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HELICOPTER PROCEDURAL INNOVATIONS (UNUSUAL ATTITUDES)

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INTRODUCTION

Responding to the recommendations of a HQ USAF All-Commands Helicopter Conference[1], the USAF Instrument Flight Center has initiated a Helicopter Procedural Innovations Program. Due to increased emphasis being placed on helicopter operations, tactical as well as non-tactical, rotary-wing procedures and techniques require study and validation for incorporation into Flight Information Publications (FLIP); AFM 51-37, Instrument Flying; AFM 55-9, Terminal Instrument Approach Procedures (TERPs); and other directives. One phase of the Procedural Innovations Program has addressed helicopter unusual attitude recovery techniques. At the present time, there are no unusual attitude recovery techniques in AFM 51-37 that specifically address rotary-wing aircraft. Although the techniques found in AFM 51-37 are adequate for fixed-wing unusual attitude recoveries, portions need amplification to apply to helicopter recoveries. This is due to the unique aerodynamics of rotary-wing aircraft, as well as a different application of the Control and Performance Concept to helicopters as compared to fixed-wing aircraft.

[1] HQ USAF All-Commands Helicopter Training Conference of May, 1969, Andrews AFB MD.

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CONCLUSIONS

The conclusions resulting from this study are as follows:

For a DIVING Unusual Attitude Recovery -

a. The preferred recovery is to eliminate bank; then assume a level attitude.

b. Increased G loading could lead to subsequent and possibly more severe unusual attitudes.

c. A rolling pullout may be used in a low altitude/low time situation provided the pilot uses smooth control applications.

d. Positive G forces must be kept to a minimum to avoid a blade stall condition.

For a CLIMBING Unusual Attitude Recovery -

a. Negative G forces encountered in a straight pushover induce a loss of control sensation.

b. If a pushover recovery is delayed, loss of yaw control may occur.

c. In an initial high power situation, a nose low climb can result if aircraft pitch attitude is decreased with no power reduction.

d. If pitch and power are reduced simultaneously, excessive negative G forces can be encountered.

e. The use of bank aids recoveries by allowing the pilot to maintain positive G forces.

f. The use of bank decreases recovery time.

g. A straight pushover recovery technique is valid for recovering from minor inadvertent pitch changes (10° or less).

RECOMMENDATIONS

As a result of this study, the Instrument Flight Center, Research and Development Division, recommends the following helicopter unusual attitude recovery techniques be incorporated into AFM 51-37 as a section of Chapter 9, Unusual Attitudes:

> Recoveries from helicopter unusual attitudes are unique due to rotary-wing aerodynamics as well as application of the Control and Performance concept to helicopter flight. Application of

improper recovery techniques can result in blade stall, power settling, or an uncontrollable yaw if recovery is delayed. Due to these differences, unusual attitude recoveries for helicopters are decidedly different from fixed-wing recoveries.

If DIVING, factors to be considered in recovery are altitude, acceleration limits, and the possibility of encountering blade stall. If altitude permits, avoid rolling pullouts. To recover from a DIVING unusual attitude, roll to a wings level indication then establish a level flight attitude on the attitude indicator/ADI. Adjust power as necessary and resume a normal cross-check.

If CLIMBING, consideration should be given to pitch attitude and airspeed. If the inadvertent pitch attitude is not extreme (10° or less from level flight), smoothly lower the minature aircraft back to a level flight indication, level the wings and resume a normal cross-check using power as required. For extreme pitch attitudes (above 10°), bank the aircraft in the shorter direction toward the nearest 30° bank index. The amount of bank used should be commensurate with the pitch attitude and external conditions but do not exceed 30° of bank in effecting the recovery. Allow the miniature aircraft to fall toward the horizon. When the aircraft symbol is on the horizon, level the wings and adjust the aircraft attitude to a level flight indication. Use power as necessary throughout the recovery.

NOTE: For helicopters encountering an unusual attitude as a result of blade stall, collective (power) must be reduced before applying attitude corrections if the aircraft is in a CLIMBING unusual attitude. This will aid in eliminating the possibility of aggravating the blade stall condition. To aid in avoiding blade stall in a DIVING unusual attitude recovery, reduce collective (power) and bank attitude before initiating a pitch change. In all cases avoid abnormal positive G loading which could lead to additional unusual attitudes and/or aircraft structural damage; prevent negative G loading and inverted flight.

EVALUATED TECHNIQUES

Recommended unusual attitude recovery techniques peculiar to rotary-wing aircraft were evaluated. These techniques were formulated by experienced helicopter pilots of the Instrument Flight Center, Research and Development Division, and employed the "two schools of thought" on climbing unusual attitude recoveries; i.e., (1) lower the miniature aircraft to the horizon without adjusting bank, and (2) use bank as an aid in lowering the miniature aircraft to the horizon. Both CLIMBING and DIVING techniques were evaluated by the subject pilots. The techniques, which varied only slightly from the recovery techniques recommended by this Report, are as follows:

a. If DIVING, factors to be considered in recovery are altitude, acceleration limits, and the possibility of encountering blade stall. If altitude permits, avoid rolling pullouts. To recover from a DIVING unusual attitude, roll to a wings level attitude indication, then raise the nose of the aircraft to a level flight attitude. Adjust power as appropriate and resume a normal cross-check.

b. If CLIMBING, consideration should be given to pitch attitude and airspeed. If the pitch attitude is not extreme (dependent on pilot judgment), bank the aircraft in the shorter direction toward the nearest 30° bank index but do not exceed 30° of bank. Allow the nose of the aircraft to fall toward the horizon, level the wings and adjust aircraft attitude to a level flight indication. Use power as necessary throughout the recovery.

DISCUSSION

Ten subject pilots evaluated the suggested recovery techniques. Six of the ten subjects were instrument instructor pilots assigned to the IFC. The remaining four subjects were pilots temporarily attending the Instrument Pilot Instructor School at the IFC. The experience level of the subject pilots was relatively high, averaging 2793.5 hours of pilot time, 649.6 hours of instructor time and 1483.0 hours of helicopter time. However, the lowest subject pilot total time was 830.0 hours; the highest was 5000.0 hours. This time spread allowed use of a wide range of experience, knowledge and techniques.

The subject pilots' helicopter backgrounds were in the H-34, H-19, H-21, TH/UH-1F, UH-1N, CH-3, and HH-53. Although the evaluations were accomplished in a TH-1F, the subjects related the recovery techniques to aircraft they had previously flown, validating the application of the recovery techniques for virtually all operational USAF helicopters.

Two aerodynamic factors peculiar to helicopters are blade stall and power settling. Blade stall can be encountered in a high airspeed/high power/increased G loading situation. Power settling results from a low airspeed/high power condition. For a more detailed discussion of these phenomena refer to 1550 ATTWg Course 1025E1 - Pilot Advanced Flying Course (H-3) - Basic.

The above mentioned aerodynamic peculiarities necessitated the use of an accelerometer in the test aircraft, an IFC/RD TH-1F (SN 66-1250). This instrument was needed to document G loading during recoveries for additional data due to the relatively narrow vertical acceleration envelopes of some helicopters. Helicopters with fully articulated rotor systems have greater problems with blade stall when compared with semi articulated rotor systems. For example, the CH-3 (fully articulated rotor system) has a maximum acceleration limit of 1.5 G, while the TH/UH-1F (semi articulated rotor system) has a maximum acceleration limit of 3.0 G. Due to this limitation the helicopter with a fully articulated rotor system is more restricted, when recovering from a DIVING unusual attitude, because blade stall can be a direct result of increased G loading.

Negative G loading was documented in conjunction with CLIMBING unusual attitude recoveries. These recoveries were accomplished using a straight pushover with no bank, in both high and low power configurations. In addition, power settling was of interest in these conditions because it is a function of low airspeed/high power situations.

Each subject pilot was given a series of twelve unusual attitudes, with six maneuvers being observed for data recording. The subjects recovered from, and data was recorded on the following unusual attitudes:

(1)	15° pitchup	15° left bank	High power
(2)	15° pitchup	15° right bank	Low power
(3)	20° pitchup	0° bank	Low power
(4)	30° pitchup	0° bank	High power
(5)	15° pitchdown	30° right bank	Low power
(6)	20° pitchdown	30° left bank	High power

Subjects were given a simulated 200 foot altitude block for recovery on Maneuver Six. This recovery allowed data collection under higher than normal G loading to document maximum aircraft acceleration units as well as subject pilot evaluation of the suggested recovery techniques.

Subject pilots accomplished the recoveries in simulated IMC through the use of vision restricting devices. For all maneuvers the pilot's windows were covered, and the subjects were hooded.

Maneuver One: 15° pitchup 15° left bank High power

Maneuver Two: 15° pitchup 15° right bank Low power

Recovery Technique: Use of bank.

Subject pilots stated that the use of bank in recovering from Maneuvers One and Two aided in the following ways:

a. Recovery time was decreased due to the aircraft nose falling more rapidly toward the horizon.

b. Positive G forces were maintained.

The aircraft was easily controlled with appropriate power changes not adversely effecting the recoveries. Subjects with heavy lift helicopter (H-3/H-53) backgrounds stated that the recovery techniques could be used successfully in these aircraft.

Maneuver Three: 20° pitchup 0° bank Low power

Recovery Technique: Straight pushover using no bank.

The technique of lowering the nose of the aircraft to the horizon in a pushover recovery from a high pitch attitude, as recommended in the discontinued AFM 51-13, Instrument Flying for Helicopter Aircraft, is not valid. In simulated IMC, subjects did not know what pitch attitude to set in order to stop the airspeed loss. If power was increased from or maintained at the initial setting, the climb rate was either increased or maintained resulting in aggravation of the unusual attitude condition. When power was decreased simultaneously with a forward cyclic input, negative G loading increased giving subjects a loss of control sensation.

Subject pilots with heavy lift experience stated that this type of recovery would be even more critical in the H-3/H-53. Rapid cyclic movements cause the blades to flap excessively, with possible blade-to-fuselage contact.

Maneuver Four: 30° pitchup 0° bank High power

Recovery Technique: Straight pushover using no bank.

The recovery technique used in this maneuver is invalid. This technique resulted in a "zero" airspeed indication for most subjects due to a rapid loss of airspeed. Pitch attitude had to be decreased at least to the horizon to prevent settling backwards in the low airspeed situation. These, also, would be conditions conducive to entry into power settling.

Subject pilots did not know how much to decrease power and lower the pitch attitude to effect a recovery. When the pitch attitude was decreased, negative G forces increased with the possibility of successive unusual attitudes multiplied. Most subjects reduced power to approximately a cruise setting, but this was found to be an insufficient amount to stop the climb. The result was a continued climb with a nose low indication when pitch attitude was decreased.

During the recoveries, as airspeed approached zero, tail rotor effectiveness was lost due to high winds (25-30 knots) and torque resulting in an uncontrollable yaw. All subjects did not experience an inadvertent yaw; however, those who did had a heading change ranging from 24° to 125° accompanied by an unscheduled left bank of 15° to 20°. In this situation, anything the subjects did to counteract the yawing tendency only aggravated the bank.

Two subjects who reduced pitch and power simultaneously experienced an inadvertent pitchdown of 20° and 28° nose low respectively. Subjects with heavy lift experience made similar statements about this maneuver that were made about Maneuver Three; i.e., blade-to-fuselage contact.

Maneuver Five: 15° pitchdown   30° right bank   Low power

Recovery Technique: Eliminate bank and pullup.

This recovery technique is valid for all helicopters. Two subjects made simultaneous control inputs, but all subjects eliminated bank prior to recovering to a level attitude. Most subject pilots left power at the initial setting until a level flight attitude was attained. No problems were encountered with this technique. Recovery in heavy lift helicopters would be similar.

Maneuver Six: 20° pitchdown   30° left bank   High power

Recovery Technique: Rolling pullout (200 foot altitude block).

Subject pilots stated that the increased G loading resulted in an uncomfortable feeling and could possibly lead into successive unusual attitudes. The maximum acceleration unit was + 1.9 G, while the minimum was + 1.4 G. Subjects preferred a rolling pullout in a restricted environment; i.e., minimum of time and altitude to recover. However, if time and altitude permitted, a "roll wings level and then pullout" recovery was preferred.

Although the subjects were effected by increased G loading, this could be overcome. The problem with a rolling pullout, high G recovery is in the type of main rotor system found on the helicopter. The semi articulated rotor system (TH/UH-1) can accept increased acceleration well. However, the fully articulated rotor system (CH-3) cannot accept increased acceleration to the degree possible in the semi articulated system. Due to the larger flapping area of the blades with the fully articulated system, blade stall is more easily encountered. This is due to the coning angle increasing proportionately with G loading. Therefore, the possibility of blade stall is increased with a more rapid/abrupt rolling pullout maneuver.

Subjects encountered a minor problem with finding a suitable power setting. Power adjustments were estimates only. If power was left alone, the high setting gave a higher angle of attack on the main rotor blades. Since blade stall is a function of high power settings, this is an undesirable situation. Conversely, if power is reduced too much, the recovery is delayed. This recovery is considered valid for low altitude/time situations; e.g., on ILS final at 200 foot above DH. However, if time and altitude permit, the bank should be eliminated before a pitch change is made.