It's what your left arm's for

…and your brain! **Richard Mornington-Sanford** warns against collective laziness

This 'harp' is for all those pilots out there who think that they do not need to keep their hand on the collective lever at all times during flight.

There will be occasions when you will have to take your hand off the lever to carry out essential tasks. However, once the task has been completed, the hand should immediately return to the collective.

The collective lever is a primary flight control, and in a lot of cases also includes the engine primary control – the throttle. There are two things we need to consider:
Pilot reaction time: the time it takes the pilot to recognise a problem (in this case an engine failure) and react to it.
Intervention time: the amount of time available to the pilot before the situation becomes unrecoverable.

Reaction time is a measure of the speed with which a pilot responds to some sort of stimulus. Reaction should not be confused with reflex; they might seem similar but are quite different. The human has various sense organs through which he or she feels and responds to stimuli. The response can be voluntary or involuntary. Reflexes are involuntary – they are there to protect the body and are faster than reactions. In a normal reaction, the sensory nerves carry the information to the brain, which evaluates and sends a message to the motor nerves to respond to the stimulus in a particular manner. This is not the case with a reflex action. Although sensory nerves are still involved, they carry the message only as far as the central nervous system, and then quickly back to the motor nerves. This has bypassed the brain, and therefore you do not have to spend time thinking about the stimulus. So a reflex is faster than a reaction.

It should be noted that the human will react to an audible stimulus quicker than to a visual stimulus.

Reaction time depends on various factors:
Perception: seeing, hearing and feeling the stimuli with certainty.
Processing: good reaction time requires the pilot to be focused and have a good understanding of the stimulus. Processing will be slowed down by distraction, but speeded up by training.
Response: motor agility – the ability to be able to move the body quickly, which also requires strength and coordination. This too can be improved with training.

The pilot's response to an engine failure will be a reaction response (the brain is involved) and not a reflex response. Training will help to speed up the response by speeding up the processing and increasing motor agility.

Let's look at the first indication of a sudden and complete loss of engine power: an uncommanded yaw, its direction dependent on the direction of the main rotor rotation.

The eyes will pick up visual stimulus (yaw). The response will be voluntary – it requires the brain to process the information and come up with a response, and to stimulate the motor nerves to move your foot to correct the yaw. The brain will also be cross-checking memory to see if this stimulus has been associated with any other response requirements (in training), and in the case of engine failure the brain will link the stimulus to a further response requirement and will stimulate the motor nerves to cause your left arm to lower the collective lever.

This all takes time. Now, if your hand is not on the collective lever at this point, then the brain has further work to do. It has to determine the hand's position and determine the location of the collective lever in relation to your hand position from memory, then stimulate the motor nerves to move your arm from its current position to the collective lever, then further stimulate the arm to lower the collective lever. This requires a further increment of time, the length of which may partly depend on why your hand was away from the lever.

Distraction will slow down brain processing. What level of pilot distraction is there at the point of the engine failure?

Firstly, is the pilot looking out? If so, then the visual stimuli will have good 'certainty', which will result in quicker processing and therefore a quicker response.

If not, then the stimuli will be the

pilot's muscles feeling a change in 'g' forces acting upon them. Without visual stimuli to add certainty, the brain has a lot of processing work to do to come up with a response. Does it have memory of such a situation? If it does, then this will speed up the response. If not, the response will take longer.

Secondly, what workload is the brain under when the engine stops? Is the pilot manually changing a radio or transponder frequency? Is he programming the navigational system? These tasks are a greater distraction if the pilot is unfamiliar with the task.

Is there stress involved because the pilot has become lost or unsure of his or her position? If stress is involved, then working capacity is reduced further, increasing the processing time and in turn the response time.

Fatigue, hydration, health, fitness, stress levels, training, experience, currency in emergency actions, alertness, phase of flight, personality traits etc, will all affect perception, processing and response.

Given the above, we can see that there will be a time increment involved before the collective lever is lowered in response to an engine failure, and the response time will depend on many factors.

So the question is, what is going to keep the main rotor RPM above stall during this event?

Stored energy: When the engine stops, the pilot has three available areas of stored energy – kinetic energy stored in the main rotor (mass x RPM); kinetic energy stored in the forward speed (aircraft mass x speed); and potential energy stored in the height above ground level (aircraft mass x height). Two of these are immediately available, and one may possibly become usefully available, subject to the correct and timely use of the other two.

Intervention time: At the moment the engine stops, the energy being used to drive the main rotor blades is the kinetic energy stored in the main rotor. The amount of kinetic energy available will depend on the aircraft type. In all cases, the main rotor will be using the energy stored within it, and as that energy is used the main rotor RPM will be reducing, the speed of the reduction in RPM being dependent on the amount of kinetic energy stored, plus a few other factors like aircraft weight. The heavier the aircraft, the more lift required to keep it airborne, therefore the greater the main rotor blade collective pitch angle required to produce that lift. High main rotor blade collective pitch angles require more energy to keep them rotating, therefore they will use the stored energy quicker, giving a faster reduction in rotor RPM than lighter aircraft. Very quickly the kinetic energy stored in the main rotor system will be sufficiently depleted to stall the main rotor blades.

Once the main rotor is stalled, there is no way of un-stalling it.

The time it takes for the main rotor RPM to decay to the point at which the blades stall is the amount of time the pilot has to intervene to prevent the stall post-engine-failure – the *'pilot's intervention time'*.

There is also a time increment required for the aircraft to change from level flight to a descent, which will change the induced flow through the disc from down through the disc to up through the disc, and enable the main rotor to use the 'potential' energy stored in your height above the ground.

During helicopter type certification, the manufacture of a single-engine aircraft will have to produce a 'height velocity diagram' which takes into account the various areas of stored energy and the average pilot's reaction time to an engine failure. The test pilot will be required to wait one second before lowering the collective lever in response to engine failure. During this imposed delay the test pilot is able to apply aft cyclic to prevent the nose from dropping. This action uses some, but not much, of the kinetic energy stored in the forward airspeed by transferring it into the main rotor, thus reducing the rate of RPM decay by a small amount.

The use of aft cyclic – flare – as part of the response to an engine failure should depend on your airspeed. There is a lot more energy stored in your airspeed than there is stored in your rotor head, so use it. However, it does not change your 'intervention time' as you still need time to move the cyclic aft.

What should come out of all this is the fact that the pilot requires a reasonable amount of time to respond to an engine failure. The heavier the aircraft is, the quicker the rotor RPM will decay, which means you have even less intervention time.

So a pilot flying around with his or her hand away from the collective lever is *not fully in control of the aircraft.*

'Keep your RPM in the green – and I will keep harping on' ❑

Now where did I leave that lever…?