WRITTEN CONTRIBUTIONS TO THE DISCUSSION

ON

" SOME THOUGHTS ON THE OPERATIONAL FUTURE OF THE TRANSPORT HELICOPTER "*

By P G MASEFIELD

A paper presented to the Helicopter Association of Great Britain on November 7th, 1952

Mr S Scott-Hall, C B (*Director General of Technical Development (Air), M O S*) I was extremely sorry to be unable to attend Mr MASEFIELD's lecture, if only to express my admiration for the clarity and logic of the arguments he had used to advance his concept of the commercially acceptable helicopter

I should also have expressed some dismay at his demand by 1960 for a 48/64 seater aircraft with a speed of 160 m p h , to which his analysis of economics leads This may be the answer from the commercial point of view, but is it from the standpoint of engineering ?

Mr MASEFIELD says that he believes that such a helicopter is " just within the technical capabilities of to-day's knowledge," and that " it is not so far ahead that it would be likely to lead to an expensive failure " Assuming a gross weight of the " BEAline Bus " of about 50,000 lb , he estimates that the development programme up to the start of production would cost £4,500,000

Let us examine these statements In my view there is a world of difference between building an aircraft which is just within the technical capabilities of to-day's knowledge and building one which is successful from an operational standpoint, particularly when one is considering civil commercial operation which makes the most stringent demands of all Dr Dornier's DOX flying boat was within the technical capabilities of its day but it was not a commercial proposition

The only type of helicopter with which we have any degree of technical familiarity at the present time is that enbodying the shaft driven rotor There is a large school of thought which considers that the scope for development of this type to larger sizes (and the largest we have built in this country so for has weighed less than 20,000 lb) is limited, and that we shall have to go to entirely novel methods of propulsion for the sizes of which Mr MASEFIELD speaks If that is true then our technical knowledge will have to cross large areas in which at least our engineering experience is nil The chances of success on such a basis—success in an operational sense—are to my mind small Who is going to risk his money on such an experiment ? Mr MASEFIELD suggests the taxpayer

The design studies which the Ministry of Supply sought from the five helicopter firms on the basis of the 1951 B E A Specification have not all yet been submitted but the lecturer says the aircraft specified is now seen to be too small and too slow, and he gives well-argued economics to prove this One wonders whether in another year's time—trends being what they are—we could not advance as good an argument for a still larger helicopter In my view every fresh step in this direction makes the project more difficult of achievement and puts the date of its introduction to commercial operation further away Surely before we raise our sights again we should first examine the present design proposals carefully to see how serious the engineering problems are

I think that we should also look at them with the object of seeing whether the designs could be adapted to military needs as well and in that way ensure the production numbers which have such a critical influence on the economics Mr MASEFIELD himself has in the past used the phrase " Civil aviation rides home on the back of military development " I believe that we should make more strenuous efforts to follow this precept in the helicopter field

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Finally I believe that what we need above all else is flying experience with our British designs At the moment this is meagre and I therefore heartily welcome his proposals to operate the Bristol 173 I am sure we have much to learn from such operations

Mr N E Rowe (*Member—Blackburn & General Aircraft Ltd*) The lecture by Mr MASEFIELD is of great value in giving explicit form to the needs of the Operator, and in giving courageous expression to the firm intention of relying on the helicopter for future short-distance transport as a major development for the future I am quite sure that the paper will give great encouragement to all concerned with the helicopter business in this country

A number of people voiced some disquiet about the size of aircraft required The size derives directly from the need for competitive economics, and in this sense is well substantiated However, it is necessary to remember that comparison is being made with the Pionair, an aircraft which has been developed over fifteen years, and which in particular has been developed to increase seating capacity by 50% very recently, and, therefore, judged on a cost per seat mile, is not a just comparator with the newly developed helicopter In my view it is unwise to force the emergence in one step of such a competitive machine without allowing for the development which comes from usage, and which is so clearly exemplified in the Pionair One has seen giant machines which have come to nought because the steps taken have been so great that the aircraft type has never emerged beyond the experimental stage, and I think this idea is at the root of the uneasiness which was expressed by a number of speakers after the lecture Personally, I would prefer to see the more gradual development, leaving the economics to come out by reason of development rather than by a very big step from present sizes

In general, steps in size seem to be about double for a given duty between existing and new types, and this would lead to something of the order of a 36-40 seater, which would be a step up from the developed Bristol 173

Mr MASEFIELD says the only thing the helicopter has to offer is the ability to land in small spaces I do not agree I think this machine has other things, notably the ability to fly slowly and to hover, and to move horizontally in any direction I am sure these are features of its unique flying qualities of which advantage will be taken in operations and which should be studied so that the best use is made of them I do not believe in the full integration of fixed-wing and helicopter services in the sense that we force the helicopter to accommodate itself to all the usages which have grown up around the particular flying qualities of the fixed-wing aircraft I am sure this is a mistake, and I think that the helicopter should be studied as a new vehicle having its own special advantages , I would go so far as to say that this point should be brought into the maintenance considerations, because the helicopter is much more of a mechanical vehicle than the fixed-wing aircraft, can take up much less floor area per unit, and hence can allow of a different maintenance shop layout

This approach can also be seen in the question of operations and the idea that the helicopter has to have very lengthy stand-off times Stand-off times are needed for the fixed-wing aircraft, because the scheduling of airports is related to clear weather conditions, so that when the visibility is low then aircraft must be delayed The helicopter must provide a regular, reliable service under the worst weather conditions, otherwise it will not compete with the parallel short-distance surface transport , hence, rotor stations must be scheduled for such conditions and then there is no reason why helicopters should ever have lengthy stand-off times I regard this as a basic point, since extensive delays on short services will just put the helicopter in bad odour and prevent its full exploitation

Finally, I entirely agree with the great potential value of the helicopter to forestall the provision of tremendous fixed-wing airports in the future Perhaps this is the most important service it can give

On a personal note, may I thank the lecturer for his graceful references to my own work

Wing-Cmdr R A C Brie (*Founder Member—B E A*) Mr MASEFIELD has undoubtedly given one of the most outstanding and forceful lectures to which the members of this Association have been privileged to listen In so doing he has displayed that crusading spirit which is inherent in our determination to ensure that the helicopter occupies its rightful place as a safe and efficient means of public transport

There are, of course, many ways of reaching this objective It is likely for instance that there are others besides myself who, whilst appreciating the potentialities of a 40-seater, feel that even a 10-seater could be persuaded to earn its keep providing it were suitably tailored and correctly employed

I think it a mistake to treat the helicopter as competitive with the aeroplane It is a new means of transport and one capable of being exploited in quite a different manner Short-haul transport which provides point-to-point convenience and time-saving can invariably command a higher than normal rate per mile covered from the fare-paying passenger An arbitrary and uneconomic rate of 6d per passenger-mile need not necessarily apply to helicopter travel Employed on carefully selected routes of from 10-50 mile stage lengths, the helicopter should have no difficulty in justifying itself in a profitable manner

Most discussions on rotorstations, airstops, or, to coin another name, ROTORSTOPS, usually disclose a lack of unanimity as to the best location and the area required I can at least claim to be consistent—for it is now approaching twenty years since I first officially suggested the possibilities of a waterway, and particularly of the River Thames It is still proving extremely difficult to get those not well acquainted with helicopter pilotage to understand that a helicopter pilot when operating to and from a confined area is quite indifferent about its size providing he has plenty of surrounding air space for manoeuvring It is so easy to say we must have a minimum ground area of 400 ft sq , or a slightly lesser area at roof-top level Actually, what a helicopter pilot most requires, and must have for maximum safety, is adequate approach and take-off paths If these are of the right order, then many existing thoughts on dimensional characteristics can be appreciably modified

It is impossible at this stage for anyone to express an authoritative opinion as to what constitutes a desirable location for a central city site Maybe there is no such thing To satisfy all needs there will probably have to be several sites around a central area Much experimentation is still required as far as London is concerned and I once again emphasize the desirability either of trying out a floating platform on the Thames or, alternatively, and better still, erecting in most simple form a girder-supported timber platform over Waterloo or Hungerford Bridge Either scheme has the advantages of cheapness and flexibility Each provides maximum safety Further, such activities some distance removed from public buildings, would do much to alleviate the new problem of excessive noise

Written contribution from **Mr J Shapiro** (*Member—Consultant*) Mr MASEFIELD, accustomed to span with his thoughts the horizons of space and time, has shown us the magnitude of the challenge He has clearly posed the questions which must be uppermost in the minds of those who advocate, sponsor or execute a project measured in millions

The first question is, how is this venture to be judged The lecturer believes that the transport helicopter must be economically competitive as an unsubsidised transport vehicle The assumptions and results of the paper under discussion are open to criticism and the meaning of subsidy requires definition but the principle that public transport needs a good helicopter measured in transport terms, cannot be questioned

Contemporary (extremely expensive) helicopters usually justify themselves economically where they can combine the functions of a vehicle and a machine for doing a certain job such as carrying out a rescue or distributing some substance at a point where it is required (fire engine) However, it seems to me that few things stand out more clearly in the analysis of helicopter performance than the inability to produce a helicopter which will top its class both as a means of sustentation and as a means of transport Either you want to stay up in the air or you want to get somewhere You cannot produce a helicopter which will be best for both duties and nothing but the best is good enough for transport because the helicopter enters the field of transport hemmed in both ways by other means in competition with it

In economic terms, the former criterion will be measured in pence per ton-hours and the latter criterion in pence per ton-miles

The conclusion which emerges from this paper is that the public transport helicopter will be either useless or will capture a market so great that it deserves the evolution of a specially adapted machine, built to satisfy economical transport criteria All successful transport aircraft have been specially designed

The second question is "How much investment is needed for this development ?" Mr MASEFIELD gives some figures for the cost of development and production I believe from experience with large helicopters that the figure of

£6 million for development costs is rather lavish But the main point I should like to make is that the line between development and production investments is drawn from the engineering point of view and may be misleading to those accustomed to think in financial and/or in budgetary terms

No one could maintain that the country could afford unlimited investments even if the profit were absolutely certain, but the investment in a gasworks or power station is a different problem involving totally different considerations from those which govern the investment into the development of an experimental machine

Perhaps it will help if we asked the hypothetical question how much expenditure is needed on development before we can expect the Stock Exchange to invest in the production of a machine whose competitive qualities are proved The answer to this question is, in my opinion, not six million, but under two million pounds I do not maintain that this will be the end of development expenditure but it will be the point at which whoever has stuck out his neck will be able to pull it in again, plus or minus head, and I believe that it is a more significant turning point than the actual beginning of production

On the other hand the total investment needed to make this venture a success, on both counts of improving transport facilities and creating an article for export, may be larger than twenty million pounds Much will be lost if this is not realised in time, though the time is not now, but two million pounds (not years) later

The third question is, whether the whole thing is worthwhile Mr MASEFIELD says " yes " without hesitation and as counsel for the defence conducts his plea by establishing his reputation as a realist, which is what pessimists like to call themselves He then hopes to sway the judges by the following argument—the thing must be worthwhile if even I say so I doubt whether this strategy is effective The judges may accept Mr MASEFIELD's caution not to expect too much and reject his conclusions They may well believe that bewteen the careful predictions and the bold determination, the link is not logic but the inspiration of Sir Alfred Tennyson Indeed, for a thoroughly conservative economist a legitimate conclusion from this paper might be that it is better to invest the money that we need for the development of the helicopter into additional aerodromes because in doing so we could get cheaper air fares in the 60's

I do not share the belief that you can't go wrong if you are always erring on the safe side Not only do I doubt that if you are determined never to underestimate, you will necessarily sway conservative and unimaginative minds, but, in aviation, pessimistic assumptions can be quite misleading First, I have pointed out before that in the economics of aviation a " multiplication of pessimisms " can take place which will distort the result out of all proportion Second, conservative assumptions bring out misleading trends Third, conservative assumptions fail to provoke the best efforts of designers I showed in an earlier discussion (JHA Vol 3, 1949) that, by improving each of the economic parameters of a large transport helicopter by a margin of 10 per cent or so, it would be possible to reduce aircraft cost per passenger-mile to about half their previous value under optimum conditions and even to one fifth of their previous value under less favourable conditions

It is difficult to judge from the paper exactly where the lecturer has been pessimistic but one point seems fairly clear Mr MASEFIELD expects only a small reduction of the indirect costs (*i e*, the percentage added to aircraft costs to obtain the total costs), namely from 80 per cent to 70 per cent of the aircraft costs It is accepted that helicopters can be economical only if they are large and fast, in other words, if the engineers take a bold step and produce a great advance Is it too much to hope that the administrators should take equally bold steps and produce equally great advances ? Perhaps we ought to say that helicopters can be economical if they are large and fast, and, last but not least, administratively efficient

This involves the engineering of the helicopter as well as the engineering of operating sites and facilities But it also involves some consideration of the methods of handling short-haul air passengers To me it seems like an article of faith that if fixed-wing aircraft need 80 per cent oncosts, helicopters should not need more than 40 per cent oncosts I hope that engineers and administrators will urge each other to outdo themselves in their respective endeavours Beyond that enough financial support from public sources should be available for helicopter site construction to redress the balance which now heavily favours aeroplanes operating from airports built wholly at public expense

When listening some time ago to a paper on prophecy and fulfilment in aeronautics, I was surprised to hear that Sir Harry Garner thought fulfilment had exceeded expectation, until it occurred to me that this view was based on official predictions It sould seem that prophets in official positions usually make sure that their predictions are conservative For the rest of us it is permissible to derive some lessons by studying past predictions, by carrying out, as it were, an extrapolation of extrapolations, or, as the mathematician would say, by studying a second derivative of prophecies This will lead us, I believe, to a helicopter which will have the same relation to the hypothetical " BEAline Bus " as the Bristol 173 Mark 3 has to the Bristol 173 Mark 1 A glance at Fig 8 of this paper will show us at once what we can expect If this guess comes true the helicopter bus will take over all the 750,000 B E A passengers per annum who can save time by using it, and Mr MASEFIELD will be the Chief Executive of British European Rotorways

The next three questions are inter-related They are concerned with the projected vehicle and its mode of operation and ask, what size, what speed, and what stage length ? In each case we get some answer if we plot the cost per seat-mile over the problematical magnitude and discover the size, speed and stage length which correspond to minimum cost This minimum cost criterion is not altogether decisive and its observance does not guarantee optimum results from the operating organisation Other factors intervene which can be loosely termed optimum sales value They are not nearly so amenable to an arithmetic study and we shall consider them in broad terms Taking sales value into consideration large size is an evil and fast speed is at first indispensable, then attractive, but finally of indifferent value

Size is evil for two reasons First, the larger the size the lower the frequency of operation with an acceptable load factor Second, the frequency can become so low when serving lines of a low traffic potential that no operations can be carried out at all Hence large size limits the network and prevents large and important populations from partaking in the benefits of helicopter communications Where a large traffic potential exists, large size has the operational advantage of simplifying traffic control by reducing the frequency of operation, but one of the objects of the helicopter is to make traffic control a less decisive consideration

High speed is indispensable until we reach a speed which makes regular and punctual schedule of operations possible It seems that this point is around 130 m p h at maximum continuous power, equivalent to a normally scheduled ground speed of about 120 m p h

Beyond this speed, additional gains may be saleable in the sense that enough people will be prepared to pay more in exchange for saving time I have always felt, however, that the calculations which relate the increased fare to the time saved are somewhat academic A large number of human factors are at play to form the statistical average of the readiness to pay for a saving of time A number of travellers have too much time and do not mind their leisure being occupied by a pleasant and comfortable journey, often in exclusive surroundings (Golden Arrow) or passing memorable scenery An important factor which affects the value of time-saving is its relation to the daily rhythm, hence the importance of daily time tables, hotel costs and other factors

The value of time does not remain constant as the speed increases , not only are the returns diminishing but a point is reached beyond which time saved has no value at all This point depends on the cost, after the inversion point only a *lower* fare can justify *faster* travel

The duration of a journey is unimportant so long as it is an insignificant fraction of the time spent by the average traveller at his destination This time depends on the cost of the journey I guess that the average traveller from London spends about a day in Birmingham If the duration of the journey is reduced below half an hour very few will care whether it is 20 minutes or 10 minutes However, if the fare is reduced to half its present level many travellers will go to Birmingham for half a day and will appreciate a reduction of the journey from half an hour to fifteen minutes I guess that at present the inversion point is reached at a speed of travel of 150 m p h A further increase in speed can be justified only by lower costs

Thus we conclude that the size of vehicle to be chosen is the smallest size at which the cost curve has flattened out The speed to be selected must be above 130 m p h , a speed beyond 150 m p h can only be justified by lower cost

We can now turn to the cost curves given in the paper I have to compare the cost plotted over size with a curve which I showed some years ago in the helicopter discussion in 1948 This curve shows a flattening out at about 30 passengers I should like to know from the lecturer what has happened since then to have produced the relation quoted by him which does not flatten out until a 60-seater is reached

Similarly I refer to a graph of mine which shows the cost plotted over cruising speed and has a minimum around 110 m p h and am somewhat puzzled by the results in the present paper

Finally, I think that, whilst the optimum stage distance for a helicopter will always be between 100 and 200 miles the cross-over point with the unit costs of a fixed-wing aeroplane will be found at much longer stage distances It seems that in order to increase the economic radius of action of the helicopter the retention of the piston engine would have to be thoroughly studied

Assuming that at this stage the decision about the precise size on purely arithmetical evidence will remain suspect I think we can profit from a comparison The overland bus has stabilised around 30 to 40 seats I believe that this is not an accidental pnenomenon but is due to the over-riding role of the cost of skilled human labour In both cases 30 passengers is the number at which the cost of the crew becomes a small fraction of the total At the same time 30 passengers is a number which allows a reasonable combination of frequency and load factor These broad human trends will always remain more important than the relatively small differences between various conceptions of the helicopter vehicle and its operation On the strength of this knowledge I insisted on the coming of the 30-40-seater when the current fashion was founded on the 10-12-seater helicopter and I see no reason to depart from my views when the fashion begins to swing towards the 100-seater

On the subject of speed I believe that some of the consequences of high speeds should cool our desires At 150 m p h is becomes necessary to introduce super streamlining, retraction, perhaps even high altitude operation and its attendant difficulties No doubt there will eventually be room for a vehicle taking-off and landing like a helicopter but cruising at 250 m p h or above Such a vehicle will have its own range where it beats all other competitors, but this will not be the range of the helicopter, cruising at 150 m p h It is, I think, fruitless to attempt a universal vehicle The range of any economical flying machine should be measured in terms of a multiple of the lowest limit of that range A range extending over four or five times its lowest limit is sufficient Since short haul transport embraces such an enormous traffic potential there is room for much greater specialisation in the short haul field than there is in the long haul field where the value of specialisation has already been recognised Flying machines depend for their economic strength on proper co-ordination of their properties with the task which they are called upon to perform in commercial operations Such co-ordination demands a correct degree of specialisation

I should like to add some remarks on isolated points of interest raised in the discussion and which refer mainly to certain details of the B E A Specification In one respect I believe this specification is not strict enough I hold certain views on take-off and landing procedures which I shall not discuss in detail except to say that they would lead to the following requirements First, the failure of one engine at any point during take-off or landing should always leave room for a safe emergency landing in vertical descent in the hands of a pilot of average skill This requirement leads to three engines or more Further I believe that a helicopter should be able to climb and descend vertically facing in any direction irrespective of the wind It should be possible to hold a helicopter in any such direction without any undue fatigue or instability This would dispense with the square, L- or T-shaped operating sites

Sitting down on unprepared sites in bad visibility in order to await their turn for entering the city site is not a practical proposition for helicopters But I cannot see why there should not be a second *prepared* site for this purpose Fuel allowance which includes 45 minutes of waiting time at the terminal is excessive and in a large urban area, where I visualise several small rotorstations, it is not a great sacrifice to provide something like a large field outside the city suitably equipped where incoming helicopters can sit and wait their turn As regards other site facilities my conclusion is that parking and servicing must be excluded altogether but refuelling cannot be The short duration of stopping, which should not exceed a scheduled interval of a few minutes, means that refuelling arrangements must be of a specialised type capable of maintaining such schedules

Another example of the lessons which constructors should learn from the operator is the avoidance of pneumatic auxiliaries I believe that there is a lot to be said in favour of pneumatics and they certainly are coming back into fashion in the United States However, pneumatics are not a practical proposition at this stage More generally if a machine is in some way novel it should contain as few subsidiary experimental elements as possible On the other hand, the provision of the specification which demands that only one type of grease and only one type of oil shall be used I would describe from my experience as bad engineering rather akin to applying the business principles of a large bargain store to a Bond Street shop

As a matter of historical interest, I think it should not be left unsaid that the second helicopter in the world to fly successfully under full control and for periods limited only by its fuel capacity was a British machine designed and built by the Weir group in Scotland These flights of two successful prototypes took place in 1938 and 1939 The machines so developed were no less original that the Focke or Sikorsky prototypes but evidently much less publicised

Mr P G Masefield (*in reply*) The first comment I should make is that all the contributors to the discussion are, gratifyingly, agreed on the major points that the helicopter has a future in commercial short-haul operations From that foundation of agreement the contributors differ only on the detail of the common objective of how to obtain the best results quickest Indeed, this discussion shows that informed opinion is already agreed that the helicopter is the best foreseeable solution—at any rate for the next 20 to 30 years—to the problem of fast transport on distances of less than about 300 miles The helicopter provides, in fact, the only solution to short-haul journey speeds in tune with those which will soon become universal over longer distances

We are therefore agreed on our objective Let us then not delay in tackling the many major problems which always beset a new conception We must see to it that this country plays a worthy part in the transport helicopter developments which can lie not far ahead

The major points raised in the discussion may be summarised under a number of headings I have accordingly grouped my comments under the subjects rather than replying to individuals one by one

Size As I made clear in the lecture, I am convinced that a reasonably large passenger capacity will be essential to achieve an acceptable cost per seat-mile in a transport helicopter I have suggested that something of at least 48-64 passenger capacity on stages up to 250 miles is necessary More precise figures should be established as soon as evaluation of the Design Studies to the B E A Large Helicopter Specification have been completed An interesting point is that all the Design Studies submitted are of 35 seats or more (going up to 82 seats) and that preliminary analysis shows that the largest is potentially the cheapest

In any case, what is beyond dispute is the fundamental that—within the limits of what is technically practical at any given time—larger size will give improved economy provided the speed is adequate, the handling characteristics are up to the job and the mechanical reliability is satisfactory

The basic reason for this is, of course, that certain costs—such as crew and handling—are spread over a larger revenue potential in the larger sizes In addition, a smaller proportion of the weight of certain essential items—such as radio—does not vary with increased size

Mr Scott Hall quotes the Do X as an example of an expensive failure caused by too large a size The Do X was not a commercial proposition because its speed, range, handling characteristics and mechanical reliability were not adequate for the job of scheduled long-haul transport Had this flying boat not been deficient in these vital respects, its size would probably have been acceptable and scheduled operations across the Atlantic might have been achieved ten years earlier than in fact they were

I agree that we must avoid repeating such a mistake and must not commit ourselves to a size which is technically out of reach On the other hand, a point of equal importance is that we should not be content with a capacity too low for economy just because we refuse to face the arguments of economics and are too timid to tackle the technical problems

Mr Scott-Hall thinks that the helicopter capacities advocated in the lecture are too large for a practical shaft-drive solution, or indeed, for any acceptable answer before 1960 I do not agree The Sikorsky S 56 and Piasecki H-16 twin-engine shaft-drive prototypes—both of which are of the order of size required—are scheduled to fly in the United States *this year* and the Americans are unlikely to take seven years to develop these aircraft into practical vehicles

Mr Shapiro, like Mr Hafner in the spoken discussion, goes even further than most of the other advocates of caution in size and doubts the validity of the economic arguments for large aircraft at all He even goes so far as to affirm that there is something magic about a capacity of 30-40 passengers simply because that has emerged as a practical size for certain types of road vehicle I cannot help remarking how similar are these arguments to those advanced in the 1920s about the most economic size for a transport aeroplane The same reasons were given then for small capacity solely because the dictates of economics were submerged by doubts about the technical possibilities of the future

The truth of the matter is that most, if not all, the fundamental factors which make a large fixed-wing transport more economic than a small one also apply to the helicopter—always provided the larger size is technically within reach of the particular stage of development and that other desirable qualities, like speed and handling characteristics, are not sacrificed

Speed I am no less certain of the requirement for a reasonable cruising speed than I am for large size I again disagree with Mr SHAPIRO in his argument that 120 m p h is sufficient for regularity and punctuality on short-hauls My figure of 160 m p h is a much more satisfactory target and I would favour an even higher speed if I thought it was achievable, with a reasonable level of vibration and operating economy, within the period we are considering Even 160 m p h , however, provides a worthwhile improvement compared with 120 m p h Thus, on the London-Paris route, wind variations commonly experienced would cause the block time of a 120 m p h helicopter to fluctuate by about an hour Increasing the speed to 160 m p h halves this time variation, while a cruising speed of 250 m p h reduces it to only about ten minutes This is a vital factor in running high frequency scheduled services quite apart from the competitive and other advantages of the shorter journey

Although each of the three Design Studies to the B E A Specification which incorporates shaft-drive promises a cruising speed of about 200 m p h , I may, perhaps, have been unduly optimistic in assuming a commercial speed of 160 m p h If so, we shall have to make do with such speed as comes out in the wash Whatever it proves to be, the higher it is the more attractive the helicopter will be as a commercial vehicle In forecasting speeds, we are obviously on less certain ground than we are when we consider size Large helicopters are well on the way in the United States Fast helicopters, on the other hand, are dependent on the development of various theoretical techniques and devices which still have to be proved The sooner we tackle these problems, the sooner we shall be able to say whether my suggested target of 160 m p h is in fact possible with acceptable levels of vibration and economy Nor must we forget that safe and reliable operation into small areas in city centres is essential and must not be handicapped by any design features which raise the speed

Cost I have already said that specific operating cost is partly an inverse function of size and for this reason we must have large transport helicopters Mr ROWE suggests that I have related my target cost levels to the Pionair DC-3 which, because it is a much developed aircraft, provides an artificially low level at which to aim with a new type of vehicle In fact, in the lecture I considered the absolute costs levels which appeared to be feasible with a future transport helicopter in relation to those of present and projected types I then compared these costs with those of surface transport and of contemporary fixed-wing aircraft The result of this comparison was not very flattering to the helicopter on any stage length of more than about 100 miles That is to say, on the figures used, the helicopter was shown to require substantially higher fares than the aeroplane on all stages of more than 100 miles The point at issue is not whether the helicopter compares in operating cost with the DC-3 but whether it can be brought to an acceptable commercial fare and yet break-even

On sectors of less than 100 miles, where the aeroplane ceases to be a serious commercial vehicle, the helicopter does indeed promise somewhat lower fares than its fixed-wing counterpart but, even so, they are still more than double the First-Class surface fare This means that, on my estimates, a helicopter of even the size of the ' BEAline Bus " will have to charge very heavily indeed for the time-savings it can offer its customers

In the lecture I have assumed that traffic will be attracted at the fares I have estimated Such an assumption is, of course, in the realm of conjecture but an interesting point is that the traffic and fare forecasts in the Port of New York Authority's recent Report, " Transportation by Helicopter, 1955-1975," provides close confirmation of the figures I presented We may expect, therefore, that the helicopter will be likely to attract sufficient business at the fares I have suggested to sustain a steady and healthy expansion until further development of the vehicle improves its economy still further and lowers the fares to a fully competitive level

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The point which must be made clear is that I have not, as Mr ROWE implies, set an economic target which is unreasonably low On the contrary, my target cost is just about the highest which can be tolerated commercially for any sort of scheduled passenger operation

Fuel Reserves seem always to be a subject of controversy in any discussion about scheduled helicopter operations Everybody who thinks about this problem feels instinctively that there is something wrong when one has to carry round large quantities of fuel which are seldom used in a vehicle whose economics are dependent on every pound of weight which can be saved

Economically undesirable as fuel reserves are—for the aeroplane as well as the helicopter—they are, I am afraid, an operational necessity which is likely to be with all forms of air transport for a very long time The fact that the transport helicopter will not require a runway for landing and may be able to hover motionless at a fixed height will not make a great deal of difference (Actually hovering is not likely to be a practical holding manoeuvre because of the higher fuel consumption which would result)

Mr SHAPIRO advances the usual suggestion which is made to avoid carrying reserve fuel This is that the helicopter should sit down at an alighting point outside the built-up area and wait its turn to go into the city there instead of holding in the air The obvious objection to such a procedure is that there will come a time when you will have to hold in the air while waiting your turn to get down at the " ground holding point " ! In other words fuel reserves are a necessity for any aircraft to get out of the air safely and reliably in low visibilities—particularly at night—wherever the landing point is situated If the traffic density is low in relation to the number of available alighting points in a given area then fuel reserves can certainly be reduced, but they are not likely to be cut in I F R conditions much below the 45 minutes B E A has asked for in the Large Helicopter Specification The objection to having larger numbers of alternative alighting points in a given traffic area than are required as normal traffic stops is that they will be extremely costly A rotorstation for all-weather day and night operation will require similar radio aids and an important part of the lighting found at airports To suggest that a large helicopter can put down just anywhere in safety in poor visibility or at night is fallacious

The result of all this will be that to reduce the cost of these ground installations and to meet the requirements of satisfactory Air Traffic Control routeing once helicopter traffic begins to get fairly heavy, fuel reserves will be required as they are to-day with fixed-wing aircraft We shall be wise to face this fact right from the start

Such are a few comments on the major points raised in the discussion I am grateful for the kindly thoughts expressed in the contributions which, as I have already remarked, vary only in their approach to the same objective, the economic commercial transport helicopter of the future

The Design Studies now submitted to the B E A Requirement will, I am sure, advance our thinking materially on the subject I am much encouraged from a preliminary review of them The next stage must now be tackled with judgment, vigour and courage Either we go forward with determination or we must resign the lead to the U S A " Get on or get out " There can be no compromise

OBITUARY

Members will regret to hear of the death on February 2nd, 1953, of MR JUAN DE LA CIERVA, JR, son of the Autogiro Pioneer MR JUAN DE LA CIERVA was an Honorary Member of our Association