Don't Stop Now!

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On a warm summer evening just after sunset, a Cessna 500 taxied out to the end of Runway 22 at Rawlins, Wyo., Municipal Airport (RWL). The density altitude at high elevation RWL (6,813 feet msl) was nearly 8,200 feet. Loaded with 800 pounds of electronic equipment as cargo and 325 gallons of Jet-A, the airplane had a gross weight of 11,703 pounds. The flight crew determined the required takeoff distance using a dry, level runway with no wind was 6,530 feet; the takeoff runway was 7,008 feet long.

The captain said that during the takeoff roll, the twin jet felt "sluggish," a condition he attributed to the high density altitude. The pilots rotated the aircraft at V1/Vr, and climbed about 10 feet, whereupon it "shuddered" and began to sink. Even though they were then past the V1 speed, the captain elected to abort the takeoff. He landed the airplane on the runway, applied brakes and deployed the drag chute at a speed estimated to be between 110 and 115 KIAS.

The crew felt a momentary deceleration as the chute inflated, but then the airplane continued its gallop down the remaining runway. The pilots didn't know it then, but the chute ripped away from the aircraft. They tried desperately to slow the aircraft, but the tires merely skidded along the last 1,800 feet of the runway and then exited the pavement still doing 80 to 90 knots. And then the terrifying cross country leg began.

The Citation rolled down a hill, crashed through a fence, careened across a road and a grassy area, then another road before smashing through a chain-link fence. At that point the airplane collided with a power pole and finally came to a stop next to three parked vehicles. Fortunately, both hapless pilots were able to escape the wreck with only minor injuries before it caught on fire and burned to ruin. The parked vehicles were destroyed by the fire as well.

In its investigation the NTSB discovered that the pilots had calculated the takeoff distance using inappropriate tables for their serial number aircraft. Using correct data would have yielded a higher fan speed, and an increase in V1, rotate speed, and V2. While the excess thrust available at a lower elevation airport may have tolerated this miscalculation, the actual high elevation, high density altitude conditions in which they were operating provided no such benefit. Additionally, the crew computed the takeoff performance assuming zero wind, but they attempted taking off with a 7-knot quartering tailwind, which is not inconsequential when the air is thin and you've figured a 472-foot margin with no wind at all. Moreover, those fumbled calculations set up a situation in which the brake energy available was less than what was required to stop the tires at the actual abort groundspeed. Furthermore, the takeoff performance numbers were computed using dry runway data, but it turned out it began raining shortly before the attempted takeoff and the runway was wet. And finally, the NTSB also cited as a factor in the parade of errors the captain's decision to abort the takeoff above V1.

Obviously, there were many issues involved in this accident that highlight the problems with rejected takeoffs (RTOs). For starters, by accepting a paltry 472-foot margin between the computed takeoff distance and the runway available, the pilots were assuming that, if necessary, they would literally perform to test pilot standards

and that their cargo-hauling CE-500 would behave like a brand-new Citation with new Pratts, tires and brakes. As stated clearly in "High-Speed Rejected Takeoffs" (March, page 48), making such assumptions demonstrates questionable optimism. Failure to use the right performance charts, and failure to account for the poor surface conditions and tailwind only magnified their error. Most important, there are no margins to account for the initiation of a rejected takeoff after V1.

Perhaps the crew had never seen the following noteworthy statement in the NTSB's special investigative report titled "Runway Overruns Following High-Speed Rejected Takeoffs" (February 1990): "Few safety margins are included in the calculations of accelerate-stop distances. Therefore, any substandard performance by the pilots, brakes or other airplane equipment related to the airplane acceleration or stopping performance will result in the airplane overrunning the end of the runway."

By the way, the Rawlins overrun is hardly an isolated incident. In fact, according to the Takeoff Safety Training Aid, more than half of the 74 airliner RTO accidents examined in a special study involved RTOs begun at speeds greater than V1. How does the recent business jet data compare? Roughly one-third of the RTO accidents in the last 12 years in business jets were aborted at a speed above V1.

At speeds near V1, the aircraft is traveling nearly 200 feet per second, and accelerating at 3 to 6 knots per second. This means that a delay of just two seconds in starting the RTO procedure can consume nearly 500 to 1,000 feet of additional runway to successfully stop. If the takeoff is at the field limit weight, with no excess runway available, the airplane will reach the end of the runway at a significant speed. Aborting the takeoff at just 4 knots above the scheduled V1 at the maximum field limit weight would result in the aircraft skidding off the end of the runway at a minimum of 60 knots, assuming the pilot used maximum braking.

After several notable RTO accidents in the late 1980s and early 1990s, the aerospace industry assembled an impressive group of experts to examine the problem. While it can be difficult to get committee members to agree, this group found lots of consensus. For instance, they noted that as speed approaches V1, completing an RTO successfully becomes increasingly difficult.

And notably, over half of the RTO accidents examined did not warrant an RTO, and in more than half the RTO accidents they examined, the accident airplane was capable of continuing the takeoff and landing safely afterwards. In other words, in most cases the decision to reject the takeoff appeared to have been "improper."

The task force concluded that after passing 80 knots and before V1, the takeoff should be rejected only for engine fire or failure, an unsafe configuration or other conditions that severely affect the safety of flight. This philosophy has been adopted by Boeing, whose latest designs inhibit part of the Warning and Caution System between 80 knots and initial climbout so that crews don't inadvertently reject a takeoff because they are "hair triggered" to respond to a warning light.

A training supplement produced by the United Airlines confirms that overall philosophy. The document says, "In the high-speed regime, the pilot's bias should be to continue the takeoff, unless there is a compelling reason to reject. Conditions that may validate a stop decision include, but are not limited to, engine failure, any fire, loss of directional control or any malfunction where there is doubt that the airplane will fly. Any malfunction that does not impair the ability of the airplane to be safely flown does not warrant an abort in the high-speed phase of takeoff. As the aircraft

approaches the high-speed regime, the pilot must make the decision to stop or go based on the nature and severity of the malfunction and its proximity to V1."

So a respected industry task group and a major airline are in agreement on the subject. What does the military have to say about high-speed RTOs? A handout to pilots of the former Military Airlift Command states, "The statistics clearly show that the wisest course of action is to continue a takeoff once the aircraft has reached 100 knots, unless there is a serious and catastrophic emergency. Many pilots agree that there are four good reasons to abort after 100 knots. These are any engine failure, any fire, any thrust reverser light or smoke in the cockpit. So what is the big deal about 100 knots? Why is that considered a cutoff? The accident and incident statistics clearly show that attempting to reject a takeoff after 100 knots has a high risk of going awry and bending metal. The accident statistics also clearly show that more than half of the rejected takeoff attempts would have resulted in less damage to the aircraft had the takeoff been continued."

With such a uniform stance among operators and experts with deep experience, it would behoove individual flight departments to consider adopting the same policies regarding high-speed RTOs.

The particulars of any runway must also be taken into consideration when weighing the risk of a high-speed rejected takeoff versus continuing the takeoff. To illustrate the consideration, imagine you are flying a Citation Ultra, loaded right up to the maximum takeoff weight of 16,300 pounds, and you are trying to take off from a sea level, 3,500-foot-long airstrip in 15 degrees C weather. The "tab data" say you will need 3,380 feet of runway for a flaps 7 takeoff. Not much margin, so a high-speed abort would quite likely result in a runway overrun. I would concur with those who would bias their "go/go-no" decision toward the "go," unless of course the malady was so serious that the continued airworthiness of the aircraft or safety of the occupants was immediately in jeopardy, such as would be the case if the aircraft were on fire.

On the other hand, put that same aircraft on a 12,000-foot dry runway and I'd side with those who would feel more comfortable with a high-speed abort because the takeoff margin is now many thousands of extra feet of concrete. However, I'm hesitant to suggest that biasing one's decision toward "stop" is necessarily appropriate even with a long runway. A blown tire at high speed is going to create major directional control problems as well as compromised braking. As discussed in "High-Speed Tire Failures: Are You Ready?" (Sept. 2004, page 56), it has been shown repeatedly that pilots who continue the takeoff, leave the gear extended, collect their wits and take a few deep breaths, determine what is working and what isn't, then make an emergency landing under control with the entire length of the runway ahead of the aircraft are much more likely to conclude their emergency with little or no damage as opposed to the crew who tries aborting on the failed tires.

An interesting (and entirely plausible) scenario that has been bantered around among the pilots hanging at a major FBO involved the correct course of action upon inadvertent thrust reverser deployment during takeoff, specifically just past V1. Interestingly enough, I've had this scenario popped on me several times in the simulator in the last three months. The first time happened in a Hawker 800XP simulator just as I moved my hand off the throttle and had begun to rotate. It made a believer out of me that such a deployment during that phase of flight is both startling and a definite handful. I had experienced the scenario a second time just a

month later in the Ultra simulator. Luckily, my sim partner was lightning fast getting the deployed thrust reverser emergency stowed.

While some pilots argue that an RTO is safer than trying to take the aircraft in the air, that isn't what the Citation Ultra manual recommends. Rather its checklist states:

(1) Emergency Stow Switch-Emer (affected engine).

(2) After establishing a positive rate of climb, retract landing gear. Do not exceed 125 KIAS until thrust reverse stows.

(3) At 400 feet, retract flaps at V2 + 10 and accelerate. Do not exceed 200 KIAS after thrust reverser stows.

Notice that the OEM's recommended procedure does not give the pilot the option of aborting the takeoff, regardless of runway remaining.

There are a lot of other scenarios often opined by inquisitive pilots. We can certainly sit around the FBO and come up with a lot of doomsday scenarios. I'm not discounting the remote probabilities of a cabin door opening and taking out an engine, or a PFD failure on takeoff in heavy IMC. It has happened, and inevitably a few of us will be unlucky enough to face these rather rare events.

But consider this: A Boeing review showed that of the RTO accidents initiated "very near V1," 80 percent of the wheel brakes failed. While the brakes were within acceptable wear limits, they were worn to such a degree that they did not have the capacity for dissipating a high-energy RTO.

And so the manufacturers, leading airline training departments, an industry task force, and the military have all spoken as one. They agree that rejecting a takeoff at speeds very close to V1 or beyond is exceptionally risky and will probably end in bent metal or worse. For this reason, a decision to abort a takeoff once past V1 should probably be made only if the captain decides that the aircraft isn't airworthy and that the risk of a continued takeoff outweighs the near certainty of damage if the aircraft remains. Hopefully very few of us will ever be placed in that no-win situation. **B&CA**

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