Development of an Aerial Spraying Contract Service

By

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This talk should perhaps begin with a brief reference to the initial development and research made by the Company into the helicopter as a crop spraying machine Many will remember the early experiments made by Dr W E RIPPER, using one of the original Sikorsky R4 helicopters These trials were made at Henley and Cambridge in the early part of 1945 The results were sufficiently encouraging to consider helicopter possibilities in this industry However, the flying limitations of the R4 helicopter did not allow a full investigation into operational and economical findings

The production of the Sikorsky S 51 made this objective possible, and delivery was obtained in August, 1947 At that time suitable spraying equipment was not available The research data available from the R 4 trials indicated that considerable development work was required into suitable airspraying nozzles Many months were spent investigating this most important item and lightweight pumps of suitable delivery and pressures capable of withstanding the effect of various chemicals The installation of the equipment was designed, manufactured and finally approved by the Air Registration Board The aircraft was then put on a programme of entomological trials to assess coverage, under varying weather conditions, and to perfect the spray deposit to a stage satisfactory for active trials

With the arrival of Spring, 1948, several weeks of intensive trials on available crops followed and sufficient experiments had been conducted to enable us to proceed with confidence, and an air spraying contract service was established This became the first commercial helicopter enterprise in the Commonwealth However, it was by no means the end of our development work The Company's ground spraying experience had been invaluable in assisting our air spraying development to reach this stage so quickly It, however, became apparent that a new technique was necessary with air spraying and that development would continue Design and inspection

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approval was obtained from the Air Registration Board to enable us to make all such alterations as became necessary Parallel with commercial operations, improvement of equipment continued, and even now certain modifications continue to become necessary

This first year of contract air spraying in 1948 not only gave us operating experience in the U K from the Humber along the East coast down to Hampshire, but also introduced the helicopter as an air spraying machine Naturally, many growers were sceptical of this inovation, and others were used to high volume ground treatment Fortunately, the season ended on the right side

Our next stage that same year was to try air spraying in Africa on cotton Some concern was felt, as no helicopter had flown in Africa before and the S 51 had done no tropical tests There was no assurance that engine overheating would not occur and ground us in operation, due to slow flying speed with little cooling a few feet above ground level and because of engine idling during chemical refilling Economics also made it important that a severe loss in pay load should not occur Finally, that the machine would stand up in maintenance to the high temperature and the operation in extremely dusty conditions

The Sikorsky S 51 was shipped to Khartoum, assembled and test flown in September, 1948 Several flights were made and found to be satisfactory, and the machine was flown south into the cotton area Entomological results on the cotton leaf hopper were proved shortly after this to be at least as good as ground spraying, and commercial operations followed immediately Our problems had been overcome in the Sudan in one way or another, such as improvement of the tropical air filter, protection of rotor blades with lightweight asbestos covers, frequent dust decontamination, etc The Sudan, however, still remains a most arduous area for air spraying, due to climatic conditions, heat and dust, resulting in operations there giving our highest maintenance costs Some of the aircraft have clocked over 9 hours' flying in a day of 5 15 a m to 6 p m —60 to 100 take-offs and landings per aircraft being common

Following requests for tobacco experimental work, the helicopter was crated at Khartoum and shipped down to Beira in Portugeuse East Africa There it was uncrated and assembled near the Docks, flight tested and flown in short hops up to Salisbury in Southern Rhodesia Again this was the first introduction of the helicopter into these territories An Autogiro had been assembled in Salisbury, in 1939, but it had refused to take off due to the heat and temperature and, therefore, many people in Salisbury were sceptical as to whether the helicopter would be of any use The machine was operated at density altitudes equivalent to 9,000 feet and, because the performance was often critical, crop spraying in Rhodesia proved difficult I would say that flying conditions due to loss of performance, obstruction, and the small fields in which tobacco is grown, and because of heavy convection turbulence, at times proved this work to be our most difficult At the altitudes and temperatures encountered I found a useful commercial load often not possible

On completion of our work in Rhodesia in March, 1949, an experimental programme was planned in South Africa which included wattle tree spraying As the range was not practical to fly this distance, the machine was dismantled and transported on a lorry over a distance of 1,400 miles Unfortunately,

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on arrival in Natal the aircraft was found to be seriously damaged and repair could not be effected in the available time and shipment was arranged back to the U K

Air spraying was resumed in the U K in April, 1949, with the addition of two Westland S 51 helicopters Treatment was made on 26,000 acres of weeds, peas, potatoes and seed crops In addition, a successful operation was undertaken in Normandy, France, on 9,000 acres of Colorado Beetle work This operation proved the speed of treatment helicopters can still achieve even on very small fields and areas, provided suitable grouping of the fields is considered Many fields were as small as an acre, and yet a daily output of 300/400 acres was obtained The work would have been impossible by contract ground spraying

In September, 1949, our second operation on cotton in the Sudan was renewed We had planned to take three helicopters, but due to over-heating problems on the British S 51 the decision was made to take the American version only

At that time the helicopter had flown very little at night due to problems of instrumentation We were anxious to assess the possibilities of air spraying by night over suitable areas The Sudan, with its short daylight hours and extremely high afternoon flying conditions, appeared a reasonable country in which to try out the production value of flying from midnight until lunch time the following day, eliminating the poor quality lift conditions of the afternoon This was, perhaps, one of our most adventurous trials The helicopter was fitted with headlights, tested, and we continued our treatment of cotton for five or six nights The spraying results were effective, and I found it possible to fly a machine at 40 miles an hour as low as 6 feet over the top of the cotton However, the lighting called for much more development work as severe dazzling occurred along the fuselage and when crossing canal banks and fallow ground, and when landing and taking off This was accelerated by the dust stirred up by the down wash In my opinion, given sufficient pilots to avoid fatigue over suitable areas and with further development of lighting and technique, air spraying by night is feasible with helicopters, another unique feature of this type of aircraft

In Spring, 1950, approach was made by the Swiss Government for an experimental contract spraying service on the Cockchafer in the mountainous area of the Valais Two British S 51s were flown and 5,000 acres were successfully treated

In early 1950 we became aware of the possibilities of the Hiller 360 helicopter, and from experience gained after 2 years operation with the S 51 helicopter a decision was made to change over The Hillers were ordered with little time to spare, the machines being air-freighted to the U K Two Hillers were flown out to Khartoum in a Bristol freighter This was, in fact, our first assembly Only a few hours' familiarisation had been gained by myself on the Hiller with no previous operating experience of this type of machine we virtually tried to overcome climatic conditions by the use of the jump and running take-off technique to carry as great a load as possible After completion of the cotton operation in the Sudan, two Hillers were sent to South Africa for treatment of 12,000 acres of cotton against the bollworm This work proved fairly difficult from the entomological point

of view, as correct timing of treatment was essential By this time it was obvious, however, that the Hiller was more suitable for crop spraying than the Sikorsky Its greater manoeuvrability and the fact that maintenance problems were less complicated, offered better serviceability In 1952 our Hiller operation in the U K was completed, with a total of approximately 32,000 acres At the end of this, our Sudan operations took place again Gradually the acreage in most of our campaigns has increased, and last year our largest air spraying operation took place in the Sudan, where over 150,000 acres were treated by air in approximately 12 weeks, with a total of 300,000 acres to include ground treatment

In the latter part of 1950 the decision was taken to supplement helicopters with fixed wing aircraft and a development programme was carried out with an Auster to find the right field of application for each type of aircraft We are not aware that anybody had previously attempted such comparison in full scale operations We are now operating 6 Austers, using them on areas suitable from a flying point of view as well as from the entomological side The main advantage of this machine is, of course, its cheapness of operation, and its use at present places us in a position to include it where suitable work occurs In the destruction of locust swarms in flight the fixed wing is more suitable due to a higher cruising speed and better range

We have at times carried out charter work of an unusual nature, but, under normal circumstances, little time is available for this type of work One job which stands out in my mind is one done in April, 1952, and involved the first cable erected by the application of a helicopter in the Commonwealth This work was done near Malvern on undulating terrain, where it was found impossible to lay this cable by normal methods without destruction of many acres of valuable forest The result was most successful, and there is no doubt of the possible use of helicopters in this field

The summary I have given you of our operations gives a fair idea of how widespread our work has been In many territories the helicopter had not flown before Often these countries offer difficult climatic conditions with problems of altitude and low performance We have at present exceeded 6,500 hours of helicopter flying Current contracts include operations in further territories for the helicopter, such as Ceylon and West Africa There is also no doubt in my mind that few operations are as arduous on the flying side or in the maintenance field as those met in aerial spraying—no better medium to train safe captains for helicopter airlines of the future !

I claim this because flying conditions are tiring due to concentration during prolonged periods of low flying , in fact, over 85% is done a few feet above the ground Continuous manoeuvring and turning, avoiding obstacles, combined with frequent take-offs and landings necessitate flying the machine all the time with no margin for error resulting in physical fatigue An average of four hours flying per day is sufficient on this type of work Some of our pilots have exceeded eight hours on some days, but it would not be possible to keep up to this figure for more than the odd occasion As the intensity of the work varies so much, three pilots per two aircraft seems to me adequate in considering pilot fatigue as well as the economic factor

The organisation necessary for an air spraying service is quite considerable and requires a great number of professional and technical workers, apart

from the flying side , far more detailed work and difficulties arise than one would expect One of our great troubles is the very high degree of mobility required in our operations The demands of mobility in some cases cannot be met, but the constant struggle to be in as many places as possible at the same time is probably the most important factor in our operational headaches In order to give some idea of the operational plan which we make before our work, the following summary is made This must be divided into main headings as follows

(1) OPERATIONAL REQUIREMENTS AND DATA This information provides a base for all details of the work involved
(2) PRE-DEPARTURE ARRANGEMENTS From (1) is calculated the C of A renewals required, overhaul life requirement of aircraft and components, spare parts, schedules, personnel
Under Transport—vehicle requirements and spare parts—any modifications necessary
Chemical requirements and testing for suitability as an insecticide and for aircraft use, if necessary
Any additional auxiliary requirements
The Administration Section—licences, permission to operate, passports, health, currency, etc
(3) MOVEMENTS—personnel, equipment, supplies, etc
(4) ARRIVAL ARRANGEMENTS Customs clearances, assembly and main base arrangements
(5) FIELD PLAN OF OPERATIONS All arrangements concerned directly with the operation.
(6) Entomological liaison and supervision of the control effected
(7) Disposal Instructions and Arrangements

In considering the methods of transport of the helicopter, due to the low cruising speed and high operating cost at the present time we have found it more economical on crop spraying operations to trail the machine by road behind the supply tanker for distances of over 80 miles This is, of course, if no serious loss of production occurs This method is often used overnight

For movements to overseas countries we have made good customers of the British Companies air charter The small helicopter has an advantage in both internal and overseas transportations , to give some idea two Hillers with spraying gear, spare parts and crew of four have been transported in a Dakota and four Hillers and spare parts have been successfully stowed in a York Obviously, the more aircraft possible to transport in a single air charter results in a decrease of transportation costs per flying hour

In regard to maintenance, the wear and tear of both the helicopter and fixed wing aircraft is higher on air spraying work In my opinion the increase of maintenance costs in comparison to normal passenger flight services could be considered at 40% in European countries to as high as 60% in Tropical countries This can be sectioned into

(*a*) *Great* number of full load take-offs per day—additional strain in continuous rapid turns, climbs and other manoeuvring action, in this also occurs periods of full power
(*b*) Climatic conditions involving over-heating of the engine, dust penetration and subsequent deterioration of the engine Also the occurrence

of dust penetration into moving parts and the temperature effect of wooden rotor blades

We have discontinued using the jump take-off method as being an unnecessary strain on the machine as a whole, and in fact detrimental to wooden rotor blade construction, especially in high temperatures The alternative method of overload take-off, namely, by running the machine off the ground has been found more positive and effective, and has reduced our maintenance costs considerably

In fact, wherever possible this method of take-off is used by us in preference even to the normal hovering take-off, except in cases where sites suitable for running take-offs cannot be found Reasonably rough ground has been used at times

In order to give you some idea of the acreage production of the helicopter, it must be appreciated that many variables affect this point These are divided into two categories

(*a*) Those influencing production per flying hour, and
(*b*) Those that have a bearing on the daily production

In the case of production per flying hour, the following points are brought to mind

(i) The gallonage of chemicals applied per acre
(ii) The distance of landing site from the area to be treated
(iii) Altitude of the take-off site
(iv) Altitude of the area to be treated
(v) Size and shape of fields and obstructions—direction of wind
(vi) The flying speed of treatment and swath width
(vii) The skill of the pilot
(viii) Flying conditions encountered at the time (wind conditions, turbulence, etc)
(ix) Type of helicopter—payload and manoeuvrability

The effect of these conditions can be clearly seen in our records where acreages as low as 12 acres per flying hour have been experienced and in other cases as high as 240

The daily output is materially influenced by the points listed below

(i) The efficiency of the ground equipment in reducing to a minimum the time spent on the ground during refuelling of chemicals and fuel
(ii) The efficiency of the re-fuelling crew
(iii) The daily working period This varies considerably in different territories Overseas, shortage of daylight hours and other considerations have to be allowed for, periods of rain and wind conditions and convection currents In some countries spraying can be done all day, in others only early mornings and late afternoons
(iv) Breakdowns and other delays during the day
(v) Distribution of the work can cause excessive movements, reducing the daily output considerably

Our highest daily output in the U K has been in the neighbourhood of 550 acres and overseas 1,260 acres for the Hiller 360 in a day

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In considering the overall efficiency of an air spraying unit several points have a direct bearing The flying requiring precision, accuracy and with little margin for error demands an experience and familiarity of the machine sufficient for it to be flown to its full capabilities, and the pilot must appreciate his limitations But will the pilot appreciate his limitations ? Over-confidence occurs only too easily after a time and as our experience indicates leads to accidents only too quickly Our avoidable accidents have been directly due to inexperience and over-confidence

We have adhered for conversion of pilots to helicopters on spraying a minimum of 1,000 hours flying experience I would further qualify this to light aircraft experience, preferably with some instructional work Pilots are converted in 50 hours helicopter flying before crop spraying commences, and then put under supervision by an experienced crop spraying pilot treating suitable areas only until released competent

I would like to see 250 hour helicopter experience to ensure safe commercial operation on aerial spraying , but crews of this experience are not obtainable Accidents have lost us considerable production at times

In referring to pilots' experience on aerial spraying the flying is of first importance but must be supplemented by a knowledge of spraying equipment and spray chemicals and also a background on entomology and agriculture

The pilot gains practical knowledge during the various campaigns, but to avoid complications short courses are given by us during training Considerable damage can be done by lack of knowledge, as was found in the States at the beginning of their crop spraying development There, inexperienced aircraft operators caused much damage to crops and in some cases to their own crews Legislation has been passed in some states that an endorsement is required on pilots licences for aerial spraying This involves a short course at an approved chemical and spraying organization, followed by a technical examination Indescriminate spraying can lead to extensive damage to crops, livestock and damage to the public and to the operators own personnel

Medical supervision of the pilots is a necessity when using toxic spray chemicals Pest Control Ltd has its own medical staff involved in research Use is made of this facility and during any toxic spraying, pilots and crews are routine-checked by a blood sample method for possible contamination

The next item to be considered is the application material The spray chemical must be effective and is assessed by our Research and Technical Department, who at the same time recommend the correct dosage to be used This must be on the safe side to guarantee results , but must remain within the economical application rate In any new crop a field check must be made as laboratory results do not necessarily always agree with field conditions The spray droplet size is very important and nozzles are selected which give the right droplet spectrum and right mass median diameter Changing temperature and humidity during the day has also to be considered because this reduces effectiveness, and in some cases causing possible crop damage, scorching of plants, etc

The aircraft must be supported by suitable ground equipment We use two types of supply tankers One standard supply tanker provides two separate chemical tanks of 800 gallons total capacity, mechanically agitated, fitted with live reel hose and capable of refuelling the Hiller in 40 seconds Above these tanks a 250 gallon aviation fuel tank is fitted with suitable fixed

hand pumping unit The alternative tanker is larger and of a single chemical tank unit giving a capacity of 1,200 gallons The units are fitted to tow the helicopters on a road trailer, the supply tankers are fitted with radio telephones by which they keep in touch with the company's branch offices

The number of tanker units is dependent on the distribution of the work and aircraft involved, and the overall loading One tanker per aircraft forms a basis , but in some cases two are used allowing the helicopters to keep a high production figure by leap frogging from one unit to the others The tankers travel independently to different farms In other work of larger acreage helicopters working off two tankers from the same landing site have been kept supplied without loss of time for chemical mixing

Perhaps I should stress here how very easily hold ups can occur during operation The aircraft with its possibility of breakdown is only part of the vulnerability in this work There is also to be remembered the tanker engine, the pumping mechanism and the aircraft spray gear These mechanical breakdowns can be increased by loss of time due to chemical difficulties Lack of cleanliness and correct procedure on change over from one chemical to another can lose without trouble a complete day, especially if the tanker is in question Poor mixing of a tanker load on some chemicals can also seriously delay There are also those chemicals which require more careful mixing, and in air spraying, especially where concentration of chemical is high in proportion to water content, are difficult to spray Correct filtration of the tanker unit, down to the aircraft spraying gear and suitable nozzles are essential, and even then time is often lost because of blockages

In addition as movements can be frequent briefing is most important to avoid delays especially when two tankers are used

The Air Registration Board, because of Pest Control Limited technical knowledge in crop spraying matters, has kindly given our biological and chemical experts a free hand in the selection of spray chemicals This is not abused and before any new chemical is used, quite apart from its suitability, as a product, a special essay is made to assess its suitability for aircraft usage The approval note is signed by the Chief Chemist and Chief Aviation Inspector and contains results of corrosive tests made on various materials in the aircraft construction, inflammability condition, toxicity degree and any recommendations for its use

The spraying gear design and any necessary modifications of course play an important part in consideration of inflammability and toxicity When toxic chemicals are used the pilot is briefed on its qualities and the necessary safety precautions before and in case of contamination, in accordance with the Company's Chief Medical Officer's instructions

Extreme precautions are necessary for very toxic chemicals on the ground during re-fuelling and in the air Ground crews wear protective clothing which includes gas masks and rubber gloves The pilot has the option of flying completely-enclosed in the cockpit without protective clothing but wearing a face mask, of full protective clothing and preferably a service type gasmask In the States, accidents through toxic chemicals have occurred but we are so far without any mishap thanks to the foresight of medical science and the co-operation of the pilots, while in U S A there were accidents in which the pilot has died, not as a result of injuries but chemical poison Fields should be treated flying across wind

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starting on the leeward side and the aircraft must be de-contaminated immediately after use

Most crews are not keen on toxic spraying, and for this they cannot be blamed I think that good discipline and sound precautions overcome the psychological aspect and that with proper care the danger aspect is negligible The nuisance value appears the worst as these precautions slow the operation and fatigue the crew quickly especially in hot weather

In a comparison between the aeroplane and the helicopter for aerial spraying this side of the Atlantic there is no doubt in my mind that the helicopter is the tool for this work

There is, however, tremendous room for improvement, particularly in the economical question But for this point I do not believe a comparison between the two would arise at all However, instead of an improvement costs have increased over the past four years and development can be termed slow I feel the helicopter is losing ground in aerial spraying for economic reasons and yet in civil uses airspraying is one of the few practical applications at the present time Manufacturers must be realistic in their views and produce more suitable helicopters giving better performance and serviceability at far lower cost

In the case of crop spraying I see no reason why a helicopter at a price of £5,000 should not be produced, as surely the time has come for simplification of design and far more is known now than was the case 5 or 6 years ago A brief specification as follows would appear to apply

(i) A sturdy, simple and straightforward machine with consideration to quick change of components should be considered It should be possible to remove the engine, the main transmission, rotor head and other items with accessibility and ease

(ii) All unnecessary items should be eliminated at the expense of good looks, as after all serviceability and ease of maintenance in the primary consideration

(iii) The fuselage construction should be open and preferably of tubular construction The undercarriage should be interchangeable in between a four wheel undercarriage and a skid type undercarriage

(iv) The rotor blades would be preferred in metal The clearance of the fuselage from the ground should be sufficient to allow installation of the insecticide tank Attachment points should be provided on each side as an alternative

In regard to the cockpit, the machine would be preferred with the seating for the pilot in the centre If this cannot be the case, he should sit on the left Sutton harness is required Trimming should be electrical The controls should be light I do not consider it important whether the cyclic pitch stick is of the overhanging type or comes from the floor, but would prefer to see the lever type throttle as on the Hiller 360 in preference to the twist grip type

(v) The cockpit canopies should be easily detachable and possible to convert to completely closed or completely open, with doors separately removable

(vi) Scale effect of the machine should be kept as small as possible

(vii) In regard to horse power, an engine of 250 to 300 h p would be preferred

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(viii) The payload of a machine to be at least of 900 lb A hovering ceiling at full load of 5,000 ft with a cruising speed of 100 miles per hour, and endurance of $2\frac{1}{2}$ hours

It may well be that the jet propelled helicopter will come into crop spraying before it is suitable to be applied to passenger or freight services and the possible use of the convertible type must be considered

Discussion

Wing Commander R A C Brie (*B E A Helicopter Experimental Unit*) said that Mr HARPER had touched on several aspects of the subject which he himself had intended to mention, such as the number of flying hours that it was possible to get from the helicopter per day, the number of hours that the pilot could stand, and so on There was nothing more valuable than user experience, which was factual and realistic and from which others could benefit

There were one or two comments which Captain GREENSTED had made to which Wing Commander BRIE wished to reply That the helicopter had arrived was obvious , one could hardly pick up a paper without seeing a reference to some helicopter activity Those who had been associated with it, as he had been for a number of years, had not had an easy path to tread , there had been disappointment and frustration, but these were normal in any pioneering activity

Whether a given operator should take part in developing the use of the helicopter was a matter for decision by the operator himself Knowledge was necessary, and unless the pilots and engineers had the highest qualifications trouble could easily result Given the right background of knowledge and experience, however, Mr HARPER'S paper was an indication of what could be done Furthermore it was unlikely that a company such as Pest Control would continue using helicopters in a specialised activity for six years unless it was convinced that there was money to be made out of it

Moreover, similar activities on an even bigger scale were going on in other parts of the world In British Columbia, for instance, Carl Agar and the Okanagan Company had interested the Aluminium Corporation of Canada in the use of helicopters in connection with their gigantic hydro-electric scheme Using Bells and S 55s, they were operating at 5,000 to 7,000 feet with ease, and when they had loads too big to put in the fuselage they slung them underneath It was a pioneering effort which would greatly help the development of a project of considerable value to many people in that part of the world

The qualifications of the crews was a most important matter The B E A standard for any pilot selected for helicopter conversion was a minimum of 1,000 hours of fixed wing experience They then gave him 75 hours, dual and solo, before allowing him to undertake a helicopter job of any sort, and a further 25 hours before putting him on passenger work That might be a little high, but a minimum of 50 hours was essential to make sure that the pilot had proper handling experience under all weather conditions, and particularly in strong winds The qualifications of the engineers were of equal importance, and the " hard core " of the small Helicopter Unit organisation consisted of licensed engineers The licence was difficult to obtain, since the engineer had to qualify for it at one sitting

Captain GREENSTED seemed to be critical of the way in which helicopter experimental activity had been carried out in this country, and suggested that if it had been undertaken in some other way than by a Government-sponsored Corporation it might have been done very much better Wing Commander BRIE had brought the B E A Helicopter Unit into being and could therefore claim to speak as an expert, and he felt that he must answer that charge to the best of his ability

It had cost a great deal of money to keep the Unit going, but Captain GREENSTED was wrong if he thought that these costs were in some way hidden in the accounts of the Corporation In the Annual Report recently issued by B E A two pages were given to helicopter activities, and it was there stated that the net cost of the helicopter research project for 1952-53 was £79,113, of which £72,133 was payable