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INTEGRATION OF THE HELICOPTER IN THE AIR TRANSPORT SYSTEM

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1. ABSTRACT

It doesn't exist, so far, worldwide, any long lasting successful example of integration of the helicopter into the general air transport system.
This is due to a number of reasons related essentially to the strong disadvantages imposed to the rotary wing machines by their introduction in a pre-existing, unfitted air transport system, resulting in a poor profitability.
It is obvious, infact, that the long, straight trajectories necessary to perform a fixed wing IFR procedure become penalising and useless navigation legs for a low speed and highly manoeuvrable machine, like a helicopter, while the long and expensive concrete runways of modern airports could be reduced to grass strips of few hundred meters to host VTOL aircraft.
In addition to that, once the integration process initiated, very probably some design principles would need to be revised to optimise the helicopter's utilization in this new role.
Modern and precise navigation and approach systems are becoming available at a very competitive cost and all helicopter manufacturers are investing money in an effort to increase the safety and to reduce the noise level, so as to make "door to door" operations feasible.
In summary, the exceptional flexibility of the helicopter will permit its introduction also in sensitive environments, like densely populated areas.
The purpose of this paper is therefore to try to identify the most significant among these aspects and to present some ideas which could help in modifying the present unsatisfactory situation.
Peculiar helicopter characteristics and limits will be discussed and the present situation will be illustrated, particularly referring to the Western Europe environment.
Possible improvements will be proposed, to be introduced in somewhat different areas, like

* The air traffic control system
* The infrastructures
* The helicoper design

In conclusion some suggestions will be presented on how to try to integrate the fixed wing and rotary wing traffic into

an homogenized air transport system, with a resulting overall beneficial effect.

2. INTRODUCTION

The helicopter is demonstrating its versatility in a large number of public transport operations, whenever used in accordance with selective, dedicated procedures.
The North Sea oil rig system, The Greenland network, the emergency medical service, the Gulf of Mexico operations, etc. show that, when properly managed in a specific environment, the helicopter can be usefully and profitably exploited.
However, in order to give the rotary wing machine greater development opportunities, it would be desirable to introduce and to integrate it into the general air transport system, so as to extend the air transportation capability as close as possible to a real "door to door" service.
There are many reasons why this has not yet been done, (except maybe in some rare and short lasting occasions) but the main handicaps, for the time being, seem to be related to the higher acquisition and operational cost of the helicopter as compared to a similar class airplane, and to its unfavourable impact on the environment.
Of course both these handicaps come from the peculiar physical characteristics of a helicopter, but we must admit that not enough has been done by the manufacturers, the operators and the aeronautical authorities to identify and undertake all the possible corrective actions.
It must be kept in mind, in fact, that the helicopter's existence itself is justified, essentially, by its capability to hover and to take-off and land vertically, without any specific infrastructure.
Whenever a helicopter is operating without exploiting anyone of these peculiar characteristics, it starts being penalised in terms of cost, if compared to a similar fixed wing aircraft.
This is the main aspect to discuss because this is exactly what happens whenever a helicopter is obliged to be subjected to all the limitations and procedures which have been conceived, in the existing air transport system, to perfectly fit to the characteristics of the fixed wing aircraft.
In addition to that, the recent quick evolution of the avionic and visionic equipment (FLIR-NVG-GPS Digital Map, etc.) is even more enlarging the helicopter's operational envelope.
It is therefore time to take a close look to the conceptual differences between helicopters and airplanes typical data, and to see how an intelligent management of the formers could lead to a dramatic decrease of their operational costs and to a profitable integration with the latters, with an acceptable impact on the environment.

3. THE HELICOPTER'S TYPICAL CHARACTERISTICS

To the purpose of this paper, some meaningful characteristics of the helicopter are presented and compared to those of the average fixed wing transport aircraft.

CHARACTERISTICS	ROTARY WING	FIXED/WING
T.O.& landing spaces	*1.5x1.5 the rotor diam. Unprepared surface	*1 mile x 60 m. *Concrete runway
Operational speed range	*From-50 to+300 Km/h	*From 200 to 900 km/h
Operational altitude range	*From S.L. to 10000 ft (unpressurised)	*From S.L. to 40000 ft
Sidward movement capability range	*About 50 Km/h L&R	*NIHIL
T.O. & landing distance	*From 0 to 200 m.	*From 1000 to 3000 m
APP.& T.O. slope angle	*From 0° to 20°	*From $0^{\circ}$to 3°
Manoeuvrability	*Excellent, particularly at low speed	*Deteriorating when approaching stall speed
Maintenance facilities	*Small and rugged	*Large and sophisticated

It appears from the above table that, for its own nature, the helicopter cannot be considered a competitor of the airplane, but rather an addendum, an extension of the fixed wing operational field.

It could be stated, in fact, that the helicopter flight envelope, apart from a small overlap, starts where the fixed wing aircraft flight envelope finishes.
Therefore, in order to become profitable and appealing, the helicopter must be exploited in the areas not allowed to the airplane, reducing to a minimum the utilization of common infrastructures and facilities.
This operational criterium would influence the money saving process in two additional ways:

- by reducing the cost of the ground infrastructures to be utilized;

- by remaining clear of fixed wing T.O., approach and landing sectors, thus allowing faster traffic flow.

4. THE PRESENT SITUATION

When the helicopter began to be reliable enough to be taken into consideration for public transport use, the pre-existing and well developed air transport system had been conceived and shaped to fullfil the needs of the much more advanced, safe and profitable fixed wing component.
As a consequence, being all the infrastructures, air traffic system and support and exploitation structures sized for the characteristics, dimensions and performance of the fixed wing aircraft, it was natural for the helicopters to be operationally and economically penalised, and therefore rejected, by the air transport system.
In addition to that and in spite of the helicopter rapid progress of these late years, the very strong lobbies of the national air carriers inside each country, continuously pushed the national aeronautical authorities towards a tailoring of the air transport system more and more devoted to the specific carriers interests.
As a consequence of this short-sighted attitude, the possibility to overcome the intrinsic limits of the helicopter, taking advantage of its many positive qualities, could not be exploited, while, on the contrary, the gap between the two components became even wider.
This fact, apart from delaying the development of the helicopter itself in the role of public transport, penalises the whole air transport system, since it remains deprived of the rotary wing component that, if available, could improve the system's general efficiency, widen its range of operation, and eventually, produce a better general profitability.

5. PROPOSED ACTIONS

In order to modify the present unsatisfactory situation a number of corrective actions of different nature might be considered.

However it seems advisable to concentrate our attention on three main areas:

- the air traffic control system
- the infrastructure and navigation aids
- the helicopter design

Of course,mutual interferences among these three areas exist, but they will not impair the validity of certain conclusions.

a. The air traffic control systems

Since most fixed wing aircraft have similar performance, the air traffic control system has been conceived in order to accomodate the most demanding among the types in use and, therefore, in the ATC procedures, the spaces, the volumes, the altitude and time separations, the standard radius of turn, the procedure layouts, the runways alignment distances, etc. have been defined in accordance with their performance and flying qualities.
In other words it can be easily verified that, in an average airport,the first reporting point after take-off is about ten miles from the runway, while the initial approach point for an ILS landing can be at an even greater distance.
The interested altitudes for T.O., approach and missed approach procedures go, at least, up to 4.000 feet.
These large volumes, which involve also long separation times between traffics, are necessary for the complexity of the F/W procedures, their sluggish reactions at low speed, their relatively high speed of take-off and approach, the need to utilise a runway, and therefore, a mandatory direction for T.O. & landing operations.
The helicopter doesn't have all those constraints, and, consequently, can be much more flexibly managed.
All helicopter operations, in fact, can be conducted also at very low speeds, without any mandatory T.O. and approach direction, except when imposed by the nature of the surrounding obstacles and of the local environment.
An altitude of 1.000 feet above obstacles is a quite safe altitude for a helicopter and its low speed may allow a reduction of time and distance separation between traffics.
The use of a runway is not required and multiple take-off directions can be used simultaneously to reduce the ground holding times.
It appears from these short considerations that the helicopter traffic, if brutally injected into the F/W traffic control system, using for the helicopter the same managing criteria used for the airplanes, would end up by penalising both types of aircraft.

The helicopter traffic, instead, should be managed by a combination of two possible actions :

* by selectively using only that part of the F/W ATC system which is consistent with the helicopter characteristics;
* by creating a dedicated helicopter ATC sub-system outside

and in addition to the F/W system, taking advantage also of that part of the large volumes presently included into the F/W procedures, but not totally exploited.

It doesn't seem to be particularly complicated to adhere to these principles in VFR conditions.
In this case, apart from flight safety considerations to be discussed in the next paragraphs, time and fuel saving should be the primary concern, together with the necessity to avoid negative impact on the environment.
To this purpose T.O. & landing directions and slopes should be selected as necessary and the most quiet flight regime should be flown by each type of helicopter.
In IFR conditions, instead, different types of procedures could be conceived depending on weather minima.
When no dedicated navigation and approach system is available for VTOL, the lowest possible minima can be attained only by using the existing aids.
An optimization on the utilization of these systems can be achieved exploiting the lower airspeed and the better manoeuvrability of the helicopter, reducing whenever possible, the length of the segments or simplifying the SIDs and the STARs. However it is to be kept in mind that, even when short-cuts or simplifications are impossible and the helicopter is required to fly the standard fixed wing procedure, then the approach speed can be increased towards the high side of its speed range up to 120/130 KTS, that is about the same speed as airliners, thus avoiding any bottleneck effect on the traffic flow.
In any case, whenever possible, a noticeable advantage in the general traffic management could be obtained if the helicopters were directed to operate in accordance with the following points:

- use of selective T.O. & Landing directions, not interfering with the runways;
- short occupancy time of the alignment directions for T.O. & Landing;
- utilisation of flight altitudes below those established for F/W procedures;
- availability of low altitude radar coverage;
- selective use of VOR-DME radials and distances;
- ILS and MLS approach speeds down to about 50 KTS;
- reconsideration of the IFR fuel reserve regulations.

These precautions could help in reducing the percentage of unproductive flight time presently necessary to a helicopter to fly the F/W procedures, thus favourably affecting the overall operational costs.

b. The infrastructures and navigation aids

As we have already said, the best way to operate a helicopter would be outside the expensive and monumental airport infrastructures, with some separated T.O. & landing areas, navigation aids and ATC procedures.

It is well known in fact that helicopters do not need runways for T.O. & Landing and that neither their all up weight nor the pressure on each landing gear wheel is comparable to those of the airliners.
This means that the relevant infrastructures (T.O., landing, taxiing and parking areas) can be much smaller and less resistant, and therefore extremely less expensive.
The same concept of reduced dimensions applies to maintenance or recovery hangars, passenger areas, passenger busses, ground tractors, fuel trucks, etc.
All this involves a considerable money saving in the relevant investments that must be considered when assessing the overall helicopter operation cost. The most suitable solution therefore seems to consist of a dedicated helicopter infrastructure that, although integrated, when required, in the F/W system of a main airports, could also be conceived as a fully autonomous structure in a "door to door" local service.
Such a "modular" concept of a heliport/helipad could bring the following advantages :

- The heliport area inside airports could be situated in such a way as to reduce interferences between F/W and R/W traffic, leaving all T.O. & land time slots available to F/W aircraft.

- Relatively small areas to build dedicated heliports could be identified much more easily and with less disturbance to the environment than big airport areas, and possibly could be better and more cheaply served by ground transportation.

- The possibility to take-off and approach with short alignment distance and the excellent manoeuvrability also at very low speeds, allow the selection of inbound and outbound paths in accordance with the environment constraints (obstacles, noise, motor ways, rivers, etc.)

- A selective use of existing Navigation Aids, or other equipment supposed to be shortly available, (MLS, GPS, FLIR, NVG, etc.) combined with the specific characteristics of the helicopter, could guarantee a higher safety level and excellent navigation and approach precision, also in bad weather and at night.

Very interesting, in this context, appear to be the capabilities of the differential GPS (DGPS).
It has been demonstrated that this equipment, when coupled with an aircraft's flight management and guidance system, can fly instrument approaches to virtually any helipad in the world, indipendent of traditional ground based navaids.
It involves narrow tolerances, nearing ILS standards, and allows several course and slope changes during the approach, thus

permitting to select the most convenient approach path, depending on the environment constraints.
All these considerations show the enormous difference in the investment necessary to build and operate a modern airport from that required for a heliport.
This difference has to be taken into account in the computation of the helicopter operation cost and in the economical assessment of its integration in the general air transport system.

c. The helicopter design

Due to the complexity of the public transport requirements, it is quite difficult to list all the characteristics that a modern dedicated helicopter should be provided of.
On the other hand it is well known that probably all manufacturers would have the capability to produce a machine optimised for the public transport role, should the market demand be strong enough to justify the relevant investments.
We will deal, therefore, only with those specific characteristics deemed essential for the purpose of this paper.
The most important factor to consider is probably the safety of operation, since its trend is normally opposite to the trend of profitability.
Let's see why.

*** Safety of operation**

Fixed wing multi-engine airliners are conceived in such a way that in no circumstances, from the beginning of the take-off roll to the end of the landing deceleration, an engine failure could lead to a catastrophic event.
A public transport fixed wing multi engine aircraft, in fact, can always be operated with a combination of procedures, gross weight, runway length, and ambient conditions capable to guarantee, in case of one engine to become inoperative, the possibility to either immediately land safely or to safely continue the flight for a successive O.E.I. landing.

Unfortunately this is not always the case for the helicopter.
The relatively reduced power in O.E.I. conditions, together with the need to exploit the helicopter at the maximum possible all up weight, make it mandatory to maintain, also for multi-engine helicopters, that unsafe area of operation defined in the relevant H-V diagrams.
With the purpose to overcome this penalising limitation, operations in Category A have been introduced.
The Category A operations, for a helicopter, reflect the concept of a "balanced runway" for the fixed wing aircraft, but with a much worse penalisation, since, in order to maintain an acceptable efficiency (i.e. a profitable payload) it is required to increase the dimensions of the take-off and landing areas, thus

negatively affecting its vital capability to operate vertically, to and from almost anywhere.
It appears from the previous considerations that two main elements affecting the operability of the helicopter are strictly related to the power available: the performance, in twin engine conditions, and the safety, in O.E.I. conditions.
Some typical examples of today's helicopters show that, in most cases, the manufacturers chose to address their design effort towards either one of these two elements: very seldom towards both of them at the same time.
However, considering for instance the North Sea oil rig activity and the required general IFR capability, we realize that excellent safety characteristics are of paramount importance, not only for what concerns the O.E.I. capability, but also for the high level of redundancy necessary in all systems and components.
These concepts have so far induced the operators to select multi-engine helicopters with good power/weight ratio, where the adoption of Category A procedures, with backward take-off techniques, allows an acceptable overall safety level although, generally, at weights less than the maximum certified and, therefore, with a reduction in profitability. This limitation raises the costs to a level that can only be accepted by the market in case of lack of cheaper alternatives.
This solution doesn't seem to be sufficient to allow a perfect integration process of the rotary wing machine into the air transport system.
The helicopter must operate with safety and profitability comparable to those of the fixed wing component, which means capability to carry acceptable useful loads, to and from anywhere, also in case of critical systems malfunctions. These characteristics must be typical of any future transport helicopter, and the engine and airframe manufacturers must produce any possible effort to reduce the helicopters empty weight, to increase the useful load and to design engines capable to supply, for short period in OEI, an emergency rating well above the take off power rating.

*** The external noise**

In 1988, 400 U.S. airports were applying some kind of restriction based on aircraft noise level.
That number has grown to 593 in 1993 and to more than 600 today.
Most major european airports have also similar restrictions and it can be easily foreseen that, in case of operation to and from a heliport situated in a metropolitan area, the impact over a more and more noise sensitive population could be dramatic.
Although the helicopter instrinsic noise level is

generally much lower than the noise of a jet aircraft, we have seen that the helicopter is intended to fly much closer to the human ears of the heliport's neighbourhood.
For this reason the problem of the external noise has become a primary concern in the design of new helicopters.
During the past decade, industry has undertaken numerous technological initiatives to reduce noise, mostly addressed towards the main and tail rotors, and some successful examples show that we are moving in the right direction.
However, what has been done so far, is clearly not enough, and the number of complaints still being filed by communities or individuals living near or under an intense helicopter traffic is quite enlightening on this subject.

*** The equipment**

The equipment installed in the helicopter should allow the exploitation to the maximum extent of the extreme flexibility of the machine, in order to achieve the necessary reliability and regularity of service.
At this point in time the GPS seems to be a primary system since, with its tri-dimensional capability, when coupled to a modern AFCS, it could allow the helicopter to fly navigation and approach procedures taking advantage of its peculiar characteristics like low speed, great manoeuvrability, steeper T.O. & approach slopes, use of quieter flight parameters, etc.
This would allow the ATC to conceive navigation and approach routes with minimum interference with the fixed wing traffic, avoiding noise sensitive areas or, when necessary, reducing the noise signature of the machine.
This means, in turn, to bring the helicopter closer to the "door to door" service concept.
But, of course, the regularity of such a service should also be maintained at the same level as the airline level.
For this reason the installation of a full anti-ice system is also advisable, particularly when operating in certain regions of the world, together with an adequate automatic instrument landing system, possibly simpler and more flexible than the ILS.
Extremely precise automatic landings should be made possible, for instance, by coupling the autopilot/flight director to the Navaids, GPS and possibly, doppler. With such a system a helicopter could become capable to conclude its approaches in zero/zero wheather conditions, down to a selected hovering point at 30/40 feet of height, for the final semi-automatic touch-down.
Also the regular introduction of FLIR or NVG procedures in night operations could allow the helicopter to maintain an acceptable service reliability to and from isolated helipads.

6. CONCLUSIONS

The integration of the helicopter into the existing air transport system is technically feasible with some adaptation of the air traffic management to the peculiar helicopter characteristics, optimized for the achievement of the specific goal. The final outcome should produce a very competitive component of the system, constituting a liason between the long distance fixed wing airliner and the ground transportation, with important overall advantages on both the total travelling time and the final travel cost.
However, in order to realize this integration, some actions have to be undertaken.
In particular, these actions include :

- the introduction of dedicated helicopter ATC procedures to be integrated into an optimised, pre-existing fixed wing ATC system;

- the realisation of dedicated infrastructures and NAVAIDS for helicopters both inside the fixed wing airports or as isolated heliports in well identified, opportune locations;

- the introduction of specific public transport operational concepts in the helicopter design, so as to optimise the rotary wing machine operability in this additional operational environment.

The combined effect of the suggested actions should eliminate most of the shortcomings which have so far hampered the development of the helicopter in the public transport field, bringing its operational costs and profitability to market appealing levels.

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