PARTY SUBMISSION OF BOMBARDIER LEARJET

TO

THE NATIONAL TRANSPORTATION

SAFETY BOARD

Global Exec Aviation’s Learjet N999LJ

Columbia, South Carolina 19 September 2008
DCA-08-MA-098

I. EXECUTIVE SUMMARY

On September 19, 2008, about 2353 Eastern Daylight Time (EDT) at the Columbia Metropolitan Airport (CAE), Columbia, South Carolina, a Learjet Model 60, N999LJ, operated by Global Exec Aviation, after being cleared for takeoff on runway 11, overran the departure end of the active runway and was destroyed by impact forces and post-crash fire. During the accident investigation it was determined that the aircraft accelerated well beyond the recommended takeoff speed after experiencing tire failures starting approximately 2,300 feet into the takeoff roll. There is no data to indicate that the pilot in command attempted to rotate the aircraft for flight during the takeoff roll of over 8,600 feet. The two flight crewmembers and two of the four passengers received fatal injuries. The two surviving passengers received serious injuries. No one on the ground was injured. Weather was reported as clear with light winds. The flight was operated under 14 Code of Federal Regulations (CFR) Part 135 and had filed an instrument flight plan to Van Nuys airport (VNY), California.

Bombardier Learjet submits that the probable cause of this accident was the failure of the operator to maintain the aircraft in an airworthy condition resulting in the failure of all 4 main tires due to under-inflation, and combined with the failure of the Captain to continue the takeoff after reaching V1 speed.

Contributing factors to this accident were:

1. The resulting tire damage to the landing gear system components which caused degraded stopping performance and the uncommanded stow of the thrust reversers;
2. The Captain's non-standard takeoff briefing;
3. The flight crew's disagreement about continuing or rejecting the takeoff;
4. The Captain's non-standard abort procedure.

Key factors in this accident were:

1. The aircraft's tire life had already expired prior to the attempted takeoff and the tire failures were a direct result of the operator's failure to maintain the aircraft in airworthy condition in accordance with the tire manufacturer's servicing instructions, the Learjet 60 Airplane Maintenance Manual, and the FAA's Advisory Circular (AC) AC 30-97B with respect to tire pressure checking and servicing.

The significant under-inflation of the tires was validated from scuff marks on the inside of the inner liner of the tires discovered during laboratory tests conducted in conjunction with the NTSB investigation. As additional details were verified the NTSB's investigation concluded that tire pressures had not been checked for "about" three weeks prior to the accident flight and this length of time "would equate to ... about a 36% under-inflation".

2. The flight crew's failure to comply with the approved FAA Learjet Model 60 Airplane Flight Manual operating limitations, see Section VII, Attachment 1 of this Submission, coupled with their indecision on whether to abort the takeoff or continue in the critical seconds after the tire failures, created an unrecoverable runway excursion event. Furthermore, there is data suggesting that the accident airplane's takeoff weight was over the maximum authorized takeoff weight.

3. Bombardier Learjet aircraft performance data analysis indicates that the delayed initiation of the abort caused the aircraft to reach a speed of 27 knots above the abort decision speed while on the runway (the flight crew did not attempt to rotate) which further exacerbated the stopping performance of the aircraft.

II. FACTUAL INFORMATION

Overview: Prior to the runway excursion the flight crew experienced multiple challenges. After making an incorrect turn, ground control suggested an alternative routing to runway 11 which the flight crew accepted. While taxiing, the flight crew acknowledged they were "pretty heavy" when in fact there is data to suggest the aircraft could have been more than 300 pounds over the maximum takeoff weight. To further compound the situation, the Captain's non-standard takeoff briefing included a statement that she would abort after V1 for stated reasons. An abort above V1 is not a standard operating procedure nor is aborting at high speeds a best industry practice. Finally, and based on the cockpit voice recorder (CVR) analysis, the aborted takeoff procedure was not conducted in the correct order, nor in a timely manner.

A. Background

The National Transportation Safety Board (NTSB) investigators on the Operations Group traveled to Columbia (CAE), South Carolina, on Saturday, September 20, 2008, where they inspected the accident site, photographed the debris field, and gathered flight documents from the wreckage. The group conducted interviews with eyewitnesses of the accident flight, collected copies of flight crew records from the company, auditioned Air Traffic Control tower tapes, and conducted a preliminary review of the accident airplane weight and balance. The group conducted the field phase of the investigation from the NTSB command post at CAE, from September 21 to September 25.

After completion of the field phase of the investigation, the group conducted numerous interviews via telephone from NTSB headquarters. In addition to interviews, on-site meetings and conference calls, the group researched extensively the history of Model 60 tires, uncommanded / inadvertent thrust reverser stowage on Model 60 airplanes and flight crew training. As of October 13, 2009, the NTSB had published 35 documents relating to this accident on the Public Docket Management System at:

http://www.ntsb.gov/Dockets/Aviation/DCA08MA098/default.htm

These public documents validate in part the excellent safety record of the Model 60 Learjet and also, validate that the Model 60 Learjet meets the certification basis as mandated by the Federal Aviation Administration.

B. History of Flight

On September 12, 2008, on a scheduled flight departing from Teterboro Airport (TEB), Teterboro, New Jersey, the accident airplane had a dual bleed air overheat when a high pressure bleed valve stuck in the open position. The flight returned to TEB for repairs.

On September 18, 2008, the accident flight crew conducted a maintenance test flight in the accident airplane. The flight departed from Teterboro Airport (TEB) at about 1200 and returned to TEB. The duration of the flight was 48 minutes and the results were satisfactory.

On September 19, 2008, at about 2142, the accident flight crew and airplane departed TEB on a flight to reposition the airplane to Columbia Metropolitan Airport (CAE), Columbia, South Carolina, for a passenger flight to Van Nuys, California.

The accident airplane had arrived at CAE at about 2310. The accident captain who was flying in the right seat (first officer's seat) upon arrival at CAE exited the airplane and prepared the airplane fuel control panel for fueling while the accident first officer (flying in the left seat upon arrival at CAE) remained in the cockpit and obtained the flight clearance to Van Nuys airport from air traffic control at approximately 2312. Eyewitness accounts provided inconclusive evidence that the crew conducted a post flight walk around inspection after arrival at CAE.

The passengers arrived via ground transportation and the accident captain assisted with loading of baggage onto the airplane. According to one of the surviving passengers none of the passengers were asked their weight or the weight of their baggage. None of the passengers were physically weighed.

After fueling was completed, the accident first officer secured the fuel control panel and proceeded into the fixed base operator (FBO) building with the fueler to pay for the fuel. Eyewitness accounts provided inconclusive evidence that the crew conducted a preflight walk around inspection prior to the accident flight as required by Global Exec's operational specifications and the Airplane Flight Manual.

According to company records, the accident captain notified Global Exec Aviation via telephone at 2339 that they were about to start engines for departure. The engines were started and the first officer called Columbia ground control for a taxi clearance at 2346. Ground control asked the flight crew if they wanted to use runway 11 because of the wind direction and the flight crew acknowledged runway 11 for takeoff. Due to construction and taxiway closures, ground control issued a taxi clearance to runway 11 that required a right turn out of the ramp and across the north end of the closed runway (runway 5/23). At about 2349, the crew made a left turn out of the ramp towards runway 11/29.

Ground control observed the incorrect turn and offered the flight crew the option to back-taxi down runway 29 if they would be ready for an immediate departure. At 2350, the flight crew advised ground control they would be ready for departure and ground control issued a clearance to back taxi down runway 29 to the start of runway 11, and cleared them for takeoff on runway 11.

The flight crew taxied the airplane out of the ramp, back taxied down the runway and upon reaching the start of runway 11 the flight crew made a 180 degree turn into takeoff position and requested a wind check. The controller stated that the wind was from a direction of 070 at eight knots with gusts to 14 knots.

At 2355, the captain, who was the pilot flying (PF) began the takeoff roll. The controller said he saw the airplane begin its takeoff roll and that when the airplane was near where taxiway F intersected runway 11, he noticed sparks coming from the airplane. The controller said he thought the sparks were coming from the right main gear. He said from near taxiway F he did not see the airplane slow down on the runway. The controller said he did not see the nose of the airplane come up or "any attempt to takeoff". He said the airplane continued in a straight line right off the end of runway 11.

During the investigation, ground scars indicated that after departing runway 11, the airplane passed through the runway safety area, struck airport lighting structures, navigation facilities, the perimeter fence and some concrete posts outside the airport property. The airplane then crossed a road, struck an embankment, and came to a stop. The two crewmembers and two of the four passengers were fatally injured, and two passengers received serious injuries. The airplane was destroyed by post-crash fire.

a) Notification

Bombardier Learjet was notified of the occurrence on September 20, 2008. A team including two technical investigators and an operational investigator was dispatched to the scene to assist the NTSB during their investigation.

b) Flight Crew Information

At the time of the accident the Captain had logged 8 flight hours as pilot in command in a Learjet Model 60 and the first officer had logged 192 flight hours as pilot in command in a Learjet Model 60. The Global Exec Director of Operations stated that the flight crew flew together for the first time on April 8, 2008 [the crewmember logbook indicates that this flight actually took place on August 16, 2008], on a flight from Tucson International Airport (TUS), Tucson, Arizona to Long Beach Airport (LGB), Long Beach, California. The flight to LGB was 1.3 hours. They next flew together again the day before the accident on a maintenance test flight on the accident aircraft. The flight crew flew together for a third time on the day of the accident to reposition the aircraft from TEB to CAE.

The captain of the accident flight was hired by Global Exec Aviation on January 4, 2008. The NTSB interviewed Global Exec Aviation's Director of Operations who stated that the accident captain came to Global Exec Aviation with excellent references and recommendations. Her pilot certificates and ratings included Certified Flight Instructor (issued September 30, 2006) and Airline Transport Pilot (issued January 19, 2008). She was type rated in the CE-500, CE-560XL, LR-60 and the CE-650. Her first class medical certificate was issued on April 29, 2008 with a limitation: "Holder shall wear corrective lenses." Global Exec Aviation Crewmember Logbook Report indicated that she had logged 2.0 nighttime flight hours as pilot in command time during the previous 90 days and recorded 2 night takeoffs and 3 night landings. Simulator time was not included in the Logbook Report.

The first officer of the accident flight was hired by Global Exec Aviation on August 8, 2008. His pilot certificates and ratings included Airline Transport Pilot (issued March 1, 2007) and type rated in the CE-500 and LR-60. His first class medical certificate was issued on July 18, 2008 with a limitation: "Must wear corrective lenses; Possess Glasses for Near/Intermediate Vision." Global Exec Aviation Crewmember Logbook

Report indicated that he had logged 0.0 nighttime flight hours as pilot in command time during the previous 90 days and recorded 0 night takeoffs and 0 night landings. Simulator time was not included in the Logbook Report.

During the NTSB interview of the Global Exec Aviation's Director of Operations he stated that the first officer was hired as a part time pilot to fly as a first officer. The accident first officer had no flight training on the Learjet Model 60 under Global Exec's training program. The first officer had Learjet 60 pilot in command and second in command flight training and a Part 135.293 competency check at his previous company which Global Exec Aviation and the FAA accepted.

c) Weight and Balance

Bombardier Learjet's aircraft weight analysis (see Section VII, Attachment 2 of this Submission) suggests that the aircraft was substantially overweight with respect to both ramp weight and takeoff weight.

1. The NTSB Group Chairman's Factual Report of Operational Factors/Human Performance, subparagraph 3.0, states in part that the weight and balance manifest was destroyed by post crash fire and without exact weights, "it could not be stated whether the accident airplane was within weight and balance limits".

2. NTSB Form 6120.1 assumed that the maximum gross weight of the accident airplane was 23,500 pounds at the time of the accident and that the center of gravity was 23% Mean Aerodynamic Chord (MAC).

3. Global Exec Aviation was authorized by Operations Specifications Paragraph A096 to use "only actual weights" when determining the airplane weight and balance." A096 states in part:
    a. The certificate holder is authorized to use only actual weights when determining the aircraft weight and balance.
        i. This includes the passenger weights, carry-bag weights, checked bag weights, plane-side loaded bag weights, and heavy bag weights, and/or
        ii. Actual weights of all passengers and bags or solicited ("asked") passenger weight plus 10 pounds and actual weight of bags.

4. The FBO refueler stated that the accident captain told him to top off the fuel which he did. Fuel on board would have been about 7800

pounds prior to engine start according to the Airplane Flight Manual.

5. The Basic Empty Weight of the accident airplane was 14,755 pounds as of September 2, 2008.

6. The Operating Empty Weight of the accident airplane including the crewmembers and provisions is estimated at 15,380 pounds.

7. The weight of the four (4) passengers and baggage is estimated at 795 pounds placing the total ramp weight at approximately 23,975 pounds:

   - The Airplane Flight Manual states that the maximum ramp weight is 23,750 pounds.

   - The Airplane Flight Manual states that the maximum takeoff weight is 23,500 pounds.

   - The estimated takeoff weight of the accident airplane would have been approximately 23,825 pounds, 325 pounds over the maximum authorized takeoff weight.

8. Part 135 operators who operate multiengine aircraft are required by 14 CFR § 135.63 to prepare a load manifest in duplicate for each flight conducted. One copy of the load manifest must be carried in the airplane. Copies of these load manifests must be retained by the operator for at least 30 days at the operator's principal base of operations or at another location approved by the FAA.

   A load manifest must contain the following information:

   - Total number of passengers
   - Total weight of the loaded aircraft
   - Maximum allowable takeoff weight for that flight
   - Center of gravity limits
   - Center of gravity of the loaded aircraft or an entry on the manifest that the aircraft center of gravity is within limits according to an approved loading schedule or method
   - Aircraft registration number (N-number) or flight number
   - Origin and destination of the flight
   - All crewmember names and position assignments

9. Location of the duplicate copy of the load manifest for the accident airplane as dictated by 14 CFR 135.63 is unknown.

d) Preflight Inspection

Eyewitness accounts provided inconclusive evidence that the flight crew conducted a post flight walk around inspection after arrival at CAE or a preflight walk around inspection prior to the accident flight.

The Global Exec Aviation Operations Manual Section 10 – Normal Operating Procedures, paragraph 6 – Preflight Inspection, page 10-3 dated 3/01/07 (REV 0) stated in part: "In the case of a multi-leg trip, a preflight inspection will be performed prior to each leg. A walk-around inspection of the aircraft will be performed prior to each flight."

Interviews conducted with the Director of Operations and flight crew members at Global Exec Aviation indicated that the company procedure was to conduct airplane preflight walk around procedures while referencing the Bombardier Learjet 60 Crew Checklist and Quick Reference Handbook. The Bombardier Learjet 60 Crew Checklist and Quick Reference Handbook chapter N – Normal Procedures – Exterior Preflight, page N-3 and N-4 dated February 1999 stated in part with respect to wheels, tires and brakes:

25. Right Main Strut & Wheel Well………………CHECK
26. Right Main Landing Light & Doors…………..CHECK
27. Right Main Wheels, Tires & Brakes…………CHECK
60. Left Main Strut & Wheel Well………………...CHECK
61. Left Wheels, Tires & Brakes………………….CHECK

"Normal Procedures" was interpreted by flight crews and instructors to mean a visual inspection of the "general condition" of the tires and components to determine if there was excessive wear, sidewall bulges, visible tire cord, or noticeable under inflation of the tires. There was disagreement by those interviewed as to whether under inflation of the airplane tires could be detected by visual inspection if the inflation was "significant".

The first leg of the accident aircraft on September 19, 2008, was flown under 14 CFR Part 91. Federal Aviation Regulations part 91.7, Civil Aircraft Airworthiness, stated in part: "(a) No person may operate a civil aircraft unless it is in an airworthy condition. (b) The pilot in command of a civil aircraft is responsible for determining whether that aircraft is in condition for safe flight. The pilot in command shall discontinue the flight when unairworthy mechanical, electrical, or structural conditions occur."

The second leg of the accident aircraft on September 19, 2008, was to be flown under 14 CFR Part 135. Federal Aviation Regulations part 135.25 Aircraft requirements (A), stated in part: "no certificate holder may operate an aircraft under this part unless that aircraft – (2) Is in an airworthy condition and meets the applicable airworthiness requirements of this chapter, including those relating to identification and equipment."

It should be noted that checking tire pressure on the transport category Learjet Model 60, is considered preventive maintenance according to a legal opinion of the FAA's Office of the Chief Counsel and not a simple preflight inspection task. The FAA's position on checking tire pressure on transport category airplanes, specifically the Learjet Model 60, is that under 14 CFR 43.4(g), for aircraft not operated under part 121, 129 or 135 (e.g., part 91), a pilot may perform preventive maintenance including checking tire pressure on an aircraft operated by that pilot under 14 CFR Part 91. Pilots operating under 14 CFR 135 cannot perform preventive maintenance on an aircraft operated by that pilot including checking tire pressure without the certificate holder obtaining an exemption from the FAA. Global Exec Aviation did not have an exemption for their pilots to check tire pressure nor a maintenance schedule in place to routinely check tire pressure in accordance with recommended guidance material from the tire manufacturer, the airplane manufacturer and the FAA.

In an interview statement, the Director of Operations for Global Exec Aviation stated that "….maintenance checked the tire pressure as part of normal maintenance and that there was no requirement for crews to check the tire pressure". As noted earlier in this submission the NTSB's Factual concluded that tire pressures on the accident aircraft had not been checked for "about" three weeks prior to the accident flight and this length of time "would equate to …….. about a 36% under-inflation".

e) Taxi

The Global Exec Aviation Operations Manual Section 10 – Normal Procedures, paragraph 14 – Taxiing, page 10-6 dated 3/01/07 (REV 0) stated in part:

> *The FAA strongly recommends that training in runway safety and the specific SOP's contained in AC 91-73 and 20-74 be incorporated into Company operations including, but not limited to:*
>
> - *Read back all runway crossing and/or hold short instructions*
> - *Review airport layouts as part of preflight planning and before descending to land, and while taxiing as needed*
> - *Review Notice to Airmen (NOTAM) for information on runway/taxiway closures and construction areas*
> - *Do not hesitate to request progressive taxi instructions from ATC when unsure of the taxi route*

- *Check for traffic before crossing any runway hold line and before entering a taxiway*
- *Turn on aircraft nav lights and rotating beacon while taxiing*
- *Study and use proper radio phraseology as described in the Aeronautical Information Manual in order to respond to and understand ground control instructions*
- *Write down complex taxi instructions at unfamiliar airports*

At 23:46:45.1 the accident flight crew received clearance from Columbia ground control to taxi from Columbia Aviation to runway 11 via taxiway U and across runway 23 at the approach end of runway 23. Due to construction and taxiway closures, ATC issued a taxi clearance to runway 11 that required a right turn out of the ramp and across the north end of the closed runway (runway 5/23).

The cockpit voice recorder (CVR) captured the following conversations in the accident aircraft during taxi from the FBO to the departure runway:

AT 23:45:17.8: Captain: “parking brake is released.”

AT 23:45:20.8: Captain: “don’t know what time the tower close(es) ah it’s still open.”

AT 23:45:27.0: Captain: “thinkin’ I wanna go out this way still or can I go straight out here?”

AT 23:45:29.4: F/O: “I think we can go straight nineteen five and twenty one nine.”

AT 23:45:33.7: F/O: “ah which way do you use?”

AT 23:45:35.7: Captain: “I w- I use two.”

AT 23:45:37.2: F/O: “okay.”

AT 23:45:37.8: Captain: “yeah then I put the departure frequency over here so I can see it. And.”

AT 23:45:41.7: F/O: “see I do it just the opposite or we do it yeah.”

AT 23:45:43.2: Captain: “[sound of laugh] I don’t care what you do just tell me.”

AT 23:45:45.4: F/O: “I don’t either. Let me just get the ah what did you do with the flight plan?”

AT 23:45:49.4: Captain: “It’s on the board there’s a clipboard on your side there."

AT 23:45:50.9: F/O: " 'kay."

AT 23:45:52.3: F/O: "let me just double check the frequency for that."

AT 23:45:56.0: F/O: "thirty three four."

AT 23:45:57.5: Captain: "and was that squawk right?"

AT 23:45:58.1: F/O: "yes it's ah huh thirty three four and ten oh three so no."

AT 23:45:59.3: Captain: "I'm sorry okay."

AT 23:46:02.5: F/O: "oh oops thirty three four we'll leave it there and ten zero three. One zero zero three."

AT 23:46:12.8: F/O: "okay initial altitude is ah four thousand expect forty in ten."

AT 23:46:16.5: Captain: "okay perfect"

AT 23:46:17.3: F/O: "okay well that's good."

AT 23:46:19.1: F/O: "so here we go you ready?"

AT 23:46:20.9: Captain: "I'm ready."

AT 23:46:21.9: F/O: "what's the name of this joint?"

AT 23:46:23.3: Captain: "oh [expletive deleted] I f- Columbia."

AT 23:46:24.8: F/O: "Columbia."

AT 23:46:25.6: Captain: "I keep forgetting where we are on the way in."

AT 23:46:29.9: F/O: "Columbia ground Lear triple nine Lima Juliet Columbia Aviation with the ATIS taxi."

AT 23:46:38.1: Ground Control: "calling ground say it again please?"

AT 23:46:41.2: F/O: "it's Lear ah triple nine Lima Juliet Columbia Aviation Victor taxi."

AT 23:46:45.1: Ground Control: "Lear triple nine Lima Juliet Columbia ground ah roger taxi to runway two niner via taxiway Uniform actually the wind zero seven zero at seven gust one six altimeter three zero two one you wanna go out to one one?"

AT 23:47:01.1: F/O: "whaddya want?" to the Captain."

AT 23:47:01.5: Captain: "gust to two one?"

AT 23:47:02.5: F/O: "yeah we better do that."

AT 23:47:04:4: Ground Control: "roger taxi to runway one one via Uniform cross the approach end of two three to taxiway November to taxiway Alpha and ah taxi runway one one via Alpha."

AT 23:47:16.7: F/O: "okay Uniform November Alpha ah to one one ah triple nine Lima Juliet."

AT 23:47:21.1: Captain: "and hold short of two two I think it was."

AT 23:47:24.0: F/O: "I think he said we could cross it Uniform November Alpha to one one."

AT 23:47:24.9: Captain: "oh did he?"

AT 23:47:29.5: Captain: "and we're going right outta here, correct?"

AT 23:47:31.4: F/O: "ah well I think we have to go left outta here don't we?"

AT 23:47:35.6: Captain: "oh if we're going back over the end of that runway yeah, yeah."

AT 23:47:36.8: F/O: "we're go- we're gonna go back to the runway we landed on."

AT 23:47:40.3: F/O: "so. Alright where'd it go here it is."

AT 23:47:51.0: F/O: "alright. Let's go ah."

AT 23:47:52.0: Captain: "[unintelligible word]"

AT 23:47:54.7: Captain: "ready?"

AT 23:47:55.2: F/O: "ah huh."

AT 23:47:59.7: F/O: “so we go straight out here into Uniform and make a left.”

AT 23:48:28.8: F/O: “my head’s down here.”

AT 23:48:30.3: Captain: “okay. Doin’ left on Uniform here.”

AT 23:48:33.8: F/O: “yeah.”

AT 23:48:37.8: F/O: “this is Uniform.”

AT 23:48:49.2: F/O: “Uniform November Alpha.”

AT 23:48:51.4: Captain: “(two unlocks) two deploys.”

At about 2349, the crew made a left turn out of the ramp towards runway 11/29. Ground control observed the incorrect turn and offered the crew the option to back-taxi down runway 29 if they would be ready for an immediate departure.

AT 23:49:19.1: Ground Control: “Learjet ah I think did you ah oh I think you’re on Uniform there you need to go the other way on Uniform ah and cross the approach end of two three actually ah yea you’ll need to you’ll need to make a ah hundred and eighty degree turn looks like you’re on Uniform goin’ out towards two nine.”

AT 23:49:36.5: F/O: “yeah we are on Uniform so one eight on Uniform and back Uniform November alpha right?”

AT 23:49:42.1: Ground Control: “and I’ll tell ya what just hold your position there I’m gonna see if I can back-taxi on ah runway two nine to one one actually we can ah you ready to ready to go?”

AT 23:49:46.6: F/O: “stop here.”

AT 23:49:51.6: F/O: “ah that’s affirmative.”

AT 23:49:52.7: Ground Control: “alright you can back taxi the whole way down runway one one and once you get ah to the west ah end of runway one one then make a hundred and eighty degree turn ah turn right heading one five zero and runway one one you’re cleared for takeoff.”

At about 2350, the crew advised ground control they would be ready for departure and ground control issued a clearance to back taxi down runway 29 to the start of runway 11, and cleared them for takeoff on runway 11.

> AT 23:50.07.2: F/O: “okay we’ll back taxi ah the full length one one then cleared for takeoff ah one five zero d- degree heading on departure ah nine Lima Juliet.”

> AT 23:50:15.3: F/O: “[expletive deleted]”

> AT 23:50:24.8: Captain: “alright light me up please.”

> AT 23:50:27.3: F/O: “we are as much as we can with this thing.”

> AT 23:50:35.9: F/O: “okay right turn all the way down one eighty and back cleared for takeoff at the other end you have brakes and steering I see.”

> AT 23:50:45.4: Captain: “yup (I’m gonna).”

> AT 23:50:46:0: F/O: “reversers you did.”

> AT 23:50:47.2: Captain: “stay off the lights right here yeah reversers are done.”

> AT 23:50:50.9: F/O: “’kay.”

> AT 23:51:04.8: F/O: “’kay one one eighty six hundred feet long.”

> AT 23:51:18.8: F/O: “okay so brake steering reversers you did just a crew briefing.”

Just prior to takeoff, the captain gave a non-standard takeoff briefing to the first officer. Her briefing was captured on the CVR.

> AT 23:51:22.3: Captain: “okay ah we’ve got plenty of runway so we’ll abort for anything below eighty knots after V-one and before V-two engine failure fire malfunction loss of directional control all the big things after V-two we’ll go ahead and take it into the air treat it as an in flight emergency I think this is probably a pretty good option to come back to unless we have like a complete a hydraulic failure or something and ah then we’ll look for a longer runway nearby probably Charleston ahm after takeoff it was heading one five zero up to four thousand.”

> AT 23:51:53.8: F/O: “correct.”

> AT 23:51:54.0: Captain: “correct? Any questions comments

concerns?”

AT 23:51:56.6: F/O: “ah just it’s ah wha- reference the ah between eighty and an V one you’re only ah aborting for the fire failure loss of directional control?”

AT 23:52:06.0: Captain: “yes.”

AT 23:52:06.6: F/O: “’kay ah alrighty we’re ah.”

AT 23:52:09.8: Captain: “or an inadvertent thrust- ah T-R deployment.”

AT 23:52:12.4: F/O: “’kay.”

AT 23:52:14.6: F/O: “that will reverse in the rev- that will ah cause the loss of directional control I guess.”

AT 23:52:18.5: Captain: “exactly hah they go together.”

AT 23:52:25.8: Captain: “which I think kinda like what you’re talking about, any red light that can be so many things ya know?”

AT 23:52:31.4: F/O: “well eh if the runway is long I abort but if it’s short I kinda do different briefing depending on the what the length of the runway is but we’re pretty heavy so it’s probably not a bad idea.”

AT 23:52:41.3: Captain: “yeah.”

AT 23:52:47.0: F/O: “you know what I mean?”

AT 23:52:47.8: Captain: “yeah.”

AT 23:53:40.4: F/O: “here we are.”

AT 23:53:57.8: Captain: “do your brakes squeak like this?”

AT 23:53:59.6: F/O: “it’s not the brakes it’s the, the air being released so yes most- they all do.”

The flight crew made a 180 degree turn into takeoff position and requested a wind check. The tower controller stated that the wind was from a direction of 070 at eight knots with gusts to 14 knots.

f) Takeoff Procedures

Take off briefing: The Global Exec Aviation Operations Manual Section 10 – Normal Operating Procedures, paragraph 6 – Preflight Inspection, page 10-7 dated 3/01/07 (REV 0) stated in part:

> *Takeoff briefings will be conducted by the Pilot Flying (PF) prior to each takeoff.*
>
> *Takeoff may be a full or abbreviated briefing at the discretion of the PIC. Generally, a full briefing will be conducted for the first flight of the day for a particular crew pairing. A full briefing will include the following:*
>
> *a) Abort procedure prior to V1,*
> *b) Procedure to be followed in case of a problem after V1,*
> *c) Minimum safe altitude for flap retraction / running checklist,*
> *d) Emergency return plan,*
> *e) And the normal takeoff plan (initial departure procedure, altitude, squawk, and departure frequency).*
>
> *An abbreviated briefing will include the words "standard brief" and will include letters c. thru e. above.*

At 23:51:22.3 the cockpit voice recorder captured the take off briefing:

> *Captain:* "okay ah we've got plenty of runway so we'll abort for anything below eighty knots after V-one and before V-two engine failure fire malfunction loss of directional control all the big things after V-two we'll go ahead and take it into the air treat it as an in flight emergency I think this is probably a pretty good option to come back to unless we have like a complete a hydraulic failure or something and ah then we'll look for a longer runway nearby probably Charleston ahm after takeoff it was heading one five zero up to four thousand."

Takeoff Procedures: Normal takeoff procedures were contained in the Global Exec Aviation Part 135 Training Program Manual Appendix Learjet 60, and the Flight Safety International Learjet 60 Pilot Training Manual. Both manuals were issued to crewmembers.

The Flight Safety Pilot Training Manual, Chapter Maneuvers and Procedures, page MAP-4 states in part:

> *Takeoff Procedures*
>
> *When cleared for takeoff the PF calls for Runway Lineup Checklist. The Pilot Not Flying (PNF) reports, "Runway Lineup Checklist complete, cleared for takeoff." The PF advances power to the takeoff thrust detent. The PNF confirms the N1 setting matches the N1 bug.*

At V1 speed, the PNF calls, “V1”. The PF releases the thrust levers and puts both hands on the control column.

At Vr the PNF calls “rotate”. The PF rotates the airplane to a 9 degree nose-up pitch attitude.

The Flight Safety International Learjet 60 Pilot Training Manual, Chapter Maneuvers and Procedures, page MAP-11 contains a pictorial representation of the normal takeoff profile that is compatible with the one contained in the Global Exec Aviation Training Program Manual listed previously.

The accident first officer had no flight training on the airplane under Global Exec’s training program. The first officer had Learjet 60 pilot in command and second in command flight training and a Part 135.293 competency check at his previous company which Global Exec Aviation and the FAA accepted.

The cockpit voice recorder (CVR) captured the following flight crew conversations in the accident aircraft during takeoff on runway 11:

AT 23:54:13.5: F/O: “okay we’re cleared for takeoff cabin air is on transponder on anti-collision rec lights on and on ignitions pitot heats auto-spoilers on on armed ah anti-ice not required warning panels are normal for the conditions APR on the roll cleared for takeoff.”

AT 23:54:26.7: Captain: “okay would you get me a wind check again real quick?”

AT 23:54:29.0: F/O: “nine Lima Juliet wind check?”

AT 23:54:29.2: Captain: “do you remember what it was?”

AT 23:54:32.4: Captain: “guys all set?”

AT 23:54:32.8: Ground Control: “wind zero seven zero at eight gust one four.”

AT 23:54:35.2: F/O: “thank you sir.”

AT 23:54:36.5: Captain: “zero one zero at eight?”

AT 23:54:37.7: F/O: “ah huh.”

AT 23:54:38.4: Captain: “’kay, so pretty much straight down.”

AT 23:54:47.9: F/O: "'kay ah takeoff detent."

AT 23:54:49.5: [sound of increasing background noise].

AT 23:54:50.8: F/O: "power's set."

AT 23:54:53.7: F/O: "two good engines airspeed's alive both sides APR is armed."

AT 23:55:00.1: F/O: "eighty knots, crosscheck."

AT 23:55:02.1: Captain: "check."

AT 23:55:10.5: F/O: "V-one."
AT 23:55:12.0: [beginning of loud broadband rumbling].

AT 23:55:12.4: F/O: "go."

AT 23:55:12.8: Captain: [unintelligible].

AT 23:55:13.0: F/O: "go go go."

AT 23:55:13.7: [sound similar to metallic click].

AT 23:55:14.0: Captain: "go?"

AT 23:55:14.6: F/O: "no? ar- alright. Get ah what the [expletive deleted] was that?"

AT 23:55:15.1: [sound similar to metallic click].

AT 23:55:17.0: Captain: "I don't know. We're not goin' though."

AT 23:55:18.4: [sound similar to metallic click].

AT 23:55:19.5: Captain: "pull out." [later interpretation corrected this to "full out."]

AT 23:55:20.3: [high frequency sound consistent with brake pedal application].

AT 23:55:21.5: [sound similar to nose-wheel steering disconnect warning tone].

AT 23:55:27.7: Captain: [expletive deleted].

AT 23:55:28.7: F/O: “shut ‘em off.”

AT 23:55:29.5: Voice not identified: “what is goin’ on here?”

AT 23:55:30.8: [unintelligible vocalizations].

AT 23:55:32.4: F/O: “they’re shut off they’re shut off.”

AT 23:55:35.5: Captain: [expletive deleted].

AT 23:55:36.0: F/O: “roll the equipment we’re goin’ off the end.”

AT 23:55:38.5: Captain: “how many?”

AT 23:55:39.5: [End of transcript].

AT 23:55:41.1: [End of recording].

g) Aborted Takeoff Guidance

Guidance for an aborted takeoff is contained in the Learjet Model 60 Airplane Flight Manual and the Crew Checklist and Quick Reference Handbook. The following procedures are provided:

1. **Brakes – APPLY**
2. **Thrust Levers – IDLE**
3. **Spoilers – EXT**
4. Thrust Reversers – As Required*

* Items 1 thru 3 are considered memory items for the pilot.

Interviews with Global Exec Aviation pilots, as well as Learjet 60 instructors, pilots, and industry professionals indicated that all used nearly the same criteria to determine whether or not to abort a takeoff. During the low speed regime up to 80 knots, pilots interviewed stated that they would abort the takeoff for any abnormal or emergency event. During the high speed regime, from 80 knots up to V1, the pilots would abort the takeoff only for an engine fire, engine failure, an engine thrust reverser deployment, or a loss of directional control. Some of those interviewed indicated they would consider abnormal acceleration or deceleration elements of directional control. Above V1 speed, the takeoff would be continued. Relevant excerpts from the Airplane Flight Manual are provided in Section VII, Attachment 3 of this Submission.

h) Inadvertent Stow of Thrust Reverser after a Crew-Commanded Deployment Procedure

The Model 60 thrust reverser (T/R) system was built by NORDAM and typical of a bucket-style system, actuated by a four-bar linkage set. The control of the T/R in the Model 60 was the first Learjet thrust reverser system to use a fully electronic control, with no physical connections to the engine to physically retract the throttle levers.

During normal operation of the engine thrust reversers, there are six flight deck annunciator lights (three for each of the left and right thrust reversers) associated with the system to provide information to flight crews regarding the status of the engine thrust reversers.

The green TR ARM (Thrust Reversers Armed) lights indicate that the prerequisite conditions are met and hydraulic pressure is available to deploy the respective thrust reverser. The TR ARM lights illuminate when (1) the aircraft is on the ground with both squat switches indicating weight on wheels (this is known as the ground mode), (2) the respective engine thrust lever is in the idle position, and (3) hydraulic pressure is available at the respective deploy valve. Raising the respective engine thrust reverser lever to the deploy detent allows application of hydraulic pressure to unlock the engine reverser doors and illuminates the respective amber TR UNLOCK (Thrust Reverser Unlocked) light. When the engine thrust reverser doors are fully deployed, in a position to provide reverse thrust, a signal is sent to extinguish the respective amber TR UNLOCK light and illuminate the respective white TR DEPLOY (Thrust Reverser Deployed) light.

The left and right T/Rs are independent with respect to operation, although there are shared pre-conditions for operation. For example, both T/Rs must be in the deployed position before either engine can increase to more than idle power.

Initiation of T/R deployment requires that both main gear squat switches must be in the ground mode. To deploy a given thrust reverser, the thrust lever associated with the given thrust reverser must be in the idle position prior to raising the reverser lever. To get a given reverser into the fully-deployed position requires left and right squat switches in the ground mode, the respective thrust lever at idle, the respective reverse lever lifted to the deploy position, hydraulic power available to the respective hydraulic control unit (HCU), the respective hydraulic pressure switch in the pressure-sensed position, and the associated isolation valve, deploy valve, and actuator being energized so as to move the buckets to the fully-deployed position.

The T/Rs are controlled by the T/R Relay Boxes, which are independent from engine control. The interface between the thrust reverser system and the full authority digital engine control (FADEC) is to signal when the FADEC should use the reverse thrust schedule and to respond to the reverse lever movement for the amount of reverse thrust, including idle.

The thrust reverser control is designed to prevent deployment in flight. Each thrust reverser is independently controlled. For each thrust reverser that inadvertently stows, the following would occur:

- The white T/R DEPLOY indication would extinguish as the thrust reverser doors move out of their fully-deployed position;
- The amber T/R UNLOCK indication would illuminate during the time the thrust reverser doors are moving between the deployed and stowed positions, and would then extinguish when the thrust reverser is stowed.
- If inadvertent stow is due to squat switch input failure to air, then while the thrust reverser is moving between the deployed position and the stowed position, the green T/R ARM indication will change from being steadily-illuminated to flashing on and off. When the thrust reverser is stowed, the green T/R ARM indication will extinguish. If inadvertent stow is due to reasons other than squat switch input failure to air, then while the thrust reverser is moving between the deployed position and the stowed position, the green T/R ARM indication will remain steadily-illuminated and will extinguish or remain illuminated after the thrust reverser is stowed, depending on the failure.

For an inadvertent stow caused by squat switch failure to air mode, following the Inadvertent Stow of Thrust Reverser After A Crew Commanded Deployment, all annunciator lights on the flight deck would not be illuminated per the certified design. This condition is similar to the landing gear position indication when the landing gear are up and locked. There is no illuminated indication when the landing gear is up and locked.

III. INVESTIGATION AND ANALYSIS

Overview: As stated earlier in this submission, tire pressure on the accident aircraft had not been checked for "about" three weeks prior to the accident flight and this length of time "would equate to…..about a 36% under-inflation" based on the manufacturer's recommended tire pressure. This data indicates that each tire had already exceeded its expected useful life and tire failure was imminent. From the CVR transcript, after the first tire failed, there was indecision whether or not to abort. The PF began the abort above V1, a point of reference above which a safe outcome is not assured in terms of runway required or brake energy. Per FAA definitions and guidance, unless there are indications that an aircraft is unable to fly, a takeoff should not be aborted above V1. The available data indicates that the accident aircraft was capable of flight, but the PF made no attempt to continue the takeoff.

A. Aircraft History

The logbooks showed the following:

Manufacture date	:	January 30, 2007 When new, the airworthiness directives were current through issuance of AD 2006-25.
Serial number	:	60-314
Airworthiness Date	:	12/14/2006
First flight	:	December 4, 2006
Certificate of Airworthiness	:	December 14, 2006
Inspected to	:	FAR 2.183 (2)
Weight & Balance	:	September 2, 2008
Seating Capacity	:	10 (including crew)
Empty Weight	:	14755.93 pounds
Arm	:	378.27
Moment	:	5581794

Aircraft interior floor plan 60-2, installed per Learjet Engineering Drawing M6003000-314. Interior materials meet the requirements of FAR 25.853, ref. FAA approved Learjet Flammability Report No. FR60-314ICT Rev A, dated January 16, 2007.

January 21, 2007, weight and balance accomplished.

January 30, 2007, FAA Form 337 for Major Repair/Alteration completed by Learjet for the installation of an Airshow 400 Cabin Video System.

January 30, 2007, the airplane was purchased new by PCF Management LLC, of San Juan Capistrano, California, and the airworthiness directives were complete through Bi-Weekly list 2007-02, as published January 22, 2007.

October 25, 2007, the airplane was bought by Inter Travel and Services. The seller was PCF Management LLC.

December 22, 2007, 72.2 hours ACTT (aircraft total time). Completed maintenance tasks, including brake inspections per AD 1998-16-18-1 through -4. Replaced all tires, complying with Aero Wheel and Brake Service Corporation CRS#U8SR971J.

April 17, 2008, 81.4 ACTT. First log entry by Global Exec Aviation for oil level check and review for Service Bulletins and Airworthiness Directives (none found outstanding). Signature by the Global Exec Director of Maintenance.

May 16, 2008, 81.4 hours ACTT. Avionics entry.

June 17, 2008, 83.1 hours ACTT. Periodic inspections performed for batteries and fire bottles.

July 11, 2008, 83.1 hours ACTT (reference for airplane usage).

August 8, 2008, 83.1 hours ACTT. Annual avionics inspection.

August 11, 2008, a replacement temporary Certificate of Registration was placed in the airplane to replace one that was misplaced. A permanent replacement was mailed and installed prior to September 10, when the temporary expired.

August 16, 2008, 84.1 hours, 109 cycles, at Bombardier Learjet Service Center, Tucson:

Complied with the following Service Bulletin items:

- SB 60-23-7R1Iridium phone system
- SB 60-29-11 Replacement of return hydraulic filter indicator
- SB 60-32-24 Sealing of the anti-skid solenoid valves
- SB 60-32-26 Re-installation of the 3-rotor brakes.
- SB 60-34-14 Gasper duct

Installed main landing gear brake assemblies (p/n 6600518-003) with the following serial numbers: #1 JUL08-0951, #2 JUL08-0975, #3 JUL08-0967, #4 MAR06-0726.

September 2, 2008, 98.1 hours, 116 cycles, at Standard Aero, Station AN3R377L;

Adjusted #2 thrust reverser upper secondary lock micro-switch. Serviced thrust reverser hydraulic accumulator pre-charge, per L60MM chap 12-10-01.

September 8, 2008, 103.3 hours, 120 cycles. Log entry stating: "FWD DOOR SEAL LEAKING. LOUD WHISTLE IN CABIN."

September 10, 2008, 98.3 hours [Note: log entry with less hours than on previous flight.], 117 landings, at Meridian Jet Center, Teterboro, Station IMJR053F:

Log entry: "Found door seal loose and re-secured."

September 12, 2008, 105.0 hours, 121 cycles. Log entry stating: "@ 7000 to 8000 FT WITH WING HT SW O LEFT THEN RT BLEED AIR LTS ILLUMINATED. EXT W/SW OFF AFTER 5-7 MINS."

September 16, 2008, the Meridian Jet Center maintenance entry stated "Replaced Wiggins fittings seals in L/H & R/H pylon. R/R L/H mixing valve p/n on H106-9, s/n 12AN59 (partially illegible) Performed func test, chd satis, Ran eng @ high power with bleeds on, wing/stab heat on. No faults noted. I/A/W LR6036-10-02".

September 18, 2008, the accident flight crew conducted a maintenance test flight to insure the aircraft was performing satisfactorily. The flight crew did not report discrepancies after the flight.

September 19, 2008, the accident flight crew departed TEB at or about 2140, arriving at 2310 in CAE. The airplane took on 835 gallons of fuel at CAE.

B. Tires

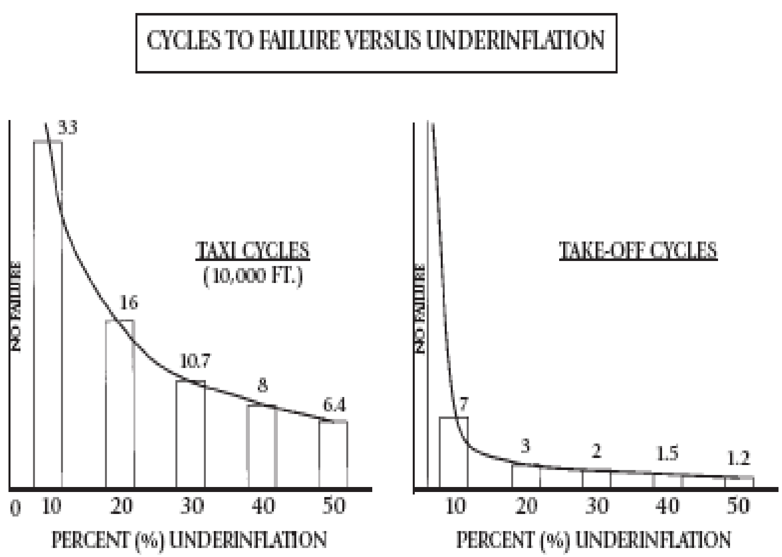
The NTSB's investigation concluded the tires were about 36% under inflated as established during the post event inspection of tire debris and validated by the estimate of typical tire leakage. Tire pressures had not been checked for "about" three weeks prior to the accident flight and this length of time "would equate to …….. about a 36% under-inflation". This translates to an average leakage rate of 1.7% per day. The NTSB reports indicated that the aircraft had conducted three (3) flights prior to the accident. Utilizing the 1.7% leak rate, it was determined that the tires were operated 24% under-inflated on the September 12, 2008 flight. The same tires experienced operation at 34% under-inflation during the September 18, 2008 flight and at 36% under-inflation during the repositioning flight on September 19, 2008.

Per the Goodyear and Learjet Maintenance Manuals, any tire experiencing operation, under-inflated by more than 10%, must be immediately removed (see chart below). As discussed above, the subject tires experienced at least three flights after they should have been removed and replaced. The condition of the tires and operations prior to September 12 was not stated in the NTSB factual report.

GOODYEAR AVIATION AIRCRAFT TIRE CARE AND MAINTENANCE

Cold Tire Service Pressure	Recommended Action
100 to 105 percent of loaded service pressure	None - normal cold tire operating range.
95 to less than 100 percent of loaded service pressure	Reinflate to specified service pressure.
90 to less than 95 percent of loaded service pressure	Inspect tire/wheel assembly for cause of pressure loss. Reinflate & record in log book. Remove tire/wheel assembly if pressure loss is greater than 5% and reoccurs within 24 hours.
80 to less than 90 percent of loaded service pressure	Remove tire/wheel assembly from aircraft (See **NOTE** below).
Less than 80 percent of loaded service pressure	Remove tire/wheel assembly and adjacent tire/wheel assembly from aircraft (See **NOTE** below).
0 percent	Scrap tire and mate if air loss occurred while rolling (See **NOTE** below).
NOTE: Any tire removed due to a pressure loss condition should be returned to an authorized repair facility or retreader, along with a description of the removal reason, to verify that the casing has not sustained internal degradation and is acceptable for continued service.	

GOODYEAR AVIATION AIRCRAFT TIRE CARE AND MAINTENANCE



The above data from the Goodyear Aircraft Tire Care and Maintenance document illustrates the significant impact of under inflation on tire life. The data also shows that the life impact of the tire is more sensitive to under-inflation during Take-Off cycles than with Taxi cycles.

Applying the Goodyear data to aircraft 60-314, the following conclusions are apparent:

1. Flight should not have been commenced with these severely under-inflated tires.

2. At 24% under-inflation, the life of the tires is expected to be 2-3 take-offs.

3. At 35% under-inflation, the expected life drops to 1.5 to 2 take-offs.

Based on the fact that the aircraft completed three full flights and one additional taxi with severely under inflated tires, there can be no expectation for a successful fourth flight. The failure of each tire was directly related to the lack of proper tire inflation. The data illustrates that each tire exceeded its expected useful life, under the given conditions, and that tire failure was imminent.

C. Thrust Reversers

The Inadvertent Stow of Thrust Reverser After a Crew-Commanded Deployment procedure was originally an ABNORMAL procedure, which was moved to the EMERGENCY section of the AFM following a Model 60 landing accident in Troy, Alabama, in 2001. In that accident, the landing airplane had a deer strike and the affected landing gear squat switch was broken, resulting in uncommanded thrust reverser stowage.

The AFM memory items and Note from this change are quoted below:

> **1. Maintain control with rudder, aileron, nose-wheel steering, and brakes.**
> **2. Both Thrust Reversers – Stow**
>
> *Note: Failure to move the thrust reverser levers to stow will result in forward thrust ranging from idle to near takeoff power, depending upon the position of the thrust reverser levers.*

Both FAA and Learjet personnel who took part in the N999LJ accident investigation during October 2008, related that the FAA originally accepted this change as sufficient to mitigate the risk of a similar landing incident.

The NTSB factual report noted that with the loss of either squat switch on the respective main landing gear, the thrust reverser relay boxes de-energize the deploy solenoids and the thrust reversers stow. The FADEC commands the engine speed to go to idle. As the thrust reversers complete the stow cycle, the stow switches open, signaling the thrust reverser relay box to remove the discrete signals. The FADECs switch to the forward thrust schedule within approximately 2.6 seconds. If the pilot fails to follow the AFM Emergency procedure for Inadvertent Stow of Thrust Reverser After Crew-Commanded Deployment and to place both thrust reverse levers in the stow position, forward thrust ranging from idle to near takeoff power can occur. The amount of thrust would depend on the position of the thrust reverser levers.

D. Nose-Wheel Steering Disconnect Tone

At 23:55:21.5, there was a sound similar to that of the nose-wheel steering (NWS) disconnect tone. The logic that triggers the disconnect tone is as follows:

1. The NWS system is disengaged using the NOSE STEER switch, or
2. The NWS system is disengaged using either control wheel Master switch, or
3. The NWS system is disengaged by the NWS Controller for any monitors that detect a failure that results in the disengage or disarm state(s).

The NWS Controller monitors each of the three wheel-speed inputs, RH outboard, RH inboard, and LH inboard. If any one of the three wheel-speed inputs fails, the NWS system will remain engaged if engaged prior to the failure. If any two or more wheel-speed inputs fail, the NWS system will disengage and the disconnect tone will sound.

The NWS system has a single squat switch input for air/ground state determination. With the NWS system engaged, if the squat switch input changes from ground state to the air state, the system will disengage and remain armed. The NWS disconnect tone will <u>not</u> be triggered for ground-to-air transition whether from a real ground-to-air occurrence or from a failed squat switch input. Therefore, the NWS disconnect tone at 23:55:21.5 is <u>not</u> a result of a failed squat switch.

E. Performance

Introduction.

This analysis combined relevant details from the docket's various factual reports with the known characteristics of the Learjet Model 60 to produce a likely ground-speed profile of the aircraft as it traveled on CAE Runway 11. The generation of this profile involves a synthesis of the known factual information with the Learjet Flight Analysis analytical performance methods. This model supports assessment of the causal elements that contributed to the final outcome, which include the Captain's decision to abort the takeoff beyond V1, the non-standard abort procedures employed and the effect of degraded stopping performance due to the blown tires, both in terms of reduced braking capability and the loss of reverse thrust. It is shown through this analysis how these decisions, procedures and failures combined to produce the high-speed runway excursion event of 60-314.

NTSB Data.

Time history data for groundspeed and N1 were available from the CVR Sound Spectrum Report (including additions per Addendum I), which were combined with the crew statements and relevant CAM sounds from the CVR Factual Report, and the approximate tire failure events as described in Factual Addendum and Study for Tires and Landing Gear. These data are shown in graphical form on Figure 1, Section VIII of this Submission. Note that the elapsed time presented in the CVR Sound Spectrum Report was synced with Eastern Daylight Time (EDT) at time zero equal to 23:54:42.2 per that document's October 6, 2009 errata publication. For reference, the corresponding elapsed time is shown on the upper x-axis of Figure 1,Section VIII of this Submission.

A time history plot of groundspeed was also presented in the Airplane Performance Study. This trace added non-linear interpolated data for which no explanation was offered, as well as the omission of the actual data points added in the CVR Sound Spectrum Report Addendum I. Attachment 1 from the Airplane Performance Study presented additional extrapolated groundspeed and N1 data. The groundspeed data was cited as approximate, with no mention of the method for its determination. There was no mention at all of the additional N1 data; however, they appear to be linearly interpolated between CVR Sound Spectrum Report data. These additional NTSB Airplane Performance Study groundspeeds and N1 are added to the CVR Sound Spectrum Report data as shown in Figure 2, Section VIII of this Submission. Note that the time sync in the Airplane Performance Study appeared to be time zero equal 23:54:42.5. The interpolated / extrapolated Airplane Performance Study data are therefore shown on Figure 2, Section VIII of this Submission, shifted -0.3 seconds from their presented EDT to be consistent with the data in Figure 1, Section VIII of this Submission. A final observation is noted that the END OF RECORDING time shown on Attachment 1 from this report is 23:56:40.1 EDT. This is one second earlier than that presented in the CVR transcript, and is assumed in error.

Acceleration Performance.

Learjet performance analytical methods apply an integration of forces acting on a mass (the aircraft) through time to generate a speed and distance profile. Relevant forces include engine thrust, aerodynamic drag, wheel / tire rolling resistance and brake force (when applied). These methods were validated by comparison to flight test data during the type certification process, and were ultimately used to generate the FAA Approved AFM performance data. Using these methods, an analytical profile was generated for the subject aircraft, using the known ambient conditions existing at the time of the accident. True airspeed was derived based on the analytical groundspeed profile and the winds reported by the tower just prior to the event (070 at 8 knots gusting to 14 knots). This wind (assumed 070 at 11 knots) was translated from the tower height down to runway height and was then resolved to a runway headwind component of 6.5 knots. The true airspeed was converted to its corresponding calibrated airspeed, and then known airspeed static source position correction and PFD display lag were applied to generate a trace of PFD displayed airspeed. These data were added to that from Figure 2, Section VIII of this Submission, for the runway acceleration portion of the profile and are shown in Figure 3, Section VIII of this Submission. Applicable V-speeds for the takeoff conditions are marked along the PFD displayed airspeed. The acceleration profile was generated using average engine thrust that would exist based on the engine N1 profile shown. Aerodynamic lift and drag changes were applied to represent spoiler deployment with the initial N1 reduction at approximately 23:55:14, and rolling resistance was increased slightly as each tire blew.

N1 Profile and Event Definition.

As noted in the NTSB factual reports, the acceleration phase of the profile is clearly defined; however, data becomes sketchy following the initial tire failure. Per the CVR Sound Spectrum Report, engine N1 data was discerned sporadically through the remainder of the runway profile. The initial reduction in N1 at approximately 23:55:14 coincides with a metallic click recorded on the cockpit area microphone (CAM). When the thrust levers of the Model 60 are rapidly reduced to idle, the levers hit a metal stop which would produce such a sound. This event was given the label “first abort”, and it was noted to occur 3.2 seconds after the ‘V1’ call. The engine N1 data decelerated from this time in a manner consistent with a spin-down to idle for approximately one second, followed by a rapid increase for approximately ½ second. This would only occur if the thrust levers had been pushed significantly forward to near the MCR / MCT / TO detents. A second metallic click was recorded on the CAM 4.6 seconds after the 'V1' call, followed by engine response again consistent with engines spooling down to idle. This event was given the label "second abort". This evidence of indecision during the abort is sequentially consistent with the pilot not flying (PNF) and pilot flying (PF) verbal statements recorded on the CVR at this time.

The engine N1 profile following the "second abort" was overlaid with flight test data collected during development of the thrust reverser performance model for the Model 60. The flight test N1 data represented a test at similar ambient conditions in which a refused takeoff was performed using maximum reverse thrust and no braking. The flight test engine N1 trace accurately fit the points available from the CVR Sound Spectrum Report. The third metallic click recorded by the CAM would be consistent with the T/R baulk solenoid releasing, signaling that the T/Rs were deployed, which was further confirmed by the PF statement "full out" recorded on the CVR. The two CVR Sound Spectrum Report N1 data points at 23:55:19.4 confirm that the engines were spooling up rapidly and show good agreement with the flight test N1 trace. From this evidence, it may be concluded that the thrust reversers completed deployment at approximately 23:55:18.4 (7.9 seconds after V1) and were commanded to a high level (likely maximum) of reverse thrust.

Much focus in the NTSB factual reports pertained to the inadvertent stow of the thrust reversers due to the loss of a squat switch. Per the Factual Addendum, Engines and Thrust Reversers report, if a squat switch signal was lost (putting the aircraft in 'air' mode) with the T/Rs deployed, the T/R Relay Box would sense T/Rs deployed in air mode and would then command the thrust reversers to stow, and concurrently instruct the engines through the FADECs to flight idle. Once the T/Rs completed their stow sequence, which would take about 2.6 seconds, the T/R Relay Box will provide a signal to the FADEC which would command an N1 commensurate with the TLA supplied by the thrust levers. If the thrust reverser piggy-backs remained full aft (commanding maximum reverse), the RVDT output would correspond to MCT forward thrust.

The final area of N1 data identified by the CVR Sound Spectrum Report began at 23:55:28.4 and continued to 23:55:32.2. Initially the data spins-up from about 86% N1 to a maximum of 92.6%, followed shortly by a rapid spin-down. Flight test data N1 traces accurately overlaid the spin-up and spin-down portions of this data. Note that for the local ambient conditions, MCT forward thrust would have been 92.9% N1, and maintaining this value for 1.2 seconds "filled the gap" between the spin-up and spin-down sections. It is clear that from 23:55:30.9 to 23:55:32.2 the engines were spinning down, but it is unclear to what level. Assuming the aircraft was in air mode, the lowest possible value would be flight idle, but there is no factual evidence to support this, or any other reduced value. There is also no convincing factual evidence as to what, if any, additional modulations in thrust were commanded by the crew.

Combining the knowledge of the system operation above with the final section of N1 data from the CVR Sound Spectrum Report, it is possible to work forward in time from the maximum reverse thrust setting and backward in time from the final section of N1 data to complete a probable N1 profile. Flight test N1 spin-down data were extended from the maximum reverse N1 of 85.9% for 2.6 seconds, at which point the engines were at approximately 59.5% N1. This value was then synced into the spin up profile which ultimately overlaid the final CVR Sound Spectrum Report N1 data. This identified a point at 23:55:24.3 where it is likely that the thrust reversers were commanded to stow.

Though sparse and not conclusive, the PF and PNF audio comments are consistent with this described N1 profile. The change in longitudinal acceleration with T/Rs stowing at maximum reverse thrust would produce an unexpected surge nearly equivalent in magnitude to going from idle to takeoff power (a delta of about 0.37g) in less than one second. It is likely the crew were disseminating and reacting to this unexpected surge, and recognized the failure when the PF uttered an expletive at 23:55:27.7 and the PNF stated "shut 'em off" one second later. About 2 seconds after his statement, the engines began their spool down and 1.5 seconds after that he stated "they're shut off they're shut off".

Figure 4, Section VIII of this Submission, presents a time history of the N1 profile described above, along with the event assignments stated herein and their respective time delays from V1. For reference, CVR audio elements are also shown.

With engine thrust established as accurately as possible for the majority of the profile, the final significant variable is the brakes, and their contribution to the stop. There are two elements to address. The first is determining when during the profile the brakes were applied, and the second is assessing what stopping force they would be capable of producing with blown tires. The most likely brake application time is commensurate with the brake 'squeal' noted on the CAM at 23:55:20.3, which is 9.8 seconds past V1. This assessment, along with a method to approximate degraded braking performance, will be further substantiated below.

Braking.

As mentioned above, the braking performance for this event is a significant element that is difficult to factually quantify both in timing and in magnitude. The only definitive factual evidence for sustained brake application occurred 9.8 seconds after the 'V1' call when the brake 'squeal' was recorded by the CAM.

Addendum I to the CVR Sound Spectrum Report added two points to the groundspeed profile with no additional clarification as to why these points were believed valid when they had been originally excluded. However, the second point added is slower than the first, and would indicate an aircraft deceleration which could only be attributed to brake application. Simple analysis of these points was performed to assess the reasonableness of this deceleration. To reduce speed 0.9 knots over 0.5 seconds, a net deceleration of just over 3 fps/s is required. However, since the aircraft was accelerating at a rate of 8.2 fps/s, the gross deceleration required to produce this net deceleration is over 11 fps/s. For a 23,500 lbs aircraft, this would require about 8200 lbs of braking force. With spoilers stowed, the simple net normal force available for the aircraft was just over 15,000 lbs, which would therefore require an aircraft braking coefficient of 0.54. Since this point exists after the first tire had blown, the aircraft would have had to achieve this performance with only 3 tires. On a very similar flight test condition, the initial aircraft braking coefficient demonstrated (with 4 good wheels / tires / brakes) was only 0.43, or 25% less. Still, if it is assumed that somehow this high level of braking was achievable and was being applied from this point, then, in combination with the derived engine performance, the aircraft should have stopped prior to exiting the runway. Finally, if the brakes had been capable of producing this level of deceleration and were applied from this point, they would have absorbed a significant amount of energy, likely in excess of the maximum demonstrated. This is not consistent with the findings of the Factual Addendum and Study for Tires and Landing Gear, which noted no excessive heat damage to any of the brake assemblies. Based on these facts, the apparent deceleration indicated by the Addendum I additional points can not be a basis for assuming sustained brake application. Although no reasons were stated, the authors of the Airplane Performance Study factual report reached the same conclusion, since their extrapolated data continue to increase in speed beyond that point.

The Airplane Performance Study factual report contains an extrapolated speed profile, which is qualified by a statement that it is only an estimate for the purpose of positioning the CVR text in an approximate location along the runway. No factual basis or explanation of the method applied to produce this extrapolation was provided. This profile was also analyzed for its required brake application time and effectiveness. To produce this profile, a heavy level of sustained brake application would be required near the “second abort” event identified above. The level of braking required would be about 75% of the maximum demonstrated by flight test with four good wheels / tires / brakes. Although it is agreed that level of performance with multiple blown tires is highly subjective and difficult to accurately quantify, it is very doubtful that 75% of maximum normal braking would be achievable. If, however, it is assumed that this level of braking was somehow achievable, a vastly different engine profile from that documented above would have to exist to counter the higher level of braking during the remainder of the stop and therefore produce a high speed runway excursion. Finally, if both of these are assumed (high level of residual brake performance along with substantially different engine thrust profile), the brakes would have absorbed about 32 Mft-lbs of energy during the abort. The maximum demonstrated energy during certification was 22 Mft-lbs. This amount of energy absorption is highly improbable and not consistent with the findings of the Factual Addendum and Study for Tires and Landing Gear, which noted no excessive heat damage to any of the brake assemblies or release of any of the wheel fuse plugs. Therefore, it is concluded that the Airplane Performance Study extrapolated speed profile, although shown as only an estimate, is factually improbable.

This leaves only the factual evidence that sustained brake application was first initiated 9.8 seconds after the ‘V1’ call at the brake ‘squeal’ event. Based on this fact, the remaining unknown of brake performance with blown tires can be solved for by applying the final constraint that the time at the end of the CVR recording (23:55:41.1 EDT) likely coincided with the aircraft’s exit from the paved surface. This requires an average aircraft braking coefficient of 0.19, which is about 44% of that achievable with good tires. Additionally, this would impart less than 17 Mft-lbs of energy to the brakes, which is more consistent with the Factual Addendum and Study for Tires and Landing Gear. Figure 5, Section VI of this Submission, presents the resulting groundspeed profile along with the data from Figures 3 and 4, Section VIII of this Submission. Figure 6, Section VIII of this Submission, shows only the ground speed profile and the distance profile, along with the ‘box’ constraint to achieve the end of the pavement near the end of the CVR recording. Figure 7, Section VIII of this Submission, replaces engine N1 data from Figure 5, Section VIII of this Submission, with the modeled aircraft acceleration.

Causal Elements.

No AFM data exists for aborts above V1, therefore there is no way for a pilot to assure a safe outcome, either in terms of runway required or brake energy, if an abort is performed above V1. However, even an abort from V1 assumes maximum effort braking applied with all four wheels / tires /

brakes fully functional. The aborted takeoff procedure assumes immediate maximum application of brakes, followed by retarding the thrust levers to idle, and then extending the spoilers. Use of reverse thrust is only specified after these first three actions, and it is not required to achieve AFM published performance on a dry runway.

Figures 8, 9 & 10, Section VIII of this Submission, present a series of analytical groundspeed profiles for various scenarios. Profiles shown on Figure 8, Section VIII of this Submission, illustrate AFM procedures in combination with the failures encountered by 60-314. Profiles are shown for aborts from V1 with good wheels / tires / brakes both with and without thrust reversers, as well as the continuation of the takeoff with all engines to a height of 35' AGL. Failure profiles are shown with four blown tires using estimated braking performance as derived above. One profile is shown for a stop without thrust reversers and a second is shown assuming thrust reversers initially deployed, then stowed uncommanded with crew reaction similar to that derived above for 60-314. Figure 9 illustrates the effect of the nonstandard procedures employed by the crew of 60-314. All profiles on Figure 9 assume four good wheels / tires / brakes and employ the "double abort" thrust profile as documented above. One set of profiles assumes maximum effort braking applied and sustained from the "first abort" event 3.2 seconds after V1. The second set of profiles assumes a delay in sustained braking until 9.8 seconds after V1. Each set contains a trace for T/R's stowed and maximum reverse thrust. Note that three of these four profiles would result in an exceedance of the maximum demonstrated brake energy of 5.5 Mft-lbs per brake. Figure 10 then combines the effects of the nonstandard procedures and the failures encountered on 60-314. Note that this plot contains the probable profile as derived above, along with a hypothetical profile assuming T/R's stowed. The three AFM profiles (good brakes with and without T/Rs and all engine takeoff to 35') from Figure 8 are also shown for reference on Figure 10 in Section VIII of this submission. Reference lines are shown on all three figures for the approximate runway end and pavement end for CAE Runway 11 as well as AFM published required field length for the ambient conditions.

There is no evidence that the aircraft was incapable of flight, and there is no evidence that the PF attempted to rotate. At the time appropriate for the ‘rotate’ call, the PNF instead said ‘go’, then ‘go go go’. As shown in Figure 5, Section VII of this Submission, the first abort event occurred at approximately V2 airspeed, and the second (final) abort event was initiated about V2 + 5. Certification flight tests demonstrated abused all-engine takeoffs with rotation initiated 10 knots below the published speed. Therefore, as much as a five second window existed between VR – 10 and the initiation of the second (final) abort where the aircraft was capable of flight by simply rotating. Had the rotation been initiated at VR, it is likely the aircraft would have lifted off with only the right outboard tire blown, and possibly the right inboard as well. Assuming rotation had occurred, future events and their outcomes are purely speculative, however, it is certain that this one action would have prevented the high-speed runway excursion of 60-314 as it transpired, and the flight crew had no basis to expect, even in a fully functional aircraft, that a runway abort from V2 or V2 + 5 under these conditions could be successfully performed.

F. Crew Performance

Two critical processes relate directly to safety of flight, crew resource management (CRM) and aeronautical decision making (ADM). CRM is less concerned with the technical knowledge and skills required to fly and operate an aircraft but rather, with the cognitive and interpersonal skills needed to manage the flight. ADM focuses more on the mental process used by pilots to consistently determine the best course of action in response to a given set of circumstances. Bombardier Learjet submits that with respect to this accident both of these processes were inadequate.

Physical evidence on the runway (tire marks) confirm that there was not a directional control problem. No evidence was found that would indicate that there was a longitudinal or lateral control problem. Since the aircraft was capable of flight and the tire failures occurred after V1, the appropriate course of action was to continue the takeoff, reduce aircraft weight by consuming fuel, and land at a suitable airfield. The Learjet time history analysis shows that if the aircraft had continued the takeoff and rotated at Vr, the aircraft would have been airborne before the point on the runway that the left outboard and left inboard tires failed.

NTSB Docket 46996 contains numerous factual reports prepared by the various group chairmen. As of October 13, 2009, none of the reports address the performance of the crew in the events leading up to this accident and their contribution to the cause of this accident. Just prior to takeoff, the captain gave a non-standard takeoff briefing. From the CVR transcript:

23:51:22.3 **Captain**	okay ah we've got plenty of runway so we'll abort for anything below eighty knots after V-one and before V-two engine failure fire malfunction loss of directional control all the big things after V-two we'll go ahead and take it into the air treat it as an in-flight emergency I think this is probably a pretty good option to come back to unless we have like a complete a hydraulic failure or something and ah then we'll

	look for a longer runway nearby probably Charleston ahm after takeoff it was heading one five zero up to four thousand.
23:51:53.8 **F/O**	correct.
23:51:54.0 **Captain**	correct? any questions comments concerns?
23:51:56.6 **F/O**	ah just it's ah wha- reference the ah between eighty and ah V-one you're only ah aborting for the fire failure loss of directional control?
23:52:06.0 **Captain**	yes.
23:52:06.6 **F/O**	'kay ah alrighty we're ah.

The briefing indicated the captain would abort for any malfunction below 80 knots. After V1 and before V2, she would abort for 1) engine failure, 2) fire, 3) loss of directional control, and 4) all the big things. After V2 the plan was to continue the takeoff and deal with the emergency in flight.

An abort above V1 is not standard operating procedure. Best industry practice is to minimize high speed aborts. Standard practice is to only abort in the high speed regime (approximately 80 knots to V1) for issues that would make the airplane unsafe or non flyable, such as engine failure, fire, and loss of control. Aborting a takeoff above V1 is typically never considered unless the aircraft is physically not capable of flying.

Standard pilot training includes teaching pilots to remove their hand from the thrust levers at V1 so it is clear that an abort will not be conducted above V1.

The correct takeoff briefing would include an abort for any abnormality below 80 knots, an abort for loss of control, engine failure, or fire between 80 knots and V1, and at V1 or higher, the takeoff would continue and the problem would be addressed in flight.

The copilot attempted to clarify this briefing by questioning "…between 80 and V1 you're only aborting for the fire, failure, loss of directional control?" The captain replied "yes", but there was no clear acknowledgement by the captain that she had incorrectly referenced V2 instead of V1 in the original takeoff briefing. The discussion continued, but focused on loss of directional control, not the correct decision speed.

The FAA regulations have a specific meaning for V1. Section 14 of the Code of Federal Regulations Part 1.2 Abbreviations and Symbols states

"V1 means the maximum speed in the takeoff at which the pilot must take the first action (e.g., apply brakes, reduce thrust, deploy speed brakes) to stop the airplane within the accelerate-stop distance…"

The FAA's "Pilot Guide to Takeoff Safety" states: "It is… recommended that pilots consider V1 to be a limit speed: Do not attempt an RTO once the airplane has passed V1 unless the pilot has reason to conclude the airplane is unsafe or unable to fly. **This recommendation should prevail no matter what runway length appears to remain after V1."** The guide further states: "Rejecting a takeoff from high speeds with a failed tire is a much riskier proposition, especially if the weight is near the Field Limit Weight. The chances of an overrun are increased simply due to the loss of braking force from one wheel. If additional tires should fail during the stop attempt, the available braking force is even further reduced. In this case, it is generally better to continue the takeoff"

Per FAA definitions and guidance, unless there are indications that an aircraft is unable to fly, a takeoff should not be aborted above V1.

From the CVR transcript, during the takeoff, the first indication of a problem (rumbling noise when the first tire failed) occurred approximately 1 second after the V1 call from the copilot. From the CVR transcript, after the first tire failed, there was indecision whether or not to abort. The following conversation is from the Cockpit Voice Recorder:

23:55:10.5 **F/O**	V-one.
23:55:12.0 **Area Mic**	[beginning of loud broadband rumbling].
23:55:12.4 **F/O**	go.
23:55:12.8 **Captain**	*? [unintelligible word]
23:55:13.0 **F/O**	go go go.
23:55:13.7 **Open Mic**	[sound similar to metallic click].
23:55:14.0 **Captain**	go?
23:55:14.6 **F/O**	no? ar- alright. get ah what the # was that?
23:55:15.1 **F/O**	[sound similar to metallic click].

23:55:17.0 **Captain**	I don't know. we're not goin' though.
23:55:18.4 **Open Mic**	[sound similar to metallic click].
23:55:19.5 **Captain**	full out.
23:55:20.3 **Open Mic**	[high frequency sound consistent with brake pedal application].
23:55:21.6 **Open Mic**	[sound similar to nose-wheel steering disconnect warning tone].

From the CVR frequency analysis and transcript, the engines were initially reduced from takeoff power approximately 3.2 seconds after V1, advanced back to high power, then reduced to idle approximately 4.6 seconds after V1. The thrust reversers were deployed approximately 7.9 seconds after V1. Brakes were applied approximately 9.8 seconds after V1.

The Learjet 60 airplane flight manual emergency procedure for an aborted takeoff follows. The bold steps are memory items.

ABORTED TAKEOFF
1. Wheel Brakes — Apply.
2. Thrust Levers — IDLE.
3. Spoilers — EXT.
4. Thrust Reversers — Deploy, if necessary.

Based on the CVR analysis, the aborted takeoff procedure was not conducted in the correct order, nor in a timely manner. To achieve the AFM field length data, the first step of the procedure (1. Wheel Brakes – Apply) must be conducted no later than V1. Application of wheel brakes is the most effective deceleration device, which is why it is listed first. Brake application on the accident aircraft did not occur until approximately 9.8 seconds after V1, after 3 tires had already failed (approximately concurrently with the fourth tire failure). The delayed initiation of the abort allowed the aircraft to achieve a maximum indicated airspeed of approximately 163 knots (ref Learjet analysis), which was 27 knots above V1 (18 knots above Vr, and 10 knots above V2).

IV. CONCLUSIONS

1. Global Exec Aviation's maintenance procedures did not include daily tire pressure checking per the tire manufacturer, aircraft manufacturer and FAA recommendations.
2. Tire life was expired prior to the accident crew's flight departure from CAE.
3. The tires of the subject aircraft were under inflated by approximately 36%.
4. The passengers and baggage were not weighed per Global Exec Aviation's operations specifications.
5. The aircraft takeoff weight was approximately 300 pounds over the maximum authorized takeoff weight.
6. The captain incorrectly planned the takeoff by stating during the briefing that a takeoff abort would be conducted (if needed) above V1 speed (up to V2).
7. The takeoff was not conducted per the briefing since the aircraft achieved a speed in excess of V2, yet the takeoff was aborted.
8. Standard call outs for speed were not briefed nor used.
9. The takeoff abort was not conducted per the AFM procedure.
10. The flight crew's decision to abort the takeoff above V1 was incorrect.

V. PROBABLE CAUSE

The probable cause of this accident was the failure of the operator to maintain the aircraft in an airworthy condition resulting in the failure of all 4 main tires due to under-inflation and combined with the failure of the Captain to continue the takeoff after reaching V1 speed.

VI. CONTRIBUTING FACTORS

1. The resulting tire damage to the landing gear system components which caused degraded stopping performance and the uncommanded stow of the thrust reversers;
2. The Captain's non-standard takeoff briefing;
3. The flight crew's disagreement about continuing or rejecting the takeoff;
4. The Captain's non-standard abort procedure.

VII. ATTACHMENTS

1. Model 60 AFM Limitations
2. M60-314 Aircraft Takeoff Weight Analysis
3. Model 60 AFM Excerpts

AIRSPEED/MACH LIMITS (Cont)

MINIMUM CONTROL SPEED AIR VMCA

VMCA is a function of altitude and temperature. During flight tests, the aircraft was controllable down to stall speed. The speed shown is this minimum demonstrated speed corrected for maximum thrust effect with rudder boost on or off. Section V Performance Charts account for the appropriate values.

VMCA

- Flaps 8° .... 120 KIAS
- Flaps 20° .... 110 KIAS

MINIMUM CONTROL SPEED GROUND VMCG

VMCG is a function of altitude and temperature. The speed shown is a maximum, which occurs at maximum thrust conditions. Section V Performance Charts account for the appropriate values.

VMCG

- Rudder boost ON .... 95 KIAS
- Rudder boost OFF .... 116 KIAS

TAKEOFF DECISION SPEED V1

Refer to applicable figure entitled TAKEOFF SPEEDS in Section V.

ROTATION SPEED VR

Refer to applicable figure entitled TAKEOFF SPEEDS in Section V.

TAKEOFF SAFETY SPEED V2

Refer to applicable figure entitled TAKEOFF SPEEDS in Section V.

ATTACHMENT 2

60-314	lb
Basic Empty Weight	14755
Crew #1 Male Assumed from AC 120-27E page 21	190
Assumed Flight Crew Roller Bag from AC 120-27E page 21	30
Assumed Pilot Flight Bag from AC 120-27E page 21	20
Crew #2 Female Assumed from AC 120-27E page 21	190
Assumed Flight Crew Roller Bag from AC 120-27E page 21	30
Assumed Pilot Flight Bag from AC 120-27E page 21	20
Operational Items Assumed (below)	145
Operational Empty Weight definition AC 120-27E Appen. 1 page 2	15380

PASSENGERS	lb
Pax 1 given by Interview of persons onboard	130
Pax 2 given by Interview of persons onboard	183
Pax 3 Assumed Average male Passenger (Summer) per AC 120-27E page 17	179
Pax 4 Assumed Average male Passenger (Summer) per AC 120-27E page 17	179
BAGGAGE	**lb**
Rolling Bag by interview of person onboard	40
Pax 1 Summer Clothing from AC 120-27E page 17	5
Pax 1 Carry on Baggage from AC 120-27E page 17	16
Pax 2 Summer Clothing from AC 120-27E page 17	5
Pax 2 Carry on Baggage from AC 120-27E page 17	16
Pax 3 Summer Clothing from AC 120-27E page 17	5
Pax 3 Carry on Baggage from AC 120-27E page 17	16
Pax 4 Summer Clothing from AC 120-27E page17	5
Pax 4 Carry on Baggage from AC 120-27E page 17	16
Total Payload	795

Zero Fuel Weight	16175

Fuel Given in Report	7800
Total Aircraft Weight Prior to Taxi	**23975**

Taxi/APU Burn in report	-150
Total Aircraft WT at Takeoff	**23825**

OPERATIONAL ITEMS ASSUMED	lb
CONSUMABLES (FOOD, DRINKS,REMOVABLE SERVICE EQIP, ECT.)	50.0
JEPPS & MISC. CREW ITEMS	60.0
LAV. WATER & SUPPLY	35.0
	145.0

ATTACHMENT 3
(Page 1 of 5)

DEFINITIONS (Cont)

V_{S1}	V_{S1} is the stalling speed in the appropriate gear/flap configuration.
V_{MCA}	Minimum Control Speed, Air — The minimum flight speed at which the airplane is controllable with up to 5° of bank when one engine suddenly becomes inoperative and the remaining engine is operating at takeoff thrust.
V_{MCG}	Minimum Control Speed, Ground — The minimum speed on the ground at which control can be maintained using aerodynamic controls alone, when one engine suddenly becomes inoperative and the remaining engine is operating at takeoff thrust.
V_{MCL}	Minimum Control Speed, Landing — The minimum flight speed during landing approach at which the airplane is controllable with up to 5° of bank when one engine suddenly becomes inoperative and the remaining engine is operating at takeoff thrust. V_{MCL} has been determined to be not more than 107 KIAS in the landing configuration.
V_1	Takeoff Decision Speed — The speed at which the distance to continue the takeoff to 35 feet or the distance to stop will not exceed the scheduled takeoff distance provided the brakes are applied at V_1.
V_R	Rotation Speed — The speed at which rotation is initiated during takeoff to attain takeoff performance.
V_2	Takeoff Safety Speed — The actual speed at 35 feet above the runway surface as demonstrated in flight during single-engine takeoff. V_2 must not be less than 1.2 times the stalling speed, or less than 1.1 times the air minimum control speed (V_{MCA}), or less than the rotation speed (V_R) plus an increment in speed attained prior to reaching a 35-foot height above the runway surface.
V_{APP}	Approach Climb Speed — The airspeed equal to 1.3 V_{S1} (airplane in the approach configuration).
V_{REF}	Landing Approach Speed — The airspeed equal to 1.3 V_{S0} (airplane in the landing configuration).
1.3 V_S	Landing approach speed for abnormal operations in which flaps are not full down. Values are presented for flaps 0°, 8°, and 20°. These speeds provide the same margin above stall as when flying a normal approach with flaps full down at V_{REF}.

DEFINITIONS (Cont)

WEIGHTS

Maximum Allowable Takeoff Weight
The maximum allowable takeoff weight at the start of takeoff roll is limited by the most restrictive of the following requirements:
- Maximum Certified Takeoff Weight.
- Maximum Takeoff Weight (Climb or Brake Energy Limited) for altitude and reported surface temperature as determined from the applicable figure entitled TAKEOFF WEIGHT LIMITS in this section.
- Maximum Takeoff Weight for the runway and ambient conditions as determined from the applicable figure entitled TAKEOFF FIELD LENGTH in this section.

Maximum Allowable Landing Weight
The maximum allowable landing weight is limited by the most restrictive of the following requirements:
- Maximum Certified Landing Weight.
- Maximum Landing Weight for the runway and ambient conditions as determined from the applicable ACTUAL LANDING DISTANCE chart in this section.
- Maximum Landing Weight (Approach Climb or Brake Energy Limited) for altitude and reported surface temperature as determined from the applicable figure entitled LANDING WEIGHT LIMITS in this section.

DISTANCES

Accelerate-Stop Distance
The accelerate-stop distance is the horizontal distance traversed from brake release to the point at which the airplane comes to a complete stop on a takeoff during which the pilot applies the brakes at or below V1.

Engine-Out Accelerate-Go Distance
The engine-out accelerate-go distance is the horizontal distance traversed from brake release to the point at which the airplane attains a height of 35 feet above the runway surface, on a takeoff during which one engine fails, recognition occurs at or above V1 and the pilot elects to continue.

DEFINITIONS (Cont)

Maximum Takeoff Brake Energy	The maximum brake energy demonstrated during emergency stop tests. Maximum effort braking at weights associated with the takeoff brake energies shown on the TAKEOFF WEIGHT LIMITS charts will meet the accelerate-stop distances expressed on the TAKEOFF FIELD LENGTH charts if the takeoff is aborted and brakes are applied at V_1. However, after the stop, wheel fuse plugs will release and brake and tire damage will occur.
Maximum Landing Brake Energy	The maximum brake energy demonstrated during landing tests. Maximum effort braking at weights associated with the landing brake energies shown on the LANDING WEIGHT LIMITS charts will meet the stopping distances expressed on the ACTUAL LANDING DISTANCE chart. Landings in which brake energy is kept below this value can be accomplished without wheel fuse plug release or tire damage. Maximum effort stops in which brake energy exceeds this value may cause excessive brake wear, and after the stop, may cause wheel fuse plug release and damage tires.
Maximum Turn-Around Brake Energy	The maximum brake energy that when coupled with a rejected takeoff maintains wheel integrity. After maximum effort stops in which brake energy exceeds this value, as expressed on the applicable LANDING WEIGHT LIMITS chart, the brakes and wheels must be allowed to cool before attempting another takeoff. Refer to the turn-around limits presented in Section I of this manual.
Runway Gradient	Change in runway elevation per 100 feet of runway length. The values given are positive for uphill gradients and negative for downhill gradients.
Gradient of Climb	The ratio of the change in height during a portion of the climb to the horizontal distance traversed in the same time interval.
Gross Climb Gradient	The climb gradient that the airplane can actually achieve given ideal conditions.
Net Climb Gradient	The gross climb gradient reduced by 0.8% during the takeoff phase and 1.1% enroute. This conservatism is required by FAR 25 for takeoff flight path determination to account for variables encountered in service.

ABORTED TAKEOFF

1. Wheel Brakes — Apply.
2. Thrust Levers — IDLE.
3. Spoilers — EXT.

4. Thrust Reversers — Deploy, if necessary.
5. • *If rejected takeoff was made at a weight above the turn-around brake energy weight (see applicable LANDING WEIGHT LIMITS chart in Section V)*, observe the Turn-Around Limits in Section I.
   • *If rejected takeoff was made at a weight above the landing maximum brake energy weight (see applicable LANDING WEIGHT LIMITS chart in Section V)*, see maintenance personnel to perform the High Energy Stop inspection.

NOTE: If the stop was conducted above the landing maximum brake energy limit, it is recommended that the PARKING BRAKE be released and chocks used. This will increase brake cooling efficiency and reduce the possibility of wheel fuse plug release and brake/tire fire.

TAKEOFF WARNING HORN ACTIVATES

The takeoff monitor warning will sound during ground operation when the right thrust lever is advanced to the MCR detent or above and one or more of the following conditions exist:

- Thrust reverser unlocked or deployed
- Flaps not set for takeoff
- Spoilers not retracted
- Pitch trim not in a safe position for takeoff
- Parking brake not released

1. Wheel Brakes — Apply.
2. Thrust Levers — IDLE.
3. After stopping, check takeoff configuration.

INADVERTENT STOW OF THRUST REVERSER AFTER A CREW-COMMANDED DEPLOYMENT

1. Maintain control with rudder, aileron, nose-wheel steering, and brakes.
2. Both Thrust Reverser Levers — Stow.

NOTE: Failure to move the thrust reverser levers to stow will result in forward thrust ranging from idle to near takeoff power, depending upon the position of the thrust reverser levers.

ENGINE FAILURE

DURING TAKEOFF

BELOW V1 SPEED

1. Wheel Brakes — Apply.
2. Thrust Levers — IDLE.
3. Spoilers — EXT.

4. Thrust Reversers — Deploy, if necessary.
5. • *If rejected takeoff was made at a weight above the turn-around brake energy weight (see applicable LANDING WEIGHT LIMITS chart in Section V)*, observe the Turn-Around Limits in Section I.
   • *If rejected takeoff was made at a weight above the landing maximum brake energy weight (see applicable LANDING WEIGHT LIMITS chart in Section V)*, see maintenance personnel to perform the High Energy Stop inspection.

NOTE: If the stop was conducted above the landing maximum brake energy limit, it is recommended that the PARKING BRAKE be released and chocks used. This will increase brake cooling efficiency and reduce the possibility of wheel fuse plug release and brake/tire fire.

ABOVE V1 SPEED

1. Rudder and Ailerons — As required, for directional control.
2. Accelerate to VR. Keep nose wheel on the ground.

NOTE: **Directional control is improved if the nose wheel is kept on the runway until VR.**

3. Rotate at VR; Climb at V2.
4. GEAR — UP, when positive rate of climb is established.
5. When clear of obstacles, accelerate to V2 + 20 and retract flaps.

6. APR Switch — OFF.
7. Refer to ENGINE SHUTDOWN IN FLIGHT procedure, Section IV or ENGINE FIRE — SHUTDOWN procedure, this section.

INTRODUCTION TO PERFORMANCE DATA

REGULATORY COMPLIANCE

Information in this section is presented for the purpose of compliance with the appropriate performance criteria and certification requirements of FAR 25.

STANDARD PERFORMANCE CONDITIONS

All performance in this section is based on flight test data and the following performance conditions:

1. Pertinent thrust ratings less installation, airbleed, and accessory losses.
2. Full temperature and altitude accountability within the operational limits for which the airplane is certified.

NOTE Should OAT or altitude be below the lowest value shown on the performance charts, use performance at the lowest value shown.

3. Wing flap positions are as follows:
   - Takeoff .... 8° or 20°
   - Enroute .... UP — 0°
   - Approach .... 8°
   - Landing .... DN — 40°
4. Power settings (N_1) from the appropriate charts or tables and indicated by the N_1 bugs.
5. All takeoff and landing performance is based on a paved, dry runway.
6. The takeoff performance was obtained using the following procedures and conditions:

ENGINE-OUT TAKEOFF — ACCELERATE GO

a. The thrust lever was set static to the takeoff (T/O) power position, and then the brakes were released.
b. The pilot recognized engine failure at V_1.
c. The airplane continued to accelerate to V_R at which time positive rotation to +9 degrees nose up pitch attitude was made.
d. The landing gear was retracted when a positive climb rate was established.
e. V_2 was achieved at or prior to the 35-foot point above the runway.

ENGINE-OUT TAKEOFF — ACCELERATE STOP

a. The thrust lever was set static to the takeoff (T/O) power position, and then the brakes were released.
b. The pilot recognized the necessity to stop because of engine failure just prior to V_1.
c. Maximum pilot braking effort was started at V_1 and continued until the airplane came to a stop.
d. Both thrust levers were brought to IDLE.
e. The spoilers were deployed (either manual or auto).

MULTI-ENGINE TAKEOFF

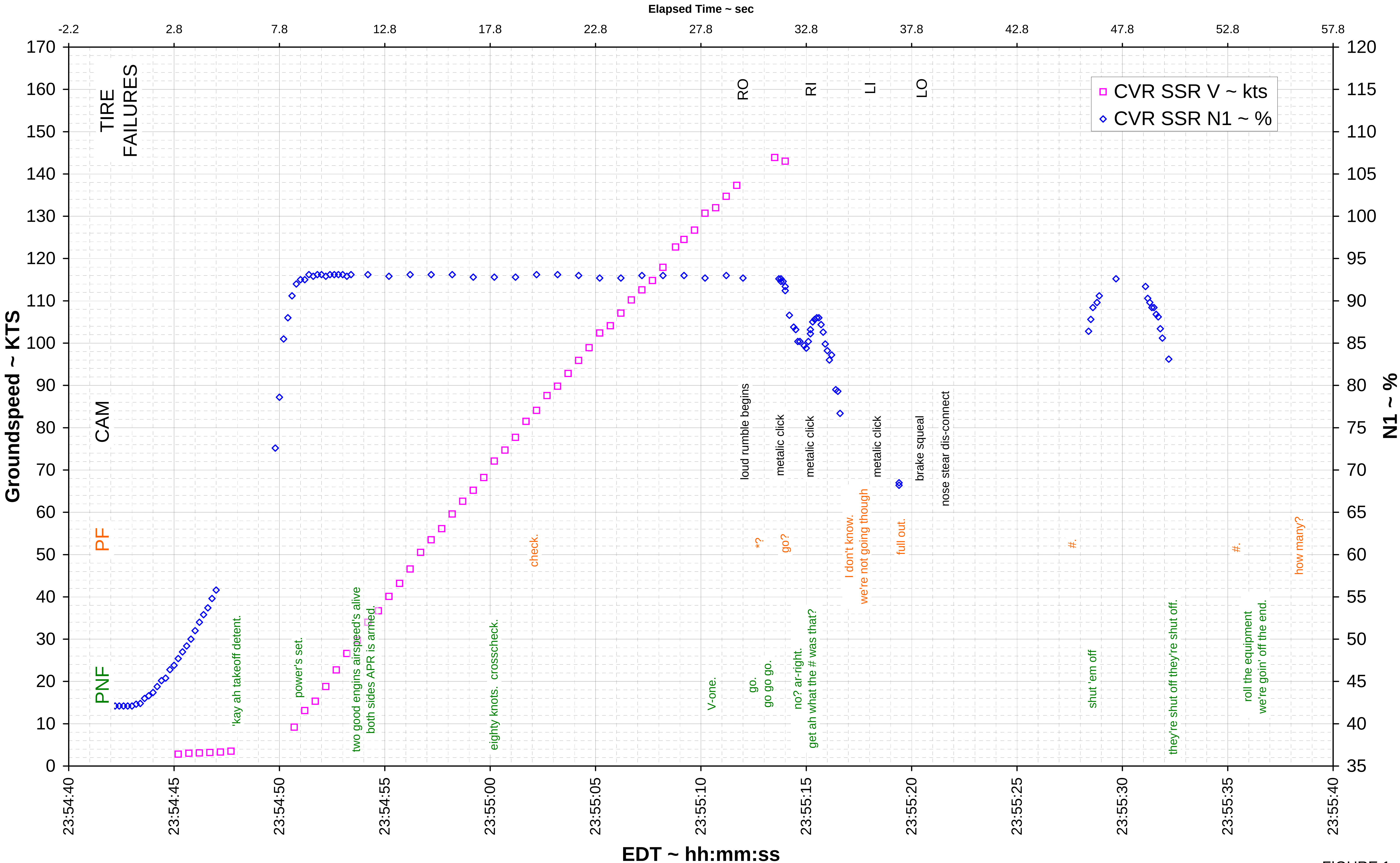
a. The thrust levers were set static to the takeoff (T/O) power position, and then the brakes were released.
b. Positive rotation to +9 degrees nose up pitch attitude was made at V_R.
c. The landing gear was retracted when a positive climb rate was established.
d. V_2 + 8 KIAS was achieved at or prior to the 35-foot point above the runway.

7. The landing performance was obtained using the following procedures and conditions:

LANDING

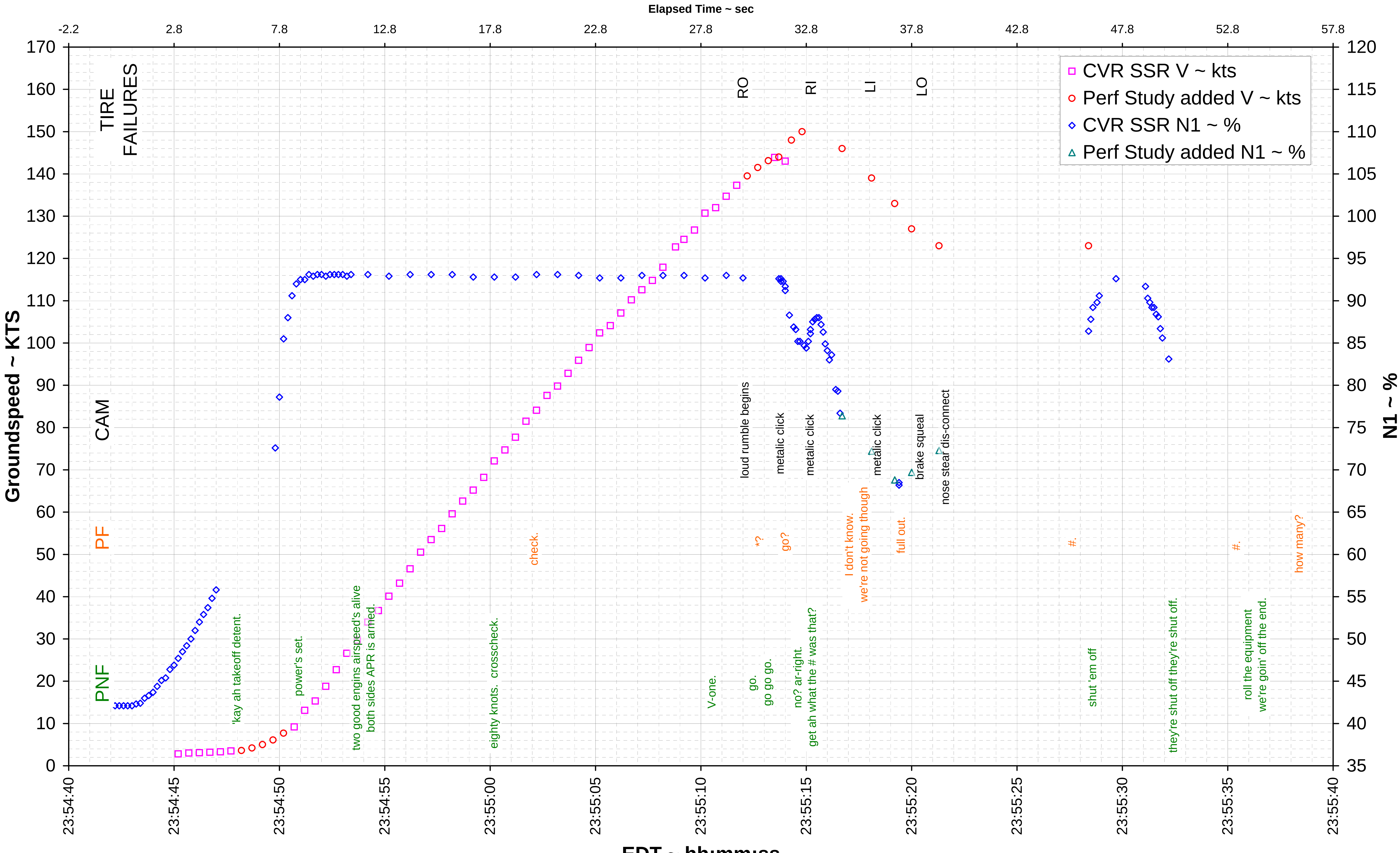
a. Approached at V_{REF} with flaps and gear down using thrust as required to maintain a 3° glideslope. Targeted touchdown approximately 1000 feet from end of runway.
b. At the 50-foot point, a slight reduction in thrust was made. At 25 feet, thrust levers were briskly moved to IDLE.
c. A firm touchdown was accomplished with little or no flare.
d. After touchdown, maximum braking was applied until the airplane came to a full stop.
e. • *On aircraft 60-001 thru 60-093, except 60-079, not incorporating SB 60-27-6,* spoilers were deployed manually.
   • *On aircraft 60-079, 60-094 and subsequent, and prior aircraft incorporating SB 60-27-6,* spoilers were deployed manually or automatically as indicated on the applicable chart.

VIII. FIGURES (listed sequentially 1 – 10)



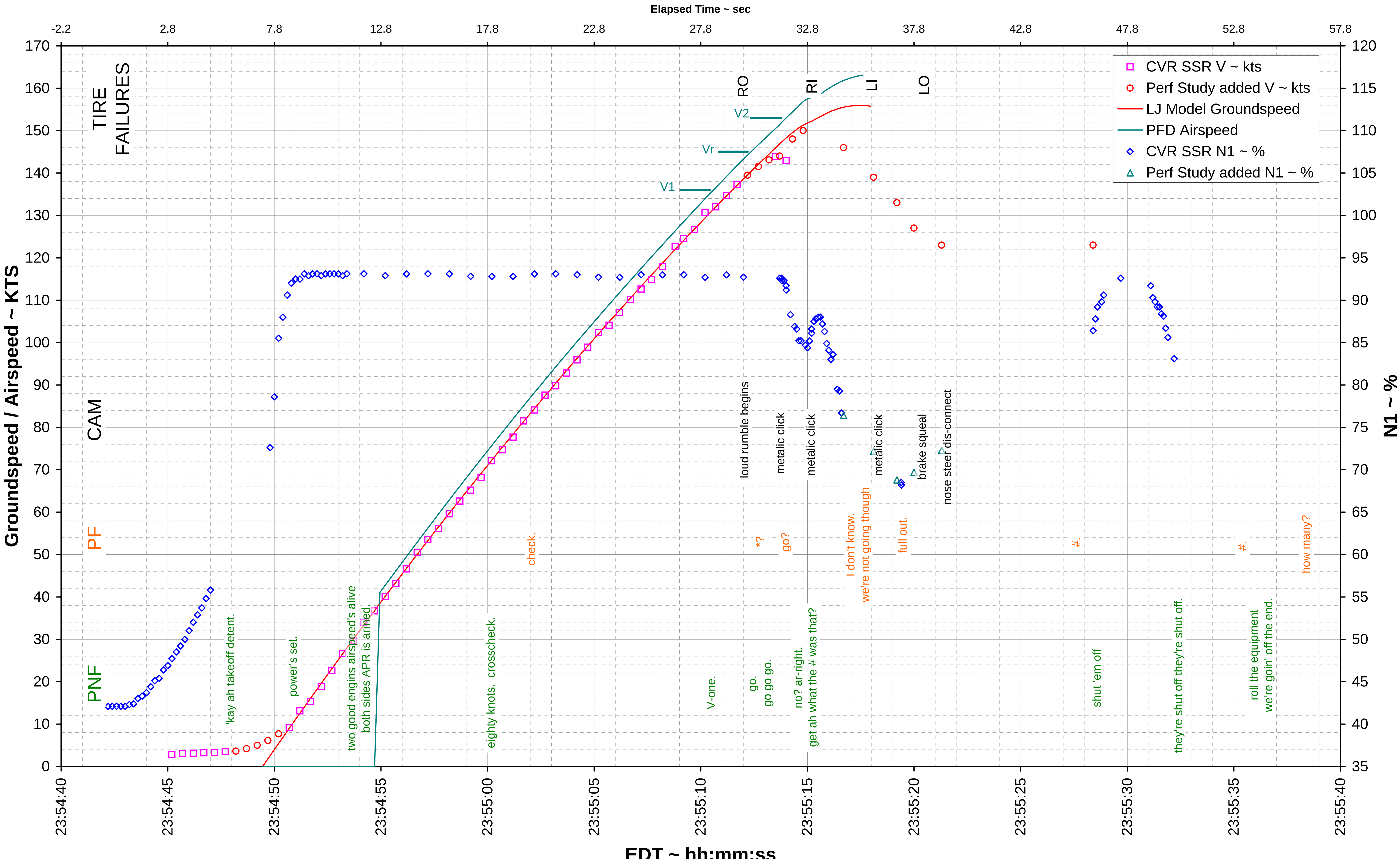
Elapsed Time ~ sec
Groundspeed ~ KTS
N1 ~ %
EDT ~ hh:mm:ss
CVR SSR V ~ kts
CVR SSR N1 ~ %
TIRE FAILURES
RO
RI
LI
LO
CAM
PF
PNF
'kay ah takeoff detent.
power's set.
two good engins airspeed's alive
both sides APR is armed.
eighty knots. crosscheck.
check.
V-one.
go.
go go go go.
*?
go?
no? ar-right.
get ah what the # was that?
I don't know.
we're not going though
full out.
loud rumble begins
metalic click
metalic click
metalic click
brake squeal
nose stear dis-connect
#.
shut 'em off
they're shut off they're shut off.
#.
roll the equipment
we're goin' off the end.
how many?

FIGURE 1



Elapsed Time ~ sec
Groundspeed ~ KTS
N1 ~ %
EDT ~ hh:mm:ss
CVR SSR V ~ kts
Perf Study added V ~ kts
CVR SSR N1 ~ %
Perf Study added N1 ~ %
TIRE FAILURES
RO
RI
LI
LO
CAM
PF
PNF
loud rumble begins
metalic click
metalic click
metalic click
brake squeal
nose stear dis-connect
check.
*?
go?
I don't know.
we're not going though
full out.
#.
#.
how many?
'kay ah takeoff detent.
power's set.
two good engins airspeed's alive
both sides APR is armed.
eighty knots. crosscheck.
V-one.
go.
go go go.
no? ar-right.
get ah what the # was that?
shut 'em off
they're shut off they're shut off.
roll the equipment
we're goin' off the end.

FIGURE 2



Elapsed Time ~ sec
Groundspeed / Airspeed ~ KTS
N1 ~ %
EDT ~ hh:mm:ss
TIRE FAILURES
RO
RI
LI
LO
V1
Vr
V2
CAM
PF
PNF
CVR SSR V ~ kts
Perf Study added V ~ kts
LJ Model Groundspeed
PFD Airspeed
CVR SSR N1 ~ %
Perf Study added N1 ~ %
loud rumble begins
metalic click
metalic click
metalic click
brake squeal
nose steer dis-connect
check.
*?
go?
I don't know.
we're not going though
full out.
#.
#.
how many?
'kay ah takeoff detent.
power's set.
two good engins airspeed's alive
both sides APR is armed.
eighty knots. crosscheck.
V-one.
go.
go go go go.
no? ar-right.
get ah what the # was that?
shut 'em off
they're shut off they're shut off.
roll the equipment
we're goin' off the end.

FIGURE 3

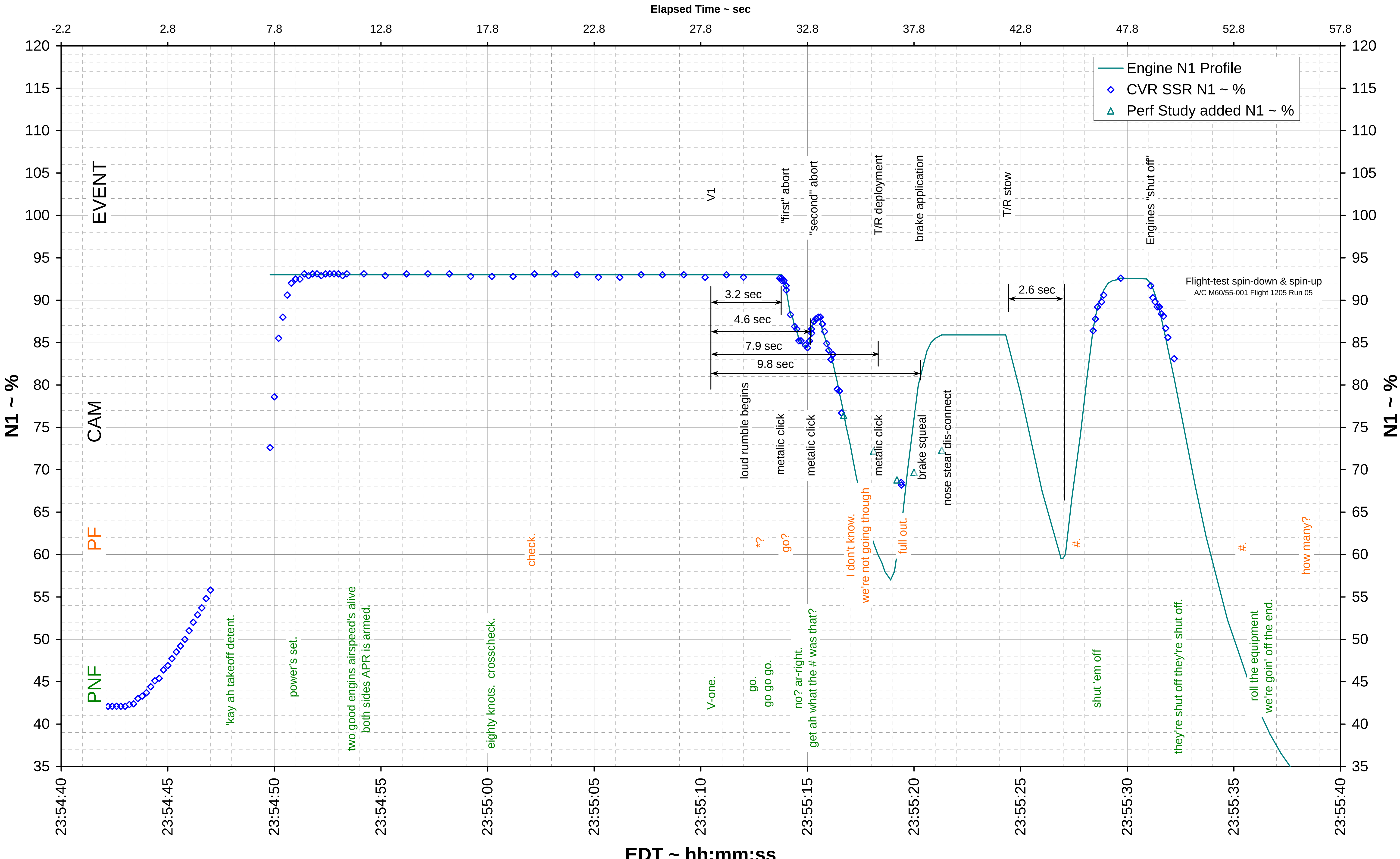
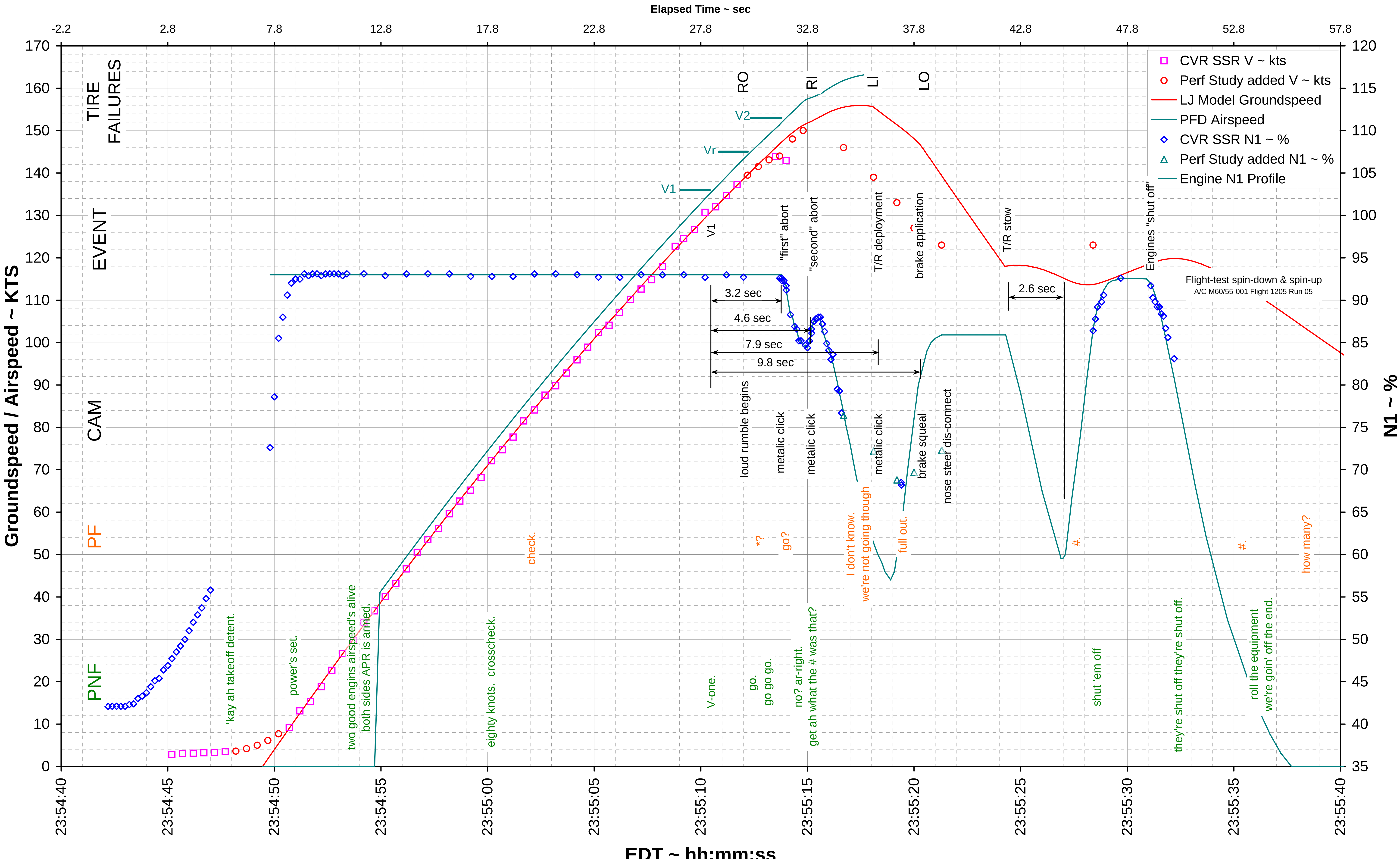

Elapsed Time ~ sec
N1 ~ %
EDT ~ hh:mm:ss
Engine N1 Profile
CVR SSR N1 ~ %
Perf Study added N1 ~ %
EVENT
CAM
PF
PNF
V1
"first" abort
"second" abort
T/R deployment
brake application
T/R stow
Engines "shut off"
3.2 sec
4.6 sec
7.9 sec
9.8 sec
2.6 sec
Flight-test spin-down & spin-up
A/C M60/55-001 Flight 1205 Run 05
loud rumble begins
metalic click
metalic click
metalic click
brake squeal
nose stear dis-connect
check.
*?
go?
I don't know.
we're not going though
full out.
#.
#.
how many?
'kay ah takeoff detent.
power's set.
two good engins airspeed's alive
both sides APR is armed.
eighty knots. crosscheck.
V-one.
go.
go go go.
no? ar-right.
get ah what the # was that?
shut 'em off
they're shut off they're shut off.
roll the equipment
we're goin' off the end.

FIGURE 4



Elapsed Time ~ sec
Groundspeed / Airspeed ~ KTS
N1 ~ %
EDT ~ hh:mm:ss
CVR SSR V ~ kts
Perf Study added V ~ kts
LJ Model Groundspeed
PFD Airspeed
CVR SSR N1 ~ %
Perf Study added N1 ~ %
Engine N1 Profile
TIRE FAILURES
EVENT
CAM
PF
PNF
RO
RI
LI
LO
V1
Vr
V2
3.2 sec
4.6 sec
7.9 sec
9.8 sec
2.6 sec
"first" abort
"second" abort
T/R deployment
brake application
T/R stow
Engines "shut off"
Flight-test spin-down & spin-up
A/C M60/55-001 Flight 1205 Run 05
loud rumble begins
metalic click
metalic click
metalic click
brake squeal
nose steer dis-connect
check.
*?
go?
I don't know.
we're not going though
full out.
#.
#.
how many?
'kay ah takeoff detent.
power's set.
two good engins airspeed's alive
both sides APR is armed.
eighty knots. crosscheck.
V-one.
go.
go go go.
no? ar-right.
get ah what the # was that?
shut 'em off
they're shut off they're shut off.
roll the equipment
we're goin' off the end.

FIGURE 5

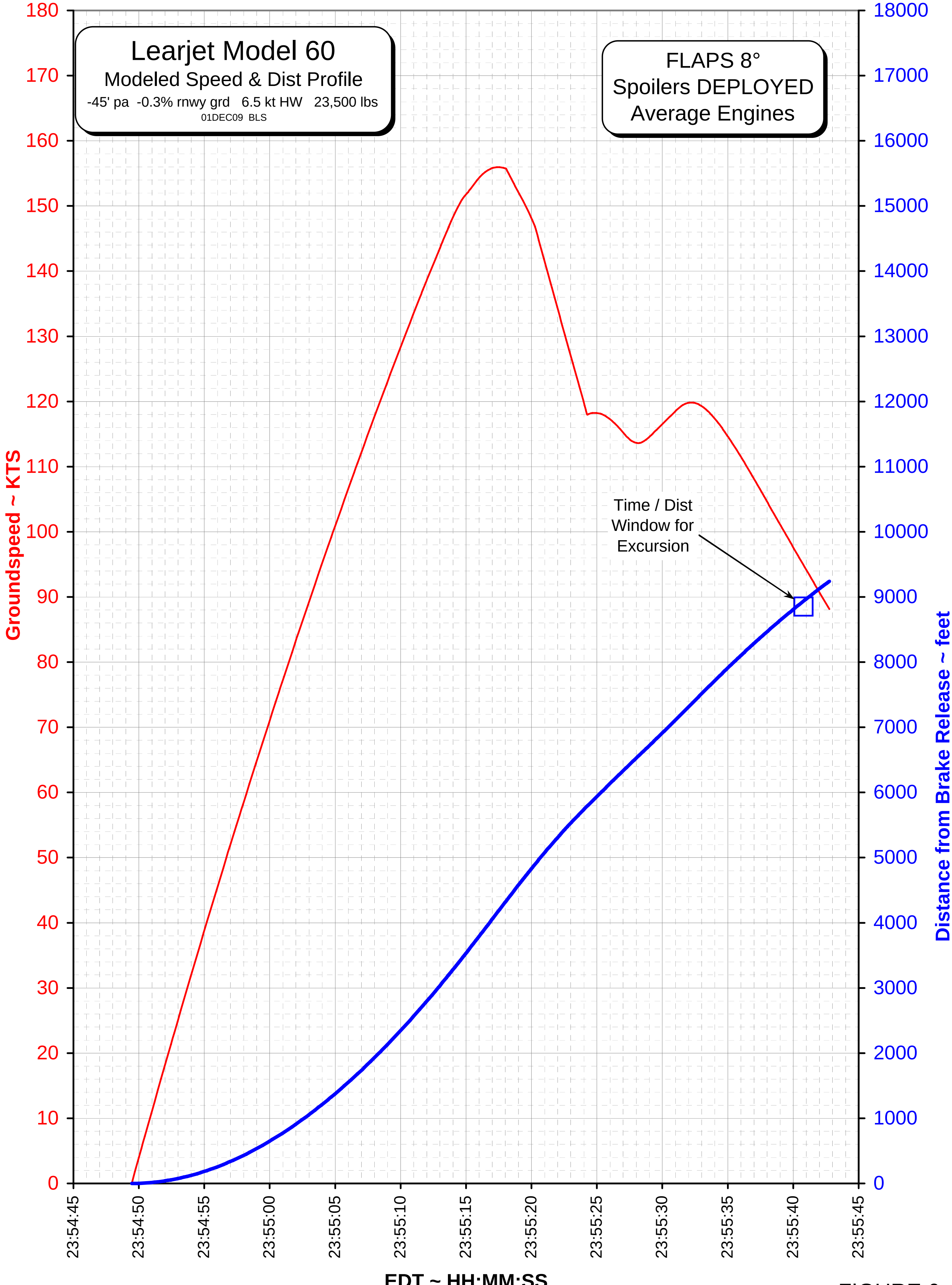

Learjet Model 60
Modeled Speed & Dist Profile
-45' pa -0.3% rnwy grd 6.5 kt HW 23,500 lbs
01DEC09 BLS
FLAPS 8°
Spoilers DEPLOYED
Average Engines
Time / Dist
Window for
Excursion
Groundspeed ~ KTS
Distance from Brake Release ~ feet
EDT ~ HH:MM:SS
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
12000
13000
14000
15000
16000
17000
18000
23:54:45
23:54:50
23:54:55
23:55:00
23:55:05
23:55:10
23:55:15
23:55:20
23:55:25
23:55:30
23:55:35
23:55:40
23:55:45

FIGURE 6

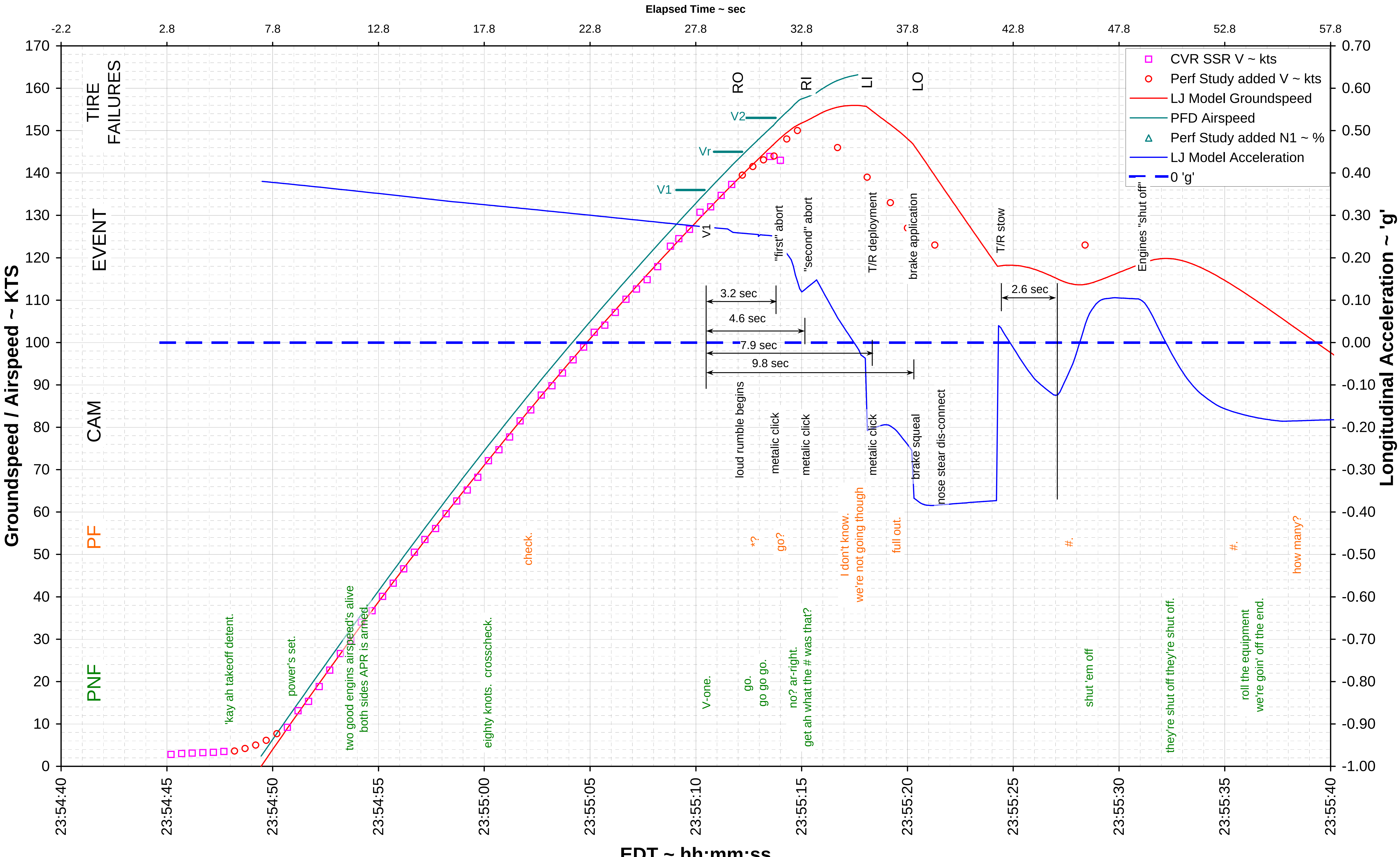
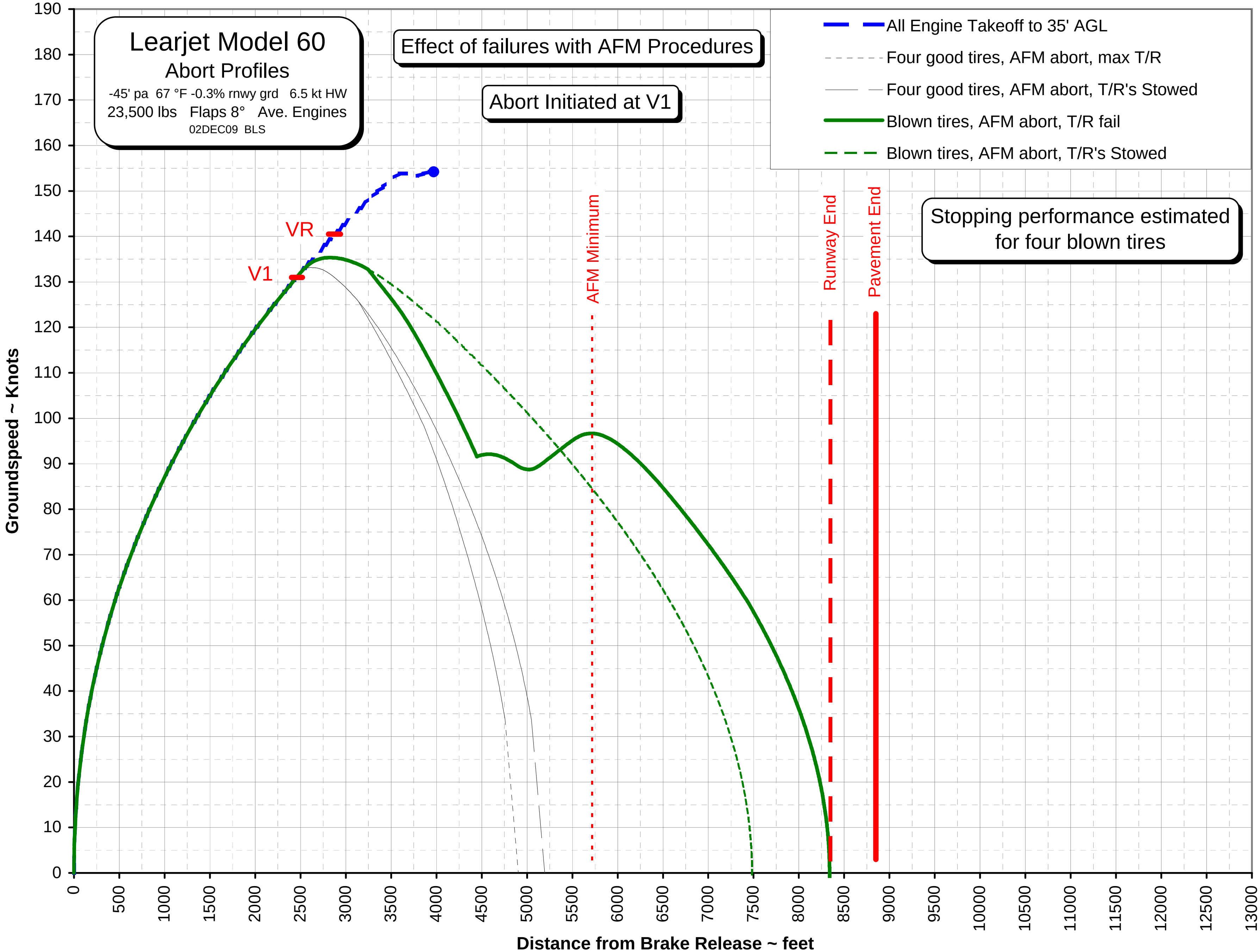
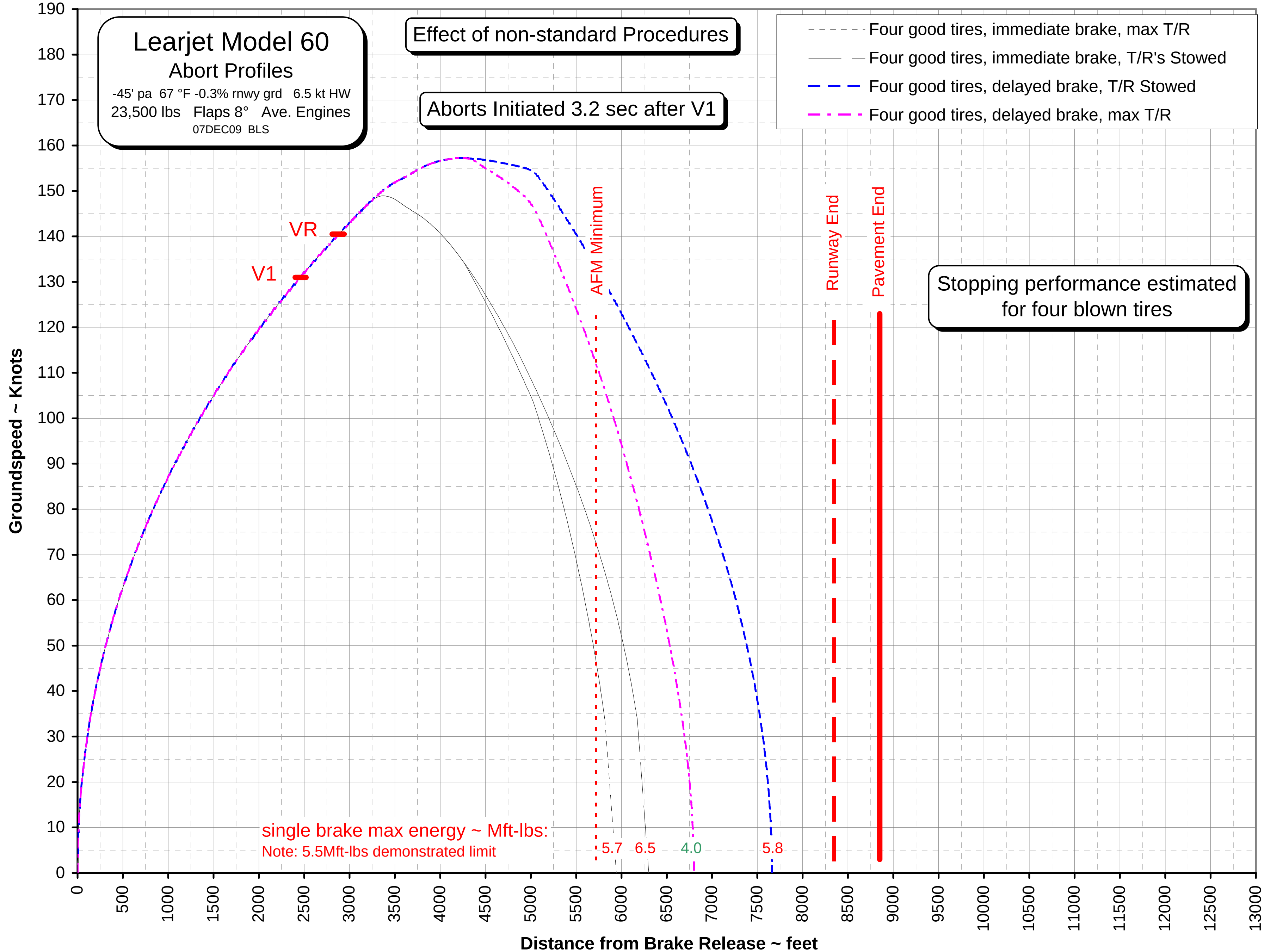

Elapsed Time ~ sec
Groundspeed / Airspeed ~ KTS
Longitudinal Acceleration ~ 'g'
EDT ~ hh:mm:ss
TIRE FAILURES
EVENT
CAM
PF
PNF
CVR SSR V ~ kts
Perf Study added V ~ kts
LJ Model Groundspeed
PFD Airspeed
Perf Study added N1 ~ %
LJ Model Acceleration
0 'g'
RO
RI
LI
LO
V1
Vr
V2
"first" abort
"second" abort
T/R deployment
brake application
T/R stow
Engines "shut off"
3.2 sec
4.6 sec
7.9 sec
9.8 sec
2.6 sec
loud rumble begins
metalic click
metalic click
metalic click
brake squeal
nose stear dis-connect
check.
*?
go?
I don't know.
we're not going though
full out.
#.
#.
how many?
'kay ah takeoff detent.
power's set.
two good engins airspeed's alive
both sides APR is armed
eighty knots. crosscheck.
V-one.
go.
go go go.
no? ar-right.
get ah what the # was that?
shut 'em off
they're shut off they're shut off.
roll the equipment
we're goin' off the end.

FIGURE 7



Learjet Model 60
Abort Profiles
-45' pa 67 °F -0.3% rnwy grd 6.5 kt HW
23,500 lbs Flaps 8° Ave. Engines
02DEC09 BLS
Effect of failures with AFM Procedures
Abort Initiated at V1
All Engine Takeoff to 35' AGL
Four good tires, AFM abort, max T/R
Four good tires, AFM abort, T/R's Stowed
Blown tires, AFM abort, T/R fail
Blown tires, AFM abort, T/R's Stowed
Stopping performance estimated for four blown tires
VR
V1
AFM Minimum
Runway End
Pavement End
Groundspeed ~ Knots
Distance from Brake Release ~ feet

FIGURE 8



Learjet Model 60
Abort Profiles
-45' pa 67 °F -0.3% rnwy grd 6.5 kt HW
23,500 lbs Flaps 8° Ave. Engines
07DEC09 BLS
Effect of non-standard Procedures
Aborts Initiated 3.2 sec after V1
Four good tires, immediate brake, max T/R
Four good tires, immediate brake, T/R's Stowed
Four good tires, delayed brake, T/R Stowed
Four good tires, delayed brake, max T/R
Stopping performance estimated for four blown tires
VR
V1
AFM Minimum
Runway End
Pavement End
single brake max energy ~ Mft-lbs:
Note: 5.5Mft-lbs demonstrated limit
5.7
6.5
4.0
5.8
Groundspeed ~ Knots
Distance from Brake Release ~ feet
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
6000
6500
7000
7500
8000
8500
9000
9500
10000
10500
11000
11500
12000
12500
13000

FIGURE 9

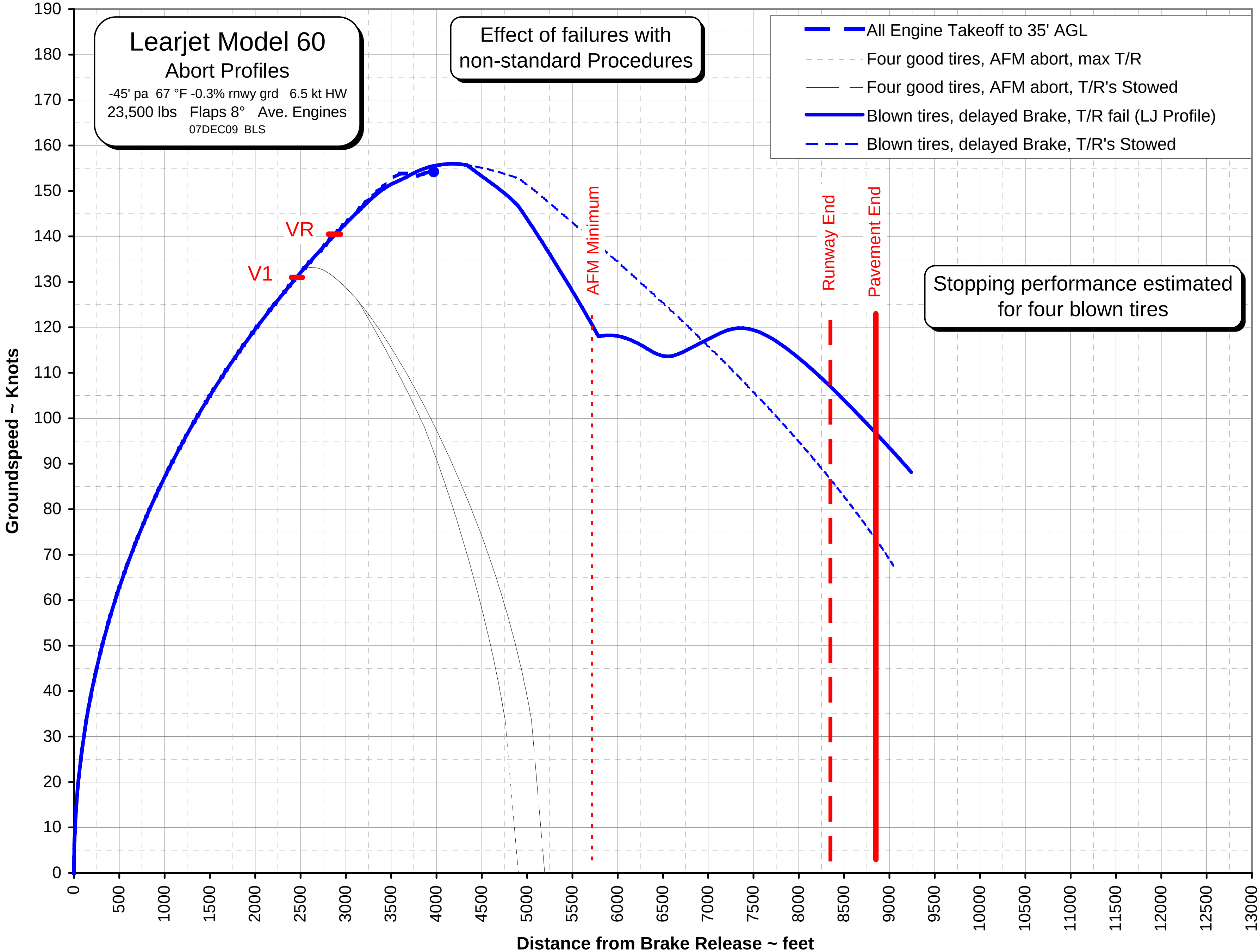

Learjet Model 60
Abort Profiles
-45' pa 67 °F -0.3% rnwy grd 6.5 kt HW
23,500 lbs Flaps 8° Ave. Engines
07DEC09 BLS
Effect of failures with non-standard Procedures
All Engine Takeoff to 35' AGL
Four good tires, AFM abort, max T/R
Four good tires, AFM abort, T/R's Stowed
Blown tires, delayed Brake, T/R fail (LJ Profile)
Blown tires, delayed Brake, T/R's Stowed
VR
V1
AFM Minimum
Runway End
Pavement End
Stopping performance estimated for four blown tires
Groundspeed ~ Knots
Distance from Brake Release ~ feet
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
6000
6500
7000
7500
8000
8500
9000
9500
10000
10500
11000
11500
12000
12500
13000

FIGURE 10