A330 REJECTED TAKE-OFF

REFERENCES

FCOM, FCTM, FAM, Takeoff Safety Training Aid

DEFINITIONS

The definition of V1 is: *"The maximum speed at which the crew must take the first action to initiate the rejected takeoff"*

By V1 the decision must have already been made …..

FAA DEFINITIONS OF V1

V1 is the maximum speed at which the rejected takeoff maneuver can be initiated and the airplane stopped within the remaining field length under the conditions and procedures defined in the FARs. It is the latest point in the takeoff roll where a stop can be initiated.

And ….

V1 is also the earliest point from which an engine-out takeoff can be continued and the airplane attain a height of 35 feet at the end of the runway.

Where these 2 V1 speeds are equal – a balanced field exists. Crew should always presume that this is the case (worst scenario).

CERTIFICATION CRITERIA

Whilst certification tests are limited in that the test pilot knows that he must reject the takeoff at V1, allowances are built into the A/C operating manual for "average" pilot behaviour. These are:

- a (minimum) 1 second allowance for recognition of engine-failure (or other problem). This is BEFORE V1

- brake application is required at or before V1

- a 1 second allowance for thrust levers to IDLE (after V1)

- an additional 1 second allowance for speedbrakes to extend (after V1)

- RTO certification is done without Reverse Thrust. However, reverse thrust does contribute to the stopping distance – especially if the runway is contaminated and the reverse thrust is applied at higher speed (more effective here).

These allowances are not meant to afford pilot delay in the RTO decision. The definition of V1 remains unchanged.

In the A330, thrust IDLE is the first step. Above 72 kts the AUTOBRAKES (MAX) and the ground spoilers will automatically engage immediately.

Reverse thrust (even on just one side) does not affect the deceleration rate but do take much of the effort out of the brakes – allowing them to be more efficient and build up less heat.

A BALANCED FIELD is one where at a certain weight the runway distance is equal for a complete stop following an RTO at V1 and a continued takeoff (to 35' AGL – dry) following an engine failure at V1. For many flights, the A/C is less than that which makes for a balanced field takeoff. Pilots may not know whether a V1 is predicated on a balanced field (the most critical case). If the actual weight is less than the balanced field weight, there will be more room for an RTO from V1 – the A/C will stop before the end of the runway. Pilots should, however presume all takeoffs are V1-critical.

Continuing the takeoff with an engine failure at V1. FLEX thrust used is still certified for 35' at the end of the runway. TOGA on the remaining engine only improves this – all else being equal.

DECISIONS

The captain bears the responsibility to reject the takeoff.

DECISIONS

BELOW 100 kts ("low speed")
- Seriously consider an RTO for any ECAM warning or caution.

ABOVE 100 kts and BELOW V1
("high speed")

Captain should be go-minded. Reject only for:
- **ENG FIRE**
- **APU FIRE**
- **Severe damage**
- **ENG FAIL or sudden loss of engine thrust**
- **CONFIG warning** *Red/Warning*
(- **ENG OIL LO PR) – now removed from the list**
- **ENG REV UNLOCKED** *Red/Warning*
- **SIDESTICK FAULT (NEW)**
- **L+R ELV FAULT** (- pitch control only by trim wheel) *Red/Warning*
- **Tyre failure when less than V1-20 kts.** After this speed it's better to get airborne, dump fuel and land with a long runway, unless the tyre debris has caused major engine anomalies.

Nose gear vibration should **not** lead to an RTO above 100 kts
A window coming open should not lead to an RTO above 100 kts.
Until takeoff power set (all of these should give a caution):
+ **F/CTL PRIM 1 FAULT**
+ **F/CTL PRIM 1 PITCH FAULT**
+ **F/CTL ELEV SERVO FAULT on 1 green servo control**
+ **HYD G SYS LO PR**

A further hidden failure may result in loss of one elevator control in flight.
A return to the gate for maintenance is required in each case above.

ABOVE V1
Only if the aircraft will not fly. Expect a runway overrun.

PROCEDURE

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Note: if F/O is the PNF: F/O calls ECAM abnormalities and Captain rejects takeoff if required/desired. If the Capt is PNF: Captain calls ECAM abnormalities and performs the rejected take-off

CPT: ……………………………… *"STOP"*
(this indicates that he HAS control)
THRUST LEVERS …………….. IDLE
REVERSE THRUST …………… MAX AVAILABLE
Monitor deceleration and use full manual braking to a stop if required
Full reverse may be used to a stop but if plenty of runway remaining, deselect reverse at 70 kts. If fire indication in an engine - do not use reverse on that side.

F/O: MONITOR
- REVERSE ("REVERSE GREEN[2]")
- BRAKE RESPONSE ("DECEL[1]")
If RTO is below 72 kts state ***"MANUAL BREAKING"***
CANCEL ANY AUDIO - (master caution or warning)
CALL ***"70 kts"***
INFORM Tower ***"STOPPING RUNWAY xx"***

CAPT:
Stop on the runway unless wind is blowing fire onto the fuselage
PARKING BRAKE ……… SET
ALERT PA ***"Attention! All passengers remain seated and await further instructions"***
"ECAM ACTIONS"

***F/O:* PERFORM ECAM ACTIONS**
Locate the EMERGENCY EVACUATION checklist (back cover of QRH)
*If evacuation is required, follow the **ECAM** in the case of **ENGINE FIRE** or the **QRH EMERGENCY EVACUATION** checklist in **every other case***
This includes informing ATC and requesting assistance from the emergency services

NOTES

The "DECEL" call means that the deceleration is felt by the Flight Crew, and confirmed by the speed trend on the PFD. It can also be confirmed by the DECEL light, however, this light only indicates that the selected deceleration rate is or is not achieved, irrespective of the functioning of the autobrake. The DECEL light might not come up on a contaminated runway, with the autobrake working properly, due to the effect of the antiskid.

Captain should avoid pressing the pedals with autobrake functioning (which might be a reflex action) unless he intends to apply manual braking.

Full reverse may be used to A/C stop although of stop is assured, reverse may be set to IDLE reverse at 70 kts. This is preferable.

In the wet or with a contaminated runway – use all stopping devices to bring the aeroplane to a complete stop.

If in doubt about A/C braking, do not wait, take over and immediately apply maximum manual braking. This is probably not a natural action since pilots are so geared to passenger comfort. Loss of braking procedure is applicable here if the A/C is not decelerating.

If there is an abnormality in the takeoff run and the Captain decides to continue then he will say ***"CONTINUE"***

The Captain does the alert PA. As well as company policy, it lets the passengers and crew know that the pilots are OK and working through procedures

The aircraft should be **parked** (on the runway if necessary) whilst the crew runs checklists and evaluates the situation.

If Autobrakes have been used to a stop, release the brakes by disarming the spoilers prior to further taxi. Autobrakes may otherwise be released by depressing at least one brake pedal with a certain force.

Before deciding to evacuate - use ATC, fire services (131.0), cabin crew, engineers or other company staff to gain as much information as possible about the aircraft state (eg. engine on fire). A suitable way to determine the state of the engines on the ground is to open the cockpit window and look out at the engine.

Cabin crew should not initiate an evacuation without first attempting to contact the flight deck.

The High/Low speed figure of 100 kts is not a critically chosen figure. It is considered to be a suitable and simple figure to define what is high speed and what is low speed.

SYSTEMS INFORMATION

ECAM inhibits warnings which are non-essential from 80kts to 1,500' (or 2 minutes after takeoff – whichever occurs first). This aids the Captain in his go/no go decision.

There is some conjecture as to whether ALL cautions are inhibited in the 80 kts to 1,500' / 2 min window. In other words, could there be a caution occurrence in this time where the pilot would still have to assess the problem and say "continue". Initial discussions would indicate YES.

The flight control page will not be automatically displayed therefore the indication of groundspoilers is not obvious. It is not considered a high priority to select the FCTL ECAM page to check on the deployment of ground spoilers. If the autobrakes are working then the groundspoilers can be presumed deployed.

If only one reverser is operative, state **"REVERSE 1 (2) GREEN" or "NO REVERSE"**

The DECEL call now comes **AFTER REVERSE GREEN**

Autobrakes (MAX) are activated by the ground spoiler deployment. The ground spoilers will not deploy with a rejected takeoff below 72 kts. Therefore below this speed there will be no Autobrakes or spoiler deployment.

The total energy that must be dissipated in an RTO is proportional to the square of speed.

The brakes bear most of this energy although the reverse thrust bears some of the load if it is used. Reverse thrust is most effectively at high speed so don't delay its use.

Blown tyres reduce the overall braking ability because of the loss of braking on that wheel. Certification testing is not done with blown tyres.

A high speed RTO results in very hot brakes, the tyre fuse plugs should melt and let out the air pressure, reducing the risk of tyre explosion. Nevertheless, no-one should approach the main landing gear until the brakes have cooled.

* If the runway is limiting then a proper RTO will result in a stop before the runway end. If the RTO is initiated 1 second after V1 then the aircraft will run off the end of the runway doing 50 to 70 kts. See the table later in this document.

STANDARD REJECTED TAKEOFF BRIEFING

(F/O = PF)

"In the event of a rejected take-off, I will expect to see you (the Captain) say "stop" and immediately close both thrust levers and select available reverse thrust. I will maintain control until I hear and see you positively taking control.

I'll call available reverse ("REVERSE (1,2) GREEN") and ensure that the Autobrakes are working and call "DECEL". I'll call you any errors or omissions.

I'll cancel the warning/cautions and call "70 kts" then advise the tower that we are stopping on runway xx.

I'll see you park the brakes, give the alert PA and call for ECAM actions. I'll locate the EMERGENCY EVACUATION CHECKLIST.

I'll request the fire services from the tower for an abort above 100 kts.

If you state "continue" then I will continue the take off as planned unless I hear and see you positively taking over."

PERFORMANCE / SYSTEMS IMPACTS

Factors which may affect RTO stopping performance and/or stopping distance: **I**=improved **W**: worse

PILOT FACTORS

W - delay in recognition of problem requiring RTO
W - delay in initiating RTO
W - improper techniques. Eg. late or no use of reverse thrust, not maximum braking when braking manually. Instictively taking over from autobrakes and not using maximum manual braking.
W - error in performance calculations (improper speeds)
W - runway line-up uses more distance than allowed in calculations (distance to V1 more than calculated in the performance figures)
W - improper (low) thrust setting (longer, slower acceleration)
W – slow to set takeoff thrust whilst rolling (longer, slower acceleration)

SYSTEM FACTORS

W - damaged tyres
W - deflated tyres
W - brakes deactivated (MEL). A V1 reduction usually applies to accommodate for this. A brake failure during the RTO will not be accounted for.
W - anti-skid faulty or unserviceable (MEL). A large V1 reduction usually applies. (unplanned) failure of the antiskid will be much more of an issue with a contaminated runway.
W - A/C weight greater than predicted by loadsheet
W - residual brake temperature (with brake temps past a certain point The braking efficiency reduces and the brakes may fail altogether). The A330 does not have Min Turnaround Tables. The basic 150 and 300 degree limitations make brake energy matters an easy assessment for departure.
W - speedbrake (no speedbrake in RTO affects drag – some 30%) and moreso weight on the wheels to aid proper braking (30% increase in braking efficiency).
I - flap setting. More flap means lower V1 and VR – reduced takeoff run and therefore more runway to stop. There is also more drag to help the A/C stop. The trade-off is climb performance (more flap reduces 2nd segment climb ability), aircraft wear & tear, longer cleanup time.
I - engine bleed air (OFF is better for TOGA takeoffs so that the engine develops greater power and reaches V1 earlier/less runway used)

For information - Worn brakes. RTOs must now be certified with brakes worn to the limit (flush pin) so if the brakes are within limits – the RTO should not be reduced in deceleration effect.

ENVIRONMENTAL FACTORS

W - less headwind or more tailwind than used for calculations
W – hot temperature (performance figures account for)
W – high pressure altitude (QNH adjustment accounts for). Engine performance is less in the latter 2 cases (ie. higher density altitude) so acceleration to V1 takes longer and more runway.

LOCATION FACTORS

W - runway ungrooved (worse than grooved in the wet/contaminated) - affords better friction.
W - runway friction coefficient worse than advertised (contamination,

rubber deposits, etc, reducing braking). Wet, icy, snow or slush-covered runways significantly reduce V1.

INITIATION OF RTO AFTRE V1

If the A/C is at a limit weight for the field, an overrun is almost certain.

Some figures (with maximum effort stop):

Speed of RTO Initiate	Speed at runway end – then overrun
V1+4 kts	60 kts
V1+8 kts	85 kts
V1+12 kts	120 kts

Contaminated runways, pilot technique errors or further system failures only increase the runway overrun speeds.

ANCILLARY MATTERS

TECH LOG ENTRY AFTER RTO

* A Techlog entry is required stating that:
- an RTO has occurred
- reason for RTO
- speed at which take0ff was rejected
- whether or not reversers were used

FIRE VEHICLE ACCESS

Fire vehicles have best access to the aircraft when it is ON the runway. If it is on the taxiway the services will have to approach on the grass - which may be long and/or boggy. Exit the runway only if sure that evacuation is not required.

V1 & ROTATE CALL

The V1 call (PNF) should be crisp and the call completed by passing V1 speed. By contrast the ROTATE call is slower (more like a drawl) – this aids in preventing snap rotates.

SOME HISTORY

From the “PILOT GIUDE TO TAKEOFF SAFETY” (Flight Operations Training Library). Data for a certain study – not just Airbus.

OVERRUNS

75% of all RTOs are under 80 kts.

Approximately 75% of RTOs – full engine power was available.

2% of RTOs are above 120 kts. Most (by far) runway overruns come from within this 2% of all RTOs.

Just over half of the overruns occurred where the takeoff was aborted **above** V1.

24% of overruns were on wet runways.
10% of overruns were on ice or snow covered runways.

More than 80% of RTO accidents were readily avoidable by:
- 55% continuing the takeoff
- 9% better pre-flight/planning
- 16% correct stop techniques/procedures

20% of RTO accidents were unavoidable.

REASONS FOR RTOs

25% engine failure
23% wheel tyre problems
12% configuration warning
10% indicator/light
8% crew coordination
7% bird strike
3% ATC initiated
13% other or reason not reported

GENERAL

Although certification test have resulted in brake fires, an RTO on line will not likely result in a brake fire (so data says). Tyres deflating in a high speed RTO are much more a likely event.