



**HUMAN PERFORMANCE FACTORS GROUP CHAIRMAN'S
FACTUAL REPORT**

Mountain View, CA

HWY18FH011

(11 pages)



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

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A. CRASH INFORMATION

Location: Southbound US Highway 101 (US-101) south of North Shoreline Boulevard at the exit ramp transition to State Route 85 (SR-85), milepost 48.38, Santa Clara County, Mountain View, California.

Vehicle 1: 2017 Tesla Model X

Vehicle 2: 2010 Mazda 3

Vehicle 3: 2017 Audi A4

Date: March 23, 2018

Time: Approximately 9:27 a.m. PDST

NTSB #: **HWY18FH011**

B. HUMAN PERFORMANCE FACTORS GROUP

Donald F. Karol, National Resource Specialist, Group Chairman
NTSB Office of Highway Safety
490 L'Enfant Plaza East, S.W., Washington, DC 20594

C. CRASH SUMMARY

For a summary of the crash, refer to the *Crash Summary Report* in the docket for this investigation.

D. DETAILS OF THE HUMAN PERFORMANCE FACTORS INVESTIGATION

The Human Performance factual investigation focused on the behavioral, medical, and operational factors associated with the driver of the 2017 Tesla Model X. A detailed human performance factors investigation of the 2010 Mazda 3 and the 2017 Audi A4 drivers was not conducted. These drivers were involved in secondary collisions with the Tesla which was not a focus of the investigation.

1. Tesla Driver

1.1. Background

At the time of the crash, the Tesla Model X P100D car driver was 38 years old and was 5 feet 11 inches tall and weighed about 176 pounds.¹ He held a California Class C noncommercial driver license with no restrictions. Records indicate the driver had no traffic-related convictions and had not been involved in a reportable crash. His license had not been suspended, revoked, or denied. The driver resided in Foster City, California and worked as a software engineer for Apple corporation at 555 N. Mathilda Avenue, Sunnyvale, CA. The driver was married and had two young children (preschool and elementary school age).

1.2. Activities Prior to the Crash

The driver's normal routine would involve waking around 7:00 a.m. – 7:15 a.m. to make breakfast for his family.² Around 7:50 a.m. he would walk his daughter to a local elementary school. He would leave between 8:40 a.m. to 9:00 a.m. to drive his son to preschool. He would then drive to work by taking southbound US-101 to the Mathilda Avenue off-ramp. He finished work usually between 4:00 p.m. – 7:30 p.m. Upon returning home he would eat dinner, and around 8:30 p.m. would give his kids a bath. Around 9:20 p.m. he would read bedtime stories to his kids. After the kids went to sleep, he usually would relax, watch TV or play video games. He showered between 10:30 p.m. – 11:00 p.m. and went to sleep around midnight.

Table 1 describes the Tesla driver's activities during the week of March 19 – March 23. The activities are based upon interviews with family and co-workers, Apple building entry/exit data, AT&T cell phone records, and Tesla Carlog data which provided information regarding the movement of the vehicle.

Table 1. Car driver's activities prior to the crash.

Time	Activity	Source
Monday March 19, 2018		
7:00 – 7:15 a.m.	Awakes	Family interview
8:40 a.m.	Departs home to transport son to preschool	Carlog data
8:45 a.m.	Arrives at preschool in Foster City, CA	Carlog data
8:50 a.m.	Departs preschool to drive to work in Sunnyvale, CA	Carlog data
9:34 a.m.	Arrives at work in Sunnyvale	Carlog data
9:37 a.m.	Enters Apple facility	Apple building entry data
2:51 p.m.	Departs work to drive home	Carlog data
3:17 p.m.	Arrives home in Foster City	Carlog data
3:52 p.m.	Departs home for local trips in Foster City, CA area	Carlog data
4:37 p.m.	Arrives home in Foster City	Carlog data
12:00 a.m.	Went to sleep	Family interview

¹ Height and weight estimates based upon information on the driver's California Class C license.

² The family provided answers to questions related to the driver's background. The answers to questions were delivered by the family's attorney in a letter dated March 20, 2019. See Witness Group Attachment 2 – Family Response to Request for Information.

Tuesday March 20, 2018		
7:00 – 7:15 a.m.	Awakes	Family interview
8:45 a.m.	Departs home to transport son to preschool	Carlog data
8:52 a.m.	Arrives at preschool in Foster City	Carlog data
8:57 a.m.	Departs preschool to drive to work in Sunnyvale	Carlog data
9:52 a.m.	Arrives at work in Sunnyvale	Carlog data
9:55 a.m.	Enters Apple facility	Apple building entry data
7:31 p.m.	Departs Apple facility	Apple building exit data
7:35 p.m.	Departs work to drive home	Carlog data
7:59 p.m.	Arrives home in Foster City	Carlog data
12:00 a.m.	Went to sleep	Family interview
Wednesday, March 21, 2018		
7:00 – 7:15 a.m.	Awakes	Family interview
8:51 a.m.	Departs home to transport son to preschool	Carlog data
9:01 a.m.	Arrives at preschool in Foster City	Carlog data
9:07 a.m.	Departs preschool to drive to work in Sunnyvale	Carlog data
9:44 a.m.	Arrives at work in Sunnyvale	Carlog data
11:10 a.m.	Departs work to drive home	Carlog data
11:37 a.m.	Arrives home in Foster City	Carlog data
2:30 p.m.	Took Uber to San Francisco for Game Developer's Conference	Family interview
11:00 – 12:00 p.m.	Work colleague from Electronic Arts (EA) drove him home from conference and he went to sleep	Family interview
Thursday, March 22, 2018		
7:00 – 7:15 a.m.	Awakes	Family interview
8:54 a.m.	Departs home to transport son to preschool	Carlog data
9:00 a.m.	Arrives at preschool in Foster City	Carlog data
9:09 a.m.	Departs preschool to drive to work in Sunnyvale	Carlog data
10:07 a.m.	Arrives at work in Sunnyvale	Carlog data
10:12 a.m.	Enters Apple facility	Apple building entry data
5:43 p.m.	Departs Apple facility	Apple building exit data
5:45 p.m.	Departs work to drive home	Carlog data
6:12 p.m.	Arrives home in Foster City	Carlog data
7:07 p.m.	Incoming cell phone call from work supervisor	AT&T cell phone records
7:22 to 10:35 p.m.	34 incoming/outgoing text messages with supervisor	AT&T cell phone records
11:30 – 12:30 a.m.	Went to sleep	Family interview
Friday, March 23, 2018		
7:00 – 7:15 a.m.	Awakes	Family interview
8:46 a.m.	Departs home to transport son to preschool	Carlog data
8:53 a.m.	Arrives at preschool in Foster City	Carlog data
8:59 a.m.	Departs preschool to drive to work in Sunnyvale	Carlog data
9:27 a.m.	Crash – Mountain View, CA	Carlog data

1.3 Driver Health

According to the driver's family and co-workers, he was physically and mentally healthy. He did not smoke and did not take any prescription medications. He did not have any known health issues but did see a physician in the weeks prior to the crash for a cough. He was prescribed cough medication for his symptoms. On the days immediately preceding the crash the driver's cough had subsided.

The driver exercised regularly. Co-workers and family said he was an avid weightlifter and would work out regularly at the gym, usually during lunch time (12:00 p.m. – 1:00 p.m.). The family did not recall him ever hurting himself during workout routines other than occasional muscle soreness. He had no current major life stressors and enjoyed spending time with family and friends during his days off from work.

His vision and hearing were reported as being good. He had Lasik surgery about 3 years earlier and his vision was 20/20.

1.4 Post-Crash Toxicology

A post-mortem toxicology test was performed by analyzing a sample of the driver's blood.³ Alcohol, cocaine metabolites, methamphetamines, opioids, and phencyclidine were not detected. Additionally, a panel of acid-base-neutral drugs were tested, and no additional drugs were detected. Caffeine use was indicated. The drugs tested for included: Amitriptyline, Amobarbital, Bupropion, Bupropion metabolite, Butabarbital, Caffeine, Carisoprodol, Chlorpheniramine, Cocaine, Desipramine, Dextromethorphan, Diazepam, Diphenhydramine, Doxepin, Doxylamine, EDDP, EMDP, Fluoxetine, Glutethimide, Ibuprofen, Imipramine, Ketamine, Lidocaine, Meperidine, Meprobamate, Methadone, Methaqualone, Nordiazepam, Norpropoxyphene, Nortriptyline, Pentazocine, Pentobarbital, Phencyclidine, Phenobarbital, Phenytoin, Propoxyphene, Secorbarbital, Sertraline, and Vendafaxine.

1.5 Fatigue Factors

The driver received between 6 ½ to 7 ½ hours of uninterrupted sleep per night. His wife reported that he usually fell asleep immediately and would not wake in the middle of the night. He snored occasionally but has never been diagnosed as having a sleep disorder such as obstructed sleep apnea. His family and co-workers reported no signs or complaints of daytime sleepiness.

³ See Human Performance Attachment 1 – Post-mortem Toxicology Test Results

1.6 Route Familiarity

The driver was very familiar with the route of travel and the location of the crash. He began working at Apple in Sunnyvale, CA on November 13, 2017, and had been driving from Foster City to Sunnyvale for over four months, several times a week. His route of travel was to take US-101 southbound and exit at the Mathilda Avenue off-ramp which was about 2.5 miles south of the crash location. Figure 1 below depicts the route of travel from his residence in Foster City to the Apple facility on 555 N. Mathilda Avenue, Sunnyvale, CA.

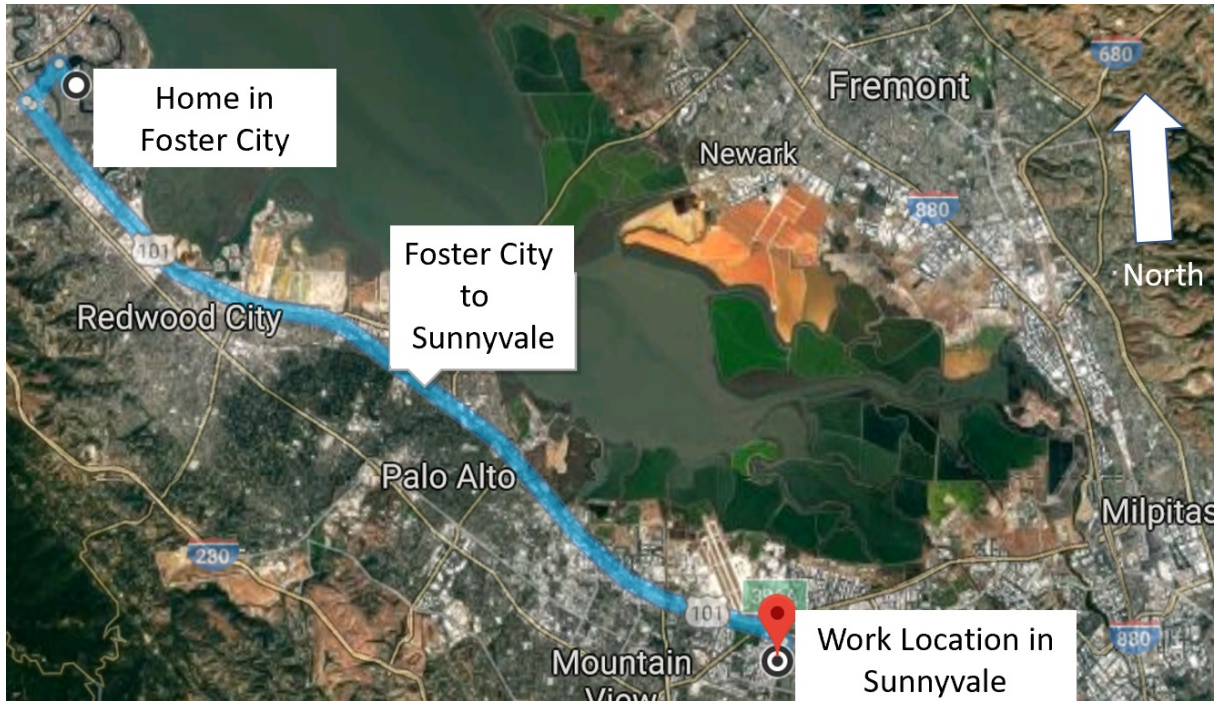


Figure 1 – Map showing route of travel from home to work (Source: Google Maps)

1.7 In-vehicle Distractions

The driver sustained fatal injuries and was unable to be interviewed regarding potential in-vehicle distractions. Two cell phones were recovered at the crash scene by the CHP. One phone, an Apple iPhone 8 Plus, was found among the debris on the highway and sustained major structural damage. The second phone, an Apple iPhone 10, was undamaged and found among the driver's personal belongings.

A review of cell phone records determined that the Tesla driver was using the Apple-owned iPhone 8 Plus during his trip to work.⁴ AT&T cell phone records showed the driver did not make any outgoing calls or texts during the time period while the Tesla was in motion from 8:59 a.m. to 9:27 a.m. during his trip to work.

The records did show evidence of data transmissions occurring while the vehicle was in motion. One data transmission showed a connection time of 9:26:48 – less than a minute before the crash (see Figure 2). In the 12 hours preceding the crash, the highest data usage (204 kilobytes per minute) was recorded during the 11 ½ minutes immediately preceding the accident.⁵

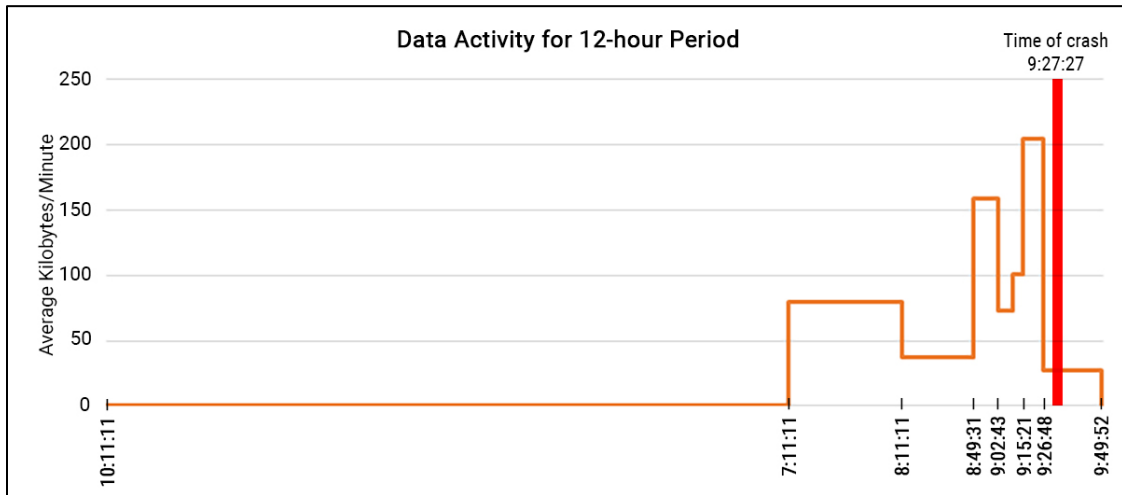


Figure 2 – Graph showing 12 hours of cell phone data usage by the Tesla driver

NTSB, with technical assistance provided by Apple, was able to retrieve some unencrypted CrashReporter logs from the Tesla driver’s Apple iPhone 8 Plus.⁶ Three logs recovered showed that a game application, “Three Kingdoms” mobile edition, was active during the driver’s trip to work. The game is a world building, strategy game with multi-player capability. When playing the game on a mobile device such as an iPhone 8 Plus, most players have both hands on the phone to support the device and manipulate game actions. The log data recovered does not provide enough information to ascertain whether the Tesla driver was holding the phone or how interactive he was with the game at the time of the crash.

⁴ See Cell Phone Records and Data Recovery Factual Report

⁵ AT&T provides general guidance regarding the amount of data used per type of activity. Estimated data usage for online game activity is about 200 kilobytes per minute which is consistent with the data transmissions recorded about the time of the crash.

⁶ See Cell Phone Records and Data Recovery Factual Report

1.8 Hands-off Wheel Driving

Tesla Carlog data shows that the ignition cycle that preceded the crash lasted about 28 minutes and 33 seconds.⁷ Autopilot was engaged for a total of 21 minutes and 53 seconds during the last ignition cycle (see Figure 3). During the final Autopilot segment, the system did not detect driver-applied steering wheel torque for 34.4 percent of the time.

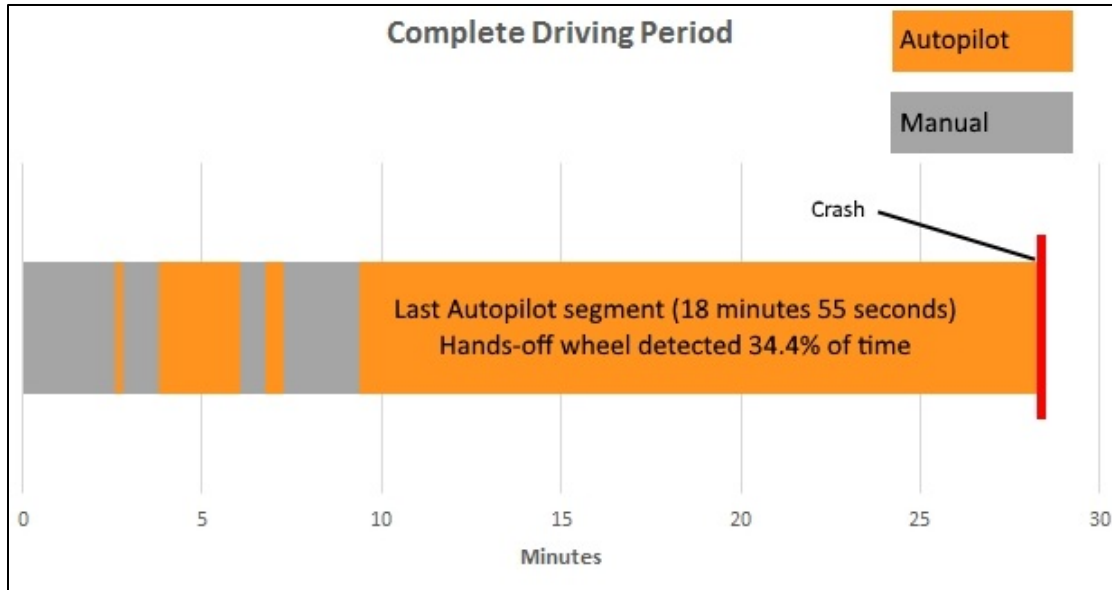


Figure 3. Depiction of manual and Autopilot controlled operation of the Tesla during the crash trip

The driver had Autopilot engaged continuously for the final 18 minutes and 55 seconds of the crash trip and was active at the time of the crash. During this last Autopilot segment, the system issued two visual alerts for hands-off driving operation and one first level auditory alert (see Figure 4).

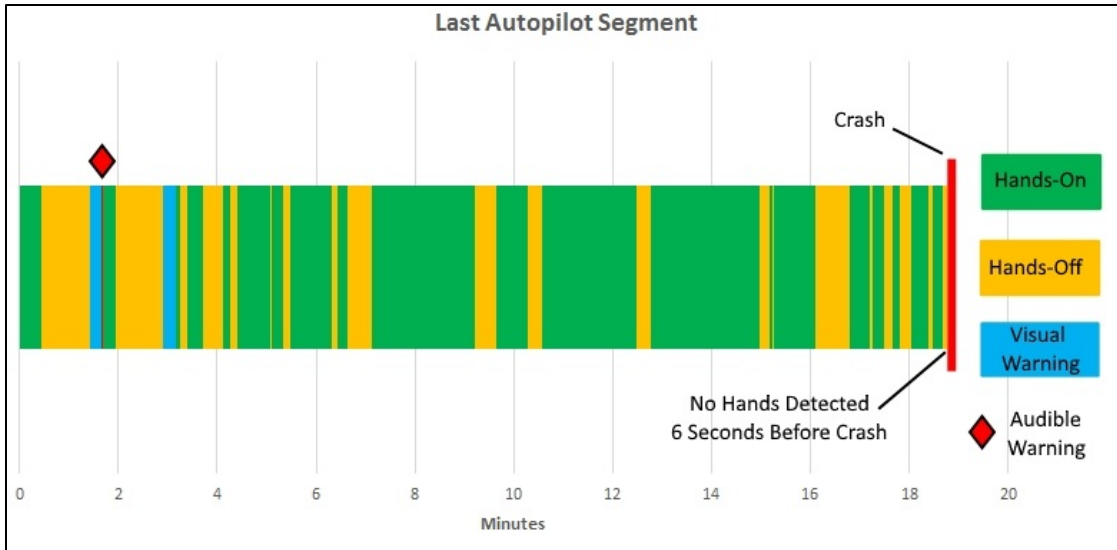


Figure 4. Depiction of the last Autopilot segment of the crash trip, including the warnings for hands-off driving operation

About 6 seconds before the crash, Autosteer did not detect driver applied steering wheel torque. This lack of hands-on detection continued until the time of the crash. During this phase of travel, the Tesla entered the gore area and traveled toward a previously damaged crash cushion with no evidence of braking or evasive steering action by the driver.

2. Vehicle Issues

2.1. Familiarity with Vehicle

The driver purchased the vehicle in October 2017, and received the vehicle at the Fremont, California Tesla dealership in November 2017. The family did not recall whether he received any training on the use of the Tesla ADAS functions, but his wife remembered the salesperson informing him the Autopilot system was not fully autopilot yet because of the “government.” She also remembered him being informed that the driver needed to keep his hands on the steering wheel while using Autopilot. The driver’s wife reported that he became very familiar with the use of the system and would watch YouTube videos on the Autopilot feature. He reportedly would use Autopilot when traveling to work and used the feature on a recent trip to Los Angeles, CA. His wife also reported that the car would emit an audible signal if the driver did not have his hands on the steering wheel when in Autopilot mode. The driver belonged to a Facebook Group called “Tesla Model X Owner’s Club” and would occasionally post about the vehicle’s features.⁸

⁸ A check of the Facebook Group Tesla Model X Owner’s Club showed that the driver joined the Group in December 2017. There were no messages made by the driver regarding any Autopilot or subsystem TACC/Autosteer malfunctions.

The driver's supervisor advised, during an interview, that the driver talked about the convenience the car provided and would frequently mention Autopilot. As a software engineer, the driver found the software behind a car that could drive itself interesting.

2.2. Driver Awareness of Vehicle Handling Issues at Crash Location

On Monday, March 26, 2018 (3 days following the crash), the team leader of the CHP's Multidisciplinary Accident Investigation Team (MAIT) visited the family of the Tesla driver and met with his wife and brother. A formal interview was not completed at the time, but the family related that the driver had experienced issues with the Autopilot steering system at the location of the collision on previous occasions. Many times, when the driver went past the crash location in the left lane, the Tesla would steer left toward the gore point area and he would have to manually take control to stay within the left lane. The family explained that it happened so often that he had told both his brother and his wife about the problem. One time, when the driver and his wife were traveling to the South Bay, he attempted to show her how the vehicle steered to the left as they passed the location but on that day the vehicle maintained its lane. The family added that the driver brought the Tesla to the service center in Sunnyvale for an issue with the rear Falcon style doors and advised the service technician of the problem with steering into the gore area.

On Tuesday, March 27, 2018, NTSB investigator Don Karol spoke with the driver's brother who reiterated the statement he provided to the CHP regarding problems with the Tesla's Autopilot system. The family provided follow-up information regarding the Autopilot statement in response to questions from the NTSB. In the response, the wife advised that the driver would usually experience problems with the Tesla steering to the left into the gore area during his morning trips to work.

On June 6, 2019, NTSB investigator Don Karol interviewed a witness who provided information regarding the Tesla's incursion into the gore area on March 19, 2018. The witness provided a screenshot of a text message sent to him on March 19th at 1:46 p.m., documenting the prior gore area incursion. NTSB reviewed the Tesla Carlog data for March 19, 2018 and confirmed that the Tesla Autosteer system made a left steering movement toward the gore area and the driver made a right corrective steering movement away from the gore during this prior incident.⁹

NTSB investigators reviewed 15 days of historical Tesla Carlog data and focused on the time period when the driver was making his trip to work. NTSB identified another similar incident on February 27, 2018. At about 9:31:30 a.m., the Tesla was being operated with Autopilot activated and the driver's hands were detected on the steering wheel. Autosteer applied a -6° steering wheel angle toward the gore area, which was followed two seconds later by a +1.3° corrective steering wheel angle away from the gore.

⁹ When the gore area incursion occurred on March 19, 2018, the Tesla driver had his hands on the steering wheel and responded within one second to the Autosteer left steering action.

E. DOCKET MATERIAL

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

LIST OF ATTACHMENTS

Human Performance Attachment #1 – Post-mortem Toxicology Test Results

END OF REPORT

Donald F. Karol
National Resource Specialist