NATIONAL TRANSPORTATION SAFETY BOARD
OFFICE OF HIGHWAY SAFETY
WASHINGTON, D.C.

FACTUAL REPORT OF INVESTIGATION

A. CRASH INFORMATION

Location:	South 6th Street, 162 feet south of Freemont Street, Las Vegas, Clark County, Nevada
Vehicle #1:	2006 International truck-tractor in combination with a 2010 Utility refrigerated trailer.
Operator #1:	E&H Distributing, LLC d/b/a US Foods
Vehicle #2:	2017 Navya Arma Transit Shuttle
Operator #2:	Keolis Transit Services, LLC
Date:	November 8, 2017
Time:	Approximately 12:07 p.m. PST
NTSB #:	**HWY18 F H001**

B. CRASH SUMMARY

At about 12:07 p.m. local time (PST) on Wednesday, November 8, 2017, a 2017 Navya Arma autonomous shuttle, occupied by seven passengers and an attendant, was traveling north on South 6th Street while operating along its route, a 0.6-mile loop in downtown Las Vegas, Clark County, Nevada. At the same time, a 2006 International truck-tractor in combination with a 2010 Utility refrigerated trailer was backing into an alley west of South 6th Street, blocking the northbound lane of South 6th Street. The autonomous shuttle stopped, and as the truck-tractor began to straighten, the front right tire on the steer axle contacted the shuttle. The contact caused minor damage to the lower left front portion of the shuttle's body. The shuttle passengers, the shuttle attendant, and the driver of the combination vehicle were uninjured. The weather was clear and the roadway was dry. The driver of the combination vehicle was cited for illegal backing.

C. DETAILS OF THE INVESTIGATION

This crash was investigated in support of the Board's interest in the ongoing deployment of autonomous and semi-autonomous vehicles. Investigators examined the circumstances of the crash, data available from the vehicles, and the operation of the shuttle.

1. Accident Location

This accident occurred on South 6th street, in the city of Las Vegas, Clark County, Nevada. The accident location is depicted graphically in Figures 1 and 2.

Figure 1. Location of Las Vegas within the state of Nevada (image from state-maps.org)

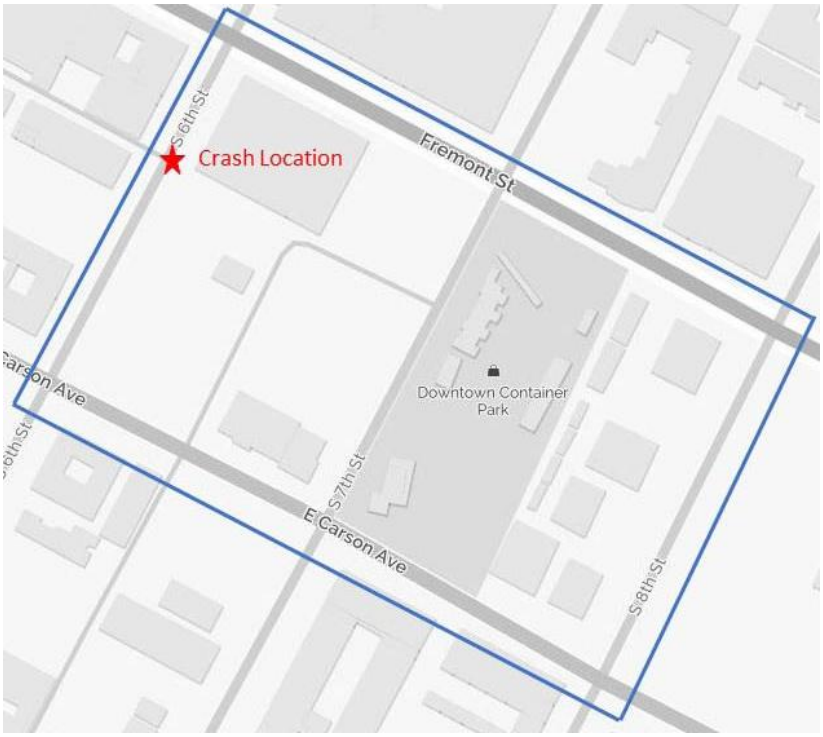

Figure 2. Crash Location with Shuttle Route, Map View (modified from Google Maps)

2. Roadway Information

At the location of the crash, South 6th Street is functionally classified as an urban local street. It is an undivided, two-way, asphalt roadway running north and south. Access is uncontrolled. One travel lane runs in each direction. The average travel lane width is 14 feet and the lanes are separated by a solid yellow centerline. On street parking spaces are present on both sides of the roadway. The parking on the east side of the street is angled parking; the parking on the west side of the street is parallel parking. The roadway is straight and level. The posted speed limit for South 6th Street in the area of the crash was 25 miles per hour (mph). The crash location is pictured in Figure 3.

Figure 3. Crash Location, Satellite View (image from Google Earth)

3. Vehicle Information

3.1. Truck-Tractor Semitrailer Combination

The truck tractor, semitrailer combination involved in this crash consisted of a conventional, 2-axle truck tractor connected to a 2-axle, 38' refrigerated van semitrailer. The truck tractor was equipped with two rearview mirrors mounted to each passenger door and an additional mirror mounted to each of the front fenders. Details for this vehicle are listed in Table 1.

Table 1. Truck-tractor and Semitrailer Information

Truck-tractor	
Make/Model:	International, 8600 4x2
VIN:[1]	1HSHWAHN26J330479
Company Unit #:	1029
Date of Manufacture:	October 2005
GVWR:[2]	32,000 pounds
GAWR (front axle):[3]	12,000 pounds
GAWR (rear axle):	20,000 pounds
Semitrailer	
Make/Model:	Utility Trailer Manufacturing, VS2RA 3000R Refrigerated Van
VIN:	1UYUS2366BU048501
Company Unit #:	3555
Date of Manufacture:	February 2010
GVWR:[4]	65,000 pounds

3.1.1. Damage Description

The truck tractor and semitrailer remained in service following the crash. NTSB investigators inspected both four days after the crash at a US Foods facility in Las Vegas.

At the time of inspection, investigators were told no body or mechanical damage was sustained by either the truck tractor or semitrailer; no such damage was apparent at the time of inspection. Investigators located a minor abrasion on the outboard shoulder of the right-side tire on axle 1 (the steer axle). The abrasion is depicted in Figure 4.

[1] Vehicle Identification Number (VIN).
[2] Gross Vehicle Weight Rating (GVWR) is the total maximum weight that a vehicle is designed to carry when loaded, including the weight of the vehicle itself plus fuel, passengers, and cargo.
[3] Gross Axle Weight Rating (GAWR) is the maximum distributed weight that a given axle is designed to support.
[4] Gross Vehicle Weight Rating (GVWR) is the total maximum weight that a vehicle is designed to carry when loaded, including the weight of the vehicle itself plus fuel, passengers, and cargo.

Figure 4. Abrasion on Right Front Tire of Truck Tractor (NTSB photograph)

3.1.2. Inspection Details

At the time of inspection, the brake lights, turn signals, and hazard lights were all operable. The back-up alarm and back-up light on the truck tractor were operable. The brake lights and turn signals were of the light-emitting diode (LED) style.

Employees of US Foods who observed the combination vehicle at final rest placed the truck, tractor, and steer axle in their approximate relative positions following the crash. In this orientation, the steering wheel was turned to the left. With the vehicle so oriented, investigators measured the distance from the axle 1 right side fender to the outboard tire shoulder as approximately six inches. The abraded portion of the right front tire extended from the shoulder inboard approximately 1.75 inches.

With the vehicle remaining in its approximate crash position, investigators examined the line of sight from the driver's seat and the available view through the right-side mirrors. Objects were used to represent the width and height of the Arma shuttle. Portions of simulated shuttle were visible through both the windshield and the side mirror.

3.2. NAVYA Arma Transit Shuttle

The NAVYA Arma is a 2-axle, battery powered vehicle, designed to operate in an autonomous or semi-autonomous mode. It is not equipped with a mechanical means of steering (steering wheel) nor brake or accelerator pedals. When not operating autonomously, the vehicle is steered via a joystick controller similar to a video game controller. This joystick is stored in a forward computer compartment and not readily accessible to the operator. The equipped brakes can be applied in three ways (electric regenerative, hydraulic, and mechanical spring). There are also two emergency stop buttons inside the passenger compartment which activate the spring

brakes on the front axle. The shuttle is equipped with a pneumatic suspension system allowing the operator to adjust the height of the chassis to one of three preconfigured positions. The only instrument panel is a computer screen mounted on the forward emergency door pillar.

The shuttle is designed that either end can be utilized as the front.[5] The lights on either end will change color depending which end is serving as the front. In its configuration at the time of the crash, the passenger entrance door was curbside (on the right of the vehicle when facing its direction of travel) and the vehicle battery compartment was at the rear of the vehicle. Details for this vehicle are listed in Table 2.

Table 2. Transit Shuttle Information

Transit Shuttle	
Make/Model:	2017 NAVYA Arma
VIN:[6]	VG9A2CB2CHB019031
Date of Manufacture:	UNKNOWN
GVWR:[7]	3500 pounds
Width	81 inches
Height	104.28 inches
Wheel base	113 inches
Passenger door width	88 inches
Passenger door height	91.5 inches
Passenger seat width	16.5 inches
Passenger seat back height	23.25 inches

For additional information on the shuttle and data obtained from the shuttle, please see the Vehicle Automation Report and the Recorders Group Chairman's Factual report, both available in docket for this investigation.

3.2.1. Damage Description

The shuttle remained in operation and was inspected by NTSB investigators three days after the crash at the RTC Operations and Maintenance Facility in Las Vegas, Nevada.

At the time of inspection, there was visible damage to the left front fiberglass body of the shuttle. The left front fiberglass panel was displaced to the left, leaving a 1.375-inch gap between the center access door and the left-side fiberglass body. The was also a 1.125-inch gap between the center access door and the left-side fiberglass body. Black transfer marks could be seen on the fiberglass. The damage to the vehicle is shown in Figure 5.

[5] This allows Navya to manufacture the shuttle for various countries without a redesign.
[6] Vehicle Identification Number (VIN).
[7] Gross Vehicle Weight Rating (GVWR) is the total maximum weight that a vehicle is designed to carry when loaded, including the weight of the vehicle itself plus fuel, passengers, and cargo.

Figure 5. Transit Shuttle Damage

During the inspection of the shuttle, NTSB investigators noted the location of the battery compartment was not visibly marked on the outside of the vehicle. In addition, there were no markings indicating where or how emergency responders could make entry to the vehicle or assist in passenger evacuation. Investigators also observed that, in the absence of the illuminated lights, there was no way to readily identify the front and rear of the vehicle.

4. US Foods (E & H Distributing LLC)

E & H Distributing LLC, d/b/a US Foods is an interstate authorized for-hire carrier of private property, to include general freight, fresh produce, meat, chemical, refrigerated food, beverages, and paper products. According to their most recent MCS-150 filing[8] with the Federal Motor Carrier Safety Administration (FMCSA), the company owns 12 straight trucks, 75 truck-tractors, and 87 trailers. Those vehicles travelled 1,325,039 miles in 2016. The company employed 79 drivers subject to the Federal Motor Carrier Safety Regulations (FMCSR).

Additional data from the FMCSA indicates the company last underwent a compliance review in February of 2000. Their vehicle out-of-service rate is 5.4% (national average of 20.7%) and their driver out-of-service rate is 0.0% (national average of 5.5%).

[8] June 16, 2017.

5. Keolis Transit Services, LLC

Keolis is a private company headquartered in Paris, France. The company operates urban, suburban, and regional public transport networks in 16 countries. Operations in the United States fall under Keolis North America and include fixed route, paratransit, call center, shuttle, and rail services.

Keolis operates fixed route local and express transit routes in Las Vegas for the Regional Transportation Commission (RTC) of Southern Nevada, including service along Las Vegas Boulevard and the Strip and Downtown Express routes. The routes average nearly 102,000 passengers during the week and 87,000 and 76,000 on Saturday and Sunday respectively.[9]

The shuttle service being operated at the time of the crash was operating under a special agreement with the RTC and the City of Las Vegas, and was not part of Keolis' normal service in the city. For more information on operation of the shuttle, please see the Vehicle Automation Report, available in docket for this investigation.

6. Driver of the 2006 International Truck-tractor

The driver of the 2006 International truck-tractor (truck) was a 48-year-old male. He held a Class "A" Nevada Commercial Driver's License (CDL) expiring in March of 2018.

When interviewed,[10] the driver stated he first got a CDL in 1993 after completing a commercial driving school and began to work as a driver. He began to work for US Foods in March of 1995. He told investigators he regularly undergoes various forms of driver training on a number of topics as part of his employment with US Foods.

The driver has delivered to various businesses in this area for the last 15 or 20 years. Currently, he makes the delivery he was making at the time of the crash two or three times a week. When asked, he stated he was not in a hurry and had no issues with the vehicle that day.

6.1. Driver Rest

When interviewed, the driver provided the times he went to be and got up in the days prior to the crash. This information is summarized in Table 3.

Table 3. International Driver Rest

FROM		TO		
Date	**Time**	**Date**	**Time**	**Elapsed**
November 5	8:00 p.m.	*November 6*	3:40 a.m.	7 hours 40 min
November 6	7:45 p.m.	*November 7*	3:40 a.m.	7 hours 55 min
November 7	7:45 p.m.	*November 8*	3:40 a.m.	7 hours 55 min

[9] http://www.keolisnorthamerica.com/locations/nevada/, accessed March 18, 2018.
[10] See Interview Transcripts, available in the docket.

The driver described his rest as pretty good and stated he awakes feeling rested. He has never been diagnosed with a sleep disorder.

6.2. Driver Health

When interviewed, the driver stated he was in good health. He stated he does not have any health issues and does not have a regular/primary care physician. He does wear glasses and was wearing them at the time of the crash. He described his hearing as good. He does not regularly take any medications or other drugs and only occasionally drinks alcohol. He took no medications and did not drink any alcohol on the day of the crash.

6.3. Post-Crash Toxicology

In this crash, no injuries were sustained and neither vehicle was towed from the scene. Per Federal Motor Carrier Safety Regulations, the driver's employer was not required to have him undergo post-crash drug and alcohol testing.[11]

The investigating officer from the Las Vegas Metropolitan Police Department (LVMPD) indicated he did not suspect impairment or intoxication, so no toxicological testing was performed at the behest of law enforcement.

6.4. The Crash Trip

On the day of the crash, the driver of the 2006 International awoke at his usual time and arrived at his workplace at 4:40 a.m. He departed the US Foods facility by 5:20 a.m. to begin his deliveries. The delivery he was attempting to make when the crash occurred was his sixth or seventh stop. According to the driver, the day had been a regular day to that point. He had not had any issues with the truck. He described it being the normal practice to back into the alley, as it was physically impossible to enter from Las Vegas Boulevard or Carson Avenue,

The driver told investigators as he pulled up to the alley, he activated his flashers. There were two cars behind him, which he waived past. As he began his backing maneuver, he saw the shuttle make the turn onto 6th Street from Carson Avenue. He stated he knew it was an automated shuttle; he had seen it doing "test runs" on Freemont Street. He had never seen it on 6th Street before that day. When asked by investigators, he stated he had no concerns sharing the road with the shuttle.

The driver continued his backing maneuver and was paying particular attention to vehicles parked on the east side of 6th Street, as he did not want to strike any of them. He did check to the right, and noted the shuttle was approximately halfway down the street. According to the driver, he assumed the shuttle would stop a "reasonable" distance from a backing tractor-trailer. The driver looked back to the left and observed a pedestrian walking in the alley. He watched the pedestrian until he was clear of the alley, he turned his attention back to the right and the truck contacted the shuttle.

[11] See 49 CFR §382.303.

When asked about distractions inside the truck, the driver stated he had his personal cell phone but was not using it and that the radio in the truck was on, but the volume was all the way down.

7. Shuttle Attendant

As stated above, the Navya Arma shuttle was operating in autonomous mode – without a human driver – at the time of the crash. An attendant, employed by Keolis, was on-board at the time of the crash. The attendant was interviewed to gather his recollection of the crash events; no human performance factors were examined for the attendant as he was not in control of the shuttle at the time of the crash.

7.1. The Crash Trip

The trip the shuttle was taking began with the attendant[12] boarding the shuttle at the main stop at Container Park for his first trip of the day. He replaced another attendant to allow that attendant to take a break. After taking on passengers, the shuttle departed Container Park in autonomous mode. It proceeded along Fremont Street, turned right onto 8th Street, then turned right onto East Carson Avenue. The shuttle stopped at the kiosk at 7th Street and East Carson. It departed the kiosk, still in autonomous mode and turned right on South 6th Street. According to the attendant, the shuttle was operating normally.

As the shuttle moved along South 6th Street, the attendant noticed a delivery truck backing up ahead. The attendant felt the shuttle slow as the two vehicles got closer to each other. As the shuttle continued to slow, the attendant hit the emergency stop as a precaution. At the same time, the shuttle stopped on its own. The attendant described the distance between the truck and the shuttle at the time the shuttle stopped as "several feet". When asked if he could estimate the distance, he stated it was between 5 and 8 feet. The truck kept moving, and the attendant began waving to attract the driver's attention. The truck contacted the shuttle. The attendant stated several second passed between the shuttle stopping and the collision. The attendant stated he believed the shuttle was visible to the truck driver via the right-side mirror from the time the shuttle stopped until the collision.

The attendant described his duties as answering passenger questions about the shuttle, dealing with any emergencies (falls, illness, and accidents), serving as a representative of Keolis, and dealing with any vehicle issues. He had received training on the basics of shuttle operation, troubleshooting the onboard computers, placing the shuttle in autonomous and manual mode, operating the shuttle in manual mode, and loading/unloading onto a tow truck in January 2017, when pilot testing took place on Fremont Street. He received refresher training in October 2017.

When asked about the shuttle's manual mode, the attendant stated its primary purpose was to allow the shuttle to loaded on/off a tow truck. It is also used when the shuttle, operating in autonomous mode; encounters obstacles, such as traffic cones or emergency vehicles; the attendant enters manual mode to go around the obstacle and return the autonomous path. Manual mode is also used to maneuver the shuttle in the yard and to pull into parking spaces. In manual mode, the shuttle is controlled with a game console controller. The shuttle is equipped with a horn and a

[12] See Interview Transcripts, available in the docket.

bell, both of which can be activated with the controller. At the time of this crash, the controller was stored in the shuttle's front compartment.

When asked if he considered using manual mode to move the shuttle, the attendant said he did consider doing so, but that he had very little time. He further stated that manual mode is not designed or intended for emergency mode.

8. Weather

Weather data from station KVGT in North Las Vegas for the two times closest to the time of the collision are shown in Table 4.[13]

Table 4. Weather Data

	11:53 a.m.	12:53 p.m.
Temperature	63.0° F	64.9° F
Dew Point	18.0° F	19.0° F
Humidity	18%	17%
Pressure	30.16 in.	30.12 in.
Visibility	10 mi.	10 mi.
Wind Direction	SE	S
Wind Speed	3.5 mph	6.9 mph
Precipitation	N/A	N/A
Conditions	Clear	Clear

9. Illumination

According to the U.S. Naval Observatory Astronomical Applications Department, on November 8, 2017, for the accident location, the sun rose at 6:11 a.m., reached transit at 11:24 a.m., and set at 4:38 p.m. At the time of the accident, the sun was at an altitude of 36.1 degrees above the horizon at an azimuth of 192.7 degrees east of true north.[14]

The position of the sun is depicted graphically in Figure 6. The location of the collision is shown with a red balloon; the direction of the sun is indicated by the blue line:

[13] See Weather Data in the docket.
[14] See Astronomical Data in the docket.

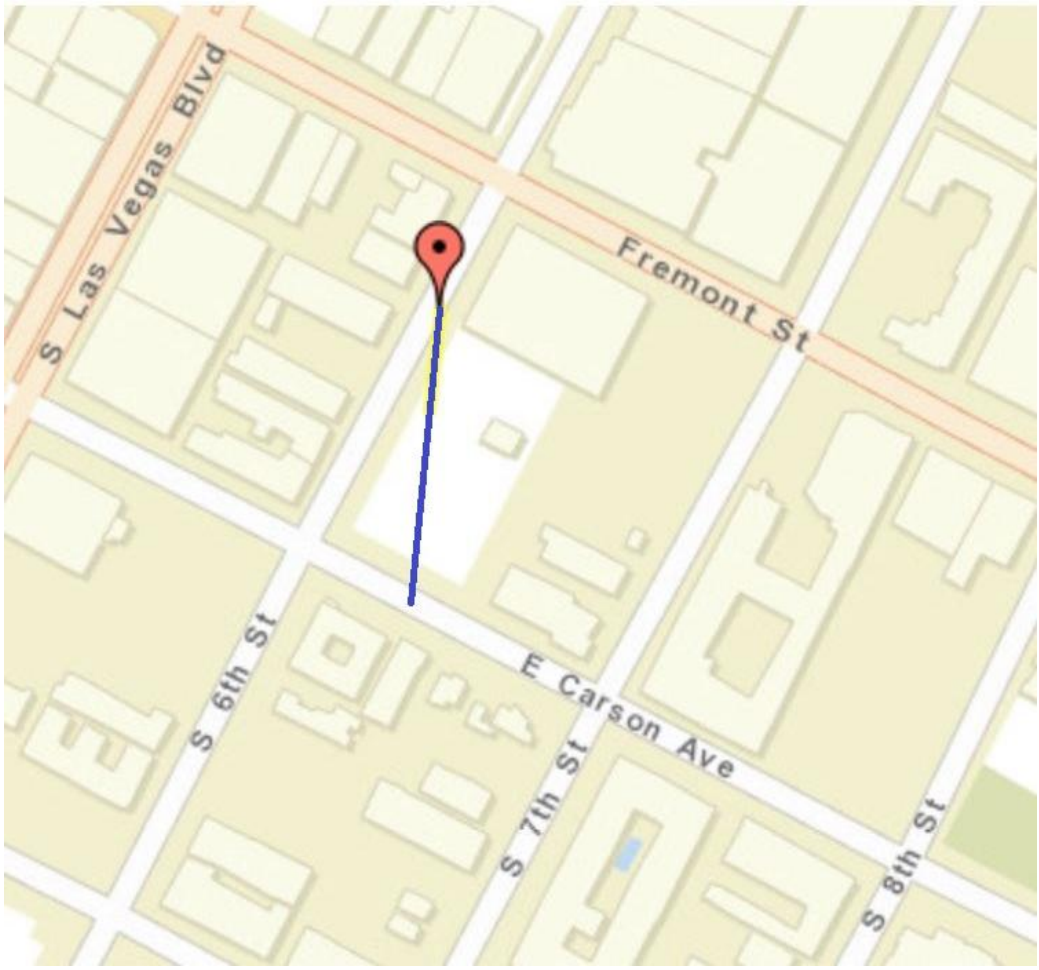

Figure 6. Graphic Representation of Sun Position

END OF INFORMATION

D. DOCKET MATERIAL

The following attachments and photographs are included in the docket for this investigation:

LIST OF ATTACHMENTS

Factual Report Attachment 1 - State of Nevada Traffic Crash Report

Factual Report Attachment 2 - US Foods MCS-150

Factual Report Attachment 3 - Interview Transcripts

Factual Report Attachment 4 - Weather Data

Factual Report Attachment 5 - Astronomical Data

LIST OF PHOTOGRAPHS

Photo 1 - Damage/Mark on US Foods Truck-Tractor Tire

Photo 2 - Damage to Navya Shuttle, Covered

Photo 3 - Damage to Navya Shuttle, Visible

END OF REPORT