SEVENTH EUROPEAN ROTORCRAFT AND POWERED LIFT AIRCRAFT FORUM

Paper No. 23

PARAMETRIC CRITERIA
AND
IMPACT ON DESIGN TRENDS

by

Lt.Col. Roberto de' POMPEIS
Flight Test Centre
PRATICA DI MARE (ROMA)

and

Col. Fulvio GAGLIARDI
Ministry of Defence
ROMA

ITALIAN AIR FORCE

September 8-11,1981
Garmisch - Partenkirchen
Federal Republic of Germany

Deutsche Gesellschaft fur Luft-und Raumfahrt e.v.
Goethestr. 10, D - 5000 Koln 51, F.R.G.

PARAMETRIC CRITERIA AND IMPACT ON DESIGN TRENDS

by

Lt.Col. R. de' Pompeis and Col. F. Gagliardi

ITALIAN AIR FORCE

ABSTRACT

This procedure derives from theoretical studies already applied to aircraft selections and consists of three main steps :

- Effectiveness program;
- Total operating cost estimation;
- Evaluation of effectiveness-cost ratio and optimization of the fleet selection.

The operative requirement, taking into account the main factors affecting the mission is transferred into a mathematical model.

From the observation of present technology, on statistical basis, are obtained laws or trends of typical parameters which contribute to the definition of an "ideal" specific helicopter which can be used as a reference and, compared to the existing ones, gives a nondimensional measure of effectiveness.

All the costs (manufacturing, maintenance, training, operating etc.) for the whole operative life are estimated with a similar methodology and lead to the determination of the effectiveness-cost ratio which may be optimized taking into account the fleet consistency required to fullfil the task.

Possible application of the above philosophy to meet the industrial trend with operational requirements is also envisaged.

1. INTRODUCTION

High development costs and considerable interval between the rise of a new operative requirement and the realisation of the right solution, do not permit, as in the past, to accept a minimum risk, both operative and industrial, so that, at present, it is necessary to use technical evaluation criteria to define the objectives to aim at.

The above is applicable to three different purposes:

a) selection of the most convenient helicopter among the existing ones which fullfils totally or partly the operative requirement;
b) definition of development lines and preliminary definition (architecture and main characteristics, compatible with the state of art) of a new helicopter which best fullfils the operative requirement;
c) identification by a firm of an helicopteristic solution to fullfil particular market requirements.

This is summarized in fig. 1.

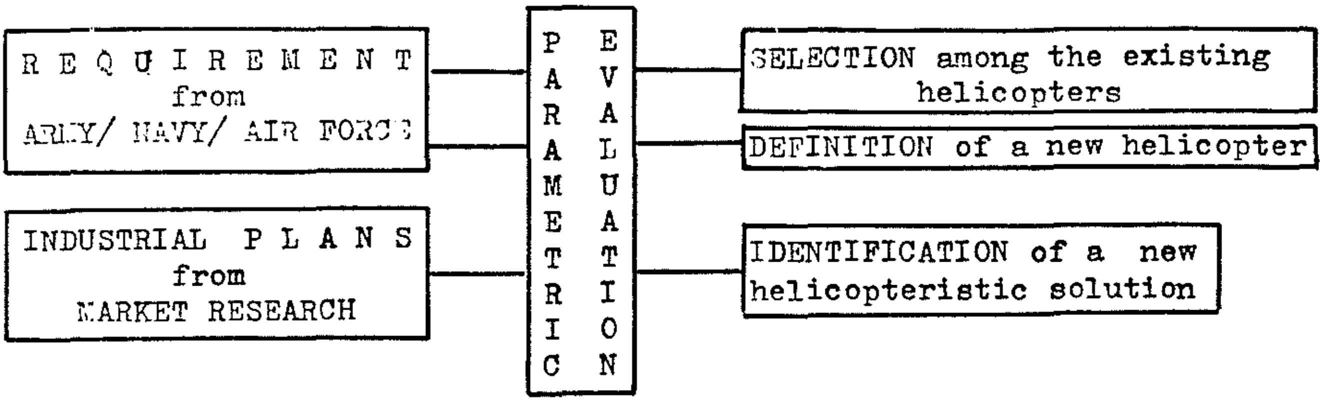


FIG. 1

Starting from the operative requirements it is necessary, in the initial development of a new weapon system, to:

- verify the level of feasibility with technology available or to be expected;
- define possible solutions which fullfil "ad hoc" the requirements, taking into account beyond the currently realizable strength of materials, airfoil maximum lift, or minimal drag coefficient other operational requirement such as maximum discloading or requirements, of legislational nature (e.s. trasmissible noise level, or other enviromental requirements);
- compare them in terms of cost/effectiveness, with similar identified solutions already available in the market;

- evaluate either the convenience of the industrial undertaking or the selection of the best solution among the existing ones.

If development of a new weapon system will be required, it is necessary to undertake a specific feasibility study and following development activity.

This can be summarized in fig. 2.

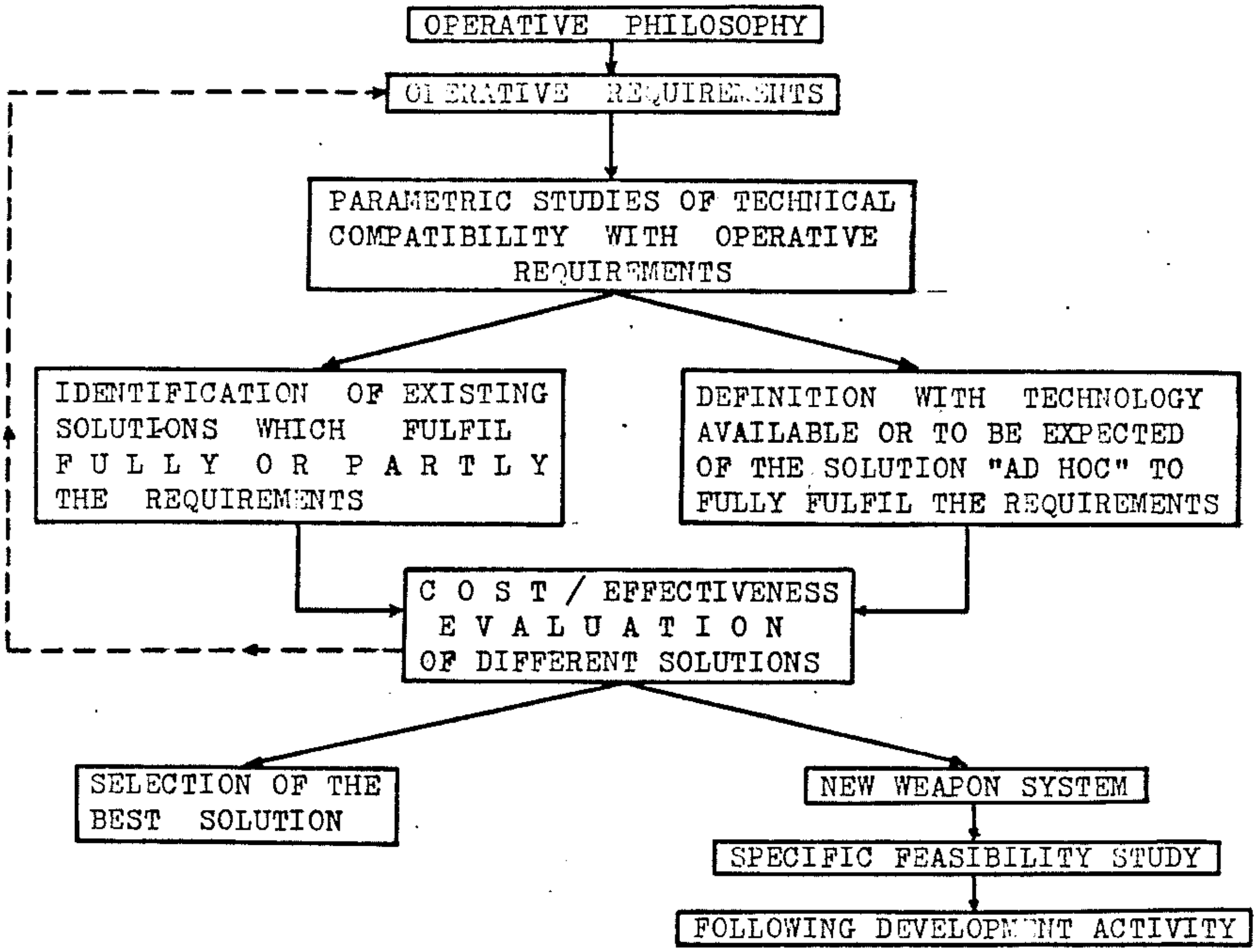


FIG. 2

Assuming already defined the operative requirements, and specifications, which could be turned over via "operative research" according to a similar parametric approach, will be explained the methodology employed for the selection of an helicopter among the existing ones.

It derives from theoretical studies already applied to aircrafts selections or definition and consists of three main steps:

- Effectiveness program;
- Total operating cost estimation;
- Evaluation of effectiveness-cost ratio and optimisation of the fleet selection.

2. EFFECTIVENESS PROGRAM

The operative requirement, taking into account the main factors affecting the mission, is transferred into a mathematical model. In parallel, from the observation of present technology, are obtained laws or trends which contribute to the definition of an "ideal" specific helicopter which can be used as reference and, compared to the existing ones, gives a non-dimensional measure of the effectiveness.

2.1. Translation of the operative requirement into a mathematical model

The difficulty concerned with this point depends on the complexity of the operative requirements.

It not possible to give generally applicable orientation, but the solution will be specific for the operative mission.

It is possible to show as an example, the study carried out where the required mission was to patrol a defined area at a selected distance from the coast.

The first step is the discrimination of factors affecting the success of the mission.

The acquisition of a mobile target in this area is affected by the following phases:

a. interception and identification capability of the target;
b. communications capability from and to the helicopter to and from the ground or other ships or a/cs;
c. surviving capability beyond eventual attack actions of the target;
d. deterrent capability against the evasive actions of the target.

The helicopter's total capability (Fi) can be therefore determined in terms of global probability resulting from the single-phase probabilities:

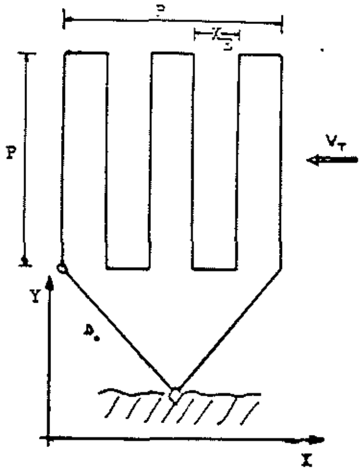
$$Fi = PI \cdot PCC \cdot PS \cdot PDT \qquad (2.1)$$

where: PI is the interseption probability
PCC is the communications probability
PS is the survival probability
PDT is the deterrent probability

2.1.1. Target interception probability (PI)

To determine the target interception probability it is useful to outline the route to follow in the patrol-area.

According to the typical existing routes, one of these is the "comb-patrol" drawn in the following figure:



where :

VT	target's speed
X_E	distance between the comb's teeth.
P , B	area lenght and width
Do	distance from base to initial patrol-area

FIG. 3

Indicating with :

V : true helicopter speed
$\bar{V}$: helicopter speed component along
DA : range of vision
A : helicopter's range

it is possible to write:

$$\bar{V} = \frac{X_E \quad V}{2P + X_E} \quad , \qquad X_E = \frac{P \cdot B}{A - 2D_o - B - P}$$

$$\frac{\bar{V}}{V_T} \cdot \frac{DA}{X_E} = \frac{V}{V_T} \cdot \frac{DA}{2P + \dfrac{P \cdot B}{A - 2D_o - B - P}}$$

and the target interception's probability results:

$$PI = 1 - e^{-\left(\frac{\bar{V}}{V_T} \; \frac{DA}{X_E}\right) \cdot h} \qquad (2.2)$$

The "h" is an added corrective factor which takes into account the possibility to fit in specific equipments such as radar (η_R), deep light (η_F) or infrased system (η_{IR}).
Introducing the radar detection probability (PDR) and assuming a target mark's resolution on the radar display (Qv) this factor can be expressed as follows:

$$h = (1+K \; PDR \; \eta_R) \left[0.6 + 0.4 \; (.48 \; \eta_F + .42 \; \eta_R + \; .1 \; \eta_{iR}) \right] \qquad (2.3)$$

Where :

$$\eta_F,\ \eta_R,\ \eta_{IR} = \begin{cases} 1 & \text{with the equipment fitted in} \\ 0 & \text{without equipment} \end{cases}$$

$$K = 0.1 \left(\frac{X_D}{DA}\right)^2$$

$$PDR = 1 - e^{-\left(Q_V \cdot \frac{x_D}{x_1}\right)} \qquad (2.4)$$

$$Q_V = \frac{RRM - x}{0.5 \quad RRM} \qquad (2.5)$$

X_1	target sight distance from flight line;
X_D	target identification distance on radar display;
x	target distance;
RRM	maximum radar range.

The expected maximum radar range, on the other side, can be obtained from the technical radar characteristics, using the following practical expression:

$$RRM = \left(\frac{n \cdot \gamma \cdot Pp \cdot G^2 \cdot \lambda \cdot \sigma}{B_W \cdot N_F \cdot L \cdot (S/N)_o}\right)^{1/4} \qquad (2.6)$$

Where :

n	is number of integrated impulses
γ	corrective foctor (1 + 0.7)
Pp	transmitter's peak power (MW)
G	Antenna Gain
λ	wave's lenght (cm)
σ	Target's radar cross section (m^2)
B_W	Receiver's band-width (MHz)
N_F	Receiver's noise (db)
L	Overhaul loss in the system
S/N	signal to noise ratio of the operative system

2.1.2. Communication capability (PCC)

In first approach it is not necessary to consider the performances of all single equipments which will be fitted in, but for ower purpose, will be considered only those performances which are phisically restricted by the helicopter characteristics.

Whith this consideration the most restrictive is the possible lenght of antenna which limits specially the communications in high frequency (HF).

The communication capability in HF, can be expressed in terms of transmission's efficiency, related to helicopter's lenght (L), by the following practical expression :

$$\eta_{HF} = \frac{1}{10^7} \left(43572.9\, L - 17548.2\, L^2 + 5816.4\, L^3 - 989.1\, L^4 + 76.7\, L^5 - 1.78\, L^6\right) \qquad (2.7)$$

This expression, anyway, has to be considered valid only for comparison's analysis.

So, the probability to assure HF communications is defined by :

$$PCC = 1 - e^{-\frac{\eta_{HF}}{0.05}} \qquad (2.8)$$

2.1.3. Survival probability (PS)

This has to cover the survival during target's control phase and, when required, during deterring phase.
In the deterring phase, indicating with NP the number of letal projectiles, the survival probability is a function of this type :

$$PS_s = e^{-NP \frac{VP}{VP_o}} \qquad (2.9)$$

Where :

$$NP = \frac{RF \cdot S\,eq}{s} \left(\Delta t + K \right) \qquad (2.10)$$

RF : target's rate of fire
S eq : $nlc + L_E \cdot Y_E$ Helicopter's equivalent exposed area
n,l,c : number, lenght, chord of helicopter's blades
L_E, Y_E : helicopter's lenght and width
s : corrective factor for fire's dispersion
Δt : exposition time of the helicopter to fire
K : pilot's reaction time

and the ratio betwen projectile's speed at distance R (VP) and its initial speed (VP_o) is.

$$\frac{VP}{VP_o} = \left(1 + \frac{\bar{R}}{d} \right)^{\frac{1}{2}} \qquad (2.11)$$

Where :

d : fire's maximum range
$\bar{R}$: mean useful fire's distance

Assuming that the helicopter's evasive action is a direct function of its excess-power (second region) and that resulting speed is a linear function of excess-power it is possible to write:

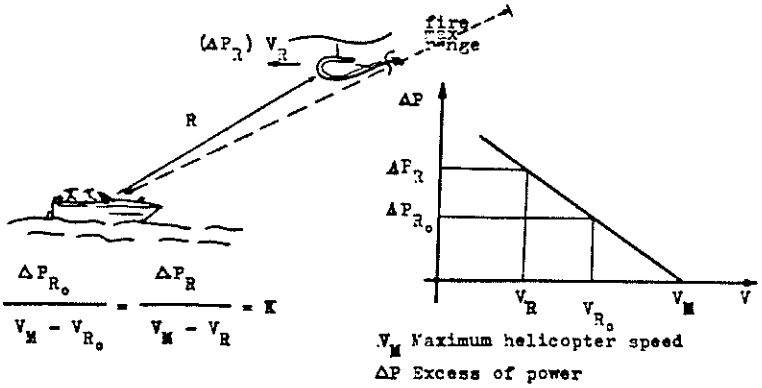


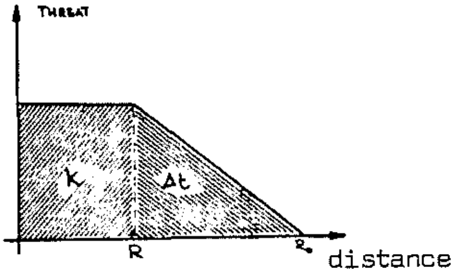
FIG. 4

From this, developping, it is possible to formulate the following expression, whose solution gives the helicopter's exposition time to target's fire (Δt).

$$\left(\frac{2\ \Delta P_R}{V_M - V_R}\ V_R\right)\Delta t^3 + \left(\frac{2.10^3 \Delta PR}{VR} - \frac{2\ R \cdot \Delta\ PR}{VR} - \frac{4\ W\ V_R^2}{9.81} + 2\Delta P_R \cdot \frac{R + 10^3}{V_M - V_R}\right)\Delta t^2 + \left(12\ \frac{W \cdot V_R}{9.81}\ (10^3 - R)\right)\Delta t +$$

$$+ \left(8\ \frac{W}{9.81}\ (2.10^3\ R - 10^6 - R^2)\right) = 0 \qquad (2.13)$$

To evaluate $\bar{R}$, after the pilot's reaction time, helicopter's motion is assumed uniformly accelerated, so that the threat decreases linearly with distance R :



$$\bar{R} = \frac{KR + \Delta t\ \left(\frac{R_o - R}{3} + R\right)}{K + \Delta t}$$

FIG. 5

Indicating with ND the number of flights (every 100) where deterrent action is necessary, and with NM the number of flights (every 100) when the target fires, the survival probability during deterrent action is:

$$PS_D = 1 - \frac{NM \cdot ND}{10^4}\ (1 - PS_S) \qquad (2.14)$$

The target control phase, on the contrary, happens "100 - ND" times and the target fires always NM times.
So, the probability of survival during control phase is :

$$PS_{CT} = 1 - \frac{NM}{10^4}\ (100 - ND)\ (1 - PS_S) \qquad (2.15)$$

The total probability of survival is, therefore:

$$PS = PS_D \cdot PS_{CT} \qquad (2.16)$$

2.1.4. Deterrent probability (PDT)

It is necessary to obstruct the evasive manoevres of the target ND times every 100, so that deterrent probability is :

$$PDT = 1 - \frac{ND}{100} \eta_g e^{-CM} \qquad (2.17)$$

where :

$$\eta_g = \begin{cases} 0 & \text{helicopter without gun} \\ 1 & \text{helicopter with gun} \end{cases}$$

CM is the helicopter maneuver capability.

The maneuver capacity is related to the architectonic and powerful characteristics of the helicopter and to its handling qualities, in particular the manauverability.
This could require very detailed informations, but in simple terms the maximum load factor (n max) is assumed to be representative enough of the maneuver's capacity.
Taking into account that, at present, the maximum load factor is 4, the CM results in :

$$CM = \frac{n\ \text{max}}{4} \qquad (2.18)$$

2.1.5. Helicopter's total capability (FI)

Limiting to max T/O weight of about 5 tons and twin engines helicopters, all previous expressions have been applied to the following european helicopters available in 1980:

- the french SA365 Dauphin 2;
- the german BO105;
- the british WG13 Lynx;
- the italians A109 and AB212.

with different possible equipment fitting.
A panorama of main input's data to the program is presented in the following figuras where is written also the value of the reference-helicopter, which will be dealt in next paragraph.
Fig. 6 represents max take-off weight:

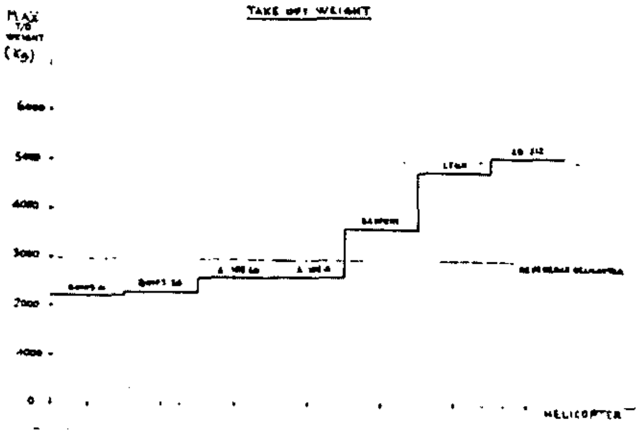


FIG. 6

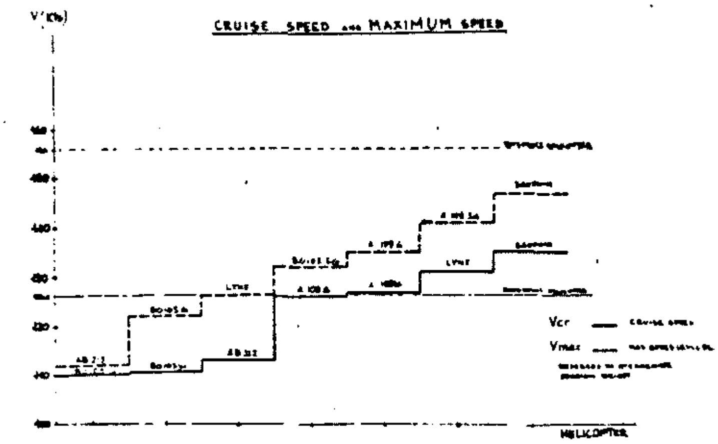


FIG. 7

Fig. 7 represents cruise speed and maximum speed in level flight, referred at the intermediate mission weight and sea level.

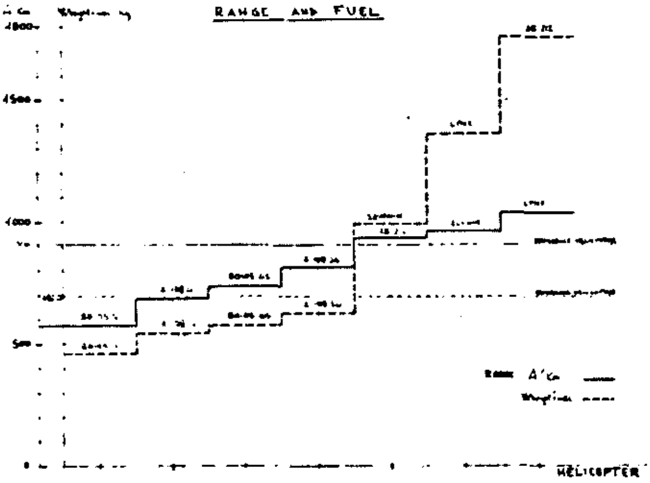


FIG. 8

In Fig. 8 are represented the maximum range feasible with the fuel put in.

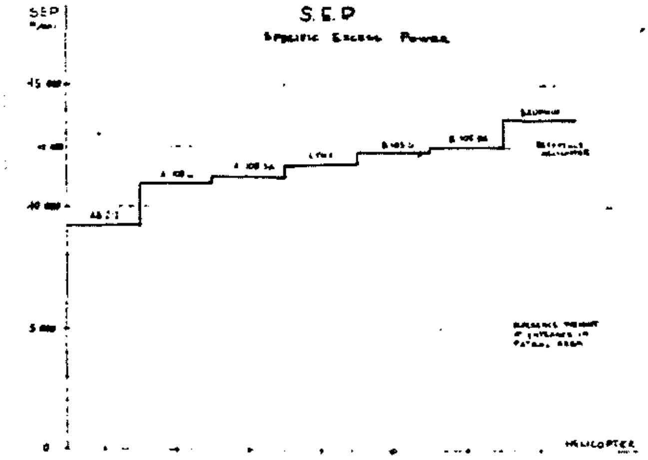


FIG. 9

In Fig. 9 is reported the specific excess power (S.E.P.) referred to weight at entrance in patrol-area.

The results of the complete computation, obtained by the aid of an IBM 370 computer are reported in fig. 10.

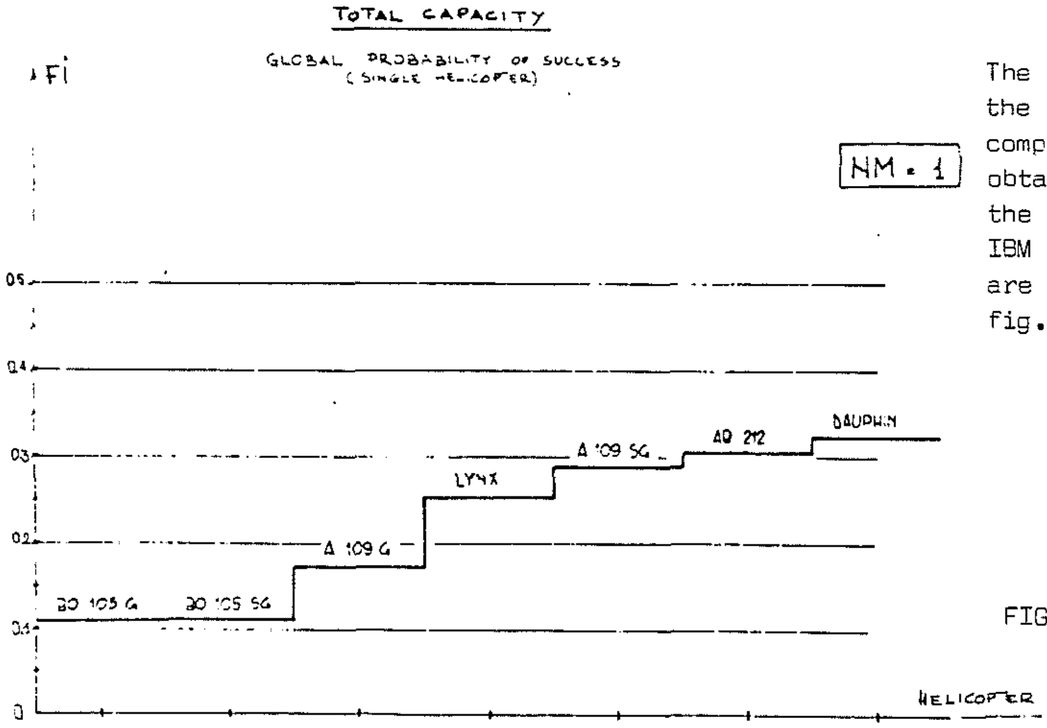


FIG. 10

The highest probability of success can be obtained by the Dauphin, while the lowest belongs to the BO105.

2.2. Definition of reference helicopter

The aim is the definition of an "ideal" helicopter with now days technology which fullfils fully or the best the requirements. First step is to limit the area of interest. This is logic because it is nonsense to consider all helicopters existing which would present excessive technological, differentiations and consequently comparisons would not be expressive.

The class of helicopters to be considered has been already defined.
It is not necessary for the reference helicopter to entangle into the definition of details, but you should define the helicopter globally and only those parameters or characteristics which are directly involved in the effectiveness program: you should determine the inputs to the mathematical model as previously defined.
For our case it is necessary to define at least the maximum take off weight, the dimensions, number and geometric carachteristics of blades, main performances (max range, max speed, cruise speed, S.E.P.), and load factor.

2.2.1. Weight evaluation

Total weight (W) can be defined as the sum of structure (WST), fuel (WF), engines (WM) and all equipments (WE) weights.

$$W = WST + WF + WM + WE \qquad (2.19)$$

Meaning WST and WF as part of total weight with relative coefficients:

$$WST = w_s \quad W \qquad (2.20)$$

$$WF = w_f \quad W \qquad (2.21)$$

the (2.19) can be written :

$$W = \frac{WE + WM}{1 - w_s - w_f} \tag{2.22}$$

Introducing some characteristic ratios as:

$$PPE = \frac{\text{Helicopter's total weight}}{\text{Engine Power}}$$

and

$$PPM = \frac{\text{Engine's weight}}{\text{Engine continous power}}$$

engine's weight can be expressed by :

$$WM = \frac{PPM}{PPE} \cdot W \tag{2.23}$$

so that (2.22) becomes :

$$W = \frac{WE}{1 - w_s\,(W) - w_f\,(W) - \dfrac{PPM}{PPE}} \tag{2.24}$$

where w_s and w_f are both dependent on total weight W and, together with PPM and PPE on the present technology.
Also WE is function of present technology and could be expressed, in the same way, by characteristic ratio, but to simplify, has been considered constant and equal to the sum of all avionic and auxiliar equipments required to accomplish the mission :

- communication equipments;
- navigation equipment;
- search and identification equipments;
- stabilisation and autopilot equipments;
- weapons availability;
- safety and emergency equipments.

The laws of variation of w_s and w_f (fig. 11 and 12) together with the determination of present values for PPM and PPE (fig. 13 and 14) will allow the weight's determination for the reference helicopter.

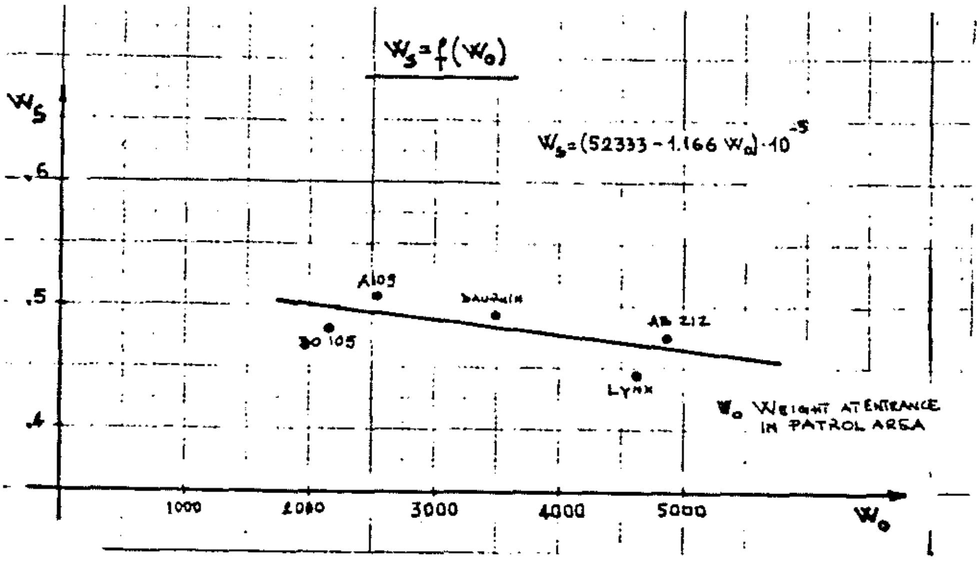

$W_s = f(W_o)$
W_s
$W_s = (52333 - 1.166\ W_o) \cdot 10^{-5}$
.6
.5
.4
A105
DAUPHIN
AB 212
BO 105
LYNX
W_o WEIGHT AT ENTRANCE IN PATROL AREA
1000
2000
3000
4000
5000
W_o

FIG. 11

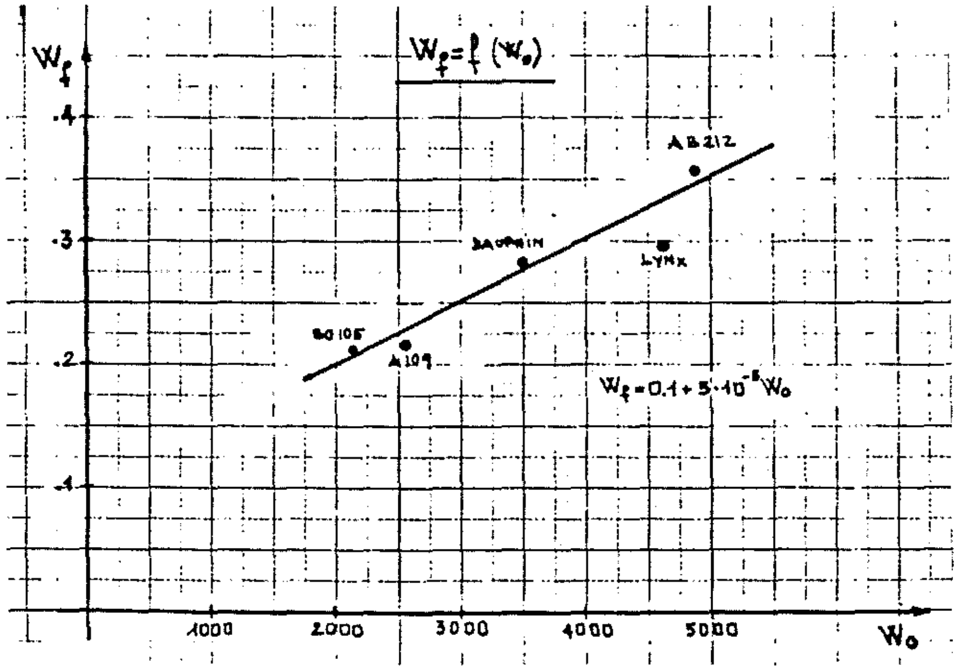

$W_f = f(W_o)$
W_f
.4
.3
.2
.1
AB 212
DAUPHIN
LYNX
BO 105
A109
$W_f = 0.1 + 5 \cdot 10^{-5} W_o$
1000
2000
3000
4000
5000
W_o

FIG. 12

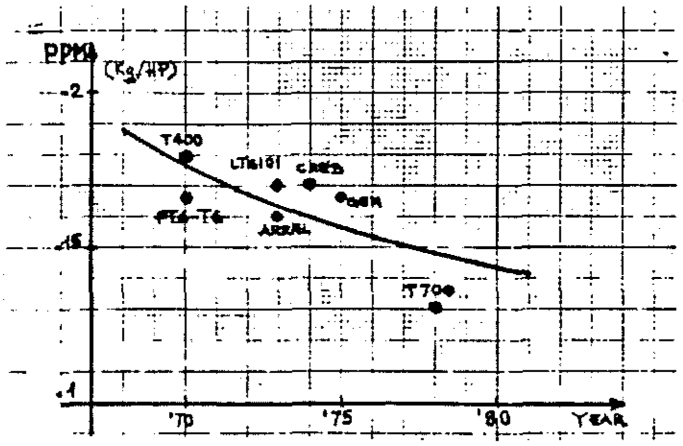


FIG. 13

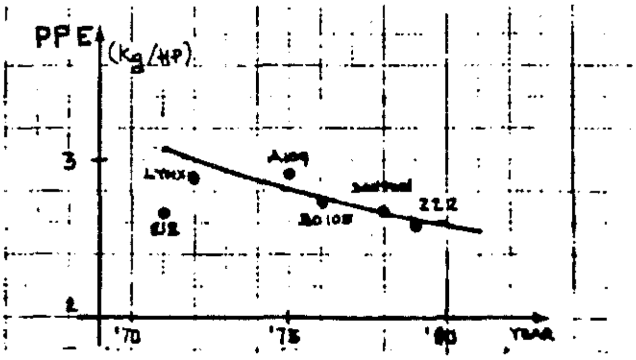


FIG. 14

2.2.2. Drag evaluation and main performances

In the required mission the reference helicopter has to be optimized for cruise flight, so that parasite drag is preeminent.
Fig. 15 represents parasite drag of many helicopters against gross weight.

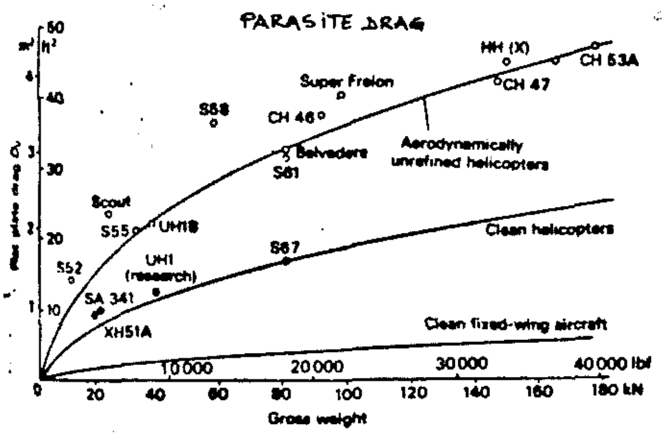


FIG. 15

The points define fairly well a typical curve of drag against weight.
The second curve refers to aerodynamically clean helicopters based on a number of examples, some being experimental models designed for high-speed flight. This latter curve represents the lowest drag which can reasonably be achieved in helicopter design, although it falls far short of best fixed-wing practice.

The particular basic shape which must be adopted by helicopter fuselages, and the fact that the helicopter is normally expected to fullfil a variety of roles, means that it is unable to reach the degree of aerodynamic refinement which is possible in fixed-wing practice.
In fact, both helicopter-drag curves are ronghly proportional to $W^{\frac{1}{2}}$ as might have been expected, which is an indication of a large amount of separation drag.
The drag curve of the much cleaner fixed-wing aircraft is more nearly proportional to $W^{2/3}$.

Writing in the same diagram the values of $\frac{2\ P_{cr}}{\rho\ V_{cr}^3}$ proportional to global helicopter drag against $W_{T/O}^{\frac{1}{2}}$ (fig. 16) it is evident the aerodynamic differentiation among the helicopters considered.

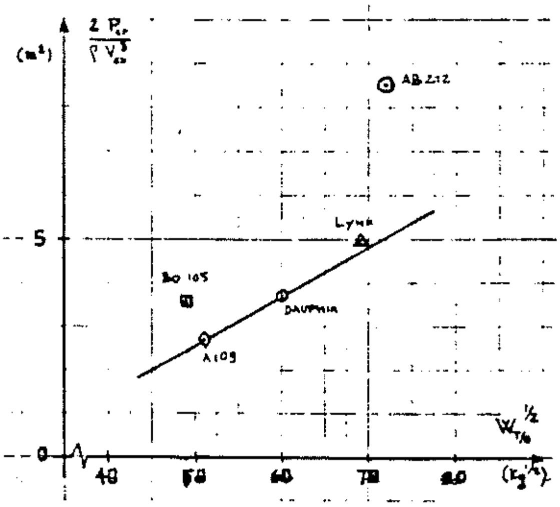


FIG. 16

The best aerodynamic belongs to Dauphin and A109, and will be the aerodynamic of the reference helicopter.
Moreover the same aerodynamic, together with the best present specific fuel consumption (fig. 17), allows the definition of the engine power and the determination of range and endurance.

With a similar procedure, finally, it is possible to define all others necessary inputs.

It is like a puzzle: a toy in which the joint of a new element let to recognize and combine near elements' up to the whole image composition, which results in fig. 18.

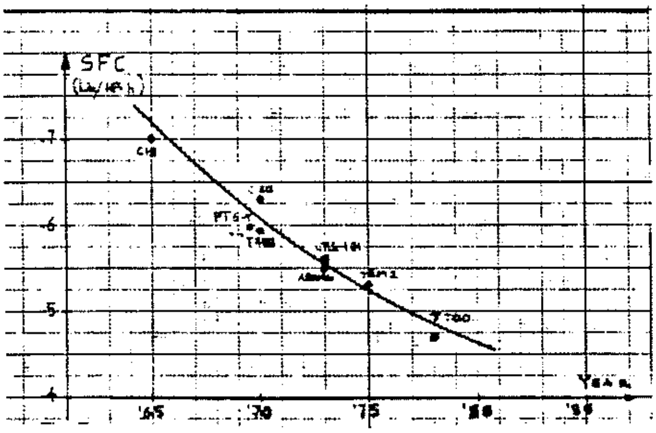


FIG. 17

REFERENCE HELICOPTER

W_{max}TO (kg)	W_{fuel} (kg)	P_{CR} (HP)	PMC (HP)	SFC ($\frac{kg}{HPh}$)	ΔP, W (m/sec)
2958	692	588	845	.267	12.5

A (km)	V_{CR} (kts)	V_{max} (kts)	n_{max} (g)
906	126	156	3

L (m)	l (m)	L/Y	N°Bl.	L_B (m)	c (m)
11.6	1.4	7.8	4	5.38	.358

FIG. 18

2.3. Adimensional effectiveness

The previous data, used as inputs in the program give the effectiveness of this ideal helicopter, and used as reference can provide an adimensional measure of effectiveness (FIA in fig. 19). It represents the % of maximum probability allowed by current technology.

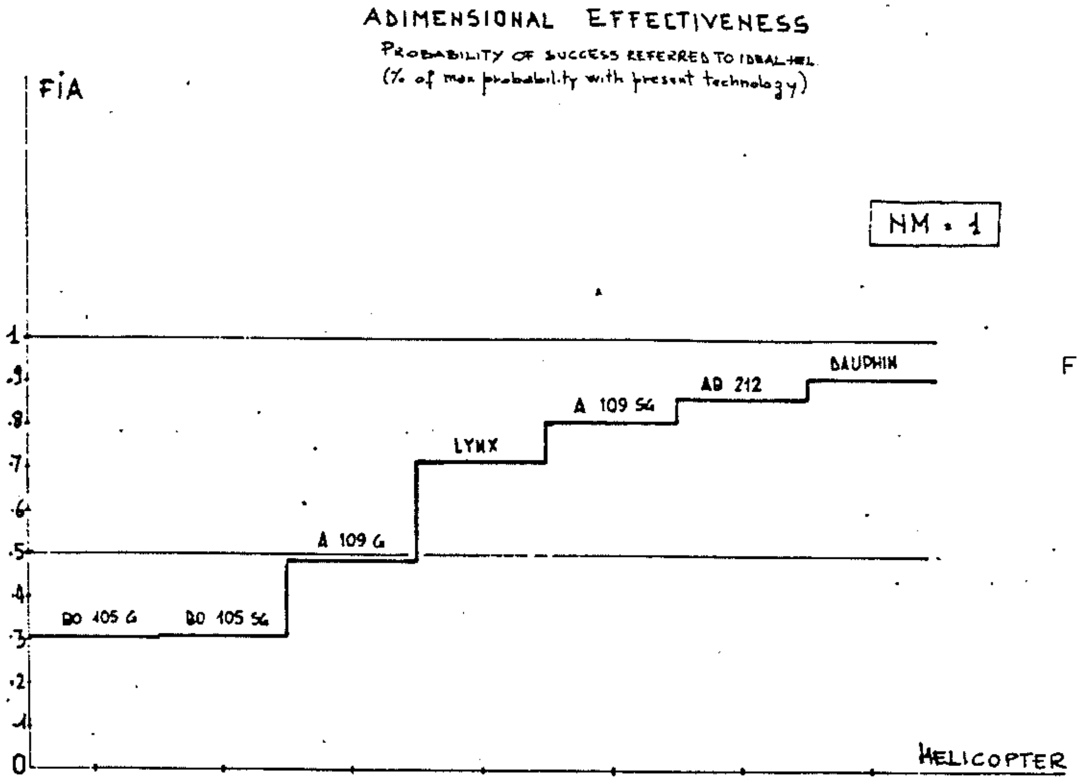


FIG. 19

As, intermediate conclusion, taking into account the only operational point of view, the choise to fullfil the requirements should be orientated towards the Dauphin 2.

3. COST EVALUATION

The second major step, wether to select or to start a new helicopter, is the costing of its different components.

It is necessary integrate poor and scrapable true cost data with others common and achievable in order to create parametric formula whose coefficients are derived on statistical base from present market and projected technology. Must be pointed out that these coefficients, related to local market and user, have to be updated and if necessary the same formula structure has to be changed.

Finally ought to be noted that the single formula may be incomplet but due to their parallel use, there is mutual compensation, so that the overhaul results are acceptable.

The total cost could be shared in three main areas:

- purchase cost
- maintenance cost
- operating cost.

3.1. Purchase cost (CAU)

The purchase cost of a single helicopter (CAU) includes:

- single manufacturing cost;
- development and industrialization cost;
- initial support cost.

The single manufacturing cost (CPU) can be shared in structure and equipment cost (CS), engine fitted cost (CMT) and avionic fitted cost (CAV). Every one can be expressed in the following way :

$$CPU = CS + CMT + CAV \tag{3.1}$$

$$CS = \varphi \chi \Sigma A \left(\frac{WS}{10^4}\right)^{3/4} \tag{3.2}$$

$$CMT = \varphi \chi \Sigma \frac{SHP}{10^4} \tag{3.3}$$

$$CAV = \varphi \chi \Sigma \frac{WAV}{10^3} \tag{3.4}$$

Where :

WS	is the weight of the structure equipped
WAV	is the weight of avionic equipments
SHP	is the shaft horse power
φ	depends on structure (easy or complex)
χ	depends on architecture
Σ	takes into account co-production with different parteners
A	depends on learning curve and currency value.

The development (CD) and industrialization costs (Ci) are quoted in first approximation as function of the purchasing cost and of the number of series helicopters produced (n) :

$$CD + Ci = \frac{44 \quad CPU}{1 - \frac{k}{n}} \tag{3.5}$$

where k = 25, 30 or 35 if there is no development, medium development, or new design.

The initial support cost (CRI) can be expressed:

$$CRI = \varepsilon \ CM + h_1 \ CAV + h_2 \ CS + 1,2 \frac{CR}{FIGR} \tag{3.6}$$

where the singolar coefficient figure changes depending on conseption design and percentage of spare parts, while CR and FIGR will be defined in next para.

The above applied to our helicopters gives the values reported in fig. 20 where the costs are in miliards of italian lire referred at end 1979.

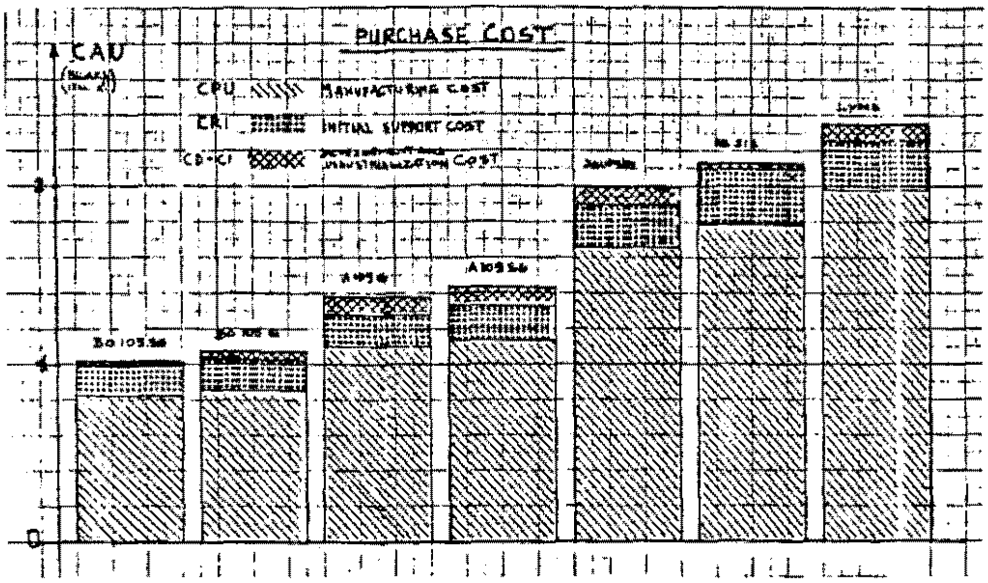


FIG. 20

3.2. Maintenance cost (CM)

It includes:

- spare parts cost (CR)
- engine overhaul cost (CRRM)
- manpower cost (CP)

$$CM = CR + CRRM + CP \tag{3.7}$$

The spare parts cost is directly related to the helicopter operative life (FIGR) in flight hours which includes planned technical life (τ) and obsolescence.

$$CR = (h_3\, CS + h_4\, CAV + RM \cdot CMT)\ \frac{FIGR}{10^5} \tag{3.8}$$

$$FIGR = SIGMAR\ (1 - e^{-\frac{\tau}{SIGMAR}}) \tag{3.9}$$

$$SIGMAR = SIGMA\ \left(1 - \frac{NT}{100}\ (1 - PS)\right) \tag{3.10}$$

where :

RM depends on the type of engine (modular, conventional)
SIGMA is the mean time between two flight incident in flight hours

The engine overhaul cost (CRRM) depends on the time between overhaul (TBO), so CRRM can be :

$$CRRM = RM \cdot CMT \cdot \frac{FIGR}{10^2\ TBO} \tag{3.11}$$

The maintenance manpower cost is directly related to time rate cost (TO) and to maintenance design (γ).

$$CP = 1.7 \left(\left(h_5 \, VM \, n + RM \cdot TBO + h_6 \frac{WS}{10^4} + h_7 \frac{WAV}{10^3} \right) \gamma - 15 \right) \frac{TO \cdot FIGR}{10^9} \qquad (3.12)$$

The maintenance ccst evaluated for the five helicopters considered, at and 1979 are reported in fig. 21.

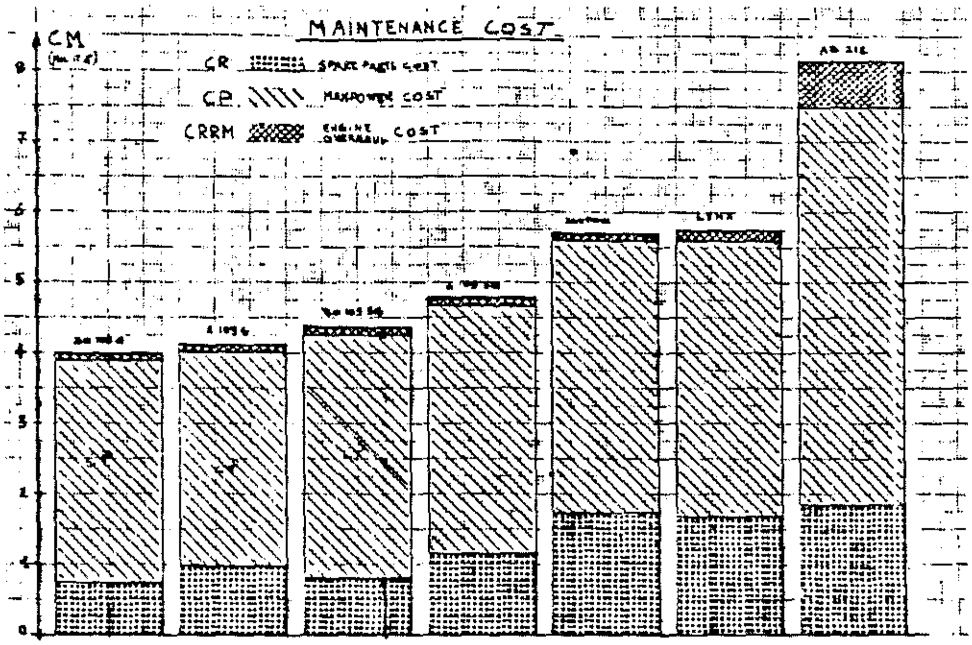


FIG. 21

3.3. Operating cost (CG)

Could be shared in fuel/oil consumption costs (CCC) and in training crew (CE).

$$CG = CCC + CE \qquad (3.13)$$

$$CCC = CC \cdot SFC \cdot SHP \cdot \delta \cdot \frac{FIGR}{10^9} \qquad (3.14)$$

where CC is the fuel cost and δ is a coefficient to take into account the type of mission (operative, carry, training etc.).

$$CE = CED + \frac{\tau}{FIGR} \left(h_8 \, VM \cdot n + \xi \right) NP \, \frac{CM + CCC + CED}{500} \qquad (3.15)$$

$$CED = \frac{5 \, M \cdot FIGR \cdot NE}{10^5} \qquad (3.16)$$

where :

M	represents the currency value
NE	is the number of crew components
NP	is the number of pilots
ξ	is the degree of piloting difficulty

The operating cost relative to our five helicopters are shown in fig. 22.

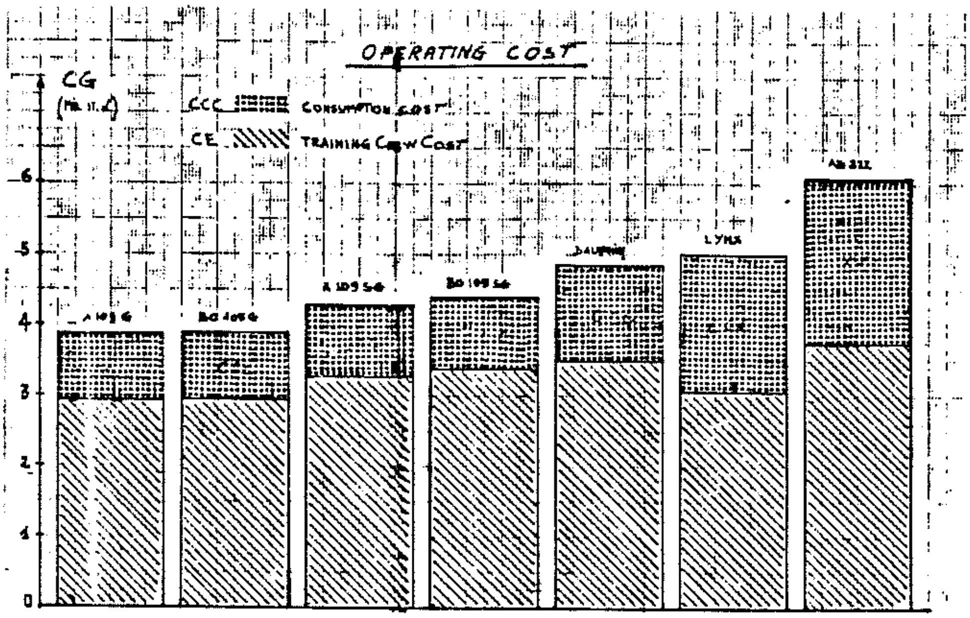


FIG. 22

3.4. Life cycle cost (CGU)

Now it is possible to calculate the total cost of the helicopter, (fig. 23) which is the sum of purchasing cost including development and shared investment, maintenance cost and operating cost for all mean operative life.

$$CGU = CAU + CM + CG \qquad (3.17)$$

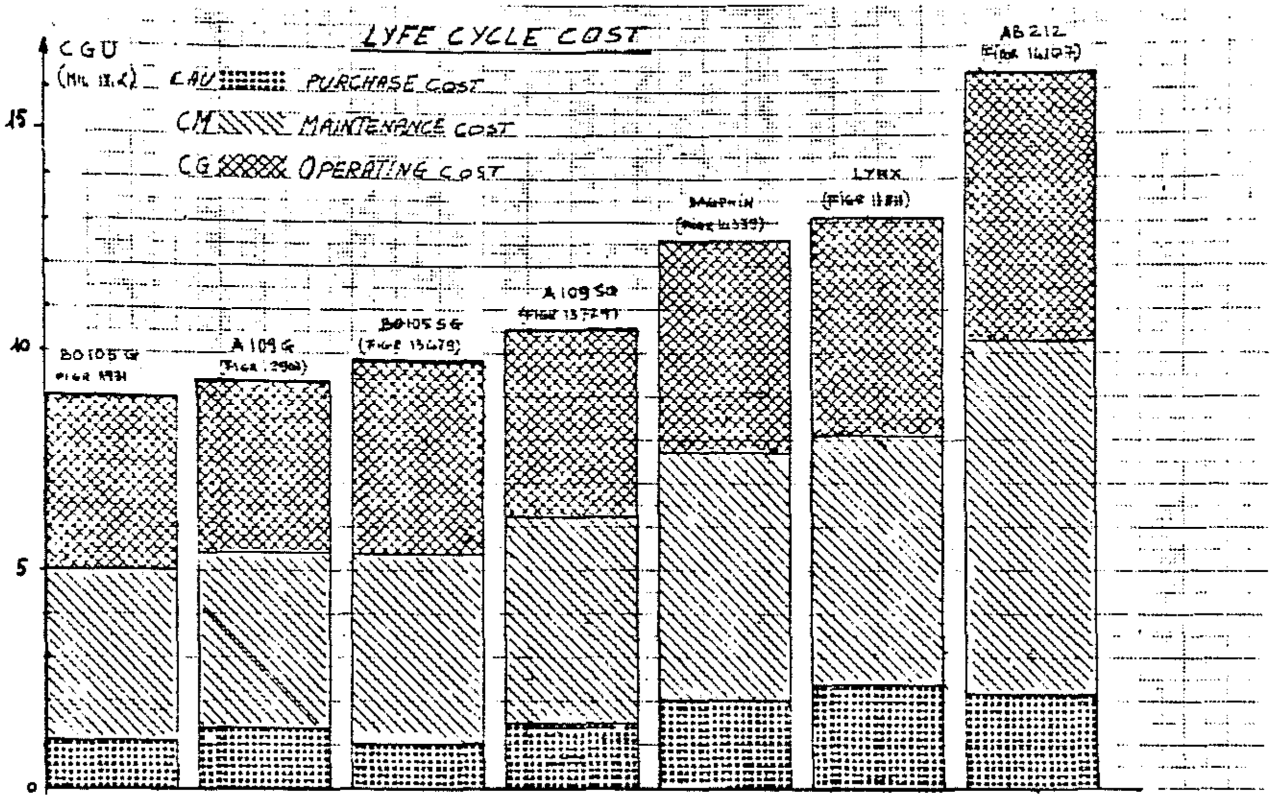


FIG. 23

4. COST EFFECTIVENESS EVALUATION

The previous evaluations let us to procede to the computation of cost-effectiveness ratio for a single helicopter.

The cost for the reference mission will be :

$$\frac{CGU}{FIGR}\ \Delta\ t\ =\ \frac{CGU}{FIGR}\ \frac{A}{V} \qquad (4.1)$$

and the effectiveness-cost ratio (EC) for single helicopter, which represents the number of detectable targets per miliard of italian lire spent is :

$$EC = Fi\ \frac{FIGR}{CGU}\ \cdot\ \frac{V}{A} \qquad (4.2)$$

The results of the application of this formula are shown in fig. 24.

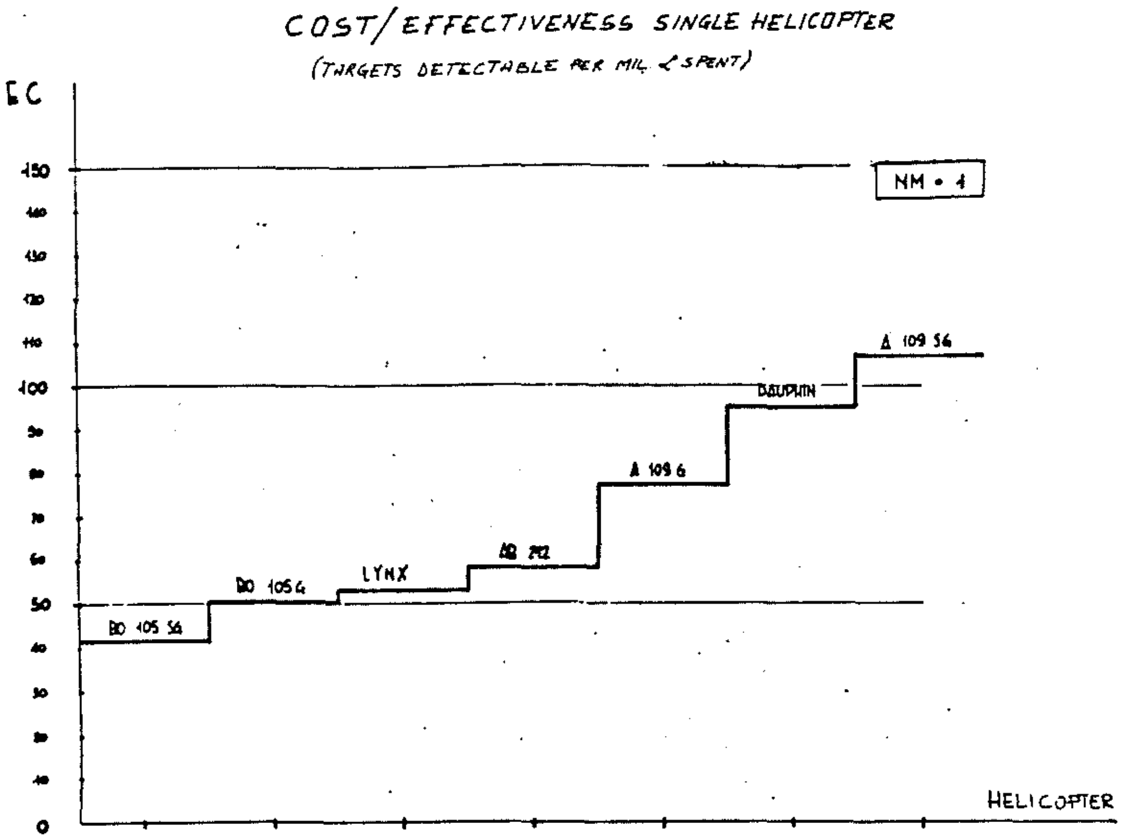


FIG. 24

Extending this evaluation to the whole fleet formed by a fixed number of helicopters, without considering variations due to starting production or attrition during life, the effectiveness of the fleet (FiF) which represents the probability to detect targets potentially present within the operative theatre is :

$$FiF = Fi \cdot HRS \cdot \frac{NEL^2 \cdot HRM}{55 \cdot 10^3 \cdot NZP} \qquad (4.3)$$

where :

HRS are flight hours every 100 dedicated to operative mission
HRM are possible flight hours per month
NEL is the number of helicopters of the fleet
NZP is the number of areas to patrol

The effectiveness of the fleet compared with a fleet formed by the same number of "reference" helicopters, will provide an adimensional value:

$$FiAF = FiA \cdot \frac{HRM}{74} \qquad (4.4)$$

At the end, the effectiveness-cost ratio of the fleet, which represents how many times is possible to detect the targets potentially present, in the operative field, will be :

$$ECF = FiF \frac{FIGR}{NEL \cdot CGU} \frac{V}{A} \qquad (4.5)$$

The conclusive situation is shown in. fig. 25.

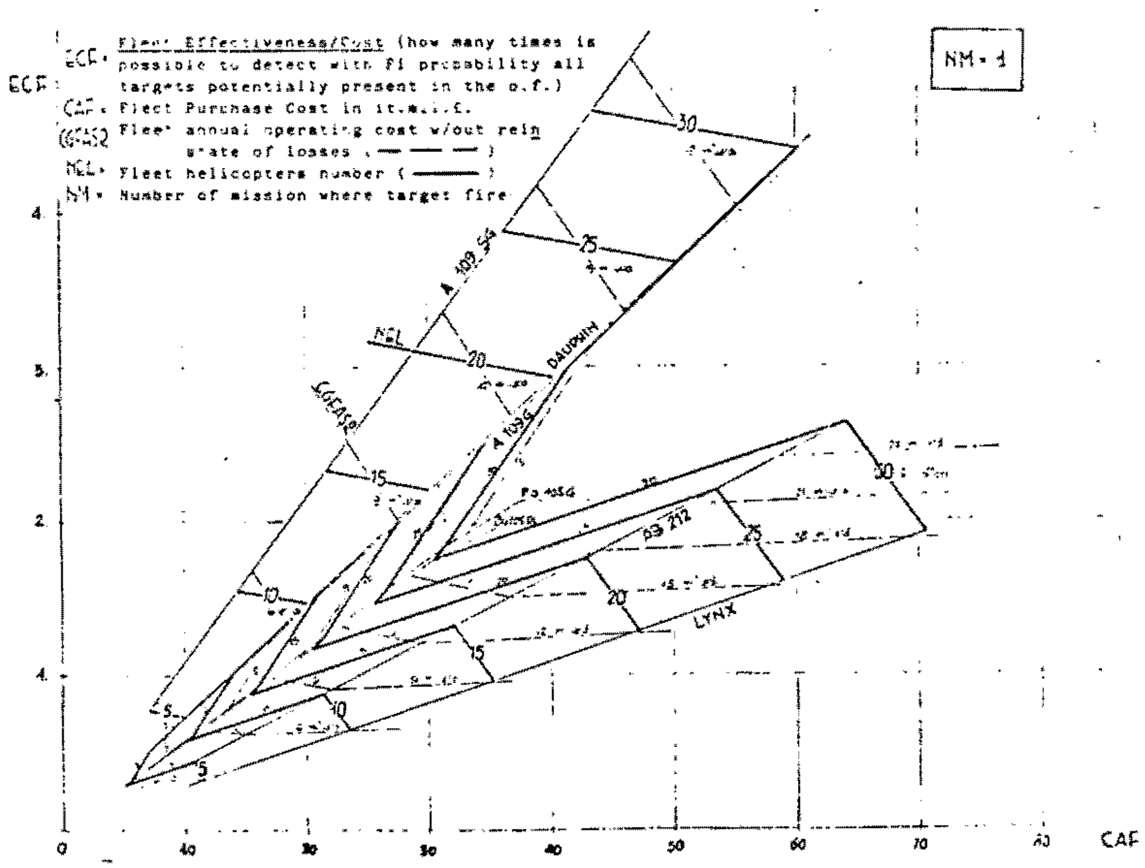


FIG. 25

The values refer to different number of helicopters component the fleet and in the same graph is quoted the annual operating cost of the fleet without reintegration of losses, (CGFASR) computed with following formula :

$$CGFASR = 12 \cdot HRM \cdot NEL \quad \frac{CGU - CAU}{FIGR} \qquad (4.6)$$

5. ADDITIONAL REMARKS

The procedure just showed is an aseptic way to identify the best effectiveness/ cost helicopter among existing ones when you have to select a new fleet to fulfil a specific requirement.

It has been possible to observe relative balance and how the classification changes along the different steps of calculation.

The same method, extended and/or modified identifying more or new typical parameters, may be helpful in the definition of pre-feasibility of a new helicopter design derived from market research. On this way, this paper outlines main features of some structural characteristics and powerplant based on present market and its immediate trend.

The method may be further refined but, and here may be its merit, cannot go beyond the definition of the main characteristics: the helicopter is seen as a whole, making an envelope of technical features correlated to the taskes to be fulfilled .Of course evaluation skill should discriminate carefully main elements affecting the requirement and give them the right weight.

Only, later on, will be possible carry on further parametric studies of specific feasibility.

Finally very useful is the identification of typical formula for costs evaluation, whose quantification in the preliminary stage showes where go to reduce them and for the management of a new maintenance line let program a correct financial plan.

* * *

References

1.	Gen.Isp. G.A.r.i. G.B. NICOLO', Col. G.A.r.i. L. GIORGIERI	Linee concettuali per la definizione di un progetto aeronautico.
2.	Gen.Isp. G.A.r.i. G.B. NICOLO'	Criteri per la valutazione della convenienza economica della produzione integrata multinazionale.
3.	Col. G.A.r.i. L. GIORGIERI	Metodologie di individuazione di un progetto aeronautico di efficacia/costo ottimale.
4.	Magg. G.A.r.i. M. FASSIO	Memoria tecnica per la valutazione comparata di radar di ricerca.
5.	A.R.S. BRAMWELL, Arnold	Helicopter dynamics.
6.	W.Z. STEPNIEWSKI L.M. SLOAN 5º R.E.R.A.P.L.A.F 1979	Some thoughts on design optimization of transport helicopters.