Automotive maintenance used to be about being able to take apart an engine, fix a carburetor, replace a fuel pump or accurately measure the gap in the points and plugs. Today it’s all about computerized diagnostics. Same thing with today’s digital helicopters – only more so.

Today’s new “Next Generation” helicopters are going all-digital, providing computerization from the all-glass cockpit to sensor-monitored dynamic components. Along with providing operators with enhanced performance and better economics, this is also allowing new Preventive Maintenance concepts that are more “New Age” than “Next Generation.”

Simply stated, this New Age PM means “using new technology and methodologies to improve the ease of maintaining the aircraft,” according to Larry Thimmesch, Bell Helicopter Textron’s Vice President for the 525 program.

“This concept uses trend analysis and preventive diagnostics, in conjunction with the latest technological innovations, to evolve the maintenance process from a manual to a reliability-centered approach,” he said.

And it doesn’t matter if the aircraft are Bell’s new Short Light Single 505 Jet Ranger X or the giant three-engine, seven-bladed USMC CH-53K King Stallion being built by Sikorsky. The fact that the new aircraft are going digital means that sensors can be put on a range of dynamic components to determine their specific maintenance requirements – knowing something is going wrong before it does.

The practice of replacing or overhauling a component based on number of hours flown or flight segments is being replaced with monitoring the components and repairing or replacing them based on actual need – on-condition. It is greatly expanding the capabilities already being used by Health and Usage Monitoring Systems (HUMS). And HUMS itself is time-based maintenance to condition-based maintenance. That is going to be a key part of changing the whole paradigm of maintenance in the future.”

These key sensors are distributed throughout the aircraft in the form of an Integrated Vehicle Health Monitoring System, of which HUMS is an integrated part. While HUMS monitors the loads and vibratory patterns of the dynamic components, the IVHMS combines the HUMS data with all of the onboard diagnostics data generated by assorted electrical/ electronic/avionics systems to provide a comprehensive view of the overall operation of the aircraft.

“The IVHMS is more of the mechanical systems – driveshaft, gearbox, temperatures, vibrations, blades—things like that,” said Mike Torok, Sikorsky VP for the CH-53K program.

“So in combination, those two systems generate a significant amount of data, and it is through that data that we develop a lot of fault detection, to find any fault and isolate it, making it easier to repair or replace. There are also cases where it eliminates false removals, which is another big issue on aircraft – removing good parts as we hunt for a problem.”

**Vibration Monitoring**

An example of the development of sensor monitoring of major components is a study being done by AgustaWestland and LORD Corporation on rotor hub wear, aimed at “improving the monitoring of rotor systems, in order to 1) further enhance safety by the early detection of incipient failures, and 2) reduce the
Component manufacturers are also increasing the capability to determine “wear and tear” on their products to increase maintenance that can be programmed into the scheduled maintenance program.

One of these is the elastomers used on rotor hub systems. Miller said LORD has now developed its own “marker layer” technology for elastomeric rotor hubs. This is based on the fact that degradation of many elastomeric rotor head parts results in fatigue cracks that grow in the rubber from the outer diameter to the inner diameter. A removal criterion is determined by measurements of crack depths, “which are very difficult to make.”

The LORD marker layer system is integrated into a bearing stack that includes a series of elastomeric layers sandwiched between non-elastomeric shim layers. At least one of these elastomeric layers includes a marker layer, a different-colored elastomer at a known depth from the surface, designed to indicate wear of the bearing through optically different characteristics. As the fatigue crack grows, the particles of the different-colored elastomer migrate into the crack, indicating when maintenance is needed.

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Vibration has, in fact, become a greatly increased area of consideration, with anti-vibration systems now going into virtually all helicopters bigger than light singles. In the old days, helicopter passengers were basically considered self-loading cargo, particularly for markets such as offshore oil and gas operations. Today, vibration control is considered important not only for passenger (and pilot) comfort, but also as a way to reduce maintenance costs associated with the vibration impact on aircraft components, from avionics to the airframe structure, as well as increasing time between overhauls (TBOs), while greatly decreasing the need for unscheduled maintenance.

As such, the manufacturers are designing in active vibration control systems at various levels. For instance, Sikorsky has designed its new S-76D with the capability to take up to six active vibration control boxes, allowing the customer to determine what degree of comfort they can afford and how much they want to reduce vibration-induced maintenance requirements.
to the surface of the part, indicating the part is approaching its life limit. This dramatically simplifies inspection, Miller said.

It's like the blue strip on a shaving razor that turns white to indicate the need to replace the shaving head.

While sensors and fault detection are becoming a major aspect of New Age maintenance capabilities, they are not only the items going into the design and production of "Next Gen" helicopters.

In designing the new helicopters, the OEMs are taking a page out of the fixed wing manual, learning from what the airliner manufacturers have been doing for years – using industry steering groups made up of a wide range of specialists within the industry to identify how best to design a single part or a major component. These finding are then fed into virtual reality CAD/CAM systems to design and build the new helicopter.

For the civil helicopter industry, OEMs are using the Maintenance Steering Group-3 (MSG-3) for the maintenance side of the equation. This basically determines the aircraft’s maintenance requirements from the beginning of its life to the end. These findings are then turned over to the industry steering group, where they find their way into the design of the aircraft.

On the military side – or at least NAVAIR – the MSG-3 is called the "Design for Maintainer Working Group," according to USMC Col. Hank Vanderborght, H-53 Program Manager. He said that numerous suggestions from the maintenance working group are already a part of the production phase. This includes enlarging access to the tail rotor gearbox to allow the maintainer to more easily initiate repairs, and moving the access panel to the fuel bladders from the top of the sponson to the belly to allow fuel pumps to be removed more easily and efficiently.

Vanderborght pointed out that on the CH-53E, predecessor to the -53K, the access panel had to be removed, the fuel pumped out of the fuel bladders, then air forced through the sponsor for 48 hours to remove the fumes so the maintainer could climb in and replace the fuel pump. “The maintainer said that 48 hours of downtime just to replace the fuel pumps makes no sense.”

On the -53K, the access panel on the belly of the sponson is removed, the fuel pump dropped down and disconnected, the new pump is attached and placed back in the sponson, and the access panel screwed back in place.

Bell’s Thimmesch said that in designing its new 525 Super Medium helicopter, it did things as simple as designing it so that any repair could be made using basic tools found in any commercial aerospace tool box. It also designed the aircraft to minimize the need to remove major structural access panels and unrelated system components to gain access to troubleshoot, remove, inspect, clean and reinstall the many line replaceable units (LRUs).

Thimmesch also noted that Bell is the first helicopter OEM to place RFID tags on all parts for the 525. This provides “quick and easy access to technical data on the part [as well as] improve the management of critical components by increasing the accuracy of information while decreasing the costs of compiling the information.”

**Virtual Reality Planning**

While the use of virtual reality design and manufacturing tools such as the Computer Aided-Three-dimensional Interactive Application (CATIA) developed by Dassault Systèmes have been around since the 1980s, it is just now becoming instrumental in the helicopter industry in the area of improved maintenance requirements.

“We’ve always heard the idea of ‘build it before you build it’ through virtual reality,” Torok said. “But the idea of ‘maintain it before you maintain it’ is equally true here for getting that early forward look when it is much easier to adapt and manage it.”

Physical changes to the helicopters are not the only changes taking places. New maintenance management software is being introduced, aimed at making the entire process easier, more effective and more economically viable.

Essentially, this software takes charge as soon as a problem is reported, determining the parts that will be needed and calling up the appropriate procedures to correct it. The software then orders the parts and tracks them from the producer to the maintenance floor, allowing both the mechanics and the maintenance managers to know exactly where the parts are in the process and the estimated time at which they will be in the mechanics’ hands.

But that’s a story for another day.

**About the Author**

Douglas Nelms is a retired Army rotary-wing pilot, and previously served as the managing editor of Rotor & Wing magazine. He is now a freelance writer for publications such as Rotor & Wing, Business & Commercial Aviation and Aviation Maintenance, specializing in all phases of the helicopter industry, including writing pilot reports on new civil and military helicopters. He can be contacted at dwnelms@msn.com.