VEHICLE DATA RECORDERS SPECIALIST'S FACTUAL REPORT

Flushing-Queens, New York

HWY17MH015

(12 pages)

NATIONAL TRANSPORTATION SAFETY BOARD
Vehicle Recorder Division
Washington, D.C. 20594
November 16, 2017

Vehicle Recorders

Specialist's Factual Report
by Joseph A Gregor

1. EVENT SUMMARY

Location:	Northern Blvd, Queens, New York
Vehicle #1:	2015 MCI J4500 Motorcoach
Operator #1:	Dahlia Group, Inc.
Vehicle #2:	2015 New Flyer, XD40 Transit Bus #7430
Operator #2:	New York City Transit Authority
Date:	Monday, September 18, 2017
Time:	Approximately 6:16 a.m. eastern daylight time (EDT)
NTSB #:	**HWY17MH015**

For a summary of the accident, refer to the *Crash Summary Report*, which is available in the docket for this investigation.

2. VEHICLE RECORDER GROUP

No group was convened.

3. DETAILS OF RECORDER INVESTIGATION

The following devices were brought to the Vehicle Recorder Laboratory in Washington, DC, for readout and analysis:

Manufacturer/Device:	Continental MCM2.1 A0014462835
Serial Number:	HDE0279824 17
Vehicle #1:	2015 MCI J4500 Motorcoach
Manufacturer/Device:	Continental-CPC-4 A2C83553200
Device Serial Number:	7104U4250304003
Vehicle #1:	2015 MCI J4500 Motorcoach

Manufacturer/Device:	Bendix EC60 ABS[1] K112594
Device Serial Number:	MI5S31140971
Vehicle #1:	2015 MCI J4500 Motorcoach
Manufacturer/Device:	TracManager GPS data file
Device Serial Number:	n/a
Vehicle #1:	2015 MCI J4500 Motorcoach
Manufacturer/Device:	Clever Devices IVN4 data file
Device Serial Number:	n/a
Vehicle #2:	2015 New Flyer, XD40 Transit Bus #7430

3.1. Engine Control Module Device Description

The Detroit Diesel Engine is electronically controlled using a DDEC 10 Engine Control Module (ECM) system consisting of three separate modules: a Motor Control Module (MCM), a Common Powertrain Controller (CPC), and an After Treatment Module (ACM2). The primary functions of the ECM are to control the engine's performance, fuel efficiency, and emissions. The ECM interfaces with many onboard sensors that help monitor and perform its functions.

The ECM has a secondary function with the capability to record three categories of recent historic data – *hard brake*, *last stop*, and *diagnostic records* - to non-volatile memory[2] (NVM).

A *hard brake* recording is triggered when vehicle deceleration exceeds a pre-set level (default = 7 mph / s, changeable by owner). The most recent two *hard brake* records are retained in NVM. Each *hard brake* record contains 15 seconds of post trigger data and 1 minute of pre-trigger data recorded at 1 second intervals.

The *last stop* recording is triggered when the vehicle speed changes from the drive state (greater or equal to 1.5 mph and engine RPM greater than zero for two seconds) to the stop state (vehicle speed less than 1.5 mph and ignition *off*). The *last stop* record is written when the vehicle's speed reaches zero miles per hour (mph), it is then overwritten when the wheel speed reaches 1.5 mph. The *last stop* record contains 15 seconds of post trigger data and 1 minute and 45 seconds of pre-trigger data.

Diagnostic records are stored corresponding to the last three active fault codes reported to the ECM. New faults will over-write old faults. *Diagnostic records* contain one minute of pre-trigger data recorded at 5 second intervals.

3.1.1. Engine Control Module Data Recovery

A download of the ECM through the vehicle's onboard vehicle network system (J1939) was not attempted on-scene due to impact and post-rescue damage to the vehicle's electronic data network. The MCM and CPC modules were removed and sent to the

[1] Antilock Braking System.

[2] Semiconductor memory device capable of retaining data in the absence of power.

Vehicle Recorder Lab for evaluation. An exterior inspection of both modules revealed the devices had sustained no overt mechanical damage. To prevent the over-writing of any existing fault code records, the CPC module was downloaded using a vehicle forensic adapter which simulated the vehicle network. Using this forensic adapter, the manufacturer's standard software was used to obtain the hard brake, last stop record, and diagnostic fault code records. Recovery and download of any error message data that may be resident in the MCM but not reported to the CPC module will be the subject of a follow-on report. Figures 1 and 2 show the modules as-received.

Figure 1. DDEC 10 MCM2.1 as removed from the MCI motorcoach.

Figure 2. Continental CPC4 as removed from the MCI motorcoach.

3.1.2. Engine Control Module Time Correlation

The DDEC 10 ECM is equipped with an onboard real-time clock with battery backup. At the time of the data download, the ECM clock time was found to be 45 minutes 37 seconds earlier than the time reported by an accurately synchronized time source (see figure 3). Time is reported in ECM clock time in this report.

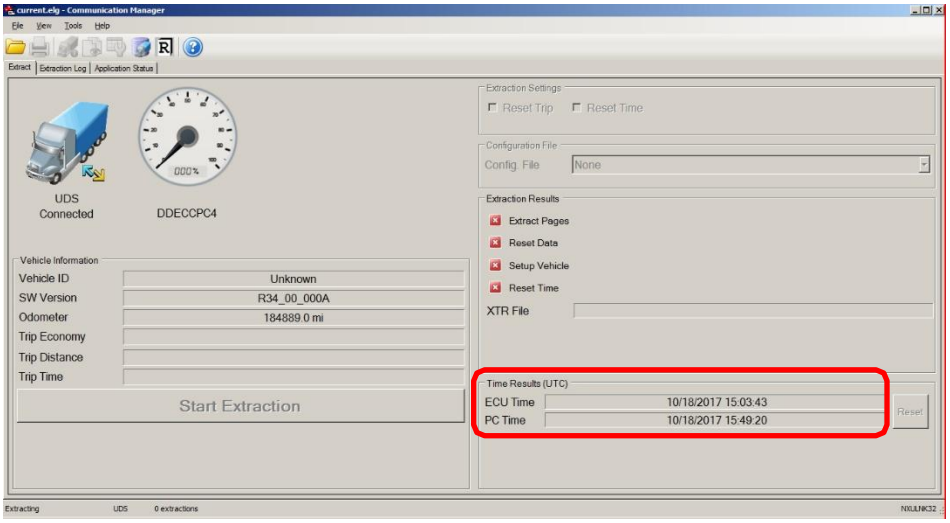

Figure 3. Screenshot showing clock synchronization between download computer and ECM.

3.1.3. Engine Control Module Data Description

Data extracted from the ECM included the following:

- One last stop record, timestamped September 18, 2017 at 04:31:23 EST[3] (odometer 184889.0 miles) that appeared related to the crash.
- Two hard brake records, related to events occurring on September 3, 2017 and August 12, 2017 that were not associated with the crash.
- A Trip Activity report, containing the vehicle's operating history such as vehicle distance, total engine time, total fuel used over the period from March 10 to October 18, 2017.
- A Monthly Activity report, containing the vehicle's operating history such as vehicle distance, total engine time, total fuel used for the months of October, August, and July of 2017. The October 2017 monthly activity record contained no data (all parameters zero).
- A Configuration report, indicating that the hard brake limit was set to the default value of 7.0 mph/s.
- A Life-To-Date report, containing additional vehicle performance parameters such as peak road speed and peak engine RPM over the period from March 10 to October 18, 2017.
- Vehicle Speed/RPM, Engine Load/RPM, and Over Speed/Over Rev reports, containing data over the period from March 10 to October 18, 2017.
- Daily Engine Usage reports, containing engine operating state information (off/idle/drive) over the period from August 17 to October 18, 2017.
- Diagnostic Records relating to the last three error codes recorded by the CPC4 module. All three occurred prior to the date of the accident. The most recent was timestamped September 16, 2017 at 04:27:34 EST,[4] and was associated with Diagnostic Code [4374/0] relating to a mismatch between pump speed and pressure.
- A set of vehicle parameters, including:
    - Engine speed limit while vehicle stopped == 3000 rpm
    - Maximum adjusted idle speed == 700 rpm
    - Minimum engine speed == 700 rpm
    - Limiter0 maximum engine speed enabled == 4000 rpm
    - Limiter0 maximum road speed enabled == 72.0014 mph
    - Limiter0 maximum vehicle acceleration == 10 m/s^2
    - Limiter1 maximum road speed enabled == 72.0014 mph
    - Limiter1 maximum vehicle acceleration == 10 m/s^2
- A set of trip data including:
    - Engine total hours of operation == 5455.10 hrs
    - High resolution total vehicle distance == 184964.3271 miles

[3] This corresponds to 06:17:00 EDT after correcting for clock delay and time zone.

[4] This corresponds to 06:13:11 EDT after correcting for clock delay and time zone.

The total engine time from the life-to-date report was found to be 5454.83 hours with an odometer of 184889.0 miles. This is generally considered to be the most accurate record of engine time and mileage.

Parameters recorded by the last stop record included: vehicle speed, engine RPM, throttle, engine load, brake application, and clutch application. The last stop record contained four data points covering the last three seconds immediately preceding the trigger time (t = 0). These indicated vehicle speed slowing from 17.5 mph, and engine RPM dropping from 716 to 109 rpm. This data is consistent with a momentary power interruption erasing accident information from the data buffer before being temporarily restored, causing a subset of new data to be written into the last stop record.

The full report generated by the ECM software is included in this report as Attachment 1.

3.2. Bendix EC60 ABS Device Description

The Bendix EC60 is an intelligent braking system controller that takes as input individual wheel speed and provides control signals to modulator valves used to control individual wheel speeds to improve vehicle braking and handling characteristics. The ABS controller used in the MCI motorcoach also supported features designed to provide automatic traction control (ATC), a proprietary electronic stability control system named Bendix® ESP®, and a proprietary collision mitigation system named Bendix® Wingman™. The Bendix Wingman™ is an active cruise-control with braking (ACB) system and a stationary object alert (SOA) system that combines the capabilities of the vehicle's cruise control, electronic stability program (ESP), roll stability program (RSP), and antilock braking system (ABS) with a radar sensor mounted on the vehicle's front bumper. Figure 4 shows the device as-received.

Figure 4. Bendix EC60 ABS as removed from the MCI motorcoach.

3.2.1. Bendix EC60 ABS Data Recovery

The EC60 was removed and sent to the Vehicle Recorder Lab for evaluation. An exterior inspection revealed the device had sustained no overt mechanical damage. The manufacturer's standard software[5] was used to obtain the EC60 Event report including active and inactive diagnostic trouble codes (DTC), ESP counters related to levels of electronic stability system engagement; and a basic Wingman™ report including active cruise with braking (ACB) status information.

3.2.2. Bendix EC60 ABS Data Description and Parameters Provided

The EC60 Wingman™ ACB Information indicated that Stationary Object Warning, Collision Mitigation Technology, and ABS Fusion Enabled flags were all in the *OFF* state.

The EC60 Event report recorded two diagnostic trouble codes potentially associated with the accident (see Table 1). Both DTCs were timestamped 5455.05 engine hours, and indicated occurrence at a power up time interval of 10 s – 15 min.

Table 1: EC60 EVENT HISTORY – INFO Events

Vehicle Speed	Description
61 mph	RSP Intervention
2 mph	Large Air Gap Detected

[5] Bendix® ACom® Diagnostic software.

The Bendix Wingman™ system is designed to record additional data in the event of an RSP Intervention DTC is triggered. This includes 20s of parametric data acquired at 2 Hz that records: vehicle speed, braking information, and steering input. Conversion of this parametric data into engineering units requires Bendix direct support, and will be the subject of a follow-on report.

The full report generated by the ACom® software – which includes an EC60 Event Report and a Wingman™ Report - is included in this report as Attachment 2.

3.3. TracManager Description

TracManager produces GPS tracking devices for fleet following and provides data services associated with this function. A small GPS receiver is installed with the vehicle to be tracked that communicates with TracManager company servers via wireless internet. This data can be accessed and viewed by any organization contracting with TracManager for services using a simple login available on the TracManager website. The web-based interface can provide a simple map overlay showing the track of the vehicle, along with a limited set of computed statistical information such as mileage, speed, and driving time. Track log information is also recorded on the servers and can be downloaded by the user, including: time, longitude, latitude, altitude, speed, and course.

3.3.1. TracManager Data Recovery and Description

Track log data was downloaded from the TracManager servers using Dhalia's standard login. A Google Earth plot of this data is given as figure 5. The track log started at 0611:19 EDT with the MCI motor-coach in the Dahlia yard. Thirty-five points were recorded over the course of the 22 minute, 25 second long track log. The update rate of the GPS track data varied from 1 point per second, to 1 point per 164 seconds. Speeds during the drive were below 30 mph until the vehicle crossed the bridge under the Van Wyck Expressway. Starting at 0615:46 EDT, as the vehicle crossed under the expressway and approached College Point Blvd, it began to accelerate to a recorded maximum of 61 mph just prior to the crash; which occurred at approximately 0616:10 EDT. The vehicle was travelling at an average of 60 mph for approximately 10 seconds prior to the crash. The system continued to send and record GPS data for about 17 ½ minutes after the crash with a spread of latitude / longitude positions consistent with standard GPS measurement accuracy. The last GPS position was recorded at 06:33:44 EDT.

The parameter data recovered from the TracManager system is included in this report as Attachment 3. Parameters include: time, longitude, latitude, altitude, speed, and course. All parameters except for speed and course are derived from GPS signal measurements. Speed and course are computed based on latitude, longitude, and time information.

3.4. Clever Devices IVN4 Description

The Clever Devices Intelligent Vehicle Network IVN4 is a fleet management system designed to support real-time vehicle tracking, messaging, voice and data communications between fleet vehicles and the command center. The system supports a data reporting function that can be accessed via a suite of web-based tools to generate

Event Reports for various events including last stop events. A typical event report includes time stamped: latitude, longitude, vehicle speed, engine speed, engine load, brake application, ABS activity, throttle position, ACTM[6] torque, and vehicle acceleration.

3.4.1. Clever Devices IVN4 Data Recovery and Description

The last stop reports were downloaded by NYMTA using the standard manufacturer software tools. These reports were timestamped 06:10:29 EDT and 06:11:36 EDT and were not related to the crash event. Damage to the MTA bus electrical system as consequence of the crash caused an uncoordinated shutdown of the IVN4 data collection system resulting in data corruption.

Clever Devices engineers in conjunction with the NYMTA recovered additional data recorded after the downloaded last stop reports. This data included 44 system messages that included timestamps and latitude / longitude information. GPS latitude / longitude information is plotted in figure 6 showing MTA transit bus position during the last 14 seconds of recovered data. The source of the timestamp information is being researched and timing correlation for this data will be the subject of a follow-on report.

4. OVERLAYS AND TABULAR DATA

Figure 5 shows the TracManager data related to the 2015 MCI J4500 motorcoach described in section 3.1.1 above. The recorded track is shown in red. The weather and lighting conditions depicted in this figure do not necessarily correspond with the weather and lighting conditions present at the time of the crash.

Figure 6 shows the Clever Devices data related to the 38-passenger MTA transit bus described in section 3.4.1 above. The recorded track is shown in blue. The weather and lighting conditions depicted in this figure do not necessarily correspond with the weather and lighting conditions present at the time of the crash.

[6] AC induction traction motor; related to operation of the vehicle transmission system.

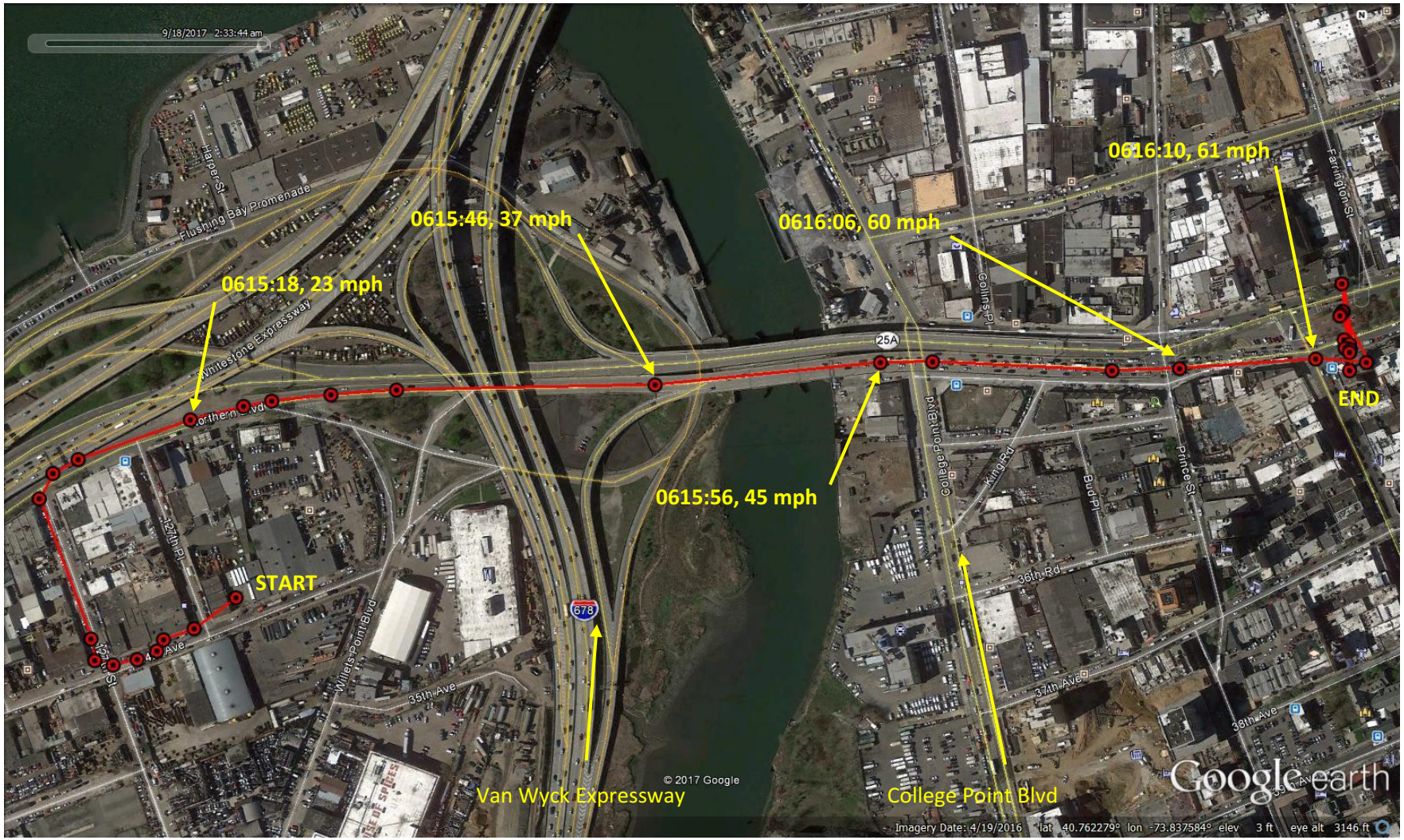

Figure 5. Google Earth overlay showing MCI motor-coach drive from Dhalia yard to crash site. Time is expressed in EDT

Figure 6. Google Earth overlay showing position of the MTA transit bus during the last seconds prior to the crash. Time is expressed in EDT.