ROTOR STATIONS

A Meetıng of the Associatıon was held at the Royal Aeronautıcal Socıety, 4 Hamılton Place, London, W 1, at 2 30 p m on Saturday, 24th February, 1951, at whıch four Papers were presented a maın paper entıtled " Rotor Statıons—The Scheduled Operator's Vıewpoınt " by Mr R H WHITBY, D I C, A F R Ae S, and supportıng papers on " Sıtes for Rotor Statıons —Some Town Plannıng Consıderatıons " by Mr FRANK H LITTLER, A R I B A, A M T P I, " Rotor Statıons—Some Archıtectural and Engıneerıng Aspects " by Mr R S COLQUHOUN, A M I C E, A M T P I, and " Rotor Statıons—Publıc User Vıew " by Aır Commodore W HAROLD PRIMROSE, C B E, D F C Mr L S WIGDORTCHIK presıded

Mr N J G HILL Thıs afternoon we are contınuıng on the lınes of the successful experıment whıch we trıed some twelve months ago, that ıs to gıve a number of speakers an opportunıty to delıver rather short papers havıng a central theme, to be followed by a dıscussıon I am goıng to ask Mr Wıgdortchık to take the chaır, there ıs no need for me to ıntroduce hım to you as you all know hım very well

INTRODUCTION BY THE CHAIRMAN

Mr L S WIGDORTCHIK It ıs my pleasant task thıs afternoon to ıntroduce the varıous speakers who are goıng to address us, and our first speaker ıs Mr R H WHITBY, who ıs known to you all He studıed physıcs and aeronautıcal engıneerıng at the Imperıal College and served sıx years on the staff of the Royal Aırcraft Establıshment, Farnborough, and was ın charge of the Project Sectıon of Aero Department at the tıme when he left to joın Brıtısh European Aırways, where he has served for the last four years ın the Research and Specıal Development Branch Hıs maın ınterest ıs ın the research and development of helıcopters and helıcopter operatıonal problems

Rotor Stations—The Scheduled Operator's Viewpoint.

By R H WHITBY, D I C, A R C S, B SC, A F R Ae S

When first I heard that I was to be asked to give this Paper to the Association, one of those present asked me what I knew about Rotor Stations I had to admit that it was very little Some of the remarks I shall make in the paper will seem so obvious as to appear platitudes Others, particularly those relating to the dimensions of the landing area, are offered in the absence of a significant amount of directly applicable data and may be treated as one individual's guess In these circumstances, the discussion which follows should be of even greater importance relative to the Paper than is normally the case in our meetings

A Rotor Station can be viewed from a number of standpoints Those of the public user, the town planning authority and the civil-engineer-architect will be dealt with by other speakers I propose to look at it from the standpoint of the scheduled operator The non-scheduled operator must not, of course, be overlooked, and I have no doubt that his requirements will be brought forward in the discussion if they differ significantly from those of the scheduled operator

The operator's requirements will be discussed under the following headings —

(*a*) *Situation*—in relation to the travelling public
(*b*) *Dimensions and disposition*—of take-off and landing area for safe exit and entry in all likely operating conditions
(*c*) *Ground aids*—for convenient and safe operation in weather conditions more or less poor
(*d*) *Parking space*
(*e*) *Servicing facilities*
(*f*) *Traffic requirements*—for booking and handling passengers

(*a*) Situation

I shall say little about situation Town planning considerations will be dealt with by Mr LITTLER, who will be speaking later Fairly obviously a situation near to the business centre of a city and close to bus and rail stations is the one which should first be sought Other considerations should not be entirely lost sight of, however High obstructions in the form of spires are frequently found in city centres, these will have adverse effect on regularity for some considerable time, due to the need to observe higher weather limits, ground rents are highest in city centres, " smog " is bad near railway stations which are served by coal-driven locomotives

Many of the smaller provincial towns possess open spaces within five or ten minutes of the city centre which would be nearly as convenient to intending passengers as a site in the town centre itself and much less costly

(*b*) Dimensions and Disposition

In what follows I shall confine my detailed remarks to rotor stations situated at ground level So far as I know, in the United Kingdom there are no existing buildings with roofs which could readily be adapted for the use of even moderately large passenger-carrying helicopters The cost of a

https://doi.org/10.1017/S2753447200001037 Published online by Cambridge University Press

building especially designed to carry a rotor station on its roof would be very considerable, and I cannot help feeling that much experience in the operation of representative helicopters from ground sites will have to be accumulated before specifications for such an undertaking could be laid down with a high degree of precision

Nevertheless, Mr COLQUHOUN will be speaking later on some of the engineering problems of large buildings suitable for roof-top rotor stations For purposes of illustration, he will be assuming a minimum roof diameter of 250 ft With this size, if a large helicopter under- or over-shoots by one aircraft length, its wheels would still be on the roof

Turning now to the ground site , in a recent paper[1], I emphasised that lack of experience of the operation of large multi-engined helicopters made it impossible to dogmatise on the dimensions which will be required for safe operation into and from future rotor stations * However, if one assumes an approach at 35° to the horizontal, which clears obstructions passed over by an aircraft length and which is aimed at a point to give half an aircraft length clearance from obstructions ahead of the aircraft, a ground dimension of about 400 ft between obstacles 30 ft high is required From the point of view of the emergency landing following part-power failure during take-off and landing, the unobstructed ground space is about three aircraft lengths About three aircraft widths might similarly be needed to allow for inaccuracy in alighting after part-power failure The ground space required for take-off and landing would then take the form of a truncated " runway " about 400 ft long and 200 ft wide with rounded ends if allowance is made for the lower probability of a large lateral error being associated with a large fore and aft error Since the landing technique adopted even after part-power failure will aim at touching down without forward ground run (see for example Ref 2) I would prefer to describe the take-off and landing strip as a " hoverway "—even though following power failure the hovering period is of strictly limited duration as set by the time in which the rotor energy is being expended in supplying the power required to support the weight of the aircraft and overcome the rotor profile drag

To assist handling and minimise the chance of sideways drift in an emergency, the touch-down will normally be made with the nose of the aircraft into wind The approach will, therefore, be made approximately into wind and the minimum rotor station would then be of 400 ft diameter The space not occupied by the hoverway in any particular wind condition will then be available for parking, as will be discussed later

It is worth underlining the considerations implicit in proposing the above dimensions When all power plants are operating satisfactorily, the dimensions should be ample, provided sufficiently precise information on the approach path to be followed can be supplied to the pilot In the event of part-power failure during landing or take-off, the aircraft should be able to maintain or take up its normal approach and landing procedure on the remaining engine or engines, but the pilot will not have the means of significantly checking his descent and making corrections to the aircraft flight path at leisure Inaccuracies are bound to creep in and it will remain to be seen whether the margins allowed are adequate In the event of *en route* power failure, a pilot is no more likely to go to a minimum size restricted town site

*It is assumed that operation into urban Rotor Stations is restricted to multi engined helicopters than a fixed-wing pilot would go to a small airfield after a power failure if a large one were nearby In such event, the helicopter pilot would make for a neighbouring airfield, which, even if of the very smallest size, would provide ample dimensions for a completely safe landing At points where helicopter maintenance would be undertaken this would usually be done out of town, commonly at an airfield where maintenance facilities already exist At major towns the irregularity which would result from the observance of relatively high limiting cloud ceilings in the presence of tall obstructions might be unacceptable and an out-of-town maintenance base would then additionally serve as an occasional traffic stop for use in the very worst weather conditions Such a point would be well situated for use as an emergency landing ground after power failure

Complete power failure is assumed only to result from the simultaneous occurrence of a number of unlikely events, as with fixed-wing aircraft The helicopter's peculiar flying characteristics make such a situation less hazardous than in the case of a fixed-wing aircraft

(*c*) Ground Aids

The categories of ground aids required for night and poor visibility operation is now fairly well established as a result of operations to date, their precise form is still, however, in some cases a matter of development, while in others a need can be foreseen but only a limited amount of work has been undertaken

Ground to air communications are required, and in keeping with short-range fixed-wing usage very high frequencies are employed and are likely to continue in use These frequencies have a quasi-optical range and in a submerged site (*i e*, a ground site more or less surrounded by obstructions) the aerial would necessarily be mounted on a neighbouring high building

An area navigational aid which will involve no provision at the rotor station is likely to be carried In the event of breakdown VHF/DF would be a suitable standby, and this could be installed at the out-of-town emergency landing field where this exists

Eventually a radio let-down aid will be needed if high regularity is to be achieved without recourse to an alternate bad-weather landing field outside the built-up area The form this might take cannot be stated at the present time but similar or even more stringent siting problems will be involved in a submerged site, to those which will arise with the communications equipment

Turning now to visual aids, the first requirement is for one or more identification beacons A suitable design of beacon requiring 1 to 2 kw has already been manufactured to B E A specification To avoid overshoots in very poor visibility it might be desirable to install three beacons in a line across the approach path of the aircraft, although this device is a matter of convenience rather than of safety (1) When close to the beacon, its high intensity light (of the order of 100,000 candle power) is liable to dazzle a pilot approaching in certain directions One of two possible ways of avoiding this would be to duplicate the main rotor station beacon so that the one in use in any wind condition is situated so as to cause negligible dazzle by night To avoid this complication it would be possible for the Rotor Station Control to dim the beacon on the request of the pilot of a helicopter which is landing or taking-off At first sight this might appear to deny valuable information to other approaching aircraft, but this is not so, since they will be relying entirely on their navigational aid in the worst weather conditions until close to the rotor station, and in these conditions the object of control will be to ensure that only one aircraft at a time is airborne near the rotor station (1) Whichever device is found the more satisfactory in practice, in a submerged site the beacon or beacons could with advantage be placed on neighbouring high buildings

It will have been noted that all the aids so far mentioned would best be placed on a high building near a submerged site While they could be remotely operated (with the possible exception of VHF/DF) the control staff who would be responsible would best be situated nearby A control tower in the form of a penthouse on the roof of a high building adjacent to the rotor station would be suitable for this reason Such a position would possess other important advantages It would give a bird's-eye view of the hoverway and parking areas without being liable to obstruction from ground movements of any form It would give far greater scope for observation of air movements and would permit weather observations to be made with greater ease

To make a satisfactory descent, the pilot of a landing aircraft will require further information by night or in poor visibility Firstly, the correct direction from which to make the final approach to the hoverway must be indicated , it was suggested above that this will be roughly along the direction of the surface wind Information as to the safe descent path which will carry the aircraft clear of obstructions surrounding a submerged site must be available to the pilot During the final approach, which will be visual for a long time to come, the pilot's main attention will be concentrated on the ground, and the references observed must be sufficient to allow him to dispense with his artificial horizon or equivalent instrument Approaching touch-down, the pilot will require information from light pattern or ground texture as to his distance above the ground and, from the aircraft's lateral drift, the direction of the surface wind at the moment of touch-down Equipment to satisfy these requirements is under development at the present time Whatever its final form, it is unlikely to consume more than a few kw As a general requirement this type of equipment should at most present only a minor obstruction forward of where the helicopter is normally landed and it should then be in clear view of the pilot , its design should be such, moreover, that when proven in practice, it should be capable of installation flush with the ground so as to present no hindrance to helicopter ground movements over the restricted surface of the rotor station

The boundaries of the rotor station, permanent obstructions within its limits and obstructions immediately around it will require obstruction warning lights In addition, high obstacles within an area around the rotor station whose extent depends on the accuracy of the area navigational aid(1) will require marking in a similar manner

(*d*) Parking Space

It was suggested above that to meet operation in all wind directions, a site about 400 ft square is needed if it is bounded by 30 ft high obstructions, while at any one period a clear hoverway about 400 ft by 200 ft is required The difference between these two requirements provides space for fixed buildings, mobile installations and parked aircraft Fig 1 illustrates the situation when the South-East Hoverway is in use The traffic and control buildings are shown in one corner of the 400 ft square, in a very restricted site, the control building would, as previously suggested, best be situated off the landing area, while, if a small plot abutting onto the 400 ft square were available, it would be helpful to put the other buildings on this However, the more critical case where all the rotor station facilities are accommodated within the 400 ft square is considered here It will be seen that there is space for at least four large helicopters parked off the hoverway, or, say, two large helicopters with rotors unfolded and up to eight parked with rotors folded

Now let us consider the ground movements which may be required of the helicopter If an intermediate stop is considered, it is clear that, to avoid imposing delays on through passengers, the time spent on the ground must be kept small From experience accumulated in the U S, a turn-round time of not more than three minutes may be expected for a movement of up to ten passengers In these circumstances, the aircraft would normally remain on the hoverway At an intermediate refuelling stop, the hoverway would have to be cleared at a busy station and the aircraft taxied or towed to one side for refuelling and passenger movement At terminals, the aircraft would normally have to be cleared from the hoverway If it is assumed that there is unlimited parking space, that it takes two minutes to remove a helicopter from the hoverway to the park and two minutes to bring it back again, and that reasonable clearances are imposed by traffic control between

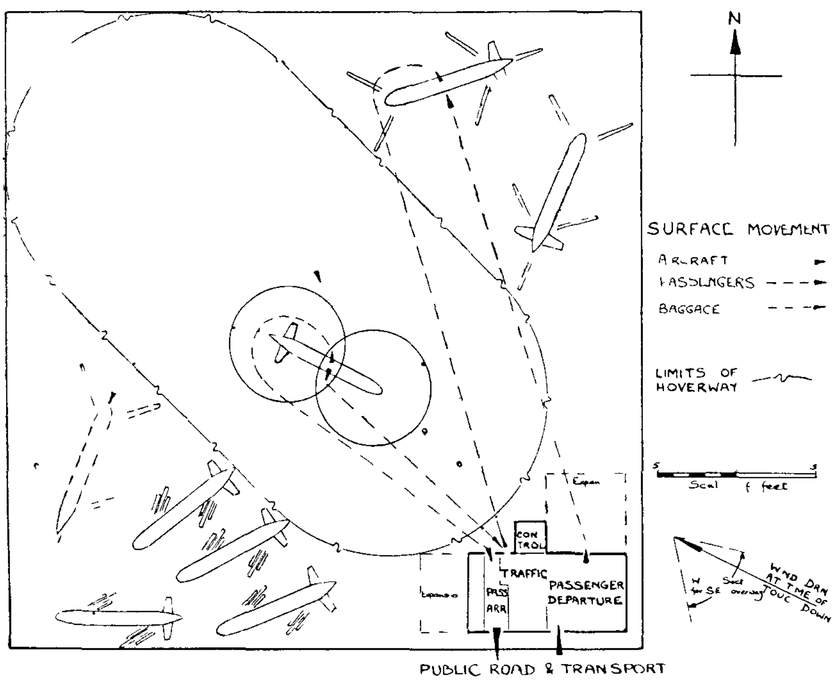

Fig 1 Layout of surface rotor station S E Hoverway in use

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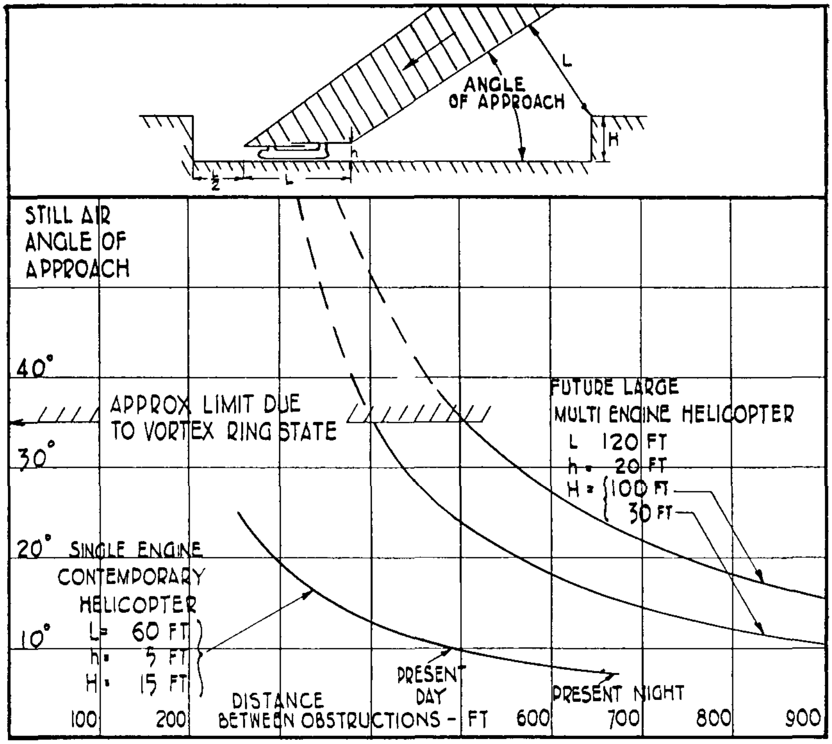

Fig 2 Linear dimensions of rotor station as affected by approach angle

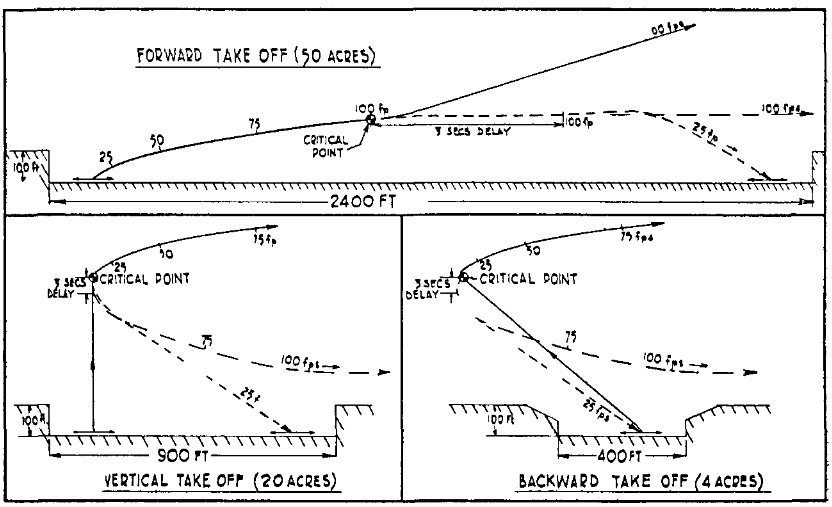

Fig 3 Safe take-off procedures and effect on site dimensions

https://doi.org/10.1017/S2753447200001037 Published online by Cambridge University Press

airborne helicopters which are arriving or departing in poor weather conditions, then it can be shown that the peak movement rate is about ten per hour If two tractors and crews are used so that only two minutes must elapse between a landing and a take-off instead of four minutes, the movement rate is increased to twelve per hour If no time need elapse between touch-down and take-off (*e g* , with dual hoverways), the rate increases to about 15 per hour It can be shown that if the average time of the aircraft spent on the ground is 30 minutes (*e g* , 10, 30, 10, 70 minutes), the provision of parking space for four helicopters does not impose limitations on the movement rate If, however, the time spent on the ground is increased to an average of one hour (*e g* , $\frac{1}{2}$, 1, $\frac{1}{2}$, 2 hours), the possible movement rate is limited to about seven per hour by there being insufficient space to accommodate waiting aircraft In the case of helicopters with the longer turn-round times, however, the folding of rotors could be undertaken if necessary This operation should not normally take a crew of three more than ten minutes

It can be concluded that if the average turn-round time is not in excess of $\frac{1}{2}$-hour, the available parking space in a 400 ft rotor station will impose no limits on the movement rate that control can accept in poor visibility conditions In good weather, however, with a higher movement rate, which would still be safe, the average turn-round time must be less than $\frac{1}{2}$-hour if congestion from lack of parking space is not to arise

Fig 1 suggests the possible paths of the aircraft between the touch-down point and the parks Little difficulty should be experienced in getting a radius of turn as low as 60 ft , this would be quite small enough for towing the aircraft on the desired paths It will be noted that forward and backward towing is necessary If it is difficult to make both front and rear wheels castor, this would involve means of steering the castoring front wheels by the leader of the towing party when the aircraft is being towed from the rear Sideways movement of the aircraft is not essential and it might be rather difficult to devise means of sideways movement using only one tractor, while if two were used it would be difficult to ensure foolproof co-ordination of action

When no aircraft are parked on the side of the hoverway to which the helicopter must be moved, an air taxi might be undertaken, unless conditions were gusty This would be much quicker than ground towing

Clearly the conception of hoverway and parking areas outlined above requires that the position of the hoverway be changed in various wind directions From an inspection of records of surface wind direction at a representative height in the U K , it appears that the hoverway would have to be changed about once during each day of operation between 7 a m and 10 p m , while on about two days a month rapid changes of wind direction would make it necessary to change a hoverway after operational use of two hours or less Sometimes this might entail the shifting of parked aircraft or movable installations, but with the above frequency of occurrence this would not be unduly troublesome

(*e*) Other Ground Installations

Other ground installations will only be mentioned briefly

Tractors have already been discussed Two will normally be required to guard against breakdown since they will be essential to move the aircraft unless air taxying can be resorted to

Mobile refuelling equipment will be needed at most stations Since aircraft will not always be refuelled from the same point, this equipment should be automobile

Proposed fire regulations would require foam equipment with a capacity of about 4,000 gallons and a rate of discharge of about 1,000 gallons per minute , about 300 lbs of carbon dioxide would also have to be provided To operate this equipment at least five men would be needed , these would normally be engaged on other duties from which they could instantly be called in case of emergency In view of the low approach speeds of the helicopter by comparison with the fixed-wing aircraft, the chance of a fire resulting from a crash landing should be relatively much smaller On the other hand, the small size of the area within which a crash landing is likely to occur by comparison with the size of a fixed-wing airport makes it more likely that the fire and rescue service will be on the spot in time for effective action

Garage space for the above equipment should be provided on the rotor station A small workshop and rest room for the tractor drivers and engineers will also be needed

(*f*) Traffic Requirements

The basic characteristic of the helicopter which distinguishes it from the fixed-wing aircraft is its ability to land in the centres of population and near centres of existing surface transport This means that the intending passenger will find his own way to the rotor station just as he does to the railway or bus station While coach parks are not needed by the operator at the rotor station, facilities must be available nearby for the parking or garaging of private cars , this will be more necessary at rotor stations which are not really centrally placed in towns since in this case the use of public surface transport would involve at least one change and the private car is more likely to be used

In another respect traffic requirements may differ Since most of the journeys which may be made by helicopter will be of short duration, they may be made at short notice This means that the unbooked passenger is likely to be more common than with fixed-wing aircraft

The shorter duration of helicopter journeys suggests in general that the passenger handling should be of the most expeditious , at intermediate traffic stops this is doubly important

A/Cdre Primrose will be speaking later on the traffic side of a rotor station from the standpoint of a member of the travelling public From the operator's point of view, two factors have to be borne in mind Firstly, he must obtain a minimum amount of information to ensure the safe loading of the aircraft and to provide commercial information on which to base developments of the service Secondly, although the seasoned traveller may be inclined to forget this, it is a fact that people in a group in strange surroundings behave like sheep and, if not led, will stray

With these considerations in mind let us consider a possible cycle of operations through which a passenger must pass On arrival at the rotor station, the passenger purchases a ticket (if this has not been done in advance) and registers baggage which he does not propose to carry himself* The ticket would contain the service number, destination, fare paid, and passenger's name With the larger multi-rotor helicopter, there will be no need to take individual passenger weights The booking clerk would hold a copy of the ticket and from it would make up the passenger list

The passenger would then go to the waiting space (where a refreshment bar could be available), and which would be in a clear view of an indicator board showing the number of the next service to depart and points served When the departing helicopter was ready to receive oncoming passengers, an announcement would be made over a loudspeaker asking passengers to assemble at the departure gate The gate would then be opened and passengers conducted to the waiting helicopter by a traffic clerk to have their tickets checked against the passenger list by the aircraft flight attendant or purser

If the helicopter is boarded at the point where it is parked, the passenger may have to walk as much as 400 ft in the open air One American authority(3) has suggested that passengers should not be expected to walk more than 600 ft between arrival at an airport and entering his aircraft The distance involved is not, therefore, serious if the increased chance of passengers losing their way between the passenger building and the aircraft and wandering over the hoverway and parking areas is ignored In the British climate, however, long walks in the rain would frequently result and these are not to everyone's taste For these reasons, it appears desirable that the helicopter should be brought fairly close to the terminal building in wet weather before passengers board it When the movement rate is high, this will not always be possible, but on other occasions this might be done A partial solution would be for aircraft parked some distance from the terminal building to be boarded on the hoverway if movement rates permit If the aircraft is next to the terminal building or distinctly separated from other parked aircraft by being on the hoverway, the shepherding of passengers from the terminal building to the aircraft might be dispensed with and the passengers left to find their own way

Having got the passengers aboard, the flight attendant, with the authority of the co-pilot, makes a final check of the load sheet, returns a copy of the load sheet to the waiting baggage loader, who has loaded registered baggage, closes the door and signals the pilot that he is ready to take-off

The duties of the flight attendant are a novelty as far as short range operations in this country are concerned They are particularly important in getting quick turn-rounds on intermediate stops, as South-West Airways have demonstrated on their D C 3 feeder service in California During flight, he would sort out registered baggage required for the next stop and ensure that passengers disembarking there are warned to be ready

After arrival, similar considerations to those discussed above will determine where passengers are disembarked, *i e* , movement rate, position of available parking space and whether it is wet or fine On receiving permission from control to disembark passengers, the pilot instructs the flight attendant

* There may be a natural tendency of helicopter passengers on short journeys to wish to carry with them into the aircraft larger bags than are permitted on fixed wing aircraft to eliminate the delay in collecting registered baggage when the journey is over This possible tendency might be encouraged by the provision of stowage near the passenger seat for larger bags than are normally the case on fixed wing aircraft

to open the door and lower the steps The flight attendant takes disembarking passengers' tickets from them and directs them to the exit gate, which would be clearly marked The baggage loader takes registered baggage from the holds and loads oncoming baggage He could also receive the off-loaded passengers' tickets from the flight attendant for delivery to the traffic office where they could be held as amendments to the passenger list, if the information is required in case of accident The flight attendant will also receive from the baggage loader the list of oncoming passengers and will commence reworking the load sheet while awaiting their arrival at the aircraft

At points with low passenger traffic, the functions of booking clerk, traffic officer and baggage loader could be combined in the person of a single ground attendant, as is done by South-West Airways where a system on these lines has worked successfully In some respects, the multi-rotor helicopter is better able to operate such a system, since the pilot will have a check on possible errors in the working of the load sheet by the flight attendant I am referring to the pre-flight hover check, which would reveal dangerous conditions of overloading or trim while the aircraft is only a few feet from the ground

Fig 1 shows the surface movements of passengers, baggage and aircraft during these operations The layout of the passenger Terminal Building should be such as to allow the segregation of outgoing and incoming passengers Room for expansion of the waiting facilities is desirable and this is indicated on the sketch

Concluding Remarks

If this paper has done nothing else, it should have served to underline the opening remarks on the need to get practical data on the requirements of rotor stations A certain amount of information has already been obtained in B E A helicopter operations and it is hoped to extend the information from this source in the near future The biggest cause of delay, particularly as relating to the operational safety aspect, is the lack of a multi-engined helicopter

In conclusion, while the views expressed are personal, I am indebted to British European Airways for permission to give this paper

References

(1)	Whitby, R H	Some Operational Problems of Public Transport and Helicopters	*Jour Royal Aero Soc , Jan , 1951*
(2)	Fay, J S	Some Present and Future Aspects of Helicopter Piloting	*Jour Hel Assoc of G B , Jan -March, 1951*
(3)	Froesch & Prokosh	Airport Planning	*John Wiley & Sons, 1946*

INTRODUCTION BY THE CHAIRMAN

Mr L S Wigdortchik Our next speaker is Mr Frank H Littler, who wishes to stress that he is speaking as an individual and not on behalf of the Ministry Mr Littler was trained as an architect at the Liverpool School of Architecture He was awarded a Commonwealth Fund Fellowship to study airport planning and design at the Massachusetts Institute of Technology, and he took a Master's degree course in Town Planning

From 1942-1946 he was Regional Planning Officer to the Department of Health for Scotland, and from 1946-1950 he was Regional Planning Officer (London) to the Ministry of Town and Country Planning He is now Headquarters Planning Officer in the Ministry of Local Government and Planning, being concerned with research into planning principles, standards and techniques

Sites for Rotor Stations—Some Town Planning Considerations.

By F H LITTLER, ARIBA, AMTPI

The previous speaker has briefly stated the requirements which for satisfactory operation of a helicopter service should govern the siting of a Rotor Station they may be summarised as—commercially " a central location in the town, with convenient access by road and rail ", and—operationally " relative freedom from local ' smog ' and from high obstructions "

It is probable that the *travelling* public also would describe their chief requirement as " a central location and convenient road and rail access ", but when the question of siting is viewed disinterestedly—as it must be by the town planning authority—when account is taken of the probable effect that the Rotor Station, its use and its situation, may have upon the public in general, and on the owners and occupiers of adjacent property in particular—a rather different set of criteria must be considered

The planning problem involved in the siting of a Rotor Station in or near the central area of a town will be settled very largely by the extent to which it may be possible to make this new type of user into a " good neighbour " Competition for central area land is keen, and planning authorities have a public duty to encourage the full economic use of all parts of the central area this is largely secured by insuring, through use of the powers of control given by the Town and Country Planning Act, 1947, that the interests of adjacent owners, and of the general public, are protected from any form of development that will cause annoyance or danger, or which will unduly increase traffic congestion

The siting of a Rotor Station appears likely to raise the following problems

(1) Danger of accidents, (2) Noise nuisance, (3) Traffic congestion, and, depending largely on the gravity of the three problems

(4) Economic land use implications

These four questions will be examined briefly in the light of possible advances that may be expected in multi-engined helicopter design—in order to assess the size of the problem of assimilating a Rotor Station into the central area of a large town

Danger

Danger of injury to life and property, however remote, may arise from flying, over any part of the built-up area but especially in the vicinity of the Rotor Station In regard to the general hazard, it can be assumed that the reliability of the multi-engined helicopter will have been demonstrated before