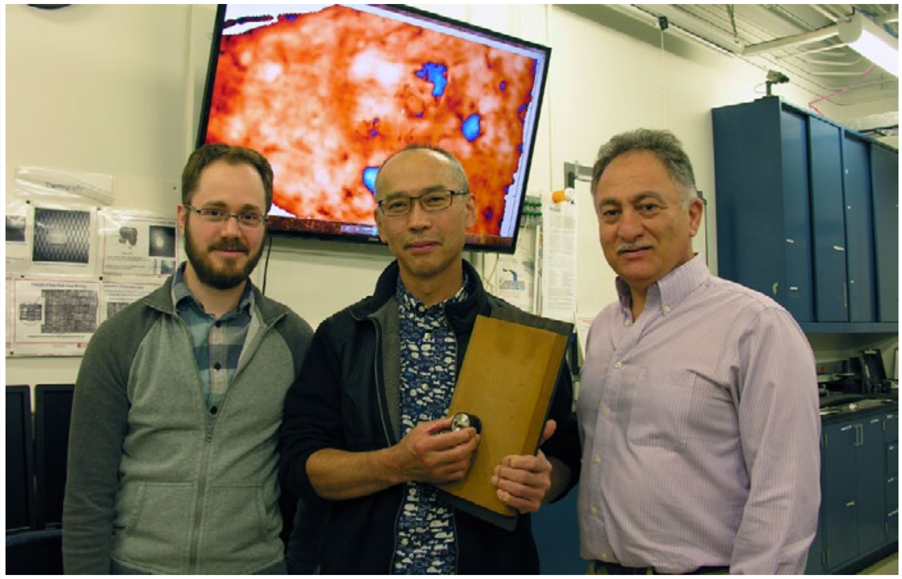
Orbiter
November 2016

Testing an Impenetrable Shield

by **Gabriel A Spera**
November 21, 2016

In just a few years, NASA's Orion space capsule will transport its first crew of astronauts into deep space. When it comes screeching back through Earth's atmosphere, it will generate temperatures hot enough to melt rock. To protect the capsule and its inhabitants, Orion is equipped with an advanced heat shield designed to endure the extreme conditions of the rapid descent. In fact, it's so effective, even sound has a hard time penetrating it.



From left, Dr. Toby Case, Dr. Yong Kim, and Dr. Shant Kenderian, of the Space Materials Laboratory, developed a nondestructive technique for examining the bond quality on the Orion heat shield. Here they are shown with the ultrasonic transducer and a sample of the heat-shield material; the monitor behind them shows the type of imagery produced by the technique. (Photo: Jasen Ross)

That's a problem, at least here on Earth. The heat shield is a critical component, and needs to be thoroughly tested before flight, as the slightest flaw can be catastrophic. NASA tried many methods to probe the heat shield material, with limited success. Traditional nondestructive methods, such as x-ray and ultrasonic inspection, were simply not up to the task.

NASA then asked Aerospace to apply its considerable expertise in nondestructive evaluation (NDE). According to Dr. Shant Kenderian, director of the Materials Processing Department in the Space Materials Laboratory, Aerospace has a reputation for tackling the most frustrating testing problems. "The NDE staff routinely takes on inspection challenges that other experts have deemed undoable," he said. "The easy ones don't come to us."

NASA supplied samples of the heat shield material, with known defects in them. Working with these samples, Kenderian's team arrived at a unique technical solution: they combined a special low-frequency wave generator with signal processing techniques that allowed them to tailor the frequency, duration, size, and shape of ultrasonic bursts. By processing multiple echoes from a single scan, they were able to detect relative changes in the bonding region, regardless of the material uniformity. Using additional information from the phase of the reflected waves, they were able to outline each flaw with high precision.

Incorporating all these techniques into a single prototype system enabled the team to create highly accurate maps showing the location, size, and shape of poorly bonded regions, simply by performing a two-dimensional ultrasound scan of the heat shield's exterior.

Developing the technique even further, Aerospace built and demonstrated a portable unit for use in the field. The heat shield material cannot be easily removed from the vehicle without causing damage, but NASA engineers can use the hand-held probe to scan the structure and get images back in real time.

"Aerospace has one of the most advanced NDE laboratories in the country," Kenderian said. "Not only is it equipped with a wide range of capabilities, but it is run by an innovative staff with advanced degrees in materials science, physics, electrical engineering, and mechanical engineering."

The Aerospace technique was successfully demonstrated on a manufacturing design unit. The effort will enable NASA to verify and repair, as necessary, the heat-shield construction and make well-informed risk assessments for the future. It may also serve to save astronaut lives.

"This project is a prime example of the role Aerospace can play in solving critical problems on a national level," Kenderian said.

In recognition of this innovative work, NASA presented Kenderian the Engineering Excellence Award at a ceremony at Langley Research Center on Nov. 17, while the whole Aerospace team along with NASA staff received a Team Award.

Aerospace Develops New Method to Detect 3-D Printing Mistakes

by **Gabriel A Spera**
November 15, 2016

Additive manufacturing (also known as 3-D printing) can create parts with complex geometries, building them up one layer at a time. One common version uses a laser to fuse or sinter powdered composites. The technique has been gaining popularity, in part because it can rapidly produce unique components with complex shapes that have customized and graded material properties. In many cases, multiple parts can be combined without the need for subsequent assembly and bonding.

Bill Hansen, who has since retired, works with equipment used to detect defects as 3-D printed products are being made. (Photo: Eric Hamburg)

Space system designers are eager to adopt the technology; however, certifying the processes and products remains a challenge. Variations in equipment, the way the tooling is used, and the source-material attributes can affect the final component quality and reliability. When errors and defects do creep in, they are typically not detected until well after production, using conventional testing techniques.

Dr. Henry Helvajian, senior scientist with the Center for Laser Material Processing (part of the Space Materials Laboratory), has been looking for ways to detect manufacturing defects during the manufacturing process itself. He and his team (Dr. Anthony Manzo, William Hansen, who retired this summer, and Lee Steffeney) have developed a laser-based ultrasound system to measure temperature and surface finish at the build location, with pinpoint accuracy.

"We rely on the fact that the speed of sound in materials depends on the temperature of the material that it travels through," Helvajian explained. The technique uses a pulsed laser to generate ultrasound waves (greater than 10 megahertz) and monitors a specific wave mode that travels along the surface, typically called a Rayleigh wave. By measuring the arrival time of this Rayleigh wave, it is possible to discern the temperature of the zone through which it travelled.

"To sense the arrival time, we had to develop a surface-displacement sensor that could measure down to several angstroms, since acoustic waves do not displace the surface very much," Helvajian said. "We applied the technology used in FM radios, which is heterodyning, and put it into the optical domain, so that with two lasers (the ultrasound source and the sensor source) placed in very close proximity about the build zone, we can measure the local temperature in between." Also, by analyzing the frequency content of the sensed-wave packet, the system can discern which waves were scattered (i.e., never reached the sensor), and this provides information regarding the surface roughness of the sampled area.

The team has tested the technique using both a calibrated heat source and a laser-beam heat source to verify the ability to measure relative temperature changes and a commercial surface profilometer to verify the surface roughness results. "We have shown that the technique works on flat and curved surfaces and are now exploring how to image embedded defects," Helvajian said. "We have also built logic circuits that give the temperature information on a time scale that allows us to make corrections, if necessary."

The experimental results have recently been accepted for publication in the peer-reviewed *Journal of Laser Applications.* **"**Pulsed Laser Ultrasonic Excitation and Heterodyne Detection for In Situ Process Control in Laser 3D Manufacturing," by Anthony J. Manzo and Henry Helvajian will be published later this year.

One long-term goal is to design a system that will not only detect anomalies and defects, but correct them as part of the process. In this case, signals from the sensors would activate a tertiary laser to repair the build. A detailed record, correlated to the 3-D tool-path for that build, would indicate the exact locations of temperature anomalies and subsequent repairs to aid in qualification and certification. This would require circuitry fast enough to keep up with high-speed additive manufacturing tools. "This may require the development of specific DSP [digital signal processor] chips, which will require that we collaborate with electronic circuit developers," Helvajian said.

The technology can be adapted to all types of 3-D processing (e.g., laser or electron beam) as well as conventional processing (e.g., machining where surface roughness information might be desired). It has already spawned two patent applications and has been awarded two Small Business Technology Transfer Research grants from the U.S. Navy to spur further development. "We also have the interest of a laser company that wants to collaborate with us to help build the next generation of 3-D printers," Helvajian said.

Awards and Recognitions, November 2016

by **Gail Kellner**
November 04, 2016

Aerospace employees frequently earn recognition for their professional accomplishments. This Orbiter feature acknowledges those honors and awards, including the publication of books. To nominate someone for consideration in this section, send details of the award in a timely fashion to orbiter@aero.org, or contact Gail Kellner at gail.d.kellner@aero.org.

Mark Bender

Mark Bender, systems director, Alternative Launch Vehicles, received NASA's Silver Snoopy Award, the astronaut's personal achievement award for professional excellence.

Col. Robert L. Behnken, U.S Air Force officer and NASA astronaut, presented the award to Bender on Oct. 5 for outstanding achievements related to human flight safety or mission success.

The award citation is "for professionalism, dedication, and outstanding support that greatly enhanced space flight safety and mission success."

Behnken said in a letter to Bender that "his efforts have enabled a diverse team of engineering experts, representing various technical disciplines, to share detailed technical insight into the evolving commercial launch systems designs for U.S. government customers." In addition, he said that "Bender's continual collaboration with NASA helps to ensure the success of the nation's goal to restore American capability to safely launch astronauts from U.S. soil to the International Space Station."

Terry Rector

Terry Rector, senior project engineer, MILSATCOM Division, received an Outstanding Service Award from the International Council on Systems Engineering (INCOSE) in July.

The award is for outstanding service to the Los Angeles Chapter of INCOSE and promotion of systems engineering and technical education through leadership of the Conference of Systems Engineering Research (2011 and 2014) and the regional mini-conference (2016).

Marilee Wheaton

Marilee Wheaton, systems engineering fellow, Systems Engineering Division, will receive the 2016 Volunteer Service Award from the Oviatt Library, California State University at Northridge on Nov. 18. She is being honored for her service to Women in Science and Engineering (WISE). Wheaton is a current member of the advisory board for the Bonnie J. Campbell Endowment for WISE and also a past president for the WISE board.

The WISE mission is to encourage women to build careers in the fields of science and engineering; to advance in their careers; to preserve the story of women who have pioneered in the science and engineering disciplines; and to inform leaders and educators about the contributions women make to these fields.

Dr. Chris Tschan

Dr. Chris Tschan, Systems Integration and Protection, Vaeros Operations, has been selected to receive the American Institute of Aeronautics and Astronautics (AIAA) Intelligent Systems Technical Committee Distinguished Service Award for his service for the past three years (2013-2016). He was selected by his peers in government, industry, and academia to be officially recognized in January 2017.

As a chair for the committee, Tschan advocated for and edited a technology roadmap that articulates a vision for intelligent systems and provides recommendations for increased research to overcome technology barriers. This resulted in the first edition of the "AIAA Roadmap for Intelligent Systems in Aerospace," released in June 2016.

Dr. Bob Minnichelli

Dr. Bob Minnichelli, principal director, Systems Engineering Division, received the 2016 Excellence in Arts Award for Drama and Theatre Arts last month by the City of Torrance Cultural Arts Commission. He was recognized for his role of Tevye in last summer's production of "Fiddler on the Roof" by the Aerospace Employees Association club, The Aerospace Players (TAP).

TAP first came to the Armstrong Theatre 22 years ago with a production of "Guys and Dolls." The club has produced shows there since that time, and since 2000 the group has performed exclusively at the Cultural Arts Center where the Armstrong is housed.

November 2016 Obituaries

by **Elaine Young**
November 01, 2016

Sincere sympathy is extended to the families of:

Zegmund Bleviss, member of technical staff, hired Oct. 17, 1960, retired Dec. 1, 1989, died Sept. 27, 2016.
Eraine Bromley, office of technical staff, hired Aug. 30, 1960, retired Nov. 1, 1987, died Oct. 7, 2016.
Richard Fleming, member of technical staff, hired Dec. 31, 1979, died Oct. 12, 2016.
James Massey, member of technical staff, hired March 11, 1985, retired July 1, 1999, died Oct. 8, 2016.
Betty Mayhew, office of technical staff, hired Feb. 4, 1974, retired July 1, 1983, died Oct. 5, 2016.
Michael Millea, technical support, hired July 31, 1962, retired Oct. 1, 1993, died Oct.12, 2016.
William Pritt, technical support staff, hired Sept. 4, 1962, retired April 1, 1989, died Oct. 17, 2019.
Steve Scesa, member of technical staff, Feb. 14, 1966, retired April 1, 1977, died Oct. 13, 2016.
Harold Yerondopoulos, member of technical staff, hired Sept. 24, 1990, retired Aug. 1, 2008, died Sept. 18, 2016.

To notify Aerospace of a death and have it included in the Orbiter, please contact Human Resources at 310-336-5107.

November 2016 Notes

by **Elaine Young**
November 01, 2016

Notes of appreciation to fellow employees and Aerospace for thoughtfulness and sympathy have been received from:

Jeffrey Childs, on the recent passing of his mother, Jessie Rice.
Mary Ann Greenelsh, on the passing of her mother, Doris Greenelsh.

November 2016 Anniversaries

by **Elaine Young**
November 01, 2016

40 Years

Vaeros

Diane Apgar

35 Years

Engineering and Technology Group

Dan Mabry, James Hecht, Stanley Kohn

National Systems Group

Franklin Stamps

Space Systems Group

Evelyn Ramirez

30 Years

Engineering and Technology Group

Jeffrey Hall, Thomas Gottschalk

Enterprise Information Services

Gregory Gustafson

Space Systems Group

Jo-Chieh Chuang

25 Years

Systems Planning, Engineering, & Quality

David Voelkel

20 Years

Engineering and Technology Group

Hai Vo, Jandria Alexander

Space Systems Group

Michael McAtee, Paul Stelling, Wayne Hartman

Systems Planning, Engineering, and Quality

Sonia Cruz

15 Years

Engineering and Technology Group

Aaron Brown, Carmen Melendez, Gregory Mulert, Rosemarie Dejesus

Enterprise Information Services

Steven Patera

National Systems Group

Glenn Creel

Space Systems Group

Emanuel Bucur, Jennifer Lew

Systems Planning, Engineering, and Quality

Eric George

Vaeros

Patricia Maloney, Eric Breckheimer

10 Years

Engineering and Technology Group

De-Ling Liu

Enterprise Information Services

Joanne English

National Systems Group

Norman Modlin, Randy Cheng

Vaeros

Nelda Ishikawa-Ward

5 years

Engineering and Technology Group

Donald Carter

Operations and Support Group

Jawad Jilani

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