Engine failure on take-off "hey, what's it doing now?"

"BestAir 11, runway 18, cleared for take-off, left turn..." The old Airbus 340 of Best Airways starts its take-off run and is gaining speed majestically. Just when it is passing the halfway point of the runway, a flock of birds ahead thinks they had the clearance first. As the inevitable collision occurs, the number 1 engine takes a direct hit and emits some flames to show its displeasure. Soon the aircraft's nose starts to rise…

Mac, let's try and set up the FMS just once without saying "Oopsy daisy"...

In normal operations an aircraft should fly according to the given departure clearance, which may be using a published SID or using some other ad hoc clearance.

Acceptance of such clearances assumes that all engines are functioning normally. For engine-out situations the aircraft operator is responsible for checking obstacle clearance and performance data and detailing for each departure any variations which might be needed to retain sufficient obstacle clearance.

The engine failure response procedures adopted may vary from operator to operator. The operators may also have outsourced obstacle clearance evaluation and the planning of engine-out procedures to an external service provider - although of course that does not affect their responsibility in this matter. It is normal to keep these procedures as simple as possible. The procedures are planned for each runway separately. Typically, an engine-out initial flight path will continue on the extended centre line of the runway to a pre-determined distance and/or height, after which a turn towards an engine-out holding position may be specified. These procedures are planned so that an aircraft can continue climbing after level acceleration and clean up of the aircraft configuration.

…In the fictitious example we began with, the Captain was the pilot flying and the First Officer was the monitoring pilot. "V1", the First Officer called when the aircraft passed 130 knots, "Oh my… birds! many birds!" As several large birds hit the aircraft, a number of thumping sounds were audible in the flight deck along with a momentary vibration of the airframe. The cabin crew heard this too. The engine failure drill appeared on the ECAM. The Captain maintained directional control and after the "Rotate" call from the First Officer, he began a rotation towards the engine-out target pitch attitude…

In modern air transport aircraft, the take-off performance is established before each flight. This can be done using an EFB or more traditionally by reference to the performance manual or by use of pre-calculated take-off weight tables and a speed booklet. Performance calculations take into account a number of factors such as runway characteristics and conditions (e.g. runway slope, length, possible contamination etc), weather factors

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(e.g. temperature, wind velocity), aircraft weight and intended engine thrust settings (full or reduced to extend engine life).

Applicable regulations define margins for each part of the take-off and initial climb, which must be met for every take-off. The main principle is that the most demanding requirement defines the maximum weight of the aircraft for take-off. The required take-off distance is defined as the distance from a standing start to a height of 35 feet and both all engines and the engine-out scenarios are considered. The obstacle clearance of 35 ft may be reduced to 15 feet if the runway is wet or contaminated. The obstacle clearance requirement is based on calculated net flight path, which is the gross, or theoretically achievable, flight path reduced to account for an aircraft flown in a typical way rather than with perfection.

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… Meanwhile the aircraft started to lift off from the runway surface. After checking, the First Officer called "positive rate" and the Captain responded by calling "gear up". From the Tower it looked like the aircraft barely avoided hitting the runway lighting installations. There was no transmission from the pilots and it quickly became obvious that the aircraft was not going to follow its departure clearance. The aircraft had passed the SID initial turn and appeared to be flying straight ahead. At last there was a PAN call advising of an engine failure and the pilots' intention to turn towards the VOR after they had passed 1700 feet…

In the flight deck, the priority is to fly the aeroplane. The priority is "aviate, navigate, communicate". However, even with this priority, many aircraft operators expect their pilots to at least inform ATC of a problem that will affect compliance with a clearance early on without getting involved in what the alternative will look like by following with a "stand-by". This allows flight crew resources to be focussed on the initial piloting and engine failure tasks.

Typically, when abnormal check-lists are being performed, the pilot flying temporarily takes over communications with ATC to allow the monitoring pilot to focus fully on the prescribed engine failure tasks. Whether this happens or not, the priority for the pilots is to establish and maintain overall situational awareness.

… The flight joined the holding pattern over the VOR about 20 miles from the airport. Once the aeroplane was in the hold, the First Officer finished the engine failure checks according to the ECAM and started to prepare landing distance calculations for an overweight landing. The First Officer took over as pilot flying whilst the Captain called the cabin crew chief and explained the situation and requested appropriate preparations for landing. He also made a public address announcement to the passengers to keep them informed and asked them to follow any the instructions given by the cabin crew…

Landing performance is calculated in a similar way to take-off performance, with corresponding safety margins. Landing performance calculations must also take account of go-around performance. Again the operator is responsible for ensuring that the engine-out climb gradient would meet obstacle clearance requirements. If the normal published go arounds can't be used in the case of an engine failure, the operator can use higher decision altitudes or publish a special procedure, which may differ from the ATC expectations - at least if the flight crew don't remember to tell ATC about it.

… Finally the aircraft joined the ILS for runway 18 and the Captain made a smooth touchdown, selected full reverse on the three still-functioning engines and the auto brake took effect. Almost the whole length of the runway was used and as the brake temperatures rose, the tyre safety plugs began to melt and some of the main gear tyres deflated. As the aircraft could not now taxi, it blocked the only runway at the airport. The passengers had to disembark to buses down external stairs. Although the flight ended without any drama, the working day of the crew and the ATC still had some way to go.

SIDESTORY / FACT-BOX – the pre-departure briefing for engine failure during take-off given by the pilot designated as the pilot flying.

These briefings will vary from operator to operator and between aircraft types. They are often only given in full on the first flight if the crew will be operating more than one flight. But the following example of one shows the increased workload for pilots during the initial stages of an engine-out situation. Remember, the priorities of cockpit crew are aviate, navigate, communicate!

"After V1 continue take-off, when you call positive rate, I call for gear up. Initial target 12.5 nose up, when indicating - follow SRS. Fly and trim, after trim and at least 100 feet radio altitude – autopilot on. After 400 feet I call for the ECAM actions. In case of a flame out, continue to master switch, if fire or severe damage, continue to fire bottles according to ECAM. At acceleration altitude, push to level off, accelerate, clean configuration. At green dot speed (optimum engine-out climb speed) set safe altitude and pull the altitude knob. The local procedure here is to continue ahead to 8 miles, and then turn left to the beacon. Safe altitude here is 2300 feet. The SID assumes an early turn, so inform ATC with mayday and tell them to standby..."