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NEW HUMS PHILOSOPHY

BY

B.LACIPIERE
HELI-UNION, FRANCE

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INTRODUCTION

Life is the most precious thing we have. Science has enabled us to develop different systems to protect and to extend it. Life is also one of the reasons we love the helicopter. It is the first aircraft, which saves more lives than it causes deaths.
If death and sickness are a part of life and are unavoidable, the latter is sometimes predictable and curable.

During the course of our life we must, from time to time, go to the doctor to check our health. To do so the doctor has at his disposal special instruments that he adapts on our body to monitor or control some parts of it, the heart for instance. The doctor then analyzes the data and gives a diagnosis. The analysis and monitoring of our health allows us now to perform a preventive maintenance on our body and gives us quite more than just the "on condition" status. We can know with the help of an adequate system, monitor our body and know when it is necessary to change or repair a part before it breaks down.

★ A question appears: *Is it possible to use a similar concept to monitor the health of an aircraft?*

For helicopters, up to twenty years ago we were in the early stages of medicine. Like the old time doctor took a blood sample, we extracted a part of the blood of the helicopter to analyze it. We tried also, when we heard some noises to know if something was wrong, but without a stethoscope.
A big difference between humans and aircraft is that the aircraft parts have a known life limit. This turns out to be more expensive but safer than the "on condition" part. Only few parts are "on-condition", their accessibility permits an easy checking.

But around twenty years ago a new era awakened and that is the beginning of our story.

Science allowed to monitor the usage and later the health of an aircraft . The name of this new system is Health and Usage Monitoring System (HUMS). We now know how the helicopter is used and what is its state. The result is that we can perform a safer preventive and "on condition" maintenance.
As it often happens, we tried to go too fast and too far without sufficient experience. But now after many years of problem solving and lengthy studies, we have the new HUMS at our disposal. Its philosophy is different and it takes into account the need of the customers to understand the health, to pay a reasonable price that allows a quick Return On Investment (R.O.I.) and to have a system adapted to the aircraft type. The new system is designed to be used without interpretation by the on-line mechanic and also by the engineer, in order to apply a preventive and "on condition" maintenance.

So, for a better understanding, we need now to define and to look at the first HUMS before we see what has changed.

I. OLD HUMS

I.1. HUMS definition

The definition of the HUMS is not so easy and many who have tried to define this product have had some difficulties.

So to avoid any mistakes, we must first give a simple definition of *HUMS*, and then interpret the different ways to understand it :

- *HEALTH* : The detection and downloading to an Airborne System and/or a Ground Station of ground and flight vibration signatures coming from the aircraft (including the engine) that enables vibration health to be determined.

- *USAGE* : The automatic recording, on a Ground Station, of airframe hours, cycles, takeoffs/landings starts/stops enabling flight time computation. It also provides the monitoring of all the data included in the flight and maintenance manual that possesses specified thresholds.

- *MONITORING* : Surveying and storage of the data.

- *SYSTEM* : The complete assembly working as we want it.

When we read the definition of health, it appears that there are several and different ways to interpret what we mean by this.

I.2. Interpretation

What is the interpretation chosen for the first HUMS ?

In an effort to include all health parameters, the first systems attempted to monitor all the points which could be at the origin of an accident in case of health failure. That means all the gears, the bearings and shafts.

So, as you can see, there was no interpretation, *all the possible points of failure had to be monitored.*

I.3. What are the flaws of the old HUMS ?

This conception of the HUMS was very disappointing for the customer, the supplier and the manufacturer. The points to be monitored were too many and the vibration thresholds of a big part of them were unknown. The result was a very expensive system and a arduous technical challenge.

It also quickly became necessary to monitor the trends for which an engineer was necessary in order to analyze the results and pass them to the on-line mechanic. That also increased the investment.

The HUMS definition was too wide for an optimal search for added flight safety and did not take sufficiently into account the customers' and the manufacturer' experience. This definition should have avoided mixing the maintenance and the health (vibration monitoring of all the gears and bearings avoids the chips but it is the chip detection that avoids the accident). Indeed the repair costs could be decreased by removing the bearings or the gears before their deterioration started causing damage to other parts of the rotary assemblies, but at that price, was it really economically viable ?

In fact it was **not** ! At the price of the first systems it was almost impossible to have a positive return on investment.

This wide definition also included the engine. However, until today no HUMS followed the manufacturer's recommendations laid out in the maintenance manual (TURBOMECA manual) on how to monitor the engine vibration. No engine vibration monitoring system was approved nor correlated by the engine manufacturer. That showed clearly another problem of the old HUMS. The engine was not being monitored correctly.

During flight, the engine is well balanced. When something happens it is often too late. *The best way to monitor the engine vibration is* ***during the transient state (run-up)***, because that is the way to check the level of the critical frequencies hence providing **a pre-alarm or pre-alert warning**.

Another problem laid in the fact that *the old HUMS was not a modular tool.* The customer was forced to buy a complete system without having the possibility to choose between several options (i.e. Rotor Track and Balance for instance).

Therefore, when talking about health and flight safety, it *is necessary in some case to analyze the data* ***before*** *and not after the flight*. Similarly, in the case of the engine, the vibration analysis performed after or during the flight can be too late. The old HUMS did not take this point into account.

II. WHY A NEW HUMS?

II.1. Customers' needs

- Increased aircraft reliability and availability
- Enhanced flight safety
- Reduced "Direct Maintenance Cost" and "Direct Operation Cost" (DMC and DOC)
- Clear knowledge of current and future DMC and DOC

II.2. Manufacturers' needs

- Increased revenues (aircraft sales and margins)
- Provide safer and more reliable machines
- Meet customer needs through increased customer support
- Be better than the competition

II.3. The petroleum companies needs

- Increase aircraft availability
- Enhanced flight safety
- Reduced lease rates

II.4. What are the questions ?

What is the state of the aircraft and how it is being used ?

How to improve the flight safety ?

How to make a preventive maintenance (trends) and an "on condition" maintenance ?

How to be at an advantage with respect to the competition ?

How to reduce the DMC and DOC ?

How to monitor the relevant vibrations ?

II.5. What are the answers ?

A new system.

> It should be better in term of R.O.I. if it is *approved by the "Original Equipment Manufacturers"* (O.E.M.) who will have taken a part in its definition (algorithms, thresholds etc.) and will be willing to grant lower PBH rates and modified maintenance procedures to customers who have installed the system on their aircraft.

Assistance in training the pilots and the engineers.

III. A LOOK TO THE FUTURE : THE NEW HUMS -A DIFFERENT PHILOSOPHY.

III.1. Its arguments

- An affordable price (from 60 to 120 000 US$)

- Lower DMC and D.O.C. (preventive maintenance – "on condition" – personalized maintenance – Power By Hour (P.B.H.) decreased)

- Increases flight safety (monitors all the critical points and alerts the pilot before the failure even before the flight [engine])

- Gives precise information on how the aircraft is being used and on how it performs. Provides a better knowledge of some critical parts. So it gives a good or better knowledge of the aircraft (also in case of an investigation)

- Increases aircraft availability

- Provides a fast R.O.I.

- Decreases repair costs and inventories

- Enhances customers' support (computer network)

- Provides strategic advantages over competition

- Helps the engineers and the pilots

- A modular system, which allows to optimize a supply schedule (purchase of one specific part then another etc.) and performs the following functions:
  -***Vibration "on-condition"***: Possess all the accelerometers necessary to balance the aircraft vibrations and to monitor the engine vibrations. That means to monitor all the vibrations as determined by the manufacturers and set out in their maintenance manuals. This function is included
  in the HEALTH but it is also possible to add this function to a simple usage monitoring system. The system then performs a vibration monitoring "on condition" allowing to decrease the D.M.C. and the D.O.C.
  -***Vibration adjustment*** (R.T.& B.): The detection and downloading of flight vibration signatures and blade track information allows to adjust and optimize rotor system track and balance. This function is not a HUMS function but it increases the life of some parts or instruments. The ability to continuously tune out rotor induced vibrations results in a reduction of secondary damage to the airframe, avionics and drive train components cause by unbalanced rotors.

- Facilitated and improved workload of the engineers :
  -***An easy to use ground station***: A ground based computer terminal capable of processing downloaded aircraft HUMS data to produce reports/logs/trends. This system is added to obtain the results of the HUMS monitoring. It is an important part of HUMS due to its complexity or easiness to be used and interpreted if necessary. It is fundamental that this ground station be very convivial for the mechanic on-line (**go / no-go**) but that it also allows a more thorough analysis for a technical team in a central base.

III.2. The evolutions

III.2.1.Vibration monitoring

① Engine

The *engine vibration monitoring* with the "Power Assurance Check" (P.A.C)., the boroscopic inspection and the oil analysis provide information on the state of the engine and must avoid engine failure and power loss.

Some studies ascertain that on the airframe rotary assemblies, as the rotational speed is very low, the vibration monitoring is not always necessary to help prevent failures.

It is now possible to monitor the engine vibration as the manufacturers want it (mainly TURBOMECA). In the past the engine vibrations monitoring was made at the nominal or during the run-down (EURO-ARMS [slowing down too fast and not regulated by the pilot]), but never during run-up.

Now a new ***airborne*** "**E**ngine **V**ibration **M**onitoring **U**nit" (E.V.M.U) allows to monitor the engine vibration during run-up. This tool can be added to old HUMS, incorporated in new HUMS or stand alone.

That is really a very important point to improve flight safety, decrease the D.M.C. and the D.O.C. and monitor "on-condition" vibration.

As you know, the engine is also the component in which pilots have less confidence. Being able to monitor the engine's state and performance, will help the crew (both pilots and mechanics) to haven more confidence in the engine. The engine vibration monitoring is a way to do that.

② Airframe rotary assemblies

⇨***Insuring that the maintenance manual is being followed***

The first goal of the HUMS is to avoid failures by vibrations analysis. But when you analyze the results and the way the HUMS works, you understand that the one of the main results is the *monitoring of the maintenance*. In fact, you check if the maintenance manual is being followed. That is the most important work of HUMS. The helicopter is already certified without a HUMS; hence if the mechanic applies the maintenance manual there shouldn't be any problems. Only an incomplete certification by the manufacturers and/or the aviation authorities could cause an important failure. We know that it is highly unlikely.

The vibration monitoring of a few critical points, added to a strict compliance with the maintenance manual, will avoid failures. A simple vibration analysis that requires checking the alignment and primary unbalance of a shaft and in some critical cases brinelling (tail rotor drive shaft bearing for instance) or gear marking *will let you know if the maintenance is being properly done*. In this case, the thresholds are not very difficult to define and the work of the mechanic can easily be monitored by himself with the HUMS.

III.2.2. A new health definition

A SIMPLE DEFINITION OF THE HEALTH

Precise monitoring of specific points as defined by the manufacturers, with the input drawn from the customers' experience, whose purpose is to increase the flight safety and check the maintenance manual application. The first purpose is not to obtain a different type of maintenance.

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This point is very important because a big part of the price is linked to this definition and to the number of accelerometers and algorithms that are needed to monitor the vibrations. It is important to stress the difference between the flight safety (health), the personalized maintenance, the repair costs decrease. No accident in flight, to my knowledge, has been caused by the failure of a bearing or a gear inside the main gearbox (chips are detected by the chip detectors).
The question is : Is it really necessary to monitor all or a large part of the bearings and of the gears? Why monitor a component that you know will not fail ? The health monitoring starts with the chip detectors. The monitoring of these non-critical parts will only cause the price of the system to increase unnecessarily.

Only some very specific components are critical and need to be monitored.

The focus should be on monitoring those parts, or subsystems, of the aircraft that have a failure history. In the case of a new aircraft, who, at first, has a better knowledge of the critical parts than the manufacturer who has certified the aircraft ? Hence the purpose of the HUMS will be to prevent a failure and not to know exactly when a component will be worn out. The manufacturer knows that already.

So if we are able to improve the flight safety with a simple system, decrease the D.M.C. and D.O.C., provide a fast R.O.I., using an "on-condition" vibrations monitoring, we will have reached the first milestone.

III.2.3. The preventive maintenance and the "on condition"

With respect to the thresholds (some of which are now well known, the others being defined in the maintenance manuals) it is possible to have different trends for the airframe, the rotary assemblies and for the engine. For this one with the new *airborne* E.V.M.U, it is possible first to compare the vibration level to the threshold curve and *to obtain directly the result, without interpretation*, then ***to analyze engine and modules trends***.
In this case, it will soon be possible to apply preventive maintenance hence avoiding unnecessary inventory costs. It allows the operator to plan the exchange of a part around his operational commitments and *decreases the risk of aircraft unavailability.*
Furthermore, mainly for the engine, it reduces the repair costs as the part is removed prior to its failure which in some cases could cause damage to the surrounding components.

These are the advantages that will lead to a substantial decrease in the D.M.C and D.O.C.

III.2.4. A modular system

First, each aircraft manufacturer or operator has different requirements in terms of the way the parameters should be monitored, and which functions are to be incorporated into the HUMS. These requirements all translate into the necessity for a modular, upgradable system.

Second, HUMS has different components. We can easily talk about usage differently than we talk about health. So the main point is that it is now possible to start with an usage system and subsequently go to a HUMS system. But from the usage system it is also possible to go first to the vibration "on condition" (**h**UMS) and then to the complete health (**H**UMS). Eventually you can add the R.T.& B. function and obtain a complete and totally modular HUMS. You can also start with an Engine Vibration Monitoring System and go to a HUMS system.
I will not talk about the Ground Station, because to upgrade it, you only need to change the software.
The modularity allows you to choose from an UMS, an E.V.M.U., or a hUMS, for instance, to a complete HUMS and adapt to your financial possibilities.

III.3. The light helicopters

Why were there never talks about installing HUMS systems on light helicopters ? ***Is it because they carry less passengers ? Is it because light helicopters are safer ? ...***

A glance to the comparative U.S. civil helicopter safety trends and a G.F.H. analysis shows what is the truth.

Safety Statistics By Helicopter Type (Comparative U.S. Civil Helicopter Safety Trends through 1st quarter January 1 – March 31, 1999 – 1995 by H.A.I.)	**1999**	**1998**	**1997**	**1996**	**1995**
Estimated Total Flight Hours (in millions):					
Single Engine Turbine	0.341	0.337	0.328	0.321	0.305
Multi-Engine Turbine	0.114	0.110	0.107	0.062	0.102
Total Number of Accidents :					
Single Engine Turbine	19	16	13	14	13
Multi-Engine Turbine	3	1	2	1	4
Accident Rate per 100,000 Hours Flown:					
Single Engine Turbine	5.57	4.75	3.96	4.36	4.26
Multi-Engine Turbine	2.63	0.91	1.87	1.61	3.92

Analysis made by G.F.H.(Groupement Français de l'Hélicoptère), 1997.
Informations coming from EUROCOPTER-TURBOMECA-DGAC-DGAC/Monaco
Concerning F- registration helicopters (in and out french territory)

Characteristic Ratio	Single-Engine Turbine	Multi-Engine Turbine
Working helicopters	322	69
Flight hours	82 000	20 000
Accidents	26	1
Dead persons	14	
Injured persons	18	
Destroyed helicopters	18	
Accident/helicopter	1/14	1 / 69
Flight hours/accident	1 / 3 200 h	1 / 20 000 h
Flight hours/dead pers.	1 / 6 000 h	
Flight hours/injured pers.	1 / 4 600 h	
Flight hours/destroyed hel.	1 / 4 600 h	

... ***No, the answer is because old HUMS are too expensive.***

Is it really reasonable to look for measures to prevent accidents only on the more expensive helicopters? The answer is clearly no. If we believe the HUMS is essential then we must make sure it is available for the lighter machines as well.

Suppliers and manufacturers seem understand this requirement and are now trying to offer systems that can be adapted on different types of helicopters from the light to the heavy ones.

Regulation tends to make a difference between the different types of applications and the number of passengers, but should we do the same?

The answer is **no**, but only if there exist affordable systems that can pay for themselves rapidly.

It seems that we are now entering a new generation of HUMS offered at prices that have decreased substantially, hence bringing us closer to our goal

CONCLUSION

Safety is one of the most important points, but there is always an economic constrain to it. Maximizing profit remains the number one goal for a company. Hence we cannot ignore that aspect, close our eyes, and think that companies do not respect or want to improve safety. With the old HUMS the economic viability was just not there for the vast majority of aircraft. However now, with the advent of the new HUMS, we have the chance to maximize both.

I think the question is not, "do I install a HUMS on my helicopter?" but "what type of HUMS must be installed on my helicopter?". As you know, our requirements are not always exactly the same, so it is important to have the opportunity to choose a HUMS adapted to our helicopter and our missions. I believe a modular HUMS can help us achieve that and provide for a fast R.O.I..

Checking the health of a human being and of a helicopter is possible, but in the two cases the human factor must be taken into account, if not, the therapy could be unsuccessful.
Around 80% of the accident are due to pilot error, so our next goal should be to work to improve the help given to the pilot. He is not a machine, and is not perfect. Sometimes he has good ideas or reactions, sometimes bad ones. We must work to avoid the bad reactions or ideas and improve our knowledge of the pilot level and of the stress.
We invest a lot of money to try to decrease something like 20% of the crashes that are a result of mechanical breakdown. I think it is also possible with less money to try to work on the 80% that are due to pilot errors.

So it appears that an other way to increase the flight safety is to assist the pilot, not only to supervise, but also to check him. He needs help when all his attention is focused outside the helicopter, or when it is difficult for him to appreciate the outside situation. Some manufacturers and suppliers are taking this point into account and are designing new instruments or systems to assist the pilot.

We know some old functions to assist the pilot, like the cockpit voice alarm, the horn, the Electronic Flight Instrument System (E.F.I.S.) or the F.A.D.E.C. But now some new functions are available on the market, and I talk for instance about the obstacle avoidance warning system (diode laser), the carefree maneuvering system (hardening of the pitch) or the Vehicle and Engine Multifunction Display (V.E.M.D.).
We must have a look to the future and try to obtain a better flight safety with all this new systems and with some new ideas and developments, but we also need a decreasing of the costs and mainly of the DMC, DOC.

The new HUMS has arrived we can hope that like the "Beaujolais nouveau" it will become vastly popular as ***it is a way for the manufacturers and the suppliers to listen and help the customers.***

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