GUIDANCE ON THE SIMULATION OF ENGINE FAILURE IN AIRPLANES
SAFETY NOTES FOR COMPANY TRAINERS

There are many aspects to be considered when flight training or testing is conducted in airplanes instead of simulators. Much depends on the depth of the training planned, and what training situations are permitted in the airplane. The information provided below does not apply if the characteristics of a particular airplane make the exercise unworkable, impractical, or hazardous. The trainer should observe any guidance and limitations in the Flight Manual, as well as any restrictions applied by the company and the airworthiness authority. The trainer should consider:

PRE-FLIGHT PREPARATION

- The composition of the operating crew
- Which seats will be occupied by whom (the examiner should occupy a pilot's seat)
- Whether an additional safety pilot should be carried to monitor the drills from the jump seat and provide an extra pair of eyes
- The suitability of:
  - Airfield/airspace for training, including alternative airfields
  - Weather - cloud, visibility, surface wind, possible icing
  - Crosswind for simulated engine failure
  - Runway condition for simulated engine failure – wet/contaminated limitations
  - Aircraft serviceability
  - Optimum fuel state
  - Runway length adequate for touch-and-go landings
  - Runway width adequate for engine cuts and abandoned/rejected takeoffs (ATO/RTO)
  - Aircraft de-ice

PRE-FLIGHT BRIEFING

- Responsibilities of each individual, including those of the safety pilot, if carried
- Use of checklists – when a "Training Checklist" will be in use
- Power settings, speeds, gear/flap limits
- Method of taking/handing over control
- Handling of real emergencies
- Taxiing, thrust settings, braking techniques, turning circles
- Takeoff techniques, rotation, pitch angles (tail scrape)
- RTO action, engine-out takeoff (if allowed) and V_{MCG} speed
- Flight Director logic – limitations in single-engine flight

- Minimum height for actual engine shutdown
- Minimum heights/speeds for stalling
- Conditions for stalling – clear of cloud, good horizon, aircraft configuration
- Incipient or full stall recovery techniques
- Landing techniques, flare, maximum pitch (tail scrape)
- Action/calls during touch-and-go landings
- Use of speed bugs – training speeds, target speeds on go-around, minimum speeds
- V_2 calculations and interpretation of V_2 on go-around

INFLIGHT HANDLING

- "Following through" during takeoff/landing/touch-and-go
- Taking control/use of autopilot for debrief/instruction
- Attention to gear/flap limit speeds
- Crosswind factor for engine failure practice
- Simulation of engine failure, zero-thrust setting
- V_{MCG} consideration
- The relationship between V_{MCA} and V_2 at low weights (V_{MCA} increases with angle of bank – reminder of maximum bank angle at V_2)
- Maximum speed for RTO practice (if allowed)
- Brake cooling considerations
- Method of restoring power after an asymmetric exercise
- Airspace/lookout/ATC coordination
- V_{MCA} demonstrations – precautions/minimum height
- Liaison with ATC for emergency descent practice
- Airport/circuit procedures
- Clear instructions prior to and during touch-and-go landings
- Avoidance of "landing on one engine, then rolling on two engines"
- Positive decision to stop if brake/speed brake/reverse is used inadvertently
- Use of reverse thrust
- Early decision to go-around from long and fast approach
- Incapacitation – how to simulate, how far to continue

Amplification on the topics above will be necessary to ensure all training personnel maintain the same high standards. Company Operations Manuals or Training Manuals should include very specific guidelines. These take the form of Standard Operating Procedures for training flights (Training SOPs), general limitations and aircraft handling notes. Here are some examples as to what additional details might be appropriate:

- Training airfields can be specified and preferred training airspace defined.
- Minimum altitudes and the need for a good horizon for stalling exercises should be specified. Airplanes with an artificial stall protection system will

also require minimum flight speeds at which recovery will be initiated if stickshaker or stickpusher has not occurred.

- Other criteria may be given for upper air work – e.g., demanding exercises should be conducted in visual conditions (clear of cloud). If the airplane has penetrated into icing conditions, it is unwise to continue maneuvers if there is a risk that flying controls or airplane surfaces are contaminated. Note that de-icing fluid is also a contaminant.
- Minimum cloud base, inflight visibility and surface wind can be stipulated for circuit work for each aircraft type.
- Provision of a Training Checklist that covers multiple circuits, to allow for simplified circuit checks. Training Checklists must only be issued to trainers.
- A stated maximum crosswind for simulated engine failure. For larger airplanes, this should not be more than 15kts, but smaller airplanes may need a lower limit. Apart from handling considerations, crosswind conditions make it difficult to monitor rudder input and detect any degree of incorrect or insufficient movement.
- A minimum runway length for touch-and-go landings should be determined and published. The parameters used in the derivation of minimum length, such as weight, altitude, temperature, tailwind, wet or dry runway, and additional safety factors should also be given.
- Individual responsibilities during touch-and-go must be clear – who resets trim/flaps, etc.
- A suitable runway width for engine cuts/rejected takeoffs should be specified, if this maneuver is allowed.
- Abandoned/rejected takeoff – Joint Aviation Authorities (JAA) rules [Europe] encourage RTO practice to be accomplished in a simulator. Company policy should be clear and follow the appropriate regulatory guidance. If in-airplane RTOs are permitted and practiced, the method to be used should be stated, and a speed restriction of not more than 50% V_1 should be imposed.
- Engine-out on takeoff. Company policy must be very clear so that trainers have no doubt about what is permissible and what is not. There are two schools of thought as to the wisdom of simulating an engine failure on the runway or shortly after takeoff. Some find the concept of a V_1 cut on the runway completely abhorrent, whereas others believe there is an essential training need to conduct the training in-airplane if no simulator is available. Still others would prefer to practice all engine-out work at altitude, thereby avoiding the risks associated with critical maneuvers close to the ground. Regulatory authorities may prohibit certain practices or may specify minimum heights. Note that many accidents have resulted from conducting engine-out training near to the ground.

Notwithstanding the above disclaimers, the following is necessary information for all those who train for the engine-out scenario by whatever means.

TRAINING STANDARDS

Trainers should be checked regularly to verify competence in briefing, initiating and handling engine-out situations. There should be particular emphasis on student mishandling. For safety reasons, this last topic should be dealt with by discussion, unless a simulator is available for Instructor/Examiner training.

ASYMMETRIC TRAINING

Simulated failures on the runway after V_1 are potentially very hazardous. Consequently, many organizations and individuals consider it an area best avoided. European JAA policy allows simulated engine failures as soon as safety considerations permit after passing V_2. Any additional restrictions addressing minimum speeds and heights for engine failure drills should be observed.

Engine failure training close to the ground is simulated by a power reduction. The best method of simulation of engine failure through power reduction will vary from one class of airplane to another. The rate of power lever retardation should simulate normal engine deceleration. All drills close to the ground should be touch drills only.

The recommended minimum altitude for actual engine shutdown in a turboprop for training purposes is 5,000 feet. This can be reduced to 4,000 feet in four-engine airplanes, and 3,000 feet for smaller aircraft below 12,500 lbs (5700 kgs). These recommended minimum heights are listed in the Appendix at the end of this section.

Trainers should be aware that simulating engine failure by throttling back to idle to train for manual feather produces a much higher drag condition than certification requirements may have considered. Certification usually assumes that autofeather, NTS, or other drag-limiting devices are operative. This potentially hazardous situation can rapidly lead to control difficulties in some airplanes. Therefore, simulation of an engine failure by setting zero thrust at the outset is the recommended option. The training captain must know the torque value (zero thrust) for the equivalent drag of a fully-feathered propeller.

Trainers should also be aware that autofeather or other low-drag safety devices are inhibited with one engine throttled back. In the event of a real failure of the 'failed' engine, a high-drag situation will result unless the retarded engine control is immediately advanced to match the other, or a manual feather is carried out.

Immediately before the failure is simulated, the training captain's feet must be positioned such that any application of wrong rudder by the trainee can be prevented. Throughout the exercise, the training captain must be particularly vigilant in monitoring airspeed, heading, pitch and roll attitude, rudder position, and yaw indication. The training captain must also carefully monitor engine instruments, especially on those types of airplanes in which a genuine failure of the idling engine would produce an abnormal hazard. Recommended bank angle toward the ‘live’ engine should be applied, as well as ‘live’ engine power setting. After ensuring safe initial control application, the training captain should monitor the trainee's rudder input by testing lightly on the rudder pedals. Any tendency for flight parameters to move significantly from their target values must be pointed out to the trainee. The training captain must take control if the airspeed reduces below V_2 due to an incorrect technique such as excessive nose-up attitude.

Spool-up times to restore thrust from low-power settings should also be taken into consideration.

Simulated engine failures after a touch-and-go, or go-around, are not recommended because the speed bugs will be pre-set for the approach and landing.

V_{MCA} DEMONSTRATIONS

While V_{MCA} demonstrations can allow pilots to see the effects of a loss of airspeed, the onset of uncommanded yaw and roll at V_{MCA}, and to learn the correct recovery technique, some organizations have restricted or eliminated these demonstrations in the airplane. Many fatal accidents have occurred as a result of letting airplane speed drop below V_{MCA} near the ground. Furthermore, not all aircraft are suitable for inflight demonstrations of V_{MCA}. Where permitted, this exercise must be conducted only at a safe altitude with an instructor who is both knowledgeable in the particular airplane’s characteristics and proficient in recovery. A prompt recovery is essential to ensure that yaw/roll couple does not develop to any extent; otherwise, the altitude loss will be excessive and airframe limitations may be exceeded. Recovery should be accomplished by lowering the nose to regain airspeed and reducing power on the “live” engine as soon as symptoms of departure from controlled flight are seen (yaw and roll). This will occur very shortly after full rudder and aileron deflection has been achieved.

Only at a height that is known to be safe in relation to the control characteristics of the airplane should the training captain demonstrate, or permit the occurrence of, an actual loss of directional control. Loss of control can be identified by the limiting deflection of any one control surface or the failure to arrest yaw and roll motion; actual loss of control must not exceed conditions where it is only necessary to increase airspeed and reduce power in order to regain control.

It is unwise to conduct demonstrations of aircraft handling and performance if there is any risk that the flying or control surfaces are contaminated. Similarly,

V_{MCA} demonstrations should not be conducted if the aircraft has penetrated icing conditions, as the aerodynamic condition of the aircraft will be unknown.

Note that flight simulators may not always simulate realistically in the corners of the flight envelope.

CONCLUSION

The above notes provide general principles for guidance purposes only. What may be a suitable method of simulating an engine failure for a particular type of aircraft/engine may not be appropriate for another type. Trainers must be technically knowledgeable, and fully aware of the effects of their actions with regard to the potential hazards that exist when simulating emergencies in airplanes. Adequate safety margins must always be maintained throughout each training or testing exercise.

APPENDIX

(adapted from UK CAA AIC 52/1999)

RECOMMENDED MINIMUM SAFE HEIGHTS FOR COMPLETE SHUTDOWN OF A POWERPLANT FOR TRAINING PURPOSES

Piston or turboprop airplanes with Maximum Total Weight (MTWA) not exceeding 12,500 lbs (5700 kg)	3000 ft agl
Four-engine airplanes (Note 1)	4000 ft agl
Twin-engine piston or turboprop airplanes with MTWA exceeding 12,500 lbs (5700 kg)	5000 ft agl
Triple-engine turbojet or turbofan airplanes	5000 ft agl
Twin-engine turbojet or turbofan airplanes	8000 ft agl

Note 1: For four-engine performance, this height may be reduced to 1500 ft above ground level provided that the airplane's instantaneous weight will permit a gross rate climb of at least 200 feet per minute in the two-engine-out enroute configuration.

Note 2: It is recognized that, for certain airplane types, some regulatory authority's Airworthiness Flight Test Schedules require engine shutdown for performance measurement at lower heights than those tabulated above. Appropriately-qualified pilots conduct such flight tests; the heights in this Appendix are considered to provide minimum safety margins for pilot training and testing.

Note 3: Since different types of airplanes have widely-differing characteristics, the advice of the manufacturer should be sought if there is any doubt about the safety of methods and procedures to be adopted.