Military Aspects of the Transport Helicopter*

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(ABRIDGED)

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N J G HILL, A M I MECH E, A R AE S, *in the Chair*

INTRODUCTION BY THE CHAIRMAN

For the second occasion during the 1951/52 session of lectures, this Association has been honoured by the presence of an eminent member of the United States aircraft industry, since this evening we have Mr FRANK PIASECKI as our lecturer

You all know Mr PIASECKI very well by name In 1940 he founded an engineering group known as the P V Engineering Forum This later became the Piasecki Helicopter Corporation, and today he is Chairman of the Board of Directors In 1943 the first single rotor helicopter designed by that small band of people emerged, it was the PV2, and was flown successfully by Mr PIASECKI himself Quick to appreciate the military possibilities of a helicopter capable of carrying a large load and with ample cabin space, he initiated and led the development of the big PV-3 tandem-rotor helicopter, and the United States Navy, recognising the merits of the design, awarded a contract for the supply of a quantity of machines of this type

In but thirteen months after the award of the contract the first machine of the type took to the air, with Mr PIASECKI at the controls This created a record and was in fact a considerable feat, being the world's first transport type of helicopter and the first tandem-rotor machine to fly successfully Some seven or eight different configurations of Piasecki helicopters are now flying with the United States forces, and two new models have recently been added to the range, namely, the XH-16 and YH-21

I understand that the plant which is headed by Mr PIASECKI now totals a staff of some 2,800 He is a young man, only 31 years of age, and his career is typical of what can happen in that great industry in the United States where ability and initiative such as he possesses are so quickly recognised

*ACKNOWLEDGMENT Thanks are due to The Aeroplane and Air Pictorial for the use of illustrations

Amongst his other accomplishments, Mr PIASECKI is a Past President of the American Helicopter Society, he is Chairman of the Helicopter Council of the Aircraft Industries Association in America, and he has a place on many United States Government Advisory Panels He is a member of the Institute of Aeronautical Sciences, a member of the Society of Automotive Engineers, and we, the Helicopter Association of Great Britain, are privileged to name him amongst our membership

I introduce to you Mr PIASECKI, and invite him to present to us his paper, which is full of interest

MR F N PIASECKI

Thank you, Mr Chairman It is a great honour to be invited to speak to you in this respected hall I see recorded around us here the names of engineers who have created revolutions in their day , perhaps our industry will create something of a revolution, as indeed we hope it will

I have chosen the title of the paper, " Military Aspects of the Transport Helicopter," because I think this is the first era wherein the helicopter will play a really significant part in helping man to achieve some of his goals

INTRODUCTION

Dynamic changes have occurred in the emphasis placed upon the helicopter as a military tool Experiences in the Korean War have proven and confirmed under combat conditions concepts of helicopter operations which were but projected theories heretofore Although the number of helicopters utilized was but a handful, their service was so vital and so dramatic, that everyone from the G I 's to the Generals was equally impressed This feeling can be best summarized by a statement of the Commanding General of the Pacific Fleet Marine Force, Lt -General Lemuel C Shepherd, Jr , who pointed out that " with more helicopters available, the military uses of this unusual weapon are almost unlimited," and although this was the " first time they have been in actual combat, their extreme value as a military weapon is established beyond dispute Moreover, the usefulness of the helicopter is not by any means confined to a situation such as encountered in Korea "

In fact, the impact of the transport helicopter is so tremendous that it is responsible in large part for the development of a potent new concept of military tactics—the principle of vertical envelopment This concept projects a third dimension into the employment of ground forces by which large numbers of troops and their equipment, operating from carriers on land bases, would throw their decisive weight onto the enemy from the air Both the Marine Corps and the Army of the United States have adopted this concept and are procuring transport helicopters in sizeable quantities to implement this new tactic

At this time when newspapers headline the helicopter's myriad activities, it is of importance to evaluate whether this is just a spectacular and singular " show " that has attracted the public eye, because of its newness, or whether its true value is proportionate to the publicity received The answer to

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this evaluation is of real importance to military planners today and is worthy of review at this timely moment In view of the extended front that must be defended and the stretched supply lines leading to them in this period of a perimeter war, this subject is of especial interest to those forming the new armies of the United Nations

The objectives of this paper are to enumerate some of the helicopter's applications and experiences in military operations, to explore the future potential to be derived from improved performances of the helicopter, and to indicate what the use of this vehicle costs in terms of money and manpower

Although the small helicopter has been active in military service for eight years, it has been but recently that the larger transport type of helicopter has been in military use The discussion following is limited to this larger transport type of helicopter since the applications of the smaller size machines are already familiar and are almost limitless in military operations For, as one report stated, the helicopter " is becoming even more necessary to military commanders that the jeep " Since the heavier weight-carrying machines extend the application of the helicopter to new and larger tasks, this paper devotes its attention to the new *transport* class of helicopters

Applications of the Transport Helicopter

It is beyond the capacity of this paper to discuss all of the varied applications of the transport helicopter in military operations, but some typical illustrations will be given to point out where the small helicopter has been applied effectively and where larger sized helicopters could do an even greater job Also, we will consider applications beyond the scope of the small helicopter and unique to the transport helicopter

The functions of the helicopter in military operations have been classified into four general divisions of effort initial establishment and construction , deployment and supply , defence , and attack

(a) initial establishment and construction

The job of setting up military facilities where large masses of material must be moved over unprepared land Use of helicopters can eliminate dependence upon prepared port facilities for water-to-land transfer of material The removal of such concentration points in supply systems is of even more importance when the possibilities of an atomic attack are considered The helicopter also can eliminate the delivery of material into a central depot thence to be re-transferred to an area of demand

Construction Work

The helicopter can offer tremendous savings of time and labour in construction work Such jobs as erecting towers, bridge-sections, prefabricated housing, camouflage materials, handling dam construction materials, etc , present the most difficult problem of obtaining a hoist lift—a problem which is readily solved by the helicopter This area of helicopter employment has seen little actual application, since the amount of minimum lift required for such operations is usually in terms of one or two tons, and such machines have not been available in the past However, by reducing

the load into components, it is possible to transfer large quantities speedily by multiple trips

Near Vancouver, for the first time in the world, all of the materials, equipment and supplies needed in the building of a dam were flown in by helicopter The dam site was 3,000 feet above sea level , the distance from the loading base was five miles , and the landing spot, only 15 feet square, was blasted out of rock Although the small type helicopter used was in most respects quite unsuited for this application, approximately 400,000 lbs were flown in, taking over 1,000 trips—each of 12 to 15 minutes duration In a single day, as many as 40 trips were made and as many as 10 hours flown Future transport helicopters of the Piasecki H-21 size could do this job in 100 trips

Development of New Areas

In the development of new areas, the helicopter can replace other equipment or methods of transportation more economically and in many instances make possible projects which would otherwise be prohibitive because of the initial cost of other types of transportation facilities Therefore, when making a cost comparison of helicopter transportation with that of other means, the cost of the roads, bridges, tracks, docks, channels, runways, etc , required by other means of transporttaion, should be taken into consideration In the development of new territories such as exist in Canada, Australia, and other members of the British Commonwealth of Nations, the saving of time, manpower and money in initial establishment of operations can be great But even still greater can be the reduction of the huge capital outlays and the time required for construction of the supporting facilities of other transport media Critical ores, chemicals, etc , necessary to support military production can be found, collected and delivered by helicopter transport in times of emergency, such as the last war's dire need of South America's mica and rubber

Mapping, Surveying, and Geophysical Work

The helicopter has facilitated and reduced the cost of geodetic survey operations by delivering personnel and equipment to isolated positions and performing varied tasks in the surveying process Not only has the helicopter resulted in the saving of considerable time and money by replacing other means of transportation, but it has made possible survey operations in Alaska during seasons when they could not have been accomplished using any other means of transport

With larger helicopters, entire survey parties with all their supplies and equipment can be transported to new bases in any season

Communications Facilities

Although fixed wing aircraft have been used for wire-laying to a limited extent, the helicopter is ideally suited for precision applications of communications media Helicopters have already established themselves as being an economical means of inspecting transmission lines, and of transporting personnel and equipment to out-of-the-way locations for setting up,

maintaining, and supplying remote radio, radar, television and power transmission stations

Laying of Pipe Line

Late in the last war, successful trials were made in laying pipeline in otherwise difficult terrain Using the smaller helicopter of that period, it was necessary to carry the equipment for pumping stations in sub-assemblies With the use of larger types, entire sections of pipe line can be laid in one assembly, and pumping stations similarly can be established and supplied

(B) DEVELOPMENT AND SUPPLY

Helicopter supply operations can start from the very source and deliver directly to the points of utilization This saves the lost time of trans-shipments where combinations of other transports are used The amount of supplies necessary to maintain the " pipe line " can thus be reduced, and the overhead and delays of transfer operations from dock to rail, rail to truck, truck to jeep, can be eliminated Also, throughout these considerations, we must remember that surface supply lines are always attractive and vulnerable targets The helicopter on the other hand, requires no " right of way "

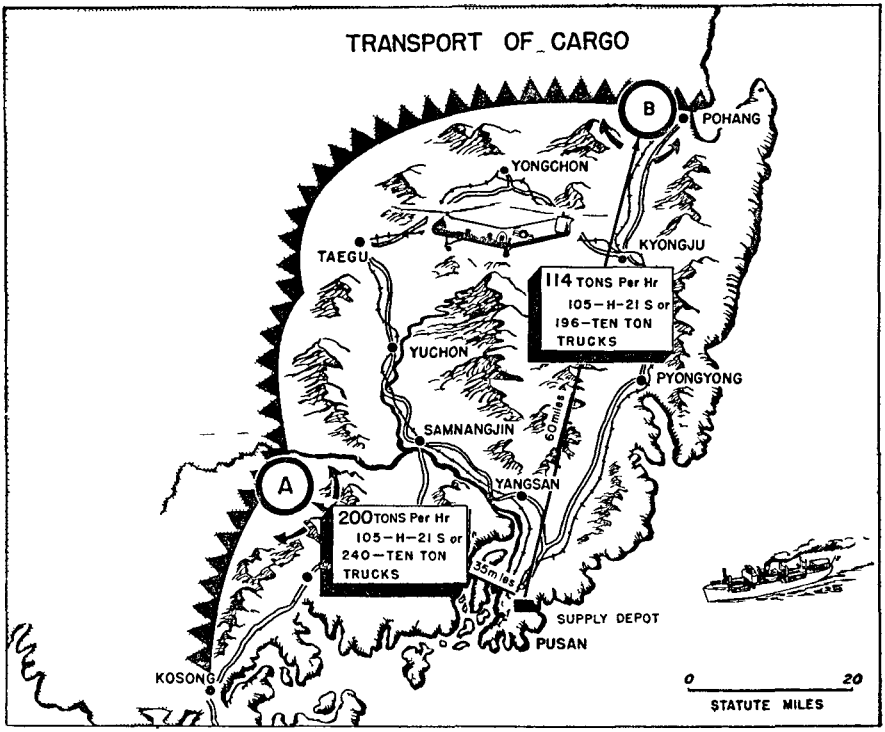
In Fig 1 is presented a graphical representation of the capabilities of the Piasecki H-21 helicopter in cargo transport operations

This concept of direct supply lines can be made even more efficient when a system of pre-packed standard containers is employed This would allow the direct shipment of material in ready-to-use assemblies directly from the manufacturer's plant , from plant to local airport by helicopter , from there to the general area of operations by cargo aeroplane , and then by re-attachment to a transport helicopter for delivery to its final destination It is obvious that the time saved by such systems could be tremendous Where the quantities or distances are too great for air transport, the containers upon arrival at the overseas port, can be re-transferred from ships by helicopter for direct supply to the area of demand Fig 2 illustrates the Fairchild XC-120 " pack " plane transferring its pack or pod to the Piasecki XH-16 at an advanced base

The helicopter's capabilities in military transportation and supply are so great and so clearly evident that the United States Army is forming Helicopter Transport Units as a basic organ of its Transportation Corps The helicopters currently being procured will be as organic to the Army's transportation system as are trucks Fig 3 shows the relationship of the helicopters currently in production (or under development in the case of the XH-16) at Piasecki Helicopter Corporation, to the familiar Army trucks

Land and Sea Rescue

The most publicized applications of the helicopter have been its rescue operations News reports in recent years have brought to public attention the saving of literally hundreds of lives by rescues of personnel from aircraft forced down in inaccessible areas, by removing persons from ice floes, flooded areas, sinking ships, and other dangers, and by speedy transfer of medical cases from ships at sea directly to hospitals



By courtesy of The Aeroplane

Fig 1

PIASECKI H-21 HELICOPTERS IN CARGO TRANSPORT OPERATIONS

The sketch above represents a tactical situation where H-21's could maintain a steady flow of supplies to front line units Not being restricted by terrain, rivers, etc, this form of transportation would have a flexibility of operation extremely desirable in order to keep rapidly moving front units supplied

The above sketch shows the helicopters operating from a depot being supplied by shipping This could be a railhead or an airhead to continue airlift directly to front lines Or, the helicopters could operate from beach supply dumps maintained by DUKWs from offshore shipping A further development of this would be the operation of the helicopters directly from the supply ships—eliminating need for DUKWs

The study above represents " spot task " type operation For normal operations with 75% availability and increased loading and servicing times, approximately 1,650 tons could be transported to point B in 24 hours, 69 tons to B in 1 hour and 134 tons per hour to point A

High density loads such as ammunition, small arms, etc, could be transported by suspending beneath the helicopter in a cargo type net Small field pieces and vehicles such as howitzers, rocket launchers, jeeps and trailers could be transported completely assembled and ready for immediate use by slinging beneath the fuselage Troops and low density equipment would be transported in the cabin

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Navy aircraft carriers use the helicopter on a constant stand-by basis to rescue crewmen from the ocean after landing or take-off accidents, performing this operation much more speedily, efficiently, and economically that the destroyers which previously performed this vital function, but which the helicopter has now replaced Moreover, the far more costly destroyer, with its crew of several hundred trained men, can be used in the tactical duties for which it was built

Most of the above operations have been conducted with small helicopters, picking up one or two casualties at a time The transport helicopter will allow the rescue of entire bomber or patrol crews at one time, over longer ranges, and higher altitudes The H-21 helicopter is designed to meet such requirements of the U S Air Force Air Rescue Service Retrieving of personnel from one-and-one-half way missions can thus be assured

Arctic Rescue

The greatest need for extensive and effective rescue systems using transport helicopters is that requisite to arctic operations, where victims can withstand exposure only for minimum periods The long range aerial operations envisaged in global and trans-polar strategies generally involve aircraft manned by fairly large crews With respect to rescue or evacuation of portions of the crew, removing the whole crew in several trips would result in the probable loss of those not immediately retrieved It is, therefore, obvious that helicopters capable of rescuing the entire crew in one evacuation are required It is clearly evident that the ranges, the length of search required in rugged arctic territories, and the necessity to remove numbers of personnel at the earliest opportunity, combine to make transport helicopters requisite for arctic operations

Evacuation of Wounded

If we had to find one use for the helicopter which would alone pay for itself in military operations, a most satisfactory compensation would be in the evacuation of wounded from forward areas Over 5,000 men owe their lives to helicopter evacuation in Korea Crashed and injured pilots have been rescued by helicopter from as far as 125 miles behind enemy lines ! Blood transfusions have been performed in the helicopters while in flight

Fig 2 Pack transfer from Airplane to Helicopter

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And many of these lives have been saved not only by the speed and directness of helicopter evacuation, but also by the necessary comfort of helicopter transportation when severe wounds could not survive the rigors of a long and jolting surface ride over rugged terrain

PIASECKI TANDEM HELICOPTERS

MODEL HELI TON MI / HR @ CRUISE SPEED COMPARABLE ARMY VEHICLE IN TON MILE CAPACITY @ 15 MPH	*HUP 1* 60 4 TON TRUCK	*H-21 (PRESENT)* 180 12 TON TRUCK	*H 21 (FUTURE)* 240 16 TON TRUCK	*XH 16* 500 33 TON RUC
WEIGHT EMPTY	3840 lbs	7450 lbs	7850 lbs	22 600 lbs
USEFUL LOAD	1900 lbs	4020 lbs	5340 lbs	11380 lbs
PAYLOAD TROOPS (225 LBS. EA)	6 troops	15 troops	20 troops	40 troops
CARGO	1425 lbs	3400 lbs	4600 lbs	10000 lbs
CABIN SIZE	158 Cu Ft	610 Cu Ft	610 Cu Ft	CABIN 2100 C Ft CAPSULE 1390 C Ft
FUSELAGE SIZE	LENGTH 32 0 WIDTH 6 10	LENGTH 52 6 WIDTH 14 6	LENGTH 52 6 WIDTH 14 6	LENGTH 77 7 WIDTH 25 3
SPEED-CRUISE	84 mph	106 mph	104 mph	100 mph
RANGE	100 mi	100 mi	100 mi	100 mi

Fig 3 *By courtesy of The Aeroplane*

Medical Service and Decontamination

The Piasecki XH-16 pod-carrying helicopter will permit the rapid carriage of fully equipped surgical stations close to the line of battle The economy of transporting the stations in this manner is great in both time and equipment , but, moreover, the saving of lives is incalculable in terms of money

As so effectively demonstrated by British agricultural spraying by helicopter, the helicopter makes possible the spraying of malarial and other infested areas before occupation by troops, with more complete coverage than by other methods Perhaps it could fill needs in the decontamination procedures of germ warfare

Salvage

Salvaging either the downed aircraft or its undamaged components is of importance when all possible use must be made of replacement parts available in the theatre of operations

Communications

Studies have been made of the use of helicopters to act as relaying stations to extend the range of television transmitters The helicopter has been used both by the military and commercially in radar calibration work, television tower site selection, and other operations where a fixed point in space is desired The large helicopter can act as a relaying station in radar

operations or in television operations It can also be utilized by the fleet or by individual ships in extending the distance of their radar coverage

(C) DEFENCE

Anti-Submarine Warfare

Where the defence job involves a patrol or a searching operation, and requires detailed examination of the surface or under-surface conditions, the helicopter provides an ideal medium for such a mission It is particularly suitable in Naval activities such as anti-submarine warfare or mine clearing It is also an ideal transport vehicle for evacuating civilian populations in the event of large scale destruction of a city, where surface transport is destroyed or contaminated

Use of the helicopter as an aerial platform from which submarines can be searched for and attacked has been the subject of tests by the United States Navy near Key West and has resulted in a large portion of Piasecki Helicopter Corporation's current helicopter production We are particularly proud of the fact that our HUP-2 helicopter (Fig 4) has been selected as the standard anti-submarine helicopter for current usage

Mine Sweeping

The use of ship-based helicopters for spotting and destroying floating and fixed mines, as well as general harbour purposes, is a new use discovered through Korean experience

Land mine-fields can be traversed and opened by the use of helicopters equipped with devices for towing across the ground

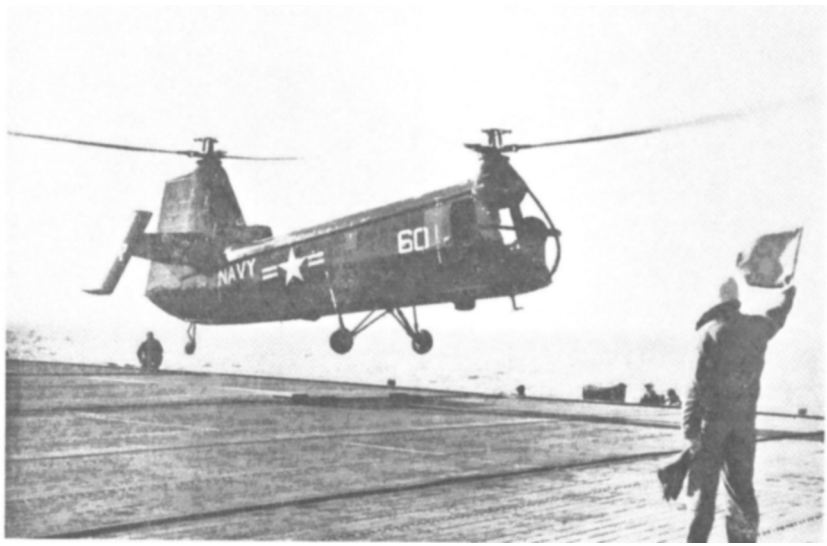

Fig 4 U S Navy HUP—1 Utility Helicopter
Piasecki Helicopter Corp

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Atomic Emergency

In the event atomic bombs were to be dropped on critical and populous industrial and military centres, the resulting destruction is difficult to comprehend Physical devastation combined with radioactivity would make these areas practically impenetrable to ordinary means of transportation The helicopter is the only vehicle which could function as a transport under such circumstances The basic flight characteristics of the helicopter should prove invaluable in decontamination work, and for the transfer of medical supplies, food, equipment and personnel In the Eniwetok atom bomb tests, the helicopter was used to remove photographic equipment from the contaminated atoll, and to transport inspecting personnel over the contiminated areas, proving the feasibility of this type of operation

(D) ATTACK

The attack functions of the helicopter may be broadly divided into carrying assault troops and weapons directly to the scene of attack , rapid redeployment of troops as the course of battle may require , and directly attacking tanks or emplacements with rockets and other weapons

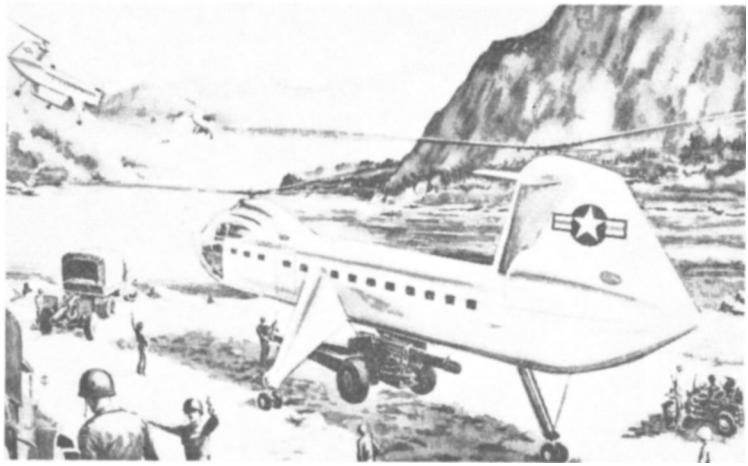

Fig 5 *By courtesy of The Aeroplane*

Assault Transport

The helicopter's unique ability to land forces at strategic points behind enemy lines and to bring up troops and supplies to exploit a break-through or reinforce a threatened sector offer a new degree of military mobility that has resulted in recent military demands for greatly increased helicopter production in the United States

Specially Trained Troops not needed

General Lee, Commanding General of the U S A F Technical Air Command (Ref 12), has said " The parachuting of troops and equipment onto an assault area is an expensive method of aerial delivery Specialized troops, equipment, and aircraft are required, and only the Army's highly

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trained airborne divisions are capable of doing the job A suitable assault helicopter could make all standard infantry divisions capable of being air lifted into a forward airhead where there are no prepared runways The requirements for extensive parachute training facilities, highly qualified volunteers, and specially fitted aircraft could be deleted"

Pick Your Landing Spot

The U S Marine Corps pioneered the use of transport helicopters in assault operations and the U S Air Force and Army are procuring transport helicopters in sizeable quantities for such use (Fig 5) No longer is the

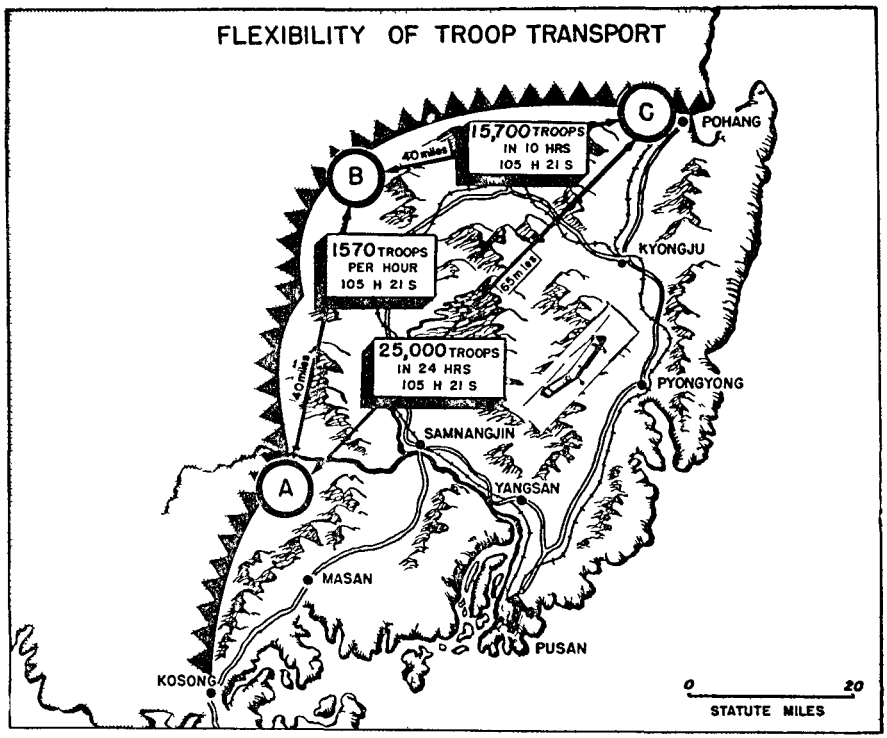

Fig 6 *By courtesy of The Aeroplane*

PIASECKI H-21 HELICOPTERS IN TROOP TRANSPORT OPERATIONS

The drawing above represents a situation where transport companies equipped with H-21's could make front line tactical forces extremely mobile Entire infantry regiments or a division could be transported laterally or longitudinally a distance of 100 miles in a matter of hours In areas of few or no roads, in jungles or in the arctic this mobility and flexibility could be of high tactical value In such operations, the same helicopter companies could maintain a supply line from supply depots and evacuate wounded on the shuttle trips Helicopter air lanes do not invite density of movement problems encountered in ground transportation nor are helicopter "air truck" routes affected by rivers or rugged terrain

The study above represents a "spot task' transport operation For normal operations with approximately 75% availability and increased loading and servicing times, approximately 940 troops per hour could be transported from point A to B and 9,400 troops from B to C in 10 hours and 15,750 troops in 24 hours from C to A

beach-head assault a " must " for an amphibious assault For, through use of the transport helicopter, the attacking force can choose a more defensible, inland landing area Moreover, the helicopter-borne troops and equipment land in fully organized fashion in predetermined spots, eliminating the " area " types of landing and the subsequent reorganization necessary in parachute, glider, and other types of assault landings

Fig 6 provides a graphical representation of the Piasecki H-21's capabilities in the transport of troops

The tremendous troop-mile capacity of transport helicopters is deservedly impressive But of even grater importance is the unique flexibility and mobility which the transport helicopter gives to ground forces Troops and equipment can be moved from one front to another , from centralized reserve pools to combat areas, and to other scenes of action—regardless of intervening terrain and without the need of prepared terminal facilities—with speeds and degree of surprise unprecendented heretofore A vital corollary of this flexibility and mobility is the substantial reduction in reserves and pipe-lines of troops and equipment that is afforded by the helicopter

All-Weather Flight

All-weather flight long has been a natural advantage of the helicopter, since it can reduce its speed and utilize any field for emergency landings However, this advantage could not be fully realized in the past since the machines had insufficient stability and, therefore, required considerable concentration by the pilot to fly the helicopter on blind flying instruments This was more easily done at higher speeds but was very difficult when these speeds went below 30 m p h A recent development by our company has been the successful utilization of an automatic pilot, allowing the helicopter to be flown throughout the flight range (including the hovering condition) with full stability This will now enable the pilot to give more attention to his tactical mission or navigational duties without the intense concentration upon the blind flying instruments that was previously required This development now opens to the helicopter areas of operation where 24-hour all-weather service is required

Relative Cost

(a) initial, operating and maintenance costs

Initial Cost

There is nothing fundamental about the construction of the helicopter that makes it particularly expensive when produced in reasonable quantities In fact, the helicopter lends itself more readily to quantity production than does the aeroplane, for two basic reasons (1) the helicopter does not require the fabrication of large sections of extremely thin materials distributed over large areas as is the case with the aeroplane wings and tail assemblies, entailing expensive large jigs, use of expensive plant floor area, and much hand work , and (2) most of the specialized helicopter components (*e g* , transmission and rotor head) are inherently of such nature that they are readily producible by economical machine manufacturing methods Such production economies, of course, can be achieved only over a reasonable volume of production This need not be mass production in terms of the volume of automobiles,

home appliances and other consumer goods, but need only be such volume as can be expected in the helicopter industry through a reasonably attainable level of military and commercial orders

A direct comparison between aeroplane and helicopter costs penalizes the helicopter, unless the costs of airport and airways facilities are taken into account It appears appropriate to give some indication of the relative investment required in helicopters as compared to fixed-wing aeroplanes in order that it may be clear to all concerned that the transport helicopter is not basically more expensive than an aeroplane of the same size Let us compare a ten-place helicopter at a price of a general order of magnitude of $120,000 to $150,000 with each of the fixed-wing transports currently in production in the United States

	Number of Passengers	*Price*	*Initial investment per passenger seat*
10 place helicopter	10	$ 120,000 to 150,000	$ 12,000 to 15,000
Convair 240	40	500,000	12,500
Douglas DC-6	60	900,000	15,000
Lockheed Cons	60	1,000,000	16,667
Boeing Strato	75	1,500,000	20,000

Thus it is readily apparent that the purchase cost of a transport helicopter per seat is certainly of the same order of magnitude as that of any transport aeroplane in production today

With the advent of large volume orders, the unit cost of the helicopter will be reduced by normal production efficiencies and perhaps even further by the application of high volume machine tooling

Operating and Maintenance Costs

The Helicopter Association of Great Britain is privileged to have among its membership outstanding experts on helicopter operating and maintenance costs I refer particularly to the personnel of British European Airways' Experimental Unit who have contributed so largely to the development of economic data on helicopter operations Accordingly, I shall not presume to discuss the subject at length Suffice it to say that perhaps the best American attestation to the fact that helicopter operating and maintenance costs are reasonably economical is the fact that the helicopters in the mail service of Los Angeles Airways perform their tasks at a lower ton-mile cost than any other feeder airline in the entire United States !

Elimination of Major Associated Costs

In comparing costs between aeroplanes, other media of transportation and the helicopter, again due consideration must be given to the fact that the helicopter does not entail the expenditures that are a basic requisite of any other form of transportation Transportation by surface motor vehicles

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involves the cost of highways, railroads must have large investment and expense in the construction and maintenance of trackage, and the conventional aeroplane requires the expensive investment and operating costs of airports The helicopter, on the other hand, requires less supporting facilities and indirect expenditure than does any other means of transportation Thus, any realistic comparison of the helicopter with other transportation media really should include all of the costs inherent to the other media, both direct and indirect

(B) BATTLE VULNERABILITY

There has been much speculation regarding the effects of gunfire and other weapons on the helicopter, in order to ascertain its vulnerability under battle conditions This, of course, only affects the military functions that bring the aircraft in close proximity to enemy positions, a situation which occurs in only a relatively small percentage of the total functions envisioned for this aircraft For these cases, the problem can be broken down into several issues

Areas of Vulnerability

The vulnerable sections of the helicopter are fairly comparable to an aeroplane's, with the addition of the transmission system and the rotor system However, unlike the aeroplane, the helicopter has these vulnerable points concentrated within its fuselage, and does not offer the large target of vulnerability represented in the fuel tanks, control linkages, and other vital areas encompassed by the aeroplane's wings The helicopter transmission, being small in area, can be protected against small calibre ammunition by suitable armour without excessive weight penalty The rotor hinge assembly and hub present a more difficult area to protect, but are composed of relatively small compact units, and vulnerability would be not unlike propeller hubs of aeroplanes The blade has little chance of protection and must rely upon its own structural design for resistance against gunfire It is hoped that it will be possible to provide constructions of varying resistance to gunfire

Rotor Exposure

It may be guestimated that there is an average chance of 5% for a critical hit on a helicopter rotor, assuming 100% aim and lead

Evasive Tactics and Cover

The helicopter can be manoeuvred rapidly about all axes even when flying at slow speeds However, this manoeuvring rate could not escape gunfire if in an open area, but if any terrain obstructions are available, then the manoeuvrability of the helicopter can be utilized in such a way as to receive cover from these obstructions Where the terrain is not flat, flying at extremely low altitudes (10 to 20 feet) minimizes the number of guns that can be brought to bear on the helicopter and, further, makes for an extremely high rate of change in an azimuth angle of hostile fire Indications from front line operations in Korea show a low degree of vulnerability of the helicopter to small arms fire

Several tests of the helicopter's vulnerability from air attack have been

conducted, and the subject demands a great deal more investigation However, as in all other offensive operations, control of the air is envisaged and so the threat from enemy aircraft must be calculated on the basis of other factors as well as the relative vulnerability of the fully-exposed helicopter

Conclusions

From the above discussion of transport helicopter applications, it is evident that the helicopter has the unique ability to perform certain functions that cannot be performed by any other means, such as evacuation from contaminated atomic areas For such work, the helicopter's value is infinite Therefore, it would be meaningless to compare the relative cost of such operations with other standard means of transportation even if the helicopter's costs, both initial and operating, were many times greater Yet, in most of these " monopoly " applications, a standard type of transport helicopter can be used and no special, single-duty, stand-by equipment need be an economic burden For the helicopter is basically a vehicle, and not a weapon or machine that is specialized functionally in its design

In the main, the helicopter's major value lies in performing routine missions with a large factor of increased efficiency over existing methods In the above discussion, specific cases have been illustrated where the increased efficiency was of such high magnitude as to over-shadow and reduce associated costs of existing procedures and to far out-weigh the additional cost of operating the helicopter

Sympathetic trials and testing will result in the application of the transport helicopter to many new military utilizations of real advantage With broader use, many of the unknowns and questions which are now the subject of speculation can be attacked and solved

What is even more important in these days of basic planning is realization of the impact of the combination of these various increases of efficiency upon the great technical, logistical and organizational complex embodied in modern military operations The cumulative effect of the reductions of time in transport and in transfer of military material and personnel in the large scale operations of our military establishments is beyond the scope of this paper However, the effect of higher transport efficiency on the movement of military material and personnel in a perimeter war operation, or in preparation therefor, can substantially reduce the overall size of standing armies and navies Consequently, these economies offer, to those nations who choose to be prepared against attack, timely help in counteracting the tremendous drain of resources that our enemies may have designed as a long-range economic weapon

The rapidly increasing load-carrying capacity of the helicopter, its ability to land at almost any spot, its hovering qualities and its reasonably rapid forward speed, give it a place that fixed-wing aircraft cannot fill It also has the ability to operate under conditions of low visibility at times when fixed-wing aircraft are grounded

The Transport Helicopter is ready for service !

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