The Design of Helicopter Operating Sites

By H T HOUGH,

M I C E, M I MUN E, M T P I, City Engineer and Surveyor, Liverpool

A Paper presented to The Helicopter Association of Great Britain in the Library of The Royal Aeronautical Society, 4 Hamilton Place, London, W1, on Friday, 11th November, 1955

DR G S HISLOP (*Chairman of the Executive Council*) in the Chair

INTRODUCTION

The CHAIRMAN said the Association were transferring their thoughts for the evening from the pure technicalities of the vehicle to the equally important problem of what facilities it required for operation, particularly for the inter-city transport role which had caught the imagination in the last two years, not only in this country but in the United States and elsewhere abroad

They had been very fortunate in that Mr Hough, the City Engineer and Surveyor of the City of Liverpool, would address them on the subject Liverpool was one of the cities in this country which had given a great deal of thought to the matter

The CHAIRMAN well remembered the time when he was with B E A and plans were prepared and ideas put forward to provide facilities for the new vehicle and he looked forward to hearing a practicing civil engineer's views on this vital aspect of helicopter usage

The Author was a chartered civil engineer, a member of the Institution of Civil Engineers, Past-President of the Institution of Municipal Engineers and a member of the Town Planning Institute, being past Chairman of the North West Division He was senior Vice-President of the Liverpool Engineering Society

He was appointed City Engineer and Surveyor of Liverpool in 1947 and before then had been deputy city engineer Altogether, he had had over 30 years municipal engineering experience During the 1914-18 war he joined the Royal Air Force on its formation in April, 1918, and for a time was engaged in work connected with the DH 6, the Sopwith Camel and the Salamander aircraft, names which would arouse memories among many present

The Author had visited the United States and had travelled throughout Europe This year he had visited Turkey He was a great believer in air travel and had travelled thousands of miles by air, mainly in fixed-wing aircraft but also in helicopters where they were available He thus spoke from practical as well as theoretical knowledge

He assisted in the work of construction of Liverpool airport, which airport was normally administered by his Department but had been under requisition since the war by the M T C A

He was responsible for design, construction and maintenance of roads, bridges, sewerage disposal schemes, river walls and many other engineering duties, including the maintenance of the Mersey Road Tunnel Liverpool being both an industrial and shipping centre, it could be said that the Author had had a very wide experience of the problems associated with municipal engineering in all its facets

MR H T HOUGH

When I was invited to present this paper I realised that an honour had been conferred upon me by the Helicopter Association, for although I have been concerned with airport design and management, I am not engaged in the aviation industry and must therefore be regarded as a layman

I also realise that this paper will cover similar ground to that already covered by others more expert in aviation matters, but in accepting the invitation of the Association I felt that a good purpose would be served by giving the views of a Municipal Engineer on the question of helicopter operation and by provoking a discussion on various important aspects of the problem of providing helicopter stations

Although I have been non-controversial in the selection of the title, I have throughout the paper adopted the term helicopter station Station as applied to travel in this country generally denotes comparatively short journeys as in the case of bus stations and railway stations, and I consider it preferable to "port," which brings to mind, both in the case of airports and maritime ports, the idea of long distance travel To describe the station I can think of no more appropriate word than that which describes this Association

It is very difficult to keep up-to-date with helicopter development, since new pronouncements are made by various authorities from day to day on the time factor, and I would like at this early stage to refer to the necessity for some official clarification to be given to Local Authorities in connection with the reservation of sites Large cities are not likely to leave sites in their valuable central areas vacant until 1965, and I would like to warn those interested in helicopter development for commercial use, that very soon the nearest available open spaces to some of our city centres will be airports at present used by fixed wing aircraft

My own view has always been similar to that expressed in Appendix D of the First Report of the Interdepartmental Helicopter Committee in 1950, which I take the liberty of quoting—" We felt that in the field of helicopters, we should from the outset require manufacturers to produce helicopters to fit landing areas and not to rely on landing areas being provided to fit helicopters "

I hope that the Committee's second report will soon be forthcoming and that either on the list of Committee members or on the list of witnesses there will appear the name of a Local Authority representative

The Author's Own Experience

Although I am a layman in matters of aviation, I can claim to have travelled in four different types of helicopter in this country, on the Continent and in America In addition, my position as City Engineer and Surveyor of Liverpool has caused me to follow with keen interest the development of this new aircraft and to study the types of helicopter stations which will be required in a town My first flight in a helicopter was a demonstrative one in a British-built Westland Sikorsky S 51 in 1950 when the first regular inter-city service in the world was being operated by B E A between Liverpool and Cardiff with request calls at Wrexham In this case no special landing station was required as the helicopters used Liverpool Airport as their terminal point

The airport in Liverpool is 6 miles from the City centre, and it was soon appreciated that it was too far from the business centre for any advantage to be gained by using a helicopter as against a normal aircraft However, much experience was gained by B E A before they removed their machines to another part of the country to continue their experiment Later I was able to take two flights in a Bristol 171, which the Bristol Aeroplane Co kindly sent to Liverpool, with Mr C D Hosegood as pilot This machine made demonstration landings in the centre of Liverpool on a war damage site

My most useful experience, however, was in New York where, by invitation of the New York Port Authority I flew in a Bell 47D from Newark Airport to the landing platform on the roof of the Port Authority's 16-storey building in Manhattan I have also flown in a Sikorsky S55 on the regular Sabena service from Antwerp to Brussels Heliport

The Helicopter is suited to relieve Surface Traffic Congestion

From these experiences I can with first-hand knowledge affirm that although it is still in its infancy, the helicopter can perform those magic carpet feats which have made it " news "—that is to say it can definitely take off from and land on an area scarcely larger than that which it covers It can hover at varying heights, and it can travel at an average speed considerably in excess of most forms of surface vehicles I would add, however, that in its present form I do not consider that it is yet sufficiently comfortable and safe for general use by the public

At the present time, in both town and country, and particularly in large cities, traffic congestion on the roads is one of our major problems, and is causing so much waste of time that many eminent people have expressed the opinion that it will soon have a serious adverse effect on our national economy due to increased transport costs In New York, for a number of years, the position has been reached where it is almost impossible to reach the centre in a private car, and if one does, there is nowhere to park it ! A similar position is being reached in London and other large cities in this country, and as more people own cars the congestion will undoubtedly get worse

Not only is the time to reach a city centre becoming exasperatingly long, but the time taken to travel in the opposite direction to an airport now nullifies the speed advantage of fast aeroplanes over rail traffic for distances up to two or three hundred miles Thus there is obviously a need for an aircraft in the short haul range which can operate from small stations in our cities, and the helicopter promises to be the first to fill that need

THE DEVELOPMENT OF SUITABLE TYPES OF HELICOPTERS

I feel that the designer of a helicopter station should obtain as much knowledge as possible of the types of helicopter which may use the station before embarking upon such a project I propose, therefore, before coming to the siting and design of landing stations, to review briefly the types of aircraft which are likely to use them

I have already referred to the unsuitability of present helicopters, and while I do not agree with the description given by an eminent operator in this country that they are an excellent substitute for vibro-massage, I would point out that they do suffer from the defects of excessive noise, vibration, the lack of multi-engine safety, and high cost of operation It has been said that such defects will not be overcome, whatever the configuration of the aircraft, until it is powered by at least two turbine motors and will carry at least forty passengers Since no prototype of an aircraft with these features has yet flown in this country, and as far as I can ascertain one only quite recently in the U S A , I feel that at this point I should refer to the time factor in relation to helicopter development I would remind you that the first prototype of the successful Vickers Viscount flew in 1948, but did not go into regular passenger service until 1953, and the Bristol Britannia prototype which flew in 1952, will not carry fare paying passengers until 1956

These are aircraft of the fixed wing type with many less problems left unsolved than the multi-engined helicopter I will leave the aircraft industry to hazard a guess when the latter will enter passenger service

However, it appears that the type of aircraft which will be used between town centres will undoubtedly be a multi-engined machine with turbine motors, and with passenger capacities from 20 to 40, with an all-up weight of between 20,000/45,000 lbs

The maximum size of such machines would be up to 140 ft in length, with an overall width of up to 105 ft (The width would probably be the extent of the rotor disc or discs) It may appear in several guises, *e g* , single or multi-rotor, with or without small wings, and the method of driving the rotor will probably vary

Certain machines which may be suitable for preliminary services between towns are in the course of development and have flown These include the Bristol 173 tandem rotor helicopter with 16/20 seats which is at present being developed for military purposes, with two piston engines which it is expected will be replaced by turbine engines , the Sikorsky S 56, a twin-engined single rotor machine designed to carry perhaps 40 passengers, which is at present being developed for military purposes in the U S A and which may be manufactured in a modified form in this country by the Westland Aircraft Company under the name of the Westminster , and the Piasecki YH16 tandem rotor twin-engined helicopter being developed in America for military purposes, which would also appear to be capable of carrying about 40 passengers It is reported that a turbine-engined prototype of the last named has recently flown In addition, several projected designs have been produced by aircraft companies in Great Britain to a specification of the British European Airways Corporation and the Ministry of Supply have placed an order for a Fairey Rotodyne—a helicopter with a single rotor, two small wings and two turbine motors which would power the rotor during ascent and descent, and propellers during forward flight

It will be appreciated that the various aircraft mentioned are "rotor craft," which can hover and, if necessary, make vertical take-offs and landings Rotor aircraft also have a safety factor in case of engine failure at certain heights, for the kinetic energy stored in the rotor blades can be used in steep auto-rotational descents to minimise the landing shocks Publicity has recently been given to devices designed to increase the lift of fixed wings on normal aircraft so that they can operate from very small strips It is felt, however, by some authorities that although such devices may help in reducing the size of our main airports, they will not make fixed wing aircraft as versatile as the helicopter, or as safe in gusty weather The possibility of using direct jet life, by such means as the Rolls-Royce "Soar," is too far in the future for comment I am of the opinion that if we design our central city stations for 40-seater rotor craft, we shall probably have achieved the maximum size that physical conditions in our cities will allow, and if other types of aircraft are to be developed for short distance operation, they will also have to use such stations

The Behaviour of Helicopters

I feel that the following brief references to the behaviour of helicopters will remind the audience of some of the basic factors to be considered when siting and designing landing stations

(*a*) *Take-off and landing techniques*

Reference has been made to the fact that a helicopter is capable of truly vertical ascent and descent and because of this and the fact that it can hover in a stationary position in the air, it may lead people to believe that the siting of landing stations is quite simple However, this is not so, for although rotor craft can perform these evolutions, it is necessary for them to be carried out with full engine power which is not always desirable, and at present, climbs and approaches are normally made at an angle

It should also be borne in mind that in the case of partial power failure after take-off the climbing angle would be seriously affected It would appear therefore that it would be unwise to site a landing ground near to high structures unless present techniques change, with the coming of multi-engined machines, towards more vertical take-offs and landings

It is of course essential that every precaution should be taken to prevent forced landings in city streets, and take-off techniques are therefore being studied which can take advantage of the helicopter's ability to fly sideways and backwards It is thought by some that the safest method of take-off would be for a helicopter to make a backwards climb to a safe height, before proceeding on its course Should a power failure occur during the climb the pilot would then have a good view of the landing ground if an emergency descent became necessary (*b*) *Noise*

Noise is one of the most serious factors to be taken into consideration when planning a helicopter station As has been stated, excessive noise could be a reason for banning helicopters in town centres Silencers have already been fitted to some machines and noise is likely to be reduced considerably as improvements are introduced

When helicopters were first tried at South Bank, London, noise measurements were made with the following results

Quiet countryside	=	35	decibels
Underground train	=	108	„
Painful sound	=	120	„
S 51 helicopter at 1,000 ft	=	62	„
At take-off	=	92	„
Street noise at ground floor level in Piccadilly	=	82	„

Messrs Horonjeff and Lapin, in a paper presented to the Institute of Transport and Traffic Engineering, University of California, state " so far no noise standards have been agreed upon, but some measurements of noise suggest that a noise level of not exceeding 75 to 80 decibels at 150 feet would be a desirable target to aim at for daytime operations This appears to be a stringent requirement in so far as the manufacturers are concerned, and compromises will eventually have to be made "

" The area adjacent to the flight path where the noise factor is most critical is under the path of take-off On take-off and climb-out, a high proportion of the problem in this area will depend on the orientation of the landing pad If at all possible the landing pad should be so oriented that take-offs and landings are made over areas where noise would be least objectionable "

However, the noise factor is mostly a problem for aircraft manufacturers It is possible that turbine-driven helicopters with exhaust nozzles specially shaped, will reduce noise to a level not noticeably greater than that of a town's surface traffic It may be, however, that the volume of noise will eventually be the limiting factor in the size of helicopters allowed in central areas, since it is related to the power of the engines

(*c*) *Down draught*

My experience of the down draught from the rotors of a helicopter has been limited to single engine machines of comparative small passenger capacity It is considerable !

There is no doubt that a 40-seater will produce a gale for some distance around it during take-off and landing, and it would be very useful if manufacturers could give some idea of the magnitude and extent of such a down draught, so that its effect in the streets around landing stations could be considered It would be interesting to learn whether the draught from a large helicopter taking off would affect other helicopters parked nearby

Regulations Governing Helicopter Flights

The existing Ministry of Transport and Civil Aviation regulations are at present applied to helicopter operators, but it would appear that any helicopter regulations are likely to be amended following the international conference at Montreal

As is well known, all aircraft, including helicopters, when flying over towns must do so at heights not below 1,000 ft and at such a height as would enable them to land outside the town in the event of engine failure

I am informed, however, that with the Minister's permission helicopters need not comply with these regulations provided that they operate in accordance with any conditions attaching to the Minister's permission

It is understood that specific rules will be made for helicopters which will be different from those applicable to fixed wing aircraft and that these rules will take account of the special attributes of helicopters in order to allow them the maximum freedom of operation compatible with safety

Site Selection

Passenger potential

If a helicopter service is to fit into the general scheme of travel, it must operate between stations on sites suitable to the passengers

In order to determine the best locations for helicopter stations, it is necessary to consider the types of journeys for which helicopters will be used Taking Liverpool as an example, it is felt that the main use of helicopters will, in the first place, be to enable business executives, whose time is valuable, to visit the centres of other towns such as London, Newcastle, Glasgow, Cardiff, Barrow-in-Furness, do their business there and return on the same day Thus not only saving time which can be spent in the office, but also saving the cost of hotel accommodation at night If an individual wishes to travel before going to the office in the morning, the helicopter station would be equally convenient for him if it were nearer his home than his office, and in Liverpool the Speke Airport is probably nearer to many residences in the south of the city than is the city centre However, if he resides other than in the south of Liverpool, Speke is not convenient and in any case his business at the other end of the journey is likely to be in the town centre Likewise, visitors to Liverpool on business would most likely need to land in the town centre and since in most towns the local surface transport services all converge to the centre, such a location for one of their helicopter stations would obviously be most suitable

In large towns it is obvious that several helicopter stations will be required not necessarily all near the town centre They may be needed near the industrial districts and near the more populous suburbs It can be imagined too that a helicopter landing station would be very useful near a big race course or sports ground

In smaller towns the need for a town centre site is not as important as in London or other large cities, and the siting of helicopter stations on the outskirts of some of our county towns—perhaps less than a mile from the centre—should not be difficult The helicopter may certainly be the means of giving the advantages of air travel to towns far away from a civil airport, and never likely to be able to afford to construct one in fact it may provide feeder services from such towns to airports and so enable more persons to enjoy air travel in its broader sense

The Town Planning Aspect

Once the general location best suited to the traffic potential has been decided upon it is necessary to select a site which will enable a helicopter service to operate safely and with the least possible inconvenience to the public The following factors given in the previously mentioned paper by Messrs Horonjeff and Lapin are certainly a most useful guide

> " Minimum obstructions in the approach and departure areas
>
> Minimum disturbance from noise and best location in general from the viewpoint of adjacent land use
>
> Good access for surface transport
>
> Minimum cost to acquire and develop "

Good visibility is an additional factor and a location subject to regular low cloud, fogs or smoke would not be suitable

It is quite obvious that a helicopter site must fit in with a Town Plan As most people are aware the aim of town planning is to ensure that a site suitable for an important purpose is reserved for that purpose and not covered by some other building

It would appear that under the Town and Country Planning Acts there is nothing to prevent the provision of helicopter operating sites, either on ground level, or on the roofs of buildings A Local Authority has power to disapprove a project if it will injure the amenities of a district and therefore a helicopter station could be disapproved for the following reasons

(1) Wrongly sited
(2) Architecturally badly designed operating buildings
(3) Architecturally badly designed building supporting the operating roof
(4) Noise
(5) Danger

Once the operating site has been chosen then, especially if it is on ground level, the surrounding area must be restricted to prevent the erection of obstructive buildings

Main Requirements for Helicopter Stations

It is proposed to refer only to stations suitable for inter-town or inter-city passenger services

The main requirements are

- Take-off and landing area
- Passenger embarking arrangements
- Helicopter waiting space
- Terminal building with control room and accommodation for passengers and staff
- Car park
- Refuelling, starting and firefighting appliances
- Night and bad weather navigational aids

As the location of the station is usually likely to be in an area where land is expensive, overhauls and servicing (except in an emergency) should

https://doi.org/10.1017/S2753447200002730 Published online by Cambridge University Press

normally be envisaged at a nearby airport as should any prolonged parking of aircraft

Ground Level Stations

Take-off and Landing Area

When taking-off it is usual at present for a helicopter to rise a few feet vertically and then to climb at an angle (not necessarily forwards) Likewise, when landing the approach is made at an angle, the machine hovers a few feet above the place on which it is to land and then makes its final descent vertically

For normal operations in good weather the alighting area itself need, therefore, be no greater than a circle with a diameter equal to the length of the fuselage However, to allow for varying weather conditions and emergency landings, it is generally recommended that two " strips " should be provided at right angles The Interdepartmental Helicopter Committee, in 1950, recommended the dimensions of such strips to be 300 ft by 150 ft, based on an aircraft with a maximum dimension of 125 ft , Mr Martin A Warskow, of the U S A, suggests dimensions 400 ft by 200 ft, and in the Ministry of Transport and Civil Aviation paper of August, 1955, on the planning of air stations for single-engined helicopters, the minimum dimensions suggested are 400 ft long with a width of 150 ft, or three times the diameter of the largest rotor likely to be used in operations there, whichever is the greater A study of statistics available in respect of projected 40-seater helicopters indicates that aircraft with single rotors of about 100 ft diameter will probably be among those used It appears therefore that strip dimensions of 400 ft by 300 ft should be envisaged

I suggest, however, that some definite dimensions should be fixed at an early date, so that both station designers and aircraft manufacturers will be working towards the same end

The Ministry suggest that a climb area plane should be free from obstructions at each end of the strip and that its slope should be 1 10, its sides diverging 15° on either side from the end of the strip They also recommend that obstructions within 100 ft of the side edges of the strip should not project above a plane inclined at 45° and passing through the side of the strip (Fig 1) A 1 10 climb plane will undoubtedly be difficult to achieve at ground level in a city centre, but is it possible that for multi-engined machines steeper planes may be allowed, perhaps 1 6 which is suggested by Mr Warskow as a possible safe gradient In view of the fact that a Local Authority must control the height of buildings around the landing site it would be an advantage if official regulations were issued regarding climb planes for city centre conditions

The recommendations of the Ministry in respect of the maximum gradient of the strip itself is 1 50 This should easily be attainable, in fact it might well be restricted to 1 100

There should be no difficulties in providing a suitable paving for the strips at ground level to withstand weights of aircraft up to 50,000 lbs, and normal aerodrome practice can be followed

It would probably be an advantage to cover a concrete slab with asphalt which can be dustless and has low reflective properties when well drained

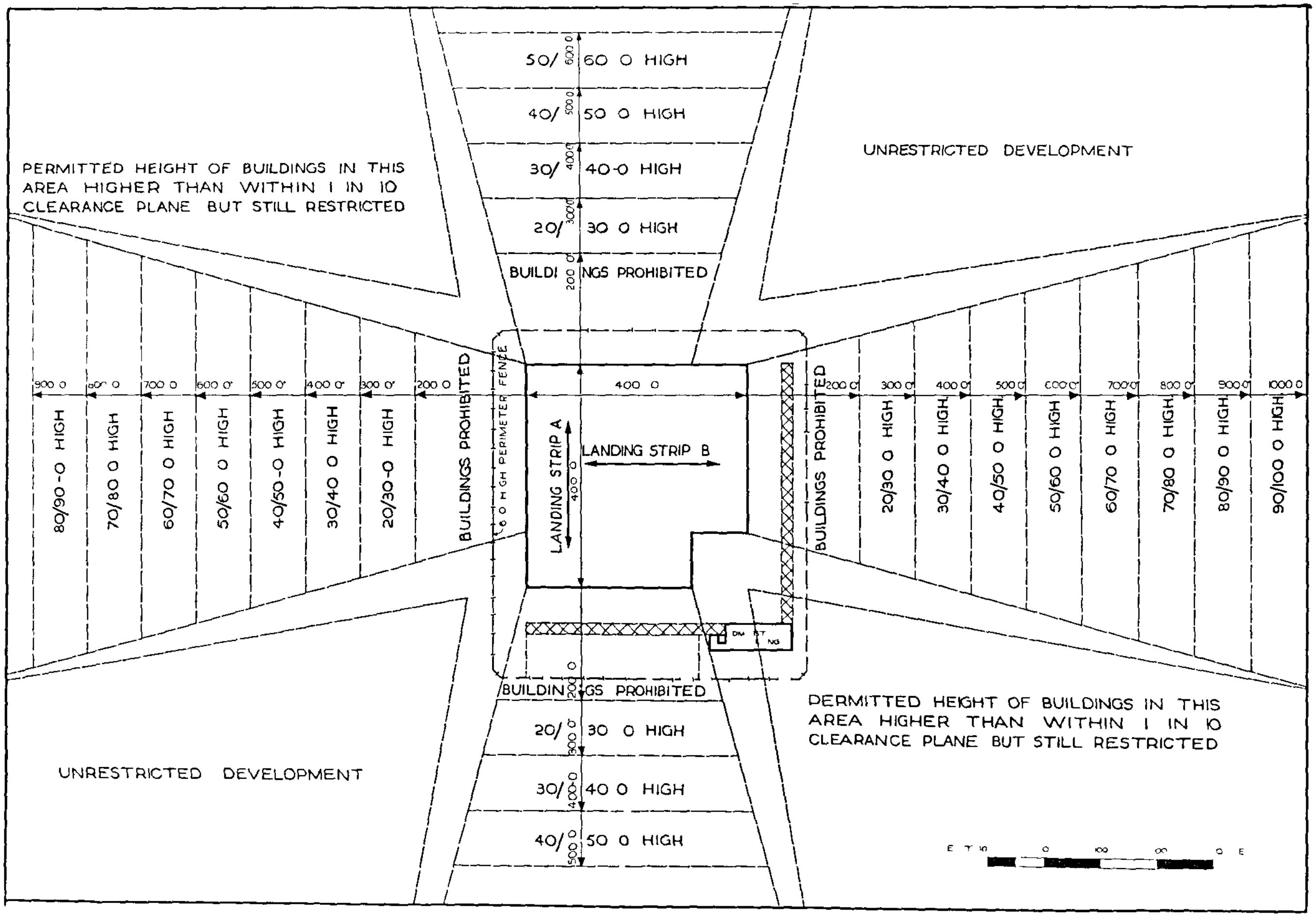

Fig 1 Hypothetical Helicopter Landing Ground Areas of building height restrictions (Climb plane 1 10)

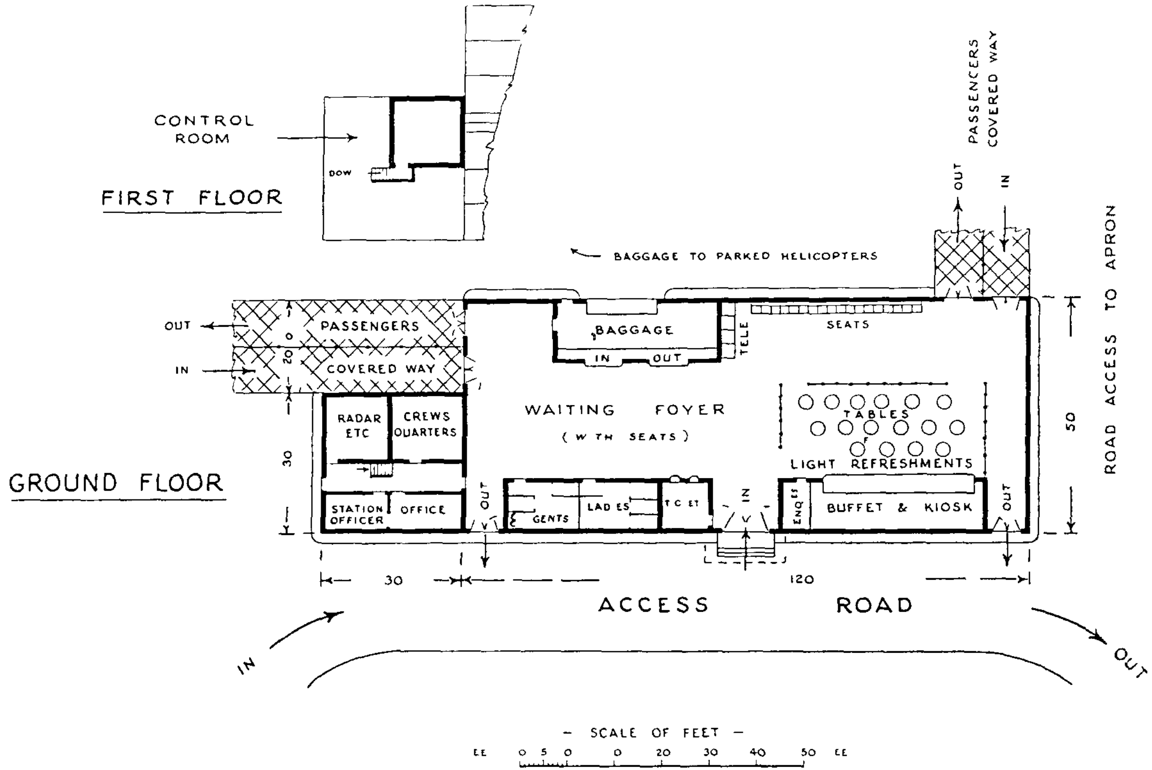

Fig 2 Hypothetical Helicopter Landing Ground Suggested layout of administrative building

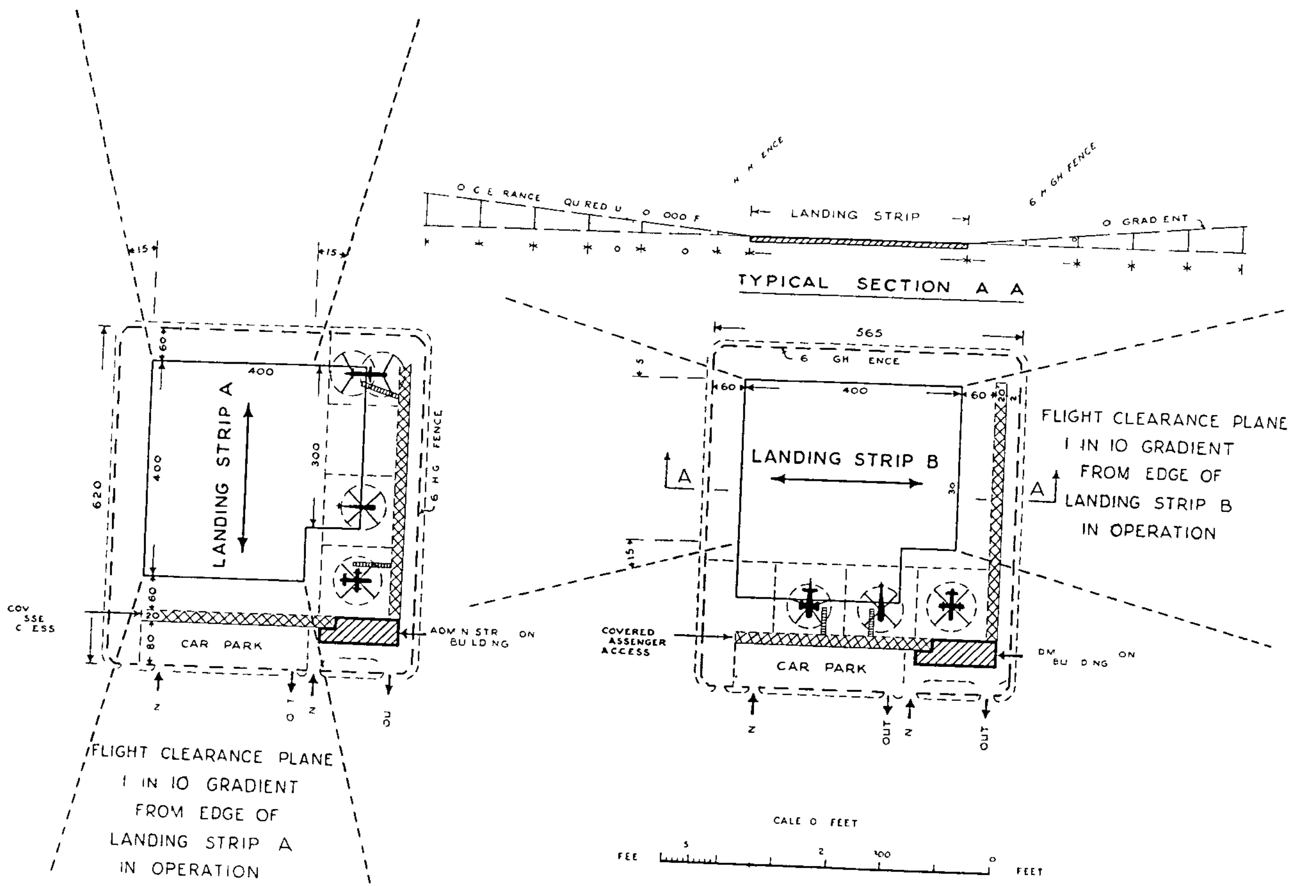

Fig 3 Hypothetical Landing Ground (Minimum requirements for future 15 years)

HYPOTHETICAL HELICOPTER LANDING GROUND AREAS OF RESTRICTED BUILDING HEIGHTS				
Restriction on Building Height	FLIGHT CLEARANCE PLANE 1 in 10		FLIGHT CLEARANCE PLANE 1 in 6	
	Distance from Landing Strip	*AREA (Sq Yds)*	*Distance from Landing Strip*	*AREA (Sq Yds)*
Prohibited	To 200	33,100	To 120	18 600
Between 20 and 30	200 — 300	21 400	120 — 180	12 000
Between 30 and 40	300 — 400	24 600	180 — 240	12 820
, 40 and 50	400 — 500	27,000	240 — 300	14 200
50 and 60	500′ — 600	31,200	300 — 360	15 600
60 and 70	600′ — 700	34,400	360 — 420	17 000
70 and 80	700 — 800	37,800	420 — 480	18 350
80 and 90	800′ — 900	41,000	480 — 540	19 800
,, 90 and 100	900 — 1 000′	45,000	540 — 600	21 200
Greater than 100	Over 1 000′	No Restriction	Over 600	No Restriction

Fig 4

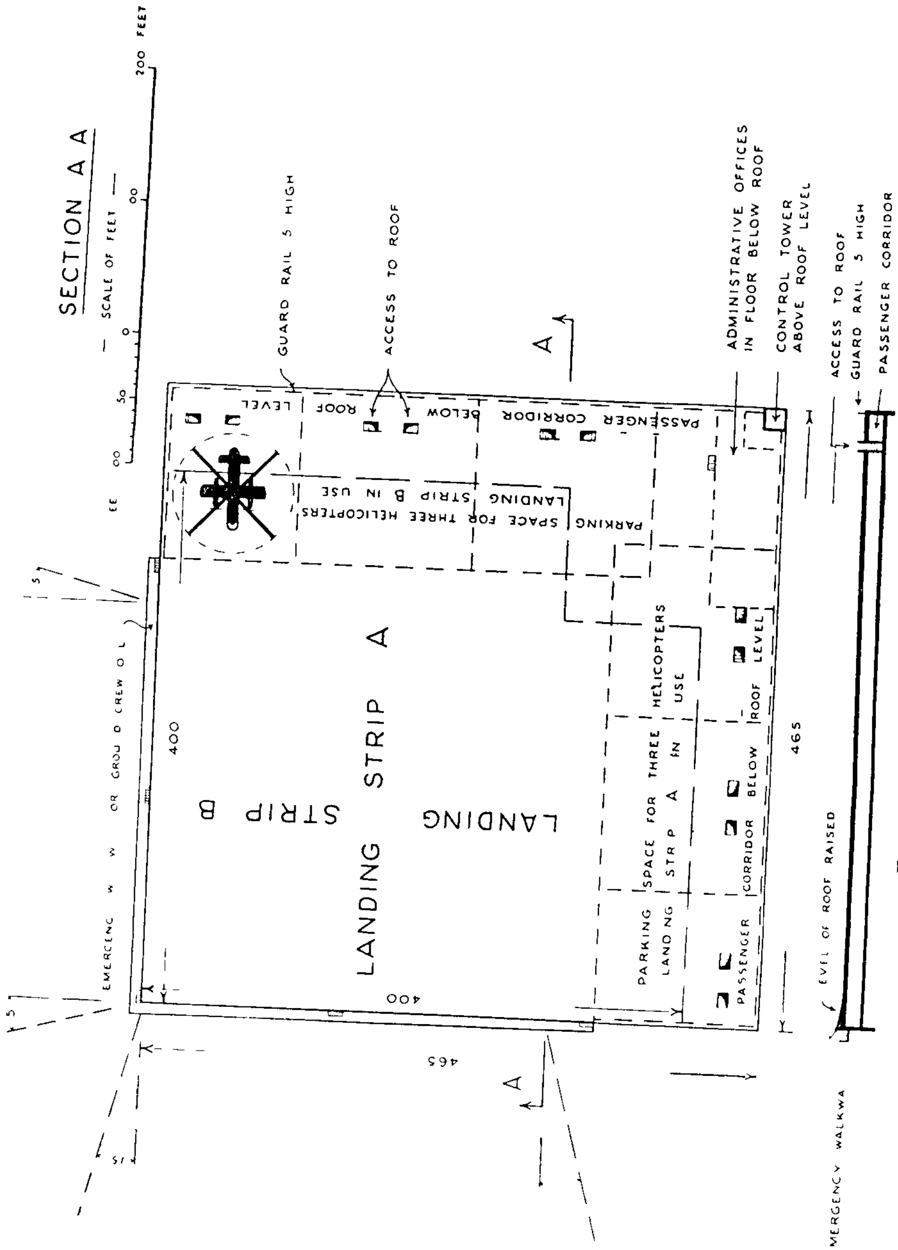

Fig 5 Hypothetical Helicopter Roof Section

https://doi.org/10.1017/S2753447200002730 Published online by Cambridge University Press

Passenger Embarking Arrangements

It is considered that if a helicopter station is to justify itself it will be used to full capacity at peak hours, and I would appreciate an authoritative statement on the maximum density a scheduled service could be expected to maintain

I have assumed for the purpose of this paper that one aircraft movement, arrival or departure could be made every 5 minutes and that the average turn-round time for the helicopter would be 20 minutes, during which time refuelling would normally take place

Under these conditions there would probably be 4 machines at the station at once during busy periods and one of these would probably be loading and one unloading

It would appear therefore that four gangways should be provided leading from main corridors to the spots on the helicopter waiting apron near the aircraft doors Such gangways should be covered to protect passengers from weather or down draught, and they should be so sited that they could not be short circuited by passengers who might otherwise court danger from tail rotors In cases where the unused strip would be used for parking, such gangways would be movable

Helicopter Waiting Space

The area required for waiting helicopters depends upon the size of helicopters to be used Tandem or triple rotor layout may produce unwieldy shapes, and in view of the necessity for advance planning of sites it would be an advantage if manufacturers could be given a yardstick to which they could work

I envisage the inter-city helicopter as an " Airbus " with closer seating than an air-liner and suggest that the overall length of the fuselage, including space for power units (if mounted within) should not exceed the length of the Viscount Major of about 85 ft

In the case of a single rotor, the whole aircraft would then be contained within a circle of little over 100 ft diameter, but a tandem rotor machine like the Piasecki YH16 with 85 ft diameter rotor discs, even with a rotor overlap of 30 ft, has a maximum overall length in the region of 140 ft I would suggest, however, that the provision of an apron with four squares of 130 ft sides should be ample, and would like to hear the views of the meeting on this size I would also like to hear views as to whether folding rotor blades are feasible on large helicopters which operate on quick turn-round schedules

The waiting areas cannot reasonably be located at the end of a landing strip in use and must be at least 35 ft (the probable maximum height of a helicopter) away from the side of the strip to allow for the obstruction free side plane of 45° The part of a strip not in use can be a part of the waiting space, provided that there are no technical objections such as the proximity of waiting aircraft to the draught from helicopters landing and taking off

Road access to the apron will, of course, be necessary for various reasons

The paving of the apron should be similar to that of the landing strips

Manoeuvring Devices

In high density traffic conditions, the helicopter must be moved rapidly to and from the parking area It would appear that wheels should be incorporated in the ultimate type of undercarriage, so that the aircraft can be towed or proceed under its own power No doubt the method will be standardized in due course, but the earlier this can be done the better for the station designer

Terminal Building

If this description conjures up a vision of the London Airport's recent erections, it is bringing to mind the exact opposite of what is needed for helicopter operations We require the minimum accommodation that will enable passengers to use the station without fuss or delay

With a 5 minute frequency a maximum rate of 50 people can be expected every 5 minutes, half arriving and half departing, or possibly at certain times over a period of 20 minutes all arriving or departing

There should be no need for passengers to arrive in the station itself long before their flight, but one might assume an average wait of 15 minutes which would mean that up to 150 people may be in various parts of the station at one time With "short haul" travel it is not expected that the amount of luggage to be handled separately will be anything approaching that at our present airports, and I propose to ignore customs accommodation which I feel will be needed only at very few stations in this country

The requirements of the terminal building may be summarized as follows

Spacious foyer with comfortable seats and a few tables ,
Ticket and Inquiry office ,
Luggage counter and left luggage accommodation ,
Toilets ,
Telephones ,
Sales counters for light refreshments, newspapers, sweets and cigarettes ,
Separate accommodation for the station staff ,
Control room

An illustration has been prepared of a suggested layout (Fig 2)

Car Park

Although a town centre helicopter station should be readily served by public transport, it will be necessary to provide car parks There will be no difficulty in the case of a ground station, as it will be possible to use some of the land which is sterilized for building by the approach paths

Refuelling, Starting and Firefighting Appliances

It is anticipated that fuelling will be carried out by a mobile equipment No difficulty will be experienced in finding space for storage tanks

Firefighting appliances will be based on similar standards to those in use at airports

Starters and service units will move about on the apron as at airports

Night and Bad Weather Navigational Aids

Helicopter services must have a very high factor of regularity if they are to be successful Consequently they must operate at night and during low visibility conditions

It would appear that the ability of the rotor craft to fly slowly and hover should greatly assist the solution of navigational problems near the station, but there will no doubt be some difficulty in visual location at nights over cities with many and varied lights, particularly of the advertisement type

No doubt regulations regarding lighting and sufficiently precise radar navigational aids will be made long before central area stations are in full operation

Fencing

The area of the landing station must be protected with an unclimbable fence not less than 6 feet high so that full control can be exercised over all persons on the station premises

Such a fence must not obstruct the climb plane at the end of a strip nor the 45° plane at the side of a strip It will therefore sterilize a certain area of land within the boundary of the station and add to the size of the site required

Size of Site, etc

Using the data outlined, I have prepared plans showing a typical design for a landing station and terminal building on a level site in order to illustrate how the various components may fit together in the smallest possible way (Fig 3)

It will be seen that the actual site area is approximately 8 3 acres, the additional area on which buildings 30 ft high would be prohibited is 8 3 acres, and the area beyond this on which buildings up to 80 ft high would be restricted is 31 5 acres (Fig 4)

These latter two areas would be reduced to 3 7 acres and 16 2 acres respectively if the climb plane gradient were 1 6

Although the design is probably as compact as the data used will allow, I feel that few, if any, of the large cities in Great Britain have, or can afford to reserve, sufficient space in their central areas to accommodate such a ground level station and approaches In view of the fact that the transport helicopter can only be justified for travel between central areas, it would appear that surface stations will be suitable only for smaller towns or for central areas of cities with parks near their business centres, unless the developed helicopter is capable of vertical ascents and descents of several hundred feet with an adequate safety margin, regardless of wind direction

Possible Sites for Surface Stations in Liverpool

Wavertree Park is about 2 miles from the business centre of Liverpool and I have prepared a suggested layout to indicate how a ground level station could be accommodated there It is possible that such a location could be used temporarily pending the construction of a roof station in the business centre

Dukes Dock for which a tentative layout has also been prepared, is little more than a half mile from the business centre, but although a strip could be provided with adequate approach paths from S W and N E , warehouses would prevent the provision of a satisfactory alternative strip It is possible, however, that a high percentage of use could be made of such a station, particularly if large helicopters could take off and land in moderate cross winds

The erection of a new warehouse on this site would enable a satisfactory roof landing area to be provided at a reasonable cost

Examples of Ground Level Stations in Cities

London The South Bank station adjoining the River Thames is at present being used by B E A for their service to and from London Airport with single-engined, Westland-Whirlwind helicopters, fitted with silencers, floats and anchors Its use is understood to be temporary as the site will be required for other purposes in a few years time

Rotterdam The " Heliport " at Rotterdam is situated in the open spaces left as the result of extensive war damage in the centre of the city It is about 5 acres in extent and is a grass field with two concrete landing areas Concrete taxi-ways connect these to an apron adjoining a compact terminal building which includes Custom facilities Open spaces around the " Heliport " enable safe operations to take place with S 55 Sikorsky single-engined helicopters on the Sabena service between Rotterdam and Antwerp and Brussels

Brussels The " Heliport " at Brussels is within easy reach of the heart of the city and is in a densely built-up area It is situated between a road and a railway and is about 650 yards long by about 40 yards wide giving an approximate area of 5 4 acres There are buildings on either side within 22 yards and the approach is over the main railway A concrete landing area is connected by a taxi-way to the apron adjoining a somewhat similar terminal building to that at Rotterdam It is owned by Sabena who operate services with S 55 Sikorsky helicopters to various cities in Belgium, Holland and Germany

Roof Helicopter Stations

General considerations

A roof station has certain obvious advantages over a ground level station The height reduces the difficulty of siting in relation to high buildings so simplifying approach path planning and drastically reducing the area of land affected by height restrictions , the area of the site itself can be reduced, since the terminal buildings and car parking can be incorporated under the landing strips , the noise and downdraught are removed further from the streets and adjoining buildings , the buildings can partly be used for other purposes so that only a portion of the site value is attributable to the helicopter station

It may also be possible for more helicopters to wait on a given area since there would appear to be no objection to rotors overhanging the edge of the roof

Whether there are advantages or disadvantages in taking off from, or landing on a roof as compared with a central city ground level station of the same area is a matter for the aviation experts, whose views on this aspect would be welcomed Roof landings with small aircraft are common in the U S A and no doubt landings on ships and aircraft carriers with helicopters have given British pilots somewhat similar experience

If there is doubt that roofs will be suitable because of turbulence or other factors, I suggest that the Ministry of Transport and Civil Aviation should sponsor an investigation including wind tunnel tests on models, so that Local Authorities can be informed at an early date whether they should continue thinking in terms of roof stations

The only apparent disadvantage of the roof station is the possibility that the extra cost of providing and supporting a sufficiently strong roof slab would be so much more than the cost of constructing a ground station landing area, that it would more than outweigh its advantages I feel that in the centre of a city this extra cost may be no more, and in some cases possibly less, than the cost of sterilizing either wholly or partly, much valuable building land in the climb planes of the ground level station It is important to remember, however, that owing to the large area of roof which would reduce natural light, the building would to some extent be limited to such uses as warehousing, car parking and bus stations, except around the periphery of the building where offices may be situated provided they can be insulated from noise and vibration

The use of a roof over a railway station or sidings may not be so economical since the structure to support the landing area would have little or no secondary use, but the possibility is well worth investigation in view of the fact that the location and size of a railway station would often be quite suitable, and may in some cities offer the only possible central sites

Design data

The design data for a roof station would be generally similar to that of a ground station of the same size with the following main differences

Passenger embarkation could be simplified by the use of short stairways to embarking points from a floor beneath the landing area

Economies in helicopter waiting space may be possible by allowing the rotors to overhang the edge The control room need be the only building above the level of the landing area

Lifting arrangements from the street would be required for starting, refuelling and firefighting appliances These could be either in the form of internal " goods " lifts or external hoists somewhat similar to ships' davits which would also be capable of lowering engines or fuselages of " grounded " helicopters to road vehicles

Special fuel pumping arrangements would be needed

Safety fencing would not of course be required to prevent the public from walking on to the landing area, but some device to prevent helicopters over-running the strips must be provided These may take the form of short slopes at the edges of the landing area surmounted by kerbs with further protection in the form of cables on cantilevers below the gradient of the climb plane

Constructional Problems

The design of a roof suitable for helicopter landings presents a number of problems in relation to point loading and the isolation of the general structure from vibration or shock

The distributed load would not appear to offer any design difficulty since with a helicopter of 50,000 lbs maximum weight spread over an area of 100 ft × 100 ft the distributed live load should not exceed

$$\frac{2 \times 50{,}000}{100 \times 100} = 10 \text{ lbs per square foot}$$

Such a load is very small as compared with the total distributed loads normally carried by steel framed or reinforced concrete framed buildings, but when 50,000 lbs is likely to be applied suddenly to any part of the roof on probably three small areas, the design of the roof beams and slab assumes a problem of magnitude

I have not tackled this problem in detail I feel that with the uncertainty of whether large helicopters can be accepted into central areas at all on account of noise and economy, etc, it is not at present an urgent matter for the staffs of Local Authorities, already in short supply It would appear, however, that the landing and waiting areas should, if possible, be in the form of a superstructure above a normal roof slab and overhanging the building to some extent It would be so designed that heavy landing shocks and engine or rotor vibrations would not be transmitted directly to the frame of the building It has been suggested that this might be achieved by "tanking" the roof and using a floating raft for landing A project of this nature has been reported from the U S A for small helicopters, and it will be interesting to learn whether it would be a feasible and economic solution in the case of heavy machines I suggest that the manufacturers of helicopters may well be the right people to prepare a design in light metals for a roof superstructure in conjunction with the design of a suitable type of undercarriage for the helicopter itself It would certainly be interesting to know whether modern methods of aircraft wing manufacture could be economically applied to such roof construction

The design of the roof slab is not far removed from that of the decking of a road bridge The Ministry of Transport, over twenty years ago, produced a simplified formula which is still in use, to enable Engineers to calculate the effect of bridge loading by the heaviest road vehicles The Ministry also control the weight of vehicles allowed to use such bridges

It would be very helpful if this same Ministry (now with the words "and Civil Aviation" added to its title) would give similar assistance in connection with helicopters

Examples of Roof Helicopter Stations

The Port of New York Authority, as has been previously mentioned, uses the roof of its building for operating small helicopters, while there are several other examples in the U S A

The station of the Port Authority is 40 ft × 45 ft, and has an elevation of approximately 250 ft above sea level The approaches are clear of obstructions from all directions The helicopters operating from this roof are Bell 47 machines, equipped with floats and two-way radio As a matter of safety, it has been policy to suspend operations when winds are above 30 m p h

I am not aware of any actual roof station suitable for heavy aircraft, although a number of sketch proposals have appeared in the press I have, however, prepared a layout of a hypothetical roof station (Fig 5) based on the data given in this paper, and also an outline scheme for a roof station in Liverpool The latter is on a site in the centre of the city reserved for a coach station and multi-storey car park It is approximately 600 ft long with a maximum width of 290 ft, and it would be possible to provide a roof landing strip of approximately 400 ft × 300 ft, with waiting spaces for two large helicopters

Floating Helicopter Stations

Towns or cities with large stretches of water near their central districts are obviously attracted by the possibility of using a floating landing platform for helicopters Provided shipping can be prevented from obstructing the climb planes, there would appear to be no objections

The design data would be very similar to that for a ground station, but the terminal building would be best situated on land There are problems to solve in connection with access to the platform both for passengers and for servicing aircraft, but whether a floating roadway or a boat service were used, such problems should not prove difficult to solve

Floating platforms for other purposes have been used previously and the designers have already turned their activities to schemes which will provide for helicopters I consider that floating stations are well worth investigation by Local Authorities with suitable stretches of water

I have already looked into the possibility at Liverpool, but find that the needs of shipping in the busy Mersey are likely to prove an unsurmountable obstacle However, it is, at least, a site that cannot be lost for the future due to building operations

Special Structures

Apart from roofs and floating platforms, it is easy to envisage other types of structures which would overcome difficulties in siting helicopter stations, and several proposals have been published

One of these which is certainly attractive is the idea of combining the station with a river bridge—over the Thames for example

Another possibility which springs to the mind is the erection of a platform on columns over a river

I feel that where circumstances dictate, such possibilities are worthy of consideration, but in the end it is a matter of economics, for we must not forget that a helicopter may only be able to compete with other forms of transport if it is freed from the high costs of ground equipment

Financial Considerations

I have not prepared an estimate of the cost of either a ground level station or a roof-top station I feel that the investigations of the Interdepartmental Committee in this direction are a sufficient guide to Local Authorities

It is obvious that in a similar location a helicopter station would be much cheaper than an aerodrome for fixed wing aircraft, so that provided the helicopter itself can in the future operate at a reasonably low cost, the governing factor would be the cost of using and restricting land in our city centres, or the cost of constructing a roof-top station

For comparison purposes, the following estimated costs of land purchase and loss of land values due to building restrictions in the vicinity have been prepared for sites of a hypothetical surface station in different locations, and for a hypothetical roof station in a city centre The land values given do not refer to any particular city but I consider that they are sufficiently realistic to indicate how site costs may be affected by different design conditions

(*a*) *Ground Level Station away from the centre of a town* where an average building height of 30 ft may be expected

	Climb Plane 1 10		*Climb Plane* 1 6	
	Sq Yds	£	*Sq Yds*	£
Site area	40,000 at 10/-	20,000	40,000 at 10/-	20,000
No buildings area	18,000 at 10/-	9,000	6,100 at 10/-	3,050
Buildings, 20 ft —30 ft	21,400 at 2/-	2,140	12,000 at 2/-	1,200
Totals		£31,140		£24,250

(*b*) *Ground Level Station in city centre* where an average building height of 80 ft would be allowed

	Climb Plane 1 10		*Climb Plane* 1 6	
	Sq Yds	£	*Sq Yds*	£
Site area	40,000 at £6	240,000	40,000 at £6	240,000
No buildings area	40,000 at £6	240,000	18,000 at £6	108,000
Buildings, 30 ft —80 ft	155,000 at £2	310,000	78,000 at £2	156,000
Totals		£790,000		£504,000

(*c*) *Roof Station in city centre* high enough to make restriction of building heights unnecessary It is assumed that fifty per cent only of the site cost would be attributed to the helicopter station part of the building (Probably a high percentage)

Site area 24,000 sq yds at £3 = £72,000

From these figures it would appear that ground level stations designed according to data at present available are not likely to be acceptable in areas of high land values even if physical conditions allowed I consider that the extra structural cost of a roof station may be considerably less than the saving in site value, especially should it be possible for good commercial use to be made of the remainder of the building

It would certainly appear that a special investigation into the merits of roof stations would be well worth while

Conclusion

A general conclusion to be drawn from the paper is that I believe the helicopter to be a vehicle of promising importance, and that from present knowledge there would appear to be no unsurmountable difficulty which would prevent the construction of suitable operating stations in the right places in our towns and cities I am concerned, however, about the difficulty of obtaining adequate official information regarding the types of aircraft and operational techniques for which Local Authorities should make provision

I feel that this meeting should not forget that there are many people, including elected representatives in local councils, who do not believe that the helicopter will ever be used for inter-city services, and that they are not likely to change their views either until it is too late to make proper provision for helicopters, or until an official pronouncement on the subject of inter-city passenger services by large helicopters is made by the Ministry of Transport and Civil Aviation

It would be very helpful if the Interdepartmental Committee could produce a second report in the near future, particularly if its terms of reference could include the following

(1) To determine first of all in the light of recent experience whether the helicopter *can* be developed into a safe, suitable and economic vehicle for inter-city passenger services

(The following terms, of course, depend entirely on the decision on this)

(2) A realistic estimate of the date when it will be available

(3) To determine suitable passenger capacities, overall dimensions and flying requirements for transport helicopters to which the aviation industry should work

(4) To provide Local Authorities with the necessary official data to enable them firstly to reserve suitable sites, and secondly to prepare designs for stations from which the type of helicopter envisaged by the Committee could operate

I would like to congratulate the various British aircraft firms engaged in the manufacture of helicopters on their enthusiasm and efforts to keep this country in the forefront of helicopter development, and to thank them personally for the help I have received from them in my investigations over the past 5 years

I would also like to congratulate B E A on their efforts to further helicopter travel both by experimental services run at a loss and by producing specifications and ordering prototype aircraft I wish to thank them, too, for the help I have received from their officers

I would like to refer also to the assistance I have received from the Ministry of Transport and Civil Aviation, whose papers on the subject have proved most valuable, and whose officers were most helpful to me

The efforts of both the industry and B E A are at present, as far as I am aware, independent of any co-ordinating investigations by the R A E at Farnborough, where such valuable work was carried out in connection with the Comet Am I being over-bold if I suggest that now is the time for them to be asked to help with the helicopter, so that it will be assuredly accepted by the public as a safe machine when it is ready to operate in large numbers over our crowded streets ?

If, in this paper, I have displayed ignorance in respect of the subject on which I have spoken, I must ask for the indulgence of the meeting as a layman, but suggest that it may be a further reason for asking for more official information