The relation between Weight and Direct Operating Costs of military helicopters

Direct Operating Cost (DOC) represents an essential metric for aircraft operators in order to properly assess and manage the life cycle costs of their helicopter. The purpose of this short article is to provide empirical demonstration that the known positive linear relation between weight and DOC holds true also in the case of military helicopters.

DOC: a summarising overview

It is debatable which elements of costs belong to DOC and which don’t, but it is accepted that DOC include those variable cost elements which depend on the aircraft itself (Scholz, 1998:1); these costs are attracted by that single, operational and accounting unit represented by the Flight Hour (FH). In this context, therefore, DOC include the cost of fuel and lubricants and Direct Maintenance Costs (DMC):

\[ \text{DOC}_{\text{FH}} = \text{Fuel}_{\text{FH}} + \text{Lubricants}_{\text{FH}} + \text{DMC}_{\text{FH}} \]

**Fuel** is the cost per FH and directly relates to aircraft gross weight (all other variables being constant, i.e. speed, pressure altitude, temperature, humidity) and the cost of fuel at the pump.

**Lubricants** is conventionally estimated at 3% to 4% of Fuel cost (HAI, 2001).

**DMC** is the cost of maintenance due to the FH (HAI, 2001:5); it is the sum of Airframe maintenance (labour and material) and Engine maintenance cost (labour and material). For the Airframe, labour and material are directly proportional to the Manufacturer Empty Weight (MEW)\(^1\) and the cost of the airframe. For the Engine, labour and material are directly proportional to the Thrust of the engine (Kundu, 2010:547). DMC include provisions for scheduled and unscheduled maintenance, repairable or discardable items, life limited components, overhaul and consumables. Inspections triggered by calendar events rather than FH, should not be accounted in the DMC. The labour element is derived from the aggregation of all required Maintenance Man Hours (MMH) divided by the amount of corresponding FH and multiplied by the labour rate.

The linear relation between DOC and MGTW

The positive linear relation between DOC and aircraft weight is known and, in its most common form, it is used to predict aircraft DOC at design stage (Westphal, Scholz, 1997:36; Kundu, 2010:547).

To discuss here which weight (MEW or MGTW) and elements of maintenance are linearly related and the theoretical grounds regulating the predicting relation, would require a much more detailed analysis, which lies outside the scope of this

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Let's therefore accept that DOC is correlated to Maximum Gross Take-off Weight (MGTW) and that MGTW is a strong predictor of DOC:

$$DOC_{FH} = K_1 + K_2 \times MGTW$$

The formula means that the DOC in US$ per FH is the sum of a constant value $K_1$ plus as many $K_2$ as the MGTW expressed in pounds; an increase of 1 lbs in MGTW contributes to DOC with $K_2$ US$.

**The case of military helicopters**

These relations are easily explored for civil helicopters through publicly available data, but it is more complex for military aircraft. Relevant weight information can be found, but the DOC is a concept which does not necessarily apply in the same way to military assets. Civil DOC include an element of maintenance which relates to the actual flight activity and to compliance with airworthiness regulations. In addition to that, military aircraft are also maintained to a prescribed level of operational readiness, thus potentially attracting costs which is not immediate to quantify and model. Finally, to provide statistical significance, it is required to access data extracted from a large fleet, composed of many types and as many units of the same type as possible and compiled with a consistent methodology. There is only one operator which makes this possible: the US Department of Defense.

The Office of the Under Secretary of Defense (Comptroller) publishes, every Fiscal Year, tables for the reimbursement for the use of Department of Defense (DoD) aircraft (OUSD, 2012). The tables report the Operations and Maintenance (O&M) chargeable rate within DoD, net of direct cost of military personnel and of asset utilisation. O&M can here represent a proxy for DOC. Data for the MGTW is available on the institutional websites of the Army, Navy and Air Force.

Correlation analysis between MGTW and O&M resulted in a strong positive correlation coefficient of $r=.950$, $p<0.01$; it means that the two variables are almost perfectly correlated and there is less than 1% probability that this relation occurs by chance. The scatterplot is shown in Figure 1.
Assuming a causal relation between the two variables, the Rates were regressed on the MGTW and the equation of the regression line (shown in Figure 1) resulted in the following:

\[ Rates_{FY2013} = 1054 + 0.184 \times MGTW \]

\[ p < 0.01; R^2 = 90.2 \]

It means that the O&M rates are approximately 1,054 US$ plus 0.184 US$ per lbs of MGTW; 90.2% of variations in Rates are explained by variations in MGTW and there is less than 1% probability that this relation occurs by chance.  

**Conclusions**

Based on the assumptions introduced in this analysis, it can be concluded that the linear relation between the weight of a helicopter and its operating costs holds true also in the case of military aircraft.

Although predictable, this result is not obvious and such an accurate relation was not expected. The reason is that in military design and engineering, mission systems are not an optional extra to be later installed, but often the key design driver to achieve specific operational performances. As in the case of heavily mission orientated helicopters (Huey Cobra, Apache, presidential H-3 and H-60 and MV-22B) the O&M costs are not necessarily related to weight, but are affected by a tight relation with the on-board systems, so that it is difficult to differentiate between maintenance of the airframe and of the mission equipment. It would have been reasonable to expect a weaker relation.

It is reasonable to accept that civil and military helicopters share so much in terms of design and engineering that the underlying link between operating cost...
and weight cannot be questioned, with few exceptions requiring focused analysis.

Direct Operating Costs confirm to be a key management tool for any operator and it is of paramount importance in financial planning to understand in detail what are their determinants, what they represent and how they behave. Whether in a civil or military environment, financial sustainability is, today more than in the past, the key enabler of the smooth and long lasting utilisation of any flying asset.

Notes

(1) The Manufacturer Empty Weight is the weight of the aircraft without any fluid, engines and any interior configuration. It can be calculated from the weight of the baseline configuration less the dry weight of the engines, the weight of any ballast, unusable fuel and lubricants. The dry weight of the engines can be found on the engine Type Certificate; the baseline weight can be found on the Flight Manual, Maintenance Manual, Weight and Balance Sheet, Flight Planning Guide or Marketing Technical Information.

(2) The correlation analysis highlighted four aircraft whose O&M were significantly far away from the regression line hence capable of affecting the robustness of the model. Those types were the AH-64, the VH-3D, the VH-60N and the CV22-B and were subsequently excluded from the analysis. The missions flown by these a/c are so peculiar that the on-board equipment heavily affect the O&M rates.

References


