49 *CFR* Parts 40, 382, and 383.

⁴⁹ Washington Administrative Code 480-30-241(1).

violations of five other regulations.⁵⁰ Noncompliance with acute regulations and patterns of noncompliance with critical regulations have been linked quantitatively to inadequate safety management controls and higher-than-average crash rates (WUTC 2015).

The WUTC also uncovered 304 recordkeeping violations of 17 non-acute/non-critical regulations. On December 15, 2015, the WUTC proposed an unsatisfactory safety rating for the acute violation, six violations of critical regulations, and two recordable accidents.⁵¹ On January 27, 2016, the WUTC issued RTD Seattle a conditional rating based on the company's request to change the proposed safety rating. RTD Seattle submitted a written safety management plan to the WUTC that described the corrective actions the company planned to take to address each specific violation and outlined how it intended to stay in compliance with each requirement.⁵²

On May 3, 2016, the WUTC modified and approved a settlement with RTD Seattle. The carrier admitted to violating 463 motor carrier safety rules that were identified in the WUTC investigation and was assessed increased penalties, as the WUTC stated in its report that the violations reflected "an insufficient approach to public safety which the commission cannot tolerate." On March 17, 2016, the WUTC assessed a total penalty of \$308,000 against RTD Seattle. The WUTC suspended \$152,000 of the total penalty amount on the condition that RTD Seattle commits no new violations of the laws, as specified in their agreement, for 24 months, commencing on May 3, 2016. (See www.utc.wa.gov/docs/Pages/recordsCenter.aspx [accessed November 1, 2016] and search for filing TE-151906).

When asked by the WUTC about SB-00-14-13, RTD Seattle maintenance personnel told commission investigators that the company implemented the recommendations from SB-00-14-13 by conducting visual examinations of the wheels on each vehicle during pretrip inspections, including checking for any vertical canting of the front wheels. Maintenance personnel reported that they observed no canting and therefore took no further action regarding the bulletin.

On August 5, 2016, the WUTC released its findings from its 6-month review of RTD Seattle (completed on July 28, 2016), per the agreement associated with the January 27, 2016, upgraded safety rating given to RTD Seattle. The WUTC found no repeat violations from the 2015 postcrash investigation and that the 2015 violations had been corrected. Two new minor

⁵⁰ (a) The WUTC used 49 *CFR* Part 385, "Safety Fitness Procedures," which it has adopted, to conduct the postcrash CR. (b) As defined in 49 *CFR* Part 385, appendix B, acute regulations are those where noncompliance is so severe as to require immediate corrective actions by a motor carrier regardless of its overall safety posture. Critical regulations are those identified as such where noncompliance relates to management and/or operational controls. These are indicative of breakdowns in a carrier's management controls. Also per appendix B to 49 *CFR* Part 385, referencing no pattern established: "A pattern is more than one violation. When multiple documents are reviewed, the number of violations required to meet a pattern is equal to at least 10 percent of those examined."

⁵¹ A recordable accident means an occurrence involving a commercial motor vehicle on a highway that results in a fatality; bodily injury to a person who, as a result of the injury, immediately receives medical treatment away from the scene of the accident; or one or more vehicles incurring disabling damage that requires the motor vehicle to be transported away from the scene by a tow truck or other motor vehicle. The frequency of accidents is a factor considered in determining the carrier's overall safety fitness rating.

⁵² Passenger motor carriers have 45 days from the date the proposed unsatisfactory rating is issued to request a change to the safety rating. The request must be based upon evidence that the company has taken corrective actions to address the violations identified and that company operations currently meet the safety fitness standard as specified in 49 *CFR* 385.5 and 385.7. Carriers with proposed unsatisfactory safety ratings are generally allowed to operate during this 45-day period. However, if on the 46th day the carrier has not adequately complied with these requirements, it is prohibited from operating.

recordkeeping violations were found. WUTC staff recommended no further action. The WUTC will conduct followup compliance and vehicle inspections in January 2017 and January 2018 to determine if the company is following its safety management plan and to verify compliance with state and federal safety requirements. (See appendix C for a list of all violations found in the postcrash CR.)

Relevant violations of 49 *CFR* Part 396 found pertaining to vehicle maintenance and company operations were as follows:

- Failing to require the driver to sign the last vehicle inspection report when defects or deficiencies were noted. The carrier failed to have the driver sign stating the discrepancy was either repaired or did not require repair. (Part 396.13(c)). 90 violations found.
- Failing to retain periodic inspection reports for 14 months from date of inspection. [Part 396.25(e).] Three violations found: RTD Seattle vehicles *DUCK 12, 14, and 15* did not have documentation of an annual periodic inspection completed in 2013.

On November 5, 2015, RTD Seattle also underwent an FMCSA “nonrated” CR pertaining to 49 *CFR* Parts 40, 382, and 383. The FMCSA CR identified one acute and one critical violation as well as other violations pertaining to the *CFR* sections on alcohol and controlled substance testing. The FMCSA CR was incorporated into the WUTC CR. The FMCSA issued a separate Notice of Claim to RTD Seattle for \$10,890 in civil penalties for the critical and acute violations. (See appendix C for the FMCSA-noted violations.)

Postcrash Risk Management Actions. In January 2016, RTD Seattle announced modifications to its routes and services. Under an agreement between RTD Seattle and the Seattle Department of Transportation, RTD Seattle tours will no longer use the SR-99 Aurora Bridge. Instead, RTD Seattle tours will travel on Westlake Avenue and then cross the Fremont Bridge before entering the water portion of the tour at Lake Union.

In addition, per an agreement made with the WUTC in January 2016, all future RTD Seattle tours will include two employees: one driver/captain responsible for operation of the APV and one tour guide/deckhand responsible for tour narration and other entertainment duties.⁵³ Drivers no longer narrate tours or provide entertainment. RTD Seattle has also installed GPS tracking systems in all its vehicles to provide a real-time location, speed, and critical driving event log (with cell phone alerts) to dispatchers.

As part of its corrective action settlement with the WUTC, RTD Seattle agreed to hire a specialist to evaluate the front axle housings on its stretch APV vehicles. This specialist will provide recommendations to the company if any action is needed. RTD Seattle has stated that it will not operate the stretch APV vehicles until this evaluation is complete and any recommendations are implemented. As of September 2016, RTD Seattle had not completed this

⁵³ RTD Seattle has installed an additional seat for the tour guide, equipped with a lap-belt restraint, adjacent to the driver.

process and was not conducting any stretch APV tours. The company is continuing to conduct tours using its truck duck APVs.

Coast Guard Oversight of RTD Seattle. The Coast Guard oversees and regulates RTD Seattle's operations because part of each tour is on the navigable waters of Lake Union, Washington. This oversight is in three parts: qualification of the vessel captain and crew, APV construction and maintenance, and navigation rules underway in the navigable waterways.⁵⁴

1.6.2 Bellair Charters

Bellair Charters began operations in 2007 and is a registered for-hire inter- and intrastate motor carrier of passengers, domiciled in Ferndale, Washington, with terminal locations in Yakima and Federal Way, Washington.⁵⁵ It has a fleet of vans, minibuses, and motorcoaches in charter and regular service. As an intrastate carrier, Bellair Charters is regulated by the WUTC under permit number C001073. As an interstate carrier, the company passed the FMCSA New Entrant Program safety audit in 2008 and underwent one CR in 2013. It received a satisfactory rating. Its out-of-service rates for both driver and vehicle inspections were below the national average. Postcrash, Bellair Charters underwent a full CR conducted by the FMCSA, and it received a conditional rating.⁵⁶

1.7 Highway Factors

1.7.1 Description and Characteristics

This crash occurred in the southbound lanes of SR-99, on the Aurora Bridge, approximately 865 feet north of the bridge structure's south end, about 3 miles north-northwest of downtown Seattle. SR-99 was functionally classified as an urban principal arterial roadway. The speed limit on SR-99 was 40 mph in both directions.

Both the southbound and northbound roadways at this location consisted of three individual lanes, averaging 9.2–9.75 feet in width, marked by broken white pavement stripes and delineated by two solid yellow pavement stripes. In section 7.3.3 of its *A Policy on Geometric Design of Highways and Streets*, the American Association of State Highway and Transportation Officials (AASHTO) states that under operating conditions of interrupted flow (45 mph or less), narrower lane widths are normally adequate and have some advantages (AASHTO 2011).⁵⁷ One advantage is that, to meet capacity demands, the reduced lane widths allow more lanes to be provided in areas with restrictive right of way.

⁵⁴ See 72 COLREGS, 33 *CFR* Parts 80–90, and 46 *CFR* Parts 175–187. Coast Guard Navigation and Vessel Inspection Circular (NVIC) 1-01 outlines the construction specifications, maintenance requirements, and inspection procedures for these vehicles.

⁵⁵ The company USDOT number is 1699132.

⁵⁶ The rating was a result of critical violations of 49 *CFR* Parts 382 and 395; the violations did not involve the accident driver or vehicle.

⁵⁷ *A Policy on Geometric Design of Highways and Streets* recommends that lane widths normally be maintained between 10 and 12 feet.

Both sides of the asphalt portion of the roadway were flanked by approximately 4-foot-wide pedestrian walkways, separated from the travel lanes by a concrete traffic barrier and steel pedestrian railing. The outside edges of the sidewalks were flanked by the original pedestrian railing and a pedestrian fence.

Bridge Geometry and Traffic Volume. The bridge was a cantilever and steel underdeck truss bridge with a total length just under 2,950 feet and a center span with a length of approximately 800 feet.⁵⁸ In the collision area, the roadway had a downgrade of approximately 2.5 percent in the northbound direction. In 2014, the average daily traffic in the vicinity of the crash was 70,234 vehicles (including buses) per day.

1.7.2 Physical Evidence at Crash Site

Roadway evidence consisted of tire friction marks, as well as pavement surface scrapes and gouges indicative of pre- and postimpact vehicle movement.

Investigators found a single arced tire mark in the northbound center lane approximately 223 feet before the location of impact. The location and trajectory of the tire mark are consistent with its having been created by the left front wheel of the *DUCK 6*. The mark is indicative of the vehicle having entered the right lane and then being redirected back to the left. A single linear tire mark was documented (beginning approximately 74 feet before *DUCK 6* made contact with the motorcoach) at an angle of 15 degrees relative to the travel lanes and in line with the arced mark. The tire mark exhibited characteristics consistent with the left front wheel motion being retarded as the vehicle crossed from the northbound lanes to the southbound lanes. The tire mark ended approximately at the location of contact with the motorcoach.

1.8 Weather

Data from the weather station NW Queen Anne (KWASEATT372) in Seattle indicated that at 11:16 a.m. on September 24, 2015, the temperature was 68.9° F, the wind direction was from the south at 2.7 mph, and it was not raining.

1.9 Regulation of APVs as Motor Vehicles

1.9.1 NHTSA

NHTSA has the authority under the National Traffic and Motor Vehicle Safety Act (Safety Act, 49 *USC* 30101 *et seq.*) to regulate motor vehicle safety. In their land-based operations, APVs fall within the definition of a bus, per 49 *CFR* 571.3(b) of the *Federal Motor Vehicle Safety Standards (FMVSSs)*, as follows: “A motor vehicle with motive power, except a trailer, designed for carrying more than 10 persons.” APVs also fall within the definition of “motor vehicle,” at 49 *USC* 30102(a)(6), as follows:

⁵⁸ The George Washington Memorial Bridge was originally constructed in 1931 by the State of Washington Department of Highways and was referred to as the Lake Union Bridge. It is now commonly referred to as the Aurora Bridge.

[A] vehicle driven or drawn by mechanical power and manufactured primarily for use on the public streets, roads, and highways, but does not include a vehicle operated only on a rail line.

The term “crashworthiness” refers to the protection that a passenger motor vehicle provides its occupants against personal injury or death in a crash. NHTSA establishes test requirements to ensure the minimum level of safety or crashworthiness for various vehicle types in the *FMVSSs*.⁵⁹ According to NHTSA, not later than 30 days after the manufacturing process begins and before offering a motor vehicle for sale in the United States, the vehicle manufacturer must submit to NHTSA information on itself and the products it manufactures to the *FMVSSs* (see 49 *CFR* Part 566, “Manufacturer Identification”).⁶⁰

RTDI never registered with NHTSA as a motor vehicle manufacturer. Postcrash, NHTSA contacted RTDI to determine whether the company was a manufacturer at the time the *DUCK 6* was built. NHTSA notified the NTSB in September 2016 that the agency’s Office of Chief Counsel had determined that RTDI was a manufacturer and, as such, should have been meeting the requirements and regulations outlined in Chapter 301 of Title 49 of the *USC* and Chapter V of Title 49 of the *CFR*.⁶¹

1.9.2 State

Individual states, rather than NHTSA, are responsible for titling or registering motor vehicles and for regulating the operation of motor vehicles on US public roads. According to NHTSA, if an unregistered manufacturer name appears on vehicle certification labels or ownership documents, it may cause confusion or delays when titling and registering vehicles. In 2005, RTD Seattle registered the *DUCK 6* with the state of Washington, and the vehicle title application/registration certificate showed the vehicle make as GMC and the body as “DUKW/AMP.”

⁵⁹ Title 49, Chapter V, *CFR* Parts 523–595, set forth the *FMVSSs* and how they are applied. Which *FMVSSs* apply to a particular vehicle depends on factors including the type of vehicle, date of manufacture, and intended use of the vehicle.

⁶⁰ (a) NHTSA maintains on its website a list of manufacturers that have made Part 566 submissions. (See www.nhtsa.gov/apps/manufacturer/index.htm, accessed August 12, 2016.) (b) Among other things, NHTSA regulations at 49 *CFR* Part 565 require a motor vehicle manufacturer to assign to each motor vehicle manufactured for sale in the United States a 17-character vehicle identification number (VIN) that uniquely identifies the vehicle. The VIN has become the key identifier in data systems that track compliance with federal and state safety programs and that manage and analyze information on vehicle manufacturing processes, registrations, insurance programs, crash investigations, and safety research. Organizations that use VINs in data systems include NHTSA, manufacturers, state motor vehicle departments, law enforcement agencies, insurance companies, and motor vehicle safety researchers. (See appendix B for more information on NHTSA regulations affecting manufacturers.)

⁶¹ Manufacturers may be subject to substantial civil penalties for failure to meet the requirements of the statutes and regulations that NHTSA administers. Penalties may be as high as \$7,000 for each violation with a maximum civil penalty of \$17,350,000 for a related series of violations.

1.10 Other Relevant NTSB-Investigated APV Accidents

The NTSB has investigated several other APV crashes that have included factors of interest to the Seattle crash, including risk management in APV operations, Coast Guard guidance, and vehicle maintenance practices.

1.10.1 Crash of *PENELOPE PRU* in Boston, Massachusetts, in 2016

About 11:40 a.m. on April 30, 2016, in downtown Boston, Massachusetts, a 2013 Lance Havana Classic 50 motor scooter, ridden by a 29-year-old female operator and a male passenger, was stopped for a red signal in the outside right-turn-only lane on Charles Street at the traffic-light-controlled intersection with Beacon Street. (See figure 14.)



Figure 14. Boston Beacon Street at Charles Street intersection. (Source: Google Earth modified)

One vehicle was stopped in front of the motor scooter. Stopped behind the motor scooter was a 2009 37-passenger APV, the *PENELOPE PRU*, operated by Boston Duck Tours (BDT). The *PENELOPE PRU* was occupied by a 41-year-old male driver and 27 passengers. The *PENELOPE PRU*, a 1972 military Jeep chassis with a 32-foot steel hull, was built in 2009 by

Chance Manufacturing in Wichita, Kansas, for RTDI. RTDI later sold the vehicle to BDT. BDT is an RTDI licensee.

As well as serving as the driver of the APV vehicle during tours, BDT drivers perform the duties of a narrator and tour guide. The *PENELOPE PRU* was equipped with a video system that recorded the driver's activities during the crash tour. The video showed that while the APV was stopped at the intersection for the red traffic signal, the driver continued to speak to the passengers and point out landmarks during the stop.

When the light turned green, both the motor scooter and the truck duck accelerated from the stop bar on Charles Street and turned right (eastbound) onto Beacon Street. Beacon Street has a slight uphill slope for traffic traveling east from the intersection. The *PENELOPE PRU* accelerated onto Beacon Street at a faster rate than the scooter, and it overrode the scooter about 50 feet from the intersection. The scooter and both its riders were knocked to the pavement; the female driver was killed, and the male passenger was injured.⁶² (See figure 15.)



Figure 15. Boston crash motor scooter, showing damage.

Postcrash, the Boston Police Department conducted a visibility study using the *PENELOPE PRU* and the involved motor scooter. A driver and passenger of similar size to the female operator and male passenger were seated on the scooter, which was put in front of the truck duck. A similarly sized driver to the crash driver was put in the driver seat of the *PENELOPE PRU*. When the scooter was very close to the front of the truck duck, the scooter and its riders were not

⁶² For details about this crash, see the NTSB public docket, at www.nts.gov/investigations/SitePages/dms.aspx, and search for NTSB accident ID HWY16FH010.

visible to the driver looking directly over the front of the *PENELOPE PRU* (its bow). However, they were visible in the front-mounted mirrors on the *PENELOPE PRU*; these mirrors were curved and showed the front and bumper area of the truck duck. (See figure 16.) When the scooter was moved out ahead of the truck duck to the point the scooter was no longer visible in the mirrors, the tops of the riders' heads were visible to the *PENELOPE PRU* driver over the vehicle's bow.



Figure 16. Boston Duck Tours truck duck, the *PENELOPE PRU*.

BDT issues all its drivers a 45-page safety manual that outlines many of the duties required of its truck duck drivers. The manual includes a list of the four “most accident-prone” intersections for BDT, one of which is the intersection of Beacon and Charles Streets. (See appendix A for information on this NTSB investigation.)

1.10.2 Sinking of *MISS MAJESTIC* in Hot Springs, Arkansas, in 1999

On May 1, 1999, the *MISS MAJESTIC* (a converted 1944 DUKW amphibious vehicle) rapidly sank in 60 feet of water about 250 yards from shore in Lake Hamilton, near Hot Springs, Arkansas. Of the 21 people on board, 13 passengers, including 3 children, died. The NTSB’s investigation of this accident identified numerous safety issues, such as vehicle maintenance and

Coast Guard inspection guidance. Based on its findings, the NTSB made recommendations to the Coast Guard and the governors of New York and Wisconsin (NTSB 2002a).⁶³

The NTSB determined that the probable cause of the uncontrolled flooding and sinking of the *MISS MAJESTIC* was the failure of Land and Lakes Tours, Inc., to adequately repair and maintain the DUKW. Contributing to the sinking was a flaw in the design of DUKWs as converted for passenger service, that is, the lack of adequate reserve buoyancy that would have allowed the vehicle to remain afloat in a flooded condition. Contributing to the unsafe condition of the *MISS MAJESTIC* was the lack of adequate oversight by the Coast Guard. Contributing to the high loss of life was a continuous canopy roof that entrapped passengers within the sinking vehicle.

A Coast Guard Marine Board of Investigation also investigated the sinking, and the NTSB and the Coast Guard concurred that DUKWs have vehicle design features that make them inherently less safe than conventional small commercial passenger vessels. The Coast Guard Marine Board report recommended that the Coast Guard and the APV industry meet and develop comprehensive guidelines containing best practices on the inspection and operation of these vehicles. During a 2-day meeting held in February 2000, which was attended by owners/operators of DUKW vehicles, industry experts, and Coast Guard personnel, the foundation for the Coast Guard guidance document NVIC 1-01, *Inspection of Amphibious Passenger-Carrying Vehicles*, was developed.⁶⁴ An NVIC provides detailed guidance about the enforcement of, or compliance with, federal marine safety regulations and Coast Guard marine safety programs. NVIC 1-01 was issued in December 2000 and later incorporated into 46 *CFR* Parts 175–187. The Coast Guard uses NVIC 1-01 as its guide for approving an APV as a passenger vessel.

The NVIC 1-01 guidelines serve a number of purposes. They—

- Summarize and consolidate technical information pertaining to the design and inspection of amphibious DUKW vehicles,
- Promote uniformity in the approach to certification requirements among the various marine inspection offices, and
- Consolidate best practices currently being used in the industry.

1.10.3 Sinking of RTD Seattle *DUKW 1* in Seattle in 2001

A year after NVIC 1-01 went into effect, and while the NTSB was still investigating the *MISS MAJESTIC* accident, on December 8, 2001, another APV sinking occurred. RTD Seattle's *DUKW 1*, with an operator and 11 passengers on board, began flooding during a tour of Lake Union in Seattle. When the bilge alarm sounded repeatedly and the vehicle's Higgins pump began discharging water, the operator headed for shore, where all the passengers were transferred without injury. The local harbor patrol, not knowing that the problem was the result of a missing

⁶³ New York and Wisconsin have commercial APV operations that are not subject to Coast Guard jurisdiction; the vehicles are under state jurisdiction. Consequently, in its 2002 report, the NTSB issued recommendations directly to New York and Wisconsin.

⁶⁴ See NVIC 1-01, December 11, 2000.

4.5-inch-diameter access plug, attempted to tow the *DUKW 1* back across the lake; the *DUKW 1* sank when water continued to flood the hull through the plug opening.⁶⁵

The NTSB investigated the sinking of the *DUKW 1* and determined that the *DUKW 1* sank because of a human error that occurred during routine maintenance (NTSB 2002b). The vessel flooded because a mechanic had failed to replace the access plug, the absence of which went undiscovered during a preoperational inspection.

At that time, RTD Seattle procedures required that, before a tour was conducted, both the mechanic and the operator sign the daily maintenance checklist attesting that they had checked 55 items, including engine fluid levels, tires, brakes, driveshaft rubber boots and clamps, and hull plugs. On the day of the sinking, however, because the operator was in a hurry to pick up waiting passengers, he did not take the time to examine all the items on the safety checklist. The operator subsequently told NTSB investigators that he thought the access plug had been in place.

A review of the RTD Seattle daily maintenance checklist for the *DUKW 1* showed not only that all 55 items on the daily checklist were checked, but also that both the operator and the mechanic had attested that the items had been verified. NTSB investigators later found that the *DUKW 1* access plug was in a different RTD Seattle vehicle; thus, it had not become loose in the *DUKW 1* but had previously been removed and not replaced.

The NTSB determined that the probable cause of the flooding and sinking of the *DUKW 1* was a missing access plug, which, in turn, was caused by inadequate supervision of company personnel and inadequate management oversight of APV maintenance. Contributing to the sinking was a flaw in the design of DUKWs, that is, the lack of adequate reserve buoyancy that would have allowed the vehicle to remain afloat in a flooded condition.

1.10.4 Collision of Tugboat/Barge *Caribbean Sea/The Resource* with *DUKW 34* in Philadelphia, Pennsylvania, in 2010

On July 7, 2010, the empty 250-foot-long sludge barge *The Resource*, being towed alongside the 78.9-foot-long tugboat *Caribbean Sea*, collided with the anchored 33-foot-long APV *DUKW 34* in the Delaware River at Philadelphia, Pennsylvania. The *DUKW 34* carried 35 passengers and 2 crewmembers. The *Caribbean Sea* carried five crewmembers. As a result of the collision, the *DUKW 34* sank in about 55 feet of water. Two of its passengers died, and 26 suffered minor injuries. No one on the *Caribbean Sea* was injured (NTSB 2011).

The NTSB determined that the probable cause of this accident was the failure of the mate of the *Caribbean Sea* to maintain a proper lookout due to (1) his decision to operate the vessel from the lower wheelhouse, which was contrary to expectations and to prudent seamanship, and (2) distraction and inattentiveness as a result of his repeated personal use of his cell phone and company laptop computer while he was solely responsible for navigating the vessel. Contributing to the accident was the failure of RTDI maintenance personnel to ensure that the *DUKW 34*'s surge

⁶⁵ The access plug is located under the engine, forward of the front axle, on the centerline of the vessel. When removed, the plug provides access to the engine's oil filter and drain plug from below the hull. Before the tow, the harbor patrol asked the operator to turn off the engine and leave the *DUKW*; while the vehicle was being towed, because the engine was not operating and, in turn, the Higgins pump was not dewatering the vehicle, it sank.

tank pressure cap was securely in place before allowing the vehicle to return to passenger service on the morning of the accident, and the failure of the *DUKW 34* master to take actions appropriate to the risk of anchoring his vessel in an active navigation channel.

Based on its findings, the NTSB made recommendations to RTDI to review its existing safety management program and develop improved means to ensure that its safety and emergency procedures are understood and adhered to by employees in safety-critical positions.

2 Analysis

2.1 Introduction

On the morning of September 24, 2015, a stretch APV, the *DUCK 6*, was traveling north on the Aurora Bridge in Seattle when it departed the northbound lanes, entered the southbound lanes, and struck a motorcoach, a pickup truck, and an SUV. A fifth vehicle struck the pickup truck during the crash sequence. Five motorcoach passengers died; all were NSCC students on a tour heading to downtown Seattle. Many of the remaining motorcoach passengers, most of the *DUCK 6* passengers, and both commercial drivers were injured.

Crash sequence analysis indicates that the *DUCK 6* departed the northbound lanes and entered the oncoming southbound lanes at a 15-degree angle, crossed the left southbound lane, and collided with the motorcoach at an off-set angle of approximately 21 degrees. The NTSB determined, using the video from the motorcoach's forward-facing camera, that the speed of the *DUCK 6* was close to 39 mph at impact.⁶⁶ The NTSB also determined, from ECM and GPS data, that the motorcoach was traveling approximately 43 mph before impact.

This analysis discusses the failure of the front axle on the *DUCK 6*, which caused a loss of vehicle control and the subsequent collision with the oncoming vehicles (see section 2.2). In addition, it discusses the following safety issues:

- Failure by an unregistered vehicle manufacturer to properly remedy a defective safety-related motor vehicle part under the federal recall process (sections 2.2 and 2.3),
- Lack of adequate oversight of APV maintenance and failure to conduct effective safety repairs as recommended in service bulletins (section 2.3),
- Lack of adequate occupant protection in APVs used in commercial passenger tours (section 2.4), and
- Risk management in APV operations (section 2.6).

As a result of its investigation, the NTSB determined that the following factors did not contribute to the cause of the crash:

- ***Driver licensing, experience, substance impairment, fatigue, and distraction:*** No evidence was found to indicate that either driver made driving errors that contributed to the crash. Additionally, the *DUCK 6* and motorcoach drivers held current CDLs with appropriate endorsements. They were both experienced drivers with no notable crash or violation histories. Both drivers' postcrash toxicology test results were negative, and their work/rest histories for before the crash indicated adequate time for rest. The drivers were not using their cell phones nor were they distracted by external factors at the time of the crash.

⁶⁶ The actual speed of the *DUCK 6* before the crash was most likely higher than 39 mph, given that the physical evidence indicates the stretch APV was retarded during the immediate crash sequence by the damage to the left front wheel and the driver's braking before impact.

- **Highway or bridge factors:** No highway- or bridge-related issues were found. As is the case with many bridges, the lanes on the Aurora Bridge were narrower than on other portions of SR-99. Although RTD Seattle might have chosen another route for its APV tours than the Aurora Bridge (and did so following the crash), per AASHTO guidance, in operating conditions of 45 mph or less, narrower lane widths are normally adequate.⁶⁷
- **Motorcoach motor carrier operations:** The FMCSA and Washington State rated Bellair Charters as a satisfactory motor carrier before the crash, and its out-of-service rates were well below the national average for both drivers and vehicles.
- **Mechanical condition of non-APV vehicles:** NTSB investigators examined the motorcoach, Toyota Highlander and Tundra, and Ram pickup truck and found no preexisting mechanical conditions that could have contributed to the circumstances of the crash.
- **Weather:** The weather was clear, and there was no precipitation at the time of the crash. The crash occurred during daylight.

The NTSB, therefore, concludes that none of the following were factors in the crash: (1) *DUCK 6* or motorcoach driver performance; (2) highway or bridge factors; (3) motorcoach motor carrier operations; (4) motorcoach or passenger car mechanical condition; or (5) weather conditions.

Sufficient response resources were allocated to the crash, and first responders were arriving on scene within 4 minutes of the event. The NTSB therefore concludes that the emergency response to the crash was timely and effective.

2.2 *DUCK 6* Front Axle Failure

Postcrash, the left front axle housing on the *DUCK 6* was found to be fractured in the tapered area adjacent to the knuckle ball. The fracture surface of the separated knuckle had visible progressive crack arrest marks and ratchet marks consistent with fatigue cracking, as well as numerous very fine ratchet marks and striations consistent with diffuse-origin fatigue crack initiation. This fatigue cracking initiated at axle housing machining marks in the tapered area; these machining marks may have been created during the original process of producing the axle housing.⁶⁸

The growth of the fatigue cracking over time reduced the load-carrying capacity of the axle housing; once the fatigue cracking reached a critical size, a complete fracture through the axle housing resulted.⁶⁹ After the fracture occurred, the axle housing contacted the top of the rotating axle shaft, which caused significant frictional heat buildup that weakened the axle shaft metal. This

⁶⁷ The speed limit on the Aurora Bridge was 40 mph in both directions.

⁶⁸ Similar machining lines of varying depth and consistency were found during an inspection of the *DUCK 6*'s right front axle housing and multiple spare axle housings in the RTD Seattle stretch APV inventory.

⁶⁹ The fracturing was due to cyclic loading of tensile stress on the outer diameter of the knuckle at the 6 o'clock position, most likely resulting from the bending stress on the axle during vehicle operation.

process ultimately caused a torsional fracture through the axle shaft while the *DUCK 6* was traveling northbound on the Aurora Bridge. The NTSB concludes that the left front axle housing on the *DUCK 6* failed due to multiple initiation fatigue cracking.

Examination and testing also indicated deficiencies in the welding in the failure area. The outboard weld on the tab spanning the tapered area of the left axle housing was separated from the knuckle, and parts of this weld showed lack of fusion and lack of penetration. Some areas of the welds on the right side of the axle housing also showed lack of fusion and lack of penetration. The short portion of the outboard weld that had fused to the knuckle was cracked to a degree that the tab was not attached on the outboard side. A remnant of the weld still attached to the separated left knuckle showed similar cracking.

NTSB investigators used finite element modeling to examine local stresses in the axle housing assembly that fractured during the accident. The original axle housing, as well as the modified versions with welded tabs, were studied. The results of the modeling showed that a stress concentration developed in the transition region of the unmodified axle housing when loaded. The position of this stress concentration corresponded to the position of the fatigue crack that caused the separation of the axle housing in the *DUCK 6* crash.

Investigators observed that the tab modification had been installed with welds that exhibited lack of fusion and lack of penetration. Modeling this weld condition showed that a high local tensile stress developed at both the inboard and outboard weld interfaces due to the lack of fusion and lack of penetration. Such local tensile stress has the tendency to open up (crack) the weld interface. The stress concentration and the poor weld most likely led to a fracture through the welded interface, removing any reinforcement provided by the tab, leading to the high stress concentration in the transition region observed in the case without a stiffening tab. The NTSB concludes that the 2004 tab modification was flawed due to inadequate stiffness to eliminate the stress concentration in the transition region and because of poor weld quality, specifically, the lack of fusion and lack of penetration; moreover, it is likely that the weld of the tab fractured before the axle housing fractured.

Once the axle housing and axle shaft fractured, the fractured left side of the axle housing separated from the vehicle, and the wheel assembly was torn away from steering components, including the drag link and steering arm. This development made it impossible for the *DUCK 6* driver to steer effectively.

When the wheel assembly detached, the hydraulic fluid line for the disc brake broke away from the left front brake caliper, draining the front reservoir of the master cylinder, causing a loss of front braking capability. Although rear-only braking may have been available just before the collision, in the limited time available, the overall vehicle braking performance could not have slowed the vehicle enough to prevent the collision.⁷⁰

In his statement to investigators, the driver of the *DUCK 6* said that the vehicle “went clunk, clunk” and made a sudden uncommanded drift to the right. He said the steering felt loose.

⁷⁰ Based on a video study performed by the NTSB, the *DUCK 6* struck the motorcoach within approximately 2.5 seconds from when the *DUCK 6* started to deviate from its northbound lane of travel.

The *DUCK 6* then veered to the left before colliding with the motorcoach. During this movement, the driver attempted to regain steering control of the vehicle but could not. He also applied the brakes heavily. As described above, the NTSB's examination of the *DUCK 6* revealed a mechanical failure that would have resulted in loss of steering control and braking. The driver could not have regained control of the *DUCK 6* once the axle fracture occurred, due to the loss of steering and braking capability. The NTSB concludes that the mechanical failure of the *DUCK 6*'s axle housing resulted in a loss of steering and vehicle control; the failure also resulted in a loss of front braking and an overall reduced braking capability, which contributed to the severity of this collision.

2.3 Front Axle Defects on RTDI Stretch APVs

RTDI, the manufacturer of the stretch APVs operated by RTD Seattle, provided the carrier with a vehicle manual that detailed the service procedures and replacement parts required to service RTD Seattle's 10 stretch APVs. RTD Seattle also maintained a binder of service bulletins issued by RTDI. At the time of the crash, RTD Seattle employed 13 mechanics to conduct maintenance of its APV fleet.

2.3.1 RTDI 2004 Tab Modification to Strengthen the Front Axle Assembly

The *DUCK 6* was manufactured in 2005 with a tab in place at the bottom of its axle housing to stiffen the axle housing's tapered area. RTDI had determined in 2004 that this modification to its stretch APVs was necessary, after axle fracture events occurred on other RTDI stretch APVs manufactured before 2004. However, postcrash inspection of three additional RTDI stretch APVs operated by RTD Seattle showed that there were cracks in four of the six tab modification welds on these three vehicles, as well as inconsistent tab placement, indicating problems with the implementation of the 2004 modification.

With respect to the *DUCK 6* and three other RTD Seattle stretch APVs, the 2004 modification did not prevent tab weld cracks from initiating. The welds attaching the tabs showed inadequate joint penetration as well as incomplete fusion. The fracture occurred at the root of the tab weld to the knuckle, and the tabs most likely provided no long-term benefit in translating forces applied to the axle housing assembly across the knuckle. This modification, regardless of weld quality, is not a well-designed approach for two reasons: (1) the tab plate does not provide sufficient stiffness to fully relieve the local stresses in the transition region and (2) the shape of the plate makes a high-quality weld difficult to achieve and could introduce high local stresses at the weld interfaces.

Finite element modeling, supported by NTSB laboratory examination, indicated that the tab modification on the *DUCK 6* most likely fractured due to poor welding. Moreover, the modeling indicated that the tab would have provided insufficient stiffening even if it had been welded properly.

The NTSB examination and modeling of the failed axle housing showed fatigue cracking that initiated in the location of highest stress and propagated over a prolonged period of use. The high-stress location was inherent to the design of the knuckle used by RTDI in its manufacturing of the stretch APVs. The presence of machining marks that acted as stress risers also contributed

to the failure. Neither of these two original design problems was properly addressed by the RTDI 2004 modification. Consequently, the NTSB concludes that the 2004 modification that RTDI made to the axle housings on its stretch APVs was poorly executed and provided no long-term benefit in preventing future axle failures. Instead of being recalled for equipment replacement, the RTDI stretch APVs with these inadequately modified axle housings remained in use.

2.3.2 RTDI 2013 Service Bulletin on Modification to Avoid Axle Fractures

Although RTD Seattle documented consistent, ongoing maintenance for its APV fleet, the NTSB found that the work detailed in many of the RTDI bulletins had not been completed. In fact, of the 74 service and maintenance bulletins issued by RTDI, RTD Seattle filed only 15 as completed, which reflects about a 20 percent completion rate. In particular, RTD Seattle did not complete the work recommended in RTDI service bulletin SB-00-14-13, which concerned a repair modification intended to avoid axle fractures. By not acting on SB-00-14-13, RTD Seattle left vehicles unrepaired and operating for over 18 months with a known safety defect that could result in axle failure.

When interviewed by NTSB investigators after the 2015 crash, some RTD Seattle mechanics reported that they had never seen the 2013 service bulletin SB-00-14-13. They also said they were unaware of its content, although the bulletin was in the RTD Seattle maintenance binder. When responding to WUTC postcrash inquiries, RTD Seattle maintenance personnel said that, during pretrip inspections, they had visually checked the front wheels of the stretch APVs for vertical canting, but they took no other action to implement the bulletin in the nearly 2 years preceding the crash. Inspection might have been an appropriate temporary precaution, but it did not address the underlying problem in the long term. This is not the first time the NTSB has investigated RTD Seattle and found its maintenance practices to be directly linked to an accident.

The NTSB determined that an RTD Seattle vessel, the *DUKW 1*, sank in Lake Union on December 8, 2001, because of a human error that occurred during routine maintenance when a mechanic had failed to replace an access plug. The plug's absence then went undiscovered during a pre-operation inspection. In that case, the NTSB identified inadequate supervision of company personnel and inadequate management oversight of APV maintenance as the probable cause of the *DUKW 1* flooding and subsequent sinking (NTSB 2002b). With respect to the 2015 Seattle crash, the NTSB has again found inadequate management oversight of maintenance of an RTD Seattle APV. The NTSB concludes that RTD Seattle did not have adequate protocols in place to verify that the work specified in service bulletins from RTDI was completed, even though the company knew that the bulletins addressed work important to the safety of its stretch APV fleet.

Although it is unknown whether implementation of SB-00-14-13 would have prevented the *DUCK 6* axle failure, no commercial passenger carrier should ignore service bulletins, especially those that have an implementation deadline and safety implications. The NTSB concludes that RTD Seattle's lack of procedures to ensure that work called for in the manufacturer's service bulletins was performed on its stretch APV fleet resulted in a failure to address the known risk of axle failure. The NTSB recommends that RTD Seattle add to its 250-hour and annual inspection processes a procedure to verify that all actions indicated in service bulletins have been completed on all inspected vehicles.

Per the license agreement between RTDI and RTD Seattle, RTDI could not conduct compliance inspections concerning its service bulletins. In this case, however, even if RTD Seattle had completed the work necessary to comply with SB-00-14-13 (installation of the 2013 modification), visual inspection of the weak point in the axle design and identification of an initial fatigue crack would not have been possible during any subsequent safety inspection, such as the annual inspection, because the 2013 modification covered the tapered area.

Evidence, both from RTDI's own subsequent experience with fractured axle housings and the NTSB's postcrash examination of the 2004 modification on the *DUCK 6* and other RTD Seattle stretch APVs, indicate that the modification was not fully effective. Moreover, there is no engineering evidence that the 2013 modification would have prevented failure of the front axle housing on stretch APVs, such as the one experienced by the *DUCK 6*. RTDI failed to perform engineering analyses to determine the effectiveness of either the 2004 or 2013 modification intended to address a known axle failure risk. Therefore, the NTSB concludes that RTDI did not adequately remedy the front axle fractures on the stretch APVs it manufactured, which led to the axle housing failure that caused the *DUCK 6* crash.

To address this continuing problem, the NTSB recommends that RTDI develop a thoroughly verified and tested repair or alternative axle housing for the front axles of its stretch APVs, and repair or replace the axle housings on its own stretch APVs as necessary (Safety Recommendation H-16-20). To ensure that RTDI APV operators are aware of this development, the NTSB further recommends that RTDI communicate the repair or replacement information concerning the front axle housings of its stretch APVs, developed in response to Safety Recommendation H-16-20, to its franchisees and licensees. In addition, the NTSB recommends that RTDI instruct its franchisees and licensees to immediately halt operation of their stretch APVs and not resume operations until they complete the axle housing repair or replacement process developed in response to Safety Recommendation H-16-20.

2.3.3 RTDI as a Motor Vehicle Manufacturer

RTDI also needs to begin fulfilling its responsibilities as a motor vehicle manufacturer. Although it built vehicles that transport large numbers of passengers on US highways, RTDI did not identify itself to NHTSA as a manufacturer of motor vehicles, as required by federal law. (See appendix B.) Under authority of the National Traffic and Motor Vehicle Safety Act of 1966, NHTSA requires that manufacturers and companies that participate in finalizing vehicles for use on US roads identify themselves (49 *CFR* Part 566) through reporting that is governed by 49 *CFR* Parts 551–574.⁷¹

One reason for requiring such registration is NHTSA's notification and remedy process, commonly referred to as a "safety recall campaign" or more simply a "recall." A recall is issued when a manufacturer or NHTSA determines that a vehicle, equipment, car seat, or tire creates an unreasonable safety risk or fails to meet minimum safety standards. Manufacturers are required to

⁷¹ The Vehicle Safety Act was enacted to reduce traffic crashes and deaths and injuries resulting from traffic crashes and requires that motor vehicles and regulated items of motor vehicle equipment manufactured for sale in the United States be certified to comply with all applicable *FMVSSs*. NHTSA issues and enforces the *FMVSSs* that apply to motor vehicles and certain items of motor vehicle equipment. (See 49 *USC* 30111 and 30115.)

fix the problem by repairing it, replacing it, offering a refund, or in rare cases, repurchasing the vehicle.⁷²

Manufacturers have a duty to notify NHTSA if they learn the vehicle contains a defect and they decide, in good faith, that the defect is related to motor vehicle safety (49 *USC* 30118(c)). The manufacturer must notify NHTSA within 5 working days after determining the existence of a safety-related defect (49 *CFR* 573.6). Alternatively, NHTSA may determine the existence of safety-related defect in a particular motor vehicle and order the responsible manufacturer to recall the product.⁷³ NHTSA monitors the program to ensure successful completion of recalls.

In September 2016, NHTSA's Office of Chief Counsel determined that RTDI is a manufacturer and should have been meeting the requirements and regulations outlined in Chapter 301 of 49 *USC* and 49 *CFR*. The NTSB agrees with NHTSA's position. Therefore, the NTSB concludes that, as a vehicle manufacturer under the National Traffic and Motor Vehicle Safety Act of 1966, RTDI should be registered as a vehicle manufacturer with NHTSA to address any safety defects through the recall program. The NTSB recommends that NHTSA require that RTDI, as a manufacturer, issue a recall for the stretch APV front axle safety defect to provide owners a remedy as required under the Safety Recall Campaign.

Under NHTSA requirements, final-stage manufacturers must also affix to the manufactured vehicle a label that identifies the manufacturer and provides, among other items, the vehicle's GVWR and vehicle-type classification (such as a bus). An RTDI label on a stretch APV would also have been required to state the following: "*This vehicle conforms to all applicable Federal Motor Vehicle Safety Standards, in effect in (month, year).*"⁷⁴ RTDI did not put such a label on the *DUCK 6* or the other stretch APVs that it manufactured.⁷⁵

NHTSA does not approve or endorse any vehicle classification before the manufacturer itself has classified a particular vehicle. NHTSA may reexamine the manufacturer's classification during the course of an enforcement action.⁷⁶ Consequently, because RTDI did not identify itself to NHTSA as a manufacturer and so did not notify NHTSA of the classification of the vehicles that it would manufacture, no definitive information is immediately available about the GVWRs, vehicle-type classifications, or *FMVSSs* compliance of the stretch APVs that RTDI produced. The lack of this basic information complicates discussions on the safety regulation of stretch APVs as highway vehicles, including their compliance with occupant protection regulations.

⁷² See vinrcl.safercar.gov/vin/faq.jsp, accessed August 21, 2016.

⁷³ See 49 *USC* 30118(b). The *United States Code for Motor Vehicle Safety* (Title 49, Chapter 301) defines motor vehicle safety as "the performance of a motor vehicle or motor vehicle equipment in a way that protects the public against unreasonable risk of accidents occurring because of the design, construction, or performance of a motor vehicle, and against unreasonable risk of death or injury in an accident, and includes nonoperational safety of a motor vehicle." A defect is "any defect in performance, construction, a component, or material of a motor vehicle" (49 *USC* 30102(a)(3)).

⁷⁴ See 49 *CFR* 567.5(d).

⁷⁵ RTDI did not provide a GVWR as required, but it did provide information on the vehicle weight in technical data to RTD Seattle.

⁷⁶ See isearch.nhtsa.gov/files/21069.ogm.html, accessed September 8, 2016.

2.4 APV Occupant Protection

Sixteen *DUCK 6* passengers were seriously injured and 11 passengers were ejected before the stretch APV came to final rest in this crash. Because of the large window portals and lack of occupant restraints, *DUCK 6* passengers sustained serious injuries and experienced ejections in the crash, even though the *DUCK 6* itself sustained relatively little crash-related damage.⁷⁷ The NTSB has addressed occupant injury and ejection from commercial passenger vehicles, such as traditional-style buses and motorcoaches, for over 30 years. (See appendix D for more information on NTSB's history of recommendations in this area.)

APVs are unusual vehicles in that they operate both in highway and marine environments. Because they typically are involved in passenger-carrying operations, it is particularly important that this special category of vehicle adhere to the safety requirements of both highway and marine modes. To date, only the Coast Guard has issued federal safety regulations aimed specifically at APVs. However, the Coast Guard regulations focus on the marine operations of these hybrid vessel/vehicles, not on safety standards to prevent highway crash-related injury, such as the *FMVSSs* for motor vehicles.

As high-capacity commercial passenger vehicles operating on public roads, APVs should be required to meet applicable *FMVSSs*. NHTSA regulations indicate that APVs should be required to adhere to these safety standards. Per 49 *CFR* 390.5, APVs, including the *DUCK 6*, meet the definition of a commercial motor vehicle (CMV) because they are designed and used to transport more than 15 passengers and have GVWRs greater than 10,000 pounds. In addition, 49 *CFR* 571.3(b) defines a "bus" as "A motor vehicle with motive power, except a trailer, designed for carrying more than 10 persons." Again, APVs fall within this vehicle category. Title 49 *CFR* 393.93 requires that buses manufactured on or after January 1, 1971, conform to NHTSA's *FMVSS* 207 ("Seating systems"), and buses manufactured on or after January 1, 1972, conform to *FMVSS* 208 ("Occupant crash protection") and 210 ("Seat belt assembly anchorages"). Despite these requirements, however, APVs like the *DUCK 6* often do not meet the *FMVSSs*, including those for occupant protection.

Recently, NHTSA issued a final rule that amends *FMVSS* 208, "Occupant crash protection" (49 *CFR* 571.208), and defines a specific type of bus, a body-on-frame bus with a GVWR greater than 10,000 pounds, as an "other than over-the-road bus" (78 *Federal Register* 70416 [November 25, 2013]). This category of bus may be referred to as a non-over-the-road bus (non-OTRB). Again, APVs fall within this regulatory classification. The final rule on occupant crash protection, which goes into effect on November 28, 2016, requires that all over-the-road buses (OTRB) and non-OTRBs weighing more than 26,000 pounds GVWR be equipped with lap/shoulder belts at the driver and all passenger seating positions.⁷⁸

⁷⁷ A portal is an opening that could permit partial or complete ejection of an occupant from the vehicle in the event of a crash.

⁷⁸ For buses other than OTRBs, the final rule requires a lap/shoulder belt at all passenger seating positions on new buses with GVWRs greater than 26,000 pounds, except for certain excluded bus types.

Neither the *DUCK 6* nor any vehicle in the RTD Seattle APV fleet was equipped with passenger seat belts.⁷⁹ Seat belts can prevent drivers and passengers from being thrown from their seats and ejected from the passenger compartment during a crash; they also mitigate injury-causing forces. Occupants not wearing seat belts are 30 times more likely to be ejected from a vehicle than those who are belted (NHTSA 2009). According to 2013 data on fatal crashes, 79 percent of passenger vehicle occupants who were totally ejected from vehicles were killed. Seat belts are effective in preventing total ejections; in 2013, only 1 percent of occupants reported to have been using restraints were totally ejected, compared with 31 percent of unrestrained occupants (NHTSA 2015).

Most of the seats on the *DUCK 6* failed (were deformed and bent forward) as a result of the crash. RTDI indicated that its APVs were built with seating of a school bus type. However, the level of occupant protection provided to the *DUCK 6* passengers, who were both unrestrained and in poorly designed seats—including one seat row secured by a toggle clamp that failed in the crash—was inferior to that provided by *FMVSSs*-compliant school bus seats. The fact that the *DUCK 6* sustained only minimal vehicle damage, while its occupants experienced high rates of ejection and injury, indicates that occupant protection on APVs during land operations is a significant problem. The NTSB concludes that the failure of the majority of seats in the *DUCK 6* and the lack of occupant protections, such as effective seat design and seat belts, contributed to passenger ejections and injury.

According to RTDI, about 100 of its APVs operate in 8 different US cities, providing 1.5 million people excursions on 50,000 tours annually.⁸⁰ In addition, there are at least 20 other APV operators of both new and vintage World War II-era APVs throughout the United States. The Passenger Vessel Association (PVA) estimates that more than 140 fleet, truck, and stretch APVs operate in the United States.⁸¹ Given these numbers of APVs serving as high-occupancy passenger vehicles on public highways, the NTSB is concerned about passenger occupant protection in the event of a crash.

The occupants of the *DUCK 6* were largely unprotected when the crash occurred. However, the effects of the crash on these occupants could have been more severe, given that the *DUCK 6* was traveling only about 40 mph when the crash took place. The crash outcome likely would have been worse at the *DUCK 6*'s maximum speed of 55 mph. For the land portion of any APV tour, well-designed occupant protection systems are critical to keep occupants from being ejected, from striking injury-causing interior materials, and from being affected by high applied crash forces. Such systems for CMVs are defined in the *FMVSSs*. The NTSB concludes that the crashworthiness of APVs would be improved by requiring such vehicles to meet existing, applicable sections of the *FMVSSs* for buses.

⁷⁹ The FMCSA interpretation for 49 *CFR* 393.93, “Seats, seat belt assemblies, and seat belt assembly anchorages,” states that if a CMV, other than a motorcoach, is equipped with a passenger seat, a seat belt is required for the passenger seat. (See www.fmcsa.dot.gov/regulations/title49/section/393.93?guidance, accessed September 27, 2016.)

⁸⁰ See ridetheducks.com/, accessed August 4, 2016.

⁸¹ See www.passengervessel.com/SitePages/maritrends.html, accessed August 12, 2016.

The NTSB has recommended passenger restraint systems in motorcoaches and certain buses, and NHTSA has recognized the benefits of such systems. When NHTSA issued its rulemaking to amend FMVSS 208 on occupant protection, the NTSB objected to the arbitrary weight threshold of 26,000 pounds for non-OTRBs for providing passengers with vital occupant protections, such as seat belts. Nevertheless, APVs like the *DUCK 6* should be considered to meet this weight threshold.

As has been noted, stretch APVs like the *DUCK 6* that were built by RTDI do not have an easily identifiable GVWR, because they do not carry a manufacturer's label identifying their GVWR.⁸² Under NHTSA's certification regulation (49 *CFR* Part 567), a highway vehicle's GVWR "shall not be less than the sum of the unloaded vehicle weight, rated cargo load, and 150 pounds times the number of the vehicle's designated seating positions."⁸³ For most vehicles, NHTSA uses an AAWPP of 150 pounds, which is based on data from the 1960s. By contrast, the Coast Guard updated its AAWPP for calculating vessel stability weight to 185 pounds in 2011, based on new, and more realistic, average weight data for Americans. The difference in the AAWPP used by the two federal agencies is particularly important because of the 26,000-pound weight threshold that NHTSA chose to use in its occupant protection rulemaking.

Using NHTSA's outdated AAWPP of 150 pounds to calculate the APV's gross weight would result in a total under 26,000 pounds; on this basis, the *DUCK 6* and similar APVs would not be required to meet certain highway occupant protection standards. Yet the same vehicle would not only have a registered Coast Guard stability weight higher than 26,000 pounds, but it would also have a higher GVWR, if calculated using the Coast Guard AAWPP for the land portion of the tour. Obviously, the same vehicle should be considered to have the same weight, whether on the road or in the water.

Using an accurate weight is vital to vehicle safety. Underestimating vehicle weights (such as by using low passenger weight estimations for a fully loaded condition) can result in the vehicle being overweight on one or all axles, causing an unsafe center of gravity. If the actual vehicle weight is heavier than its design-assumed weight, important component parts (for example, tires, steering, or brakes) may be undersized, inappropriate, or put under excess stress. Underestimating weight can also place passengers at risk in situations involving emergency vehicle handling, causing the vehicle to be sluggish in response to steering inputs or slow to brake. The Coast Guard's 2011 AAWPP of 185 pounds is a more realistic and recent figure than the AAWPP of 150 pounds that NHTSA adopted decades ago. The NTSB concludes that to ensure the consistent and uniform application of federal safety requirements, the Coast Guard's AAWPP should be used when calculating gross vehicle weights for APVs. The NTSB recommends that NHTSA adopt the Coast Guard's AAWPP and amend the certification regulation in 49 *CFR* Part 567 to specify that the GVWR for an APV "shall not be less than the sum of the unloaded vehicle weight, the rated cargo load, and 185 pounds times the vehicle's number of designated seating positions."

Using the Coast Guard standard of 185 pounds AAWPP for occupants of passenger vessels, the *DUCK 6* had a gross vehicle weight of 26,710 pounds. This weight is above the

⁸² Per 49 *CFR* 571.3, a GVWR is the value specified by the manufacturer as the loaded weight of a single vehicle, including driver, passengers, and cargo.

⁸³ For school buses, NHTSA uses a weight of 120 pounds per passenger.

26,000-pound threshold for NHTSA's occupant protection requirements. The NTSB concludes that because APVs are high-occupancy passenger vehicles operating on public roads, NHTSA should take action to provide occupant protection to their passengers. Therefore, the NTSB recommends that NHTSA classify all APVs as non-OTRBs and, under the authority of the National Traffic and Motor Vehicle Safety Act of 1966, make newly manufactured APVs subject to applicable *FMVSSs* in effect at the time of manufacture.

Some APVs being used in land and water tours in other countries are equipped with restraints. For example, Viking Splash Ducks in Dublin, Ireland, operates DUKWs with seat belts provided for all passengers.⁸⁴ This operator's drivers ask their passengers to wear their available lap belts at all times while the vehicle is on the road but to unbuckle the belts and put on their life preservers before beginning the water portion of the excursion. Other newly built APVs, called "amphicoaches," physically resemble motorcoaches and can seat up to 50 passengers; they can be equipped with seat belts, if requested.⁸⁵

The NTSB recognizes that because of the unique hybrid operating nature of APVs, installing occupant protections suitable for the highway environment could negatively affect safety when the vehicle is in the marine environment. In an emergency that occurs on the water, such as a sinking, passengers would have to quickly extricate themselves from any restraints to avoid being pulled down with the vessel. The NTSB concludes that although installing seat belts in APVs would most likely reduce ejections and injuries in crashes that occur on land, seat belts could pose egress problems during emergencies on water.

Consequently, any developments concerning APV restraint systems and seating in general should reflect a design appropriate for both operating environments of this hybrid type of passenger vehicle. As far as possible, any equipment installed to provide land-based occupant protection should not pose new dangers in a water-borne vessel emergency. Communication with passengers about the occupant protection systems will be vital. In particular, passengers must be informed of the possible risks posed by highway seat belts in a water evacuation. To address issues associated with passenger egress in a marine emergency, the NTSB recommends that the Coast Guard amend NVIC 1-01 to ensure that (1) APV operators tell passengers that seat belts must not be worn while the vessel/vehicle is operated in the water and (2) before the APV enters the water or departs the dock, the master or other crewmember visually checks that each passenger has unbuckled his or her seat belt.

2.5 Motorcoach Occupant Protection

The severe intrusion by the *DUCK 6* into the motorcoach's interior and the associated damage compromised survival space and opened a path for passenger ejection. The motorcoach's interior damage correlated with the exterior damage down its driver side. Emergency responders found some fatally and seriously injured passengers trapped in the intrusion area, in the interior compartment wreckage, or partially ejected. Several injured passengers seated on both the impact

⁸⁴ See the Viking Splash Ducks website at vikingsplash.com/health-safety/, accessed September 9, 2016.

⁸⁵ The manufacturer of amphicoaches is Ultimate Technology Ltd. of Malta. (See www.amphicoach.net/, accessed September 9, 2016.)

(driver) side and passenger side of the motorcoach (in rows 1 and 2) reported being partially or fully ejected through the front windshield and loading door.

Motorcoach occupants seated on the driver side of the motorcoach were in proximity to the window and sidewall intrusion by the *DUCK 6*'s pointed bow during the accident sequence. These occupants were also vulnerable to ejection when window and sidewall integrity was lost. Passengers who sustained minor-to-no reported injuries were either seated in the last rows of the motorcoach or on the passenger side, areas not compromised by intrusion. Therefore, the NTSB concludes that survival space was compromised for motorcoach passengers in the path of the *DUCK 6*, as it traversed the motorcoach interior upward to the roofline and for almost the entire length of the vehicle.

Three-point seat belts might have mitigated injuries to those seated outside of the intrusion area or who were thrown from their seats or ejected from the motorcoach; however, the 2009 motorcoach was not equipped with passenger restraints. Beginning in November 2016, newly built motorcoaches will be required to have passenger restraints. Given the circumstances of the intrusion by the APV, in this case, the lack of such seat belts was not a major factor in the crash. The NTSB concludes that, for those in the intrusion area, the bow of the *DUCK 6* striking the side of the motorcoach at close to 40 mph caused catastrophic intrusion damage and severe injuries that additional motorcoach sidewall protections and seat belts most likely would not have prevented.

2.6 Managing APV Operational Risks

Although some of the issues discussed in this section are not directly applicable to the circumstances of the Seattle crash, the NTSB believes that they are of particular importance to the safe operation of APVs. APVs are vehicles that pose special operational challenges because, among other distinctions, they have an unusual vehicle profile, they function in two transport environments, and they often involve tourist service activities as well as transportation.

Driver distraction is a significant risk in such complex operations. Wherever the APV industry finds that driver distraction can be eliminated, reduced, or mitigated, companies should do so. In fact, although driver distraction did not factor into the Seattle crash, following the September 24, 2015, event, RTD Seattle recognized that requiring its APV drivers also to conduct the tour posed an unacceptable distraction risk. Per its agreement with the WUTC, the company now employs a tour guide to conduct each tour.

2.6.1 Driver Distraction

In the case of the April 2016 crash in Boston, Massachusetts, when a truck duck operated by BDT struck a motor scooter, driver distraction may have played a role. In the BDT operation, the APV drivers also served as narrators and tour guides. Immediately before the BDT driver struck the motor scooter, as both vehicles were stopped at a busy intersection in downtown Boston and then turned onto another street, the driver was speaking to passengers and indicating points of interest. These activities may have distracted the driver's attention so that he did not retain sufficient awareness of the traffic around his APV, including the small and difficult-to-see motor scooter. Distraction also could have caused him to fail to consult the curved mirrors on the front of his vehicle, which might have made the motor scooter's position clearer.

APV drivers/captains who are expected to provide tour narration while driving are particularly prone to the risk of distraction. They are frequently responsible not only for moving large commercial vehicles through urban environments and busy waterways, but also for simultaneously entertaining the vehicle passengers. These incongruous tasks can compete for drivers' mental and physical resources and strain their capacities to operate their vehicles safely. The NTSB has found that a driver's ability to operate a vehicle safely is hampered by the addition of secondary duties not related to the primary driving task.

Distraction may be considered anything that diverts the driver's attention from the primary tasks of operating the vehicle and responding to critical events. In the highway environment, NHTSA has taken the position that a distraction is anything that takes the driver's eyes off the road (visual distraction), mind off the road (cognitive distraction), or hands off the wheel (manual distraction).⁸⁶ Any APV driver who, like the RTD Seattle and BDT drivers, also narrates the tours for passengers, may be engaging in all three of these distractions when performing the duties of a tour guide.

The first step toward removing deadly distractions is to disconnect the driver from non-mission-critical information. For decades, the aviation industry has recognized the need for "sterile cockpit" procedures to restrict pilot activities and conversation to the task at hand. (See for example, 14 *CFR* 121.542 and 135.100.) A few APV operators, such as RTD Seattle, have added a tour guide to each excursion to assume the duties of tour narration and passenger interaction. This permits the driver to focus on the safety-critical task of operating the vehicle. The NTSB concludes that by adding a tour guide to each APV on every excursion, RTD Seattle has reduced the risk of driver distraction in its operations.

2.6.2 Other Operational Risk Factors

Another operational element that can affect risk in transportation is route selection. Although the NTSB did not find that the tour route RTD Seattle used contributed to this crash, RTD Seattle reexamined its route selection after the crash and subsequently altered its excursion course to avoid the Aurora Bridge. Such risk assessment and management is vital to safer APV operations and should take place before, not after, a crash occurs. Because of their entertainment nature, APV tours often operate in high-density urban areas, and APV tour companies must weigh safety against sightseeing value in selecting an appropriate route.

In addition, APVs are large vehicles that may have issues concerning the driver's limited field of vision with respect to surrounding traffic. They also have unusual profiles and are less maneuverable than many other vehicles. Consequently, operating them in areas of high speed, traffic, and challenging roadway characteristics may pose problems. Risk assessment of APV operations should include such considerations.

Hazard mitigation and management entail a company's assessing all operational risk factors. In transportation, these factors must include possible driver distraction, route planning, vehicle characteristics, traffic density, and vehicle speed. APV operations, which include many complexities due to their hybrid highway and marine nature, must take risk management especially

⁸⁶ See www.nhtsa.gov/Research/Crash+Avoidance/Distractio, accessed August 29, 2016.

seriously. The NTSB concludes that, given the recent Seattle and Boston APV crashes, which resulted in multiple deaths and numerous injuries, the APV industry should develop and implement risk management practices geared to the special needs of APV operations. Therefore, the NTSB recommends that the Coast Guard distribute a safety alert on APV operations that addresses the role of risk assessment to mitigate driver distraction, as well as the need to tell passengers to remove seat belts before waterborne operations begin.

The NTSB has issued its own safety alert on these topics. (See appendix E.)

The PVA is the national trade association for US-flag passenger vessels of all types, including APVs.⁸⁷ The PVA, working with the Coast Guard, has developed the *PVA Risk Guide*, which provides passenger vessel owners and operators with procedures for assessing risk in their operations and helps them to develop ways to reduce or eliminate those risks. US ferry operators, which conduct marine vessel activities that have some parallels to APV operations, use PVA guidance materials in their risk management efforts.

Therefore, the NTSB further recommends that the PVA notify all its APV operator members of the importance of the following: (1) learning the lessons from the Seattle, Washington, and Boston, Massachusetts, crashes; (2) completing proper maintenance and service bulletin repairs; (3) using the pretrip safety orientation to tell passengers of APVs equipped with passenger seat belts to unbuckle their belts before the APV begins any marine operations; (4) conducting a visual inspection to ensure that passengers have unbuckled their seat belts prior to water entry; (5) reducing the risk of driver distraction by having a tour guide conduct each tour; (6) managing risk in tour operations by addressing such factors as driver distraction, route planning, vehicle characteristics, traffic density, and vehicle speed; and (7) conducting operations according to NVIC 1-01 guidance and Coast Guard safety alerts.

⁸⁷ See www.passengervessel.com, accessed July 19, 2016.

3 Conclusions

3.1 Findings

1. None of the following were factors in the crash: (1) *DUCK 6* or motorcoach driver performance; (2) highway or bridge factors; (3) motorcoach motor carrier operations; (4) motorcoach or passenger car mechanical condition; or (5) weather conditions.
2. The emergency response to the crash was timely and effective.
3. The left front axle housing on the *DUCK 6* failed due to multiple initiation fatigue cracking.
4. The 2004 tab modification was flawed due to inadequate stiffness to eliminate the stress concentration in the transition region and because of poor weld quality, specifically, the lack of fusion and lack of penetration; moreover, it is likely that the weld of the tab fractured before the axle housing fractured.
5. The mechanical failure of the *DUCK 6*'s axle housing resulted in a loss of steering and vehicle control; the failure also resulted in a loss of front braking and an overall reduced braking capability, which contributed to the severity of this collision.
6. The 2004 modification that Ride the Ducks International made to the axle housings on its stretch amphibious passenger vehicles was poorly executed and provided no long-term benefit in preventing future axle failures.
7. Ride the Ducks of Seattle did not have adequate protocols in place to verify that the work specified in service bulletins from Ride the Ducks International was completed, even though the company knew that the bulletins addressed work important to the safety of its stretch amphibious passenger vehicle fleet.
8. Ride the Ducks of Seattle's lack of procedures to ensure that work called for in the manufacturer's service bulletins was performed on its stretch amphibious passenger vehicle fleet resulted in a failure to address the known risk of axle failure.
9. Ride the Ducks International did not adequately remedy the front axle fractures on the stretch amphibious passenger vehicles it manufactured, which led to the axle housing failure that caused the *DUCK 6* crash.
10. As a vehicle manufacturer under the National Traffic and Motor Vehicle Safety Act of 1966, Ride the Ducks International should be registered as a vehicle manufacturer with the National Highway Traffic Safety Administration to address any safety defects through the recall program.
11. The failure of the majority of seats in the *DUCK 6* and the lack of occupant protections, such as effective seat design and seat belts, contributed to passenger ejections and injury.

12. The crashworthiness of amphibious passenger vehicles would be improved by requiring such vehicles to meet existing, applicable sections of the *Federal Motor Vehicle Safety Standards* for buses.
13. To ensure the consistent and uniform application of federal safety requirements, the US Coast Guard's assumed average weight per person should be used when calculating gross vehicle weights for amphibious passenger vehicles.
14. Because amphibious passenger vehicles are high-occupancy passenger vehicles operating on public roads, the National Highway Traffic Safety Administration should take action to provide occupant protection to their passengers.
15. Although installing seat belts in amphibious passenger vehicles would most likely reduce ejections and injuries in crashes that occur on land, seat belts could pose egress problems during emergencies on water.
16. Survival space was compromised for motorcoach passengers in the path of the *DUCK 6*, as it traversed the motorcoach interior upward to the roofline and for almost the entire length of the vehicle.
17. For those in the intrusion area, the bow of the *DUCK 6* striking the side of the motorcoach at close to 40 mph caused catastrophic intrusion damage and severe injuries that additional motorcoach sidewall protections and seat belts most likely would not have prevented.
18. By adding a tour guide to each amphibious passenger vehicle on every excursion, Ride the Ducks of Seattle has reduced the risk of driver distraction in its operations.
19. Given the recent Seattle and Boston amphibious passenger vehicle (APV) crashes, which resulted in multiple deaths and numerous injuries, the APV industry should develop and implement risk management practices geared to the special needs of APV operations.

3.2 Probable Cause

The National Transportation Safety Board determines that the probable cause of the Seattle, Washington, crash was the mechanical failure, due to improper manufacturing by Ride the Ducks International (vehicle manufacturer) and inadequate maintenance by Ride the Ducks of Seattle (operator), of the left front axle housing of the stretch amphibious passenger vehicle (APV) *DUCK 6*, which resulted in loss of vehicle control. Contributing to the severity of the motorcoach occupant injuries was the APV's structural incompatibility with the motorcoach, causing intrusion into the motorcoach sidewall, windows, and interior passenger compartment. Contributing to the severity of the APV passenger injuries were the lack of occupant crash protections and the high impact forces.

4 Recommendations

4.1 New Recommendations

As a result of its investigation, the National Transportation Safety Board makes the following new safety recommendations:

To the National Highway Traffic Safety Administration:

Require that Ride the Ducks International, as a manufacturer, issue a recall for the stretch amphibious passenger vehicle front axle safety defect to provide owners a remedy as required under the Safety Recall Campaign. (H-16-17)

Adopt the US Coast Guard's assumed average weight per person and amend the certification regulation in 49 *Code of Federal Regulations* Part 567 to specify that the gross vehicle weight rating for an amphibious passenger vehicle "shall not be less than the sum of the unloaded vehicle weight, the rated cargo load, and 185 pounds times the vehicle's number of designated seating positions." (H-16-18)

Classify all amphibious passenger vehicles (APV) as non-over-the-road buses and, under the authority of the National Traffic and Motor Vehicle Safety Act of 1966, make newly manufactured APVs subject to applicable *Federal Motor Vehicle Safety Standards* in effect at the time of manufacture. (H-16-19)

To the US Coast Guard:

Amend Navigation and Vessel Inspection Circular 1-01 to ensure that (1) amphibious passenger vehicle (APV) operators tell passengers that seat belts must not be worn while the vessel/vehicle is operated in the water and (2) before the APV enters the water or departs the dock, the master or other crewmember visually checks that each passenger has unbuckled his or her seat belt. (M-16-26)

Distribute a safety alert on amphibious passenger vehicle operations that addresses the role of risk assessment to mitigate driver distraction, as well as the need to tell passengers to remove seat belts before waterborne operations begin. (M-16-27)

To Ride the Ducks International:

Develop a thoroughly verified and tested repair or alternative axle housing for the front axles of your stretch amphibious passenger vehicles (APV), and repair or replace the axle housings on your own stretch APVs as necessary. (H-16-20)

Communicate the repair or replacement information concerning the front axle housings of your stretch amphibious passenger vehicles, developed in response to Safety Recommendation H-16-20, to your franchisees and licensees. (H-16-21)

Instruct your franchisees and licensees to immediately halt operation of their stretch amphibious passenger vehicles and not resume operations until they complete the axle housing repair or replacement process developed in response to Safety Recommendation H-16-20. (H-16-22) (Urgent)

To Ride the Ducks of Seattle:

Add to your 250-hour and annual inspection processes a procedure to verify that all actions indicated in service bulletins have been completed on all inspected vehicles. (H-16-23)

To the Passenger Vessel Association:

Notify all your amphibious passenger vehicle (APV) operator members of the importance of the following: (1) learning the lessons from the Seattle, Washington, and Boston, Massachusetts, crashes; (2) completing proper maintenance and service bulletin repairs; (3) using the pretrip safety orientation to tell passengers of APVs equipped with passenger seat belts to unbuckle their belts before the APV begins any marine operations; (4) conducting a visual inspection to ensure that passengers have unbuckled their seat belts prior to water entry; (5) reducing the risk of driver distraction by having a tour guide conduct each tour; (6) managing risk in tour operations by addressing such factors as driver distraction, route planning, vehicle characteristics, traffic density, and vehicle speed; and (7) conducting operations according to Navigation and Vessel Inspection Circular 1-01 guidance and US Coast Guard safety alerts. (M-16-28)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

CHRISTOPHER A. HART
Chairman

ROBERT L. SUMWALT
Member

T. BELLA DINH-ZARR
Vice Chairman

EARL F. WEENER
Member

Adopted: November 15, 2016

Appendix A: Investigations

Seattle, Washington. The National Transportation Safety Board (NTSB) was notified of the Seattle, Washington, crash on September 24, 2015, and it dispatched an investigative team. The NTSB established groups to investigate human performance; motor carrier operations; and highway, survival, and vehicle factors. Member Earl F. Weener, accompanied by Special Assistant Kristen Shea, was the spokesperson on scene.

Parties to the investigation were representatives from the Federal Motor Carrier Safety Administration, National Highway Traffic Safety Administration, US Coast Guard, Seattle Police Department, Washington Utilities and Transportation Commission, Washington Department of Transportation, Ride the Ducks International, and Ride the Ducks of Seattle.

Boston, Massachusetts. The NTSB was notified of the Boston crash on April 30, 2016, and an investigative team was dispatched. Groups were established to investigate motor carrier operations and vehicle factors.

The Boston Police Department was a party to the investigation.

Appendix B: NHTSA Manufacturer Regulations

Among other requirements, National Highway Traffic Safety Administration (NHTSA) regulations at 49 *Code of Federal Regulations (CFR)* Part 565 call for a motor vehicle manufacturer to assign to each motor vehicle manufactured for sale in the United States a 17-character vehicle identification number (VIN) that uniquely identifies the vehicle.¹ A motor vehicle must be manufactured to comply with all applicable *Federal Motor Vehicle Safety Standards (FMVSSs)* and bear a label certifying such compliance that is permanently affixed (riveted or affixed in such a manner that it cannot be removed without destroying or defacing it) by the vehicle's manufacturer (that is, the actual assembler of the vehicle). Certification labeling requirements are necessary to establish that the vehicle was manufactured to comply with all applicable *FMVSSs*. Because the label also identifies the type classification of the vehicle, it also helps to identify which of the *FMVSSs* apply to the vehicle.

Completed Vehicle: One that requires no further manufacturing operations to perform its intended function.

Incomplete Vehicle: An assemblage consisting, at a minimum, of chassis (including the frame) structure, power train, steering system, suspension system, and braking system, in the state that those systems are to be part of the completed vehicle, but requires further manufacturing operations to become a completed vehicle. Manufacturers of incomplete vehicles must furnish at or before the time of delivery an incomplete vehicle document or "IVD" that contains, among other things, a list of each FMVSS applicable to the incomplete vehicle's type classification and a statement whether the vehicle will or will not conform to each applicable FMVSS, or that FMVSS conformance cannot be determined. Incomplete vehicle manufacturers must generally affix to their vehicles a label that identifies the incomplete manufacturer, the vehicle's date of manufacture (month and year), its GVWR [gross vehicle weight rating], GAWR [gross axle weight rating], and VIN.

Final-Stage Manufacturer: Person who performs such manufacturing operations on an incomplete vehicle that it becomes a completed vehicle. The intermediate manufacturer must affix a label that identifies that manufacturer, states the vehicle's GVWR, GAWR, and VIN, and identifies the month and year in which the intermediate manufacturer performed its last manufacturing operation on the incomplete vehicle.

¹ The VIN has become the key identifier in data systems that track compliance with federal and state safety programs and that manage and analyze information on vehicle manufacturing processes, registrations, insurance programs, crash investigations, and safety research. Organizations that use VINs in data systems include NHTSA, manufacturers, state motor vehicle departments, law enforcement agencies, insurance companies, and motor vehicle safety researchers.

Intermediate Manufacturer: Person, other than the incomplete vehicle manufacturer or the final-stage manufacturer, who performs manufacturing operations on a vehicle manufactured in two or more stages. The final-stage manufacturer must affix a label that identifies that manufacturer, states the vehicle's GVWR, GAWR, vehicle type classification, and VIN, and identifies the vehicle's date of manufacture (month and year). The date selected must be the date of manufacture of the incomplete vehicle, the date of final completion, or a date between those two dates.

Both the final-stage and intermediate manufacturers assume legal responsibility for all certification-related duties and liabilities under the Vehicle Safety Act with respect to the components and systems they install or supply for installation on the incomplete vehicle, unless changed by a subsequent manufacturer. Both have responsibility to further manufacture or complete the vehicle in accordance with the IVD furnished by the incomplete vehicle manufacturer. (See table B-1.)

Table B-1. Certification label content requirements by manufacturer type.

Manufacturer Type	Co. Name	Date of Manufacture	GVWR	GAWR	Vehicle Type	VIN	Cert. Statement Source
Completed Vehicle	Yes	Yes	Yes	Yes	Yes	Yes	Yes, 1 of 3 567.4(g)
Incomplete Vehicle	Yes	Yes	Yes	Yes	No	Yes	No, IVD 567.5(b)(2)
Intermediate	Yes	Yes	Yes	Yes	No	Yes	No 567.5(c)(2)
Final-stage	Yes	Yes	Yes	Yes	Yes	Yes	Yes, 1 of 3 567.5(d)(2)

49 CFR §566.1 Scope.

This part requires manufacturers of motor vehicles, and of motor vehicle equipment to which a motor vehicle safety standard applies, to submit identifying information and a description of the items they produce.

49 CFR §566.2 Purpose.

The purpose of this part is to facilitate the regulation of manufacturers under the National Traffic and Motor Vehicle Safety Act, and to aid in establishing a code numbering system for all regulated manufacturers.

49 CFR §566.3 Application.

This part applies to all manufacturers of motor vehicles, and to manufacturers of motor vehicle equipment, other than tires, to which a motor vehicle safety standard applies (hereafter referred to as "covered equipment").

49 CFR §566.5 Requirements.

Each manufacturer of motor vehicles, and each manufacturer of covered equipment, shall furnish the information specified in paragraphs (a) through (c) of this section to: Administrator, National Highway Traffic Safety Administration, 400 Seventh Street SW., Washington, DC 20590.

- (a) Full individual, partnership, or corporate name of the manufacturer.
- (b) Residence address of the manufacturer and State of incorporation if applicable.
- (c) Description of each type of motor vehicle or of covered equipment manufactured by the manufacturer, including, for motor vehicles, the approximate ranges of gross vehicle weight ratings for each type.
 - (1) Except as noted below, the description may be of general types, such as “passenger cars” or “brake fluid.”
 - (2) In the case of multipurpose passenger vehicles, trucks, and trailers, the description shall be specific enough also to indicate the types of use for which the vehicles are intended, such as “tank trailer,” “motor home,” or “cargo van.”
 - (3) In the case of motor vehicles produced in two or more stages, if the manufacturer is an incomplete vehicle manufacturer, the description shall so state and include a description indicating the stage of completion of the vehicle and, where known, the types of use for which the vehicle is intended.

Example: “Incomplete vehicle manufacturer—Chassis-cab intended for completion as van-type truck.”

If the manufacturer is an intermediate manufacturer, or a final stage manufacturer, the description shall so state and include a brief description of the work performed.

Example: “Multipurpose passenger vehicles: Motor homes with GVWR from 8,000 to 12,000 pounds. Final-stage manufacturer—add body to bare chassis.”

49 CFR §566.6 Submittal of information.

Each manufacturer required to submit information under §566.5 shall submit the information not later than February 1, 1972. After that date, each person who begins to manufacture a type of motor vehicle or covered equipment for which he has not submitted the required information shall submit the information specified in paragraphs (a) through (c) of §566.5 not later than 30 days after he begins manufacture. Each manufacturer who has submitted required information shall keep his entry current, accurate and complete by submitting revised information not later than 30 days after the relevant changes in his business occur.

Registered Importers (RIs) are by definition manufacturers under the National Traffic and Motor Vehicle Safety Act of 1966, as amended (Act), 49 USC §30101 et seq. As such, they have the same recall responsibilities as motor vehicle and replacement equipment

manufacturers under the Act, including the duty to ensure that there are no outstanding safety recalls on the vehicles they import before they sell or release custody of those vehicles.² (**REGISTERED IMPORTER NEWSLETTER No. 32, National Highway Traffic Safety Administration, Office of Vehicle Safety Compliance, September 2006: RECALL RESPONSIBILITIES OF REGISTERED IMPORTERS.**)

² See www.nhtsa.gov/cars/rules/import/newsletters/news032.html, accessed August 29, 2016.

Appendix C: Violations in Postcrash Compliance Reviews of RTD Seattle

The State of Washington Utilities and Transportation Commission (WUTC) conducted postcrash a compliance review (CR) investigation of Ride the Ducks of Seattle (RTD Seattle) in December 2015. Its CR resulted in a proposed unsatisfactory safety rating for RTD Seattle (WUTC 2015). The factors that contributed to the proposed rating included one violation of an acute regulation and six violations of a critical regulation, as well as two recordable accidents in 2015: a February 7, 2015, crash involving an RTD Seattle duck vehicle collision with another vehicle, and the September 24, 2015, crash on the SR-99 Aurora Bridge.¹ The WUTC found 131 violations of 5 other critical regulations, but the violations found for those regulations did not establish a pattern and therefore were not factors in determining the proposed safety rating. The WUTC also found 304 recordkeeping violations of 17 non-acute/non-critical regulations. The following listing explains each violation type found by the WUTC in its review and provides the total number of violations found:

Violation of Acute Regulation

1. One violation of 49 *Code of Federal Regulations (CFR)* 383.37(b)—Allowing, requiring, permitting, or authorizing an employee to operate a commercial motor vehicle (CMV) during any period in which the driver has a commercial learner’s permit or commercial driver’s license (CDL) disqualified by a State, has lost the right to operate a CMV or has been disqualified from operating a CMV. One driver’s CDL was inactivated by the Washington State Department of Licensing on April 4, 2015, following the expiration of his medical certificate. WUTC found this driver then drove on 11 occasions without a valid CDL.

Pattern of Non-Compliance with Critical Regulations

2. Six violations of 49 *CFR* 382.305(b)(2)—Failing to conduct random controlled substances testing at an annual rate of not less than the applicable annual rate of the average number of driver positions. The WUTC found that only 14 random drug tests were completed of the 20 required in 2014.

Other Violations of Critical Regulations—No Pattern Established²

3. One violation of 49 *CFR* 382.305(b)(1)—Failing to conduct random alcohol testing at an annual rate of not less than the applicable annual rate of the average number of driver positions. The WUTC found that only three of the four required random alcohol tests were completed in 2014.

¹ Per 49 *CFR* 390.5—Definitions: a recordable accident means an occurrence involving a commercial motor vehicle on a highway that results in a fatality, bodily injury to a person who, as a result of the injury, immediately receives medical treatment away from the scene of the accident, or one or more vehicles incurring disabling damage that requires the motor vehicle to be transported away from the scene by a tow truck or other motor vehicle.

² A pattern is more than one violation. When multiple documents are reviewed, the number of violations required to meet a pattern is equal to at least 10 percent of those examined. (See appendix B to 49 *CFR* Part 385, “Explanation of Safety Rating Process.”)

4. One violation of 49 *CFR* 391.45(b)(1)—Using a driver not medically examined and certified during the preceding 24 months. One driver’s medical certification expired on April 3, 2015. The WUTC found that driver then drove on 11 occasions without current medical certification.
5. One violation of 49 *CFR* 391.51(b)(7)—Failure to maintain medical examiner’s certificate in driver’s qualification file. WUTC found that the carrier failed to maintain copies of the medical examiner’s certificate within a specific driver’s driver qualification file.
6. Thirty-five violations of 49 *CFR* 395.5(b)(2)—Requiring or permitting a passenger-carrying CMV driver to drive after having been on duty 70 hours in 8 consecutive days. The WUTC examined 1,230 records related to this requirement and found that the carrier allowed 14 drivers to violate the 70-hour rule a total of 35 times. The 35 violations found did not establish a pattern because they did not amount to at least 10 percent of the records examined.
7. Ninety-three violations of 49 *CFR* 395.8(a)—Failing to require a driver to make a record of duty status. The WUTC examined 1,230 records related to this requirement and found that the carrier failed to require drivers to make a record of duty status (log book) when exceeding limitations for short-haul operations. Thirty-one drivers failed to make a record of duty status a total of 93 times. The 93 violations found did not establish a pattern because they did not amount to at least 10 percent of the records examined. This is a repeat violation from the 2012 compliance review inspection. The WUTC determined RTD Seattle knew or should have known how to comply with this requirement.

Recordkeeping Violations (Non-Acute/Non-Critical Regulations)

8. Twenty-six violations of 49 *CFR* 380.509(b)—Failing to maintain a copy of the driver’s training certificate in the driver’s personnel or qualification file. The WUTC found that the carrier failed to maintain a copy of entry level drivers’ training certificates on file in accordance with Part 380.513 for 26 drivers.
9. Two violations of 49 *CFR* 382.305(i)(3)—Failing to ensure that drivers are tested within the selection period. The WUTC found that out of nine random drug and alcohol selections during the second quarter, one driver failed to test as required.
10. One violation of 49 *CFR* 382.305(k)(2)—Failing to ensure that random testing dates are reasonably spread throughout the calendar year. The WUTC found that in 2014, the carrier had drivers entered into its random drug and alcohol pool during all four quarters with selections made in each quarter, but only tested during the first, third, and fourth quarters.
11. One violation of 49 *CFR* 382.601(b)—Failing to provide to employees a written policy on misuse of alcohol and controlled substances that meets the requirements of 49 *CFR* 382.601(b). The WUTC found that the carrier’s policy was missing required information concerning the effects of alcohol and controlled substances use on an individual’s health, work, and personal life; signs and symptoms of an alcohol or a controlled substances problem (the driver’s or a co-worker’s); and, available methods of intervening when alcohol or a controlled substances problem is suspected, including confrontation, referral to an employee assistance program, and/or referral to management.

12. One violation of 49 *CFR* 390.15(b)(1)—Failing to keep an accident register in the form and manner prescribed. The WUTC found that the carrier's accident register fails to show city and state of accident, number of fatalities, and whether any hazardous materials, other than fuel spilled from the fuel tanks of motor vehicles involved in the accident, were released.
13. One violation of 49 *CFR* 390.19(b)(2)—Failing to file the appropriate form under 49 *CFR* 390.19(a) (MCS-150, 150B, or 150C) each 24 months, according to the schedule. The WUTC found that the carrier failed to ensure a current MCS-150 was on file with the USDOT. The previous MCS-150 was filed on June 6, 2009.
14. Fifty-one violations of 49 *CFR* 391.21(a)—Using a driver who has an incomplete employment application. The WUTC found that the carrier failed to ensure that complete applications were on file, as applications were missing the date of birth for all employees. Date of birth is essential to determine driver minimum age requirements for all CDL-licensed personnel.
15. Three violations of 49 *CFR* 391.23(b)—Failing to maintain a copy of the motor vehicle record(s) obtained in response to the inquiry of each state within 30 days of the date of the driver's beginning employment. The WUTC found that the carrier hired three drivers and failed to maintain a copy of each driver's abstract in the driver's file within 30 days of hire.
16. Twenty-one violations of 49 *CFR* 391.25(a)—Failing to make an inquiry into the driving record of each driver to the appropriate State agencies in which the driver held a CMV operator's license at least once every 12 months. The WUTC found that the carrier failed to inquire about driver records within 12 months for 21 drivers.
17. Twenty-one violations of 49 *CFR* 391.25(b)—Failing to review the driving record of each driver to determine whether that driver meets minimum requirements for safe driving or is disqualified to drive. The WUTC found that the carrier failed to review the driving records for 21 drivers within a 12-month period.
18. Twenty-one violations of 49 *CFR* 391.27(a)—Failing to require drivers the carrier employs to prepare and furnish with a listing of all violations of motor vehicle traffic laws and ordinances at least once every 12 months. The WUTC found that the carrier failed to require drivers to complete a listing of all violations of motor vehicle traffic laws at least once every 12 months for 21 drivers.
19. Two violations of 49 *CFR* 391.51(b)(4)—Failing to maintain the responses of each state agency to the annual driver record inquiry required by 49 *CFR* 391.25(a). WUTC found that the carrier failed to maintain an annual drivers' abstract for calendar year 2014 for two drivers.
20. Fifty-one violations of 49 *CFR* 391.51(b)(9)—Failing to place a note related to the verification of the medical examiner's listing on the National Registry of Certified Medical Examiners required by 40 *CFR* 391.23(m) in driver qualification file(s). The WUTC found that the carrier failed to place a note in the driver qualification file related to the verification of the medical examiner's listing for 51 drivers.

21. One violation of 49 *CFR* 392.2—Operating a motor vehicle not in accordance with the laws, ordinances, and regulations of the jurisdiction in which it is being operated (RCW 81.70.280 and WAC 480-30-191(3)). The WUTC found that the carrier failed to ensure that the Liability Insurance Form E was current and on file with the commission. RTD Seattle maintained the proper insurance coverage but did not have the current Form E on file with the commission as required. The WUTC obtained and reviewed the carrier's insurance history for the last 10 years. There was no lapse in coverage. However, on December 7, 2015, RTD Seattle's insurance carrier notified the commission that it intended to cancel the company's insurance policy effective April 15, 2016.
22. Ninety violations of 49 *CFR* 396.13(c)—Failing to require a driver to sign the last vehicle inspection report when defects or deficiencies were noted. The WUTC found that on 90 separate occasions, a daily vehicle inspection report was noted with a discrepancy from the previous day, and the carrier failed to have the driver sign a statement that the discrepancy either was repaired or did not require repair.
23. Three violations of 49 *CFR* 396.21(b)—Failing to retain periodic inspection reports for 14 months from date of inspection. The WUTC found that DUCK vehicles 12, 14, and 15 did not have documentation of an annual periodic inspection completed in 2013.
24. Eight violations of 49 *CFR* 396.25(e)—Failing to retain evidence of brake inspector's qualifications. The WUTC found that the carrier had no documentation of brake inspector's qualifications on file for eight employees. The carrier has since corrected this omission by providing evidence of qualifications.

The WUTC also conducted inspections of the company's 10 truck duck vehicles. The vehicles received an overall passing grade; however, the WUTC found 11 total violations of 49 *CFR* Part 396, "Inspection, Repair, and Maintenance." The WUTC also inspected the company's eight operational stretch duck vehicles and found six violations of 49 *CFR* Part 396 and one violation of 49 *CFR* Part 393, "Parts and Accessories Necessary for Safe Operation," as follows:

- Four violations of 49 *CFR* 396.17(c)—Periodic inspection: operating a CMV without proof of periodic inspection. RTD Seattle failed to ensure that each of the stretch duck vehicles had a copy of its periodic inspection report on board. Copies of periodic inspections have since been placed on all vehicles, verified by the WUTC.
- Two violations of 49 *CFR* 396.5(b)—Lubrication: oil and/or grease leak. The hubs on the front axles of *DUCK 8* and *DUCK 21* had minor grease leaks. Defects must be corrected prior to the vehicles being operated again.
- One violation of 49 *CFR* 393.9(a)—Lamps operable, prohibition of obstructions of lamps and reflectors: inoperable required lamp-brake lights. Staff placed *DUCK 1* out of service for having inoperable brake lights. RTD Seattle maintenance staff corrected this condition prior to the end of the inspection. The WUTC verified this repair.

The December 2015 WUTC report found that all operational truck duck vehicles passed WUTC inspections. Of the eight stretch duck vehicles inspected, six passed WUTC inspection.

The Federal Motor Carrier Safety Administration (FMCSA) conducted a postcrash non-rated CR of RTD Seattle. The FMCSA CR identified the following violations:³

- §383.37(b)—Allowing, requiring, permitting, or authorizing an employee to operate a CMV during any period in which the driver has a commercial learner’s permit or CDL disqualified by a state, has lost the right to operate a CMV in a state, or has been disqualified from operating a CMV. Two of 56 were checked. This is an acute violation.
- §382.305(b)(2)—Failing to conduct random controlled substances testing at an annual rate of not less than the applicable annual rate of the average number of driver positions. Six of 20 were checked. This is a critical violation.
- §382.305(b)(1)—Failing to conduct random alcohol testing at an annual rate of not less than the applicable annual rate of the average number of driver positions. One of four were checked.
- §382.305(i)(3)—Failing to ensure that drivers are tested within the selection period. Two of nine were checked.
- §382.305(k)(2)—Failing to ensure that random testing dates are reasonably spread throughout the calendar year. One of one was checked.
- §382.601(b)—Failing to provide to employees a written policy on misuse of alcohol and controlled substances that meets the requirements of 382.601(b). One of one was checked.

As a result of its CR, the FMCSA issued a Notice of Claim to RTD Seattle because of the acute violation of 49 *CFR* 383.37(b) and the critical violation of 49 *CFR* 382.305(b)(2). The Notice of Claim resulted in \$10,890 in civil penalties. The FMCSA CR was incorporated into the CR performed by the WUTC in December 2015.

³ The RTD Seattle postaccident CR details the violations. (See Motor Carrier Attachment 5 in the accident docket.)

Appendix D: NTSB Recommendation History on Motorcoach and Bus Crashworthiness and Occupant Protection

For more than 40 years, the National Transportation Safety Board (NTSB) has addressed the issue of motorcoach and bus crashworthiness and occupant protection (NTSB 1968, 1974, and 1996). The NTSB has long held that, during a crash, keeping passengers in the vehicle and within their seating compartments is essential to safety.

In its 1999 bus crashworthiness report, the NTSB concluded that a primary cause of preventable injury in motorcoach accidents involving a rollover, ejection, or both, is occupant motion out of the seat during a collision when no intrusion occurs into the seating area (NTSB 1999). The NTSB further concluded that the overall injury risk to occupants in motorcoach accidents involving rollover and ejection may be significantly reduced by retaining the occupant in the seating compartment throughout the collision. Numerous recommendations designed to mitigate occupant injury during a crash were issued in the 1999 bus crashworthiness report. Two of these recommendations to the National Highway Traffic Safety Administration (NHTSA) have been reiterated in NTSB reports of investigations of motorcoach crashes over the last 15 years, including the 2008 motorcoach rollover accidents near Sherman, Texas, and Mexican Hat, Utah (NTSB 2009a, 2009b, 2008, and 2004):

In 2 years, develop performance standards for motorcoach occupant protection systems that account for frontal impact collisions, side impact collisions, rear impact collisions, and rollovers. (H-99-47)

Once pertinent standards have been developed for motorcoach occupant protection systems, require newly manufactured motorcoaches to have an occupant crash protection system that meets the newly developed performance standards and retains passengers, including those in child safety restraint systems, within the seating compartment throughout the accident sequence for all accident scenarios. (H-99-48)

Both recommendations were “Closed—Acceptable Action” in 2014 when NHTSA issued a final rule requiring the installation of lap/shoulder belts at all passenger seating positions in over-the-road buses, including motorcoach-style buses.

NTSB motorcoach investigations have concluded that passengers would be safer with an occupant protection system, and NHTSA crash testing shows that injury risk is much lower for lap/shoulder-belted dummies than for unrestrained dummies.

Appendix E: NTSB Safety Alert on Amphibious Passenger Vehicle Operations (SA-059)

**NTSB****SAFETY ALERT**

National Transportation Safety Board

★ Risk Assessment, Driver Distraction, and Seat Belts in Amphibious Passenger Vehicle Operations ★

The problem

Amphibious passenger vehicles (APV) are large vessel/vehicle hybrids. Their design limits the driver's field of vision when operating on land with respect to surrounding traffic and pedestrians. In addition, APV tours often operate in high-density urban areas with heavy traffic and high numbers of pedestrian intersections, or in high-speed areas. APV tour companies must weigh safety against sightseeing value in selecting an appropriate route.

In addition, many APV drivers conduct or narrate the tour, as well as operate the vehicle, which constitutes a distraction risk. The addition of each auxiliary task can impair a driver's processing of the primary task of driving safely, and focusing on any task other than safe driving impairs performance and can lead to deadly consequences. For safety-critical operations, distraction must be minimized to ensure safe operations. Requiring APV drivers to provide entertainment as well as to drive poses an unacceptable risk of distraction.

Lastly, beginning in November 2016, all newly manufactured non-over-the-road buses, a category into which APVs fall by definition, are required to have seat belts. Although seat belts are necessary to protect APV passengers during the land portions of the tour, to mitigate the risk of impeding emergency marine egress, they must be unbuckled during the water portion of the tour.

Related crashes

- On Thursday, September 24, 2015, about 11:11 a.m., the *DUCK 6* APV, operated by Ride the Ducks of Seattle (RTD Seattle), was traveling north on the Washington State Route 99 Aurora Bridge in Seattle, Washington. At the same time, a 2009 Motor Coach Industries motorcoach was traveling south in the center lane. The *DUCK 6* driver heard a loud noise at the left front of the APV; the vehicle drifted to the right and then veered left suddenly; the driver lost control of the vehicle. The APV crossed the centerline into the southbound lanes of oncoming traffic and struck the motorcoach. Three other vehicles were damaged during the crash event: a southbound 2011 Ram Trucks pickup truck and

two northbound vehicles—a 2006 Toyota Highlander sport utility vehicle and a 2007 Toyota Tundra pickup truck. As a result of this crash, five motorcoach passengers died. Seventy-one motorcoach and APV occupants reported injuries ranging from minor to serious. (HWY15MH011)

- On Saturday, April 30, 2016, about 11:40 a.m., the 2009 37-passenger *PENELOPE PRU* APV, operated by Boston Duck Tours, was stopped for a red signal on Charles Street at the traffic-light-controlled intersection with Beacon Street in downtown Boston, Massachusetts. The *PENELOPE PRU* was occupied by a 41-year-old male driver and 27 passengers. Stopped just in front of the APV was a 2013 Lance Havana Classic 50 motor scooter, ridden by a 29-year-old female operator and a male passenger. When the light turned green, both the motor scooter and APV accelerated from the stop bar on Charles Street and turned right (eastbound) onto Beacon Street. The *PENELOPE PRU* accelerated onto Beacon Street at a faster rate than the scooter, and it overrode the scooter about 50 feet from the intersection. The scooter and both its riders were knocked to the pavement; the female operator was killed, and the male passenger was injured. (HWY16FH010)

What can APV operators and permitting authorities do?

- Disconnect your drivers from non-mission-critical tasks by providing a secondary crewmember to be responsible for tour narration and entertainment.
- Isolate situations in which driver distraction could occur, and provide steps to eliminate, reduce, or mitigate these situations during all tour operations.
- Emphasize the potential safety threat of distraction during driver and tour guide training, and highlight countermeasures in company manuals and policies.
- Determine the existence of potential route hazards (such as traffic conditions and density, vehicle characteristics, and speeds).
- Select routes to mitigate risk and avoid preventable crashes.
- Tell passengers during pretrip safety briefings to remove their seat belts when the APV enters the water portion of the tour.
- Institute a visual inspection process by which the deckhand or captain verifies that all passengers have unbuckled their seat belts prior to water entry.

Interested in more information?

With respect to the September 24, 2015, crash in Seattle, on March 17, 2016, the Washington Utilities and Transportation Commission (WUTC) assessed a total penalty of \$308,000 against RTD Seattle. The WUTC suspended \$152,000 of the penalty on the condition that RTD Seattle commits no new violations of the laws, as specified in their agreement, for 24 months, beginning May 3, 2016. (See www.utc.wa.gov/docs/Pages/recordsCenter.aspx and search for filing TE-151906.) The Federal Motor Carrier Safety Administration issued a separate Notice of Claim to RTD Seattle for \$10,890 in civil penalties.

The NTSB's Seattle highway accident report (NTSB/HAR-16/02) is available online at www.nts.gov/investigations/AccidentReports/Pages/highway.aspx. Investigative information for the Boston crash is accessible from the NTSB's Docket Management System web page at www.nts.gov/investigations/SitePages/dms.aspx; search for NTSB accident ID HWY16FH010.

Additional information on distraction in commercial transportation accidents may be found on the Most Wanted List web page on the NTSB website at www.nts.gov/safety/mwl/Pages/mwl8-2017-18.aspx.

This NTSB Safety Alert (SA-059) and others can be accessed from the NTSB's Safety Alerts web page on the NTSB website at www.nts.gov/safety/safety-alerts/Pages/default.aspx.

Information on the US Department of Transportation's National Highway Traffic Safety Administration (NHTSA) final rule requiring lap and shoulder seat belts for each passenger and driver seat on new motorcoaches and other large buses can be accessed from NHTSA's website at www.nhtsa.gov with docket number NHTSA-2013-0121. NHTSA's final rule amending Federal Motor Vehicle Safety Standard 208 requires, starting in November 2016, that newly manufactured buses (considered non-over-the-road) with a gross vehicle weight rating greater than 26,000 pounds be equipped with lap and shoulder belts for each passenger seat. Title 49 *Code of Federal Regulations* 571.3(b) defines a bus as "a motor vehicle with motive power, except a trailer, designed for carrying more than 10 persons."

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