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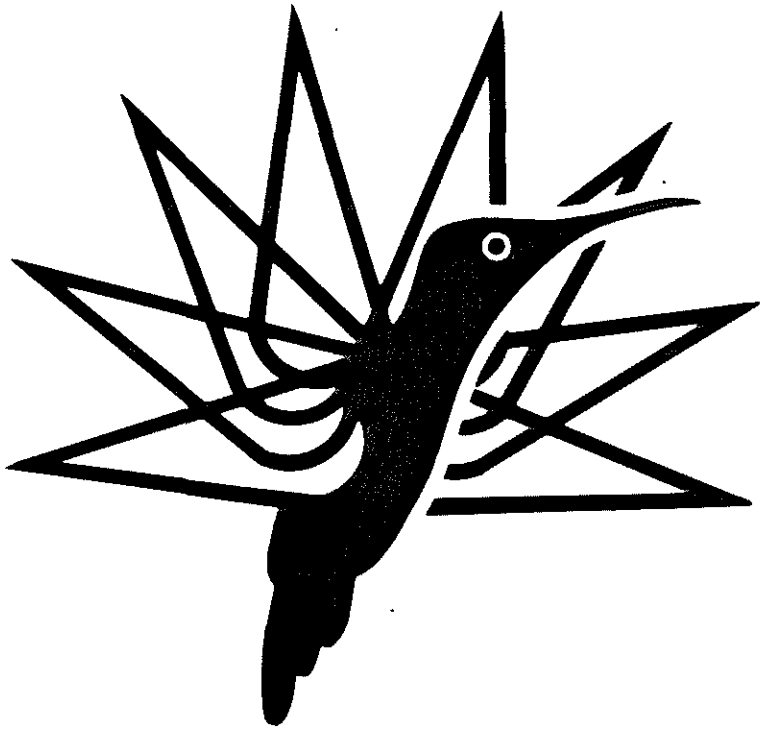

A FIRST STEP FOR REDUCING HELICOPTER IFR APPROACH MINIMA AGUSTA A109 IFR CAT II CERTIFICATION

BY

F. BANAL
Chief Airworthiness Engineer

G. ZANETTI
Senior Flight Test Engineer

ENGINEERING DEPARTMENT
COSTRUZIONI AERONAUTICHE G. AGUSTA
CASCINA COSTA – GALLARATE, ITALY

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ABSTRACT

The first part of this paper discusses about the reasons for and against the efforts to lower the helicopter IFR weather minima using the current ILS system on airports. To this end the applicable regulations for certifying and operating an IFR CAT II helicopter will be displayed, referring to avionics, kinds of operators (private or commercial), airborne documents, crew qualification, ect. The second part describes the IFR CAT II certification flight test program carried out on Agusta A109 helicopter at Houston, Texas, September '83. At the end of this program a FAA STC had been issued. The third part contains some considerations on new proposal regarding helicopter approaches in foul weather conditions. Starting from the present regulations and the normal ILS system, the need, as a first step, of particular helicopter rules for IFR approaches, due to the inherent flight characteristics of these aircrafts, will be discussed. It will emphasise the possibility of carrying out approaches down to a DH lower than CAT II minima, as an intermediate step before to achieve zero/zero landing capability, demonstrating a level of safety equivalent to CAT III a) for airplanes.

1. INTRODUCTION

Present efforts in reducing helicopter landing weather minima are quite exclusively dedicate to IFR approaches on heliports and to the development of MLS techniques. In this respect it is sufficient to instance the "National Prototype Heliport Demonstration and Development Program" being run by FAA (see FAA Rotorcraft Master Plan, Dec. '83). This program has been shared in two different and subsequent steps, the first one consisting in the development of non-precise IFR approach techniques, while the second one, the final aim of all the entire effort, will consist in the achievement of a full IFR capability through precision approaches, probably using the MLS systems.

Another relevant goal in the future will be the achievement of the IFR capability for landing on offshore helipads, through radar approaches and automatic zero-zero landing techniques. This conquest shall permit to overcome the present burden of the high number of missed mission, typical for this kind of operations, today accepted by the operators with impotent resignation. Both these targets intend to take the maximum advantage of the peculiar operational abilities of the helicopter, encouraging in the meantime the IFR utilisation of this mean of conveyance, still meeting some understandable reservation from the crew-people.

The achievement of the above-mentioned goals will bring the helicopter in its maturity, but for the moment they are still constituting a technical problem, then we are not yet close to an airworthiness definition of this kind of approaches. That means for many years in the future the practical utilisation of an IFR approach procedure by a helicopter will be only allowed on airports conceived for ILS airplane approach techniques. That being true in the United States, all the more reason for the remaining part of the world (Europe included), where such a heliport development program is not yet scheduled. Moreover, some kind of operations exists, such as corporate/executive and commercial/aerotaxi, where the utilisation of conventional ILS airports will remain in their own normal operational tasks.

2. IMPROVING ILS HELICOPTER PROCEDURES

In the light of the above considerations, it's not useless to verify if possibilities exist, right from now, in improving the helicopter ILS approach capabilities, lowering the landing weather minima, exploiting the existing technologies with the aim of the cost containment. This need leads to run along two ways:

1) To proceed to the helicopter certification and crew qualification for operations in CAT.II or below, meeting the existing airworthiness and operational requirements for airplanes.
2) To change the present requirements taking into account the inherent characteristics of the helicopter, as such as to make a low visibility instrument approach less risky than those of airplanes.

The first way is immediately practicable, but the second one should be considered as more logical.

This paper shows the Agusta experience on A109A,MkI & II, certification program carried out to obtain the FAA STC for IFR CAT II operations. In the second part of the paper it will be shown how the results of the flight evaluation conducted during the program demonstrate the possibility to change the present helicopter requirements.

3. IFR CAT.II FAA CERTIFICATION

3.1 Landing weather minima for helicopter.

In the present, the landing weather minima for IFR helicopter approach procedures are the same than for airplanes.In figure No 1 these minima are reported regarding to DH (Decision Height, a specified height at which a missed approach must be initiated if the required visual reference to continue the approach to land has not been established) and RVR (Runway visual range, the horizontal visibility along the runway centerline), versus the different instrument approach categories.

Most of present helicopter with an basic IFR certification can operate in CAT I. Only a few ones have been certified for CAT II operations. The Agusta A109A, MkI & II, helicopter obtained the CAT II STC from FAA in September '83.

3.2 An opportunity evaluation.

Before starting a CAT II certification program, it should be necessary to carry out an opportunity evaluation about the benefits in reaching that certification, taking into account the cost/effectiveness ratio for the operators. That means to evaluate the additional costs regarding avionics and equipment, maintenance and flight crew, versus a real need to operate down to lower visibility levels. Consequently a statistical survey should been developed combining the kind of operations conducted by helicopter operators, or group of operators, together with the weather conditions likely to occur on the airports normally utilized from them. From this survey the probability of coming against

visibility levels between CAT I and CAT II minima and the foreseeable number of the mission likely to miss, will be deduced.

Such a kind of survey, conducted on the activity of the Italian operators of Agusta A109A, demonstrated the opportunity of a CAT II qualification, even if the most ones were operating as "executive", taking into account the foul weather conditions likely to occur in the airport of Northern Italy, mainly in wintertime.Althought the probability to operate below the CAT I landing minima was found as relatively modest (about 5%) the fact the basic IFR version of A109 was already featuring the same avionics and equipment required for CAT II operations, made the CAT II qualification as suitable. In the case of commercial and aerotaxi operations the same level of suitability exists, because of balance between the increase of the operational costs (crew qualification and maintenance) and the increase of number of missed mission, taking into account the need of the maximum exploitation for this kind of operations.

3.3 Certification basis

The FAA requirements for CAT II operations are the same as for airplanes and are spread between several "parts" of CFR title 14 and in Advisory Circulars. In the cost/ effectivness evaluation it has to be taken into account that the CAT II operation approval requires the compliance to airworthiness and operational requirements in these three major areas:

a) Equipment and airborne avionics.
b) Crew qualification
c) Maintenance

The most relevant requirements are contained in (FAA) part 91, Appendix A, featuring the following arguments:

1) CAT II Manual
2) Required instruments and equipment
3) Instrument and equipment approval
   (including an in-flight evaluation program)
4) Maintenance program.

This Appendix covers requirements both for a) and c) areas and for the certification flight test program.

Furthermore, some other paragraphs of part 91 refer specially to CAT II operations:

(FAR) 91.2 - Certificate of authorization for certain CAT II operations.

(FAR) 91.6 - CAT II & III operations, general operating rules.
(FAR) 91.33 - Instrument and equipment requirements.
(FAR) 91.34 - CAT II Manual.

For General Aviation aircrafts,as such as for the most of helicopters, a guidance for CAT II operations approval is:

A.C.No 91-16: "CAT II OPERATIONS-GENERAL AVIATION AIRPLANES".

This Advisory Circular covers aspects for both b) and c) areas and evaluation program.

In regard of crew qualification, special references to CAT II are included in FAR part 61, paragraphs:

(FAR) 61.3 f) - Category II pilot authorization
(FAR) 61.3 g) - Category A aircraft pilot authorization
(FAR) 61.21 - Duration of Category II pilot authorization
(FAR) 61.67 - Cat.II pilot authorization requirements.

Additional requirements for commercial and aerotaxi operations are contained in (FAR) 135.111. "Second in command required in Category II operations".

A summary of the FAR involved is shown in figure 2.

From the analysis of these requirements two different applications for helicopter such as the A109 emerge: private use (part 91) and commercial use (part 135).

- PRIVATE use:
  Since helicopters fall into "Aircraft approach Category A" (FAR 97.3), because of their low approach speed, it is possible to obtain a special CAT II authorization certificate, exempting both helicopter (FAR 91.2) and crew (FAR 61.3 g))to meet the full CAT II requirements, in case the Authority recognizes the capability of safe operations. Pratically even now many airport towers permit IFR private helicopters to land below the CAT I weather minima. Such authorization does not permit operation of helicopter carrying persons or property for hire and compensation. CAT II Maintenance Manual is not required.

- COMMERCIAL use:
  All the requirements have to be applied. The heaviest differencies from the basic IFR certification consist in:
  - duplication of many instruments, the addition of two localizer and glide-slope system and of either a Flight Director or an Automatic approach coupler;

- heavier maintenance program for equipment and system, including the obligation of a CAT II Maintenance Manual.
- The obligation of a CAT II pilot authorization and operations with a second in command.

3.4 Flight test program

FAR part 91, App.A, requires to carry out a flight evaluation program, consisting in 50 ILS approaches to be flown on three different ILS facilities (part 91, App.A,3.2 (e)).

Ninety percent of the total approaches made must be successful. The judgement is based both on localizer and G/S deviations at middle marker and DH, and on runway alignement extended from touchdown zone to middle marker. A.C. No 91-16, attachment 2, sets forth acceptable means of compliance for instruments and flight control systems, requiring the Flight Director and Automatic Pilot Coupler performances shown in figure 3.

The Agusta A109 flight test program was carried out from August to September '83 at the facilities of: Milano-Malpensa (Italy), Houston-Texas (USA) and Shreveport-LA (USA). The tests were flown on two A109A helicopters both featuring a Sperry Helcis II AFCS, with duplex system on pitch and roll and single on yaw (figure 5). The data recorded during the tests were:

- LOC deviation
- G/S deviation
- Radioalt - sensivity 1 (700 ft Full scale)
- Radioalt - sensivity 2 (2800 ft Full scale)
- Airspeed

The LOC and G/S signals were taken from HSI, radioaltimeter from cockpit instrument and airspeed from FD. The airborne recorder was a Schlûmberger Photobrush recorder. The data were shown as time history of all the parameters on the same paper strip. An example of data recording is reported in figure 4). Airspeed is not shown in figure because FAA considered it just as control parameter and not important for the evaluation, because the helicopter was not featuring an automatic power-control system (FAR 91,3e)2i)).The approaches were carried out in the following conditions:

- T/O weight and CG : 2490 Kg, neutral
- Approach Airspeed: from 60 to 120 Kias
- FD mode: Coupled and Uncoupled
- DH: 100 ft and 50 ft
- End of approach below DH: Landing, Autolevel,Go-around

Many of all possible combinations were tested.

The CAT II certification target was the achievement of a 100 foot-DH. Nevertheless thirty-two of the fifty approaches were flown down to a 50 foot-DH, to demonstrate the system capability to safely lower even the CAT II weather minima. Special emphasis was laid on the helicopter behaviour after a nose-down hardover at DH of 100 feet and 50 feet, with the pilot recovery after the normal reaction time delay (nominally zero at DH) plus the recognition time of the failure. A total of seven hardovers were carried out from 120 to 60 Kias. Besides one approach down to 100 foot-DH and subsequent go-around, after an engine failure at 500 feet, and two approaches down to 50 foot-DH and subsequent go-around, with SAS 1 and SAS 2 off respectively were carried out.

3.5 Test results

Forty-seven of the fifty approaches were successful down to the CAT II 100 foot-DH. That means the 94 percent of the total approaches, then the FAR 91, App. A requirements were met.

Most of approaches were satisfactory even down to 50 foot-DH. When in coupled mode, the automatic recovery due to the 50 feet autolevel function diverted the helicopter from the G/S path, but when uncoupled, the G/S indication was well into the allowable deviation. Due to a better behaviour on directional stability, uncoupled mode was a bit better than the coupled one, specially at low airspeed. So, just before the official tests, it was decided to increase the former lower approach speed from 50 to 60 Kias. No problems came out during one-engine off and single SAS approaches. In both cases having reached the DH, a sufficient automatic go-around capability was shown.

The helicopter behaviour after a nose-down hardover was extremely satisfactory. The total altitude loss compared to the intended trajectory was less than 20 feet in the worst case, i.e. 120 Kias. For this reason the maximum approach speed below 100 feet has been prudentially reduced to 100 Kias. All the hardovers were easy to recover because of the very soft change on the approach trajectory and the recovery time was never less than three seconds at 100 feet, well above the minima required and two second at 50 feet. The recovery technique was very simple: a small stick correction and retrimming of the operating actuator. After that the AFCS system was still able to make a full autolevel and subsequent automatic go-around.

4. CATEGORY "H "- A REALISTIC GOAL

As already noted above, the IFR approach procedure

requirements were made taking in mind airplanes rather than helicopters. However it is generally recognized that helicopter operations, approach and landing included, can be conducted in foundamentally different ways than those of airplanes, due to the inherent helicopter characteristics. In fact four peculiarities make a helicopter IFR approach much less critical than an airplane approach:

1) lower approach speeds;
2) more manouvrability near the ground at very low airspeeds;
3) a precision alignement to runway is not necessary
4) a touchdown immediately after the flare is normally not necessary.

These inherent characteristics make easier the last minute correction for precision alignement after DH.

In a certain amount, this peculiarity is recognized by the FAR themselves, where in part 97.3 (d-1), "Copter Procedures", allowance for helicopters to halve the landing weather minima reported in the approach charts is granted. However this allowance is restricted to RVR, while we believe a real capability for basic IFR certified helicopters exists even to halve the published DH. Many Air Traffic Controls (ATC) are already giving this possibility.

For these reasons we could affirm that time is ready to issue a new helicopter IFR approach procedure regulations, called CATEGORY H.

This category will permit the basic IFR helicopters to operate down to the CAT II airplane landing minima on CAT I landing sites, provided a slight improvement in airborne equipment and an airport performance check.

The above concept was already advanced in a draft paper titled "Category H. Criteria for helicopter low weather/ visibility operations" issued by the FAA Southwest Region a few years ago. In the present paper we would enhance this concept, affirming that the A109A CAT II certification program demonstrates the capability to halve not only the CAT I but even the CAT II landing minima down to CAT III a).

In A.C. No 120-28C is set forth the primary CAT III mode is automatic-to-touchdown using automatic landing system (ALS), providing the capability of a go-around any point in the approach. However the use of systems with the pilot -in-the-active-control-loop is not precluded, when an equivalent level of safety is shown. The need of an ALS for automatic-to-touchdown is fully giustified for large airplanes, because their relatively high speeds in proximity of the ground in very poor visibility prevent the pilots to

accomplish the flare and the touchdown or the airplane recovery after any failure. The ALS must to be redundant, because it should perform the capability to complete the landing and/or the rollout after one airplane or system failure. This capability is not required if a Fail-Passive Automatic Flight Control System is installed. In paragraph 5, h) of the same A.C. this system is defined in such a way that, upon occurance of any single failure, it should not:

"(1) Cause significant displacement of aircraft from its approach path or altitude loss below the nominal glidepath.
(2) Upon system disconnection, involve any out-of-trim conditions easily controlled by the pilot.
(3) Cause any action of the flight control system that is not readily apparent to the pilot either by control movement or advisory display."

Fail passive CAT III operations are conducted with a 50 foot-DH and are limited to CAT III a). Furthermore, just prior to passing 50 feet, the pilot has to determine if adequate visual reference is available to verify the correct aircraft position before the touchdown (same A.C.,7b)).

The A109A behaviour in the approaches down to 50 foot-DH shows an equivalent level of safety of CAT III a) operations. At the lowest approach speed this level can be achieved even without the Autopilot coupling and Autolevel modes, because manual approaches were more precise than the automatic ones and because the need, for CAT III a), to reach visual reference prior to passing 50 feet (see above), enables the pilot to begin either the flare or the go-around with full safety, due to the very low vertical and horizontal speeds. This possibility is also recognized by ICAO "ATM-Guidance Material on Airworthiness Certification of Aeroplanes for Precision Approach Operations" (par. 4.2a)1)).

Higher approach speeds, useful on crowded airports, could required an automatic approach system with Autolevel mode at 50 foot-DH, as featured on the A109A. If we equalize the airplane automatic-to-touchdown to the helicopter autolevel mode, we find the A109A AFCS is performing the characteristics required in paragraph 5,h) of the A.C. (see above). The loss of the radio-altimeter (coupled to FD for the Autolevel mode) or a nose-down hardover are readily detectable and without significant conseguencies such that a go-around (even automatically) can be performed.

The advantages of the Autolevel mode at the 50 foot-DH are the following:

- the helicopter performs automatically the flare from 100 to 50 feet without the need of visual cues;
- at 50 foot-DH much more time is given to the pilot to check the precision of the alignement and the required visibility; this is due to the fact the helicopter needn't to lay down the landing gear on the touchdown zone.
- The demonstrated capability of the A109A AFCS to complete the autolevel and/or an automatic go-around upon occurance of a critical hardover, overcomes the CAT III a) equivalent level of safety. The installation of a second radioaltimeter could improve that level further on, but that is not required for the intention of this paper.

5. PROPOSALS

5.1 "Copter procedures" in part 97.3 (d-1) could be re-issued in such a manner to grant full allowance for helicopters to halve the published landing weather minima, both RVR and DH,for CAT I and CAT II facilities, unless: (a) the Flight Manual of that type of helicopter sets forth more stringent approach limitations come-out from the airworthiness evaluation program, and/or (b) that facility is not complying with the required standards.

5.2 These new helicopter procedures could be called CAT H/I and CAT H/II.

5.3 CAT H specific airworthiness requirements,if any,should be introduced into FAR 27 and 29, App. B, Amdt. No 22, and into FAR 91, App.A.

5.4 Allowance to choice either CAT I & II or CAT H/I & H/II operations should be granted.

5.5 An A.C. to better introduce to CAT H operations and airwothiness requirements shall be useful.

5.6 In the airport approach chart a normal availability of CAT H operations should be indicated.

5.7 At the beginning of the approach, the pilot should specify to ATC his intention to use a CAT H procedure. From the ATC point of view this workload increase should not represent such a heavy burden.

6. CONCLUSION

We are aware the experience on helicopter IFR ILS approach procedures is not so wide to permit a ready availability of special helicopter procedure, such as

CATEGORY H, however we believe it is on the interest of manufactures and operators to push strongly in this direction.

We think the experience collected during the CAT II certification program of the A109A, MkI & II, represents a significant step along this way.

FIG. 1

LANDING WEATHER MINIMA

CATEGORY	D.H. ft	R.V.R. ft
I	200	2400 (1800)*
II	100	1200
III A	100←→0	700
III B	50←→0	150
III C	0	0

* (with operative touchdown zone and runway centerline lights)

FIG. 2

CAT II APPLICABLE REQUIREMENTS FOR PRIVATE AND COMMERCIAL OPERATIONS

AIRBORNE AVIONICS & EQUIPMENT	CREW QUALIFICATION	MAINTENANCE
par. 91.2	par. 91.2	—
" 91.6	" 91.6	—
" 91.33	—	—
—	—	par. 91.34
part 91 App.A	—	part 91 App.A
—	par. 61.3 f)	—
—	" 61.3 g)	—
—	" 61.21	—
—	" 61.67	—
—	par. 135.111	—
AC n° 91 - 29	AC n° 91 - 29	AC n° 91 - 29

FIG. 3

LOCALIZER AND GLIDE/SLOPE

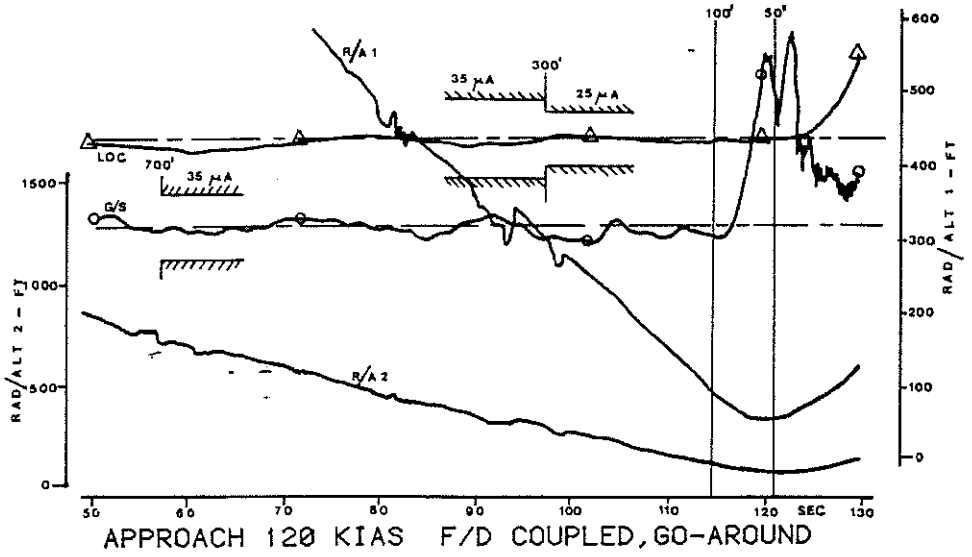
CAT II ALLOWABLE DEVIATIONS

RUNWAY ELEVATION from / to	LOCALIZER FD/ACPL	GLIDE/SLOPE FD/ACPL
OUTER MARKER / 300'	∓35μA/∓35μA	---
300' / DH	∓25μA/∓25μA	---
BEFORE 700'	---	helicopter stabilized
700' / DH	---	∓75μA/∓35μA(∓75μA)*

FD : Flight Director
ACPL : Automatic Pilot / Coupler
μA : Microamperes
* with the pilot in loop.

FIG. 4

EXAMPLE OF DATA RECORDING



APPROACH 120 KIAS F/D COUPLED, GO-AROUND

A 109A Mk I & II

SPERRY HELCIS II AFCS

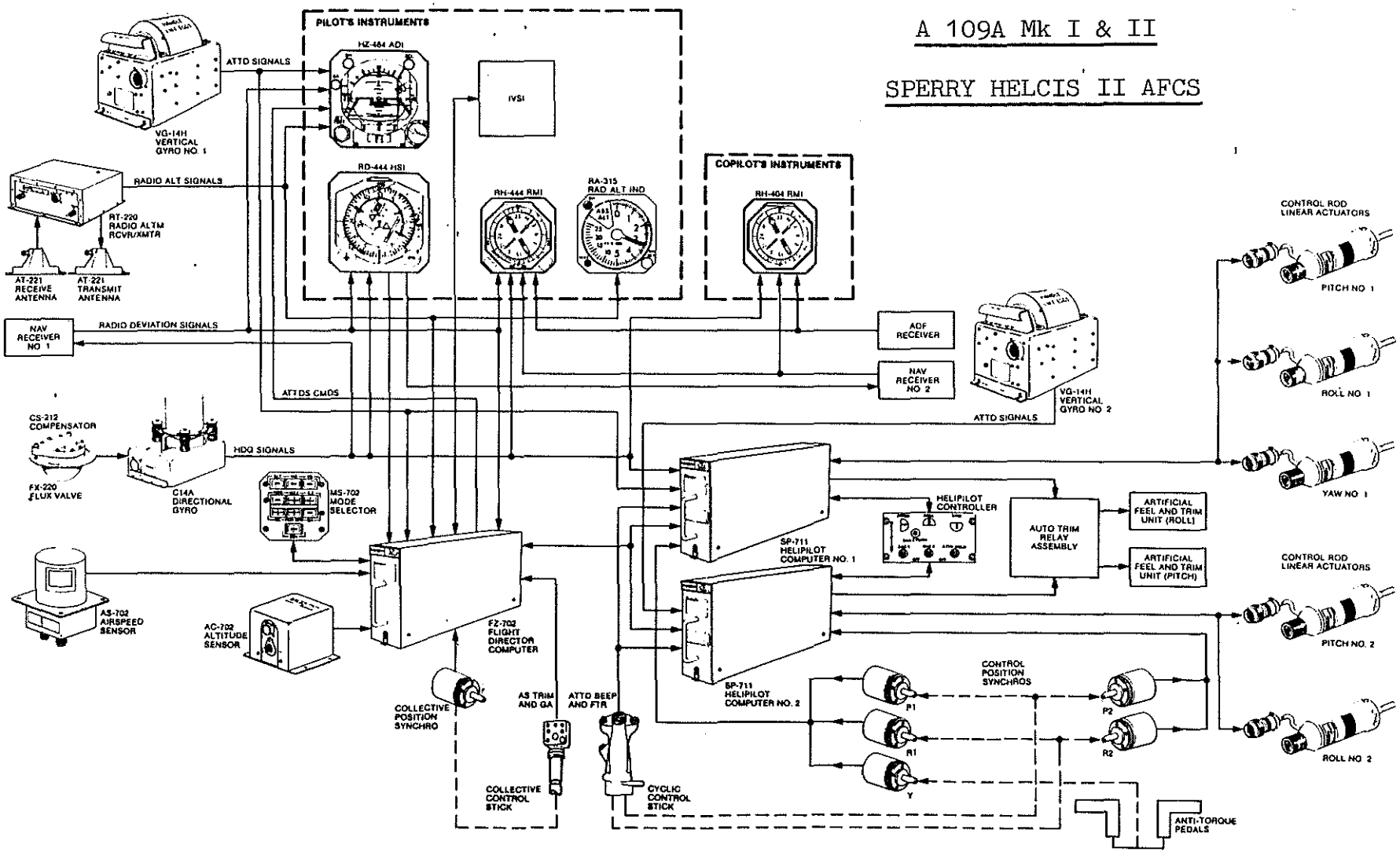


FIG. 5