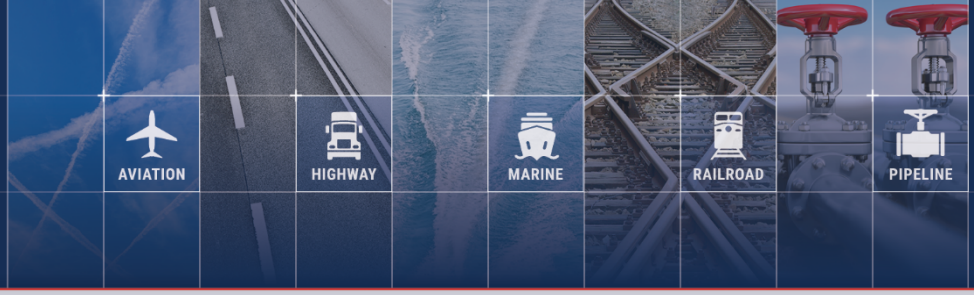

Aviation Investigation Final Report

Location:	Oroville, California	**Accident Number:**	WPR19FA230
Date & Time:	August 21, 2019, 11:32 Local	**Registration:**	N91GY
Aircraft:	Cessna 560XL	**Aircraft Damage:**	Destroyed
Defining Event:	Runway excursion	**Injuries:**	10 None
Flight Conducted Under:	Part 135: Air taxi & commuter - Non-scheduled		

Analysis

The crew was conducting an on-demand charter flight with eight passengers onboard. As the flight crew taxied the airplane to the departure runway, the copilot called air traffic control using his mobile phone to obtain the departure clearance and release. According to the pilot, while continuing to taxi, he stopped the airplane short of the runway where he performed a rudder bias check (the last item in the taxi checklist) and applied the parking brake without verbalizing the parking brake or rudder bias actions because the copilot was on the phone.

After the pilot lined up on the runway and shortly before takeoff, the flight crew discussed and corrected a NO TAKEOFF annunciation for an unsafe trim setting. After the copilot confirmed takeoff power was set, he stated that the airplane was barely moving then said that something was not right, to which the pilot replied the airplane was rolling and to call the airspeeds. About 16 seconds later, the pilot indicated that the airplane was using more runway than he expected then made callouts for takeoff-decision speed and rotation speed. The pilot stated that he pulled the yoke back twice, but the airplane did not lift off. Shortly after, the pilot applied full thrust reversers and maximum braking, then the airplane exited the departure end of the runway, impacted a ditch, and came to rest 1,990 ft beyond the departure end of the runway. The airplane was destroyed by a postcrash fire, and the crew and passengers were not injured.

Postaccident examination of the airplane and computed tomography scanning of the parking brake valve revealed it was in the ON position at the time of the accident. Calculations based on airplane performance data and airport surveillance video indicated that the accident airplane was able to accelerate to the speed required for the airplane to rotate and lift off as configured for a normal takeoff. However, the airplane's performance was substantially degraded during the accident takeoff roll by an unexpected retarding force acting at the wheel/runway interface. Based on the parking brake valve examination and the performance of the airplane during the accident sequence, it is likely that the engaged parking brake produced the unexpected

retarding force at the wheel/runway interface, and at a magnitude and direction that adversely affected the airplane's acceleration and rotation capability during the attempted takeoff.

Review of the airplane's before takeoff and takeoff checklists revealed no explicit item that directed the flight crew to release or check the parking brake. The operator and manufacturer's taxi checklists direct the flight crew to check brakes but do not specifically refer to the parking brake, and the operator's flow diagram for that checklist did not point to the parking brake pull knob. Additionally, the position of the parking brake lever was not evaluated as part of the conditions that trigger a NO TAKEOFF annunciation.

Review of the CE-560XL parking brake's certification revealed that the parking brake was designed to prevent the airplane from rolling if one engine is at takeoff power and did not require a cockpit indication if the parking brake was not fully released. These conditions met the parking brake standard at the time of certification. However, the standard was updated in 2002 to require an annunciation if the parking brake was not fully released when takeoff power was applied, and the CE-560XL parking brake was not required to be updated to that standard.

The manufacturer did not test the parking brake with both engines at takeoff power and was not required to as part of certification. The head of training where the pilot and copilot received their CE-560XL training stated that no airplane flight manual, checklist, or training curriculum provided a caution or warning that takeoff speeds may be achievable with full or partial pressure applied by the parking brake, and the pilot reported that he expected the airplane not to move with takeoff power applied.

Available evidence, including continuous, heavy rubber deposits on the runway consistent with the main landing gear wheel spacing throughout the acceleration segment of the takeoff roll, indicates that it is likely that the pilot did not release the parking brake after setting it to perform the rudder bias check. Because the parking brake pull knob was located on the pilot's left side and was obstructed from the copilot's view, it is unlikely the copilot could have seen the pull knob before or during the takeoff. Although the crew was aware of the airplane's slow acceleration, it was not clear at the time that it was related to an unexpected retarding force or the unsafe condition of the engaged parking brake. Had the parking brake lever position been incorporated into the conditions that trigger a NO TAKEOFF annunciation, as required for airplanes certificated after 2002, the pilot and copilot likely would have identified that the parking brake remained engaged and corrected the unsafe setting before attempting takeoff, just as they did for the unsafe trim setting. Despite the flight crew's non-adherence to standard operating procedures, a checklist item that directed the pilot to fully release the parking brake before takeoff could have also served as an important redundancy to an annunciation, but none appears in the before takeoff checklist.

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this accident to be:

The pilot's failure to release the parking brake before attempting to initiate the takeoff, which produced an unexpected retarding force and airplane nose down pitching moment. Also causal was the flight crew's delayed decision to abort the takeoff, which resulted in a runway excursion. Contributing to the accident was the lack of a NO TAKEOFF annunciation warning that the parking brake was engaged, and lack of a checklist item to ensure the parking brake was fully released immediately before takeoff.

Findings

Personnel issues	Use of equip/system - Flight crew
Aircraft	Brake - Incorrect use/operation
Personnel issues	Delayed action - Flight crew
Aircraft	Central warning - Design
Aircraft	Brake - Design
Organizational issues	Design of document/info - Manufacturer

Factual Information

History of Flight

Takeoff-rejected takeoff	Runway excursion (Defining event)

On August 21, 2019, about 1132 Pacific daylight time, a Cessna CE-560XL airplane, N91GY, was destroyed when it was involved in an accident near Oroville, California. The two pilots and eight passengers were not injured. The airplane was operated as a Title 14 *Code of Federal Regulations* (*CFR*) Part 135 on-demand charter flight.

The pilot and copilot reported that, after a normal preflight inspection was completed, the passengers boarded the airplane, and the pilot briefed the passengers. Both the pilot and copilot conducted the before engine start checklist through the after-start checklist and began taxiing to runway 2. Review of the cockpit voice recorder (CVR) recording revealed that, before engine start, the copilot called out "parking brake" and the pilot replied, "set"; the crew did not otherwise mention the parking brake. According to the pilot, the pilot and copilot completed most of the items on the taxi checklist during the taxi before the airplane neared runway 2, then the copilot used a mobile phone to call the Federal Aviation Administration Air Route Air Traffic Control Center and obtain their instrument flight rules departure clearance and release. Review of the CVR recording reveals that the pilot and copilot did not verbalize most of the items on the taxi checklist.

The pilot reported that he continued to taxi and stopped short of runway 2, where he performed a rudder bias check. The pilot stated that, as part of the rudder bias check, he applied the parking brake then kept his feet on the pedals to feel the rudder pedal movement. Review of the CVR recording confirmed that the pilot did not verbalize the rudder bias check or setting or releasing the parking brake as part of the rudder bias check. The pilot reported that, after obtaining their instrument flight rules clearance, the flight crew updated the flight management system. Review of airport surveillance video showed the airplane holding short of runway 2 for about 3 minutes 44 seconds.

Review of the CVR recording revealed that, about 1 minute 30 seconds before takeoff, the pilot and copilot discussed that a NO TAKEOFF annunciator had illuminated in the cockpit for an unsafe trim setting and that the autopilot had engaged. The CVR captured a sound consistent with the autopilot being disconnected, then the flight crew discussed that a tablet had accidentally shifted and engaged the autopilot. The pilots then discussed resetting the trim, which the copilot corrected.

About 30 seconds before the application of takeoff thrust, the pilot and copilot discussed a turn knob annunciator that had illuminated in the cockpit. The copilot discussed that he did not know the meaning of the message and asked whether the pilot wanted to continue with the flight. The pilot responded they would go and would not turn the autopilot on until they figured it out.

The airplane's engine RPM increased about 7 seconds later, followed by the confirmation of takeoff power set by the copilot 8 seconds after that. About 2 seconds after the copilot confirmed takeoff power set, he said that the airplane was barely moving then stated that something was not right. About 3 seconds later, the pilot stated the airplane was rolling and told the copilot to call speeds, which the copilot acknowledged. About 16 seconds later, the pilot indicated that the airplane was using more runway than he expected. The copilot called out the takeoff-decision speed 2 seconds later and said "rotate" for rotation speed 1 second after that. The pilot then said "rotate."

The pilot stated in a postaccident interview that "it was just a weird sensation" as he pulled the yoke back and the airplane didn't lift off, and he noticed no movement of the nose when pulling the yoke back a second time "harder" to his chest. Shortly after, the pilot applied full thrust reversers and maximum braking. A sound consistent with thrust reverser application was captured on the CVR recording about 1 second after the airplane had exited the frame of the airport surveillance camera. The position at which the airplane moved out of the surveillance camera frame was about 730 ft beyond the runway 20 threshold. The airplane exited the departure end of the runway and impacted a ditch. The landing gear separated from the airplane during the accident sequence, and the airplane skidded to a stop across a grass-covered area, and a postcrash fire ensued.

Pilot Information

Certificate:	Airline transport; Commercial	**Age:**	38,Male
Airplane Rating(s):	Single-engine land; Multi-engine land	**Seat Occupied:**	Left
Other Aircraft Rating(s):	None	**Restraint Used:**	5-point
Instrument Rating(s):	Airplane	**Second Pilot Present:**	Yes
Instructor Rating(s):	None	**Toxicology Performed:**	No
Medical Certification:	Class 1 With waivers/limitations	**Last FAA Medical Exam:**	March 24, 2019
Occupational Pilot:	Yes	**Last Flight Review or Equivalent:**	May 10, 2019
Flight Time:	6482 hours (Total, all aircraft), 192 hours (Total, this make and model), 2191 hours (Pilot In Command, all aircraft), 122 hours (Last 90 days, all aircraft), 41 hours (Last 30 days, all aircraft)		

Co-pilot Information

Certificate:	Airline transport; Commercial	**Age:**	40,Male
Airplane Rating(s):	Single-engine land; Multi-engine land	**Seat Occupied:**	Right
Other Aircraft Rating(s):	None	**Restraint Used:**	5-point
Instrument Rating(s):	Airplane	**Second Pilot Present:**	Yes
Instructor Rating(s):	None	**Toxicology Performed:**	No
Medical Certification:	Class 1 Without waivers/limitations	**Last FAA Medical Exam:**	April 8, 2019
Occupational Pilot:	Yes	**Last Flight Review or Equivalent:**	August 7, 2019
Flight Time:	4748 hours (Total, all aircraft), 858 hours (Total, this make and model), 2219 hours (Pilot In Command, all aircraft), 99 hours (Last 90 days, all aircraft), 27 hours (Last 30 days, all aircraft)		

The pilot, who was the pilot flying during the accident flight, held a pilot-in-command type rating for the CE-560XL, CE-525S airplanes. The pilot's most recent proficiency check about 3 months before the accident flight was his initial type rating for the accident make and model.

The copilot was the pilot monitoring for the accident flight and qualified as captain by the operator. He held a pilot-in-command type ratings in the CE-560XL, CE-750, and second-in-command privileges for the ERJ-170/190. About a month before the accident flight, the copilot completed his most recent simulator training, which included recurrent training for the CE-560XL.

Aircraft and Owner/Operator Information

Aircraft Make:	Cessna	**Registration:**	N91GY
Model/Series:	560XL	**Aircraft Category:**	Airplane
Year of Manufacture:	2003	**Amateur Built:**	
Airworthiness Certificate:	Normal	**Serial Number:**	560-5314
Landing Gear Type:	Retractable - Tricycle	**Seats:**	10
Date/Type of Last Inspection:	April 12, 2019 100 hour	**Certified Max Gross Wt.:**	20200 lbs
Time Since Last Inspection:		**Engines:**	2 Turbo fan
Airframe Total Time:	9876.6 Hrs at time of accident	**Engine Manufacturer:**	Pratt & whitney
ELT:	C126 installed, not activated	**Engine Model/Series:**	PW545A
Registered Owner:		**Rated Power:**	4119 Lbs thrust
Operator:		**Operating Certificate(s) Held:**	On-demand air taxi (135)

Parking Brake

According to the manufacturer's operating manual, the accident airplane's parking brake was part of the CE-560XL's "normal brake system" and employed "controllable check valves that could prevent the return of hydraulic fluid after the brakes have been set." The left-seat pilot normally sets the parking brake by "depressing the toe brakes and pulling out the black parking brake handle [pull knob] located on the lower left side of the instrument panel" (see exemplar CE-560XL in figure 1). The parking brake's power (or resistance) could vary and is dependent upon the amount of force the pilot applied to the toe brakes before pulling the parking brake pull knob. The manufacturer's operating manual does not specify how much force or length of time to apply to the toe brakes while setting the parking brake.

If the CE-560XL toe brakes are not fully depressed when the parking brake valve is engaged, then only partial pressure would be trapped by the parking brake valve. In a submission for this investigation, the manufacturer stated that the parking brake valve is designed to also trap pressure in the brake lines if the parking brake pull knob is pulled first, followed by application of the toe brakes, but the manufacturer's operating manual does not include that information. The parking brake pull knob on the CE-560XL is located on the lower left side of the instrument panel near the left-seat pilot's left knee, which obscures it from the view of the right-seat pilot (see figure 2).

Figure 1: View of the parking brake pull knob in the ON position in reference to the instrument panel in an exemplar CE-560XL.

Figure 2: Location of the obscured parking brake pull knob within an exemplar CE-560XL

When asked how to normally engage the parking brake during a postaccident interview, the pilot stated that he normally pressed on the toe brakes enough to stop the airplane's taxi movement then pushed the toe brakes "a little bit more" and pulled the "lever." He added that "you're not standing on [the toe brakes]." The pilot further reported that it was his understanding that if the parking brake was set on the CE-560XL, the airplane "shouldn't move" with takeoff power applied. When the copilot was asked if he believed the airplane could move with the parking brake engaged, he reported, "I have no expectations for anything." According to the head of training at the training center where the pilot and copilot received their CE-560XL training, no CE-560XL airplane flight manual, checklist, or training curriculum provided a caution or warning that takeoff speeds may be achievable with full or partial pressure applied to the parking brake.

Takeoff Warning Annunciator

The airplane was equipped with a NO TAKEOFF warning light as part of the annunciator panel, but the parking brake lever was not a part of the alerting conditions. The airplane operating manual stated, in part:

> *On the ground, the amber no takeoff annunciator will illuminate steadily if one or more of the following conditions exist: Flaps not within takeoff range (less than 7° or more than 15°), elevator out of trim for takeoff, horizontal stabilizer is out of takeoff position, or speed brakes are out of takeoff position. … Pressing the master caution will cause the flashing annunciator to change to steady on and the master caution to extinguish.*

Checklists

Delta Private Jets (the operator) produced its normal CE-560XL checklists, which were adapted from the manufacturer's airplane flight manual checklists, and the operator required its pilots to use the operator's checklists. The Federal Aviation Administration certificate managing office accepted these adapted operator checklists in May 2017. The manufacturer's "before starting engines" checklist called for the "park brake" to be set and the operator's "before start" checklist called for the parking brake to be set by the left-seat pilot; therefore, both the manufacturers and operator's checklists call for the parking brake to be set before the engines are started. There were no further checklist items referring to the parking brake in the manufacturers and operator's checklists until the shutdown checklist.

The third item of manufacturer's taxi checklists stated, in part, "brakes…check"; the manufacturer stated that this step calls for the brakes to be tested. The operator's taxi checklist also includes this item, but its flow diagram in the standard operating procedures points to the toe brakes rather than the parking brake pull knob for this checklist item.

The rudder bias system is a check item in the operator's taxi checklist and the manufacturers before taxi checklist. The operator's rudder bias check procedures direct the pilot flying to verbalize "left throttle, left rudder… right throttle, right rudder" while checking the rudder bias. The pilot stated that he typically would have verbalized "parking brake on, parking brake off" when performing the rudder bias check; however, because the copilot was on the phone obtaining clearance and release for the flight, he did not verbalize those callouts during taxi.

Certification

The parking brake standard outlined in 14 *CFR* 25.735, Brakes and Braking Systems, was first established in 1965 and remained the standard until May 2002. To meet the original requirements of 14 *CFR* 25.735 in force between 1965 and 2002, the parking brake must prevent the airplane from rolling on a paved, level runway when set by the pilot with takeoff power on the critical engine. To certify the CE-560XL parking brake to that standard, the manufacturer demonstrated that the parking brake prevented the airplane from rolling when set with full parking brake pressure applied and one engine at takeoff power. The parking brake was not required to be tested with both engines at takeoff power, and the manufacturer did not test this condition.

Effective May 2002, the Federal Aviation Administration amended 14 *CFR* 25.735 (Amendment 25-107) to state, in part, "There must be indication in the cockpit when the parking brake is not fully released." However, the CE-560XL was initially certificated in 1998 (4 years before the parking brake indication amendment) and built to the initial 1965 standard, which does not require a cockpit indication if the parking brake is not fully released.

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	**Condition of Light:**	Day
Observation Facility, Elevation:	KOVE,190 ft msl	**Distance from Accident Site:**	0 Nautical Miles
Observation Time:	18:53 Local	**Direction from Accident Site:**	54°
Lowest Cloud Condition:	Clear	**Visibility**	10 miles
Lowest Ceiling:	None	**Visibility (RVR):**	
Wind Speed/Gusts:	/	**Turbulence Type Forecast/Actual:**	None / None
Wind Direction:		**Turbulence Severity Forecast/Actual:**	N/A / N/A
Altimeter Setting:	29.94 inches Hg	**Temperature/Dew Point:**	28°C / 14°C
Precipitation and Obscuration:	No Obscuration; No Precipitation		
Departure Point:	Oroville, CA (OVE)	**Type of Flight Plan Filed:**	IFR
Destination:	Portland, OR	**Type of Clearance:**	IFR
Departure Time:	11:32 Local	**Type of Airspace:**	Class E

Airport Information

Airport:	Oroville Municipal OVE	**Runway Surface Type:**	Asphalt
Airport Elevation:	194 ft msl	**Runway Surface Condition:**	Dry
Runway Used:	02	**IFR Approach:**	None
Runway Length/Width:	6020 ft / 100 ft	**VFR Approach/Landing:**	None

Wreckage and Impact Information

Crew Injuries:	2 None	**Aircraft Damage:**	Destroyed
Passenger Injuries:	8 None	**Aircraft Fire:**	None
Ground Injuries:		**Aircraft Explosion:**	None
Total Injuries:	10 None	**Latitude, Longitude:**	39.497222,-121.61666(est)

Examination of the accident site revealed that the airplane came to rest about 1,990 ft beyond the departure end of runway 2 on a heading of about 078°.

Examination of the runway revealed tire transfer marks which originated from near the runway 2 hold short line and progressed onto the runway then continued throughout the entire length of the runway, runway overrun, and a perpendicular oriented runway (see figure 3). The

tire marks extended into a grassy area, across a taxiway, and within the grassy area near the main wreckage (see figure 4).

Figure 3: View of the approach end of runway 2, with right main landing gear (MLG) transfer marks annotated.

Figure 4: View of the accident site and runway environment.

All major structural components of the airplane were located within the vicinity of the main wreckage.

Examination of the wreckage revealed that the postcrash fire consumed a majority of the airframe. The right wing was ruptured open and extensively fire damaged. The left wing was mostly intact just outboard of the wing root. The empennage (rudder, vertical, horizontal, and elevators) was intact and unremarkable. The cockpit area was heavily damaged by the postcrash fire.

The parking brake cable and handle were located in the wreckage, but the parking brake plastic knob was not present. The cockpit end of the parking brake cable and handle was found in a position consistent with the OFF position. The cable was continuous from the handle to the parking brake valve.

The parking brake valve was located loose in the wreckage and was damaged by fire. The parking brake control cable was attached to the valve and all attaching hardware was present. The cable was removed from the valve without disturbing the valve lever position, but the cable could not be actuated due to unknown obstructions/interference that could not be determined on scene. Based on a visual inspection of the lever position, the brake valve was in the ON position, as shown in figure 5. No part identification or data plate could be found on the component.

Figure 5: Parking brake valve after removal from the wreckage

The parking brake valve was scanned using computed tomography and the resulting images showed internal valve components in a closed position, which is consistent with an ON position.

Additional Information

Data obtained from the onboard flight data recorder revealed that 16 of the 59 parameters, including airspeed, contained invalid data. A performance study based upon longitudinal acceleration data (which was found to be valid) revealed that the airplane had reached a maximum speed of about 120 knots during the takeoff sequence, as shown in figure 6. The calculated takeoff-decision and rotational speeds in a normal configuration for the accident takeoff were 106 knots, and angle-of-climb speed was calculated to be 123 knots.

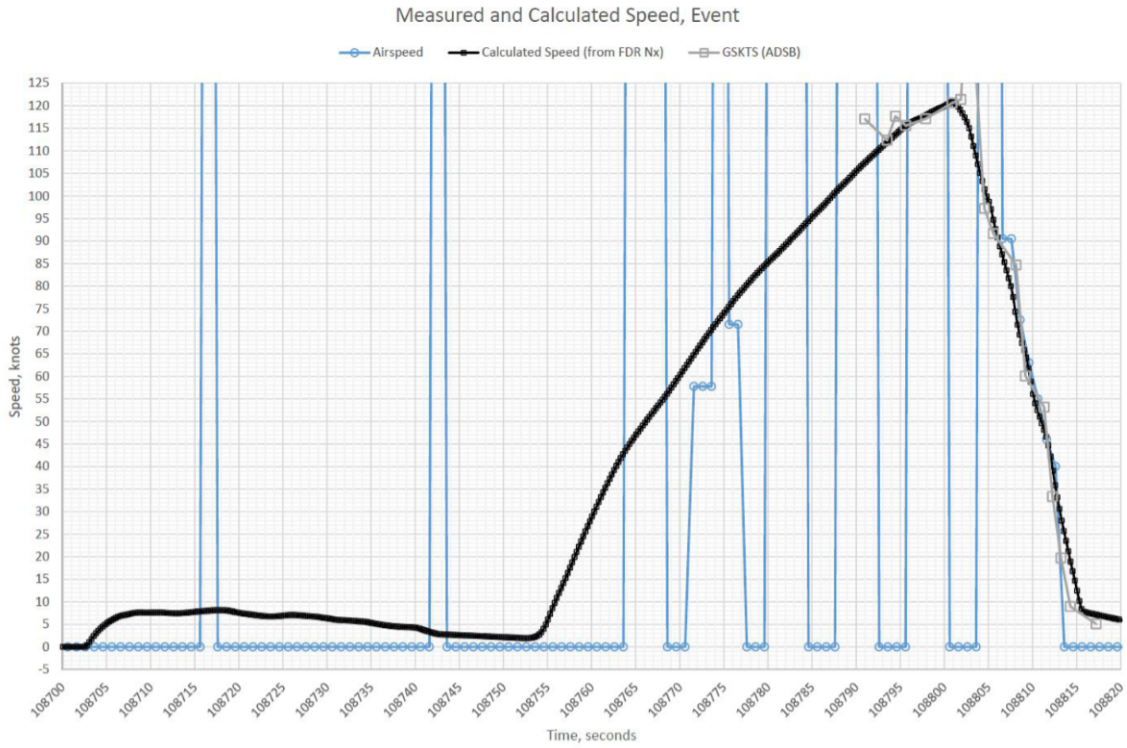

Figure 6: Comparison of calculated ground speed, flight data recorder airspeed, and automatic dependent surveillance-broadcast data.

The aircraft performance study, which used information from the flight data recorder, CVR, automatic dependent surveillance-broadcast, airport surveillance camera, tire witness marks, and the airplane flight manual, indicated that the accident airplane was able to accelerate to the rotation speed required for the airplane to lift off and had adequate takeoff performance capability to safely take off from runway 2 when configured for a normal takeoff. However, the information from the above sources and engineering models used to calculate the lift, drag, and engine thrust components during the accident takeoff roll, indicated that the airplane's performance was substantially degraded by an unexpected retarding force acting at the wheel/runway interface.

Using the CE-560XL weight and balance envelope and the accident airplane's full-forward center of gravity (CG) position when loaded at the aft limit, the airplane nose up CG pitching

moment capability was calculated between about 10,300 and 12,800 ft-pounds (ft-lb). Based on CE-560XL engineering drawings and the accident airplane's weights, a vertical moment arm was estimated at 3.5 ft. The airplane nose down pitching moment calculations using CE-560XL engineering models (figure 7) indicate about 13,000 ft-lb for groundspeeds between 90 and 110 knots and a 3.5 ft moment arm, which matches or exceeds the available airplane nose up pitching moment capability for the accident CG loading values. Thus, the accident airplane's unexpected retarding force directly competed against and could inhibit airplane nose up elevator/horizontal stabilizer authority at rotation speed for the accident CG loading value.

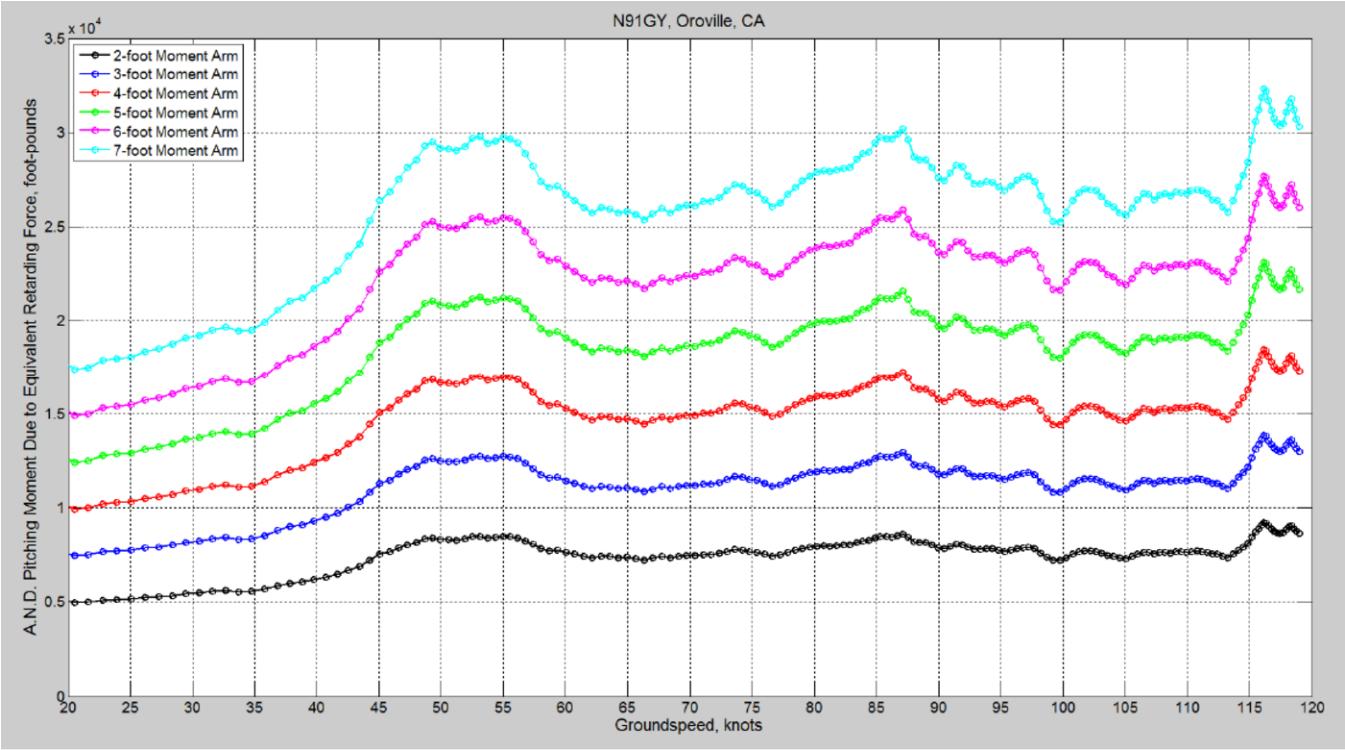

Figure 7: Estimated airplane nose down pitching moment due to calculated equivalent retarding force during the accident takeoff ground roll.

The magnitude and direction of the unexpected retarding force adversely affected the airplane's acceleration and rotation capability during the attempted takeoff as well as deceleration capability when stopping. Figure 8 shows the airplane's groundspeed for previous takeoff sequences as compared to its degraded groundspeed during the accident takeoff (black line and symbols).

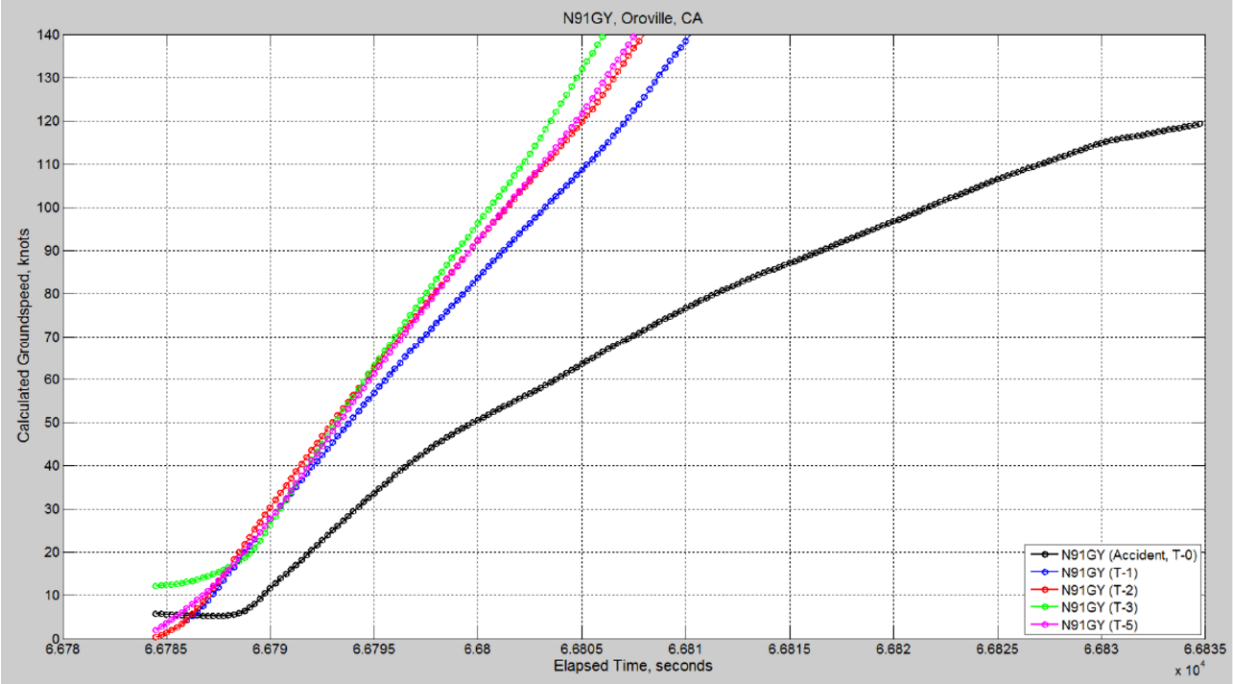

Figure 8: Calculated airplane groundspeed values for previous takeoffs and the accident takeoff.

Administrative Information

Investigator In Charge (IIC):	Cawthra, Joshua		
Additional Participating Persons:	Jeff Snider; Federal Aviation Administration; Sacramento, CA Henry Soderlund; Textron Aviation Inc.; Wichita, KS Mark Carroll; Delta Private Jets; Erlanger, KY Patrick Lusch; Federal Aviation Administration; Washington, DC		
Original Publish Date:	May 17, 2022	**Investigation Class:**	3
Note:			
Investigation Docket:	https://data.ntsb.gov/Docket?ProjectID=100109		

The National Transportation Safety Board (NTSB), established in 1967, is an independent federal agency mandated by Congress through the Independent Safety Board Act of 1974 to investigate transportation accidents, determine the probable causes of the accidents, issue safety recommendations, study transportation safety issues, and evaluate the safety effectiveness of government agencies involved in transportation. The NTSB makes public its actions and decisions through accident reports, safety studies, special investigation reports, safety recommendations, and statistical reviews.

The Independent Safety Board Act, as codified at 49 U.S.C. Section 1154(b), precludes the admission into evidence or use of any part of an NTSB report related to an incident or accident in a civil action for damages resulting from a matter mentioned in the report. A factual report that may be admissible under 49 U.S.C. § 1154(b) is available here.