Rejected Takeoff Authority

Is dividing the captain's command **ever a good idea?**

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GREG BONGIORNO

A view from the power levers.

If you are the pilot in command (PIC) and the pilot flying (PF) in the left seat, can the second in command (SIC)/pilot monitoring (PM) call for a takeoff abort? If he or she does that, will you abort? Even more interesting (and controversial) is the opposite scenario. If you are the PIC/PM in either seat, can the SIC/PF initiate a rejected takeoff (RTO) without your consent? You probably think both answers are obvious. You may be surprised that not everyone agrees.

The answers depend more on who you are flying for than what you are flying. At one extreme, the captain has total and absolute abort authority and the first officer (F/O) can do nothing more than offer an opinion. On the other extreme, both pilots can call for the abort and the other pilot must comply. Which way is right? It depends.

A Matter of Philosophy

Most experienced captains don't think there is any debate here at all, even if our view is diametrically opposed to the captain in the very next airplane. But consider that there are pros and cons to each philosophy, that each carries with it a risk during high-speed aborts you may not know about, and many high-speed aborts are a result of decision-making delays that could happen to you.

The core of your abort authority philosophy is how much faith you are willing to place in your first officer versus how sure you are that the captain can make a timely decision in either the PF or PM role. If you are in a situation where the captain has lots of experience and the first officer has only a little, then your choice may be cut and dried. But even in this "ideal" situation, there are costs measured in seconds. And those seconds can be crucial.

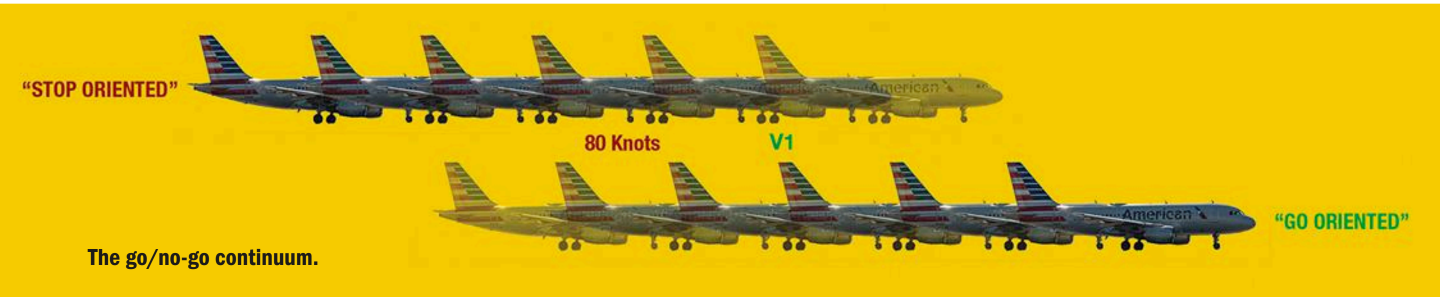
There are three basic models to describe who has abort authority in a two-pilot cockpit crew and quite often the model determines who has control of the throttles, power levers or thrust levers. (I'll call them thrust levers from this point forward.)

- Captain has complete abort authority/first officer only allowed to announce the nature of the problem. Many major airlines use this philosophy, but it can also be found in business aviation flight departments. Some operators will have the captain retain control of the thrust levers during the takeoff with the first officer flying, while others may relinquish control at certain points during the takeoff roll or once the aircraft is airborne.

The primary reason given for this autocratic philosophy is that there can be no confusion about who is making the decisions. But removing the first officer from the decision-making process can necessarily add time to whatever decisions are made.

- Captain can always call for an abort/first officer can only call his own abort. Some airlines and many regional airlines seem to have adopted this philosophy. Once again, there is no confusion about who is making the decision. But allowing the first officer to call his or her own abort facilitates faster execution if the F/O detects a problem and executes the abort without waiting for the captain's approval.

- Either pilot can call for the abort and must execute it when called. A few airlines use this philosophy and it is the prevalent philosophy for most business aviation flight departments with highly experienced pilots. The PF, even if that



The go/no-go continuum.

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pilot is not the captain, will normally have control of the thrust levers by the time the takeoff has progressed into the high-speed regime. Decision-making and execution is faster than with the previous philosophies, but there are risks of decisions with which the captain disagrees.

So, it seems we have two issues with which to contend. First, we worry about confusing command authority in the cockpit, especially when we are not fully confident about the F/O's ability to make a timely and correct decision. Second, we worry about extending the delay from when a problem is first detected until taking corrective action.

How Much Decision Time?

So, what's the big deal? Many pilots think they have 2 sec., and 2 sec. is a long time! Well, no, you don't have 2 sec., and even if you did, it isn't enough.

From a regulatory standpoint, there is no specified decision-making time. But the decision must have already been made by V_1. From 14 CFR §1.1: "V_1 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. V_1 also means the minimum speed in the takeoff, following a failure of the critical engine at V_{EF}, at which the pilot can continue the takeoff and achieve the required height above the takeoff surface within the takeoff distance."

While we've labeled V_1 "decision speed" it would be more correct to call it "action speed." By the time you reach V_1, you will have either begun action to abort the takeoff or committed to continuing the takeoff. So, where does the so-called 2-sec. decision time come from?

Transport category airworthiness standards (14 CFR §25.109) define takeoff accelerate-stop distance by adding a safety factor to the distance required to accelerate on a dry runway from a standing start with all engines operating until a point known as Vef (engine failure speed), having the pilot take the first action to reject the takeoff at V_1, and then come to a full stop. The safety factor distance is determined by using a distance equivalent to 2 sec. at the speed achieved at V_1.

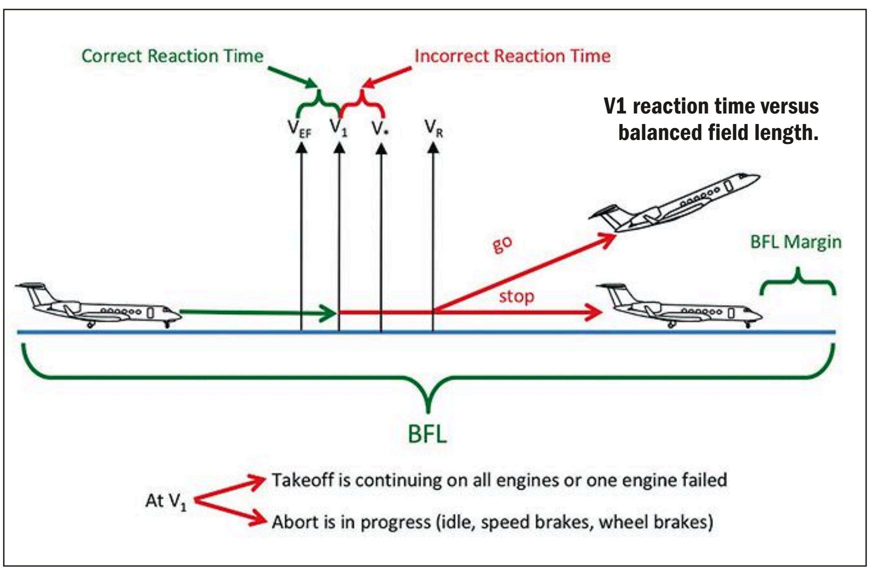
It may seem like we are splitting hairs here; isn't 2 sec. at V_1 the same as 2 sec. after V_1? It is not and learning this shows just how thin the margins can be. Every millisecond you continue accelerating, you are (1) eating into that safety margin and (2) invalidating the math because you are accelerating.

Let's say you are taking off in a Gulfstream GV on a balanced field at maximum weight on an ISA day at sea level where the balanced field length is equal to the runway length. If you begin the abort right at V_1, you should have just over 400 ft. in front of you when you come to a complete stop, based on having 2 sec. margin at your top speed of 130 kt. when you began the rejected takeoff. Starting the abort 2 sec. after V_1 adds 500 ft. to your distance. You are now off the runway.

But wait, you say, your manufacturer says you have 2 sec. It might. My manufacturer (Gulfstream) varies reaction time from as little as 1 sec. to as much as 1.25 sec. Whatever your manufacturer says, the reaction time comes before V_1. So, it is clear you don't have a lot of time to make your decision, as little as 1.00 sec., depending. Furthermore, this decision to reject the takeoff must be completed before V_1. So, how long does it take to make a decision in the most obvious case of an engine failure? (I say obvious because it is the one takeoff failure we practice the most.)

In 2010, the National Aerospace Laboratory (NLR) of the Netherlands issued a study of high-speed rejected takeoffs by analyzing accidents and serious incidents before and after a 1993 joint industry study, led by Boeing, known as the Takeoff Safety Training Aid. The NLR study found that the accident/serious incident rate of high-speed rejected takeoffs had dropped by 24% but was still too high.

According to the study, "Each takeoff includes the possibility that the pilot needs to stop the aircraft and reject the takeoff. Analysis of pilot reported rejected takeoff occurrences showed that the rejected takeoff maneuver occurs approximately once in every 1,800 takeoffs. With this rate, a pilot who flies primarily long-haul routes may be faced on average with a rejected takeoff only once in 25 years. In contrast, a pilot on a regional jet may face a rejected takeoff every four years on average. The pilots in each of these fleets must be prepared to make an RTO decision during every takeoff. Even to the regional pilots it will not be a common thing to do other



V1 reaction time versus balanced field length.

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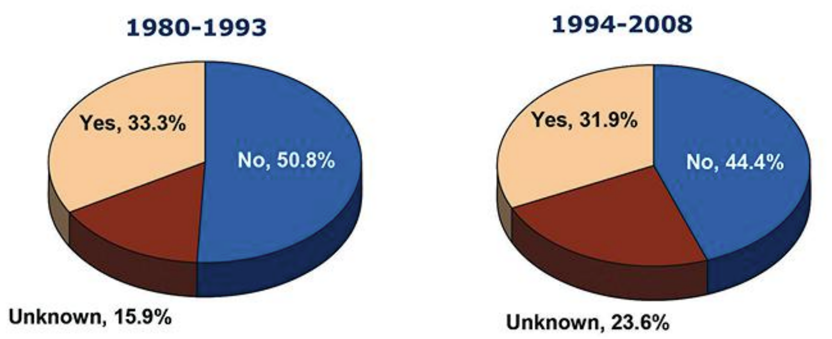
Correct Decision to Abort or Not



Source: National Aerospace Laboratory of the Netherlands 2010 study.

than in the simulator. Analysis of pilot reported rejected takeoff occurrences showed that about 56% of the rejected takeoffs occurred at speeds lower than 60 kt. and almost 90% below 100 kt. Even if a pilot faces the decision to reject, it is most likely at a low speed. To reject a takeoff at high speeds is very rare.

"Some operators and aircraft manufacturers have defined a speed up to which a takeoff should be rejected for all observed failures or warnings. Above this speed and to the takeoff decision speed V_1, the takeoff should be rejected only in case of an engine failure and conditions affecting the safe handling of the aircraft. However, amongst the operators different policies exist regarding these takeoff rejection criteria. The speed up to which a takeoff should be rejected for all observed failures varies between 70 and 100 kt. with a typical value of 80 kt. or 100 kt. In the high-speed regime, the pilot's bias should be to continue the takeoff, unless there is a compelling reason to reject."

The study concludes, however, that in many cases pilots make an incorrect decision to abort.

The study did not speculate as to why we are getting (marginally) better, but I suspect it mostly has to do with better simulator training and cockpit electronics that inhibit nuisance warnings at higher speeds. But the fact we continue to get nearly half of these decisions wrong is worrisome. Most of us employ two-stage RTO criteria, typically saying we will only abort for critical items above 80 or 100 kt. The report states the obvious that these decisions are easy at lower speeds. But when the runway is racing by at 200 ft. per second (120 kt.), it is no wonder the decision becomes more difficult nearing V_1.

The same study cites a Qantas Airlines simulator test that measured the time between an engine failure and the first callout, and then the time between that first callout and the pilot's first reaction to initiate the abort. These data show that the time between the engine failure and pilot's reaction can be very long.

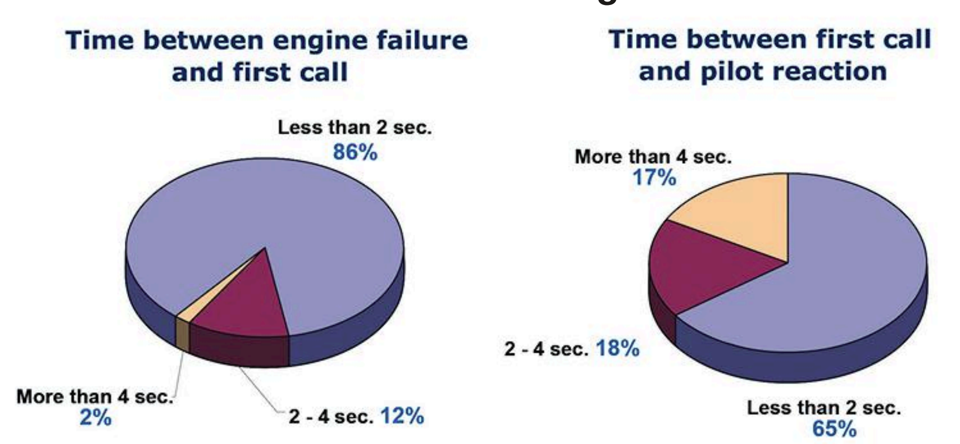
For the most part, we do indeed react very quickly (in less than 2 sec.) when it comes to recognizing the problem and making the abort callout. We also react to the callout fairly quickly (in less than 2 sec.).

For the sake of argument, let's say we have a sharp crew and our reaction time is 1 sec. for evaluating the problem and making the callout. We will also say our pilots are on their game and it only takes 1 sec. to initiate the RTO. So, in theory, we can go from problem to abort in 2 sec. But consider a few hypotheticals where the F/O does not have the authority.

First, let's say the captain is the PF (attention is outside) and the F/O is monitoring crew alerting systems (attention inside). If the issue is apparent from outside the cockpit, it takes the captain 1 sec. to evaluate and decide to abort, and 1 sec. to react, for a total of 2 sec. between problem and RTO initiation. If the issue is apparent from inside the cockpit, it takes the F/O 1 sec. to evaluate and make the callout, the captain 1 sec. to evaluate the callout, and 1 sec. to react, for a total of 3 sec. between problem and RTO initiation.

Now, let's say the F/O is the PF (attention is outside) and the captain is the PM (attention inside). If the issue is apparent from inside the cockpit, it takes the captain 1 sec. to evaluate and make the callout, the first officer 1 sec. to evaluate the callout and 1 sec. to react, for a total of 3 sec. between problem and abort initiation. If the issue is apparent from outside the cockpit, it takes the first officer 1 sec. to evaluate the problem and 1 sec. to make the callout. It then takes the captain 1 sec. to look up, evaluate and make the abort callout, the first officer 1 sec. to evaluate the callout, and 1 sec. to react, for a total of 5 sec. between problem and RTO. Of course, you can argue the captain might spot the problem as quickly as the F/O or that the captain could decide to initiate the abort while simultaneously making the

Reaction Times After Engine Failure



Source: National Aerospace Laboratory of the Netherlands 2010 study.

callout. There can be a number of variations, but not allowing the F/O to make the decision or initiate the abort will cost time. I think we all understand this situation lengthens the time needed to initiate the RTO and this puts enormous pressure on the captain to make these decisions quickly.

Case Study: Lonely at the Top

A high-speed abort happens very quickly and usually as a result of something else going wrong. It may seem unfair to second-guess a crew's actions when the decisions came so quickly and the causal factors can be interrelated. But we should look at a few cases just to stimulate the thought process needed to evaluate our own abort authority philosophy.

On May 25, 2008, the captain of Kalitta Air Flight 207, a cargo Boeing 747, aborted his takeoff from Brussel-Zaventem Airport (EBBR), Belgium, after his No. 3 engine ingested a bird, causing a momentary compressor stall. On the face of it, this may seem cut and dried. Pilots who have experienced a compressor stall in this situation have said the bang is louder than any noise they have ever heard in a cockpit. But the compressor stall occurred 5 sec. after V_1 and the engine recovered immediately. Two seconds later the captain brought all four thrust levers to idle and initiated braking. He did not deploy the thrust reversers or speed brakes. The aircraft left the runway still doing 72 kt., dropped into an embankment, and broke into three parts. The crew of four and one passenger escaped uninjured but the aircraft was damaged beyond repair.

The accident investigation revealed the initiating cause was a 6-oz. kestrel that left feathers and other remains in the engine but did not damage any part of it. Analysis also confirmed the engine recovered from the compressor stall immediately. It is apparent, therefore, that the captain made the wrong decision at the wrong time. But what isn't apparent is why.

I first assumed the title of "captain" of a multi-pilot aircraft in 1984, flying an U.S. Air Force Boeing 707 (EC-135J). Our rules gave absolute abort authority to the captain, and other cockpit crewmembers could only state the nature of the problem, leaving the decision on the shoulders of the captain. We required our captains to recite a very limited list of reasons to abort prior to every takeoff, but we were "stop oriented." In other words, when in doubt, abort the takeoff. I worried that one day I would face a problem above V_1 and make the wrong decision. During my last year flying that airplane, I did experience an engine failure right at V_1 and elected to continue the takeoff.

My next airplane was the Air Force version of the Boeing 747 (E-4B) where we adopted a new philosophy of designating a second speed to divide the low-speed and high-speed regimes. We were "stop oriented" below 100 kt. and "go oriented" above. We also allowed either pilot or the flight engineer to call for the abort. I soon realized my go/no-go decisions were being evaluated by the rest of the cockpit crew. I think this had the subconscious effect of helping me to rule out any actions that violated our Standard Operating Procedures (SOPs).

The Kalitta Air General Operations Manual could have been written by my Boeing 707 squadron. Only the captain could make the decision to continue or abort the takeoff. First officers and flight engineers were forbidden from using the words "reject" or "abort," except to confirm the captain's decision. When given this amount of solitary power, a captain can become stricken by indecision or the tendency to second-guess his or her decisions. Having a crew back up those decisions as they happen can reassure the captain that following SOPs is the right thing to do.

Case Study: A Silent First Officer

Regardless of who is flying the airplane during takeoff, even a few seconds of delay can mean the difference between an easy low-speed abort and one at high-speed when everything has to go just right. There are times when the PM has a clearer idea of the problem than the captain. The captain also carries the ultimate responsibility of making sure the flight succeeds in its Point A to Point B mission, possibly placing a go-oriented bias in his or her decision making. No matter the motivation, removing the F/O from the decision-making process can cripple the captain's effectiveness under pressure.

On March 13, 2014, the F/O of US Airways Flight 1702 made a minor mistake in programming the aircraft's flight management computer (FMC) that cascaded into a series of errors by the captain that ended in a high-speed abort and substantial damage to their Airbus A320. A video taken from the ramp at Philadelphia International Airport (KPHL) clearly shows the airplane's nose come up, the aircraft become airborne, but then immediately return to the runway with enough force to collapse the nose gear. The NTSB correctly notes the accident was caused by the captain's decision to abort the takeoff after rotation. But that is what happened, not why it happened.

I think to understand why this accident happened we need to dive into the realm of pilot psychology. As is common with many airlines, US Airways vested total abort authority with the captain. Both pilots on Flight 1702 were highly experienced in terms of hours in type and years with the airline. But one was an experienced captain and the other had been an F/O in the A320 for seven years. Reading through the cockpit voice recorder transcripts, it becomes clear the captain is the assertive decision maker and the F/O is a timid assistant.

It was a clear and cold day in Philadelphia and everything about the

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Kalitta Flight 207 after the high-speed abort.

day's flight was routine. The first officer's initiating mistake was to enter Runway 27R as their takeoff runway into the FMC, instead of their actual assignment of Runway 27L. Both runways were more than adequate in length, but it was a mistake worth correcting. The captain didn't notice the error until they were cleared onto the runway. He asked the first officer to make the change. After the fact, both pilots acknowledge that making the change was routine, something they had done before many times. The F/O made the change but forgot to reenter the assumed temperature. (The assumed temperature tells the FMC that a reduced thrust setting was planned.) The first officer failed to notice a "Check Take Off Data" FMC message and both pilots failed to notice the V-speeds normally shown on their pilot flight displays had dropped out.

Once cleared for takeoff, the captain placed the thrust levers into the FLEX detent, causing the electronic centralized aircraft monitoring (ECAM) system to chime and issue the message that the thrust levers were not set. The crew didn't know that without the assumed temperature, the ECAM was expecting the thrust levers to be in the Take Off/Go Around (TOGA) detent, or that the corrective action was to select the TOGA detent. The first officer reported, "Engine thrust levers not set." Contrary to procedures, the captain retarded the throttles below FLEX and back to FLEX and said, "They're set." At this point they were still in the low-speed regime and would have had the perfect opportunity to discontinue the takeoff and sort things out.

Before they got to 80 kt. the F/O noticed their V-speeds had disappeared, a situation for which she wasn't prepared. She failed to make the required "80 kt."callout and, while accelerating through 86 kt., an aural "Retard" sounded in the cockpit. The "Retard" call is normally made during landing; post-accident interviews with several US Airways pilots confirmed none had ever faced this situation.

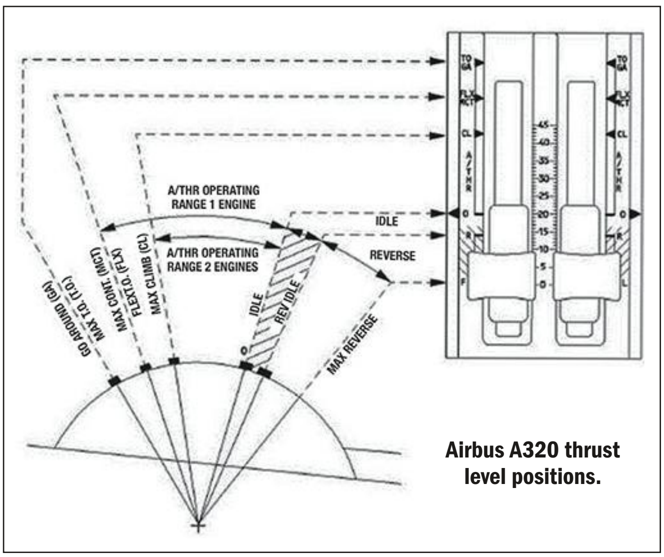
As the airplane continued to accelerate, the captain said, "What did you do? You didn't load. We lost everything." At 143 kt. he said, "We'll get that straight when we get airborne." The first officer said, "I'm sorry."

The captain rotated the nose at 164 kt., but his pitch became erratic, cycling between 16 deg. nose up and 16 deg. nose down. The main gear left the runway for 2 sec. and the radio altimeter height reached 15 ft. Surveillance video from the airport ramp shows the airplane impacted the runway first with the tail, then the main landing gear, and then rotated onto the nose gear with enough force to cause it to collapse. There were no fatalities, but the aircraft was substantially damaged.

When asked why he didn't push the thrust levers to TOGA after receiving the "Engine Thrust Levers Not Set" ECAM message, the captain said there was "no harm" in not doing so. Asked why she didn't say anything when she had noticed the V-speeds had dropped out, the first officer said she "assumed [the captain] wouldn't continue the takeoff if he didn't know the V-speeds."

The captain said he aborted the takeoff after rotation because he "had the perception the aircraft was unsafe to fly." But he also acknowledged that everything was normal except the chime and "Retard" aural alert, and that the main landing gear "came off the ground fine and the initial pitch felt fine."

So, once again the flight data and cockpit voice recorders help us to understand what happened; we are left looking at pilot psychology to understand why this accident happened. I think we can trace this to a captain who didn't react favorably to bad news and a first officer reluctant to offer any.



Airbus A320 thrust level positions.

The F/O was rushed into making the FMC runway change after they had already been cleared onto the runway. She made the proper callout upon discovering the thrust levers were not set, but the captain's dismissive tone, "They're set," failed to extinguish the warning but served to shut down further communication. When looking to her PFD for the V-speeds, she was confused momentarily because they were gone.

The aural "Retard" message had to have been monumentally confusing, given that neither pilot had ever experienced it on the line or in training. It appears the F/O had already made an internal decision that the takeoff should be aborted but didn't feel free to say so. It appears the captain had made the decision to go but had enough doubts to later abort after takeoff rotation.

My first takeoff attempt in the Boeing 747 resulted in a low-speed abort. I was getting my initial type training from United Airlines and the aircraft was extremely light. We didn't have any passengers, we had a minimal fuel load and both galleys had been removed. The flight engineer's takeoff data placed the stabilizer trim at an extreme end of the green band, but we didn't know that. My simulator instruction introduced the idea that below 100 kt., any vote to abort meant we aborted. But above 100 kt., the list of causes to abort for became very short.

The captain on Flight 1702 was go oriented and in the absence of effective CRM, the crew became go oriented. I believe the captain's decision making became corrupted by panic that is a problem unto itself. For the purpose of deciding who should have RTO authority, however, our focus should be on the F/O. In an environment where she wasn't allowed to utter the words "abort" or "reject," she may have become unpracticed in the art of making these kinds of decisions. I think had she been schooled by the airline to command a rejected takeoff when she thought it necessary, the outcome of this flight would have been nothing more than a low-speed abort and FMC reprogramming.

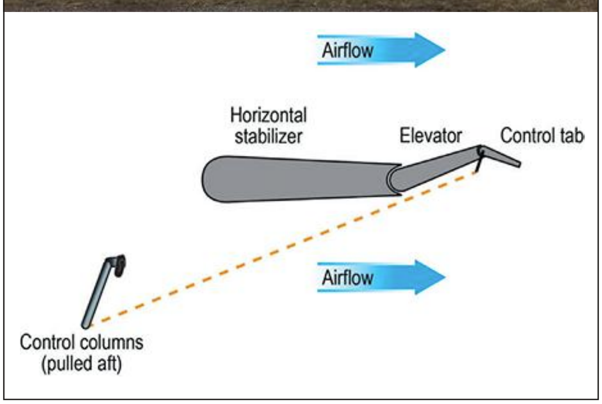
Case Study: When CRM Empowers the Crew

I am as guilty as the next Monday morning quarterback when it comes to reading headlines about aircraft failing to stop on the paved surface of a runway after a high-speed abort. But I also realize there are times a high-speed RTO is unavoidable. Not only is the case of Ameristar Charters Flight 9363, detailed in last month's Cause & Circumstance (page 20), just such an incident, it provides a textbook lesson about how a crew that adheres to SOPs and utilizes effective CRM can turn a potential catastrophe into a survivable incident.

On March 8, 2017, the crew of an Ameristar Charters McDonnell Douglas MD-83 rejected their takeoff from Willow Run Airport (KYIP), Ypsilanti, Michigan. One of the two elevators was jammed and 3 sec. after the PF realized the aircraft could not leave the ground, he aborted. Despite the fact the aircraft did not stop on the paved surface, this crew did everything right before, during and after the decision was made.

NTSB

The wreckage of Ameristar Flight 9363 following its high-speed abort.



Simplified diagram of an MD-83 elevator control.

Unlike the previous case studies, the left-seat pilot flying was upgrading to captain with a check airman in the right seat. So, in this case the acting F/O was the PIC. Like the accidents already cited, the moment of the abort was highly stressful and the pilots did not have a clear idea of what was causing the problem. Unlike the first two events, however, the Ameristar crew's strict adherence to SOPs allowed CRM to maximize the chances of a successful outcome.

Six seconds after the check airman/first officer called V_1, he called rotate. The captain pulled back with normal forces at first and then increasing force. Four seconds later, the captain (not the PIC) realized full aft forces on the yoke were not changing the pitch of the aircraft and called "Abort." The check airman said, "Don't abort above V_1," but the captain had already begun executing the RTO. From that point both pilots acted as a team to execute the abort according to SOPs. The NTSB concluded:

"The flight crew's coordinated performance around the moment that the captain rejected the takeoff showed that both pilots had a shared mental model of their responsibilities. By adhering to SOPs — rather than reacting and taking control of the airplane from the captain trainee — the check airman demonstrated disciplined restraint in a challenging situation. Had the check airman simply reacted and assumed control of the airplane after the captain decided to reject, the results could have been catastrophic."

The crew of six and 110 passengers were able to walk away from what could have been a catastrophe. It took the pilot flying 4 sec. to decide the takeoff had to be aborted. Their speed at the time was 150 kt.; they were covering 253 ft. every second. Had the captain deferred to the check airman, the results could have been very different.

My Answer: It Depends

So, up for debate, which abort philosophy is best? Should the captain have absolute authority while allowing the rest of the crew only the power to recommend? Or should the rest of the cockpit crew be allowed to say "Abort!" and expect the PF to do just that? As with many things in aviation, the answer is, "It depends."

I realize this is an issue that divides the professional pilot population into two distinct camps, so my answer is likely to generate responses in opposition and support. Keep in mind, what follows is opinion. (But, ahem, the right opinion!)

When simulator training is unavailable and a first officer's experience is limited, it may be appropriate to withhold abort authority during operational flying. In this case, it would be wise to require the captain to fly every takeoff when close to a balanced field condition and emphasize to the F/O that any callouts must be short, succinct and forceful. For example: "Overtemp, right engine" and not "I think the right engine has a problem."

When simulator training is available, F/Os should be well-schooled on the dangers of a high-speed abort and the need to become go oriented at higher speeds except for specific instances the aircraft manufacturer or operator agree upon. At our company, for example, we would condone an abort above 80 kt. and below V_1 for a loss of directional control, a fire anywhere on the aircraft or other conditions that make the aircraft unflyable.

Once an F/O becomes fully qualified (either through an in-aircraft or simulator training program), he or she should have abort authority. The first officer should be allowed to call for the rejected takeoff and, if acting as the pilot flying, should be able to initiate it. The captain should initiate the abort when the F/O calls for it.

When I was first assigned to crewed aircraft, the standing philosophy held that only the captain had abort authority. Our simulators were laughable by today's standards and we did most of our training in the aircraft. But once I progressed to modern-day aircraft and simulators, I was schooled to become stop oriented at low speeds and go oriented at high speeds. As a first officer I was well trained to make the go/no-go decision. As a captain, I expect nothing less from my first officers. If the first officer calls for an abort, that's what I do. **BCA**