

LORD Corporation: Creating Product Value

By Douglas Nelms



By the 1920s, the automobile was a viable mode of transportation, albeit with problems yet to be worked out. One flaw was the loud squealing of metal-on-metal contact at the leaf spring joints that supported the car's body. Early attempts to resolve this by attaching rubber to the metal failed. The vulcanized rubber used as a damper would not adhere to the metal, pulling away as it cooled.

Then, in 1924, Hugh Lord, a patent attorney in Erie, Pennsylvania, began working on the problem of bonding rubber to metal. By 1927 he had found the solution; a way to make rubber bushings that could be inserted into the eyes of the leaf springs to carry the weight. That year he made his first sale — rubber mountings for the air compressors of trolley cars being produced by General Electric.

The ability to bond rubber to metal to form industrial mountings became the legacy of the LORD Corporation, with those rubber mountings leading to the development of engine mountings for both automobiles and aircraft, and later for the instruments used in aircraft.

In the 1950s, Donald Alstadt, who would become Chairman of LORD

LORD Corporation is headquartered in Cary, North Carolina (shown). It also has a major plant in Erie, Pennsylvania, where it was founded. (LORD photo)

Corporation, invented a revolutionary rubber-to-metal adhesive under the trade name Chemlok. In 1960, Tom Lord, son of and successor to Hugh Lord, took that product worldwide, turning LORD Corporation into an international company. Today, according to LORD Corporation President and CEO Edward Auslander, "everything that moves, from

a train to a plane, automobiles, buses, trucks, have a LORD product on them. Everything except cars made in Iran."

That includes helicopters, going back to the reciprocating engine helicopters of the 1950s. He also noted that, "all of our competitors use our Chemlok adhesive."

Since then, the company has



The company was founded by Hugh Lord (left) in 1924; his son Thomas Lord (right) then led the company from 1960 to 1989. Today, 55% of the company's sales are outside the US. (LORD photo)



Circular Force Generators (CFG) are a more effective type of Active Vibration Control System (AVCS) particularly suited for medium and larger rotorcraft. (LORD photo)

developed a wide variety of helicopter components designed to reduce noise and vibration, or to eliminate mechanical bearings with limited lifetimes. LORD is currently working on a revolutionary type of Active Vibration Control Systems (AVCS) that uses Circular Force Generators (CFG) to give the helicopter omni-directional vibration suppression rather than lineal vibration suppression. This new system is being used to help the company move even more into the global market, Auslander said.

Tom Lord took over the company after his father's death in 1952, continuing to run the company under a family management environment until his own death in 1989. At that point, the company began moving into more of a professional environment, Auslander said. In 2002, Richard McNeel was named President and CEO, and started taking the company into an even more global business direction, "focusing on business processes and emerging markets." Between 2002 and 2012, the company opened plants in China and Germany, and established regional headquarters in Geneva and Hong Kong. Today, 55% of the company's sales are outside the United States.

LORD also recently signed with AOG Heliservices to support its worldwide operations. AOG Heliservices will serve as its global distributor for the company's elastomeric helicopter components, reducing direct operating costs while improving the service life of helicopter parts, according to Rodolphe Leroy, LORD's Manager of Global

Sales, Business Development and Marketing for the Aftermarket.

Auslander took over the leadership in January 2013. "We saw very clearly in 2013 what is happening today. It is a much slower economy, a much slower emerging marketplace, very uncertain economic environment, and very uncertain global environment. So in the middle of 2013, we changed a lot. We went from

an internally focused company that was focusing on business processes to an externally focused company focused on growth. Not only focusing on our core business, but growing into some adjacent markets, adjacent applications, adjacent technologies and products."

Diversification

Today, the company's business is half mechanical- and electro-mechanical-oriented, and half

chemically-oriented. Those two halves are further divided up into one-third aerospace and defense, one-third industrial and one-third automotive.

Although emerging markets are weaker than they were, LORD Corporation, "is still very actively pursuing international emerging markets," Auslander said. "Even though China is slowing, we know it will be a gigantic economy in the future, so we continue to invest there."

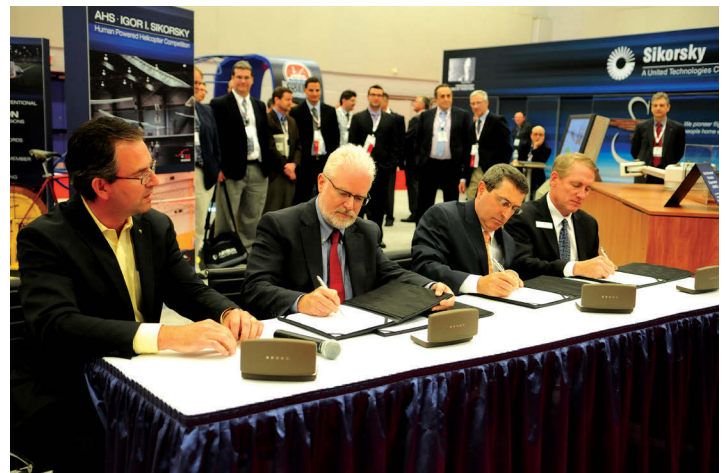
The company

expects a bright future for the rotary-wing industry. In fact, the company works with and supplies every commercial helicopter company in the world, "except that we don't do any business with any helicopter company in China," he said. However, LORD does support chemical manufacturing and parts for industrial customers in China.

In Asia, LORD is working with Korea Aerospace Industries, putting its AVCS on the KUH-Medevac, a variant of the KUH-1 Surion.

Auslander said that to counter the slow growth in today's worldwide economy, the company has prioritized 10 investment areas, "ten growth programs that we are continuing to invest in significantly to expand beyond our core markets into some new markets."

One example is that the company is getting back into the oil and gas industry. LORD had a heavy presence in that industry back in the 1970s and '80s, but decided to get out of it to focus more on the aerospace industry. However, after taking another look 20 years later, "we realized that the oil and gas industry had never really evolved in vibration or motion control. So we are taking our aerospace technology that's 20 years advanced back into that market — and having a lot of success."



Forum 70 in Montréal was the venue for Sikorsky and LORD to sign an agreement to commercialize HMVS technology. (Top: AHS photo. Left: Sikorsky photo.)



The computer-controlled HMVS active vibration management solution (right) puts counter-rotating masses near the main rotor in place of a heavy, passive bifilar (left). (AHS photo)

One area involves the extremely powerful impact of waves and tides against the pylons of oilrigs. "Think about a main rotor bearing for a helicopter," he said. "Now blow that picture up to about six feet [2 m] in diameter. We are providing products just like that, high capacity laminated bearings to control the motion of oil platforms. The tendons get connected to the ocean floor and into the platform, allowing it to absorb the motions of the waves and the tides. So instead of mechanical bearings for that, they are elastomeric bearings. That's all LORD helicopter bearing technology."

Today, LORD is developing components for all the major helicopter manufacturers, except those in China. In the United States, the company is working with original equipment manufacturers (OEMs) on the next generation of aircraft: Sikorsky on SB-1 Defiant and the S-97 Raider, with Bell on the 525 Relentless and V-280 Valor.

Along with vibration and noise control, LORD is getting into the systems sensing field, allowing helicopter on-board computers to detect problems on a growing number of components. Three years ago LORD bought MicroStrain, a company developing sensor systems, wireless sensing and data tracking "where you can track and analyze through the cloud using our sensor cloud technology," Auslander said. MicroStrain had been involved in programs to flight-test a range of energy harvesting and wireless devices embedded in helicopter rotor head key components, as well as vibration measurement devices on platforms such as the V-22.

In early 2014, LORD also acquired Stellar Technologies, saying at the time

that Stellar's "pressure, load, force, torque, displacement and temperature products are highly complementary to LORD Corporation's existing capabilities in sensing systems and motion control technologies.

Looking Outside the Box

As previously mentioned, LORD's big thing now is the Circular Force Generators (CFG) for its Active Vibration Control Systems. Developed by Dr. Mark Jolly, Senior Manager of Mechanical and Sensing Research and Development at LORD, the CFG systems are placed on the transmission and rotor head.

Auslander noted that the AVCS has now become standard on almost any new helicopter. However, current helicopters using AVCS tend to have the system components mounted either in the floor or sides of the cabin, or in the cockpit area. This means that vibration

reduction is limited to those areas.

Future systems will move the AVCS components up the mast toward the rotor hub, "Or in some cases even into the rotor itself," said Lane Miller, VP, Global Technologies at LORD. "The rotor is the source of the vibration; so intuitively, the closer you get to the source of the vibration, the more effective the system becomes."

"The idea is that the rotor head and gear box are vibrating, and that causes the whole aircraft to vibrate," he said. "If you can magically grab a hold of that vibration with these actuators and make it sit still, you'll get essentially zero vibration everywhere."

Miller noted that this new concept is a scaled-up version of the latest generation of active vibration control that's going on the AgustaWestland AW139 and Bell's 525. "So we are moving

our latest technology up toward the gearbox."

When a helicopter lifts up to a hover, a lot of the vibration in the cabin is vertical. But as the helicopter starts to move forward and accelerate, that vibration is no longer truly vertical — there is fore and aft, and lateral. Generally the vibration is very high in hover, but it goes down and changes direction, then comes back up as you approach cruise speed, he said. "At that point, the direction of the fuselage vibrations is in three dimensions. The paradigm of having a fixed force in only one direction really is a limiting factor. With the circular forces we can actually handle that variation much more



In 2012, LORD bought MicroStrain, a company developing sensor systems, wireless sensing and data tracking. (LORD photo)

effectively.”

However, as the vibration suppression systems moves out of the cabin and up the gearbox and rotor system, it is dealing with greater forces and the criticality of vibration cancellation becomes more significant. “So we are designing hardware, electronics and software to increasingly higher levels of reliability and safety criticality because of that.”

LORD is currently working with Sikorsky to develop a Hub Mounted Vibration Suppression (HMVS) system as part of Sikorsky’s “Zero-Vibe” program that will have CFGs mounted in the hub and in the fuselage near the main gearbox.

Bill Welsh, Dynamics Technical Fellow at Sikorsky, noted that the linear force generator is not necessarily better or worse at vibration suppression than the CFG, but devices that produce a linear force are often heavier. Both devices use spinning masses, but unlike the CFG, a linear force generator uses two counter-rotating spinning eccentric masses at the end of a radius that are mechanically tied together.

“When the two counter-rotating masses are opposed to each other in their cycles, they don’t produce a load. It’s when they are up and down together, or linear, that they produce the load that counters the vibration. In getting two wheels, one going clockwise and one going counter-clockwise, it takes weight to do that. It’s dead weight that you don’t want. CFGs are more weight-efficient.”

In the AVCS with LORD CFGs, the actuators are near the rotor drive system, with sensors monitoring the rotor speed and position distributed throughout the fuselage. Douglas Swanson, an engineering fellow at LORD, explained that the accelerometers used as vibration sensors measure the vibrations correlated with the main rotor speed sensor. That information is then sent to the electronic controller, processing through a vibration control algorithm, which takes the information from the sensors to determine the source of the vibration. That then goes to the circular force generator, which negates and suppresses the vibration wave.

This system weighs less than the older linear systems, and works well with the new variable rotor speed helicopters being developed, Swanson said.

Along with weight reduction, the AVCS with CFG requires less power. It also needs fewer actuators per helicopter. For instance, to get virtually zero vibration on a UH-60 Black Hawk, it would require eight linear force generators, but only four of the CFGs, plus the HMVS on the rotor head, Welsh said.

Testing and Adapting

Sikorsky and LORD did early testing of the HMVS system with CFGs using a CH-3 fuselage test rig at the LORD facility in Cary, North Carolina. This was followed by a flight test on a UH-60A Black Hawk in 2013-2014, conducted by the Army’s Aviation Development Directorate-Aviation Applied Technology Directorate (ADD-AATD) flight test facility at Ft. Eustis, Virginia, with Sikorsky and LORD.

That test was finished last year, with the results of the testing published in a paper, “Ground and Flight Testing of a Hub Mounted Vibration System,” presented at the 70th Annual AHS Forum in May 2014. Forum 70 was also the venue for Sikorsky and LORD to sign an agreement to commercialize HMVS technology.

The HMVS flight testing, completed in March 2014, was performed as part of the Active Rotor Component Demonstration (ARCD) program, a joint effort among AATD, Sikorsky Aircraft and LORD Corporation. Flight testing included progression from a hover to 150 kt (278 km/hr), auto-rotations and 60° angle-of-bank turns. Successful testing in the maneuvering conditions proved the HMVS technology suppressed vibration even in the most dynamic flight conditions.

The HMVS cancels the largest vibratory loads near the source of the vibration, the main rotor hub, thus keeping the loads from propagating



LORD acquired Stellar Technologies — a systems sensing company focused on pressure transducers — in 2014. (LORD photo)

into the airframe. In preliminary flight testing, the HMVS was found to reduce vibration significantly, with a 30% weight reduction. For its groundbreaking work, the LORD-Sikorsky-Army “Hub Mounted Vibration Suppressor Design and Test Team,” received the AHS Grover E. Bell Award, given for “outstanding research and experimentation contribution to the field of vertical flight development,” at Forum 71 in May 2015.

A second test to demonstrate the Zero-Vibe helicopter concept is now underway, under the Combat Tempered Platform Demonstration (CTPD). Marcus Cappelli, Sikorsky’s program manager for CTPD, said that for the second test there will be multiple CFGs near the main gearbox and an HMVS on the main rotor hub. The biggest vibratory loads come from the rotor, with six loads, one from every direction. The multiple CFGs, plus the HMVS, cancel those six loads.

While the ideal situation would be for all the CFGs to be on the rotor hub, they are simply too big. “If someone could invent a CFG or another type of force generator that is as small as a pack of cigarettes, we’d put them right on the rotor head on every helicopter,” Welsh said. “But nobody has invented such a thing. The units we now have are several inches in diameter, so if you put them up there they would induce drag, so we put them on the gearbox.”

The AVCS is adaptable to any size helicopter, and LORD currently has



LORD President and CEO Edward Auslander states that "everything that moves, from a train to a plane, automobiles, buses, trucks, have a LORD product on them." (LORD photo)

testing going on with small, medium and large aircraft.

Mike Janowski, manager, electromechanical technology at LORD, is working on a new Improved Vibration Control System (IVCS) for the CH-47 Chinook. He noted that the IVCS is essentially two CFG AVCS "back-to-back." This replaces the old self-tuning vibration absorber on older CH-47s, and means better performance and weight savings for the customer, he said.

LORD will start serial production of the IVCS during 2016, and it is a "drop in" system, so that both the new generation CH-47F and MH-47G can be retrofitted, Janowski said.

The AVCS with LORD CFGs has already been certified by the European Aviation Safety Agency (EASA), and the company said that it expects Federal Aviation Administration (FAA) certification sometime during 2016. A paper on "Active Vibration Control Using Circular Force Generators" was presented at the 2015 European Rotorcraft Forum in Munich, Germany.

A major factor in LORD Corporation's success over roughly the past century has not been its ability to patent new inventions, but rather its ability to transform invention into innovation that betters their customer's products that they produce and develop, Auslander said. "We put zero value on invention. We could care less about invention. All we focus on is innovation and transforming that idea into value for our customers. If it ends up in a product that's providing value, that's what it's all about."

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.



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