NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

May 31, 2017

Attachment 16 - Boeing Rejected Takeoff Decision Making

OPERATIONAL FACTORS/HUMAN PERFORMANCE

DCA17FA021

Rejected Takeoff Maneuver

The RTO maneuver is initiated during the takeoff roll to expeditiously stop the airplane on the runway. The PM should closely monitor essential instruments during the takeoff roll and immediately announce abnormalities, such as “ENGINE FIRE”, “ENGINE FAILURE”, or any adverse condition significantly affecting safety of flight. The decision to reject the takeoff is the responsibility of the captain, and must be made before V1 speed. If the captain is the PM, he should initiate the RTO and announce the abnormality simultaneously.

Note: If the decision is made to reject the takeoff, the flight crew should accomplish the rejected takeoff non-normal maneuver as described in the Maneuvers Chapter of the QRH.

If the takeoff is rejected before the THR HLD annunciation, the autothrottle should be disconnected as the thrust levers are moved to idle. If the autothrottle is not disconnected, the thrust levers advance to the selected takeoff thrust position when released. After THR HLD is annunciated, the thrust levers, when retarded, remain in idle. For procedural consistency, disconnect the autothrottles for all rejected takeoffs.

If rejecting due to fire, in windy conditions, consider positioning the airplane so the fire is on the downwind side. After an RTO, comply with brake cooling requirements before attempting a subsequent takeoff.

Go/Stop Decision Near V1

It was determined when the aviation industry produced the Takeoff Safety Training Aid in 1992 that the existing definition of V1 might have caused confusion because they did not make it clear that V1 is the maximum speed at which the flight crew must take the first action to reject a takeoff. The U.S. National Transportation Safety Board (NTSB) also noted in their 1990 study of rejected takeoff accidents, that the late initiation of rejected takeoffs was the leading cause of runway overrun accidents. As a result, the FAA has changed the definition of V1 in 14 CFR Part 25 to read as follows:

- V1 means the maximum speed in the takeoff at which the pilot must take the first action (e.g., apply brakes, reduce thrust, deploy speedbrakes) to stop the airplane within the accelerate-stop distance and
- V1 also means the minimum speed in the takeoff, following a failure of an engine at which the pilot can continue the takeoff and achieve the required height above the takeoff surface within the takeoff distance.

Pilots know that V1 is fundamental to making the Go/Stop decision. Under runway limited conditions, if the reject procedure is initiated at V1, the airplane can be stopped before reaching the end of the runway. See RTO Execution Operational Margins diagrams for the consequences of initiating a reject after V1 and/or using improper procedures.

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When the takeoff performance in the AFM is produced, it assumes an engine failure or event one-second before V1. In a runway limited situation, this means the airplane reaches a height of 35 feet over the end of the runway if the decision is to continue the takeoff.

Within reasonable limits, even if the engine failure occurs earlier than the assumed one second before V1, a decision to continue the takeoff will mean that the airplane is lower than 35 feet at the end of the runway, but it is still flying. For example, if the engine fails 2 seconds before V1 and the decision is made to go, the airplane will reach a height of 15 to 20 feet at the end of the runway.

Although training has historically centered on engine failures as the primary reason to reject, statistics show engine thrust loss was involved in approximately one quarter of the accidents, and wheel or tire problems have caused almost as many accidents and incidents as have engine events. Other reasons that rejects occurred were for configuration, indication or light, crew coordination problems, bird strikes or ATC problems.

It is important to note that the majority of past RTO accidents were not the result of an RTO initiated because of an engine failure. Full takeoff thrust from all engines was available. With normal takeoff thrust, the airplane should easily reach a height of 150 feet over the end of the runway, and the pilot has the full length of the runway to stop the airplane if an air turnback is required.

Making the Go/Stop decision starts long before V1. Early detection, good crew coordination and quick reaction are the keys to a successful takeoff or stop.

RTO Execution Operational Margins

A successful rejected takeoff at or near V1 is dependent upon the captain making timely decisions and using the proper procedures.

The data in the following diagrams, extracted from the Takeoff Safety Training Aid, are provided as a reference. The individual diagrams show the approximate effects of various configuration items and procedural variations on the stopping performance of the airplane. These calculations are frequently based on estimated data and are intended for training discussion purposes only. The data are generally typical of the airplane at heavy weights, and except as noted otherwise, are based on the certified transition time.

Each condition is compared to the baseline condition. The estimated speed at the end of the runway and the estimated overrun distance are indicated at the right edge of each figure. The distance estimates assume an overrun area that can produce the same braking forces as the runway surface. If less than the baseline FAA accelerate-stop distance is required, the distance is denoted as a negative number.

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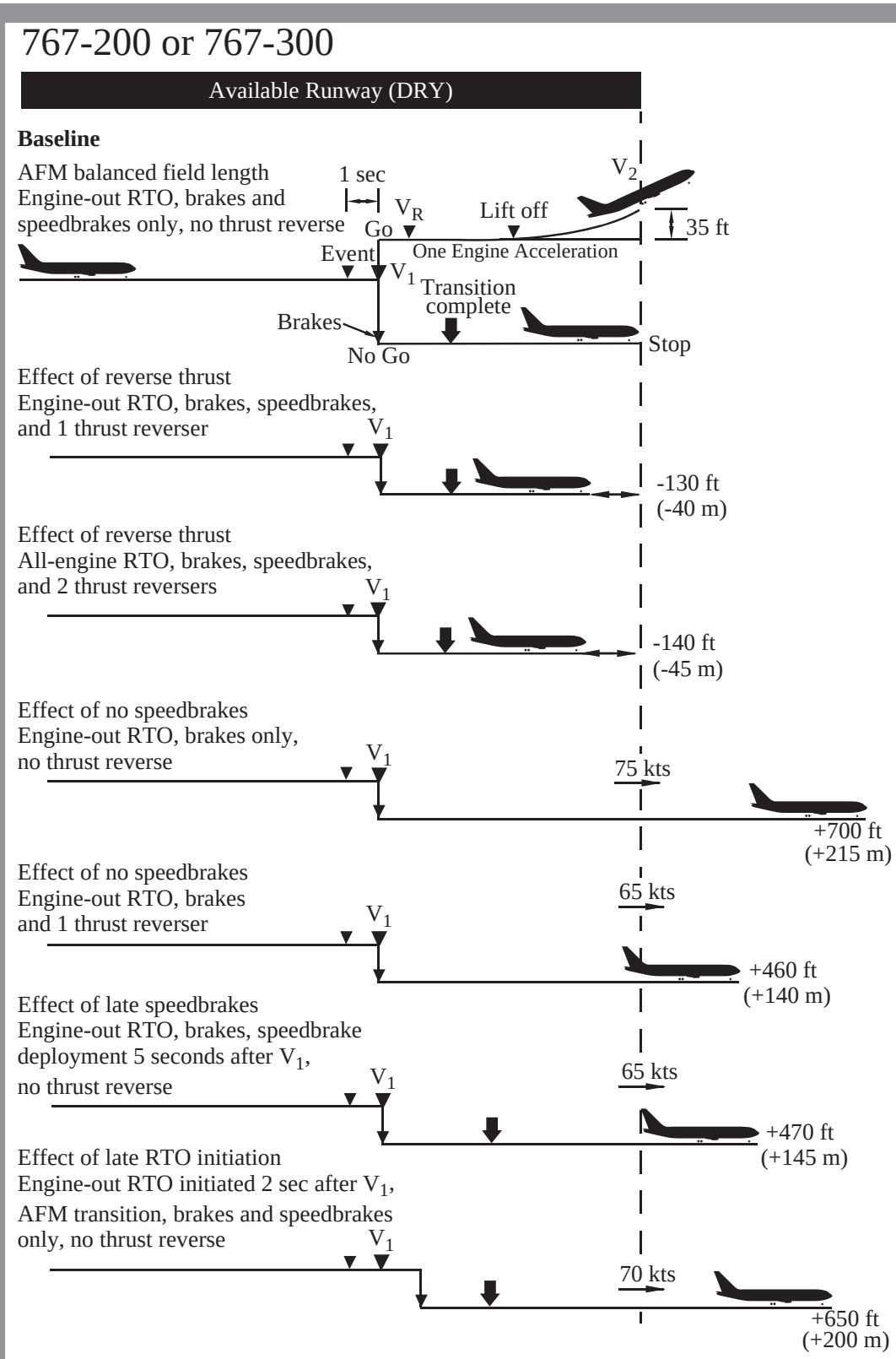
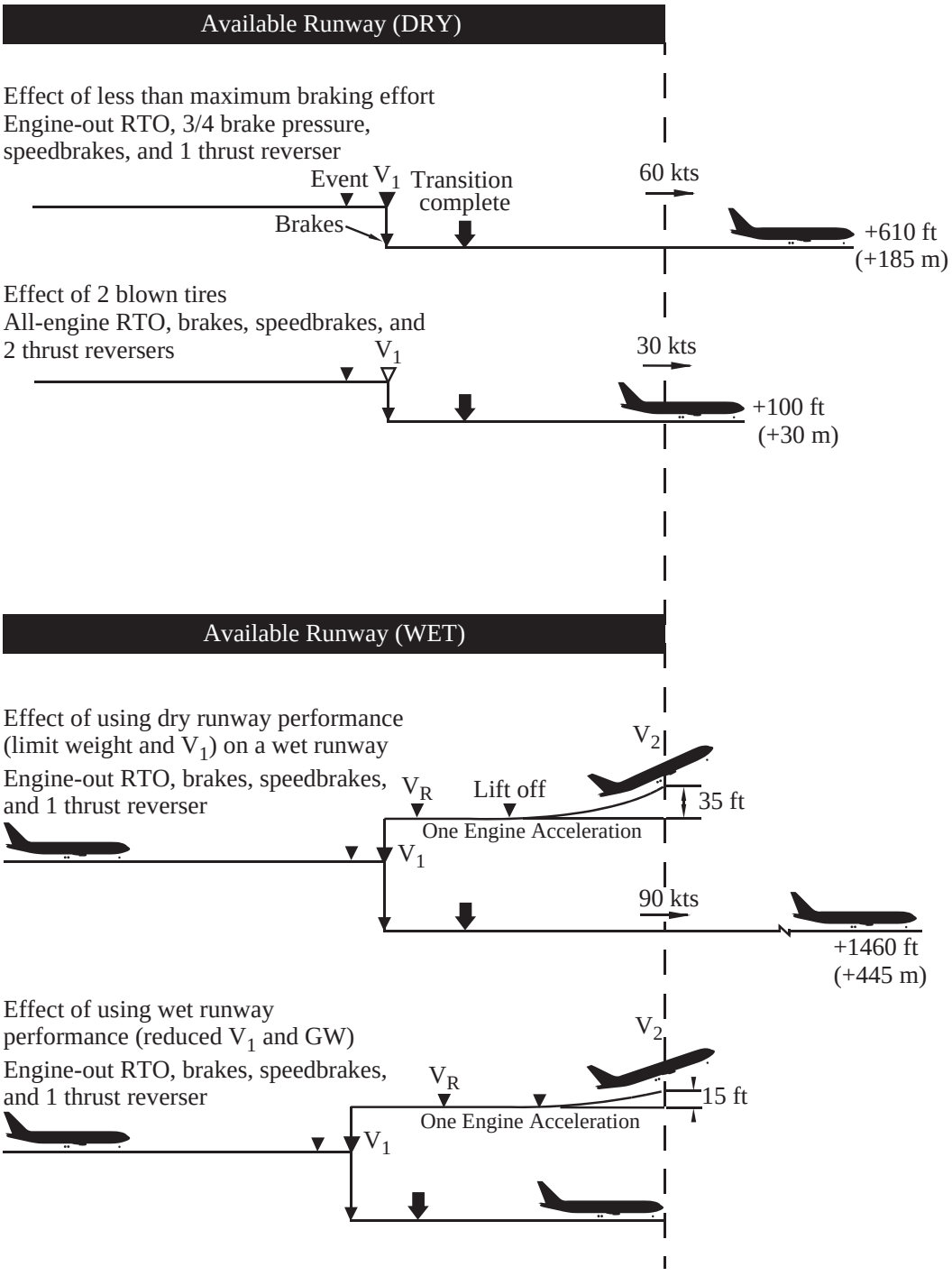
767-200, 767-300



767-200, 767-300

767-200 or 767-300



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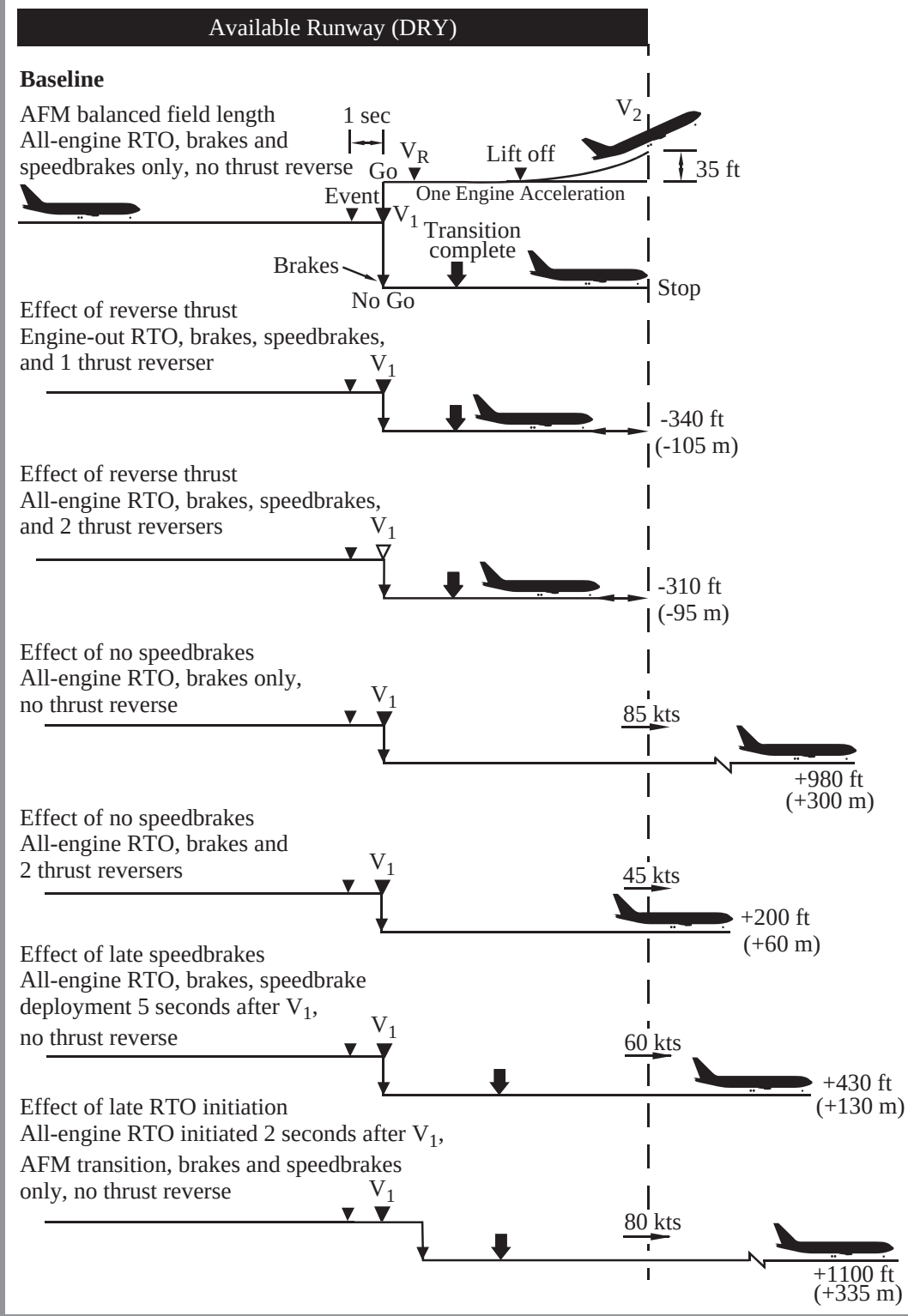
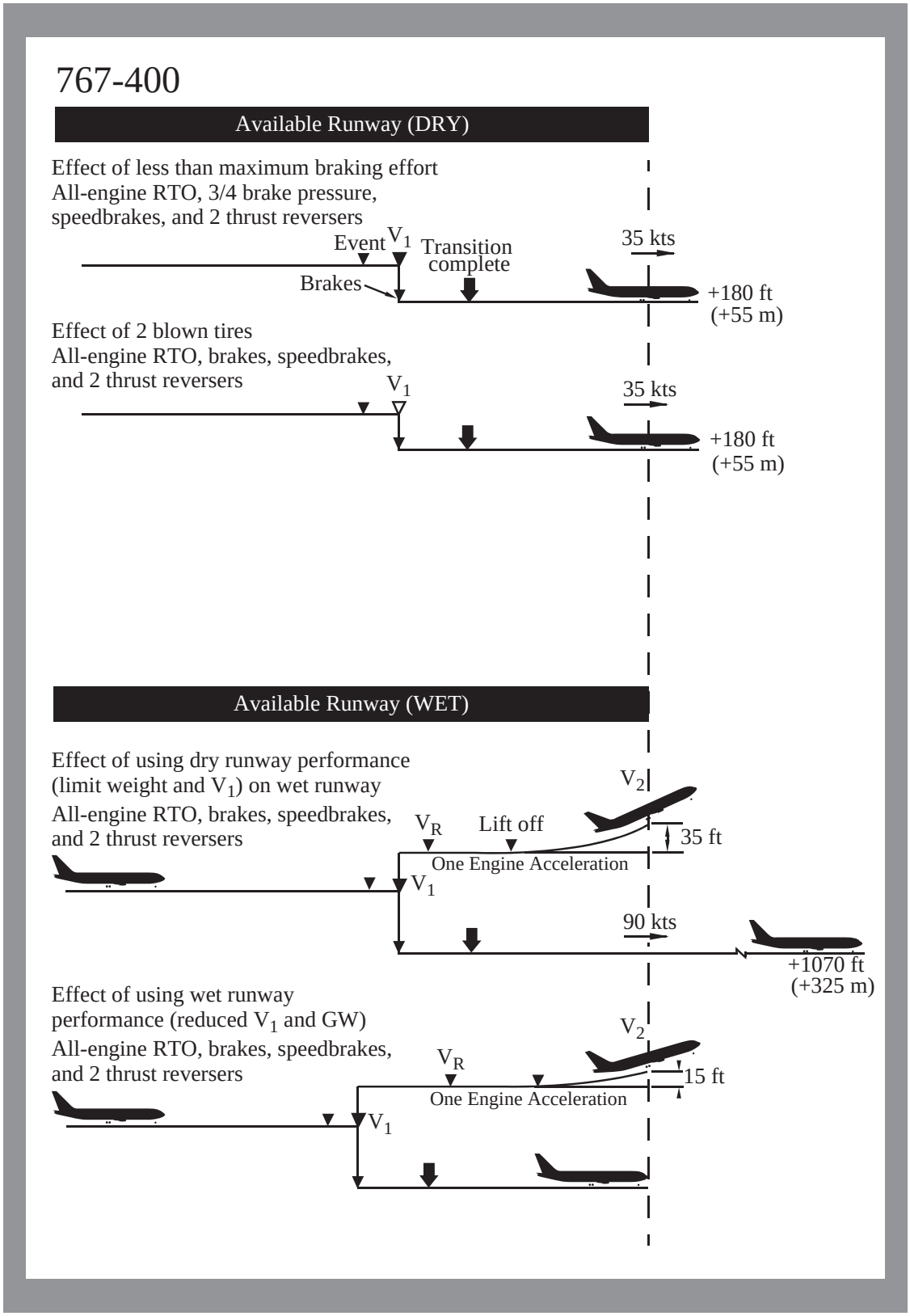

767-400
Available Runway (DRY)
Baseline
AFM balanced field length
All-engine RTO, brakes and
speedbrakes only, no thrust reverse
1 sec
V_R
Go
Event
V_1
V_2
Lift off
35 ft
One Engine Acceleration
Transition
complete
Brakes
No Go
Stop
Effect of reverse thrust
Engine-out RTO, brakes, speedbrakes,
and 1 thrust reverser
V_1
-340 ft
(-105 m)
Effect of reverse thrust
All-engine RTO, brakes, speedbrakes,
and 2 thrust reversers
V_1
-310 ft
(-95 m)
Effect of no speedbrakes
All-engine RTO, brakes only,
no thrust reverse
V_1
85 kts
+980 ft
(+300 m)
Effect of no speedbrakes
All-engine RTO, brakes and
2 thrust reversers
V_1
45 kts
+200 ft
(+60 m)
Effect of late speedbrakes
All-engine RTO, brakes, speedbrake
deployment 5 seconds after V_1,
no thrust reverse
V_1
60 kts
+430 ft
(+130 m)
Effect of late RTO initiation
All-engine RTO initiated 2 seconds after V_1,
AFM transition, brakes and speedbrakes
only, no thrust reverse
V_1
80 kts
+1100 ft
(+335 m)



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