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Martin

the spin doctor

GLEN WHITE discusses how detailed knowledge of the tail rotor system of the AS350 series can be the difference between mere inconvenience and disaster.

PHOTOS BY **PHILLIP KNAUS, DAMIANO GUALDONI & NED DAWSON**

A Knaus Helicopters' AS355 comes in to land after an EMS mission near Salzburg, Austria.

It is a profound truth that the better a pilot know their aircraft and its associated emergency procedures, the better armed they are to safeguard the lives of all on board. The amount of knowledge that must be acquired and retained as a pilot is staggering. Understanding and remembering federal aviation regulations, meteorology, weather data, the operations manual, Op-Specs, aircraft systems, aircraft emergency procedures, airworthiness directives, service bulletins and accident reviews makes for a daunting task. The physical task of flying a helicopter is an enjoyable one, but in reality, it is but one small part of being a pilot.

We all have the natural human tendency to be attracted to tasks that are enjoyable, while avoiding boring or mundane endeavors. Tell a group of pilots that they must now review the electrical system of their machine and you can easily imagine the gasps and moans. On the other hand, tell them to go and carry out full-down autorotations – now that sounds like a lot more fun! The ability to perform an engine-off landing is obviously essential, but we can't forget the rest of the job. To illustrate, I wish to focus on a specific example – the knowledge base of the tail rotor system on the AS350/355 series of aircraft.

All helicopter pilots have a great understanding of what the tail rotor does and how to utilize it effectively. How many of them, however, have really thought through not only what could occur when this crucial component fails catastrophically, but exactly what actions and procedures they would take to manage the situation.

The tail rotor on the AS350/355 is a very good design, but has had its fair share of problems. The tail rotor system itself is often overlooked as an unimportant or mundane system, not worthy of any great amount of time or study. Unfortunately, the consequences of a less-than-thorough knowledge of the system can be fatal. It is imperative that a pilot of any make of AStar or TwinStar is fully versed in its design, airworthiness directives, emergency procedures and previous accidents and/or incidents. To a pilot seeking this knowledge, one of the best tools available is the National Transportation Safety Board's (NTSB) accident database (http://www.ntsb.gov/ntsb/query.asp). The NTSB publishes a report on every reported aviation accident that occurs in the United States, in an attempt to either avoid the same mistakes from reoccurring or provide an example of a successful outcome after a malfunction. There are numerous examples within the database of both successful and not so successful outcomes after tail rotor thrust or control problems.

GIVE THAT MAN A CIGAR!

An excellent example is an instance of the loss of tail rotor thrust that occurred over the big island of Hawaii in 2005. Upon take-off from a remote landing site located adjacent to a stream and rock dam, the tail rotor made contact with the water in the stream. The pilot indicated after take-off, while cruising level at 90 kts, 500 ft above ground level, he experienced a high-frequency vibration that lasted about five seconds. This was followed by a "bang", whereupon the helicopter violently reacted by yawing left and pitching nose down, with a 90-degree rollover to the right. The pilot recovered from the unusual attitude, and after slowing to about 60 kts, flew the

EcoCopter's B3 lets a load of skiers off high on a Chilean mountain top.

Powerline stringing in Spain with a B3.

aircraft back to Kona airport where he performed an auto-rotative descent to an uneventful landing. This is a great example of getting into a bad situation but having the presence of mind to recover the aircraft after a dramatic shift in CoG and aircraft controllability, then flying the aircraft to a safe landing area and performing the correct emergency landing procedure.

There are some very important lessons we can learn from this event. Vibrations felt through the pedals are a very good indication that a tail rotor problem is about to ensue. There is a tendency, however, for the human brain to disbelieve a situation that seems unpleasant or not right. Pilots who have suffered failures where a gauge indicated an excessively low or high value will often admit that the first thought is, "that can't be right." We want the situation to not be real. We, as pilots, need to condition ourselves to immediately and dispassionately address and analyze any indication that something is wrong.

In the instance under discussion, the CoG change when the tail rotor gearbox departed the airframe caused the nose to pitch down and rotate to the left. This was the most crucial moment in the event sequence, with regard to facilitating a successful outcome. Very high-stress situations cause the human brain to react in a very dramatic way. It is very easy to sit in a calm environment and analyze your reactions to a theoretical emergency, but acting correctly in the event of an actual failure may be much more difficult.

FIGHT OR FLIGHT

Depending on our personal conditioning, we will react to danger and stress with either a fight or flight response. When certain neurons of the hypothalamus portion of the brain (the portion associated with the nervous system) are excited in a stressful situation, an individual either becomes aggressive or flees. This is often known as the "fight or flight" reaction. Some observable symptoms of this state are; elevated heart rate, tunnel vision, tensing of muscles, loss of hearing, memory loss, pain threshold lowering and increased sweating. These are survival mechanisms that evolved to prepare us to flee, freeze or fight. The obvious preferred response to an in-flight emergency is to fight. The responses that we want to train ourselves to avoid are to flee or freeze. It is apparent that we cannot physically flee from the cockpit of a flying aircraft, but we can depart mentally. When the brain is overwhelmed in a sensory overload it attempts to protect itself, in a sense turning off or running away. In this situation the pilot freezes at the controls with no analytical thought occurring. This allows the brain to avoid the mental pain associated with the coming threat.

Conditioning that helps facilitate the proper reaction to an emergency is knowledge and practice. With correct, extensive knowledge of the associated system and emergency procedures the pilot is much less likely to be confused or use precious brain power trying to figure out what is wrong. With emergency procedure training the pilot is conditioned to react to the problem as opposed to delaying his or her response. In a broad sense, performing training on any emergency procedure helps the pilot develop the mental conditioning to react properly to an in-flight emergency.

After the pilot in Hawaii regained

Roy Knauss working the B3 in the Austrian Alps.

David Calvert-Jones works this B2 in Los Angeles for movie and film work.

control of the helicopter and re-established level flight, the aircraft obviously did not fly in a normal manner. The forward CoG shift required a more aft than normal cyclic position. Without tail rotor thrust the only components keeping the nose from spinning were the vertical stabilizers. When the tail rotor departed the airframe it sliced the lower vertical stabilizer in half, so the aerodynamic properties of the vertical stabilizer system were diminished. This caused the nose to be canted to the left, requiring the pilot to place the cyclic to the right in order to maintain forward flight. When the right cyclic was established the cabin of the aircraft listed to the right. This is a very uncomfortable feeling for most pilots. Our normal or "muscle memory" reaction to this out-of-trim feeling is to re-establish a level cabin. This reaction would create a left hand turn, slowing the aircraft and potentially causing the aircraft to go into a spin. There are two methods by which a pilot can practice this aircraft attitude. We can simply take the aircraft out of trim in flight to the left and practice flying a straight course, or utilize a full motion simulator with a tail rotor failure induced.

The other notably successful portion of the event-sequence was the landing of the aircraft without a tail rotor. The RFM recommends entering an autorotation for landing by shutting down the engine(s) on final approach. Intentionally turning off a running engine is one of the most difficult tasks for a pilot to carry out. The normal reaction is to want to fly the aircraft to the ground. There are examples of pilots who have lost tail rotor thrust in the AS350/355 models and successfully carried out a running landing, but this requires a landing speed of approximately 80 kts. During the Hawaii tail rotor failure, the pilot followed the RFM's recommendation and successfully auto-rotated the aircraft after shutting down the engine.

AS350 SPECIFICS

There are three tail rotor emergencies listed in the AS350/355 manuals – tail rotor gearbox chip light (TGB CHIP), tail rotor control failure (stuck pedal), and loss of thrust. Within the procedures

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there exist procedural differences between the various models, although they are generally very similar.

The TGB CHIP caution light indicates to the pilot that there are metal particles in the tail rotor gearbox oil. The procedures in the AStar and TwinStar models are very similar and all effectively recommend continuing flight, but avoiding prolonged hovering. The recommendation to avoid hovering is cautionary in case the tail rotor stops producing thrust. During hover all anti-torque control is produced by the tail rotor and without its thrust the helicopter would yaw rapidly to the left. With the aircraft in forward flight the rotation will be manageable and the vertical stabilizers should keep the aircraft flying somewhat forward at any airspeed greater than 40 kts. If this caution light is followed by a loss of thrust, the loss of tail rotor thrust emergency procedure is referenced.

If the loss of tail rotor thrust occurs during an in-ground-effect hover, the emergency procedures recommended by the RFMs differ slightly. In the B3 variants of the AS350, the RFM recommends rolling the throttle to the IDLE position and performing a hovering autorotation. The AS350B2 VEMD recommends retarding the fuel flow control lever and increasing the collective for touchdown. The AS350B2 and previous versions of the AS350, along with the AS355 variants, recommend landing quickly to avoid excessive rotation. The change from

the non-throttle equipped AS350's long-standing procedure to the B2 VEMD version is interesting, since there is no change in the system, although the new recommended procedure makes sense.

The flight manuals also address the loss of tail rotor thrust in an out-of-ground-effect (OGE) hover, above the height/velocity diagram. The recommendation is to reduce collective, diminishing torque from the main rotor to stop or slow the left yaw of the aircraft. The subsequent application of forward cyclic will gain airspeed to gain aerodynamic effect from the vertical stabilizers. If this procedure is performed within the height/velocity curve there is no guarantee of not hitting the ground prior to gaining airspeed, and the emergency procedures do not address the loss of tail rotor thrust in an OGE hover within the HV curve. There have been examples of other types of helicopter losing tail rotor thrust in an OGE hover within the HV curve, where the pilot was able to establish forward flight by keeping the collective in place. In these cases the pilot added a slight amount of forward cyclic to increase forward speed as the aircraft continued to rotate. In these examples, the spin became progressively larger until the vertical fin gained anti-torque ability.

Whether the loss of tail rotor thrust occurs in flight or in an OGE hover, the RFMs recommend performing an autorotational landing. It is obviously preferable, given a choice, to perform the autorotation in a runway environment.

VAGUE AND MISUNDERSTOOD

A helicopter on a flight outside Las Vegas, Nevada, in February 2004 experienced a loss of control after the bell-crank attached to the tail rotor spider bearing broke. The pilot flew the aircraft back to McCarran International Airport, and with the assistance of another pilot on the radio, proceeded to make several approaches to establish an airspeed that would hold the nose straight and allow the aircraft to land. Through trial and error (and patience) the pilot found and maintained that airspeed, then used the cyclic to land the helicopter as he was aware that if the collective was manipulated during landing the nose of the aircraft would yaw from the desired path.

The tail rotor control failure (stuck pedal) procedure in all variants of the AS350/355 series can be one of the most vague or misunderstood procedures. Because the written procedure is somewhat unclear, it has been taught to many pilots in varying methods. Many of these procedural variations make sense until it is time to make contact with the runway. In fact, the procedure is usually taught without performing the actual landing but the foregoing example effectively illustrates the principles of the correct procedure.

With some minor procedural variations, the RFMs all recommend making a shallow approach with a slight left side-slip, to a running landing. The side-slip is reduced progressively as airspeed is reduced and collective is applied to cushion the landing.

This procedure is easy to understand and apply when the following is considered. After the shallow approach to the runway the aircraft will have a nose right yaw (left sideslip). If the aircraft is slowed at a constant height

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over the runway the nose will rotate to the left because of the applied collective which is induced in order to maintain height. If speed is increased the eventual result will be a rotation of the nose to the right. A speed is sought and maintained in order to hold the nose of the aircraft straight with the runway centerline.

Once the pilot has established that constant airspeed to hold the nose straight, a slight amount of forward cyclic is used to drive the helicopter to the runway surface. Once full contact is made with the runway, because of translating tendency, the helicopter will want to drift to the left. A slight decrease in collective is initiated to stop this movement. It is important to remember that if the collective is lowered too rapidly at this point, the aircraft will rotate dramatically.

SOURCING THE INFORMATION

Having established that it is important to know our systems and associated emergency procedures, where do we get this information? The basic publications that are needed for any helicopter airframe are the RFM, a systems description manual and the associated ADs and SBs. Unfortunately, gaining ready access to these is easier said than done.

We are required as pilots to have a thorough knowledge of our aircraft's associated rotorcraft flight manual, but in order to read it a pilot needs a hard or digital copy. Because an aircraft is not airworthy without its RFM located in the aircraft, operators obviously do not want their pilots removing the manual and taking it home. Eurocopter will not sell copies to the public or non-owners, and there are no longer any online locations to view a copy of any Eurocopter manual. So we are left with two basic choices; sit in the aircraft and read the manual or gain permission to take the manual away for copying. This task is not impossible but it does take some effort.

All Eurocopter flight manuals have a brief systems description located in Section 8. The content is brief, but it does give a short overview of the systems. To get a thorough description of the aircraft systems a Eurocopter or EuroSafety systems manual is needed.

Unbeknown to many Eurocopter pilots, there is a website that contains an abundance of information on the operation and maintenance of the Eurocopter product line, including service bulletins, emergency alert service bulletins and technical letters. Free sign-up is available for the site, at https://www.eurocopter.com/techpub/ – but approximately three days is needed for a login ID and password to be supplied.

In the event of the failure of any flight-critical component, the likelihood of a successful outcome is dramatically increased when a pilot is both knowledgeable and practiced – knowledgeable about both the system in question and the correct procedure for dealing with its failure, and sufficiently practiced that the correct response is almost an automatic, or sub-conscious process. If you are a pilot, ask yourself, "When was the last time you flew a stuck-pedal exercise? And when did you last sit down and read your rotorcraft flight manual?" If it was too long ago to remember precisely, you owe it yourself, your family and your passengers to do both, as soon as you possibly can. ■

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