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IS THE PILOT NECESSARY IN A LIGHT OBSERVATION HELICOPTER?

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1. Introduction

The development of the remotely piloted surveillance helicopter has indicated the degree of automatic control which has been achieved as well as the miniaturisation and light weight of the necessary equipment. The role envisaged for the manned light observation helicopter and the surveillance drone are in many areas complementary. It is reasonable therefore to question whether there is an intermediate vehicle which combines the advantages of the human observer with the benefits which modern control technology can confer in terms of reduced weight and cost by replacing the pilot's function with a monitored computer control. This, of course, presupposes that the observer and the pilot's main activities are complementary and this point is examined in the next section. The weight saving that can be achieved by replacing the pilot by a computer controlled system is then investigated. Finally the question as to whether the advantage is increased or decreased as the operational performance requirements and the technological base are changed is examined.

2. The Role of the Pilot and the Observer

The pilot is responsible for pre-flight checks and for the take-off, cruise, operational phase flying and landing. He will obviously support the observer in his examination of possible targets. It can however be argued that the tasks which he conducts without the observer's participation are the take-off and landing, in all other phases of flight the observer will be requiring services from or giving positive help to the pilot. The pilot has a prime role in any real or indicated malfunction of the helicopter and while the observer may lend assistance the human interpretation of the indications are extremely important.

The observer will be most heavily involved in the target area where he will require the helicopter to be positioned so that he can use his surveillance or weapons system. In this case he will require his pilot to manoeuvre the helicopter to a given position and it could be that in some cases the need to convey these instructions to the pilot could introduce delays which might reduce the value of the mission. During en route flying the observer will operate the communications and navigation equipment as well as keeping watch for obstructions, other aircraft, etc. The need for much of the observation work can be caused by the visual limitations introduced by a side by side crew layout.

These points are underlined by the following extract of a paper entitled "Army helicopter operation at night and in adverse weather" (Ref.1). The author said the reasons for a two man crew are:

(a) It is essential in the Armed Action role.

(b) It increases air reconnaissance ability by having a trained observer equipped with a stabilised optical equipment.

(c) It relieves the work load on the single pilot crewed helicopter.

(a) and (b) support the need for the observer (or gunner), and (c) could be met by increased automation.

The functions which could be taken over by computer are therefore next examined.

3. The Effect of Replacing the Pilot by a Computer

In order to estimate the change in helicopter weight when the pilot is removed, an existing helicopter, the Westland Scout has been taken as the starting point. A computer programme has been written to synthesise the weight breakdown of such a helicopter so that individual components can be altered and the overall effect determined. In this study the mission has been defined in terms of a period at full power and a cruise over a given distance at a constant speed. A typical variation of specific fuel consumption with power has been used to relate the fuel required during the phases of the flight; the S.F.C. at maximum power can be adjusted to reflect improvements in engine technology. Similarly the weight of the engine varies with maximum power required. The programme also computes the main and tail rotor transmission, undercarriage, flight controls and structure weight. The programme is arranged to iterate to a given payload.

The initial parameters chosen for the Scout simulation were the main rotor area (75.9m^2), cruise speed 45~~km/hour~~ m/sec, an equivalent flat plate area of 2.2m^2 (Ref.2) to estimate cruise drag, an SFC of 0.89, at full power, a hover time of 20 mins and a cruise range of 245 kms. The payload was determined as 900 kgs (excluding fuel). This produced n helicopter mass which closely corresponded to that of the Scout (2400 kgs).

The initial items which can be removed are the pilot, his seat, controls and instruments. These result in the following mass savings (Table 1). The observer has retained full environmental supplies and control console. The armour requirements for the pilot have been retained to protect the computer assemblies which are to be installed.

Reducing the payload mass by 150 kgs reduces the mass of the helicopter by 12% for the same mission if the same rotor diameter and fuselage size are retained. Reducing the rotor area to retain the same disc loading and solidity of the Scout gives a further reduction of 4%.

It is now necessary to introduce a computer which is capable of performing the various control functions. The two functions which must first be examined are the control of the aircraft and of the engine. There are however other computers included in the aircraft - for example those associated with navigation equipment which rely on inertial and or doppler systems, and it would seem sensible to include this facility within the central processor.

Most information is available on the digital control of engines (e.g. Ref.3). It is suggested that the electronic controls will have a mass of not more than ½ kg. In terms of computer words the equivalent program would not exceed 2096 words (each of 8 bits). The total mass of a system including the monitoring, start up and shut down facilities will not exceed 7 kgs.

The computer requirements for the control of the helicopter can be defined as follows. A digital autopilot to provide the necessary motions of the helicopter in response to preset conditions entered by the observer, e.g. height, speed, requires a computer store capacity of 8500 words. Inputs from a navigation system - inertial or doppler requires some 3600 words. These are normally provided in the individual navigation system and it is assumed that this computer weight could be saved by making the main computer carry out the necessary calculations. There will need to be a logical operating system to control the computer operation which is estimated to use 5000 words. In order for the computer to have versatility in operational use a further extension of the store by some 11,000 words has been assumed. It must be stressed that this extension of the store has not been provided so that the observer can programme the computer en route but so that some pre-programmed options can be included which he can call up as required. It also gives the flexibility to integrate any weapon system into the overall system. A total of 31,200 words is therefore required based on the pessimistic assumption that time sharing between the various inputs is not feasible. It is known from work on digital engine control that this is pessimistic, nevertheless the word store requirement will be retained to avoid over optimism in the answer.

An examination of data on computers (e.g. Refs.4,5,6 and 7) for airborne use suggests that the computers used for phases 2A and 2B of the NASA fly-by-wire programme are suitable and that this would have a mass of 40 kg. Obviously two computers of similar size and capacity would be required to guard against computer failure and it is assumed that part of the 11,000 additional words will be used to check the correct functioning of the computer. The mass of the computer installation is therefore 80 kgs.

The failure of a computer is obviously a major source of worry when proposing that the pilot is replaced by a computer. Here the observer plays a major role which it is suggested makes this system much easier to validate than a triplicated or similar automatic control without human intervention. One way to achieve this result is to make the computers compare their decisions for a given set of inputs in each main area of decision, e.g. engine outputs, cyclic pitch outputs, navigation co-ordinates etc. In each case, if a preset difference is exceeded, a warning will be given to the observer both visually and aurally. However the warning system will be in two categories, namely those of prime importance to the control of the aircraft, i.e. errors in the output to the cyclic pitch controls, and those which affect the mission success but are not necessarily hazardous, e.g. discrepancy in navigational co-ordinates. In both cases an indication that a discrepancy has occurred will be given to the observer both visually and aurally in such a way that he is able to decide the importance of the fault. Within the computers a series of diagnostic programs are available for him to decide the cause of the fault and to enable him to switch out the defective unit and to reoptimise the remaining computer capacity. In the limit each computer will contain a minimal hard wired section which will link the miniature controls used by the observer to command the computer in normal operation to the primary flight and engine controls with a minimum of stability augmentation operable over a limited flight envelope which will allow the observer to abort the mission and return to base using manual navigation and elementary flying skills.

An alternative failure is the incapacitation of the observer. In the case of a two man crew obviously the other crew member could recover the machine and return it to base. In the computerised aircraft it is proposed that if no inputs are received from any of the observer controls (i.e. flight inputs, weapons systems, etc.) during a pre-determined interval the computer will then sound an alarm to alert the observer should a combination of circumstances have caused him not to make any inputs. Should the observer not respond within a limited period then the helicopter will automatically return to a pre-programmed map reference at an altitude which is either pre-programmed or which exceeds the highest altitude on the outward journey. The landing of the helicopter at the base will be achieved by the helicopter automatically entering the hover at pre-programmed altitude and lowering a cable through which signals from a ground control can be conveyed to the helicopter to make the landing.

The mass which has to be put into the helicopter to achieve this result is 40 kgs for the computers, 12 kgs for the observers control panel and information display, together with a saving of 14 kgs by replacing hydraulic jacks and linkages with electrical services, which might be more directly controlled by the computer. Thus 38 kgs has to be added to the payload making a new reduced payload of 788 kgs. It will be appreciated that this disposable load allows the helicopter to carry all the various loads which are currently available to the Scout or similar machines.

The helicopter fuselage no longer needs to have the same shape with only one crew member. Redesign of the fuselage suggests that the effective drag can be halved. This is in line with the data shown in Ref.2. Making these adjustments the computer program calculated that the helicopter would have an A.U.W. which is 16% less than the Scout simulation for the same mission.

The saving in weight can be directly related to cost if it is assumed that the development programmes are comparable. If the money expended on the order is constant then to a first order it is argued that the fleet size could be increased by 19%. This figure will be increased further because the R&D costs per aircraft will be reduced by being shared between more aircraft.

There are however different operating costs which have to be faced for the new aircraft which are not discussed here. It should be mentioned that the rapidly developing techniques of maintenance by condition which is determined with the aid of a computer could be carried out by the aircraft computer system and this would reduce down time in the fields with consequent improvement in operational efficiency.

4. Sensitivity of Conclusions to Initial Requirements

The starting point for the exercise described above used parameters which were determined in the early 1960's. It is important to assess the sensitivity of the answer to changes in mission and some technological advances. As in the above exercise, so in each case, the technological base was kept constant for the comparison thus avoiding the pitfall of comparing a system with advanced technology with a much earlier design.

The variations made in the computer program are detailed in Table 2.

It was found that over the whole range of variation of these parameters the ratio of all up weights with payloads of 750 and 900 kgs respectively showed remarkably little variation (± 1.5% on 16%). Naturally there is a very large variation if the comparison is made with different initial requirements. However it is clear that the calculated weight saving is unlikely to be affected by changes as wide as those suggested in Table 2.

The choice of a machine as large as a Scout obviously makes the percentage weight saving by removing the pilot less than in a smaller helicopter, e.g. a Gazelle. In this case the percentage gain will be larger and the argument stronger.

5. Conclusions

The calculations suggest that replacing the pilot by a computer could result in a helicopter which would perform the same mission for an AUW reduced by 16%. On the assumption that weight and cost are linearly related this could lead to an increase in fleet size of 19% for the same expenditure on the assumption that R&D costs per aircraft are negligible. This figure rises to 21% if the R&D costs represent 10% of the cost of the manned aircraft or 23% if the R&D cost fraction is 0.2. There are clearly problems to be overcome but the wide range of airborne computing facilities currently in use suggest that these are small.

6. Acknowledgments

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7. References

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Table 1

Mass Savings Resulting from the Elimination of the Pilot

Item	Mass kgs
Pilot	75
Seat	5.1
Instruments (engine)	2.9
Instruments (flight) and console	13.7
Controls	49.3
Access and environmental requirements for pilots	4.7
	150.7

Table 2

Values of Parameters Used - All Combinations Examined

Range	245	300	400
Hover time (hours)	.15	.33	.67
Cruise speed (~~km/hr~~ m/sec)	45	60	75
Fuselage drag (flat plate area m^2)	2.2	1.1	
Engine SFC (at full power)	.89	.6	
Disc loading kgs/m^2	23	26	32
Payload (kgs)	750	900	