# A320 Family Non-Normal Notes

Version 3.2

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# Contents

# Change log

Change bars show changes between version 3.1 and version 3.2.

## Version 3.2

- Section 1.4, EOSID, amended with new 800ft acceleration altitude.
- Section 2.1, Emergency descent, updated with recommendation to stay on airway/track in UK airspace and to run the CAB PR EXCESS CAB ALT ECAM prior to the QRH procedure if it is available.
- Section 2.6, Overweight landing, updated with a discussion around the incompatibility of slowing to $V_{LS}$ at threshold crossing and achieving a minimum V/S touchdown in gusty conditions.
- Removed Landing distance calculation section from Chapter 2 since landing distance tables are no longer available due to the removal of the paper QRH.
- Section 6.1, Flaps and/or slats fault/locked, updated to point to Flysmart+ as the source for configuration and $V_{app}$ due to removal of the paper QRH.

- Section 6.7 updated to give the required Flysmart+ landing module selection for spoiler runaway due to removal of the paper QRH.

- Section 7.1, Smoke and fumes, updated. This is a result of Airbus changing the line “If perceptible smoke apply immediately” to “If perceptible smoke/fumes apply immediately”, which clears up a historic ambiguity. The instruction that unconfirmed AVIONICS SMOKE ECAMs should be treated as spurious is also added. Finally the purpose of turning off the cabin fans is clarified as being to prevent distribution of smoke rather than the fans themselves being considered a likely source.

- Note added to Section 9.1, Loss of braking, that differential braking will need to be used after selecting the alternate braking system.

- Added Section 9.2, Tyre burst.

- Updated Section 10.1, All Engine Failure. This removes the discussion of how to fly a glide approach in favour of a link to the All Engine Failure Training Tool.

- Section 10.4, Engine relight in flight, rewritten to include differences for NEOs.

- Section 10.9, High engine oil temperature, updated to include slight differences for the NEO and to reference the NEO FWC error and associated OFP attachment.

- Section 14.1, Window heat fault, updated with information that PF windshield heat is non-monitored required equipment for CAT2/3.

## Version 3.1

- Section 2.3, Unreliable airspeed, rewritten to include more information about the use of DBUS and BUSS and to focus more on the fundamentals of the procedure.
- Added warning to Section 6.1 regarding the potential difficulty of diagnosing surfaces stuck at intermediate positions close to index positions from the flap/slat position indicator.

# Chapter 1

# Operating techniques

## 1.1 Rejected Takeoff

The decision to reject rests solely with CM1. This decision is communicated with the words “Stop” or “Go”. “Stop” implies that CM1 is taking control of the aircraft.

Below 100kt the RTO is relatively risk free and a decision to stop should be made for any ECAM and most other problems.

Above 100kt the RTO may be hazardous and stopping should only be considered for loss of engine thrust, any fire warning, any uninhibited ECAM[1], or anything which indicates the aircraft will be unsafe or unable to fly.

[1]There are five uninhibited amber ECAM cautions that require a high speed RTO. Only two uninhibited ECAMs are not on this list: ENG 1(2) THR LEVER DISAGREE if the FADEC automatically selects idle thrust and FWS FWC 1+2 FAULT. The first of these should never happen due to FADEC logic. The second generates a message on the EWD but no master caution (it is the computers that generate master cautions that have failed). You could therefore modify this rule to: stop for any ECAM warning or caution except the caution-like FWS FWC 1+2 FAULT.

If a stop is required, CM1 calls “Stop” while simultaneously bringing the thrust levers to idle, then to max reverse.

If the stop was commenced below 72kt the ground spoilers will not automatically deploy and the autobrake will therefore not engage. Monitor automatic braking, and if there is any doubt, apply manual braking as required. If normal braking fails, announce “Loss of braking” and proceed with the loss of braking memory items (see Section 9.1).

If the reason for the stop was an engine fire on the upwind side, consider turning the aircraft to keep the fire away from the fuselage.

If there is any chance of requiring evacuation, bring the aircraft to a complete halt, stow the reversers, apply the parking brake, and order “Attention, crew at stations” on the PA.

If evacuation will definitely not be required, once the aircraft’s safety is assured the RTO can be discontinued and the runway cleared. In this case make a PA of “Cabin crew, normal operations”.

During this initial phase, CM2 confirms reverser deployment (“Reverse green”), confirms deceleration (“Decel”), cancels any audio warnings, informs ATC and announces “70 knots” when appropriate. CM2 then locates the emergency evacuation checklist.

Once the aircraft has stopped, CM1 takes the radios and asks CM2 to carry out any required ECAM actions. Whilst the ECAM actions are being completed, CM1 will build up a decision as to whether to evacuate. If an evacuation is required, see Section 2.4. Otherwise order “Cabin crew, normal operations”.

If the aircraft has come to a complete halt using autobrake MAX, the brakes can be released by disarming the spoilers.

If, following an RTO, a new takeoff is to be attempted, reset both FDs, set the FCU, then restart SOPs from the After Start checklist. Carefully consider brake temperatures; temperature indications continue to climb for some time after a significant braking event.
[ EOMB 3.10, FCTM PRO.AEP.MISC ]

## 1.2 Asymmetric takeoff

Apply rudder conventionally to maintain runway track. At $V_r$ rotate at a slightly reduced rate towards an initial pitch target of 12½° then target speed $V_2$ to $V_2$+15kt. Bank angle should be limited to 15° when more than 3kt below manoeuvring speed for the current configuration.[2]

When the ground to flight mode transition is complete,[3] select TOGA.[4] Adjust and trim rudder to maintain $\beta$ target; this will result in a small side-slip angle towards the failed engine. Engage the autopilot once gear is up and rudder is trimmed.

## 1.3 Low level failure handling

Handling of failures that occur on the takeoff roll or at very low level is primarily a test of triage skills. Airbus provides support in three ways:

- ECAM flight phase inhibitions filter out less serious failures until 1500ft AAL is attained on climb out or speed is below 80kt on the landing roll.
- TOGA thrust is made available for an extra 5 minutes (giving a total of 10 minutes) in emergency situations, which allows

[2] This is a conservative rule of thumb. If the FMGC has correctly identified an engine out condition, the FD/AP will automatically limit bank angle according to a less conservative algorithm (see FCOM SYS.22.20.60.40)

[3] Introducing TOGA during the ground to flight mode transition (commences as the pitch increases through 8°, complete after 5 seconds) results in a pitch up moment at a time where the effect of stick pitch control is not wholly predictable: the stick will need to be moved forward of neutral to counteract the introduced pitch moment and then returned to neutral as flight mode blends in. A slight pause before selecting TOGA results in much more normal and predictable handling.

[4] FLX may be used but this tends to allow speed to decay unless pitch is reduced

more time before acceleration and cleanup is required.

- A recommendation is published at the start of the QRH, that, apart from cancelling audio warnings, "no action will be taken" until an appropriate flight path is established and the aircraft is at least 400ft AGL.[5]

Whilst below 400ft, then, the focus should be on flying and monitoring, with heightened awareness of the possibility of missing essential normal actions, such as calling rotate or raising the gear due to the distraction of the failure. It may help PF assimilate the challenges of the flying task if PM states the title of the first displayed ECAM procedure, but no action to diagnose or contain the failure should be taken. A very quick and well timed "Mayday, Mayday, Mayday, standby" and "Attention Crew at Stations" from PM may also be useful to forestall external interruptions. When and if possible, the autopilot should be engaged to reduce workload.

An extremely useful tool for dealing with low level failures is the EOSID, as described in Section 1.4. While the name suggests that this is only to be used with engine failures, in reality it is a pre-planned safe flight path that may be flown whenever there is doubt that available aircraft performance is sufficient to fly the cleared SID or go-around. Since both pilots should already be aware of the details of the EOSID, PM can simply declare their intention to fly it to generate a shared mental model. Note that flying an EOSID is higher workload than flying the planned SID in NAV or flying visually; it is an option, not a requirement.

Another useful tool, often used in association with the EOSID, is the concept of "high priority tasks". These are defined as:

- For engine failure, the master switch of the affected engine has been turned off.

[5]...although it does go on to water this statement down by saying that, for some unspecified emergency situations, the 400ft part of the recommendation may be disregarded

- For engine fires, *either* one squib has been fired and the fire warning has extinguished *or* both squibs have been fired.

These definitions help with the triage process, allowing standardised interleaving of the diagnosis and containment of the failure with the flying and monitoring tasks. In particular, the level acceleration phase of the EOSID is generally delayed until these tasks are completed, with the phrase "engine is secure" a de facto standard call to indicate that PF might like to consider interrupting the containment process.[6] Unfortunately, they are only defined for engine failures and fires, so with other failures, the crew will have to make a judgement call as to what constitutes "high priority".
[ FCTM PRO.AEP.ENG ]

## 1.4 EOSID

Before the divergence point (the last common point between the SID and the EOSID), if the aircraft detects a loss of thrust the EOSID will be displayed as a temporary flight plan. In this case the temporary flight plan can be inserted and NAV mode used. Otherwise it will be necessary to pull heading and manually follow either the yellow line or bring up a pre-prepared secondary flight plan and follow the white line.

If beyond the divergence point, pull heading and make an *immediate* turn the shortest way onto the EOSID. Airbus specifically recommends against this (FCOM AS.22.20.60), but easyJet states it as policy (EOMB 4.4.4).

Electing to fly the EOSID implies a level acceleration segment:

- Initially fly a TOGA climb at the higher of $V_2$ or current speed, up to a limit of $V_2$+15kt. If a FLEX takeoff was carried out,

[6]The phrases "Stop ECAM" and "Continue ECAM" are standard for interrupting containment.

a FLEX climb is permissible. This climb is continued until all high priority tasks are complete (see Section 1.3) and the aircraft is above single engine acceleration altitude (usually 800ft QFE, but may be higher if so specified by the takeoff performance calculation). If the FMGS has detected the engine out condition, the automatic mode change from SRS to CLB will be inhibited; if not, intervention with selected modes will be required to prevent untimely acceleration.

- The next segment is a TOGA level acceleration and clean up, either to CONF 1 and S speed if an immediate VMC return is desired or to CONF 0 and green dot. Again FLEX may be used if a FLEX takeoff was carried out. Level acceleration is usually achieved by pushing V/S; if the FMGS has detected the engine out condition, all preselected speeds entered in the MCDU will have been deleted, so the managed target speed should automatically move to 250kt. The phrases "Stop ECAM" and "Continue ECAM" can be used to interrupt ECAM procedures in order to initiate this segment.

- The final segment is a MCT climb segment to MSA, either at S speed if in CONF 1 or at green dot speed if in CONF 0. This is usually achieved in open climb; if the FMGS has detected the engine out condition, the managed target speed becomes dependent on flight phase, and in this case should automatically select green dot.

TOGA may be used for a maximum of 10 minutes.

If an EOSID is annotated as "STD", then acceleration to green dot should be completed prior to commencing the first turn. If "NON-STD", the turn takes priority.

[ EOMB 4.4.4, FCOM DSC.22_20.60.40 ]

# Chapter 2

# Miscellaneous

## 2.1 Emergency descent *(memory item)*

If an emergency descent is required, the Captain should consider taking control if not already PF. PF initiates the memory items by announcing "Emergency Descent."

Don oxygen masks and establish communication.

PF then flies the emergency descent. Descent with autopilot and autothrust engaged is preferred. The configuration is thrust idle, full speed brake and maximum appropriate speed, taking into account possible structural damage.[1] Target altitude is FL100 or MORA if this is higher. If speed is low, allow speed to increase before deploying full speedbrake to prevent activation of the angle of attack protection. Landing gear may be used, but speed must be below $V_{LO}$ when it is extended and remain below $V_{LE}$. If on an airway, consider turning 90° to the left.[2]

[1] According to Airbus, structural damage may be suspected if there has been a "loud bang" or there is a high cabin vertical speed. When limiting descent speed due to suspected structural damage, it is IAS rather than Mach that is relevant.

[2] In UK airspace it is recommended to stay on the airway or descend on

PM's only memory action is to turn the seatbelt signs on; their primary task is to ensure that PF has promptly and correctly initiated the descent.

Once the memory actions are complete and the aircraft is descending, complete the CAB PR EXCESS CAB ALT ECAM if it is available, then the QRH EMER DESCENT checklist, which covers much of the same ground as the ECAM but adds a couple of useful items. This will lead PF to finesse the speed and altitude targets and inform ATC of the descent; PM to set continuous ignition on the engines and set 7700 on the transponder. Both pilots then set their oxygen flows to the N position[3] and, if cabin altitude will exceed 14,000ft, PM deploys the cabin oxygen masks. On easyJet aircraft, the CIDS/PRAM will automatically play a suitable PA, so it is not necessary for the flight crew to carry out the EMER DESCENT (PA) action.

Once level, restore the aircraft to a normal configuration. When safe to do so, advise cabin crew and passengers that it is safe to remove their masks. To deactivate the mask microphone and switch off the oxygen flow, close the oxygen mask stowage compartment and press the "PRESS TO RESET" oxygen control slide.

[ EOMB 3.80.2, QRH AEP.MISC, FCOM AEP.MISC, FCTM AEP.MISC ]

## 2.2 Windshear *(memory item)*

### 2.2.1 Takeoff roll

Windshear encountered on the takeoff roll is *only* detectable by significant airspeed fluctuations. It is possible that these fluctuations may cause $V_1$ to occur significantly later in the takeoff roll then it should. In this case it falls to the Captain to make an assessment of

current track.

[3]There may be insufficient oxygen to cover the entire emergency descent profile if the oxygen masks are left set to 100%.

whether sufficient runway remains to reject the takeoff, or whether getting airborne would be the better option. If the takeoff is to be continued, call "Windshear, TOGA" and apply TOGA power. Rotate at $V_r$ or with sufficient runway remaining[4] and follow SRS orders. SRS will maintain a minimum rate of climb, even if airspeed must be sacrificed.

### 2.2.2 Reactive

The reactive windshear detection system is a function of the FACs. It only operates when below 1300ft RA with at least CONF 1 selected. In the takeoff phase, it is inhibited until 3 seconds after lift off and in the landing phase it is inhibited below 50ft RA.

A warning is indicated by a red WINDSHEAR flag on the PFD and a "Windshear, Windshear, Windshear" aural warning. Call "Windshear, TOGA" and apply TOGA power.

The autopilot can fly the escape manoeuvre as long as the required AOA is less than $\alpha_{prot}$. If the autopilot is not engaged, follow the SRS orders on the FDs. If the FDs are not available, initially pitch up to 17.5°, then increase as required.

Do not change configuration until out of the windshear. Once clear of the windshear, clean up the aircraft: leveraging the go-around procedure is useful for this.

In severe windshear, it is possible that Alpha Floor protection will activate. As TOGA will already be selected, this will have no immediate effect. Once clear of the windshear, however, TOGA lock will be active. This, combined with the unusual aircraft configuration, leads to a significant threat of overspeed. The most natural way to disengage TOGA lock is to disengage the autothrust using the instinctive disconnect PB on the thrust levers then use

[4] "Sufficient runway remaining" is actually Boeing advice – Airbus offers no guidance for the case where there is insufficient runway available to stop nor to rotate at normal speeds.

manual thrust until the situation has sufficiently stabilised to re-engage the autothrust.

[ FCOM PRO.AEP.SURV ]

### 2.2.3 Predictive

Below 2300ft AGL, the weather radar scans a 5nm radius 60° arc ahead of the aircraft for returns indicating potential windshear.

Alerts are categorised as **advisory**, **caution** or **warning**, in increasing order of severity. Severity is determined by range, position and phase of flight. Alerts are only provided when between 50ft and 1500ft, or on the ground when below 100kt.

All types of alert produce an indication of windshear position on the ND, provided that the ND range is set to 10nm. A message on the ND instructs the crew to change range to 10nm if not already set. A **caution** additionally gives an amber W/S AHEAD message on both PFDs and an aural "Monitor Radar Display" warning. A **warning** additionally gives a red W/S AHEAD message on the PFDs and either a "Windshear Ahead, Windshear Ahead" or "Go Around, Windshear Ahead" aural message.

If a **warning** occurs during the takeoff roll, reject the takeoff. If it occurs during initial climb, call "Windshear, TOGA", apply TOGA thrust and follow SRS orders. If it occurs during approach, fly a normal go-around. Configuration may be changed as long as the windshear is not entered.

If a **caution** occurs during approach, use CONF 3 to optimise go-around climb gradient and consider increasing $V_{APP}$; up to a maximum of $V_{LS}$+15 may be used.

If positive verification is made that no hazard exists and providing that the reactive windshear is serviceable the crew may downgrade the **warning** to a **caution.**

[ FCTM PR.NP.SP.10.10 ]

## 2.3 Unreliable airspeed *(memory item)*

The FMGCs normally reject erroneous ADR data by isolating a single source that disagrees significantly with the other two sources. It is possible, however, that *all* ADR data is simultaneously compromised or that the FMGCs reject a single remaining good ADR because the other two sources are erroneous in a sufficiently similar way.

The first problem, then, is recognition of the unreliable airspeed condition. The key to this is an instinctive understanding of the relationship between power, attitude and airspeed in all flight phases. Other clues that may aid identification include fluctuations or rapid changes in displayed airspeed, abnormal behaviour of the automatics, high speed buffet, low aerodynamic noise and stall warnings.[5]

Even with the condition correctly diagnosed by the crew, until the unreliable ADRs are disabled the aircraft systems will continue operating on the basis that the erroneous airspeed data is valid. Flight envelope protections may activate, leading to pitch inputs from the flight computers that cannot be overridden with the sidesticks. In this case, immediately switch off any two ADRs; this causes the flight computers to revert to Alternate Law with no protections, and thus allows control of the aircraft to be regained.

In unaccelerated flight, for a given weight and wing configuration, a given angle of attack will result in a specific airspeed.[6] In level flight, angle of attack is a fixed offset from attitude, the offset being dependent on wing geometry and thus configuration.

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[5] Stall warning, available in alternate or direct law, is based on alpha probes, which will likely be giving valid data

[6] $L = \frac{1}{2}\rho_0 V_i^2 SC_L = W$ where $W$ is weight, $L$ is lift, $\rho_0$ is sea level air density, $V_i$ is indicated airspeed, $S$ is wing area and $C_L$ is coefficient of lift. When well away from the stall, $SC_L$ is proportional to angle of attack, $\alpha$, with the constant of proportionality dependent on wing configuration. $\frac{1}{2}\rho_0$ is a fixed value, so $W \propto V_i^2\alpha$. Thus $V_i = k\sqrt{\frac{W}{\alpha}}$, where k is a constant determined by wing configuration.

The upshot of this is that, for any given combination of weight and configuration, indicated airspeed in unaccelerated flight may be inferred from attitude alone. This allows both for recovery of a good ADR if it has been rejected, or, if necessary, for completion of the flight without airspeed data.

The initial goal, then, is to stabilise the aircraft in level flight at a safe altitude with an attitude for which the associated indicated airspeed is known. These attitude vs. airspeed relationships are tabulated at the start of the QRH NAV UNRELIABLE SPEED INDICATION procedure.

If the aircraft is not yet at a safe altitude, a climb must be manually flown without reference to airspeed data. The required power settings and attitudes for this are[7]:

| **Condition** | **Thrust** | **Pitch** |
|---|---|---|
| Below Thrust Reduction Altitude | TOGA | 15° |
| Below FL100 | CLB | 10° |
| Above FL100 | CLB | 5° |

If configured CONF Full, select CONF 3, otherwise flap/slat configuration should be maintained. The gear and speedbrake should be retracted.

Transitioning to or maintaining level flight requires an altitude reference, and it is possible that whatever caused the unreliable airspeed is also causing erroneous altimeter readings. The most likely root cause in this case would be blocked static ports, which should be fairly obvious as the altimeters will be frozen. In general, if all the ADRs are giving sensible and near identical altimeter readings and they are in the ballpark of the GPS altitude, reliable barometric altitude data can be assumed and the FPV, VSI and barometric

[7]Airbus have recently (2022) clarified that if you transition through thrust reduction altitude you should adopt CLB 10°, and if you transition through FL100 you should adopt CLB 5°.

altimeters are available. If barometric altitude is considered erroneous, a constant GPS altitude can be flown. If GPS altitude is also unavailable, the only option is to fly a constant attitude with a sensible power setting and wait for the resulting phugoid to damp; this can take a long time, results in significant altitude excursions and will only approximate level flight, but should be sufficient for diagnostic purposes.

The initial thrust setting needs to be chosen so that the resultant airspeed in level flight will be neither too close to the stall nor at risk of overspeeding any high lift surfaces that are still deployed. Either use a rule of thumb (e.g. 50% + FL/10 for two engines) or refer to the table at the start of the QRH NAV UNRELIABLE SPEED INDICATION procedure. Sensible adjustments will need to be made if there are extra sources of drag such as radome damage or stuck gear. Thrust should then be adjusted until level flight at the target attitude is achieved, at which point the actual indicated airspeed can be read from the table.

With the indicated airspeed now known independently of the ADRs, any working ADRs may be identified and used to complete the flight.

If no working ADRs can be identified, the flight will need to be completed by inferring airspeed from attitude data. To achieve this, dependent on airframe, you may have access to, from most advanced to least, Digital Backup Speed (DBUS), reversible Backup Speed Scale (BUSS), standard Backup Speed Scale or none of these.

DBUS equipped aircraft provide a significant amount of assistance. Data from angle of attack sensors is augmented with load factor and GPS information to provide normal looking speed and altitude scales, albeit with degraded accuracy.[8] These can be used

[8]Displayed airspeed is accurate to $\pm 15kt$. Displayed altitude is derived from GPS data which is both less accurate and fundamentally different from barometric altitude. The degraded accuracy is indicated by two amber lines through the last digit of the speed scale and the last two digits of the altitude.

to operate the aircraft in a relatively normal manner. In addition, the computed speed is available as a fourth source to the computers in identifying compromised ADRs, and the computers are able to identify when an ADR becomes reliable again and provide appropriate ECAM procedures.

BUSS equipped aircraft provide more rudimentary assistance. The reversible version provides a button to turn the system on and off, whereas the older version requires all three ADRs to be turned off to activate it. When activated, the speed scale is replaced with a display showing a bar with green, amber and red sections, the aim being to fly the green. It is basically a thinly disguised angle of attack display: the green band can represent a significant range of speeds, but does not change size, it should not be used for dynamic manoeuvres such as levelling off, and it's insufficiently accurate to use above FL250. To clean up, accelerate until the speed is towards the top of the green before selecting the next configuration; to configure, reduce speed towards the bottom of the green before selecting next configuration.

When neither DBUS nor BUSS are available, pitch vs. airspeed tables are provided in the QRH which can be used to complete the flight by inferring airspeed from attitude. The advice when using these tables is to only change one of altitude, airspeed or configuration at a time; this means that clean up and configuration are both done in level flight, stabilising at the attitude associated with each new configuration before selecting the next. A 3° ILS is highly recommended for the approach, as this is the angle that the final approach attitude (and hence airspeed) are predicated on.

[ QRH AEP.NAV, FCOM PRO.AEP.NAV, FCTM PRO.AEP.NAV ]

## 2.4 Evacuation

Evacuation should be carried out in accordance with the emergency evacuation checklist. The easyJet procedure is for CM1 to call for the checklist and then send a Mayday message to ATC before commencing the checklist.

The first two items confirm the RTO actions of stopping the aircraft, setting the parking brake and alerting the cabin crew. The next item confirms ATC has been alerted.

The next four items prepare the aircraft for evacuation. If manual cabin pressure has been used, CM2 checks cabin diff is zero, and if necessary manually opens the outflow valve. CM2 then shuts the engines down with their master switches, and pushes all the fire buttons (including the APU). Confirmation is *not* required before carrying out these actions. In response to the next checklist item, “Agents”, CM1 decides if any extinguishing agents should be discharged and instructs CM2 to discharge them as required. Engine agent 2 will not be available. Agents should only be discharged if there are positive signs of fire.

Finally, order the evacuation. This is primarily done with the PA “Evacuate, unfasten your seat belts and get out”, with the evacuation alarm being triggered as a backup.

[ EOMB 3.80.1, FCOM PRO.AER.MISC, FCTM PRO.AER.MISC ]

## 2.5 Forced Landing (inc. Ditching)

There are two scenarios where off field forced landing or ditching would be considered: either you have insufficient energy to reach a suitable airfield (e.g actual or impending fuel exhaustion, catastrophic failure of both engines), or you have insufficient time to do so (e.g. uncontained fire).

Ditching and off field forced landing without power are discussed in Section 10.1. Support for such landings is provided by the ENG ALL ENGINES FAILURE ECAM and the ENG ALL ENG FAIL QRH procedure.

Support for ditching and forced landing with power is provided by the QRH MISC DITCHING and QRH MISC FORCED LANDING procedures respectively. Necessarily implicit in these checklists is the assumption that the aircraft is fully serviceable, which is unlikely to be the case. There is also an assumption that plenty of time is available for extensive preparation of cabin and cockpit. It is highly likely that these checklists will need adapting to the situation.

The fundamentals are the same with or without power. Ditching will be gear up with a target pitch attitude of 11° and minimal vertical speed, landing parallel to the swell unless there are strong crosswinds, in which case an into wind landing is preferred. Forced landing will be gear down with the spoilers armed.

The aircraft should be depressurised for the landing, with the DITCHING PB pushed for the ditching case. For forced landings or for "without power" ditching this is achieved using RAM AIR. For "with power" ditching, depressurise by turning off all bleeds, which provides a slightly more watertight hull.

The main difference between the with and without power cases is that max available slats and flaps are used in the former case, wheras CONF 2 is mandated for the latter. Approach speeds must also be high enough to prevent RAT stall (i.e. >140kt) if it is being relied upon. The combination of these factors means that much lower landing speeds can be achieved if power is available.

[ QRH AEP.MISC ]

## 2.6 Overweight landing

A landing can be made at any weight, providing sufficient landing distance is available. In general, automatic landings are only certified up to MLW, but the FCOM specifies that, for the A319 only, autoland is available up to 69000kg in case of emergency.

The preferred landing configuration is CONF Full, but lower settings may be used if required by QRH or ECAM procedures. QRH MISC OVERWEIGHT LANDING also specifies CONF 3 if the aircraft weight exceeds the CONF 3 go around limit; this will only ever be a factor for airfields with elevations above 1000ft.

Packs should be turned off to provide additional go around thrust.

If planned landing configuration is less than CONF Full, use CONF 1+F for go-around.

It is possible that S speed will be higher than $V_{FE\ next}$ for CONF 2. In this case, a speed below $V_{FE\ next}$ should be selected until CONF 2 is achieved, then managed speed can be re-engaged.

Airbus specifies that, in the final stages of the approach, speed should be reduced in order to cross the threshold at $V_{LS}$. This implies manual thrust since use of autothrust requires a 5kt increment. Airbus also specifies that V/S at touchdown should be minimised, this being achieved by an increase in flare height. It is worth considering whether these requirements are compatible, particularly if dealing with gusty crosswinds etc. — if not, an option would be to add 5kt (or more) ΔVPilot in the landing performance calculation and use a standard landing technique.

Apply max reverse as soon as the main gear touches down. Maximum braking can be used after nosewheel touchdown.

After landing, switch on the brake fans and monitor brake temperatures carefully. If temperatures exceed 800°C, tyre deflation may occur.

[ QRH AER.MISC, FCOM PRO.AER.MISC, FCTM PRO.AER.MISC ]

## 2.7 Engine failure in cruise

Engine out ceiling is highly dependent on weight; ISA deviation also has a modest effect. It will generally lie between FL180 and FL350.

The first action will be to select both thrust levers to MCT so as to allow the autothrust its full engine out range. If the N1 gauges indicate a thrust margin exists, then the aircraft is below engine out ceiling; descent may be appropriate to increase the available thrust margin, but there is no immediate threat. If, however, the N1 gauges indicate that the autothrust is commanding MCT, and the speed is still decaying, then the aircraft is above engine out ceiling and prompt execution of a drift down procedure is required.

Drift down with autopilot engaged in OP DES is preferred. Engagement of this vertical mode normally results in the autothrust commanding idle thrust, which is not what is desired. Thus, having set the thrust lever to MCT, the autothrust is disconnected. The PROG page provides a REC MAX EO flight level to use as an altitude target.

If the speed decay is modest, it may be possible to alert ATC before initiating the descent, but in-service events have shown that speed decay is often very rapid, requiring descent initiation to be prioritised.

Once drift down has been initiated, a decision needs to be made about speed.

If obstacles are a concern, the lowest drift down rate and highest ceiling are achieved at green dot. Airbus refers to drifting down at green dot as "Obstacle strategy".

Flying at green dot reduces the chance of the FADECs automatically relighting the failed engine as the engine will be windmilling more slowly. Therefore, if obstacles are not a concern, M.78/300kt is flown, a speed that will always fall within the stabilized windmill engine relight envelope; Airbus refers to this as "Standard Strategy".

If obstacles remain a problem, MCT and green dot speed can be maintained to give a shallow climbing profile. Once obstacles are no longer a problem, descend to LRC ceiling (use V/S if <500 fpm descent rate), engage the autothrust and continue at LRC speed.

[ FCTM PRO.AEP.ENG.EFDC ]

## 2.8 Bomb on board

The primary aim is to get the aircraft on the ground and evacuated ASAP.

The secondary aim is to prevent detonation of the device. This is achieved by preventing further increases in cabin altitude through the use of manual pressure control and by avoiding sharp manoeuvres and turbulence.

The tertiary aim is to minimise the effect of any explosion. This is achieved by reducing the diff to 1 psi. The method is to set cabin vertical speed to zero using manual pressurisation control, then descend to an altitude 2500ft above cabin altitude. As further descent is required, cabin vertical speed should be adjusted to maintain the 1 psi diff for as long as possible. Automatic pressure control is then reinstated on approach.

Low speeds reduce the damage from an explosion but increase the risk of a timed explosion occurring whilst airborne; a compromise needs to be found. The aircraft should be configured for landing as early as possible to avoid an explosion damaging landing systems.

In the cabin, procedures are laid down for assessing the risks of moving the device and for moving the device to the LRBL at door 2R.

[ QRH AER.80, FCOM PRO.AER.MISC ]

## 2.9 Single engine circling

It may not be possible to fly level in the standard circling configuration of CONF 3, gear down. This can be ascertained by checking the table in the QRH MISC ONE ENGINE INOPERATIVE – CIRCLING APPROACH procedure.

If affected, plan a CONF 3 landing and delay gear extension until level flight is no longer required; anticipate a L/G NOT DOWN

ECAM warning below 750ft (which can be silenced with the EMER CANC pb) and a GPWS "Too Low Gear" aural alert below 500ft RA.
[ QRH AEP.MISC ]

## 2.10 Stall recovery *(memory item)*

Aerofoil stall is always and only an angle of attack issue. It is not possible to directly prove an unstalled condition from attitude and airspeed data. The flight recorders from the December 2014 Air Asia accident recorded an angle of attack of 40° (i.e. around 25° greater than critical angle) with both pitch and roll zero and speeds up to 160kt. Importantly, it is perfectly possible to be fully stalled in the short term unreliable airspeed configurations described in Section 2.3. Identification of a fully stalled condition is thus largely dependent on identifying a high and uncontrollable descent rate that does not correlate with normal flight path expectations for the attitude and thrust applied.

To recover from a fully stalled condition, the angle of attack of the aerofoils must be reduced to below critical. The generic stall recovery is therefore simply to pitch the nose down sufficiently to break the stall and level the wings. In normal operations, the velocity vector of the aircraft is around 3° below the centerline of the aircraft (i.e. an attitude of around 3° is required to fly level). In a stalled condition, the velocity vector may be 40° or more below the centerline of the aircraft. Thus the amount of pitch down required to recover a fully stalled aircraft can be 30° or more.

In two recent Airbus accidents involving stalls, the lack of physical cross coupling of sidesticks was a major factor. If one pilot elects to hold full back sidestick, the aircraft cannot be recovered by the other pilot unless the takeover button is used. With all the alarms, it would be easy to miss "Dual Input" warnings, so *always* press the takeover button.

The aircraft's thrust vector helps to accelerate the aircraft during the recovery, and increasing speed along the aircraft's centerline acts to reduce the stalled angle of attack. Thus, while thrust is not a primary means of recovery, it does help. Unfortunately, Airbus have determined that due to the pitch couple associated with underslung engines, there may be insufficient longitudinal control authority to pitch the aircraft sufficiently to recover from a stall if TOGA is selected. It may therefore be necessary to initially *reduce* thrust to allow the primary recovery technique to be applied; this is extremely counterintuitive.

Once there are no longer any indications of the stall, smoothly recover from the dive, adjust thrust, check speedbrakes retracted and if appropriate (clean and below 20,000ft) deploy the slats by selecting CONF 1. The load factor associated with an overly aggressive pull out can induce a secondary stall; on the flip side, once reattachment of the airflow occurs, drag rapidly diminishes and exceedance of high speed airframe limitations becomes a threat. A balance needs to be found.

If a stall warner sounds on takeoff it is likely to be spurious since you are almost certainly in normal law. The procedure in this case is essentially to initially assume unreliable airspeed and fly TOGA, 15°, wings level until it can be confirmed that the warning is spurious.

A stall warning may occur at high altitude to indicate that the aircraft is reaching $\alpha_{\text{buffet}}$. In this case simply reduce the back pressure on the sidestick and/or reduce bank angle.

[ FCOM PRO.AER.MISC ]

## 2.11 Computer reset

Abnormal computer behaviour can often be stopped by interrupting the power supply of the affected computer. This can be done either with cockpit controls or with circuit breakers. The general procedure is to interrupt the power supply, wait 3 seconds (5 seconds if a CB was used), restore the power, then wait another three seconds for the reset to complete. QRH AER.RESET details the specific procedures for a variety of systems.

On the ground, almost all computers can be reset. MOC can usually supply a reset procedure if nothing applicable is available in the QRH. The exceptions are the ECU and EIU while the associated engine is running and the BSCU when the aircraft is not stopped.

In flight, only the computers listed in the QRH should be considered for reset.

[ QRH AER.SYSTEM RESET ]

## 2.12 Abnormal V Alpha Prot

If two or more angle of attack vanes become frozen at the same angle during climb, a Mach number will eventually be reached such that the erroneous angle of attack data indicates an incipient stall. When this happens, Normal Law high angle of attack protection will activate. The flight computers' attempt to reduce angle of attack will not, however, be registered by the frozen vanes, leading to a continuous nose down pitch rate which cannot be overridden with sidestick inputs.

Indications of this condition are available from the $\alpha_{\text{prot}}$ and $\alpha_{\text{max}}$ strips. If the $\alpha_{\text{max}}$ strip (solid red) completely hides the $\alpha_{\text{prot}}$ strip (black and amber) or the $\alpha_{\text{prot}}$ strip moves rapidly by more than 30kt during flight manoeuvres with AP on and speed brakes retracted, frozen angle of attack vanes should be suspected.

The solution is to force the flight computers into Alternate Law where the protection does not apply. This is most conveniently done by turning off any two ADRs. Once in Alternate Law, the stall warning strip (red and black) becomes available. Since stall warning data also comes from the angle of attack vanes, erroneous presentation is likely.

## 2.13 Overspeed Recovery

In general the response to an overspeed should be to deploy the speedbrake and monitor the thrust reduction actioned by the autothrust. Disconnection of the autopilot will not normally be required. If autothrust is not in use, the thrust levers will need to be manually retarded.

It is possible that the autopilot will automatically disengage and high speed protection will activate, resulting in an automatic pitch up. In this case, smoothly adjust pitch attitude as required.

At high altitude, there is a threat of over-correction caused by the lethargic response of the speedbrake when commanded to stow. In the worst case, a descent may be required to recover speed. This threat can be mitigated by promptly cancelling the speedbrake as soon as the overspeed condition ceases.

[ FCTM PRO.AER.MISC ]

## 2.14 Volcanic Ash Encounter

Volcanic ash clouds are usually extensive, so a 180° turn will achieve the quickest exit.

Air quality may be affected, so crew oxygen masks should be donned with 100% oxygen to exclude fumes. Passenger oxygen may also need to be deployed.

Probes may become blocked with ash, so be prepared to carry out the unreliable speed procedure.

Disconnect the autothrust to prevent excessive thrust variations.

To minimise the impact on the engines, if conditions permit thrust should be reduced. Turn on all anti-ice and set pack flow to high in order to increase bleed demand and thus increase engine stall margin. Wing anti-ice will need to be turned off again before attempting relight in case of flameout.

If engine EGT limits are exceeded, consider a precautionary engine shutdown with restart once clear of volcanic ash. Engine acceleration may be very slow during restart. Since compressor and turbine blades may have been eroded, avoid sudden thrust changes.

Damage to the windshield may necessitate an autoland or landing with a sliding window open.

[ QRH AEP.MISC, FCOM PRO.AEP.MISC, FCTM PRO.AEP.MISC ]

## 2.15 Incapacitation

Take control, using the stick priority button if necessary. Contact cabin crew ASAP. They should strap the incapacitated pilot to his seat, move the seat back, then recline it. If there are two cabin crew available, the body can be moved. Medical help should be sought from passengers, and the presence of any type rated company pilots on board ascertained.

[ FCTM PRO.AEP.MISC ]

# Chapter 3

# Air con and pressurisation

## 3.1 Cabin overpressure

There is no ECAM in the case of total loss of pressure control leading to an overpressure, so apply the QRH procedure. The basic procedure is to reduce air inflow by turning off one of the packs and put the avionics ventilation system in its smoke removal configuration so that it dumps cabin air overboard. The $\Delta$P is monitored, and the remaining pack is turned off if it exceeds 9 psi. 10 minutes before landing, both packs are turned off and remain off, and the avionics ventilation is returned to its normal configuration.
[ QRH AEP.CAB PR, FCOM PRO.AEP.CAB PR ]

## 3.2 Excess cabin altitude

An ECAM warning of excess (>9550ft) cabin altitude should be relied upon, even if not backed up by other indications.

The initial response should be to protect yourself by getting an oxygen mask on. Initiate a descent; if above FL160, this should be in accordance with the Emergency Descent procedure (see Section 2.1). Once the descent is established and all relevant checklists are complete, check the position of the outflow valve and, if it is not fully closed, use manual control to close it.

[ CAB PR EXCESS CAB ALT, FCOM PRO.AEP.CAB PR ]

## 3.3 Landing Elevation Fault

If the landing field elevation is not available from the FMGS, the landing elevation must be manually selected. This is done by pulling out and turning the LDG ELEV knob. The scale on the knob is only a rough indication; use the LDG ELEV displayed on either the CRUISE page or the CAB PRESS SD page instead.

[ CAB PR LDG ELEV FAULT, FCOM PRO.AEP.CAB PR ]

## 3.4 Pack fault

The AIR PACK FAULT ECAM indicates that the pack flow control valve position disagrees with the selected position or that the pack valve has closed due to either compressor outlet overheat or pack outlet overheat.

The affected pack should be turned off.

A possible reason for this failure is loss of both channels of an Air Conditioning System Controller (ACSC). If this occurs, the associated hot air trimming will also be lost (cockpit for ACSC 1, cabin for ACSC 2).

If there are simultaneous faults with both packs, ram air must be used. This will necessitate depressurisation of the aircraft, so a descent to FL100 (or MEA if higher) is required. If a PACK button FAULT light subsequently extinguishes, an attempt should be made to reinstate that pack.

[ AIR PACK 1(2)(1+2) FAULT, FCOM PRO.AEP.AIR ]

## 3.5 Pack overheat

The associated pack flow control valve closes automatically in the event of a pack overheating (outlet temp >260°C or outlet temp >230°C four times in one flight). The remaining pack will automatically go to high flow, and is capable of supplying all of the air conditioning requirement. This system's automatic response is backed up by turning off the pack. The FAULT light in the PACK button remains illuminated whilst the overheat condition exists. The pack can be turned back on once it has cooled.

[ AIR PACK 1(2) OVHT, FCOM PRO.AEP.AIR ]

## 3.6 Pack off

A warning is generated if a functional pack is selected off in a phase of flight when it would be expected to be on. This is usually the result of neglecting to re-instate the packs after a packs off takeoff. Unless there is a reason not to, turn the affected pack(s) on.

[ AIR PACK 1(2) OFF, FCOM PRO.AEP.AIR ]

## 3.7 Pack regulator faults

A regulator fault is defined as a failure of one of four devices: the bypass valve, the ram air inlet, the compressor outlet temperature sensor or the flow control valve. The ECAM bleed page can be used to determine which device is at fault.

Regardless of the device at fault, the ramification is the same; the pack will continue to operate but there may be a degradation in temperature regulation. If temperatures become uncomfortable, consideration should be given to turning off the affected pack.

[ AIR PACK 1(2) REGUL FAULT, FCOM PRO.AEP.AIR ]

## 3.8 ACSC single lane failure

Each ACSC has two fully redundant "lanes", so loss of a single "lane" results in loss of redundancy only.

[ AIR COND CTL 1(2) A(B) FAULT, FCOM PRO.AEP.AIR ]

## 3.9 Duct overheat

A duct overheat is defined as a duct reaching 88°C or a duct reaching 80°C four times in one flight. If this occurs, the hot air pressure regulating valve and trim air valves close automatically and the FAULT light illuminates in the HOT AIR button. This light will extinguish when the temperature drops to 70°C.

Once the duct has cooled, an attempt can be made to recover the hot air system by cycling the HOT AIR button.

If recovery is not possible, basic temperature regulation will continue to be provided by the packs.

[ COND FWD CAB/AFT CAB/CKPT DUCT OVHT, FCOM PRO.AEP.COND ]

## 3.10 Hot air fault

If the hot air pressure regulating valve is not in its commanded position, the effects will depend on its actual position.

If it is closed when commanded open, the packs will provide basic temperature regulation.

More serious is if it has been commanded closed in response to a duct overheat and it remains open. Manual control may be effective, but if it is not the only option is to turn off both packs and proceed as per Section 3.4.

[ COND HOT AIR FAULT, FCOM PRO.AEP.COND ]

## 3.11 Trim air faults

Either a fault with one of the trim air valves or an overpressure downstream of the hot air valve. An associated message indicates which condition exists.

Failure of a trim valve leads to loss of optimised temperature regulation for the corresponding zone; basic temperature regulation is still available.

The TRIM AIR HIGH PR message may be disregarded if triggered when all the trim air valves are closed. This occurs during the first 30 seconds after the packs are selected on and in flight if all zone heating demands are fulfilled.[1]

[ COND TRIM AIR SYS FAULT, FCOM PRO.AEP.COND ]

## 3.12 Cabin fan faults

If both cabin fans fail, their flow should be replaced by increasing the pack flow to HI.

[ COND L + R CAB FAN FAULT, FCOM PRO.AEP.COND ]

## 3.13 Lavatory and galley fan faults

The cabin zone temperature sensors are normally ventilated by air extracted by these fans. Loss of the fans therefore leads to loss of accurate zone temperature indication.

On older aircraft, temperature control reverts to maintenance of a fixed cabin zone inlet duct temperature of 15°C.

On newer aircraft the temperature controls for the cabin revert to controlling temperature in the ducts. If ACSC 2 has also failed,

[1]The FCOM is not very informative regarding response to overpressure when this does not apply. However the MEL operating procedures for dispatch with this condition indicate that turning the HOT AIR pb-sw off is probably a good idea.

the duct temperatures are maintained at the same level as the cockpit duct temperature, and may therefore be controlled with the cockpit temperature selector.
[ COND LAV + GALLEY FAN FAULT, FCOM PRO.AEP.COND ]

## 3.14 Pressure controller faults

Loss of a single cabin pressure controller leads to loss of redundancy only.

If both pressure controllers are lost, use manual control. The outflow valve reacts slowly in manual mode, and it may be 10 seconds before positive control of the outflow valve can be verified. It may also react too slowly to prevent a temporary depressurisation.

To activate manual pressurisation control, press the MODE SEL button. This allows the MAN V/S CTL toggle switch to directly control the outflow valve. Moving the toggle to DN closes the outflow valve causing the cabin altitude to descend, whilst moving the toggle to UP opens the outflow valve causing the cabin altitude to climb. The target climb and descent rates are 500fpm and 300fpm, these being displayed on the status page for easy reference.

A table of FL versus CAB ALT TGT is also provided on the status page; no guidance is given for the interpretation of this table. The final action of the procedure is to fully open the outflow valve when reaching 2500ft AGL in preparation for an unpressurised landing, so to avoid large pressurisation changes during this action, the final cabin altitude target needs to be aerodrome elevation plus 2500ft. This gives an indication of how CAB ALT TGT should be interpreted: it is the lowest cabin altitude that still results in a safe $\Delta$P at a given FL. A cabin altitude greater then CAB ALT TGT is always acceptable[2] and, moreover, for the final stages of the approach, it is necessary. The method is therefore to avoid cabin

[2] A reasonable maximum cabin altitude is 8800ft, which is when the CAB ALTITUDE advisory triggers.

altitudes below CAB ALT TGT for your current FL while ensuring that a cabin altitude of aerodrome elevation plus 2500ft will be achieved by the time you need to fully open the outflow valve.

Ensure cabin diff pressure is zero before attempting to open the doors.

[ CAB PR SYS 1(2)(1+2) FAULT, FCOM PRO.AEP.CAB PR ]

## 3.15 Low diff pressure

High rates of descent may lead to the aircraft descending through the cabin altitude when more than 3000ft above the landing altitude. An ECAM warning indicates that this situation is projected to occur within the next 1½minutes. If the rate of descent of the aircraft is not reduced, the pressure controllers will have to resort to high rates of change of cabin altitude, which may cause passenger discomfort. The aircraft's vertical speed should be reduced unless there is a pressing reason not to.

[ CAB PR LO DIFF PR, FCOM PRO.AEP.CAB PR ]

## 3.16 Outflow valve closed on ground

If the outflow valve fails to automatically open on the ground, manual control should be attempted. If that doesn't work, depressurise the aircraft by turning off both packs.

[ CAB PR OFV NOT OPEN, FCOM PRO.AEP.CAB PR ]

## 3.17 Open safety valve

There are safety valves for both cabin overpressure and negative differential pressure; the associated ECAM message does not distinguish between the two.

If diff pressure is above 8psi, it is the overpressure valve that has opened. Attempt manual pressurisation control and if that fails, reduce aircraft altitude.

If diff pressure is below zero, it is the negative differential valve. Reduce aircraft vertical speed or expect high cabin rates.

[ CAB PR SAFETY VALVE OPEN, FCOM PRO.AEP.CAB PR ]

# Chapter 4

# Avionics Ventilation

## 4.1 Blower fault

Defined as low blowing pressure or duct overheat. Unless there is a DC ESS Bus fault, the blower fan should be set to OVRD. This puts the avionics ventilation into closed configuration and adds cooling air from the air conditioning system.
[ VENT BLOWER FAULT, FCOM PRO.AEP.VENT ]

## 4.2 Extract fault

Defined as low extract pressure. The extract fan should be put in OVRD. This puts the avionics ventilation into closed configuration and adds cooling air from the air conditioning system.
[ VENT EXTRACT FAULT, FCOM PRO.AEP.VENT ]

## 4.3 Skin valve fault

Defined as one of three faults: the inlet valve is not fully closed in flight; the extract valve is fully open in flight; or the extract valve did not automatically close on application of take-off power. The ECAM CAB PRESS page will differentiate.

If the fault is with the inlet valve, no action is required since it incorporates a non-return valve.

If the extract valve is affected, the system should be put into smoke configuration; this sends additional close signals to the extract valve. If the extract valve still remains open, the ECAM directs the crew to depressurise the aircraft. The rationale for this seemingly extreme reaction to a relatively minor issue is that the ECAM can only really occur immediately after the take-off inhibit ceases at 1500ft AAL. The extract valve is normally held closed by the pressurisation and its motor is not sufficiently powerful to overcome this. Thus the extract valve can only be open in flight if it never closed. With the extract valve open, it will likely not be possible to complete the flight since the additional hole will make it impossible to properly pressurise the aircraft at cruise altitude, and the pressurised air rushing through the open outflow valve will cause it to be unpleasantly noisy in the cockpit. This makes depressurising the aircraft and returning for engineering attention the obvious solution.[1]

[ VENT SKIN VALVE FAULT, FCOM PRO.AEP.VENT ]

## 4.4 Avionics ventilation system fault

Defined as either a valve not in its commanded position or the Avionics Equipment Ventilation Controller (AEVC) being either unpowered or failing its power-up test. The system will automatically default to a safe configuration similar to smoke configuration. No crew action is required.

[ VENT AVNCS SYS FAULT, FCOM PRO.AEP.VENT ]

[1] The ECAM procedure associated with this failure is due to be modified in an upcoming FWC update.

# Chapter 5

# Electrical

## 5.1 Emergency configuration

Attempt to restore normal power by recycling the main generators. If that fails, try again after splitting the systems with the BUS TIE button.

If normal power cannot be restored, ensure that the emergency generator is on line (deploy the RAT manually if required) and maintain speed >140kt to avoid RAT stall. Cycling FAC1 will recover rudder trim. Once 45 seconds have elapsed and when below FL250, the APU can be started.

So much equipment is lost in the emergency configuration that QRH ELEC EMER CONFIG SYS REMAINING provides a table of *surviving* equipment. Notable losses are:

- All the fuel pumps, requiring Gravity Fuel Feeding procedures (see Section 8.4) and making center tank fuel unusable.
- The anti-skid, three fifths of the spoilers and the reversers. Combined with the higher landing speeds required to prevent RAT stall this results in significantly increased landing distances.

- Alternate Law with reduced protections (see Section 6.3). Mechanical yaw becomes Alternate Law yaw with FAC1 reset. Anticipate Direct Law at gear extension.
- Anti-icing for probes supplying ADR2 and ADR3. Only CM1 instruments should be considered reliable in icing conditions.
- Nose Wheel Steering (see Section 9.16).

The QRH ELEC ELEC EMER CONFIG SUMMARY should be applied once ECAM actions are complete.
[ ELEC EMER CONFIG, QRH AEP.ELEC, FCOM PRO.AEP.ELEC ]

## 5.2 Battery only

Battery power is available for approximately 30 mins.[1]

QRH ELEC EMER CONFIG SYS REMAINING provides details of remaining equipment. Mostly this is the same as for emergency electrical configuration (see Section 5.1). Notable additional losses are:

- The remaining ND
- The remaining FMGC and MCDU
- The remaining DME and transponder
- The remaining FAC
- Wing anti-ice
- CM1 AOA anti-ice
- Passenger oxygen masks

[1] This information was part of Airbus CBT training. There is no figure available in the FCOM.

An attempt should be made to bring the emergency generator on line with the EMER ELEC PWR MAN ON button.

[ ELEC ESS BUSES ON BAT, QRH AEP.ELEC, FCOM PRO.AEP.ELEC ]

## 5.3 IDG low oil pressure/high temperature

The IDG should be disconnected. Assuming the associated engine is running, press the IDG button until the GEN FAULT light comes on. Do not press the button for more than **3 seconds**.

The APU generator should be used if available.

[ ELEC IDG 1(2) OIL LO PR/OVHT, FCOM PRO.AEP.ELEC ]

## 5.4 Generator fault

Try to reset the generator by turning it off, then, after a short pause, turning it on again. If unsuccessful, turn it back off.

If an engine driven generator cannot be recovered, the APU generator should be used if available.

Single generator operation leads to shedding of the galley. Loss of an engine driven generator leads to loss of CAT 3 DUAL capability.

[ ELEC(APU) GEN (1)(2) FAULT, FCOM PRO.AEP.ELEC ]

## 5.5 Battery fault

The affected battery contactor opens automatically. APU battery start is unavailable with a single battery.

[ ELEC BAT 1(2) FAULT, FCOM PRO.AEP.ELEC ]

## 5.6 AC Bus 1 fault

Some or all of the equipment on AC bus 1 becomes unavailable, including TR1: DC bus 1 is powered from DC bus 2 via the battery bus.

Power must be re-routed to the essential AC bus via AC bus 2. This is automatic on some aircraft. Manual re-routing is achieved with the AC ESS FEED button. Once essential AC is powered, the essential TR powers the DC essential bus.

Notable lost equipment includes the blue hydraulic system, RA1 (and hence CAT 3 capability), half the fuel pumps, the nose wheel steering, the avionics blower fan and CM1 windshield heat.

[ ELEC AC BUS 1 FAULT, FCOM PRO.AEP.ELEC ]

## 5.7 AC Bus 2 fault

Some or all of the equipment on AC bus 2 becomes unavailable, including TR2: DC bus 2 is powered from DC bus 1 via the battery bus.

The majority of this equipment has a redundant backup, the loss of the FO's PFD and ND and a downgrade to CAT 1 being the major issues. Landing distances are unchanged.

[ ELEC AC BUS 2 FAULT, FCOM PRO.AEP.ELEC ]

## 5.8 AC Ess Bus fault

It may be possible to recover the bus by transferring its power source to AC bus 2 with the AC ESS FEED button. If this is unsuccessful, some or all of the equipment on the AC essential bus will be lost.

The majority of this equipment has a redundant backup, with the loss of the Captain's PFD and ND and a downgrade to CAT 1 being the major issues. Landing distances are unchanged.

It is worth noting that loss of AC essential bus implies loss of passenger oxygen masks. The MEL allows dispatch without operative passenger oxygen masks provided that operating altitude is limited to 10,000ft. Where possible, a descent to this altitude would seem appropriate.

Where it is not possible to immediately descend to 10,000ft, a compromise level whereby a descent to a safe altitude can be achieved without masks needs to be chosen. The main form of guidance on altitude hypoxia comes in the form of "Time of useful consciousness" tables. Working on the principal that if you remain conscious you definitely remain alive, 25,000ft would seem to be a reasonable compromise. This gives you 2 to 3 minutes of useful consciousness to dive to 18,000ft, where you would then have 30 minutes to clear any terrain.[2]

[ ELEC AC ESS BUS FAULT, FCOM PRO.AEP.ELEC ]

## 5.9 AC Essential Shed Bus lost

Some or all of the equipment on the AC ESS SHED bus is lost. The major issue is the loss of the passenger oxygen masks (see discussion in Section 5.8). Landing distances are unchanged.

[ ELEC AC ESS BUS SHED, FCOM PRO.AEP.ELEC ]

## 5.10 DC Bus 1 fault

Some or all of the equipment on DC bus 1 is lost. Most of the equipment loss causes loss of redundancy only. Landing distances are unchanged.

[ ELEC DC BUS 1 FAULT, FCOM PRO.AEP.ELEC ]

[2] These tables are obviously not designed to be used in this way – the exposure to hypoxia in the descent will likely impact the TOUC at 18,000ft, and we are really more concerned with survivability than useful consciousness – but they can at least give a feeling for the parameters involved.

## 5.11 DC Bus 2 fault

Some or all of the equipment on DC bus 2 is lost. Notable items are:

- 3 spoilers per side and one reverser. Landing distances increase by ~35%.
- Autobrake.
- FO's static probe: select ADR3 to FO's side.
- FO's window heat, wipers and rain repellent.

The other lost systems either have redundant backups or are non-essential. It should, however, be noted that the only flight computers remaining are ELAC1, SEC1 and FAC1, so not much redundancy remains.
[ ELEC DC BUS 2 FAULT, FCOM PRO.AEP.ELEC ]

## 5.12 DC Essential Bus fault

The major headache associated with DC essential bus failure is a significant loss of redundancy in communications systems.

ACP1 and ACP2 are lost, along with VHF1. This allows two-way communication to be recovered by one pilot using ACP3 (selected via the AUDIO SWTG rotary selector) with VHF2 or VHF3. Since speaker 1 is also lost, having CM2 handle the radios with speaker 2 at high volume is the only method of both pilots having awareness of ATC communications.

On some airframes,[3] this loss of communications is exacerbated by a design flaw: the audio cards for cockpit mikes and headsets are *all* powered from the DC essential bus. It may still be possible

[3] MSNs 2184–2402 and MSNs 2471–3122 at time of writing.

to receive transmissions with a combination of VHF2/3, ACP3 on FO and speaker 2, but transmission is limited to morse code on the transmit switch.[4]

Other notable lost equipment includes:

- Reverser 2 and the blue hydraulic system, leading to modestly increased landing distances.
- The HP fuel shutoff valves. This requires that the engines are shut down with the Engine Fire pushbutton switches.
- Wing anti-ice.
- Auto-thrust. This is notable because the ECAM status page incorrectly reports that CAT 3 SINGLE is available, when the actual landing capability is CAT 2.
- GPWS.

[ ELEC DC ESS BUS FAULT, FCOM PRO.AEP.ELEC ]

## 5.13 DC Essential shed

The only major issue is the loss of wing anti-ice. Therefore, avoid icing conditions, and apply landing distance procedure if ice accretes.
[ ELEC DC ESS BUS SHED, FCOM PRO.AEP.ELEC ]

## 5.14 Loss of DC Bus 1 and DC Bus 2

Some or all of the systems supplied by DC bus 1 and DC bus 2 are lost.

[4] I am only inferring this solution from the list of equipment lost; there is no specific documentation to indicate that it will work.

The implications are the same as for DC emergency configuration (see Section 5.18) except that the RAT will not need to be deployed since ESS TR will be supplied from AC bus 1 instead of the emergency generator.

[ ELEC DC BUS 1+2 FAULT, FCOM PRO.AEP.ELEC ]

## 5.15 Generator overload

Shed some load by switching off the galleys.

[ ELEC GEN 1(2) OVERLOAD, ELEC APU GEN OVERLOAD, FCOM PRO.AEP.ELEC ]

## 5.16 Loss of TRs

No systems are lost as a result of failure of a single TR. If the fault is with TR1 or TR2, DC ESS will be supplied by the ESS TR via the AC essential bus; in this case only CAT 3 SINGLE will be available.

Dual failures involving the ESS TR are similar to single failures, except redundancy is further compromised. If, however, both TR1 and TR2 fail then DC bus 1, DC bus 2 *and* the DC battery bus will be lost. The DC essential bus will remain powered by the ESS TR.

The FCOM is not very forthcoming regarding this failure; there is only a description in the DSC section and nothing specific in the PRO section. The situation is, however, very similar to the "ECAM complete" phase of DC emergency configuration (see Section 5.18), the only difference being that AC bus 1 rather than the emergency generator is providing the power to the ESS TR, and hence you don't need to worry about RAT deployment.

[ ELEC TR 1(2), ELEC ESS TR FAULT, FCOM PRO.AEP.ELEC ]

## 5.17 Battery bus fault

Some or all of the equipment on the battery bus is lost. The only notable losses are APU fire detection and APU battery start.
[ ELEC DC BAT BUS FAULT, FCOM PRO.AEP.ELEC ]

## 5.18 DC Emergency configuration

Defined as the loss of DC busses 1 and 2, the DC essential bus and the battery bus. Recovery assumes that the DC essential bus can be fully restored by deploying the RAT with the EMER ELEC PWR button.

Equipment powered or controlled through DC busses 1 and 2 and the battery bus is therefore lost.

Loss of the equipment associated with the battery bus is fairly benign: mainly APU battery start is unavailable due to loss of the APU ECB and APU fire detection.

A lot of equipment is lost with the loss of DC busses 1 and 2, but it is worth remembering that all three affected busses are also lost in emergency electrical config. Thus, you will have, at minimum, all the equipment listed in QRH ELEC EMER CONFIG SYS REMAINING. The main items of note are:

- A long runway is required. Minimum $V_{APP}$ is 140kt to prevent RAT stall. Antiskid, reversers and 60% of the spoilers are lost. Loss of nosewheel steering adds to the difficulty. Braking is from the ABCU, so only manual braking is available.[5]

- Flight computer redundancy is significantly reduced, with only ELAC1, SEC1 and FAC1 available. This is, however, sufficient to keep Normal Law, so a CONF Full landing and, indeed, CAT 3 SINGLE autoland (using AP1 and FMGS1) are available.

[5] easyJet aircraft automatically modulate to 1000psi, but the sim may not.

- Pressurised fuel is available from the #1 wing tank pumps, but center tank fuel is unusable.

- Redundancy in the pressurisation system is seriously compromised. Manual pressure control and CPC2 are lost, so you are reliant on CPC1 for control. Pack 2, BMC2 and cross bleed control are all lost, so you are reliant on ENG1 bleed and pack 1 for supply. Ram air remains available, so if required a slow depressurisation through turning off pack 1 followed by a depressurised landing with ram air is achievable.

- Communications are limited to VHF1, controlled by RMP1. All communications will be lost below 100kt on the landing roll when the DC essential bus is depowered.

- Redundancy in the fire detection and suppression systems is compromised. The engines each retain one detection loop and one fire bottle. APU fire detection and cargo fire extinguishing are lost.

- Heating for all static ports is lost, so be alert for unreliable airspeed and altitude.

[ ELEC DC EMER CONFIG, FCOM PRO.AEP.ELEC ]

## 5.19 Static inverter fault

Normal operations are not affected.
[ ELEC STAT INV FAULT, FCOM PRO.AEP.ELEC ]

## 5.20 Generator 1 line off

Pressing the GEN 1 LINE button on the emergency electrical panel has much the same effect as pressing the GEN1 button on the main

electrical panel, with the difference that GEN1 continues to supply its associated fuel pumps. It is primarily used for the smoke drill. If it's not meant to be off, turn it on.
[ ELEC EMER GEN 1 LINE OFF, FCOM PRO.AEP.ELEC ]

## 5.21 Tripped circuit breakers

It is generally not recommended to reset circuit breakers in flight. It is, however, acceptable to attempt a single reset if it is judged necessary for the safe continuation of the flight.

On the ground, any circuit breakers other than those for the fuel pumps may be reset as long as the action is coordinated with MOC.

An ECAM warning will be triggered if a green circuit breaker trips. If the circuit breaker is left tripped, additional tripped circuit breakers on the same panel will not be detected.
[ C/B TRIPPED, FCOM PRO.AEP.ELEC ]

# Chapter 6

# Flight Controls

## 6.1 Flaps and/or slats fault/locked

The most pressing concern following a flap or slat problem is to select a safe initial speed that will avoid overspeeding the stuck device. To establish a conservative $V_{max}$:

- If the failure occurred while *deploying* surfaces, use the placarded $V_{FE}$ associated with the *new* flap lever position. The $V_{max}$ displayed on the PFD will be this $V_{FE}$.[1]
- If the failure occurred while *retracting* surfaces, use the placarded $V_{FE}$ associated with the *previous* flap lever position. Consider returning the flap lever to this position to get this $V_{FE}$ displayed on the PFD.

For minimum speed, the $V_{LS}$ displayed on the PFD is calculated from actual flap and slat position and can be trusted. If $V_{LS}$ is unavailable, fly $V_{max} - 5$kt.

[1] The $V_{max}$ displayed on the PFD is a function of flap lever position. Conversely, the ECAM OVERSPEED warning is a function of actual flap and slat positions.

Unless there is an obvious reason not to (e.g. wing tip brake on, alignment fault or fault due to dual hydraulic failure), the flap lever can be recycled.

If normal operation cannot be restored, there are two major issues that must be quickly addressed:

- Fuel burn will be dramatically higher when flying with a locked device. With slats extended, fuel burn will increase by 60%. With flaps extended it will increase by 80%. With *both* slats and flaps extended, fuel burn will double. These figures are available in QRH OPS

- Landing distances are significantly increased, in the worst case by a factor of 2.2

It may be that the combination of these factors requires a prompt diversion decision.

The flap and slat systems are largely independent, so the flap lever will continue to move the slats if the flaps are locked and vice versa. In general, CONF 3 should be selected for landing. There are two exceptions. If flaps are locked at >3, CONF Full should be used. If both slats and flaps are locked at 0, CONF 1 should be used so that the AP/FD go-around is armed.

Configurations and $V_{REF}$ are available from the FS+ landing module by selecting suitable F/CTL ECAMs. Note that the surfaces can stick at intermediate positions, which can be difficult to detect from the flap/slat position indicator if they are close to "index" positions – the difference between, for example, slats 1 and slats $< 1$ on the indicator can be the width of a single pixel on the display.

If a flapless and slatless landing is required, the threshold speed may be below $V_{LS}$. This is necessary as the landing speeds in this configuration are very close to tyre limit speeds.

Generally, the deployment method is to select a speed 5kt below $V_{FE\ NEXT}$, then select the next configuration as the speed reduces *through* $V_{FE\ NEXT}$.[2]

In the case where $V_{LS}>V_{FE\ NEXT}$, prioritise $V_{LS}$: fly $V_{LS}$, select the next configuration, then track $V_{LS}$ as it reduces with the extension of the lift device. Use of autothrust with selected speed is generally recommended for all phases of the approach, but in this case it will need to be temporarily disconnected.

The autopilot may be used down to 500ft AAL, but since it is not tuned for the abnormal configuration it must be closely monitored.

Anticipate an unusual visual picture for landing.

For the go-around, initially maintain flap/slat configuration. A speed 10kt lower than max operating speed should be flown. If it is the slats that are jammed or if the flaps are jammed at 0, CONF 0 can be selected for transit to a diversion airfield. To clean up, accelerate to $V_{Max}$ − 10kt before selecting each new configuration. Transit should be at $V_{Max}$ − 10kt unless clean.

Other issues include the possible loss of the automatic operation of the center tank pumps (which is sequenced to the slats) and possible reversion to Alternate Law.

It is also worth noting that failure of the slat channels of both SFCCs appears to result in the loss of characteristic speed display on both PFDs. This is not mentioned in the FCOM but occurs in the sim.

The upshot of this is that neither $V_{LS}$ nor $V_{SW}$ are available at all, since they are not displayed and there is no way to calculate them. This is of particular concern when trying to deploy CONF 2 on the approach: CONF 1 does not extend flaps, so the aircraft will still be clean, yet it must be slowed to the $V_{FE}$ for CONF 2.

[2] $V_{FE\ NEXT}$ is a function of flap lever position, so it takes no account of the failure. Since it is likely that for any given configuration there are fewer high lift surfaces than normal deployed, the next configuration is selected as soon as possible, even at the risk of turbulence causing a slight overspeed. If $V_{FE\ NEXT}$ is not available, placarded speeds can be used instead.

It is highly likely that the stall warner will activate during this transition, and if not anticipated, the subsequent recovery will overspeed the flaps.

The solution is to brief that speed will be reduced very slowly and if the stall warning occurs the speed will be maintained whilst allowing the deployment of the flaps to recover the stall margin.

[ F/CTL FLAPS(SLATS) FAULT(LOCKED), QRH AEP.F/CTL, FCOM PRO.AEP.F/CTL ]

## 6.2 Direct Law

In Direct Law, deflection of the control surfaces is a linear function of deflection of the side-stick and trimming must be done manually. The controls are very sensitive at high speeds.

Use of manual thrust is recommended as power changes will result in pitch changes. Similarly, use of the speed brake will result in nose up pitch changes so it should be used with care.

Protections are unavailable, so speed is limited to 320kt/0.77M and great care must be taken when flying GPWS or windshear manoeuvres.

Direct Law landings are CONF 3; landing distances, in the absence of other pertinent failures, are comparable to normal CONF 3 landings.

The major handling difficulty with Direct Law is the go-around. There is no compensation for the large pitch moment introduced by selecting TOGA power on the under-slung engines, the thrust levers are non-linear, thrust onset is laggy and non-linear and the use of the manual pitch trim wheel will be unfamiliar. Apply power smoothly and progressively and anticipate a requirement for unusual side-stick inputs.

Direct Law works with or without yaw dampers. The aircraft is *always* convergent in dutch roll, so use lateral control, not rudder, if dutch roll is experienced.

[ F/CTL DIRECT LAW, FCOM PRO.AEP.F/CTL ]

## 6.3 Alternate Law

In Alternate Law, pitch is as in Normal Law, but roll is as in Direct Law. Load factor protection is retained, but other protections are either replaced with static stability or are lost, depending on the nature of the failure. Stall warnings and overspeed warnings become active.

The main effects are that speed is limited to 320kt and stall warnings must be respected when carrying out EGPWS manoeuvres.

The autopilot may be available.

Expect Direct Law after landing gear extension (see Section 6.2), and hence increased approach speeds and landing distances due to the associated CONF 3 landing.

[ F/CTL ALTN LAW, FCOM PRO.AEP.F/CTL ]

## 6.4 Elevator faults

If a single elevator fails, the SECs use the remaining elevator to provide pitch control in Alternate Law (see Section 6.3). In addition, speed brake should not be used and the autopilots are unserviceable.

If both elevators fail, the only available mechanism for pitch control is manual pitch trim, so pitch reverts to mechanical back up and roll reverts to Direct Law.

For an approach without elevators, fly a long final, initiating the descent from at least 5000ft AAL. Do not try to flare using trim and do not remove power until after touchdown. From 1000ft AAL, try to keep power changes to within 2% N1. In the event of a go-around, power *must* be applied very slowly if control is not to be lost.[3]

[ F/CTL L(R)(L+R) ELEV FAULT, FCOM PRO.AEP.F/CTL ]

## 6.5 Stabilizer jam

Manual pitch trim is a mechanical connection to the stabilizer actuator. It may be possible to use manual pitch trim when the ELACs have detected a stabilizer jam, although it may be heavier than normal. If it is usable, trim for neutral elevators.

The flight controls will revert to Alternate Law. If the stabilizer could not be moved, gear extension should be delayed until CONF 3 and $V_{APP}$ are achieved so that the elevators are properly trimmed.

If the jam is caused by the mechanical connection, it is possible that the ELACs will not detect the problem. The procedure in this case is similar, but Normal Law will remain.

[ F/CTL STABILIZER JAM, QRH AEP.F/CTL, FCOM PRO.AEP.F/CTL ]

## 6.6 Aileron faults

The lateral aircraft handling is not adversely affected even if both ailerons fail, as the systems compensate by using the spoilers. Fuel consumption will, however, increase by approximately 6%.

[ F/CTL L(R) AIL FAULT, FCOM PRO.AEP.F/CTL ]

## 6.7 Spoiler faults

The effect of a spoiler fault depends on whether the spoiler fails retracted or extended.

[3] This is Boeing advice – Airbus does not provide guidance for the flare or go-around technique when elevators are frozen.

If the spoiler fails in the retracted position, handling should not be adversely affected. A CONF 3 landing may reduce any buffeting that is encountered. Speed brake should not be used if spoilers 3 and 4 are affected. The loss of ground spoilers will significantly increase landing distances.

Airbus have identified a failure scenario that leads to high pressure hydraulic fluid reaching the extend chamber of a spoiler actuator via a failed o-ring. This has the effect of a spoiler failing in the fully extended position.

In this case, the autopilot does not necessarily have sufficient authority to control the aircraft, and it should be disconnected. Fuel burn will increase significantly; FMGC fuel predictions do not account for the failure and should be disregarded. Green dot speed will minimize this increased fuel burn, but may not be viable if there is excessive buffet – attempt to find a compromise speed. Landing will be CONF 3; $V_{APP}$ is available from the landing module of FS+ by selecting SPLR FAULT – spoiler runaway suspected.

[ F/CTL (GND) SPLR (1+2)(3+4) FAULT, FCOM PRO.AEP.F/CTL ]

## 6.8 Rudder Jam

The main indication of jammed rudder is undue and adverse pedal movement during rolling manoeuvres caused by the yaw damper orders being fed back to the pedals when they are no longer sent to the rudder.

Crosswinds from the side that the rudder is deflected should be avoided, and a cross wind limit of 15kt applies. Control on the ground will require differential braking until the steering handle can be used (below 70kt), so landing distances are increased. Do not use autobrake.

[ F/CTL RUDDER JAM, QRH AEP.F/CTL, FCOM PRO.AEP.F/CTL ]

## 6.9 ELAC fault

In normal operations, ELAC1 controls the ailerons and ELAC2 controls the elevators and stabiliser. Failure of a single ELAC will result in failover to the remaining computer. Provided no uncommanded manoeuvres occurred, an attempt can be made to reset the failed ELAC.

Failure of both ELACs leads to loss of ailerons and hence Alternate Law. One of the SECs will take over control of the elevators and stabiliser. Again, an attempt can be made to reset the computers.

If the fault is designated a pitch fault, only the pitch function of the associated ELAC is lost.

[ F/CTL ELAC 1(2) FAULT, FCOM PRO.AEP.F/CTL ]

## 6.10 SEC fault

Each SEC controls either 1 or 2 spoilers per wing. SEC1 and SEC2 also provide back up for the ELACs (see Section 6.9). Loss of a SEC leads to loss of its associated spoilers. SEC1 provides spoiler position to the FACs. If speedbrakes are deployed with SEC1 failed and SEC3 operative, spoiler 2 will deploy without a corresponding increase in $V_{LS}$. Therefore, do not use speedbrake if SEC1 is affected.

Pairs of SECs also provide the signal for reverse thrust lever angle to the reversers and spoiler deployment to the autobrake. A dual SEC failure will therefore lead to a loss of a reverser and loss of autobraking.

If all SECs are lost, in addition to the above, the controls revert to Alternate Law. Due to the normal routing of data from the LGCIUs to the ELACs being via the SECs, Direct Law will occur at selection of CONF 2 rather than at gear extension.[4]

[4]The autopilot is available with loss of all SECs. If the autopilot is engaged when CONF 2 is selected, Alternate Law will be retained; the reversion to Direct Law will occur at autopilot disconnection.

An attempt should be made to reset the affected SEC(s).
[ F/CTL SEC 1(2)(3) FAULT, FCOM PRO.AEP.F/CTL ]

## 6.11 SFCC faults

Each SFCC has fully independent slat and flap channels. A failure of a channel in a single controller will lead to slow operation of the associated surfaces, although this is barely discernible in practice. In addition, the flap channel of SFCC1 provides input to the idle control part of the FADECs and to the EGPWS.

Failure of both flap channels or failure of both slat channels is covered in Section 6.1.
[ F/CTL FLAP(SLAT) SYS 1(2) FAULT, FCOM PRO.AEP.F/CTL ]

## 6.12 FCDC faults

The two FCDCs are redundant, so a single failure has no immediate effect.

If both FCDCs fail, the ELACs and SECs can no longer supply data to the EIS. The major effect of this is that F/CTL ECAM warnings are no longer generated. The warning lights on the overhead panel continue to give valid information and should be monitored.

The aircraft remains in Normal Law with all protections, but protection indications (bank and pitch limits, $V_{\alpha\text{-prot}}$ and $V_{\alpha\text{-max}}$) are not shown and the stall warning system becomes active.
[ F/CTL FCDC 1(2)(1+2) FAULT, FCOM PRO.AEP.F/CTL ]

## 6.13 Wingtip brake fault

The wingtip brakes activate in case of asymmetry, mechanism overspeed, symmetrical runaway or uncommanded movements.

This protection is lost.
[ F/CTL FLAP(SLAT) TIP BRK FAULT, FCOM PRO.AEP.F/CTL ]

## 6.14 Flap attach sensor failure

The flap attach sensor detects excessive differential movement between the inner and outer flaps which would indicate failure of a flap attachment. This protection is lost.
[ F/CTL FLAP ATTACH SENSOR, FCOM PRO.AEP.F/CTL ]

## 6.15 Flight control servo faults

All flight controls have redundant servos. In the case of an elevator servo fault, a restriction to not use speedbrake above $V_{MO}/M_{MO}$ applies.
[ F/CTL AIL(ELEV) SERVO FAULT, FCOM PRO.AEP.F/CTL ]

## 6.16 Speed brake disagree

This indicates that the spoiler positions do not correspond with the speedbrake lever position. This may be as a result of automatic retraction ($\alpha$-floor activation or speed brakes deployed when CONF Full selected) or as a result of spoiler malfunction. In both cases retract the speedbrake lever and in the case of spoiler malfunction consider the speedbrakes unserviceable.
[ F/CTL SPD BRK DISAGREE, FCOM PRO.AEP.F/CTL ]

## 6.17 Speed brake fault

This indicates a failure of the speedbrake lever transducers rather than a problem with the spoilers. Ground spoiler activation may

be expected on selection of reverse, so, providing reversers are used, landing distances should not be affected.
[ F/CTL SPD BRK (2)(3+4) FAULT, FCOM PRO.AEP.F/CTL ]

## 6.18 Stiff sidestick/ rudder pedals

This may affect both sidesticks at the same time, but not the rudder pedals or it may affect the rudder pedals and one sidestick. Control forces will remain moderate and the aircraft remains responsive. Confirm autopilot disengagement and consider transferring control if one of the sidesticks is unaffected.
[ QRH AEP.F/CTL, FCOM PRO.AEP.F/CTL ]

## 6.19 Unannunciated sidestick faults

It is possible for a failed sidestick transducer to cause uncommanded control inputs. If no fault is detected, the result is that the aircraft behaves as if that input had actually been made. The autopilot will disconnect and any attempt to control the aircraft with the failed sidestick will fail.

The aircraft should be recovered with the other sidestick using the takeover button. Keeping this button pressed for 40 seconds will lock out the failed sidestick, and the autopilot can then be re-engaged. The autopilot should not be disconnected in the normal manner as pressing *either* takeover button will re-introduce the failed sidestick and the uncommanded input; use the FCU instead.

# Chapter 7

# Fire

## 7.1 Smoke and fumes

The presence of smoke or fumes may or may not generate ECAM warnings. If a smoke related ECAM warning occurs, run the ECAM before turning to the QRH.[1]

The SMOKE/FUMES/AVNCS SMOKE QRH procedure should be applied when:

- An AVIONICS SMOKE ECAM requests it *and* the flight crew can confirm the presence of smoke, either visually or by smell. If unconfirmed it should be treated as spurious.
- Smoke and/or fumes are detected either via any other ECAM or directly by the crew and the avionics, air conditioning or cabin equipment are suspected as the source.
- Orange peel or pine needle smells are detected in the flight

[1] For the AVIONICS SMOKE ECAM, the FCTM gives you the option of skipping the ECAM and referring directly to the QRH, since the QRH contains all of the relevant actions. However, treating this ECAM as "special" just complicates matters, since you will then have to remember which one was "special".

deck. These are due to rain repellent leaks; the former is toxic, the latter non-toxic.

What constitutes "smoke" is not especially ambiguous; whether a "smell" constitutes "fumes" is much more so. Training department guidance is that if a "smell" is detected in the cabin and it is having *no physiological effects*, no immediate action is required. If there are physiological effects, treat the smell as fumes and action the procedure.

The first priority is to protect yourself, so get an oxygen mask on. The mask must be set to 100% oxygen to exclude fumes; at minimum dispatch oxygen levels this will provide as little as 15 minutes of protection. Pushing the "Emergency pressure selector" knob will provide a few seconds of overpressure, which can be used to clear any smoke trapped in the mask as it was donned.

The QRH SMOKE/FUMES/AVNCS SMOKE checklist attempts to isolate the source of the smoke. It is possible that it may become impossible to carry out this checklist due to smoke density. In this case, interrupt the checklist and carry out the smoke removal drill (see Section 7.2). It is also possible that the situation may deteriorate to a level that an immediate forced landing becomes the preferable option. In general, unless the source of the smoke is obvious and extinguishable, a diversion should be initiated immediately. The smoke removal drill is most effective and adaptable at lower levels, so a descent to 10,000ft or MSA is also a priority.

Likely sources of smoke are the avionics and the galleys. Smoke from these sources can be contained with simple and reversible actions which can be initiated immediately: put the avionics ventilation into smoke removal mode by selecting both blower and extract fans to OVRD and turn off the galleys. Also turn off the cabin fans to avoid distributing the smoke to other parts of the aircraft.

Where the source is immediately obvious, accessible and extinguishable, isolate the faulty equipment. Otherwise the QRH provides separate drills for suspected air conditioning smoke, suspected cabin equipment smoke or suspected avionics/electrical smoke. In addition the avionics/electrical smoke drill includes undetermined and continuing smoke sources.

Suspect air conditioning smoke if it initially comes out of the ventilation outlets. Several ECAM warnings are also likely to occur as sensors detect the smoke in other areas. The displayed ECAM procedures must be applied. Following an engine or APU failure, smoke may initially enter the air conditioning system but should dissipate quickly once the failure is contained. The air conditioning drill starts by turning the APU bleed off in case this is the source. The packs are then turned off one at a time to determine if the source of the smoke is a pack.

The cabin equipment smoke drill involves selecting the commercial button off and searching for faulty cabin equipment.

Suspect avionics smoke if the only triggered ECAM is AVIONICS SMOKE. If an item of electrical equipment fails immediately prior to the appearance of the smoke, that equipment should be suspected as the source. The avionics/electrical drill (which includes the undetermined source drill) reduces the amount of electrically powered equipment to a minimum by adopting a slightly modified emergency electrical configuration.[2] The resulting ECAM *may*[3] contain instructions to reset the generators; these instructions should be disregarded, although the rest of the ECAM procedure must be actioned. The intention is to restore power 3 minutes before landing or at 2000ft aal. Since you will not be able to restore the two IRs that were depowered, the landing will be in Direct Law

[2]The EMER ELEC GEN 1 LINE button rather than the GEN 1 button is used to disconnect generator 1 which disconnects generator 1 from the electrical system but allows it to directly supply one fuel pump in each wing tank.

[3]Which ECAM procedure is displayed is dependent on whether an AVIONICS SMOKE ECAM has been triggered prior to the adoption of emergency electrical configuration.

and hence CONF 3.[4] This is not mentioned in QRH, and is only mentioned on the ECAM once gear is extended.
[ AVIONICS SMOKE, QRH AEP.SMOKE, FCOM PRO.AEP.SMOKE ]

## 7.2 Smoke/fumes removal

Smoke removal procedures initially use the pressurisation system to draw smoke and fumes overboard by increasing the cabin altitude. If there are no fuel vapours present, the packs are used to drive the smoke overboard. Otherwise it is driven overboard by residual pressure.

The final target configuration is packs off, outflow valve fully open and ram air on. As this depressurises the aircraft, it can only be achieved at lower levels (preferably FL100). If in emergency configuration, turning the APU master switch on connects the batteries for a maximum of 3 minutes and allows manual control of the DC powered outflow valve motor. Once at a suitable level and below 200kt, as a last resort PM's cockpit window can be opened.
[ QRH AEP.SMOKE, FCOM PRO.AEP.SMOKE ]

## 7.3 Engine fire

The basic sequence is to bring the thrust lever of the affected engine to idle, turn off its engine master, push its fire button, wait 10 seconds then deploy its first fire bottle. If the fire is not extinguished after 30 seconds, indicated by the fire button remaining lit, deploy the second bottle.

This sequence is modified on the ground in that both fire bottles are fired immediately. Cross confirmation is not required

[4] QRH ELEC ELEC EMER CONFIG SYS REMAINING indicates that by selecting the ATT HDG selector to CAPT 3 it may be possible to retain IR3 and hence have sufficient equipment for a Cat 3 Single landing once power is restored. This has not yet been confirmed by Airbus.

for master switches or fire buttons when operated on the ground. The emergency evacuation procedure is then applied if required (see Section 2.4).
[ ENG 1(2) FIRE, FCOM PRO.AEP.ENG ]

## 7.4 Lithium Battery Fire

If there are flames, they should be attacked with a halon extinguisher. This will necessitate PF donning a crew oxygen mask and PM donning the smoke hood.

If there are no flames, or once the flames have been extinguished, the cabin crew should remove the device from the cockpit and store it in a lined container filled with water. If the device cannot be removed, water or non-alcoholic liquid should be poured on the device, and it should be continuously monitored for re-ignition.

Note that these procedures assume that you are dealing with lithium ion batteries (i.e. rechargeable batteries found in laptops, tablets, phones etc.) where the amount of water reactive lithium metal is actually fairly low. Once the flames have been knocked down, the focus is on cooling to prevent thermal runaway in adjacent cells. Counter-intuitively, it is vital that ice is *not* used as this acts as a thermal insulator and will likely cause adjacent cells to explode. For the same reason, smothering with anything that might thermally insulate the battery pack (e.g. a fire bag) is probably a bad idea.

If smoke becomes the biggest threat, see Section 7.2. If the situation becomes unmanageable, consider an immediate landing.
[ QRH AEP.SMOKE, FCOM PRO.AEP.SMOKE, FAA VIDEOS (YOUTUBE) ]

# Chapter 8

# Fuel

## 8.1 Fuel system differences

The easyJet Airbus fleet has evolved to include a number of variations of the fuel system. The two major variations, from the point of view of non-normals, are the replacement of electrical center tank pumps with jet transfer pumps on some airframes and the simplified tank system of the A321 NEO where the normal outer and inner cells are replaced with a single wing tank. In addition, some airframes are fitted with a center tank fuel inerting system, but since there are no cockpit controls for this, it doesn't affect the non-normal procedures.

The philosophy of center tank jet transfer pumps is very different from that of the electrical pumps. With the electric pumps, fuel is supplied directly from the center tank to the engines, and any transfer between center tank and wing tank is a side effect of the fuel return system. With the jet transfer pumps, fuel is only ever transferred from the center tank to wing tanks: it is always the wing tank pumps that supply pressurised fuel to the engines. The jet transfer pumps themselves are also powered by the wing tank pumps: if there is a need to shut down a jet transfer pump, that is achieved by turning off the associated wing pumps. There also appears to be some scope for gravity feeding from the center tank when jet pumps are fitted (although 2T of center tank fuel will still be unusable),[1] something that is not possible with the electrical pumps. This leads to some subtle airframe dependent differences in non-normal fuel procedures.

The simplification of the wing tanks on the A321 NEO has less impact on non-normal procedures: it is mainly a case of changing ECAM titles appropriately.

## 8.2 Fuel leak

Whenever a non-normal fuel event occurs, the possibility that the underlying cause of the event is a fuel leak should be considered. Only when a fuel leak has been categorically ruled out should the cross-feed valve be opened.

The primary method used to detect fuel leaks is a regular check that actual fuel remaining corresponds to expected fuel remaining and that fuel used plus fuel remaining corresponds to fuel at engine start. The latter parameter is monitored on some aircraft and may trigger an ECAM warning. Other indications of a leak include fuel imbalance or excessive fuel flow from an engine. It is also possible that a fuel leak may be detected visually or by a smell of fuel in the cabin.

If a leak can be confirmed to be coming from an engine or pylon, either visually or as indicated by excessive fuel flow, the affected engine must be shut down. In this case, cross-feeding is allowable. Otherwise, the cross-feed must be kept closed.

If the leak cannot be confirmed to be originating from an engine or pylon, an attempt should be made to identify the source of the leak by monitoring the inner tank (or, for A321 NEO, wing tank)

[1] This information only appears in the FUEL CTR L+R XFR FAULT checklist. I have requested further information and will update once I get a response.

depletion rates with the crossfeed valve closed and the center tank pumps off.

If depletion rates are similar, a leak from the center tank or from the APU feeding line should be suspected. If there is a smell of fuel in the cabin, it is likely that the APU feeding line is at fault and the APU should be turned off. Fuel from the center tank should be used once one of the inner/wing tanks has <3000kg.[2]

If, after 30 minutes, one tank has been depleted by 300kg more than the other, the location of leak is narrowed down to the engine or the wing on the more depleted side. To confirm which it is, shut down the engine. If the leak then stops, an engine leak is confirmed and the cross feed can be used. If not, a leak from the wing is most likely. In this case, an engine restart should be considered.

The handling of the center tank pumps in the presence of a fuel leak is dependent on whether the aircraft is fitted with electrical center tank pumps or with jet transfer pumps. When electrical center tank pumps are on, no fuel is transferred between the center tank and the wing tank unless the engine associated with that wing tank is running. If an engine *is* running with electrical center tank pumps on, surplus fuel is returned from the engine to the associated wing tank, and thus a fairly modest rate of transfer occurs. The jet transfer pumps, on the other hand, transfer fuel directly from center tank to wing tank at a high rate regardless of whether the associated engine is running. It is therefore important not to run a jet transfer pump if you suspect its associated wing tank has a leak since significant extra fuel loss would likely occur.

[2] The logic here is strange. An unofficial explanation of the requirement for <3000kg in the inner tank was given to me: some of the fuel lines from the center tank run through the wing tanks, so fuel from a center tank leak may end up transferring to the wing tanks and with full wing tanks will be lost overboard. As for the APU feeding line leak, I would expect the left tank to decrease faster than the right in this case; my guess is that the expectation is that an APU feeding line leak will be detected as a smell in the cabin and the leak will be too small to become apparent as an imbalance.

In an emergency, a landing may be carried out with maximum fuel imbalance.

Do not use thrust reversers.

[ FUEL F USED/FOB DISAGREE, QRH AEP.FUEL, FCOM PRO.AEP.FUEL ]

## 8.3 Fuel imbalance

All fuel balancing must be carried out in accordance with QRH FUEL FUEL IMBALANCE, paying particular attention to the possibility of a fuel leak. Any action should be delayed until sufficient time has passed for a fuel leak to become apparent. The FCOM adds a note not found in the QRH that “there is no requirement to correct an imbalance until the ECAM fuel advisory limit is displayed”, an event that occurs when one inner tank holds >1500kg more than the other. The limitations for fuel imbalance in FCOM LIM.FUEL, however, show that the fuel advisory does not necessarily indicate that a limitation is likely to be breached. In particular, when the outer tanks are balanced and the heavier inner tank contains ≤2250kg, there are no imbalance limitations. Furthermore, the aircraft handling is not significantly impaired even at maximum imbalance.

To balance the fuel, open the cross-feed valve and turn the lighter side pumps and the center tank pumps off.

[ QRH AEP.FUEL, FCOM PRO.AEP.FUEL, FCOM LIM.FUEL ]

## 8.4 Gravity fuel feeding

Turn on ignition and avoid negative G. The ceiling at which fuel can be reliably gravity fed depends on whether the fuel has had time to deaerate, this being a function of achieved altitude and time at that altitude. The algorithm used to calculate gravity feed ceiling is airframe dependent and is provided in the QRH. Once calculated, descend to the gravity feed ceiling; it may be as low as FL150, so terrain must be considered.

It is also possible to gravity cross feed by side slipping the aircraft with the cross feed valve open. The section of the QRH describing this procedure has recently (June 2017) been cleaned up by moving an explanatory note into a branch title, but this has had the effect of changing the apparent intention. Previously, gravity cross feeding was indicated when single engine and required "for aircraft handling" (i.e. it could generally be disregarded), whereas with the update the procedure is indicated whenever gravity feeding on a single engine. Clarification has been requested from Airbus via the easyJet Technical Manager, and these notes will be updated once a response is received.

[ QRH AEP.FUEL, FCOM PRO.AEP.FUEL ]

## 8.5 Wing tank pump low pressure

Failed pumps should be turned off.

Failure of a single pump in either tank results in reduced redundancy only.

Failure of both pumps in a given tank means that the fuel in that tank is only available by gravity feeding. Pressurized fuel may be available from the center tank (use manual mode if necessary) or by cross-feeding. A descent to gravity feed ceiling may be required (see Section 8.4).

[ FUEL L(R) TK PUMP 1(2)(1+2) LO PR, FCOM PRO.AEP.FUEL ]

## 8.6 Center tank pump low pressure

Failed pumps should be turned off.

Failure of a single center tank pump results in a loss of redundancy. The crossfeed should be opened until the center tank fuel has been exhausted so that the remaining pump can supply both engines.

Failure of both center tank pumps makes the fuel in the center tank unusable.

[ FUEL CTR TK PUMP(S)(1(2)) LO PR, FCOM PRO.AEP.FUEL ]

## 8.7 Center tank transfer pump faults

Since the motive power for jet transfer pumps comes from their associated wing tank pumps, their main failure mode is failure of their associated center transfer valve.

If a valve fails in a not fully closed position, fuel may continue to be transferred to the wing tank even when it is full, and will thus overflow. Selecting the transfer pump off may be effective; otherwise the jet transfer pump's motive power is removed by switching off its associated wing tank pumps, with the wing tank pumps from the unaffected side supplying both engines until the center tank is empty. If both sides fail in this way, all that can be done is to turn the center tank transfer pumps off; it may not be possible to prevent fuel overflow.

If a valve fails in a not fully open position, fuel may not be transferred between center tank and wing tank on the affected side. Manual control of the transfer pumps may be effective; if not, feeding both engines with the wing tank pumps of the unaffected side until the center tank is empty is once again the solution. If both sides fail in this way and manual control is not effective, 2T of center tank fuel are unusable; the rest is available by gravity.

[ FUEL CTR L(R)(L+R) XFR FAULT, FCOM PRO.AEP.FUEL ]

## 8.8 Auto feed/transfer fault

Whenever center tank fuel is being used, fuel is transferred from the center tank to the wing tanks. In the case of jet transfer pumps this is a direct transfer; in the case of electrical pumps it is via the fuel return system. Center tank fuel can thus only be used when there is space in the wing tanks to receive this transferred fuel. The pumps therefore automatically cycle on and off, starting when there is space for 500kg in the wing tanks and stopping when the wing tanks are full, until such time as the center tank fuel is exhausted. In addition, electrical center tank pumps are inhibited whenever the slats are extended.[3]

Malfunction of the automatic cycling of the center tank pumps (electrical or jet transfer) is identified by the presence of more than 250kg of fuel in the center tank when there is less than 5000kg in one of the wing tanks. Malfunction of automatic control of electrical pumps is also indicated when they continue to run when slats are extended or the center tank is empty.

If the automatic control has malfunctioned, the cycling of the center tank pumps must be managed manually. For both types of pump, they should be switched on whenever one of the wing tanks has less than 5000kg fuel and center tank fuel remains, and switched off when one of the wing tanks is full or the center tank fuel is exhausted. In the case of electrical pumps, they must also be switched off whenever the slats are extended.

[ FUEL AUTO FEED(TRANSFER) FAULT, FCOM PRO.AEP.FUEL ]

## 8.9 Wing tank overflow

When center tank fuel transfers to a wing tank, either directly in the case of transfer pumps of via the fuel return system in the case of electrical pumps, and that wing tank has no space to accommodate it, that fuel will overflow.

[3]As always with Airbus, there is an exception. If there is fuel in the center tank, each electrical center tank pump will operate for two minutes after its associated engine is started, regardless of slat selection, to pre-pressurise the center tank fuel lines.

To stop the overflow, the fuel transfer must cease. In the case of electrical center tank pumps, this is just a matter of switching the offending center tank pump off. With jet transfer pumps, switching the pump off may also be effective; if not, remove motive power of the offending pump by switching off both of its associated wing pumps – pressurised fuel will be available via crossfeed.

[ FUEL L(R) WING TK OVERFLOW, FCOM PRO.AEP.FUEL ]

## 8.10 Low fuel level

The ECAM is triggered at approximately 750kg. This warning is generated by sensors that are independent of the FQI system. The warning may be spurious if the ECAM is triggered just before the wing cell transfer valves open. If center tank fuel remains, it should be used by selecting the center tank pumps to manual mode. If there is a fuel imbalance and a fuel leak can be ruled out, crossfeed fuel as required.

If both tanks are low level, about 30 minutes of flying time remain.

If any change to the current clearance will lead to landing with less than minimum reserve fuel, declare "minimum fuel" to ATC. This is just a heads up to ATC, not a declaration of an emergency situation. If it is calculated that less than minimum fuel will remain after landing, declare a Mayday.

[ FUEL(R)(L+R) WING TK LO LVL, FCOM PRO.AEP.FUEL, EOMA 8.3.8.2 ]

## 8.11 Outer tank transfer valve faults

Imbalances caused by the outer tank transfer valves on one side failing to sequence correctly, either by failing to open or by opening out of sequence, will not exceed limits, provided that the total fuel in each wing is the same (see FCOM LIM.FUEL).

Of more concern is the sudden loss of usable fuel when transfer valves fail to open on schedule. If only one side is affected, 700kg of fuel will become unusable. If both sides are affected, 1400kg of fuel will become unusable. This will happen when fuel levels are already fairly low, as the valves are triggered when an inner tank reaches 750kg, potentially leaving you with just 1500kg of fuel when you were expecting to have 2900kg.

[ FUEL L(R) XFR VALVE OPEN, FUEL L(R) XFR VALVE CLOSED, FCOM PRO.AEP.FUEL ]

## 8.12 Cross-feed valve fault

If the valve has failed open, fuel balance can be maintained through selective use of fuel pumps. If it has failed closed, crossfeeding is unavailable.

[ FUEL FEED VALVE FAULT, FCOM PRO.AEP.FUEL ]

## 8.13 Low fuel temperature

ECAM is triggered at approx -43°C for A319/A320 and -44°C for A321. If on the ground, delay takeoff until temperatures are within limits. If in flight, descending or increasing speed should be considered.

[ FUEL L(R) OUTER(INNER) TK LO TEMP, FCOM PRO.AEP.FUEL ]

## 8.14 High fuel temperature

This ECAM is known to be triggered spuriously by interference from communication equipment. The procedure should only be applied if the message has not disappeared within 2 minutes.

The ECAM temperature triggers on the ground are 55°C for an outer cell and 45°C for an inner cell or A321 wing tank. In the air they are 60°C for an outer cell and 54°C for an inner cell or A321 wing tank.

The temperature of fuel returning to the tanks is primarily a function of IDG cooling requirement. The immediate action, therefore is to turn the galley off to reduce the IDG load.

On the ground, the engine on the affected side must be shut down if an outer cell reaches 60°C, an inner cell reaches 54°C or, for the A321, the wing tank reaches 55°C. An expeditious taxi may, therefore, be advantageous.

In the air, if only one side is affected, fuel flow can be increased so that less hot fuel is returned to the tanks. If the temperature gets too high (>65°C outer or >57°C inner/wing), IDG disconnection will be required (see Section 5.3).

[ FUEL L(R) OUTER(INNER)(WING) TK HI TEMP, FCOM PRO.AEP.FUEL ]

# Chapter 9

# Landing gear

## 9.1 Loss of braking *(memory item)*

If it is simply an autobrake failure, just brake manually.

Otherwise, apply max reverse and attempt to use the alternate brake system. To do this, release the brake pedals and turn off the ASKID & NW STRG switch. Note that this action also disables the nosewheel steering, so differential braking will be required once the rudder ceases to be effective.

If the alternate system also appears to have failed, short successive applications of the parking brake may be used. Use of the parking brake in this way risks tire burst and lateral control difficulties (due brake onset asymmetry) so delay until low speed if at all possible.

[ FCOM PRO.AEP.BRAKES ]

## 9.2 Tyre damage

The diagnosis of a damaged tyre on easyJet aircraft is very difficult since the optional Tire Pressure Indicating System is not installed. The most likely source of pertinent information is therefore ATC reporting tyre debris, possibly combined with unusual sounds on the takeoff roll.

The QRH WHEEL TIRE DAMAGE SUSPECTED checklist indicates that Airbus consider a damaged tyre to have much the same effect as a released brake, at least in terms of landing performance.

The FCOM additionally provides taxi speed limitations for deflated or damaged tyres in the LIM section.

There is some question as to whether the effect of both tyres on one side being damaged can be extrapolated to give the Asymmetric braking case (see Section 9.5) with associated crosswind and reverser handling considerations. Guidance is being sought on this, and these notes will be updated once a response is received.

[ QRH WHEEL TIRE DAMAGE SUSPECTED ]

## 9.3 Residual braking procedure

Residual brake pressure must be checked after landing gear extension as there is no ECAM warning. A brief brake pressure indication is expected as the alternate system self tests after the gear is downlocked, but pressure should quickly return to zero. If the triple indicator shows residual pressure after this test, try to zero it by pressing the brake pedals several times. If a landing must be made with residual pressure in the alternate braking system, use autobrake MED or immediate manual braking to prioritise the normal system. Anticipate brake asymmetry at touchdown.

[ QRH AEP.BRAKES, FCOM PRO.AEP.BRAKES ]

## 9.4 Gravity extension

Gravity extension is achieved by turning the GRAVITY GEAR EXTN handcrank clockwise three times until a mechanical stop is reached. Once the gear is down, the LG lever should be set to down to extinguish the UNLK lights and remove the LG CTL message from the WHEEL page.

Availability of landing gear indications depends on the nature of the failure that resulted in the requirement for gravity extension. LDG GEAR control panel indications may still be available if LGCIU1 is otherwise unserviceable, providing that it is electrically supplied.

Gear doors may show amber on the WHEEL page after gravity extension. There may also be spurious L/G LGCIU 2 FAULT or BRAKES SYS 1(2) FAULT ECAM warnings.

[ QRH AEP.L/G, FCOM PRO.AEP.L/G ]

## 9.5 Asymmetric braking

Defined as all brakes on one gear released (indicated by amber brake release indicators on both wheels of one main gear on the WHEEL SD page). When the remaining brakes are applied, the aircraft will tend to swing towards them. This tendency must be countered with rudder, hence the braking must be progressive and co-ordinated with available rudder authority. Crosswinds from the side of the available brakes will re-inforce the swing, so anything greater than 10kt from that side should be avoided.

If a reverser is inoperative on the same side as the inoperative brakes, do not use the remaining reverser since it would also re-inforce the swing.

Landing distances will increase significantly.

[ QRH AEP.BRAKES, FCOM PRO.AEP.BRAKES ]

## 9.6 Landing with abnormal landing gear

A landing should be carried out on a hard surface runway using any available landing gear. Foaming of the runway is recommended. Manual braking should be used. Reverse thrust should not be used as it will cause ground spoiler extension. The GRVTY GEAR EXTN handcrank should be turned back to normal to allow the landing gear down actuators to be pressurised and thus reduce the chance of gear collapse.

If the nose gear is not available, move the CG aft by moving passengers to the rear of the aircraft. Use elevator to keep the nose off the runway, but lower the nose onto the runway before elevator control is lost. Braking must be progressive and balanced against available elevator authority. The engines should be shut down with the ENG MASTER switches prior to nose impact.

If one main gear is not available, consider crossfeeding to remove the fuel from the wing with the unserviceable gear. The anti-skid system cannot operate with a single main gear extended and must be switched off to avoid permanent brake release. The ground spoilers should not be armed in order to maintain the maximum possible roll authority. The engines should be shut down at touchdown. After touchdown, use roll control to keep the unsupported wing from touching down for as long as possible.

If both main gear are unavailable, the engines should be shut down in the flare. Pitch attitude at touchdown must be >6°.

All doors and slides are available for evacuation in any of the normal gear up attitudes.

[ QRH AEP.L/G, FCOM PRO.AEP.L/G ]

## 9.7 Flight with landing gear extended

Flight into expected icing conditions is not approved. Gear down ditching has not been demonstrated. FMGC predictions will be erroneous – selected speed should be used for all phases except approach. CLB and DES modes should not be used. Altitude alerting will not be available. Any failure that normally causes a degradation to Alternate Law will instead cause a degradation to Direct Law.

The dual engine failure scenario is modified to reflect the gear limiting speed. Assisted start should be preferred. If the APU is not available, gear limit speeds should be disregarded to achieve a windmill start. Flight controls will be in Direct Law; manual pitch trim should be available, even when not annunciated on the PFD.

Performance in all phases will be affected. In particular, approach climb limiting weights for go-around[1] must be reduced by 14%. Fuel burn will increase (approximate factor is 2.3). Engine out ceiling and take-off performance are also impacted.

[ FCOM PRO.NOR.SUP.L/G ]

## 9.8 Gear shock absorber fault

A shock absorber did not extend when airborne or did not compress on landing. If airborne the gear cannot be retracted. Respect the gear extended limit speed of 280kt and see Section 9.7.

[ L/G SHOCK ABSORBER FAULT, FCOM PRO.AEP.L/G ]

## 9.9 Gear not uplocked

Landing gear retraction sequence has not completed within 30 seconds. If the gear doors have closed, the gear will rest on the doors so avoid excessive g loads. If the doors have not closed, recycle the gear. If this does not work, select the gear down and see Section 9.7.

[ L/G GEAR NOT UPLOCKED, FCOM PRO.AEP.L/G ]

## 9.10 Gear not downlocked

If the landing gear extension sequence has not completed within 30 seconds, retract the gear, wait until it has fully stowed, and

[1]See FCOM PRO.NOR.SUP.L/G

then redeploy it. Recent studies show that if the gear does not immediately deploy successfully following reselection, it may deploy normally within the next two minutes as hydraulic pressure continues to act on the gear and doors throughout this time. If still unsuccessful after two minutes, attempt to deploy the gear by gravity (see Section 9.4).

[ L/G GEAR NOT DOWNLOCKED, FCOM PRO.AEP.L/G ]

## 9.11 Gear doors not closed

A gear door is not uplocked. Recycle the gear. If the doors cannot be closed, speed is limited to 250kt/M0.6.

[ L/G DOORS NOT CLOSED, FCOM PRO.AEP.L/G ]

## 9.12 Uplock fault

An uplock is engaged when the corresponding gear is downlocked. As the uplock will not move to accept the gear, the gear must be left down. See Section 9.7.

[ L/G GEAR UPLOCK FAULT, FCOM PRO.AEP.L/G ]

## 9.13 LGCIU disagreement

The LGCIUs disagree on the position of the gear. In the absence of other ECAM warnings, the gear position can be assumed to agree with the gear lever position.

[ L/G SYS DISAGREE, FCOM PRO.AEP.L/G ]

## 9.14 LGCIU fault

The FADECs use LGCIU input to determine idle mode. If a LGCIU is determined to be faulty, the system failsafes to approach idle mode, and modulated idle and reverse idle (and hence reversers) will not be available.

The GPWS uses LGCIU1 to determine landing gear position. If this LGCIU is faulty, the GPWS will need to be inhibited to prevent spurious warnings.

If both LGCIUs are lost, normal landing gear control and indicating systems are lost. The gear must be gravity extended (see Section 9.4). Additionally, the autopilots and autothrust are lost (Normal Law remains available) and wing anti-ice is limited to 30s of heating (i.e. the ground test), the only indication of which is a NO ANTI-ICE message on the BLEED SD page.

[ L/G LGCIU 1(2) FAULT, FCOM PRO.AEP.L/G ]

## 9.15 Gear not down

Indicates that the landing gear is not downlocked when radio altitude is below 750ft rad alt and N1 and flap setting indicate that the aircraft is on approach. If rad alt data is not available, it indicates gear is not down when CONF 3 or CONF Full is selected. In some cases the warning may be cancelled with the emergency cancel pushbutton.

[ L/G GEAR NOT DOWN, FCOM PRO.AEP.L/G ]

## 9.16 Nosewheel steering fault

Nosewheel steering is unavailable so differential braking must be used to steer the aircraft. The nosewheel may not be aligned if the L/G SHOCK ABSORBER FAULT ECAM is also displayed, in which case delay nosewheel touch down as long as possible. Cat 3 dual will not be available.

[ WHEEL N/W STRG FAULT, FCOM PRO.AEP.WHEEL ]

## 9.17 Antiskid nosewheel steering off

The A/SKID & NW STRG switch is off. The ABCU controls braking through the alternate braking system. Antiskid is not available so landing distance will increase significantly. Autobrake and nosewheel steering will also not be available.

[ BRAKES ANTI SKID/NWS OFF, FCOM PRO.AEP.BRAKES ]

## 9.18 Antiskid nosewheel steering fault

Either:

- both BSCU channels have failed or
- the normal brake system has been lost and the yellow hydraulic pressure is low.

Effects are as for Section 9.17, although, if yellow hydraulic pressure is low, braking will be accumulator only.

[ BRAKES A/SKID NWS FAULT, FCOM PRO.AEP.BRAKES ]

## 9.19 Brake system fault

A fault has been detected in one channel of the BSCU. Loss of redundancy only.

[ BRAKES SYS 1(2) FAULT, FCOM PRO.AEP.BRAKES ]

## 9.20 Brakes hot

At least one brake temperature is >300°C. Check Section 9.27 if the temperature is excessive or the brake temperatures are not reasonably even.

Temperature must be <300°C for takeoff to prevent ignition of any hydraulic fluid that leaks onto the brake. Use brake fans as necessary to bring the temperature down in time for the next takeoff. The brake fans also cool the temperature sensor, so assume the real brake temperature is twice that indicated if they have recently been used.

If the warning appears in flight, providing that performance permits, the landing gear should be extended to allow the brakes to cool.

[ BRAKES HOT, FCOM PRO.AEP.BRAKES ]

## 9.21 Auto brake fault

A failure was detected when the autobrake was armed. Brake manually.

[ BRAKES AUTO BRK FAULT, FCOM PRO.AEP.BRAKES ]

## 9.22 Hydraulic selector valve fault

This ECAM message may indicate two completely different conditions:

- The normal brake selector valve has failed in the open position. The normal servo valves (downstream of the selector valve) will have continuous full pressure at their inlets, but, as long as anti-skid is operative, will control brake pressure and anti-skid normally.
- The steering selector valve has failed in the open position. This means that the steering will remain pressurised as long as there is pressure in the yellow hydraulic system. This has obvious implications if towing is attempted, but will also mean that the nosewheel will go to maximum deflection if

the A/SKID & N/W STRG switch is selected off or the BSCU is reset.

[ WHEEL HYD SEL FAULT, FCOM PRO.ABN.32 ]

## 9.23 Brake system failures

Loss of the alternate braking system results in loss of redundancy only.

If the normal brake system is lost, alternate braking and anti-skid are available. Landing distance increases slightly.

Loss of both normal and alternate brake systems leaves the parking brake as the only remaining braking option. See Section 9.1 for method.

[ BRAKES NORM BRK FAULT, BRAKES ALTN BRK FAULT, FCOM PRO.AEP.BRAKES ]

## 9.24 Brake accumulator low pressure

Braking is not available unless either the green or yellow hydraulic systems are pressurised.

If the engines are shut down, attempt to recharge the accumulator using the yellow system electrical pump.

When parking the aircraft, use chocks.

[ BRAKES BRK Y ACCU LO PR, FCOM PRO.AEP.BRAKES ]

## 9.25 Released brakes, normal system

If normal braking is active and at least one engine is running, the BSCU self tests when it receives a “gear downlocked” signal from either of the LGCIUs. The BRAKES RELEASED ECAM is provided if at least one set of brakes on a main wheel is incorrectly released during this test. The failed brake is shown by an amber release symbol on the WHEEL page. Loss of a brake leads to increased landing distances. If both brakes on the same gear are released, see Section 9.5.

[ BRAKES RELEASED, FCOM PRO.AEP.BRAKES ]

## 9.26 Released brakes, alternate system

The ABCU self tests the brakes in a similar manner to the BSCU (see Section 9.25). If this test is failed, normal braking can be expected as long as the normal braking system is active. If the alternate braking system is active, braking will be asymmetric (see Section 9.5) because released brakes occur in pairs with the alternate braking system.

[ BRAKES ALTN L(R) RELEASED, FCOM PRO.AEP.BRAKES ]

## 9.27 Brake temperature limitations

Maintenance is required if:

- One brake temp is >600°C and the other brake on the same gear is 150°C less.
- One brake temp is <60°C and the other brake on the same gear is 150°C more.
- The average temp of one gear is 200°C more than the average temp of the other.
- Any brake temp exceeds 900°C.
- A fuse plug has melted.

[ EOMB 2.3.21 ]

## 9.28 Park brake on

The parking brake is set when the thrust levers are set to FLX or TOGA. Check the position of the brake handle position and for pressure indications on the brake triple gauge.

[ CONFIG PARK BRK ON, FCOM PRO.AEP.CONFIG ]

# Chapter 10

# Power plant

## 10.1 All engine failure

The entire easyJet fleet has, thankfully, now been upgraded such that the various ENG DUAL FAILURE checklists are no longer applicable. Where plenty of time is available, the response to failure of both engines is now supported by the ENG ALL ENGINES FAILURE ECAM and the ENG ALL ENG FAIL QRH procedure. For Hudson-like events, the QRH MISC EMER LANDING ALL ENG FAILURE checklist (also available on the back of the normal checklist) should be used. Note that the QRH MISC DITCHING and QRH MISC FORCED LANDING checklists are for engines operative landings and are therefore not applicable; engine inoperative ditching and forced landing are included in the ENG ALL ENG FAIL QRH procedure.

The ENG ALL ENGINES FAILURE ECAM actions ensure that emergency electrical power is online and that the aircraft is optimally set up for an immediate windmill relight (300kt/M0.77 for CEO, 270kt/M0.77 for NEO, thrust levers idle). APU start is suggested if below FL250, although this may be spurious if fuel is exhausted or the APU is otherwise unavailable. For the CEOs, a FAC1 reset is also actioned in order to recover PFD characteristic speeds and rudder trim; this does not appear to be necessary for the NEOs. The ECAM then suggests a diversion and hands off to the QRH procedure. The QRH includes the ECAM actions, so it can be used directly if the ECAM is unavailable.

Due to lack of engine bleeds, a slow depressurisation will likely be occuring. Since it would be easy to miss excess cabin altitude warnings, donning an oxygen mask may be a sensible precaution. RAM AIR can be used once below FL100 with differential pressure <1psi.

For the diversion, as a rough rule of thumb, from normal cruise levels any airfield within 80nm should be reachable with sufficient height remaining to position for a glide approach. You really want at least a 3000m runway, although if you can get the APU supporting normal electrics and the yellow electrical hydraulic pump it may be possible to make do with less. Take account of descent winds, airport elevation and available runway directions when selecting an airport.

There are two main bifurcations in the procedures, dependent on whether there is any chance of restarting an engine in the first case, and whether an emergency landing will be made on water or land in the second.

Where relight is feasible, parallel windmill start attempts may be attempted once below FL270[1] (or below FL250 on some airframes), and sequential starter assisted start attempts may be made once below FL200, provided that the APU bleed is available.

The windmill start attempts consist of selecting IGN on the ENG MODE SEL, turning both engine masters off for 30 seconds to ventilate the combustion chambers, then turning them both back

[1]Note that this is different from the old ENG DUAL FAILURE checklist, where windmill start attempts were tried immediately, even if outside the relight envelope.

on, repeating the cycle if unsuccessful.

Starter assisted start is much like the normal engine start procedure: turn both masters off for 30 seconds, ensure ENG MODE SEL IGN, pneumatic pressure is available to the starter and wing anti-ice is off, then turn one of the masters on. If the engine fails to start, turn that master off, and try the other one, ensuring 30 seconds of combustion chamber ventilation between each attempt. When making starter assisted start attempts, speed should be reduced to green dot to achieve maximum glide range; if windmill starts are required below FL200 (e.g. due lack of APU), suitable speeds can be found in the ENG RELIGHT QRH checklist.

Where relight is not a possibility, speed should be reduced to green dot to maximise glide range and available time. At windmill relight speeds, available range is 2nm per 1000ft, wheras at green dot it is 2½nm per 1000ft. If available, the APU should still be started at FL250 in order to provide normal electrics and pressurisation.

The Green and Yellow hydraulic failure aspect of the dual engine failure is interesting in that the checklists make no attempt to bring the Yellow Electric pump online once electrical power is available from the APU. The rationale for this has three parts: firstly, there are branches of the failure where the yellow electric pump will not be available, such as if the APU was inop, and accounting for these cases in the checklists would over-complicate them; secondly, the engine driven pumps continue to provide hydraulic pressure for some time due to windmilling; and lastly, the ECAM will eventually recognise the dual hydraulic failure and request the pump be turned on, and the checklist does encourage you to clear the ECAM alerts and STATUS if sufficient time is available.

The problem with this is that you will likely have given up on the ECAM by the time it makes this suggestion. In general, then, if you recognise that the yellow electric pump is available, turn the PTU off (see Section 13.1) and turn the yellow pump on. You will, of course, still need to gravity extend the gear, as the green system will not be recovered, but with blue from the RAT and yellow from the electric pump, your stopping ability is greatly enhanced.

The recommended configurations are CONF 2, gear up for ditching and CONF 2, gear down for forced landing. $V_{APP}$ is available in each of the checklists; it will always be at least 150kt to give a 10kt margin against RAT stall. The gear is available with gravity extension. If the yellow hydraulics have not been reinstated with the electric pump the stabilizer will be frozen once engine driven hydraulics are lost and elevator trimming will cease with transition to Direct Law at gear extension. Therefore, it may be advantageous to delay gear extension until CONF 2 and $V_{APP}$ are reached in this case. A pitch attitude of 11° with minimal vertical speed is suggested for ditching.

If an airfield can be reached, a glide approach and landing will need to be flown. Successful execution requires a good understanding of A320 family glide performance and navigational techniques for track mileage adjustment. I have provided a web browser based tool at `https://aeftt.hursts.org.uk` to help develop these skills. A discussion of methods can be found via the "Background Information" button in the main menu of this tool.

[ ENG DUAL FAILURE, QRH AEP.ENG, FCOM PRO.AEP.ENG, FCTM PRO.AEP.ENG ]

## 10.2 Single Engine failure

Defined as a rapid decrease in EGT, N2 and FF, followed by a decrease in N1. The crew must determine whether the engine has been damaged or whether a simple flame-out has occurred. Indications of damage are loud noises, significantly increased vibration or buffeting, repeated or uncontrollable engine stalls or abnormal post-failure indications (e.g. hydraulic fluid loss, zero N1 or N2 etc.).

Firstly, the ignitors are turned on to protect the remaining engine and to confirm an immediate relight attempt. The thrust lever of the failed engine is then moved to idle (PF moves the lever after confirmation from PNF). If the FADEC hasn't relit the failed engine within 30 seconds of the failure, it is shut down with the master switch. If damage is believed to have occurred, the associated fire button is pushed and, after 10 seconds, agent 1 discharged.

If it is believed that the engine is undamaged, a relight can be considered. The relight procedure is fairly long and highly unlikely to be successful; do not delay diversion and landing by attempting a relight. Also note that a relight attempt will erase FADEC troubleshooting data.

If there is vibration and/or buffeting, attempt to find an airspeed and altitude combination that minimizes the symptoms.

Refer to Section 10.3 if unable to relight the engine.

[ ENG 1(2) FAIL, FCOM PRO.AEP.ENG ]

## 10.3 Single engine operation

The most pressing issue is that a single engine bleed cannot support wing anti-ice and two packs. With the crossbleed valve selector in the normal AUTO position, the crossbleed valve is effectively synchronised to the APU bleed valve[2] and thus will most probably be closed; wing anti-ice, if it is in use, will be operating asymmetrically. If a fire button has been pushed, its associated side of the pneumatic system will be locked out and thus the only option is to turn the wing anti-ice off. PRO.NOR.SUP.AW MINIMUM SPEED WITH ICE ACCRETION provides mitigation of icing in the event of inoperative wing anti-ice. If both sides of the cross bleed system are available, the cross bleed valve can be manually opened at a cost of 1200ft

[2]The exception is that the crossbleed won't open if a bleed air duct leak is detected except during engine start.

to the single engine gross ceiling. With the cross bleed valve open, wing anti-ice is available, but one of the packs must be turned off[3] whenever it is used.

The remaining engine must be safeguarded. To this end, continuous ignition should be selected.

A fuel imbalance may develop. Fuel imbalance limitations are detailed in FCOM LIM.FUEL. If the outer tanks are balanced, once the fuller inner tank contains less than 2250kg, fuel balance will never be limiting. Since this first occurs with approximately 5900kg of fuel remaining, fuel balancing due to balance limitations will generally not be required. Fuel may, however, still need to be crossfed to prevent fuel starvation of the remaining engine. Balance this concern against feeding your live engine the same fuel that was feeding your failed engine when it stopped working.

TCAS should be selected to TA to avoid unflyable climb RAs.

If a reverser is unlocked with associated buffet, speed should be limited to 240kt. See Section 10.13 for more details of this scenario.

If the remaining engine is operated at maximum power with the aircraft at low speed (e.g. responding to windshear) it is possible that directional control may be lost before the flight computer protections apply. Be cautious about reducing speed below $V_{LS}$ on one engine.

The main systems lost are the generator, bleed and hydraulic pump associated with the engine. Other systems may be lost depending on the reason for the shutdown. The APU can be used to replace the lost generator and, providing the left side of the pneumatic system is available and isolated (i.e. cross bleed valve closed), provide pressurisation through pack 1, thus giving additional margin for the go-around. The BMCs automatically close the engine bleeds when the APU bleed valve is opened, so it is

[3] It will need to be pack 1 in Emergency Electrical config; otherwise it will generally be the pack on the dead engine side.

not necessary to manually turn them off to achieve this additional go-around margin. Note, however, that the APU cannot support wing anti-ice.

Approach and landing will be fairly normal. The main provisos are:

- Full flap should only be selected once descending on the glidepath; if a level off is required, the landing should be CONF 3 [QRH ENG OEI – STRAIGHT IN APPROACH]
- Only Cat 3 Single is available due to the loss of the ability to split the electrical system.[QRH OPS]
- On A319s, the autopilot cannot fly FINAL APP, NAV/VS or NAV/FPA approaches. All modes are available for manual flight with flight directors. [FCOM LIM.AFS.GEN]
- If flying manually, consider using manual thrust to better anticipate the rudder inputs required by thrust changes. Also consider setting rudder trim to zero at a late stage of the approach.[FCTM PRO.AEP.ENG]

[ ENG 1(2) SHUT DOWN, FCOM PRO.AEP.ENG ]

## 10.4 Engine relight in flight

A graphic showing the envelope for in-flight relight is provided in section ABN.ENG of the EQRH.

Automatic start abort is *not* available — crew action is required in the highly likely event of an abnormal start. Indications of abnormal start include exceedance of N2 or EGT limits and no engine light up within 30 seconds of fuel flow increasing. Additionally, for the NEO, N2 should be greater than 50% within 70 seconds of starting the attempt. It may be necessary to check the engine's response to thrust lever movement to confirm a successful relight.

NEO engines may exhibit a rapid EGT increase to below EGT limit; this is normal and start should not be aborted unless the EGT limit is actually exceeded.

A spurious ENG 1(2) START FAULT - ENG STALL may occur during in-flight start of some CEO engines — a note towards the bottom of the airframe specific EQRH checklist discriminates. Check all engine parameters are normal before disregarding.

To abort a start, simply turn off the engine's master switch; at least 30 seconds should elapse before another attempt is made in order to ventilate the combustion chambers.

To prepare for the start attempt, ensure the affected engine master switch is turned off and the affected thrust lever is at idle. Select ignition on the engine mode selector and open the cross bleed. If it is anticipated starter assist may be required, ensure wing anti ice is selected off.

To begin the start sequence, select the affected master switch on. The FADEC will determine whether starter assist is required and will open the start valve as needed.

[ QRH ABN.ENG, FCOM PRO.AEP.ENG ]

## 10.5 Engine stall

A stall is indicated by abnormal engine noise, flame from the engine exhaust (and possibly inlet in extreme cases), fluctuating performance parameters, sluggish thrust lever response, high EGT and/ or rapid EGT rise when the thrust lever is advanced.

A variety of FADECs are fitted within the easyJet fleet. The earlier FADECs do not trigger an ECAM warning if N2 is above idle, whereas the later FADECs are more capable. The FCTM warns that all FADECs may fail to detect engine stalls in some cases. Crew must therefore be ready to diagnose engine stalls on the basis of the above symptoms and apply the QRH procedures where necessary.

If an engine stall occurs on the ground, shut the engine down.

When an engine stall occurs in flight, the response is airframe specific. For the earlier FADECs, if an ECAM is triggered, the engine is simply shut down. In all other cases (no ECAM triggered on earlier FADECs; later FADECs) an attempt is made to contain the stall without shutting down the engine. The affected thrust lever is retarded to idle and the engine parameters checked. If the engine parameters remain abnormal, the engine is shut down. If, however, the parameters return to normal, stall margin is increased by turning on anti-icing[4] and the thrust levers are slowly advanced. If the stall recurs, the engine can be operated at low thrust settings, otherwise it can be operated normally.

[ ENG 1(2) STALL, QRH AEP.ENG, FCOM PRO.AEP.ENG ]

## 10.6 Engine tailpipe fire

An internal engine fire may be encountered during engine start or shutdown. It will either be seen by ground crew or may be indicated by EGT failing to decrease after the master switch is selected off.

Start by getting the engine to a known state by ensuring the MAN START button is selected off and the affected engine master is selected off.

The concept is to blow the fire out by dry cranking the engine. It is therefore essential that the fire button is *not* pressed, as this will remove external power from the FADEC and prevent dry cranking. Firstly, a source of bleed air must be available to power the starter. Possibilities, in order of preference, are the APU, the

[4]The new QRH procedure for the NEO requires wing anti-ice be turned on whereas that for the CEO requires engine anti-ice be turned on, but both then go on to mention that stall margin is increased by turning on both, albeit at a cost of increased EGT. The old QRH procedure did turn on all relevant anti-icing. I have requested more information and will update this section when I get a response.

opposite engine or a ground air cart. If using the opposite engine, the source engine bleed must be on, the target engine bleed should be off, the cross bleed should be opened and thrust increased to provide 30 psi of pressure. If using ground air, both engine bleeds should be off and the cross bleed opened.

Once high pressure air is available, select the engine mode selector to crank and select the MAN START button to on.

When the fire is extinguished, select the MAN START button off and the engine mode selector to normal.

As a last resort, external fire suppression agents may be used. They are, however, highly corrosive and the engine will be badly damaged.

[ QRH AEP.ENG, FCOM PRO.AEP.ENG ]

## 10.7 High engine vibration

The ECAM VIB advisory (N1≥6 units, N2≥4.3 units) is simply an indication that engine parameters should be monitored more closely. High VIB indications alone do not require the engine to be shut down.

High engine vibration combined with burning smells may be due to contact of compressor blade tips with associated abradable seals.

If in icing conditions, high engine vibration may be due to fan blade or spinner icing. The QRH provides a drill to shed this ice, after which normal operations can be resumed.

If icing is not suspected and if flight conditions permit, reduce thrust so that vibrations are below the advisory level. Shut down the engine after landing for taxiing if vibrations above the advisory level have been experienced.

[ QRH AEP.ENG, FCOM PRO.AEP.ENG ]

## 10.8 Low oil pressure

The sensors for the gauge on the ECAM ENG page and the ECAM warning are different. If there is a discrepancy between the two, a faulty transducer is the most likely cause and the engine can continue to be operated normally. If both sources agree, the engine should be shut down by retarding its thrust lever and selecting its master switch off and the after shutdown procedure applied (see Section 10.3).

[ ENG 1(2) OIL LO PR, FCOM PRO.AEP.ENG ]

## 10.9 High oil temperature

Both engine oil and IDG oil are cooled by heat exchange with fuel. The NEO additionally has an oil to air heat exchanger. The FADEC primarily controls engine oil temperature and fuel temperature by modulating the amount of fuel bypassed back to the tanks.

An ECAM advisory occurs when oil temperature reaches 140°C. The advisory suggests that if oil temperature increase followed a thrust reduction, increasing thrust may contain the problem. It also suggests that it might be an IDG cooling issue; again, if at low speed increasing the engine speed may help, or, if at high speed, you can try reducing the generator load or disconnecting the IDG.

The ENG 1(2) OIL HI TEMP ECAM is triggered if oil temperature exceeds 155°C or exceeds 140°C for 15 minutes. On the CEO the engine is simply shut down. On the NEO an attempt is made to reduce the temperature by reducing thrust, and only if this is unsuccessful is the engine shut down. At time of writing (November 2023) the ECAM actually presented by the FWC on the NEO is incorrect — the correct procedure is currently being promulgated as an OFP attachment.

[ ENG 1(2) OIL HI TEMP, FCOM PRO.AEP.ENG ]

## 10.10 Oil filter clog

If a warning occurs during a cold engine start with oil temperature <40°C, the warning may be considered spurious. The oil filter features a bypass mechanism, so there is no immediate problem.
[ ENG 1(2) OIL FILTER CLOG, FCOM PRO.AEP.ENG ]

## 10.11 Fuel filter clog

No immediate crew action required. I assume there is some sort of bypass mechanism, but this isn't apparent from the FCOM.
[ ENG 1(2) FUEL FILTER CLOG, FCOM PRO.AEP.ENG ]

## 10.12 Uncommanded reverser actuator pressurisation

There are two valves that prevent pressure reaching the thrust reverser actuators at an inopportune moment, plus a third that commands direction of movement. The most upstream of these, controlled by the SECs, prevents any hydraulic pressure reaching the Hydraulic Control Unit (HCU) when the thrust levers are not in the reverse quadrant. If this protection is lost, the correct operation of the HCU should keep the doors properly stowed. An HCU malfunction, however, could result in an in-flight reverser deployment. If flight conditions permit, idle thrust should be selected on the affected engine.

It is unclear from the FCOM whether the ECAM indicates pressure has reached the directional solenoid valve and hence that the reverser door jacks are pressurised, albeit in the closed direction, although the existence of the ENG REV ISOL FAULT ECAM indicates that this is probably the case.
[ ENG 1(2) REV PRESSURIZED, FCOM PRO.AEP.ENG ]

## 10.13 Reverser unlocked in flight

If one or more reverser doors are detected as not stowed in flight, the associated FADEC will automatically command idle on the affected engine. This should be backed up by setting the thrust lever to idle.

A warning without associated buffet is likely to be spurious. In this case limit speed to 300kt/M.78, keep the engine running at idle and expect to make a normal single engine approach and landing.

If there is buffet, shut the engine down and limit speed to 240kt. Full rudder trim may be required. The ECAM will provide one of two approach procedures depending on how many doors are detected as not stowed:

- If all 4 doors are not stowed on CEO or the reverser is deployed on NEO, it will be a CONF 1 landing, with approach speed $V_{REF}$ + 55kt slowing to $V_{REF}$ + 40kt below 800ft. Gear should only be deployed once landing is assured.
- Otherwise, it will be a flap 3 landing at $V_{REF}$ + 10kt for CEO or $V_{REF}$ + 15kt for NEO.

[ ENG 1(2) REVERSE UNLOCKED, FCOM PRO.AEP.ENG ]

## 10.14 EIU fault

The Engine Interface Unit (EIU) receives data from the engine start system, the auto-thrust system, the LGCIUs, the air conditioning controller and the engine anti ice system and feeds it to its related FADEC. Thus loss of the EIU leads to loss of auto-thrust, reverser, idle control (defaults to approach idle) and start for the affected engine. If engine anti ice is used, the ignitors must be manually selected.

If an engine fails whilst its associated EIU is inoperative, the usual ECAM messages will not be generated. The failure can still be diagnosed from the system pages and an appropriate drill can be actioned from the FCOM.

[ ENG 1(2) EIU FAULT, FCOM PRO.AEP.ENG ]

## 10.15 N1/N2/EGT overlimit

If the overlimit is moderate, the associated thrust lever can be retarded until the overlimit ceases, and the flight may be continued normally.

If the overlimit is excessive, the engine should generally be shut down. If there are over-riding factors precluding a shut down, the engine may be run at minimum required thrust.

[ ENG 1(2) N1/N2/EGT OVERLIMIT, FCOM PRO.AEP.ENG ]

## 10.16 N1/N2/EGT/FF discrepancy

The system can detect a discrepancy between actual and displayed values of N1, N2, EGT and fuel flow. This is indicated by an amber CHECK beneath the affected parameter. Attempt to recover normal indications by switching from DMC1 to DMC3. If this fails, values can be inferred from the opposite engine.

[ ENG 1(2) N1(N2)(EGT)(FF) DISCREPANCY, FCOM PRO.AEP.ENG ]

## 10.17 Start valve fault

If a start valve fails open, remove bleed sources supplying the faulty valve. If on the ground, turn off the MAN START button if used, and shut the engine down with its master switch.

If the start valve fails closed, it may be that insufficient pressure is reaching it. Try opening the cross bleed and turning on the APU bleed.

On the ground, a start may still be possible with manual operation of the start valve.

[ ENG 1(2) START VALVE FAULT, FCOM PRO.AEP.ENG ]

## 10.18 Start faults

Start faults include ignition faults (no light off within 18 seconds of ignition start), engine stalls, EGT overlimit (>725°C) and starter time exceedance (2 mins max).

On the ground, nearly all starts are auto starts. In this case the FADEC will automatically abort as needed. It will then automatically carry out the required dry crank phase and make further attempts. Once the FADEC gives up, an ECAM message will instruct the crew to turn off the relevant engine master. If the fault was a stall due to low pressure, consider another automatic start using cross bleed air.

If a manual start is attempted, the crew must monitor the relevant parameters (the FADECs will provide some passive monitoring) and, if necessary, abort the start by turning the engine master and man start button off. The crew must then carry out a 30 second dry crank phase manually. Note that this is not mentioned in the relevant supplementary procedure, nor are the relevant lines displayed on the ECAM. It is probably worth having FCOM PRO.AEP.ENG handy when carrying out manual starts.

Following an aborted start in flight, the engine master should be turned off for 30 seconds to drain the engine. A further start attempt can then be made.

If the electrical power supply is interrupted during a start (indicated by loss of ECAM DUs) turn the master switch off, then perform a 30 second dry crank.

If a fuel leak from the engine drain mast is reported, run the

engine at idle for 5 minutes. If the leak disappears within this time the aircraft may dispatch without maintenance action.
[ ENG 1(2) START FAULT, FCOM PRO.AEP.ENG, EOMB 2.3.8.1 ]

## 10.19 Ignition faults

Each engine has two ignitors. If both fail on a single engine, avoid heavy rain, turbulence and, as far as possible, icing conditions.
[ ENG 1(2) IGN FAULT, FCOM PRO.AEP.ENG ]

## 10.20 Thrust lever angle sensor faults

Each thrust lever has two thrust lever angle (TLA) sensors.

Failure of one sensor only leads to a loss of redundancy; the proviso is that it must have failed in a way that the system can positively detect.

More difficult is when the sensors are in disagreement. In this case, the FADEC makes the assumption that one of the sensors is accurate and provides a default thrust setting based on this assumption:

- On the ground, if neither sensor is in a take-off position, idle power is commanded. If one sensor is in take-off position and the other is above idle, take-off thrust is commanded. This leaves the completely conflicted case of one sensor at take-off and the other at idle or below; the FADEC selects idle power as the best compromise.
- In flight, once above thrust reduction altitude the FADEC will assume that the largest TLA, limited to CLB, is correct. The autothrust can then manage the thrust between idle and this position. For approach (slats extended), as long as both TLAs indicate less than MCT, thrust is commanded to idle.

If both TLA sensors fail, the FADEC again goes for sensible defaults. On the ground, idle thrust is set. In flight, if the thrust was TO or FLEX at the time of failure, this setting will be maintained until slat retraction, whereupon CLB will be selected. If the thrust was between IDLE and MCT, CLB will be selected immediately. As soon as slats are deployed, IDLE is commanded; this remains the case even for go-around. Autothrust will manage thrust between IDLE and CLB whenever CLB is assumed.

[ ENG 1(2) THR LEVER DISAGREE, ENG 1(2) THR LEVER FAULT, ENG 1(2) ONE TLA FAULT, FCOM PRO.AEP.ENG ]

## 10.21 FADEC faults

The FADECs have two redundant channels; loss of a single channel does not generally require crew action. Single channel FADEC faults during start may be considered spurious on successful application of the reset procedure detailed in FCOM PRO.AEP.ENG.

If both channels of a FADEC are lost, the thrust lever should be set to idle. Engine indications will be lost. If all other parameters are normal (check all ECAM system pages), the engine can be left running. Otherwise, shut it down.

If a FADEC overheats, reducing engine power may reduce temperature in the ECU area sufficiently to prevent shutdown. If on the ground the engine must be shut down and the FADEC depowered.

[ ENG 1(2) FADEC A(B) FAULT, ENG 1(2) FADEC FAULT, ENG 1(2) FADEC HI TEMP, FCOM PRO.AEP.ENG ]

# Chapter 11

# Navigation

## 11.1 EGPWS alerts *(memory item)*

EGPWS alerts can be categorised into warnings and cautions. A warning is any alert with the instruction "Pull up" or "Avoid" attached. All other alerts are cautions. A warning may be downgraded to a caution if flying in daylight VMC and positive visual verification is made that no hazard exists, or if an applicable nuisance warning notice is promulgated in Company documentation [EOMA 8.3.6].

The response to a "Pull up" type warning is to call "Pull up, TOGA", disconnect the autopilot and simultaneously roll the wings level, apply full backstick and set TOGA power. The speedbrake should then be checked retracted. Once the flight path is safe and the warning stops, accelerate and clean up as required. Note that it is highly likely that the autothrust ALPHA FLOOR protection will have engaged and thus the autothrust will need to be disengaged to cancel TOGA LK mode.

An "Avoid" warning indicates that a vertical manoeuvre alone is insufficient to prevent collision, and lateral avoiding action must also be taken. The response is essentially the same except that instead of rolling wings level, a turn must be initiated. The direction of the turn is at the discretion of the pilot, with the terrain or obstacle that is the source of the warning being displayed in red and black crosshatch on the ND.

The response to a caution is to correct the flight path or aircraft configuration as necessary. A configuration warning will almost always require a go around.

[ FCOM PRO.AEP.SURV ]

## 11.2 TCAS warnings *(memory item)*

TCAS warnings may be either traffic advisories ("Traffic, Traffic") or resolution advisories (anything else).

From 28th January 2017, new easyJet deliveries are fitted with the new AP/FD TCAS mode. When this mode is fitted, the autopilot is capable of autonomously flying the TCAS escape manoeuvre. PF simply calls "TCAS blue" then calls the FMAs and monitors the autopilot as it flies the manoeuvre. If flying manually with flight directors and autothrust on, the flight directors will give standard guidance to fly the manoeuvre. If flying fully manually, the flight directors will pop up and the autothrust will engage, although it may be necessary to set the thrust levers to the climb gate.

If AP/FD TCAS mode is not installed or not available, the first response to either advisory is to call "TCAS, I have control" to unequivocally establish who will be carrying out any manoeuvres. If it is a resolution advisory, the autopilot should be disconnected and *both* flight directors turned off.[1] The autothrust remains engaged and reverts to speed mode. A vertical manoeuvre should then be flown to keep the V/S needle out of the red areas shown on the V/S scale. ATC should then be notified (e.g "Radar, Easy 123 – TCAS RA"). When clear of conflict, return to assigned level

[1] If one FD is left engaged, the autothrust will not revert to speed mode, possibly resulting in speed decay and engagement of normal law protections.

and re-engage the automatics (ATC phraseology: “Radar, Easy 123 – clear of conflict, returning to FLXXX”).

If a climb resolution advisory occurs on final approach, a go around must be flown.

[ FCOM PRO.AEP.SURV, CAP413 1.7 ]

## 11.3 RNAV downgrades

RNAV operations fall into three main categories:

- RNAV approach (usually RNP 0.3)
- RNP-1 (aka PRNAV)
- RNP-5 (aka BRNAV)

The equipment that must be serviceable is listed in EOMB 2.3.18 for RNAV approach and FCOM PRO.SPO.51 for RNP SID/STAR.

The following messages indicate loss of RNAV capability:

- NAV ACCUR DOWNGRAD (MCDU and ND) on both sides[2]
- FMS1/FMS2 POS DIFF (MCDU)
- NAV FM/GPS POS DISAGREE (ECAM)
- CHECK IRS 1(2)(3)/FM POSITION (MCDU)[3]

[2]If NAV ACCUR DOWNGRAD occurs on one side only, the procedure may be continued using the unaffected FMGC.

[3]This is missing from the RNP-1 list in EOMB but is listed in the FCOM. It is not listed as a go around criteria for RNAV approach, but continuing would seem somewhat brave...

For RNAV approaches, a go-around is mandated for any of these messages or if GPS PRIMARY LOST is annunciated on both NDs[4].

In an RNP-1 (PRNAV) environment, an RNAV downgrade may leave the aircraft unsure of position and below MSA. The initial response is to notify ATC with the phrase "Unable RNAV due equipment" and request reclearance. An immediate climb above MSA should be considered if a suitable alternative navigation method (e.g. radar vectors) is not available.

Some RNP-1 procedures specify additional downgrade criteria such as a requirement for dual RNAV systems or GPS. If GPS is not specifically mandated as an additional restriction, an RNP-1 procedure may still be flown without GPS PRIMARY: set RNP to 1, check NAV ACCURACY is HIGH and carry out a raw data check prior to commencement (see Section 11.10).

Downgrades in an RNP-5 (BRNAV) environment are less critical as the aircraft will be above MSA. The IRSs provides RNP-5 required accuracy for two hours from last full alignment regardless of MCDU ENP, and it is acceptable to carry out a raw data check (see EOMB 2.3.15) to confirm that RNP-5 capability is maintained. If loss of RNP-5 capability is confirmed, inform ATC and continue with conventional navigation.

[ FCOM PRO.SPO.51, EOM A.8.3.3.5, EOMB 2.3.18.3 ]

## 11.4 RA faults

A single RA fault results in degradation of approach capability to Cat 2.

Loss of both RAs will lead to Direct Law at landing gear extension and a loss of ILS APPR mode capability. Therefore, landing

[4] If GPS PRIMARY LOST is annunciated on only one ND, the approach may be continued using the unaffected FMGC. There is also conflict between EOMA and EOMB as to whether GPS PRIMARY is required at all for RNAV(VOR/DME) or RNAV(DME/DME) etc. – I've gone with the most restrictive here.

will be CONF 3 with associated corrections and the approach should be flown in LOC and FPA. The FCTM recommends that the final stages of the approach are flown raw data as the autopilot gains are not being updated and autopilot performance is likely to be unsatisfactory. Height callouts are not available.

[ NAV RA 1(2) FAULT, FCOM PRO.AEP.NAV, FCTM AEP.NAV ]

## 11.5 ADR faults

A single ADR fault simply requires switching to the hot spare and turning the affected unit off. Loss of ADR1 will lead to the loss of the extended functions of the EGPWS. Loss of ADR2 will lead to both baro reference channels being driven by the same FCU channel, so the baro refs should be checked.

Loss of two ADRs will lead to Alternate Law with associated speed restrictions and landing configuration considerations. Air data switching is used as necessary, and the affected ADRs are turned off. ATC switching may be required to restore transponder. If ADR1 and ADR3 are lost, the landing gear safety valve is controlled closed, so the gear must be gravity extended and cannot subsequently be retracted. This is not mentioned by the ECAM – the gear will simply fail to extend normally.

If all three ADRs are lost, the result is airframe dependent. Some of the fleet now have a NAV ADR 1+2+3 FAULT ECAM and an appropriate procedure utilising the Backup Speed Scale, completing with the QRH NAV ALL ADR OFF paper procedure. For older airframes the ECAM displayed will be for Dual ADR failure and must be ignored since it will request meaningless air data and ATC switching. Instead revert to standby instruments (the standby ASI and Altimeter have direct pressure feeds from the the standby pitot and static ports) and refer to QRH NAV ADR 1+2+3 FAULT. Interestingly, when Backup Speed Scale is available, the ECAM advises that the standby instrument indications may be unreliable...

Triple ADR failure has a few additional ramifications. Of note is loss of automatic cabin pressure control (see Section 3.14 for manual pressure control methodology), Alternate Law and gravity gear extension. Of lesser concern are loss of stall warning[5], rudder travel limiter frozen until slat extension and loss of auto flap retraction.
[ NAV ADR 1(2)(3)(1+2)(1+3)(2+3) FAULT, QRH AEP.NAV, FCOM PRO.AEP.NAV ]

## 11.6 ADR disagree

The ECAM message indicates that, following an ADR fault or rejection, there is a speed or angle of attack disagreement between the two remaining ADRs. This will cause a degradation to Alternate Law. If there is a speed disagreement, apply the Unreliable Speed procedure (see Section 2.3). If the speed does not disagree, an AOA sensor is providing incorrect data and there is a risk of spurious stall warnings.
[ NAV ADR DISAGREE, FCOM PRO.AEP.NAV ]

## 11.7 IR faults

In case of simultaneous loss of the ADR and IR associated with an ADIRU, apply the ADR FAULT procedure first.

A single IR fault will simply require ATT/HDG switching. This may lead to loss of the extended functions of the EGPWS and/or loss of TCAS. It may be possible to recover the IR in ATT mode (see Section 11.9).

A dual IR fault will lead to loss of PFD indications on at least one side so use ATT/HDG switching to recover. It will also lead

[5] Most of the easyJet fleet has now been modified so that the stall warning is not lost in the event of triple ADR failure.

to Alternate Law and associated speed restrictions and landing configuration considerations.

[ NAV IR 1(2)(3)(1+2)(1+3)(2+3) FAULT, FCOM PRO.AEP.NAV ]

## 11.8 IR disagree

Following rejection or failure of an IR, there is disagreement between the two remaining IRs. Normal and alternate laws are lost, but alternate law with reduced protections can be recovered by isolating the faulty IR (use standby horizon to cross-check) and resetting the ELACs.

[ NAV IR DISAGREE, FCOM PRO.AEP.NAV ]

## 11.9 IR alignment in ATT mode

If IR alignment is lost, it may be possible to recover attitude and heading information by switching the ADIRU selector to ATT and maintaining level constant speed flight for 30 seconds. The magnetic heading will need to be entered, the exact method being dependent on the ADIRS CDU fitted.

[ IR ALIGNMENT IN ATT MODE, QRH AEP.NAV, FCOM PRO.AEP.NAV ]

## 11.10 FM/GPS position disagree

This can be disregarded if on an ILS or LOC approach. On an overlay approach, revert to raw data. On an RNAV approach, go around unless visual.

In other flight phases, manually tune a VOR and check against either the needle and DME on the ND or the BRG/DIST TO field on the PROG page. If the error is greater than 3nm in the cruise or greater than 1nm for approach, raw data navigation and AP/FD

selected lateral and vertical modes should be used.
[ NAV FM/GPS POS DISAGREE, QRH AEP.NAV, FCOM PRO.AEP.NAV ]

# Chapter 12

# Auto-flight

## 12.1 FAC faults

Failure of a single FAC results in loss of redundancy and hence loss of Cat 3 Dual. In particular, a single FAC provides all the characteristic speeds ($V_{SW}$, $V_{LS}$, $V_{FE}$, $V_{FE\ next}$, $V_{LE}$, $V_{MO}/M_{MO}$, Green dot, S speed and F speed). It may be worth cross-checking against EQRH OPS – OPERATING SPEEDS.

If both FACs are lost the rudder travel limit system, rudder trim control, yaw damper and PFD characteristic speeds are lost and Alternate Law with mechanical yaw control becomes active. Recovery of full rudder authority at flap extension should be anticipated, but use rudder with care above 160kt.

[ AUTO FLT FAC 1(2)(1+2) FAULT, FCOM PRO.AEP.AUTO FLT ]

## 12.2 Yaw damper faults

A single failure leads to loss of redundancy, and hence loss of Cat 3 Dual. On some airframes a reset of the affected FAC can be attempted.

With a dual failure a reset of the FACs should be attempted. If the yaw damper is not recovered, the flight controls revert to Alternate Law (see Section 6.3). Unless the failure occurred below alert height, only Cat 1 will be available.

[ AUTO FLT YAW DAMPER 1(2)(SYS), FCOM PRO.AEP.AUTO FLT ]

## 12.3 Rudder trim faults

Loss of a rudder trim from a single FAC leads to loss of redundancy and hence loss of Cat 3 Dual.

If complete loss of rudder trim occurs, an attempt should be made to reset the FACs. If this is not successful, only Cat 1 is available.

[ AUTO FLT RUDDER TRIM SYS(1)(2) FAULT), FCOM PRO.AEP.AUTO FLT ]

## 12.4 Rudder travel limiter faults

Loss of rudder limit functionality from a single FAC leads to loss of redundancy only.

The effect of complete loss of rudder limiter functionality depends on when the failure occurred.

In general, the rudder should be used with caution when above 160kt.

An attempt should be made to recover the limiter by resetting the FACs. If unsuccessful, full rudder travel authority may or may not be recovered at slat extension. If a landing must be made with the rudder travel limiter frozen in the high speed regime, max crosswind is reduced to 15kt and differential braking may be required on the landing roll (do not arm autobrake).

[ AUTO FLT RUD TRV LIM(1)(2)(SYS), FCOM PRO.AEP.AUTO FLT ]

## 12.5 FCU faults

Loss of a single channel will result in the spare channel automatically taking over. All that is required is a cross check of the baro refs.

Loss of both channels leads to loss of all FCU and EFIS panels. The autopilots, flight directors[1] and autothrust are lost and parameters that are normally controlled by the panels revert to sensible default values. If the weather radar image remains displayed, disregard it since the scale will be incorrect. Since it will only be possible to set the QNH on the standby altimeters, the MDA should not be set in the MCDU; instead the PM should make standard callouts from the standby altimeter.

[ AUTO FLT FCU 1(2)(1+2) FAULT, FCOM PRO.AEP.AUTO FLT ]

[1]Flight Directors will pop up to provide guidance in the event of a go-around.

# Chapter 13

# Hydraulics

## 13.1 Green + yellow systems low pressure

It may be possible to recover the yellow system using the yellow electrical pump. The PTU will need to be turned off in this case, as the yellow electric pump lacks sufficient capacity to pressurise the green system through the PTU. Systems lost because of low air pressure in the reservoir will be recoverable at lower altitudes. Systems lost due to reservoir overheats may be usable for the approach once they have cooled down.

Roll control is available from ailerons and spoiler 3. Pitch control is available from the elevators, but the THS is frozen. Yaw damping is lost. Slats are available, but slow. Flaps are frozen. Control law reverts to Alternate Law without stability protections. The autopilots are lost.

The gear must be gravity extended, but due to the frozen THS this must be delayed until $V_{APP}$ is achieved in CONF 3. Furthermore, transition to CONF 3 must be achieved with the method described in Section 6.1 due to the flaps being frozen. Transition to Direct Law on gear deployment adds to the fun, especially as pitch trim is unavailable.

Cat 2 and 3 capability is lost. The landing will be CONF 3, most probably with only the slats deployed; the flare attitude will be abnormal. There will only be one spoiler (#3), no reversers, accumulator only braking and no nose wheel steering. Hence required landing distances almost triple.

The go around, in some ways, is exceptionally straightforward. The gear cannot be raised and the configuration should be maintained. Due to the frozen stabiliser, a speed close to $V_{APP}$ should be flown.[1] As long as the flaps are frozen at zero, the slats can be retracted for a subsequent diversion; fuel flow will be approximately 3 times normal due to the extended gear. If flaps are not at zero, fuel flow will be up to 4 times normal.

A paper summary is available in the HYD section of the QRH, and this should be applied once all ECAM actions are completed.

[ HYD G + Y SYS LO PR, QRH AEP.HYD, FCOM PRO.AEP.HYD ]

## 13.2 Blue + yellow systems low pressure

It may be possible to recover the yellow system using the yellow electrical pump or the blue system using the RAT. Systems lost because of low air pressure in the reservoir will be recoverable at lower altitudes. Systems lost due to reservoir overheats may be usable for the approach once they have cooled down.

Roll control is provided by ailerons and spoiler 5, pitch control by the THS and left elevator. Slats and flaps are available at reduced rate. The autopilots are lost but Normal Law is retained. Speedbrake is unavailable.

Cat 2 and 3 capability is lost. Landing distances are increased due to loss of spoilers 2, 3 and 4 and loss of #2 reverser. Approach configuration is normal apart from slow flaps and slats and gravity gear extension (protects green system). Nose wheel steering is lost.

[1] Airbus originally suggested flying $V_{FE} - 10$kt; I assume this was found to cause handling difficulties due to pitch trim not being available.

Gear cannot be retracted on go-around. Fuel burn for a subsequent diversion will be significantly greater (approx factor 3 times normal); see Section 9.7 for further details.

A paper summary is available in the HYD section of the QRH, and this should be applied once all ECAM actions are completed.

[ HYD B + Y SYS LO PR, QRH AEP.HYD, FCOM PRO.AEP.HYD ]

## 13.3 Green + blue systems low pressure

If the blue system has been lost due to the loss of its electrical pump, it may be recovered by deploying the RAT. Systems lost because of low air pressure in the reservoir will be recoverable at lower altitudes. Systems lost due to reservoir overheats may be usable for the approach once they have cooled down.

Roll control is provided by spoilers 2 and 4 only. Use of speedbrake would therefore lead to loss of roll control. Pitch control is available from the starboard elevator; the THS remains available. Due to the limited control surfaces available, the aircraft will be slightly sluggish. The slats are frozen, but flaps are available. Control law reverts to Alternate Law without stability protections. The autopilots are lost. The approach will be flown with the autothrust off.

Due to the frozen slats, configuration changes must be carried out using the method described in Section 6.1. The gear must be gravity extended; to benefit from the improved elevator response available in Direct Law, this is done at 200kt. Manual trim will be available.

Cat 2 and 3 capability is lost. The landing will be CONF 3. Two spoilers per wing are available, reverser 2 is available, alternate braking is available and nose wheel steering is available. Landing distances approximately double.

Go around is straightforward – the gear cannot be retracted and the flap configuration should be maintained. Simply select

$V_{FE}$ − 10kt. For diversion, the flaps can be retracted. With the gear remaining down, fuel burn will increase by a factor of approximately 3 if the slats are at zero or up to approximately 3½ if they are extended.

A paper summary is available in the HYD section of the QRH, and this should be applied once all ECAM actions are completed.

[ HYD G + B SYS LO PR, QRH AEP.HYD, FCOM PRO.AEP.HYD ]

## 13.4 Green system low pressure

The major lost systems are normal landing gear operation (gravity extension is available but gear retraction is not) and the normal brake system, including the autobrake (alternate braking is available). Landing distance will be increased due to loss of two spoilers per wing and reverser 1. Flap and slat deployment will be slow.

[ HYD G SYS LO PR, FCOM PRO.AEP.HYD ]

## 13.5 Yellow system low pressure

It may be possible to recover the yellow system by using the yellow electric pump.

Two spoilers per wing and reverser 2 are lost, so landing distance will increase slightly. Nose wheel steering is lost. Flap deployment will be slow. As the alternate braking system is only available through the brake accumulator, ensure there is sufficient pressure when the parking brake is set.

[ HYD Y SYS LO PR, FCOM PRO.AEP.HYD ]

## 13.6 Blue system low pressure

One spoiler per wing will be lost but this has negligible effect on landing distance. Slats will be slow to deploy. Deployment of the RAT is not recommended unless another system is lost. If the system is lost due to low reservoir level, emergency generation capability is lost.

[ HYD B SYS LO PR, FCOM PRO.AEP.HYD ]

## 13.7 Engine driven pump low pressure

Turn off the affected pump. The PTU will pressurise the affected system.

[ HYD G(Y) ENG 1(2) PUMP LO PR, FCOM PRO.AEP.HYD ]

## 13.8 Electric pump low pressure or overheat

Turn off the affected pump. In the case of an overheat, the pump may be re-engaged for the approach providing the relevant FAULT light on the overhead panel has extinguished.

[ HYD Y(B) ELEC PUMP LO PR(OVHT), FCOM PRO.AEP.HYD ]

## 13.9 Low reservoir air pressure

Loss of air pressure to a hydraulic reservoir may lead to pump cavitation and hence fluctuating pressures. If this occurs, turn off the affected pump, and if applicable, turn off the PTU. Cavitation reduces with altitude, so it may be possible to reinstate the system during the descent.

[ HYD G(Y)(B) RSVR LO AIR PR, FCOM PRO.AEP.HYD ]

## 13.10 Reservoir overheat

Turn off all affected pumps and if applicable, turn off the PTU. The system should be reinstated for the approach if it has cooled

sufficiently. This is indicated by the FAULT light going out on the overhead panel.
[ HYD G(Y)(B) RSVR OVHT, FCOM PRO.AEP.HYD ]

## 13.11 Low reservoir fluid level

Turn off all affected pumps and, if applicable, turn off the PTU. The affected system is not recoverable. In the case of low reservoir level in the yellow system, it is possible that the fluid from the brake accumulator may also be lost. This usually occurs within 10 minutes of the initial warning. Without the brake accumulator, the parking brake is not available, so chock the aircraft before shutting down engine 1.
[ HYD G(Y)(B) RSVR LO LVL, FCOM PRO.AEP.HYD ]

## 13.12 PTU fault

In flight this indicates that either the green or yellow system is low on fluid and has low system pressure. The PTU must be turned off to prevent overheating the supplying system.
[ HYD PTU FAULT, FCOM PRO.AEP.HYD ]

## 13.13 RAT fault

Indicates that either the RAT is not fully stowed, pressure is present in the RAT stowing actuator or that the RAT pump is not available. No action is required.
[ HYD RAT FAULT, FCOM PRO.AEP.HYD ]

# Chapter 14

# Ice and rain protection

## 14.1 Window heat fault

Windshield heat for PF is non FMGS monitored required equipment for CAT2/3 landings — see EQRH OPS. Other than that, there is no immediate operational effect.

[ ANTI ICE L(R)(L+R) WINDSHIELD(WINDOW), FCOM PRO.AEP.A-ICE ]

## 14.2 Multiple pitot heat failures

The issue with loss of anti-ice on more than one pitot probe is that it is possible that the two unprotected pitot probes will ice up at the same time and provide erroneous but coherent data. This leads to a situation where the ADR associated with the remaining protected probe is locked out despite being the single correct source.

Obviously, the first thing to do is to avoid icing conditions.

If there is a working ADR connected to a protected probe, turn one of the ADRs associated with an unprotected probe off. This ensures that an ADR DISAGREE ECAM caution is triggered by significant speed discrepancies and ensures that the protected ADR will not be automatically deselected.

If pitot heat is lost on all probes, one of the ADRs should, again, be turned off to ensure the ADR DISAGREE ECAM caution is provided. If icing is expected, turn off a second ADR and be ready to apply unreliable airspeed procedures (see Section 2.3).
[ ANTI ICE ALL(CAPT(F/O)+F/O(STBY)) PITOT, FCOM PRO.AEP.A-ICE ]

## 14.3 Single pitot probe heat or static port heat fault

The ADR associated with the failed probe or port should be considered unreliable. ADR1 or ADR2 can be replaced with ADR3 using air data switching. If using standby instruments with ADR3 unreliable, air data information must be monitored closely.
[ ANTI ICE CAPT(F/O)(STBY) PITOT(L(R) STAT), FCOM PRO.AEP.A-ICE ]

## 14.4 Double AOA heat fail

If two AOA probes are affected by icing, the computers may erroneously deselect the remaining good ADR. Switching off one of the affected ADRs leaves the system in the state described in Section 11.6.
[ QRH AEP.A-ICE, FCOM PRO.AEP.A-ICE ]

## 14.5 Single AOA or TAT heat fault

No immediate operational effect.
[ ANTI ICE CAPT(F/O)(STBY) AOA(TAT), FCOM PRO.AEP.A-ICE ]

## 14.6 Probe heat computer failure

If applicable, deselect the affected ADR.
[ ANTI ICE CAPT(F/O)(STBY) PROBES, FCOM PRO.AEP.A-ICE ]

## 14.7 Engine anti-ice valve fault

If a valve fails to open when commanded, avoid icing conditions. If it fails to close when commanded, a thrust limit penalty applies.
[ ANTI ICE ENG 1(2) VALVE OPEN(CLSD), FCOM PRO.AEP.A-ICE ]

## 14.8 Wing anti-ice valve faults

If a wing anti-ice valve is open when commanded closed:

- In the air, just allow the failed side to be continually anti-iced and use wing anti-ice on the working side when required. A thrust limit penalty will apply.
- On the ground, if this occurs after the ground self-test, simply switch off the wing anti-ice with the PB. Otherwise, isolate and depressurise the pneumatic system on the failed side.

If a wing anti-ice valve is closed when commanded open, the wing anti-ice must be turned off to avoid asymmetrically de-icing the wings. Avoid icing conditions. If ice accretion does occur, landing distances and $V_{APP}$ adjustments are in QRH and speed must be maintained above either $V_{LS}$ + 10kt or Green Dot.
[ WING ANTI ICE SYS FAULT, FCOM PRO.AEP.A-ICE, FCOM PRO.NOR.SUP.AW ]

# Chapter 15

# Indicating/Recording

## 15.1 Display unit failure

Intermittent flashing of DUs may be indicative of a generator issue. If CM1 DUs are flashing, try turning off generator 1. If CM2 DUs are flashing, try turning off generator 2. The APU generator can be used if successful.

In the case of a blank DU, a large amber "F", a distorted display or minimum brightness, on some airframes a reset may be attempted by selecting the DU brightness off then back on. If the reset is not applicable or the DU does not recover after 10 seconds, the affected DU can be turned off. In the case of an INVALID DISPLAY UNIT message, an automatic recovery attempt is initiated; this can take 40 seconds or more. If automatic recovery does not succeed, the DU can be turned off.

An INVALID DATA message is indicative of a DMC problem; EIS DMC switching may recover the DU, as may turning the DU off then on. It is possible that this message will appear simultaneously on *all* DUs; this initiates an automatic recovery attempt, which, again, can take 40 seconds or more. DUs that are not automatically recovered may be recovered manually by sequentially turning them off for 40 seconds then back on. If resetting a DU triggers a recurrence of the original problem, leave that DU off for the next recovery cycle.

In the event of an unrecoverable failure of a display unit, some automatic display switching will occur: PFD will auto-transfer to NDUs and EWD will auto-transfer to SDU. Each pilot has a PFD/ND XFR button that allows their PFD to be toggled onto their NDU and their ND to be toggled onto their PFDU. An ECAM/ND XFR switch on the switching panel allows either the SD (when SDU **xor** EWDU failed) or EWD (SDU **and** EWDU failed) to be displayed on an NDU.

The most likely end result of a DU failure is that one ND must be shared and/or that the SD is not displayed. The ECAM can be operated with just the EWD. When a SYS page is needed, press and hold the required SYS page button. When STATUS is required, press and maintain the STS key. The EWD will be displayed 2s after the STS key is released. To access STATUS overflow, release then repress the STS key within 2s.

[ QRH AEP.EIS, FCOM PRO.AEP.EIS ]

## 15.2 Multiple spurious ECAM alerts

A faulty DMC can cause multiple spurious ECAM alerts (spurious as confirmed by SD pages). The EIS DMC switch should be used to identify the faulty DMC and replace it with DMC3.

[ QRH AEP.FWS, FCOM PRO.AEP.FWS ]

## 15.3 Flight Warning Computer failure

The two identical FWCs generate alert messages, memos, aural alerts, and synthetic voice messages. Loss of a single FWC leads to downgrade to Cat 3 Single due to loss of redundancy. The major effects of loss of both FWCs are loss of ECAM (including attention getters, status page and takeoff/landing memos), loss of auto callouts[1] (radio height and decision height) and loss of altitude alerting. In the sim, there is also loss of rudder trim reset, loss of APU fuel valve status and loss of cabin crew call alert as side-effects.

The procedure is simply to use the SYS pages and overhead panel warning lights to monitor the systems, and for PM to make the relevant callouts. Alternative method for cabin crew to get flight deck attention may be required.

[ FWS FWC 1(2)(1+2) FAULT, FCOM PRO.AEP.FWS ]

[1]There is some question as to whether windshear and GPWS aural alerts are included under 'auto callouts'. The FCOM is unclear on the matter.

# Chapter 16

# Pneumatic

## 16.1 Dual bleed failure

The historical failure case where supplying two packs from one bleed would overload it and cause it to fail appears to have been resolved. Furthermore, recent airframes have four new ECAM procedures associated with dual bleed failure, the variants based on whether neither, either or both bleeds have failed due to a wing or pylon leak on its respective side. The ECAMs all hand off to a new QRH paper procedure if no successful reset is achieved. Older airframes make do with just the QRH procedure.

Whilst the procedures look complex, the underlying philosophy is fairly simple:

- A depressurisation will be underway. It should be relatively slow, but unless a successful reset is achieved immediately, a prompt descent to FL100/MFA needs to be initiated.
- A bleed lost to a wing or pylon leak is lost for good, whereas a simple bleed fault or bleed low pressure may be recoverable. The cross bleed should be shut and the wing anti-ice should be off before an attempt is made to recover a bleed.

- A leak on the left side precludes the use of the APU bleed for pressurisation, but otherwise the APU bleed can be used to supply pack 1 when below 22500ft. If pack 1 is unavailable, the APU bleed can supply pack 2 via the cross bleed provided the whole pneumatic system is available.

In line with this philosophy, both the ECAM and QRH procedures start by shutting the cross bleed and turning off the wing anti-ice. The ECAM procedures each then attempt an immediate recovery of any recoverable bleed by cycling the bleed off then on. The QRH attempts an immediate recovery only in the case that both bleeds are potentially recoverable.

If no bleeds are recovered, the bleeds are all turned off and a descent to FL100/MFA is initiated. At this point, the ECAM procedures join the QRH procedure.

During the descent the APU is started. If the left hand side of the pneumatic system is available, at attempt to use the APU bleed for pressurisation is made at FL200. If this is successful, the descent is stopped at FL200 and a further attempt is made to reset the engine bleeds.

If APU cannot be used for pressurisation descent must be continued. When level at FL100/MFA, a final attempt is made to restore any available engine bleeds. If unsuccessful, the flight is completed with ram air.

[ AIR 1+2 BLEED FAULT (LEFT(RIGHT) LEAK (AND RIGHT LEAK)), QRH AEP.AIR, FCOM PRO.AEP.AIR ]

# Chapter 17

# Communications

## 17.1 Communication failure (ICAO)

If all attempts to establish contact fail, transmit message twice on designated channel, proceeded by the phrase "Transmitting Blind."

Set Mode A Transponder Code to 7600.

If in VMC, continue in VMC to the nearest suitable airfield and land, reporting arrival to appropriate ATS by the most expeditious means.

If in IMC or unlikely to be able to maintain VMC:

- If in airspace where a **procedural** separation service is being applied, maintain speed and level, or minimum flight altitude if higher, for a period of **20 minutes** following failure to report over a compulsory reporting point, then adjust level and speed in accordance with flight plan.

- If in airspace where an ATS surveillance system is in use, maintain speed and level, or minimum flight altitude if higher, for **7 minutes** after Code 7600 is set, then adjust level and speed in accordance with flight plan.

- If being radar vectored or having been directed to proceed offset using RNAV without specified limit, rejoin the flight plan route no later than the next significant point.

- On reaching the appropriate NAVAID or fix serving the destination aerodrome, hold if necessary, then at EAT, or if no EAT has been received and acknowledged, computed flight plan ETA, commence an appropriate instrument approach procedure. If possible land within 30 minutes of this time.

- Watch for visual signals from the tower:
  - Red Pyro: Permission to land cancelled
  - Flashing Red Light: Land elsewhere
  - Continuous Red: Give way to other aircraft, continue circling
  - Flashing Green: Return to circuit, await landing clearance
  - Continuous Green: Permission to land

## 17.2 Communication failure (UK airspace)

The UK procedures expand on the ICAO procedures:

- If following a SID fly the published lateral and vertical profiles, including any step climb, until the last waypoint of the procedure is reached. Maintain current speed and last assigned level (or minimum flight altitude if this is higher) until **7 minutes** have elapsed since setting 7600. Then adjust speed and level in accordance with current flight plan. This procedure also applies to RNP-1 (PRNAV) departures.

- If following a STAR, follow the lateral profile but maintain current speed and last assigned level (or minimum flight altitude if this is higher) until **7 minutes** have elapsed since setting 7600. Subsequently, arrange descent to be as close as possible to published planning profile. If no profile is published, arrange to be at the IAF at minimum published level. This procedure also applies to RNP-1 (PRNAV) arrivals.

- If under radar vectors from Approach Control Radar, comply with instructions on radar vectoring chart. If under radar vectors without specified limit from other ATS unit, continue in accordance with last instructions until **3 minutes** have elapsed since setting 7600, then proceed in most direct manner to rejoin current flight plan route. If necessary, climb to minimum flight altitude.

- If performing an SRA, continue visually or by using an alternate approach aid. If this is not possible, carry out a missed approach and continue to the holding position of a suitable aerodrome with a notified instrument approach and carry out that procedure.

[ ICAO ANNEX 10, ICAO DOC 4444, UKAIP ENR 1.1.3.4 ]

## Chapter 18

# Miscellaneous Tips

- When configuring, $V_{LS}$ is more critical than $V_{FE}$, which in turn is more critical than manoeuvring speeds (S and F speeds). Both $V_{LS}$ and $V_{FE}$ are trustworthy with jammed flaps/slats.
- When configuring on approach, flaps do not begin to extend until CONF 2 is selected.
- Slat position does not change between CONF 2 and CONF 3.
- Dual hydraulic failure fundamentals:
  - You will *always* need to gravity extend the gear, so you will never be able to retract it on the go-around.
  - If you only have blue, you lose the flaps; if you only have yellow, you lose the slats. The flaps/slats jammed procedure (including go-around modifications) is therefore incorporated into both these procedures.
  - If you only have blue or yellow, it will be a Direct Law landing; Normal Law is retained if green is available. Direct law is triggered by gear extension. If you only

have blue, the THS is frozen, so you need to trigger Direct Law *late* (at CONF 3, $V_{APP}$) to get neutral trimming of the elevators. If you only have yellow, the aircraft handling is sluggish; trigger Direct Law *early* (at 200kt) to improve responsiveness.

– You're going to need a longish runway. Worst case is if you only have blue, since you have, at best, accumulator braking and you're coming in fast due to lack of flaps. Yellow is better since you have alternate braking, and its mainly about the lack of slats. If you have green, its not really all that bad.