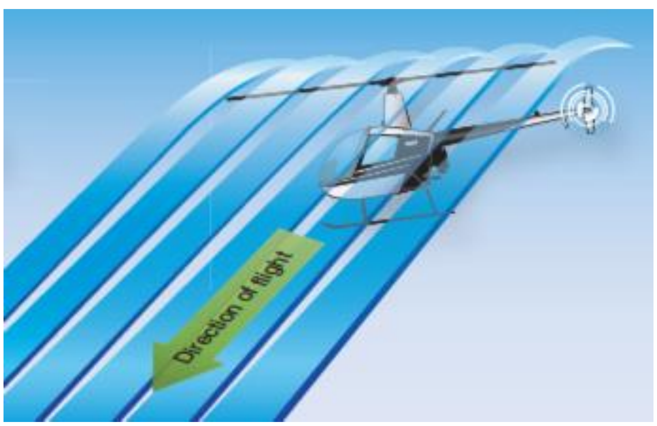
Airmanship Bulletin
Full Touchdown Autorotation Training

Purpose

The purpose of this Airmanship Bulletin is to provide specific techniques and procedures to enhance full touchdown autorotation training and safety.

Objective

The objective is to reduce the likelihood of an accident during full touchdown autorotation training. For the sake of discussion this bulletin assumes a helicopter with skids and with the rotor turning counterclockwise as viewed from the top.



Background

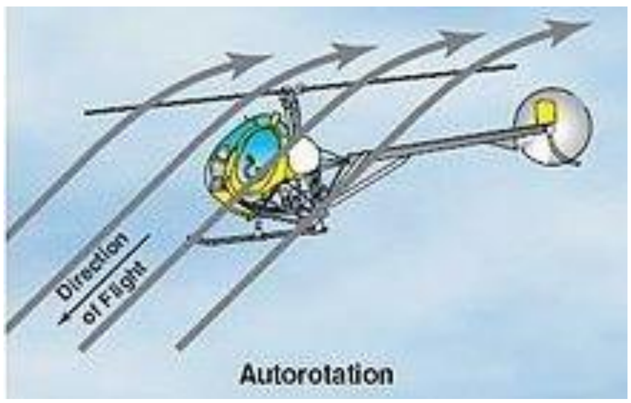
The value of full touchdown autorotation training has been the subject of constant debate within the helicopter community for many years. One side argues the benefit the pilot receives in actually experiencing an autorotative landing and the opportunity to build proficiency in the technique greatly increases pilot confidence, thus reducing the chance of a catastrophic outcome to a real engine failure. There is also a view that the power recovery aspect of the autorotation does not resemble the real situation and may even build a false sense of security on the part of the pilot. The other side claims the increased risk of damaging the aircraft with the full touchdown maneuver is not worth the benefit gained over a power recovery to the hover. They feel that with the increased reliability of today's modern engines, the helicopter community will damage/crash more aircraft practicing for an event that rarely occurs. This Airmanship Bulletin does not take either side but does acknowledge the controversy continues to exist.

The FAA Practical Test Standards do not require the applicant to demonstrate proficiency in full touchdown autorotations during the practical test for a private, commercial or ATP certificate. However, the Flight Instructor Practical Test Standards do require a CFI applicant to demonstrate proficiency in full touchdown autorotations. The thinking being the flight instructor, who is frequently splitting the needles with practice autorotations, is much more at risk to actually have to perform a real autorotation. 14 CFR part 135 training during the initial and recurrent category of training, also, does not require a touchdown autorotation. Most law enforcement agencies and many commercial operators require full touchdown autorotations during recurrent training but it's a very common practice to contract out this training rather than perform the maneuver in their own aircraft.

Teaching full touchdown autorotations requires a high degree of experience and proficiency on the part of the instructor. It is recommended these autorotations be practiced only with an instructor experienced in the particular make, model and type (if required) and be proficient and current in performing full touchdown autorotations.

Environmental/Aircraft Conditions

Due to the critical nature of the full touchdown maneuver, all environmental conditions and variables that the pilot can control, should be used to create the safest conditions in which to conduct the training. It is recommended that wind velocity be at least 5 knots and no more than 30° from the final approach heading. The stronger the headwind, the more energy available and the larger the margin for error. Aircraft weight is another large variable. The lower the aircraft weight the better the relationship between the amount of energy available versus the amount



of energy needed for a safe full touchdown maneuver. Flight instructors should adjust aircraft weight as low as practical by reducing fuel loads, prohibiting passengers and removing certain mission equipment (searchlights, cameras, etc.) when able. Once proficiency at lower weights is developed or for advanced training, organizations will want to safely and gradually increase aircraft weights closer to a normal mission profile. Wind and weight requirements should be adjusted when practicing full touchdown autorotation at higher density altitudes (above 4,000 feet). During the preflight ensure the aircraft's landing gear is in good condition. It is recommended that full touchdown autorotations be practiced to hard surfaces such as runways or taxiways. This allows the skids to slide on the hard surface if the landing is made with any sideward movement reducing the possibility of a rollover. The tradeoff is when landing with very high descent rates. The hard surface is not as forgiving as softer grass or sod surfaces. However, as long as the landing is made with the skids level, the landing gear will yield, as it's designed to do, absorbing the energy of a hard landing which may minimize damage and injury. Full touchdown autorotations require a high degree of concentration on the part of both student and instructor. Therefore, it is recommended only 3-5 full touchdowns should be performed then take a short break doing other maneuvers before returning to the full touchdowns. Schools and individual CFIs should consider limiting the number of full touchdown autorotations that can be conducted per day. This will reduce the stress and fatigue level of the flight instructor.

Preparatory Maneuvers

Prior to the actual full touchdown autorotation a number of preparatory maneuvers can be practiced to help gain an understanding of what the actual full touchdown maneuver will be like. This is especially helpful for students just beginning their full touchdown autorotation training and pilots going through recurrent training in which the full touchdown maneuver has not been practiced for an extended period of time. Power on running landings will help prepare the student for landing in the autorotation with forward speed. Hovering autorotations from both a stabilized hover and from a hover taxi simulate the final stages of the full touchdown autorotation. Finally, two or three power recovery autorotations should be practiced to properly gauge the effects of wind and aircraft weight on the autorotation technique for that particular day.

Four Phases of the Autorotation

The four phases of the autorotation are the **entry**, the **autorotational descent or glide**, the **flare** and the **full touchdown**. Elements of the entry and autorotational descent are the same as in the practice autorotation with a power recovery while the flare and full touchdown phases, although similar, have unique elements. Downwind checks, final checks, entry airspeeds and altitudes will be the same.

The Entry

The purpose of the entry in any practice autorotation is to teach or practice the elements of an autorotational descent, flare and recovery/full touchdown, not how to recognize and properly react to an engine failure (This should be done with the simulated engine failure at altitude/forced landing maneuver). Therefore, the entry into the autorotation should be accomplished as easily and smoothly as possible. A hurried, improper entry can create a very high pilot workload during the remainder of the autorotation. Smoothly but firmly lower the collective full down while simultaneously adding right pedal to maintain the aircraft in trim. When the collective is lowered during the entry the aircraft's nose will pitch down due to dissymmetry of lift and other aerodynamic factors. This will increase the Rotor RPM decay rate and, if not corrected soon enough, the nose low attitude will also increase the descent rate. Consequently, aft cyclic should be used during the decrease of collective to maintain the entry attitude. Once the airflow through the rotor has reversed and an autorotational descent has been established adjustments to aircraft attitude can be made to increase or decrease the desired glide. When the collective is full down, retard the throttle to split the needles. In some turbine-powered aircraft it may be preferable to retard the throttle prior to lowering the collective to prevent overspeeding of the RPM. Once the collective is full down, cross check attitude, Rotor RPM, trim and airspeed.

The Descent/Glide

During the descent portion of the autorotation maintain the aircraft in trim, recommended airspeed +/- 5 knots and Rotor RPM in the green range. At some point during the glide the decision must be made to reduce the throttle to idle. This decision will vary with different aircraft but should only be accomplished after the point where a landing at the intended full touchdown area is assured. Avoiding high descent rates, especially during turns, is critical during the glide phase. There are four common errors that can cause excessive descent rates during the autorotation. The instructor should focus on detecting one or, in many instances, a combination of these elements.

1. Out of trim – During the entry into the autorotation a large right pedal input is required, perhaps the largest right pedal input of any maneuver. Consequently, it is not uncommon for the student to apply too little or too much right pedal. The out of trim condition increases the parasitic drag thus increasing the descent rate. Additionally, during a turn it is not uncommon for the student to use pedal in the direction of the turn causing an out of trim condition.
2. High Rotor RPM – Rotor RPM in the higher ranges of the allowable autorotational RPM cause higher descent rates. As much as 500-700fpm difference can exist between the lowest allowable RPM and the highest. High aircraft weights can also cause the Rotor RPM to stabilize in the higher RPM ranges. When in a dual configuration (instructor & student) most small training helicopters are operated towards the high end of the weight regime resulting in higher Rotor RPMs and increased descent rates. Turns will also increase the Rotor RPM due to the increase in G loading caused by the increased load factor.
3. Nose low/high airspeed – An excessive nose low attitude causing the aircraft to dive will also increase descent rates. Aircraft attitude, especially during a turn, is perhaps the most important element to control.
4. High bank angles during a turn – High bank angles will also increase the descent rate. In training, bank angles should be limited to 40° or less. Quite commonly high bank angles will occur in conjunction with a nose low attitude greatly increasing descent rates.

The 100 ft Decision Check

A valuable technique developed by the US Army is the “100 ft decision check”. The idea is to create a decision point at which the instructor, based on specific parameters, makes a decision to either continue the autorotation or return to powered flight. The mindset of the instructor should be to not allow the aircraft to descend below 100 ft AGL in autorotation unless four parameters are met:

1. Airspeed/attitude +/- 5 kts.
2. Rotor RPM in the green range.
3. A normal rate of descent (rates vary with model helicopter).
4. All turns completed and proper alignment.

If any of these parameters are not met, the instructor must announce “my flight controls” and take the controls, reintroduce the power and commence recovery. Instructors should not talk the student through corrective action or take the controls and attempt to fix the autorotation. Remember that a “Go Around” should always be your first option to take advantage of translational lift! Students should be thoroughly briefed on the aspects of this check and well aware of the possible outcomes. Instructor training should develop the discipline and technique to initiate then react to the results of a timely 100 ft check *prior* to descending below 100 ft. Instructors

may want to increase the decision check to 200 feet AGL based on high density altitudes (above 4000 ft), specific aircraft flare altitudes, power recovery techniques and instructor/ student experience levels.

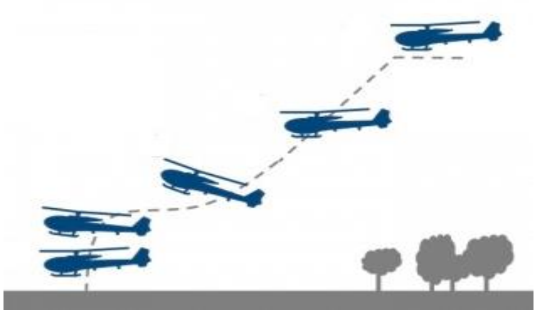
The Flare

The purpose of the flare is to decrease both rate of descent and ground speed. The flare is an extremely critical phase of the full touchdown autorotation because most of the energy available to the pilot in autorotation is in the flare.

Consequently, the flare must be well timed and correctly executed. Flight instructors must focus intently on the effects of the flare and revert to one of the pre-briefed recovery techniques at the earliest sign of a poorly executed flare. The altitude the flare is initiated varies with aircraft type, wind and gross weight but, as a general rule, the flare starts at an altitude approximately 1 ½ times the diameter of the main rotor and can be found in each aircraft Pilot Operating Handbook (POH) or Rotorcraft Flight Manual (RFM). Erring a little on the high side is preferable to erroring a little on the low side. Too much flare causes the aircraft to "balloon" risking development of a high descent rate and too little flare does not adequately reduce the ground speed causing high full touchdown speeds.

The Full Touchdown

The touchdown phase of the autorotation varies greatly between helicopter make and models. This is why instructors need to be proficient and current in the make and model in which the autorotation is being performed. By the full touchdown phase all the energy left for the landing is in the Rotor RPM. Consequently, the collective increase needs to be well timed for the conditions. Unlike the power recovery autorotation, the nose will yaw to the left when the collective is increased due to the friction through the main rotor gearbox and drive train. This need for right pedal may be contrary to the normal habit pattern of a pilot new to the full touchdown phase. Arguably, the most important aspect of the full touchdown in most helicopters is to land in a level flight attitude with the skids parallel to the ground track. Landing with the aircraft drifting left or right, skids offset from the ground track or excessively on the "heels" or "toes" of the landing gear can all result in aircraft accidents. Once the aircraft is on the ground the collective can be slowly lowered to act as a brake (assuming the landing is on a hard surface). Aft cyclic should not be used as excessive blade flapping could lead to tail boom contact.



Turbine vs Piston Engines

There are a number of differences between the turbine engine and the piston engine affecting the autorotation that instructors/pilots should be aware of. The most important is the lag in response time between the two. The piston engine will respond very quickly if the pilot decides to revert to a power recovery, however the turbine engine is slow in comparison to respond. This slower response rate of the turbine engine requires the pilot to make the decision to proceed with the full touchdown or make a power recovery much earlier (in some cases before the flare) than in the piston engine. Additionally, because of this slower response rate, power has to be brought back in at a much slower pace in the turbine. Pilots should also understand that when the turbine engine is reduced to idle the fuel control and/or FADEC deceleration schedule causes the torque to decrease gradually. Due to this additional output torque the left yaw and rotor decay rate is much more docile on the practice auto than if the engine actually flamed out. This difference can be significant however, most organizations, including the FAA, understand and accept this reality, as the alternative is not very attractive from a safety standpoint.

Conclusions

Although the value of full touchdown autorotation training is still debated there are instances where it is required and justified. Operators, instructors and pilots need to ensure that the procedures and techniques discussed in this Airmanship Bulletin are used to conduct this training in the safest possible manner. Instructor experience, proficiency, currency, instructor and student recency in conducting autorotations, aircraft characteristics and environmental conditions must be assessed and adjusted for each training flight. Additional information is available in the Helicopter Flying Handbook and the Helicopter Instructor Handbook:
https://www.faa.gov/regulations_policies/handbooks_manuals/aviation/helicopter_flying_handbook/media/hfh_ch11.pdf
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