NLR-TP-2010-177

NLR Air Transport Safety Institute

Research & Consultancy

Executive summary

REJECTING A TAKEOFF AFTER V1...WHY DOES IT (STILL) HAPPEN?

Problem area

Each takeoff includes the possibility that the pilot needs to stop the aircraft and reject the takeoff. Aborts at a high speed above V1 are rare. However when they occur the outcome can be serious accident. In reaction to a number of takeoff accidents resulting from improper rejected takeoff decisions and procedures, a Takeoff Safety Training Aid was released in 1993. The goal of the Takeoff Safety Training Aid was to minimise the probability of RTO-related accidents.

Description of work

In this study the impact of the Takeoff Safety Training Aid upon high speed rejected takeoffs is examined by analysing accidents and serious incidents that occurred before and after the introduction of the training aid.

Results and conclusions

The analysis showed that there is still plenty of room to improve takeoff safety and reduce the number of unwarranted rejected takeoffs above V1 despite the introduction of the training aid.

Report no.
NLR-TP-2010-177

Author(s)
G.W.H. van Es

Report classification
UNCLASSIFIED

Date
September 2010

Knowledge area(s)
Vliegveiligheid (safety & security)
Vliegoperaties

Descriptor(s)
RTO
TOPM
Rejected takeoffV1
Safety

This report is based on a presentation held at the FSF EASS, Lisbon, March 15-17, 2010.

NLR-TP-2010-177

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NLR Air Transport Safety Institute

Anthony Fokkerweg 2, 1059 CM Amsterdam,
P.O. Box 90502, 1006 BM Amsterdam, The Netherlands
Telephone +31 20 511 35 00, Fax +31 20 511 32 10, Web site: http://www.nlr-atsi.nl

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REJECTING A TAKEOFF AFTER V1…WHY DOES IT (STILL) HAPPEN?

G.W.H. van Es

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The contents of this report may be cited on condition that full credit is given to NLR and the author.
This publication has been refereed by the Advisory Committee AIR TRANSPORT.

Customer	NLR-ATSI
Contract number	- - - -
Owner	NLR
Division	Air Transport
Distribution	Unlimited
Classification of title	Unclassified
	September 2010

Approved by:

Author	Reviewer	Managing department
21/09/10	21-09-10	21/9/10

SUMMARY

Each takeoff includes the possibility that the pilot needs to stop the aircraft and reject the takeoff. Aborts at a high speed above V1 are rare. However when they occur the outcome can be serious accident. In 1989, in reaction to a number of takeoff accidents resulting from improper rejected takeoff decisions and procedures, a joint FAA/industry taskforce studied what actions might be taken to increase takeoff safety. From this Boeing led an industry wide effort to develop a training aid. The result was a publication entitled Takeoff Safety Training Aid and a flight crew briefing video entitled Rejected Takeoff and the Go/No Go Decision released in 1993. This material gives information on operational procedures and crew qualification programs regarding rejected takeoffs. The goal of the Takeoff Safety Training Aid was to minimise the probability of RTO-related accidents. The idea is that risks could be reduced by a higher level of flight crew knowledge and by the use of improved procedures.

In this study the impact of the Takeoff Safety Training Aid upon high speed rejected takeoffs is examined by analysing accidents and serious incidents that occurred before and after the introduction of the training aid. From this analysis it became clear that since the introduction of the Takeoff Safety Training Aid: The accident/serious incident rate of high speed rejected takeoffs has dropped by 25%; There is no unambiguous proof that that this reduction is the result of the Takeoff Safety Training Aid; The reasons for conducting a high speed rejected takeoff are the same as before the training aid; Many high speed rejected takeoffs (44%) should not have been conducted. This number is only slightly less than before the introduction of the training aid (51%); Pilots have difficulties in recognising "unsafe to fly" conditions; The Detection-Decision-Action process still takes a lot of time! and that 82% of the RTOs were non-engine related which is similar to before the training aid.

The present study shows that there is still plenty of room to improve takeoff safety and reduce the number of unwarranted rejected takeoffs above V1.

Contents

1 Introduction

March 20, 1993. During the takeoff roll on Runway 25R of Frankfurt Airport (Germany), just before reaching VR, there was a loud bang and the B747 yawed to the left. The Captain took over control and elected to abort. However, by this time the aircraft had accelerated to 177kt, close to VR and above V1. The aircraft could not be stopped on the remaining runway length and to avoid an overrun into the ILS installation the pilot steered the aircraft off to the right onto soft ground. The initial 'bang' was caused by a buzzard being ingested into the No. 2 engine. The Captain had seen a pair of buzzards hovering over the runway just before the bird strike and believed that both the No. 1 and No. 2 engines had been damaged.

Each takeoff includes the possibility that the pilot needs to stop the aircraft and reject the takeoff. Analysis of pilot reported rejected takeoffs occurrences showed that the rejected takeoff manoeuvre occurs approximately once in every 1800 takeoffs (source: NLR-ATSI). 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 4 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 than in the simulator. Analysis of pilot reported rejected takeoffs occurrences showed that about 56% of the rejected takeoffs occurred at speeds lower than 60 kt. and almost 90% below 100 kt. (source: NLR-ATSI). 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. However these are the most critical ones compared to the low speed aborts. Regulatory authorities have defined a speed up to which a safe abort can be made. Aborting a takeoff above the so-called V1 speed can result in fact that the remaining runway length is insufficient to stop the aircraft[1]. The pilot-not-flying will call out V1 as the aircraft accelerates through this speed[2]. If the pilot flying has not taken any action to stop the aircraft before this callout is made, the takeoff should be continued unless the aircraft is unsafe to fly. The concept of V1 has been the subject of many studies and discussions. Over the years changes have been made regarding the exact use and definition of the V1 concept.

[1] V1 has been referred to amongst others as the critical engine failure speed, the engine failure recognition speed, and the takeoff decision speed. To the pilot V1 represents the minimum speed from which the takeoff can be safely continued following an engine failure within the takeoff distance shown in the aircraft flight manual AFM, and the maximum speed from which the aircraft can be stopped within the accelerate-stop distance shown in the AFM. These definitions are not restrictive as other definitions may be outlined in the AFM of a particular aircraft model.

[2] On some modern aircraft there is an automatic callout of the V1 speed.

In 1989, in reaction to a number of takeoff accidents resulting from improper rejected takeoff decisions and procedures, a joint FAA/industry taskforce studied what actions might be taken to increase takeoff safety. The taskforce produced nine recommendations including the development of training practices, operational guidelines, and improvement of simulator fidelity. From this Boeing led an industry wide effort to develop a training aid. The result was a publication entitled Takeoff Safety Training Aid and a flight crew briefing video entitled Rejected Takeoff and the Go/No Go Decision released in 1993. This material gives information on operational procedures and crew qualification programs regarding rejected takeoffs. The goal of the Takeoff Safety Training Aid was to minimise the probability of RTO-related accidents. The idea is that risks could be reduced by a higher level of flight crew knowledge and by the use of improved procedures.

The big question now is, has takeoff safety improved since the introduction of the Takeoff Safety Training Aid? A fact is that high speed rejected takeoffs have not disappear since its introduction in 1993. For instance during the first month of 2010 two major overruns occurred after high speed rejected takeoffs[3].
This paper tries to answer the question why high speed rejected takeoffs after V1 still occur. This is done by analysing historical data of high speed rejected takeoffs before and after the introduction of the Takeoff Safety Training Aid.

[3] January 3rd, Boeing 737-800 at Dortmund airport (Germany) and January 19th, Canadair CRJ-200 at Yeager airport (U.S.)

2 Some operational issues related to rejected takeoffs

A pilot may reject a takeoff for a variety of reasons, including engine failure, activation of the takeoff warning horn, directives from air traffic control, blown tires, crossing aircraft/vehicles on the runway or system warnings. However high-speed rejected takeoffs are normally limited due to operator policy and aircraft manufacture guidance. Some operators and aircraft manufactures 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 V1, 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 70-100 Kt. with a typical value of 80 Kt. or 100 Kt. This operational practice will affect the number of rejected takeoffs made, especially those at high speed (say above 80 Kt.). Furthermore most modern aircraft have inhibits on aircraft systems warnings during takeoff, typically between 80 kt. and 1500 ft. This affects the opportunity for high speed RTOs due to misdiagnosis of minor system malfunctions at high speeds. Any warnings received during this period must be considered as significant. Above V1 the takeoff should not be rejected unless the aircraft is unsafe to fly. Examples of unsafe flight conditions are failure of multi engines and the impossibility to rotate the aircraft (e.g. due to extreme forward c.g.).

In the high-speed regime, the pilot's bias should be to continue the takeoff, unless there is a compelling reason to reject.

Source: Training supplement from a major US operator.

3 ANALYSIS OF HIGH SPEED REJECTED TAKEOFFS

3.1 APPROACH

The overall data analysis approach employed in this study was to:

- Develop a taxonomy for the collation and analysis of the data;
- Identify a sample of high speed rejected takeoff accidents and serious incidents in which the abort was started after V1 (the actual decision could be before V1); and,
- Analyse the data to determine what factors and to what degree they were associated to high speed RTOs. These factors were compared for data covering the period 1980-1993 with 1994-2008.

3.2 DATA INCLUSION CRITERIA

The following criteria were used to establish the data sample:

- Only occurrences that were classified as ‘accidents’ or ‘serious incidents’ according to ICAO Annex 13 definition were included;
- Both fatal and non-fatal accidents were included;
- The accidents and serious incidents involved a high speed rejected takeoff in which the abort was started after V1 (the actual decision to abort could be before V1);
- Accidents related to unlawful or military action were excluded;
- The occurrences involved fixed wing aircraft with a maximum takeoff mass of 5,500kg or higher that were used in a commercial operation (passenger or cargo) including training and ferry flights. There was no restriction to the geographical location of the occurrence;
- Both turbofan and turboprop aircraft were considered. Piston engined aircraft were excluded;
- The accidents occurred during 1980 through 2008.

3.3 DATA SOURCES

The primary data source used in this study was the NLR ATSI Air Safety database. For many years National Aerospace Laboratory NLR maintains a large database with aviation safety related data called the NLR ATSI Air Safety Database. The NLR

ATSI Air Safety Database is a collection of databases containing different types of data. The database contains detailed information on accidents and incidents of fixed wing aircraft from 1960 and onwards. Currently the NLR ATSI Air Safety Database contains detailed information on more than 40,000 accidents and serious incidents that occurred world-wide. For each occurrence a wide variety of factual information is available. For a large number of occurrences the causal and contributing factors are also available. Besides data on accidents and incidents the NLR ATSI Air Safety Database also contains a large collection of non-accident related data. These data include the following: airport data, flight exposure data (hours & flights at the level of airlines, aircraft type, and airports), weather data, fleet data, and more. The NLR ATSI Air Safety Database is updated frequently using reliable sources including data from official reporting systems, insurance claims, accident investigation boards, aircraft manufacturers, civil aviation authorities and more. Queries were conducted in the NLR ATSI Air Safety Database using the data inclusion criteria.

3.4 Taxonomy

The data were analysed using a taxonomy that was developed for this study. The reasons for the RTO were identified, as well as correctness of the decision to abort, and the runway conditions. Furthermore aircraft type, operation type and other basic factual information were collected.

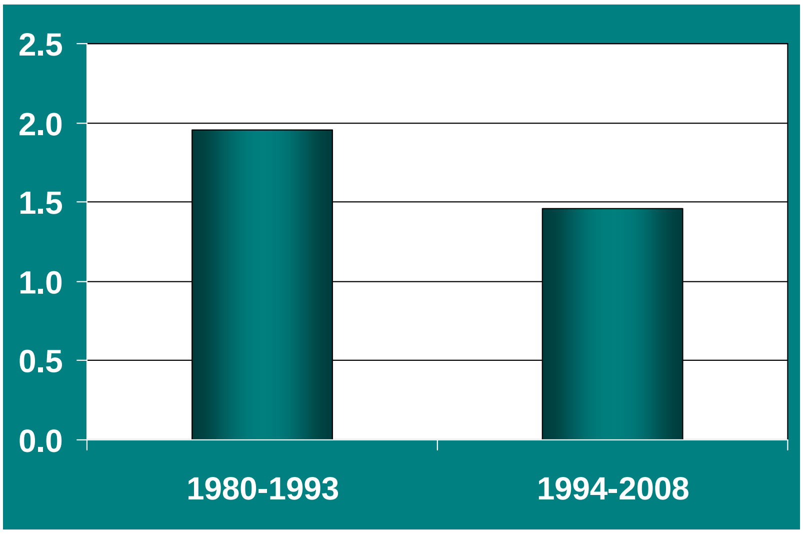
Reasons for RTO initiation	Explanation
Engine failures/engine indication warnings	Included are actual, temporary, or perceived loss of thrust and engine fires, and engine fire warnings.
Wheel/tire	Includes all kinds of tire/wheel vibrations or failures.
Configuration	Contains events such as wrong flap setting, wrong c.g., wrong takeoff mass, wrong control settings. Typically related to errors in the flight preparation.
Malfunction indicator	Reading observed on an indicator or warning light illumination.
Crew coordination	Events in which inappropriate crew actions resulted in an RTO.
Bird strike	Observed birds along the runway and experienced or perceived a problem caused by a bird strike.
ATC	Contains events related to ATC e.g. runway incursion, aborts ordered by ATC.
Noises/vibrations	Experienced or perceived vibration of the aircraft.
Directional control problems	Problems with maintain direction control.
Other/ Not reported	-

4 Results

In this section statistical results obtained from the data sample are presented and discussed. The complete sample encompassed 135 high speed rejected takeoff accidents and serious incidents. In 90% of these cases the aircraft could not be stopped on the runway. The statistical results are presented for the period 1980-1993 and 1994-2008 separately.

4.1 Safety improvement

Is there an improvement in the level of safety regarding high speed rejected takeoffs after the introduction of the training aid? This question can be answered by comparing the accident/serious incident rate before the introduction of the training aid and after. Figure 1 shows this comparison. After the introduction of the takeoff safety training aid the level of safety of high speed RTOs has improved by some 25%. It cannot be proven that this improvement of 25% is solely the effect of the training aid. For instance more reliable engines, better quality tires and better maintenance could also have contributed. Furthermore most modern aircraft have inhibits on aircraft systems warnings during takeoff. This has reduced the opportunity for high speed RTOs due to misdiagnosis of minor system malfunctions at high speeds. Although the training aid was promoted by the big aircraft manufactures like Airbus, Boeing, and McDonnell Douglas, it is unclear whether other manufacturers did likewise. For instance the emphasis in the takeoff safety training seems to be much on jet engine aircraft rather than turboprops. This could mean that turboprop operators did not incorporate the recommendations of the training aid in to their training programs.



Rate per 10 million takeoffs

Figure 1: Development of the accident/serious incident rate of high speed RTOs

4.2 Reasons for high speed RTOs

There can be several reasons for a pilot to abort a takeoff at speeds above V1. Figure 2 shows the comparison for the reasons for conducting a high speed RTO before and after the introduction of the Takeoff Safety Training Aid. More than one reason could be assigned to a single RTO. The results from Figure 2 show that since the introduction of the takeoff safety training aid the reasons for pilots to make a high speed RTO have not changed much. Engine failures/engine indication warnings (including engine fires) and configuration issues are the main reasons to abort, followed by wheel/tire issues (typically tire failures). Overall high speed RTOs were mainly conducted for non-engine related reasons both before (77%) and after (82%) the introduction of the training aid.

Although there is no simple explanation for the high share of non-engine related high speed RTOs the following reasoning could put some light on this issue. For an engine failure/fire, the crew needs to establish the condition of the engine (failed / not failed) in relation to the speed (before or after V1). This is a relatively simple comparative process involving reasonable cues (engine instruments) and predefined rules. The other reasons for RTOs are much less easy to assess by the crew. It is often not a simply comparative process and it requires a more knowledge based way of thinking than rule based like in the case of an engine failure. There is little or no guidance from aircraft certification in these situations other than engine failures/fires.

There have been others studies that examined the reasons for high speed RTOs. Well-known are the results presented in the Takeoff Safety Training Aid. Although the reasons to abort found in the present study are very similar to the ones given in the training aid, there are some important differences. For instance configuration issues have a lower frequency of occurrence in the Takeoff Safety Training Aid than in the present study. Wheel/tire issues have a somewhat higher frequency of occurrence in the takeoff safety Training Aid. There can be several explanations for these differences. First the data sample of present study included turboprop aircraft and smaller jets, whereas the takeoff training aid data only considered large western-built jets. Another reason is that the present study considered events that occurred after 1979. The data analysed in the Takeoff Safety Training Aid considered RTOs that occurred between 1959-1990. Especially during the period 1959-1979 there were a lot of events related to wheels/tires (28%). During the period 1980-1990 there were much less RTOs related to wheels/tires in the data of the Takeoff Safety Training Aid (13%). The reduction in this share could be due to the improvement in the quality of tires and/or better maintenance and inspections. This could have reduced the likelihood of having a tire failure. The occurrence data analysed in this paper are considered more representative of current operations.

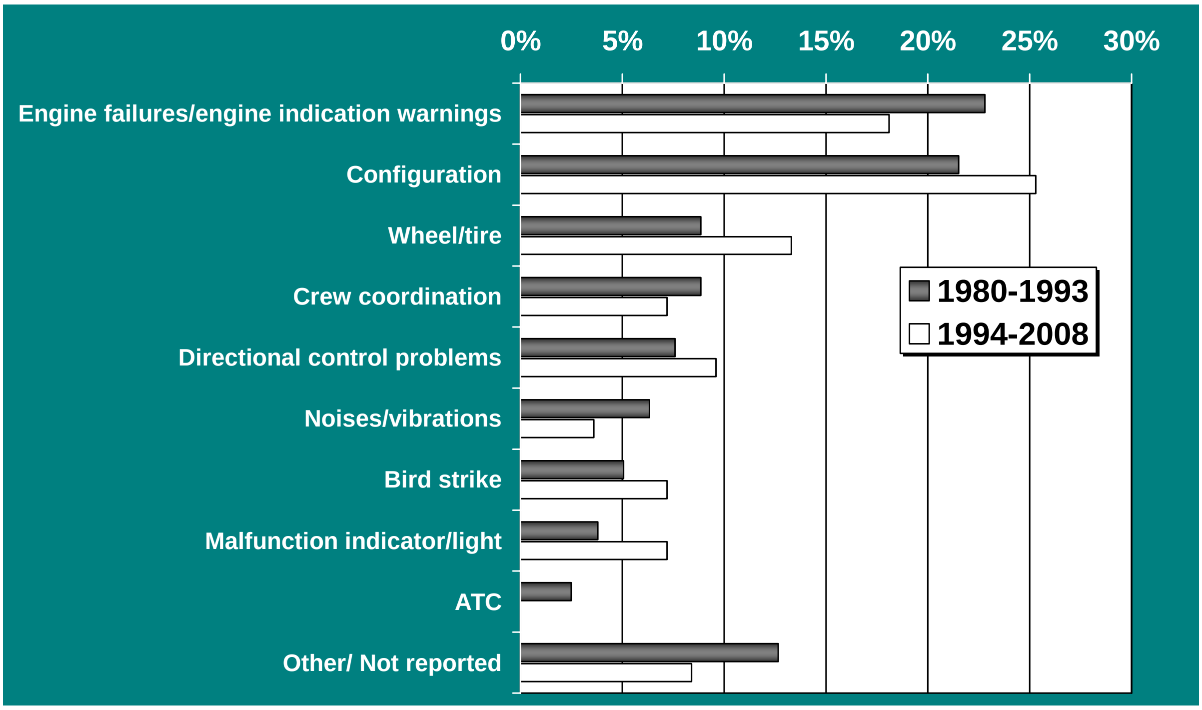


Figure 2: Reasons for initiating the RTO (More than one reason could be assigned to a single RTO.)

4.3 THE DECISION TO ABORT

Figure 3 shows a comparison of the number of unwarranted high speed RTOs. Considering the unknowns there is not much of difference in the relative number of unwarranted high speed RTOs made to abort before and after the introduction of the training aid. In both periods a relatively large number of decisions to abort were ***incorrect*** (51% and 44 % respectively). This is clearly in hindsight as most pilots really thought they were making the right decision at the time. Often it was related to complex situations e.g. an engine failure combined with significant vibrations which was judged by the pilots as an unsafe condition. Assessing such complex situations is difficult and often not well trained. There are often no references as to what might make the aircraft unsafe to fly making it difficult to the crew in recognising such a condition. The reliance on perception then provides the opportunity for errors in decision making.

In table 1 the main reasons to abort during takeoffs that should have been continued are listed. Both engine failures/engine indication warnings and wheel/tire issues were identified as the most common reason. There are some differences in the frequencies of these common reasons before and after the introduction of the training aid. No good explanation could be found for this. The present data suggest that pilots have difficulties to take a correct decision to continue the takeoff if passed V1 when something happens with an engine or tire. This is not a new observation. It has been a factor in many RTOs in the past.

During a takeoff from Frankfurt airport, just before reaching V2 there was a loud bang followed by severe vibration. The Captain concluded that the aircraft was not safe to fly and rejected the takeoff. The aircraft stopped in the remaining runway available. The vibrations were caused by a tire failure. Pieces of tyre passed forward of the wing leading edge, then back through the engine fan casing. Some pieces struck the fuselage, wing, and flaps, all without damage. The Captain later stated that he never experienced such a high level of vibration in an aircraft before and could not comprehend that such a level could ever occur.

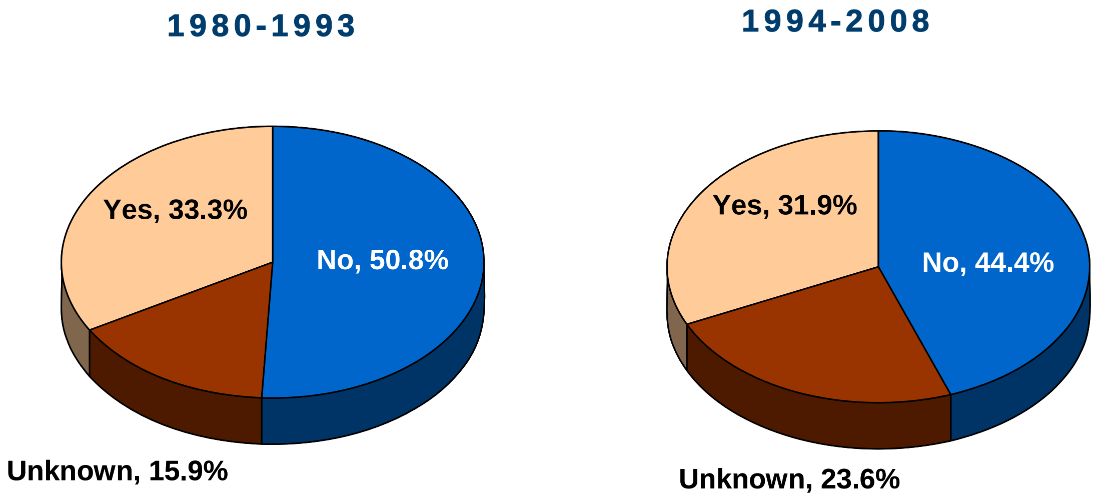


Figure 3: Correct decision to abort or not

Table 1: Reasons to abort during takeoffs that should have continued

Reason	1980-1993	1994-2008
Engine failures/engine indication warnings	50%	31%
Wheels/tires	16%	25%

4.4 Late reactions

Another critical element in rejected takeoffs is the reaction timing. Late reactions can result in aborts being made much after V1 whereas the call was made below V1[4], or it can increase the stopping length as such that it is not possible to stop on the runway. In figure 4 a comparison is made of the abort decision relative to V1. There is some improvement in the number of aborts called below V1 after the introduction of the training aid.

[4] Current certification assumes a recognition time of 1second between the speed at which an engine failure occurs and V1.During flight test brakes on/throttles to idle will be at V1. In the AFM this is expanded to a time after V1.

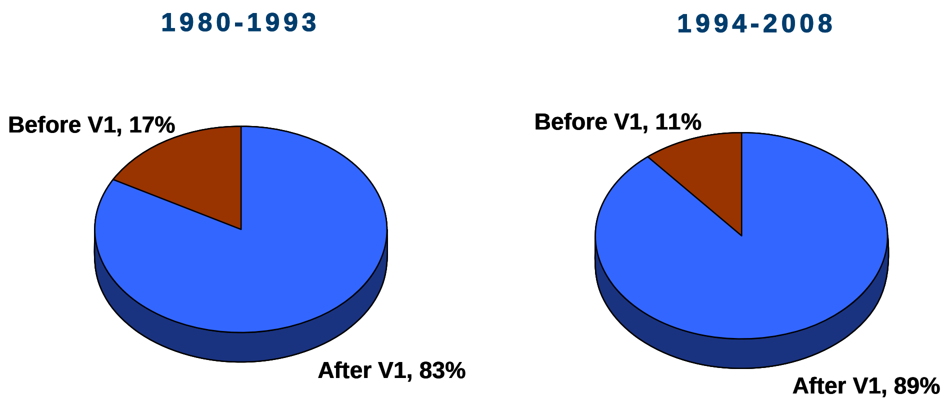


Figure 4: Abort decision relative to V1

Still in 11% of the high speed RTOs a decision was made below V1 whereas the abort itself was started much after V1. The fact that this can happen becomes clear when looking at human response phases. This starts with a recognition, then a decision, followed by a reaction. All these phases take time. A simulator study conducted by Qantas gave some interesting facts about decision and reaction times of pilots during rejected takeoffs (Qantas, 1970). In this study the pilots conducted a normal takeoff. However, they were not informed that an engine failure would occur just before V1. Some of the important results of this study are shown in figure 5. These data show that the time between the engine failure and pilot's reaction can be very long.

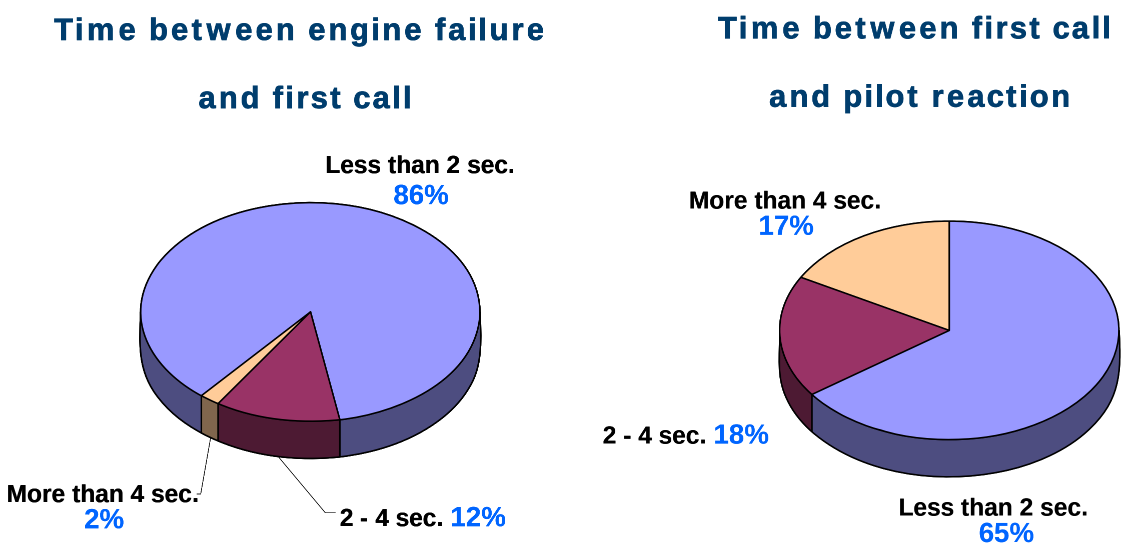


Figure 5: Reaction times after an engine failure

Another interesting study was conducted by Cranfield (Harris and Khan). A number of RTOs was conducted on a simple 747-200 simulator with a group of experienced airline pilots. Aborts were called at several speeds and the time to react was recorded. The mean response time as function of ground speed is shown in figure 6. As the ground speed increases the mean response time reduces. At low speeds the pilot has enough time to abort which is reflected by the data. Interesting is the fact that when V1 is approached the mean response time increases again. Apparently the pilot needs more time to react when approaching the decision speed V1.

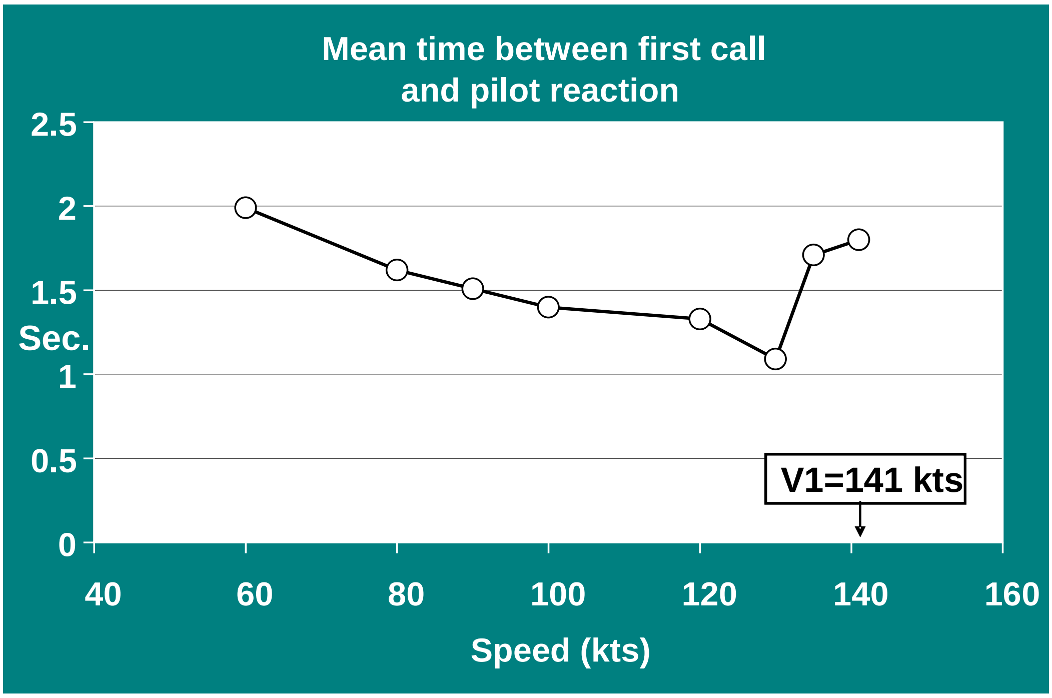


Figure 6: Pilot reaction as function of ground speed

Finally table 2 gives some examples of reaction times obtained from actual RTO accidents. These real life data show that the experimental data on reaction times are realistic.

Table 2: Examples of some reaction times from RTO accidents

	Time between recognition and call Sec	Time between call and pilot action sec
Accident # 1	2.5	1.5
Accident # 2	2.0	1.0
Accident # 3	1.0	3.0
Accident # 4	0.5	0.3
Accident # 5	1.3	0.8

Other delays in the response can occur when the F/O is the pilot flying. A study from the NTSB has suggested that difficulties and delays could occur when transferring the control of the aircraft from the F/O to the captain (as required by many airline's operating procedures[5]). This could add up to the total time of detecting a problem and reacting on it. In the present occurrence data it could not always be established who the pilot flying was and if there was a transfer of controls. The control transfer could be limited to directional controls only in the case that the captain is responsible (by SOP) for handling the thrust levers regardless if the captain is the pilot flying or not. A simulator study conducted by Boeing [Roberson and Shontz, (1992)] showed that the exchange of aircraft control influences the stopping performance during an RTO. The study concluded that if the FO calls and executes the RTO the margins in remaining runway length during an RTO are the lowest. Based on these results Boeing recommended that the Capt. should call and execute all RTOs. This recommendation has been incorporated into many operating manuals not limited to Boeing aircraft. However there are some concerns regarding these tests done by Boeing. First of all simulator tests were conducted with a limited group of Boeing instructor Captains and airline Captains. No 'real' first officers were used in these trials (an experienced Boeing Capt. played the role of the FO). This could affect the realism of the trials (e.g. behaviour of less experienced FO). Second

[5] A survey of a large number Manufacturers Operating Manuals showed that many aircraft manufacturers advice to give the decision to abort to the Captain and prescribe a transfer of controls when the First Officer is PF. Currently many airlines have therefore the policy where the Captain is the only pilot allowed to call and to execute the RTO.

the number of trials in the Boeing simulator study was low. For instance only 6 trials were conducted with the FO calling and executing the RTO. This could affect the statistical significance of the findings. Finally, the tests were conducted in one aircraft type only (B737). The results could be different for other aircraft types. However, after these experiments Boeing brought in an airline that was interested and tested a large group of their pilots to validate the results. These were airline crews that included "real" first officers. These additional tests gave Boeing more confidence in the recommended procedure for having the Capt. to decide and execute the rejected takeoff.

All these above mentioned issues with reaction times illustrate that pilots need time to assess complex situations and to react upon them. With a typical acceleration of 3 to 6 knots per second, just 3 seconds for assessing the situation and decision-making, will add 9 to 18 knots to the speed. If the aircraft is close to V1, it now most likely has exceeded it.

5 Rejecting a takeoff after V1…why does it still happen?

There is no simple reason that explains why there are pilots that reject a takeoff after V1. The Takeoff safety training aid introduced in 1993 could be seen as valuable tool to counteract this. However, the analyses in this study showed that many of the issues the training aid addressed are still occurring after its introduction. Is this due to the fact the Training Aid did not address all the issues or has the training aid not been implemented on a large scale? Fact is that all FAR part 121 operators in the USA have implemented the training aid within a few years after its introduction. Other operators have introduced parts of the training aid in their training and procedures mainly through the (large) aircraft manufactures. A very brief survey amongst some European airline pilots suggested that the Takeoff Safety Training Aid is not well-known anymore. Although there is no hard evidence it could be that this applies throughout the commercial aviation sector. The idea of the Takeoff Safety Training Aid was that risks of high speed RTOs could be reduced by a higher level of flight crew knowledge and by the use of improved procedures. Still pilots faced with unusual or unique situations may perform high speed RTOs unnecessarily or may perform them incorrectly. This has not really changed since the introduction of the training aid. More emphasis could be placed on this issue by operators and manufactures.

For pilots it is difficult to make the right decision with only limited time available. The RTO data for the period after the training aid still showed that in large portion (44%) a RTO was not the correct decision. Furthermore even if the right decision was made significant delays in making decisions and reactions occurred. Any delay could make a safe stop on the runway impossible. Experimental data indicates that long delays are not unlikely[6]. Flight crews should consider a wide range of possible failures and project the outcome, often in a short timescale and without sufficient information. These aspects increase the probability of error involving many human biases when deciding to go or not to go.
Currently pilot simulator training often presents RTOs as engine-related events while the Takeoff Safety Training Aid gives recommendations about other failure conditions to consider. As already noted, the majority of all RTO accidents were

[6] These delays in reactions can sometimes be longer than the expanded transition times used in AFM for RTO performance calculations.

not related to engine problems. In these cases it is possible that the pilots were not fully prepared to recognise cues of other anomalies during takeoff. The data analysed for this paper indicate that pilots often interpret these other anomalies (like a tire burst) as events that threaten the safety of flight and decide to reject the takeoff at any speed. Looking through the eyes of the pilots, making a proper Go/No Go decision is not always simple.

6 Conclusions and recommendations

6.1 Conclusions

Since the introduction of the Takeoff Safety Training Aid:

- Accident/serious incident rate of high speed rejected takeoffs has dropped by 25%;
- There is no unambiguous proof that that this reduction is the result of the Takeoff Safety Training Aid;
- Reasons for conducting a high speed rejected takeoff are the same as before the training aid;
- Many high speed rejected takeoffs (44%) should not have been conducted. This number is only slightly less than before the introduction of the training aid (51%);
- Pilots have difficulties in recognising "unsafe to fly" conditions;
- The Detection-Decision-Action process still takes a lot of time!
- 82% of the RTOs were non-engine related which is similar to before the training aid.

The training aid emphasised the need to adhere to the V1 decision-making concept and highlighted the inevitability of an overrun if a rejected takeoff is initiated after V1. The present study shows that there is still plenty of room to improve takeoff safety and reduce the number of unwarranted rejected takeoffs above V1.

6.2 Recommendations

- It is recommended to bring the Takeoff Safety Training Aid back to the attention of the flight community. This should not be limited to operators of large jets only. Also the operators of smaller jets or turboprops should be considered in this effort. Some topics in Takeoff Safety Training Aid might need a revision (e.g. more attention how to recognise unsafe flight conditions).
- Pilots should also be trained for RTO events other than engine failure.
- It is furthermore recommended to gain more up-to-date insight in the pilot's behaviour during rejected takeoffs. This can be done through the use of training simulators. For this unannounced problems (e.g. engine

failures, tire failures etc.) could be introduced during takeoffs conducted as part the regular simulator training of commercial airline pilots. Decision times and reaction times should be recorded and analysed.
- Operators should evaluate the takeoff training safety aid information and incorporate this in guidance and procedures. This could adjust the perception of unforeseeable/complex ‘evaluation’ situations towards the more foreseeable ‘if - then’ rule based situations.

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Acknowledgements
The author would like to thank all persons that reviewed this paper. Their comments improved the quality this paper.