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High Glide Ratio Approach on Helicopter with DGPS Guidance: Flight-tests Results and Operational aspects

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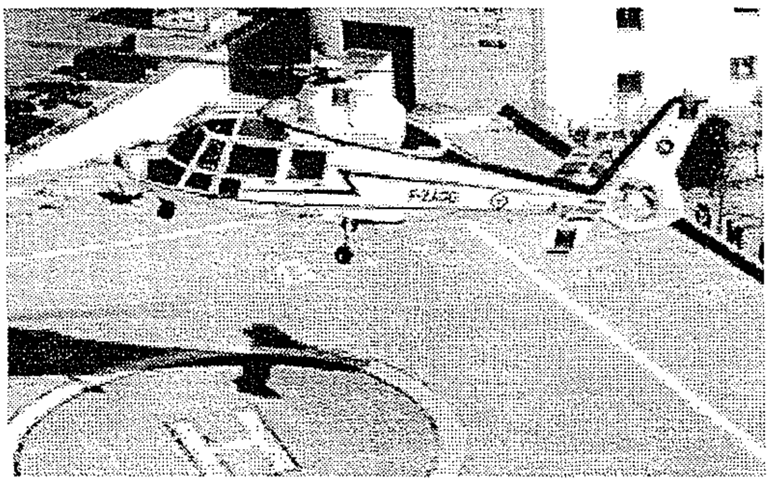
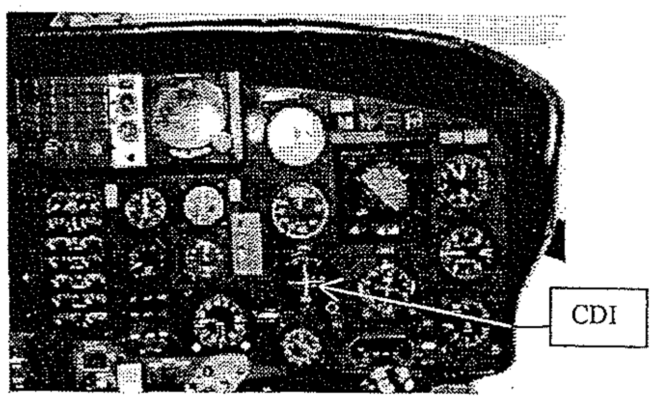
Since the beginning of public transport in helicopter, operators have felt the need of IFR operation on spot landing sites. This kind of operation implies very often high glide ratio approaches and a guidance mean appropriated. Flight tests have been conducted on an AS 365 N to evaluate the feasibility of such an approach with DGPS guidance. The paper presents the conditions of the flight test campaign and its results.



0 - Introduction

The goal of this campaign, required by DGAC, was to evaluate the possibility to conduct an IFR approach followed by a spot landing according to class one or CAT A operation rules on a helicopter of the present generation at high glide ratio with DGPS guidance. The helicopter used for these tests was a standard AS 365 N (S/N 6010) belonging to CEV. Thanks to SPAé, this helicopter has been equipped with a prototype RGPS developed by Sextant Avionnique and DCN Ruelle to demonstrate the feasibility of approaches on ships with that kind of guidance. The guidance information was given to the Pilot by a standard CDI located near the HSI.



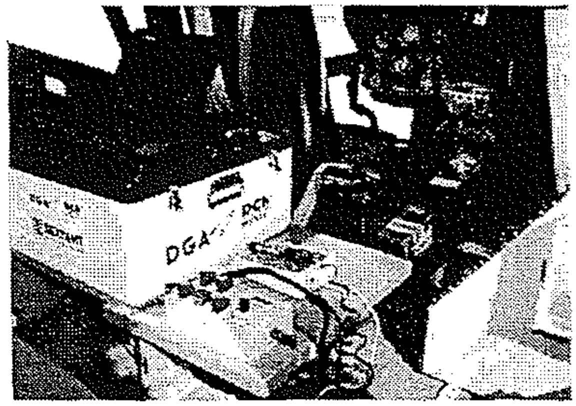
No coupling provision to the guidance system was given. These tests did not intend to study the Navigation System Error, but only the Flight Technical Error. For this reason, this RGPS system has been found representative of a DGPS.

1 – <u>Flight test installation description</u>

The AS 365 N S/N 6010 is basically equipped with a test bay which allow to record the rotorcraft parameters, that is to say attitude of the rotorcraft, control position, engine parameters, altitude, airspeed...

For this flight test campaign, The "in flight" component of the Sextant RGPS system was been installed in the rotorcraft. For this purpose, a specific VHF antenna was mounted on the nose of the helicopter, a GPS antenna at the top of the empennage.

The RGPS installation gave provision to modify the CDI needles sensitivity and to record the trajectory followed by the pilot compared to the one materialized by the system. The helicopter was also equipped with a system that allowed to inject hardovers to the autopilot in order to test their consequences on the trajectory.



The ground component of RGPS system was installed in a van. This component gave the possibility to modify the approach geometry (LOC and Glide).

2 - <u>Tests performed</u>

2.1 <u>General</u>

During this campaign, 7 pilots were involved, 5 flight-test pilots from CEV and two air line pilots. 13 hours and 80 approaches have been flown, at Istres Air base and on an elevated helipad on the roof of "palais des congrès" in Aubagne.

All flights were performed in day VFR conditions, except for one of them, which was performed at night. The right-hand seat pilot helmet was equipped with a "SIMUPACK" visor. This equipment allows simulating IMC conditions. This visor was cleared up passing the minima and the pilot continued visually the CAT A procedure. The left hand-seat pilot was ensuring the safety of the flight.

Only the final approach has been studied. The pilot was guided on final at an air speed of 100 to 120 kt. On the axis, the speed was reduced to the defined approach speed, and then the descent was initiated at this particular speed.

2.1 – Speed and glide ratio studied

Considering the conditions of the tests, it has been decided that a nominal vertical speed of 700 ft/mn was a maximum for an IFR approach. Then the pilot would normally not have to use vertical speed greater than 1000 ft/mn during corrections. For this reason, the figures used have been the following:

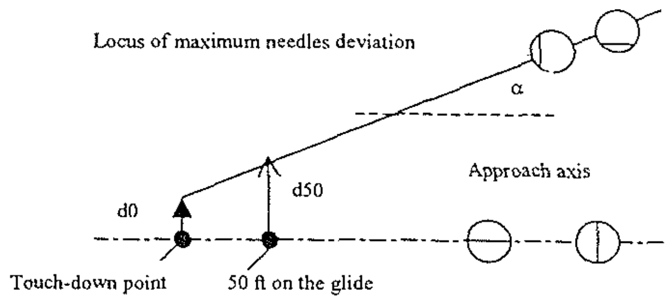
Angle	6°	8°	10°
Vs	60 kt	50 kt	40 kt
Vz	640 ft/mn	710 ft/mn	710 ft/mn

The minimum IFR speed of the Dolphin is 75 kt when no speed coupling is used and 45 kt when the speed coupling is used. These speeds have been determined during certification to comply with FAR 29 static and dynamic stability requirements for IFR certification. A draft change to AC 29 allows not to comply with these requirements during the approach phase, provided the workload induced by the handling qualities of the rotorcraft is found acceptable by the pilot. For these tests, the minimum IFR speed of the Dolphin has not been considered as a limitation. Nevertheless, the pilots have judged that below 40 kt, the workload was too high. The angle of approach has therefore been limited to 10°.

2.2 – CDI Needles sensitivity

The sensitivity can be defined, both horizontally and vertically as the locus of maximum needles deviation all along the approach path. This place is defined by two symmetrical lines each part of the approach path defined by two figures:

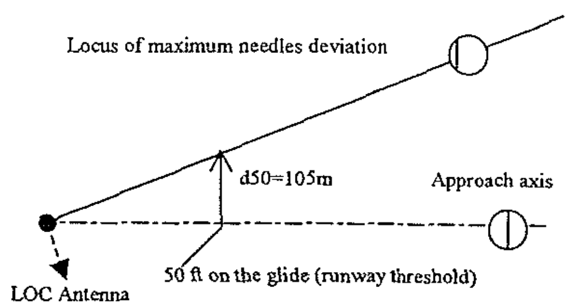
- d0: distance of that place at the touch down point;
- α: angle of the lines from the approach path;
- The parameter d50, distance of the locus of maximum needles deviation when passing 50 ft on the glide path, has been retained only for the purpose of comparison with the ILS.



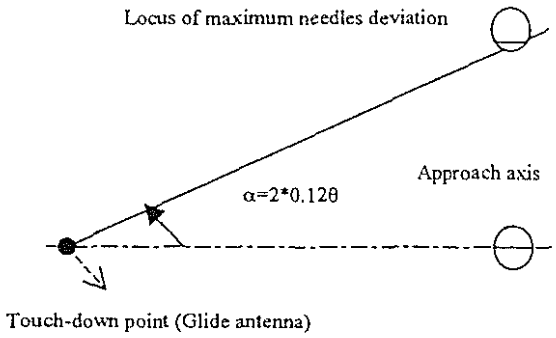
2.2.1 – ILS sensitivity

These sensitivities are defined by ICAO annex 10.

For the localizer, the locus of maximum needle deviation is an angle which vertex is by the localizer antenna and 700 ft (210 m) wide at the runway threshold (the glide path corresponds to a height of 50 ft at that point).



For the glide path, the locus of needle maximum deviation is an angle which vertex is the touchdown point and the angle from the glide path is equal to $\pm 2*0,12\ \theta$, where θ is the glide path angle. (for an approach at 4°, this angle is 0,96°)



2.2.2 – Sensitivity used for the tests

The ILS sensitivity has been optimized to guide transport airplanes on finals 8 to 10 NM long. The tests run for the demonstration of RGPS precision approach on ships have shown that:

- the ILS LOC sensitivity is not optimal to guide helicopters on shorter finals
- to reduce pilot workload, the glide sensitivity can be reduced without questioning the precision of the trajectory.

The sensitivity retained have been the following:

LOC: The parameter d50 of the ILS has been maintained and the angle α was 4.3°. This corresponds to an ILS installed on a runway where the LOC antenna is 1400 m behind the threshold.

Glide: the d0 parameter (witch is equal to 0 for the ILS) has been chosen at 70 ft. The angle α was $2*0.16\ \theta$. For a glide path of 4° that angle is 1.3°.

These sensitivities determined during the testing on ships at 4° glide have been verified to be suitable for higher glide path on the SPHERE simulator at Eurocopter. As all along the flight tests they have been considered adequate, they have been kept for the whole campaign.

3 - Flight-tests results

Several aspects have been looked for during this campaign. We will now look at them separately.

3.1 – IFR approach without wind

The tail wind situation has never been considered during these tests since it is thought to be too dangerous mainly because of the risk of vortex rings.

The trajectories defined in paragraph 2.1 have been first flown in calm air with a near zero wind. All the pilots have then been able to follow the approach path up to 10° and down to 200 ft with no unacceptable workload. They all mentioned that the 10° path was harder particularly if they ha to apply correction. For the approach below this value, they considered the approaches easier than a standard ILS.

3.2 – IFR approaches with wind

When flying these paths with wind, it has rapidly been obvious that the approach was impossible to conduct only with air data (heading and airspeed). This was even more obvious when the wind was not steady and when a wind gradient did exist. This can be explained by the fact that the wind speed is of the same magnitude as the helicopter airspeed. For example, 20 kts cross wind and 40 kts airspeed make a 30°-drift angle. This value is out of normal pilots' references.

In the same way, the corrections to join the LOC when the needle is not centered are important in terms of angle. The cause is again the low airspeed of the procedure. To give an example, with an airspeed of 100 kts and 10° of heading correction, the closing speed is 17 kts. At 40 kts airspeed, it is 7 kts.

To help the pilot, it as been decided to use ground references (ground speed and track), and to give instructions in terms of ground references. So the pilot used track to follow the LOC, and the figures of paragraph 2.1 were used as ground speed and vertical speed reference versus glide path angle. As this information coming from the DGPS system was available to the flight test engineer, but not to the pilot, a Trimble GPS, mounted as "stand alone" was used to provide the pilot with this information, even-thought the presentation of this information was not easy to interpret (numerical figures) they gave the pilot a great help and the procedure was found flyable up to 8°. At 10° the handling characteristics of the helicopter and the low speed made the correction more difficult. 8 to 9° was then considered as the limit for that kind of procedure on that kind of aircraft.

As a conclusion of the tests, it is considered that the minimum equipment to fly that type of procedure is:

- an HSI including the guidance needles;
- a track information in the HSI easily interpretable by the pilot;
- A ground speed information in a numerical form in a window of the HSI.

Other information can give help to the pilot:

- distance to the touch-down point;
- Lateral distance to the LOC.

3.3 – Speed coupling

It as been tried to follow the procedure with the coupler in the airspeed mode. This mode was not of great help to most pilots. The to main reasons are:

- these procedures induce an important piloting activity on the lateral axis, so that the pilot often interferes, on the longitudinal axis and therefore disturbs the autopilot;
- as the procedure requires flying a ground speed, in case of wind gradient, the pilot has to change paten the airspeed reference.

3.4 – Failure on the axes

3.4.1 – Autopilot failures

Hardovers have been injected through a specific "failure box" when flying the procedure at different glide path angles. On none-of the three axes these failures were a problem for the pilots. Even more, the low speed gives fewer consequences to the hardovers than when flying a standard ILS.

3.4.2 – Engine failures

To study the engine failure consequences, the helicopter was flown at spot landing Cat A training masses and the training equipment to set the engine power was used as well.

When flying on the glide path the torque was much less than the one the engines can produce in OEI. So the consequence of an engine failure was even not noticeable in the IFR phase.

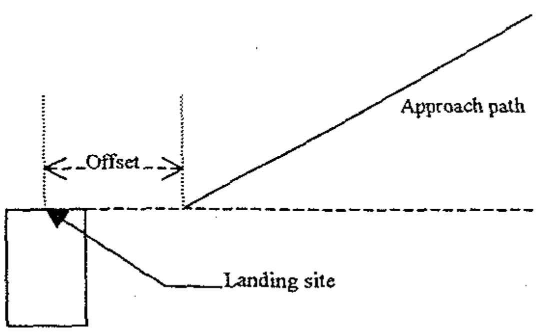
3.5 – The landing phase after the IFR minima

When reaching the IFR minima, the pilot has either to pull-up if he is still flying IMC, or to fly visually to reach the Landing Decision Point (LDP) as defined by the manufacturer.

This flight phase raised several specific problems:

1. To be able to continue the flight and to position the helicopter at the LDP visually, the pilot will has to see rapidly the landing site when coming out of the clouds at the minima. This is not easy when the landing site is, for example the roof of a building in a city center and therefore not easy to distinguish in the environment. This is even more difficult when the drift angle is important and when the structure of the helicopter can hide the landing site from the pilot's view. This difficulty was clearly highlighted during the flight in Aubagne with that kind of landing point.

2. The pilot needs to change rapidly of piloting references. He has, in a short time, to transition from the instruments to the external references. This is not an easy exercise. To fly correctly the helicopter to the LDP, the pilot needs time. This time can be given either by higher minima, or by including an offset in the procedure. An offset consists in a trajectory, which arrives before the landing point.



As the entire flight campaign was flown in very good visibility conditions, it was not possible to give definite conclusions on that final visual part of the trajectory. That part needs further tests in more realistic meteorological conditions to be concluded.

3. The easiest way to join the CAT A landing profile from the IFR glide path would be to continue on the same path. In that case, visual helps as PAPI could be used and the pilot would not have to modify his path. But, today, the CAT A glide path used to determine the procedure is not always published and is in any case unique. It is around 6°. Spot landing CAT A performances versus angle of approach would simplify such an approach.

4 - Conclusion

The campaign proved that the concept of high glide ratio approach with DGPS guidance is viable up to angles of approach of 8 to 9°. The minimum equipment defined in paragraph 3.2 is nevertheless required to be able to follow such paths.

To fly successfully such an approach, there are probably wind and wind gradient limits. Specific tests are to be flown to precise them. However, tail-wind near the ground must be prohibited to prevent vortex rings.

For that type of profile to be flown, there is a need to certify IFR approach speed below the minimum IFR speed and therefore to change certification criteria for that particular phases.

All flights were conducted on the same rotorcraft (AS 365N) and on simulated IMC. To reach final conclusions, evaluation should be made on other helicopters and in real IMC.

The final phase between the minima and the LDP needs to be further investigated. For that purpose, there is a need to make other flights in appropriate meteorological conditions to define the necessary equipment and the most efficient procedure to join the LDP from the IFR minima. The possibility of having spot landing CAT A performances versus the angle of approach should be considered.

Finally the concept is pendant to the decision to allow IFR precision approach with DGPS guidance.