Straight, Flush

U.S. Air Force photo by Master Sgt. Donald R. Allen

The Creare fastener measurement tool uses lasers to save time and money

The composite panels that make up the skin of the F-35 Lightning II are attached to its frame with tens of thousands of fasteners. To ensure that the aircraft meets operational specifications, every one of these fasteners needs to sit flush relative to the skin's surface. Even a single high fastener, if not caught until the later stages of the manufacturing process, would require the aircraft to be put back on the assembly line.

For full-rate production of the F-35, operators must install and fill 30,000 fasteners per day. Historically, the methods used for inspecting fastener features

lacked accuracy, speed, and repeatability. Traditional handheld gauges were time-consuming and prone to operator-induced errors, while previous generation laser-line scanners could only probe a single cross-section of the part, which failed to capture the complex surface curvature.

"The aircraft has many, many holes to keep the skin in place on the sub-structure," said James Poindexter, Program Manager at the Air Force Research Laboratory, "and there's a tight requirement to measure them before they're filled, and then again after they are filled, to make sure all the holes meet their tolerance specification. The operators were using handheld gauges, like a tire pressure gauge, which would take about eight seconds to manually record a measurement for each hole."

The F-35 team at Lockheed Martin and Northrop Grumman needed a better, quicker solution for fastener inspection. As a result, engineering research and development firm Creare, under multiple Small Business Innovation Research (SBIR) contracts from the Air Force and Navy, with support from the Air Force Manufacturing Technology (ManTech) program, developed the handheld fastener measurement tool.

Fast, easy to use, and highly accurate, the fastener measurement tool works by projecting multiple laser lines onto the surface of the aircraft and imaging the resulting pattern with a camera. This technique, called structured lighting, can rapidly provide 3-D measurements of fastener profiles.

"The tool allows for measurement of the depth of a fastener once it has been put in an aircraft panel, which is not quite as simple as it sounds," said Dave Kynor, principal engineer at Creare. "You can imagine an aircraft panel is inevitably curved, and it might be curved in two directions. Then you put this fastener in, and you want to know how far it lies below the surface panel."

Initial SBIR funding to build the fastener measurement tool began in 2013. Creare spent the next four years performing technology development, testing, and demonstration in close collaboration with partners at Lockheed Martin. Toward the end of the Phase II contracts, the technology was transitioned to Creare's affiliate company, Edare, for production, sales, and subsequent technical support. Last year, Lockheed Martin placed the first order of 18 systems with the expectations that additional sales will follow.

"Creare was obviously the best company for the job, since they had done previous work for the Navy in this area," said Poindexter. "In addition, Lockheed afforded Creare the time to bring the prototypes that were being developed to the shop floor to gather real-world data and feedback."

Creare's system has been identified as one of the key technologies needed to meet the F-35 production rate goals for the U.S. Department of Defense.

Based in Hanover, New Hampshire, Creare was founded in 1961. Their focus was on technology commercialization. The company has a long-running history with the SBIR program since it began in 1982. Their contracts include success stories like a cryocooler for the Hubble Space Telescope, a spin-off dedicated to micromachining, licensing of Envelop® protective coverings, and delivery of specialized equipment for aircraft carrier catapults.

Kynor joined the company over twenty years ago, bringing with him an expertise in biomedical engineering, and began work on an intraoperative imaging system that employed structured lighting. The device incorporated laser scanning capability into a surgical laparoscope to provide highly detailed, real-time 3-D measurements of organ shape and position.

Eventually, Creare found other applications for structured lighting, including underwater imaging for the Navy and aircraft inspection for the Air Force. The technique projects a known pattern of light from a laser source onto a surface. The pattern then gets captured by a camera positioned at an oblique angle. A laser line

Photo courtesy Creare

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projected onto a flat surface would appear straight, but any uneven topography distorts the shape of the line. Thus, the deformed pattern captured by the camera is able to give detailed depth and surface information.

For the fastener management tool, Creare's engineers faced the challenge of packing the structured lighting system into a handheld device that needed to calculate results very quickly. Because operators are always moving around the production floor, the system—including its processor—had to be contained in a portable device. Kynor and his colleagues eventually went with a high-speed, battery-operated processor tethered to a belt pack, and managed to whittle the acquisition time down to two seconds for a go/no-go indication.

"When we scan the fastener, we get well in excess of 50,000 3-D points, and there is a lot of fitting and image processing involved to provide the inspector with a go/no-go answer," said Kynor. "Getting the processing time down to an acceptable value was really complicated, and took a significant effort."

Another challenge was making the fastener measurements highly accurate and repeatable in a portable, handheld device. They decided to add rubber feet on the tool so it would sit on the aircraft's surface at a known distance. The final device has repeatability that is better than 1/1000th of an inch.

Creare's system has been identified as one of the key technologies needed to meet the F-35 production rate goals for the U.S. Department of Defense. Since receiving the first units in September, 2017, Lockheed Martin has trained more than 100 people in how to use the tool. The main impact will likely be a reduction of labor costs and manufacturing cycle time. Lockheed Martin anticipates that the application of the technology on unfilled fasteners alone will lead to significant savings in time, with further savings expected when the device is expanded to measure filled fastener flushness.

"The SBIR funding itself was very important, but the Air Force involvement also facilitated a process where we got connected to key stakeholders at both Lockheed and the Air Force," said Kynor. "We went through a formal research and development methodology with design reviews, and that process was incredibly valuable."

Creare, Inc.

Modernization Priority: General Warfighting Requirements (GWR)

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