

IR

LABORATORIES INNOVATION & DEVELOPMENT REPORT 2024

3 WE ARE HRL

4 MESSAGE FROM CEO

5 MATERIALS & MICROSYSTEMS

ENGINEERING THE FUTURE: MATERIALS, DEVICES & SOLUTIONS

7 SENSORS & ELECTRONICS

LEADING THE WAY IN SENSING AND COMMUNICATION

9 VISION SYSTEMS

ADVANCING FOCAL PLANE TECHNOLOGIES

11 MICROFABRICATION TECHNOLOGY

RAISING THE BAR IN WAFER FABRICATION

INTELLIGENT SYSTEMS CENTER 13

BOOSTING HUMAN-MACHINE TEAM PERFORMANCE

ADVANCING GAN TECHNOLOGY 15

REVOLUTIONIZING INERTIAL NAVIGATION 16

QUANTUM 17

THE PEOPLE OF HRL 18



WE ARE HRL

HRL Laboratories pioneers the next frontiers of physical and information science. Delivering transformative technologies in automotive, aerospace and defense, HRL advances the critical missions of its customers to help them remove limitations and create competitive advantage.

For more than 70 years, HRL's rich portfolio of scientific discoveries and engineering innovations continues to build on each other - often in unexpected, profound and far-reaching ways. As a private company owned jointly by Boeing and GM, HRL prioritizes purpose over profit, significantly advancing the state-of-the-art.



WELCOME TO HRL LABORATORIES' FIRST INNOVATION AND DEVELOPMENT REPORT.

For decades, HRL has been focused on groundbreaking research aimed at transformative technologies that create value for our customers. We perform contract research and development for various departments and agencies across the federal government, for our owner companies, and for a number of aerospace and defense firms. Our customers come to us because we are trusted to create innovations that shape the future.

So why this report, and why now? Because HRL is evolving. While our legacy is built on pioneering research, today's expectations extend beyond discovery. Our customers look to us to create and deliver advanced technologies that drive real-world impact. We're not only inventing the future; we are transforming ideas into prototypes and production-ready solutions that serve critical missions.

This first report offers a glimpse into the work happening across the company, and some key technology areas we are focused on such as quantum technologies, gallium nitride (GaN) based electronics, advanced infrared imaging products, and micro-electro-mechanical system (MEMS) based inertial measurement units (IMUs).

Materials and Microsystems Lab – Developing next-generation materials, coatings and navigation technologies.

Sensors and Electronics Lab – Advancing the state-of-the-art radio frequency, millimeter wave and electro-optical sensor subsystems.

Vision Systems Lab – Creating cutting-edge infrared sensor products for aerospace and defense applications.

Microfabrication Technology Lab – Pioneering high-mix, low-volume semiconductor technologies, including spin qubits, GaN microwave circuits and nanoscale devices.

Intelligent Systems Center – Pushing the boundaries of artificial intelligence and autonomous systems.

HRL stands at an inflection point, ready to transform research into reality. We invite you to explore the innovations that are shaping the next era of technology.

Rob Vasquez
President and CEO, HRL Laboratories

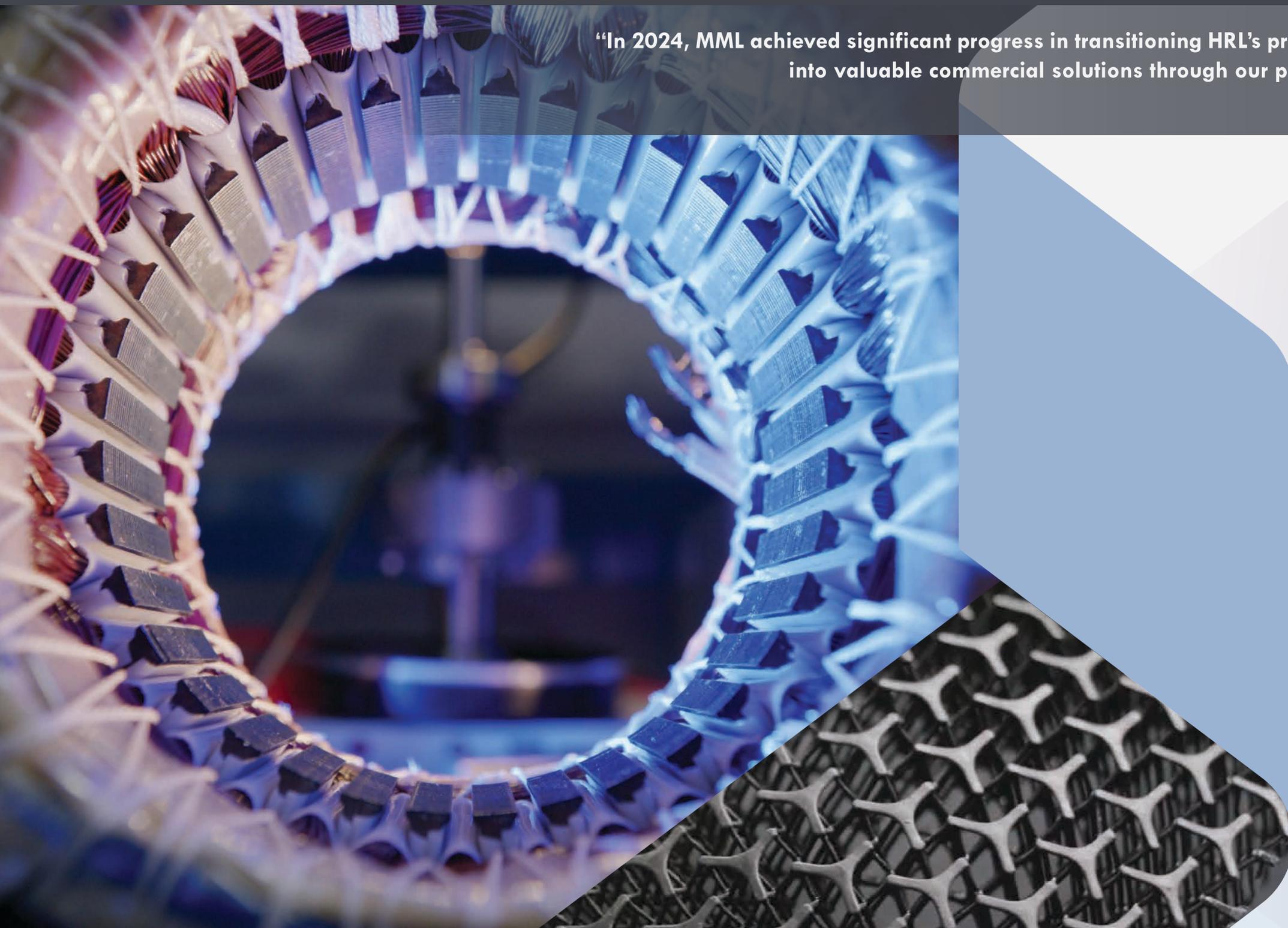


MATERIALS & MICROSYSTEMS LABORATORY

ENGINEERING THE FUTURE: MATERIALS, DEVICES & SOLUTIONS

“In 2024, MML achieved significant progress in transitioning HRL’s prototype materials and device technology demonstrators into valuable commercial solutions through our partner network of manufacturer and supplier partners.”

Geoff McKnight, Vice President



It has been a transformative year for MML. We’ve made significant strides in developing breakthrough materials and device technologies that will shape the future of aerospace, automotive and high-performance industrial systems.

This year, we completed development of an innovative antimicrobial biphasic polymer coating designed to combat viruses and bacteria on surfaces while maintaining high durability standards required for commercial vehicle applications. The biphasic design enables sustained release of actives, with **a unique capability to restore coating activity levels** on the surface through routine cleaning with common disinfectants - a first for coatings of this type.

In the realm of quantum technologies, we made major progress with our **Q4S** entanglement swapping payload, set for satellite demonstrations with **Boeing**. This patent-pending technology stabilizes quantum states in ways previously thought impossible - marking a huge step forward in quantum communication and sensing.

We’re also addressing the challenges of energy efficiency. Our new thermal management system for data centers aims to **significantly reduce cooling power usage while also increasing cooling performance**, improving the overall sustainability of hyperscale computing for AI computing centers.

In partnership with VICIS, we transitioned our **microlattice energy absorption technology** into **NFL helmets**, enhancing player safety on the field.

Collaborating with top universities like Stanford and Purdue, we’ve been at the forefront of advancing **integrated microcooling technologies** - setting the stage for groundbreaking developments in future 3D heterogeneously integrated electronics subsystems for use in high power density compact radars and high bandwidth communications systems.



SEL SENSORS AND ELECTRONICS LABORATORY

LEADING THE WAY IN SENSING AND COMMUNICATION

“SEL is proud to embrace a culture of transition, driving solutions to meet critical challenges. In 2024, we provided open foundry access to industry-leading millimeter wave GaN technology, field tested ultra-low-cost radar sensor prototypes and made key advancements in microelectronic packaging solutions.”

Seong Kim, Vice President

We're not just imagining the future- we're building it. In 2024, SEL made remarkable strides in developing groundbreaking technologies that are already making an impact for our customers and partners.

We created a daytime star-tracking celestial navigation system that performed exceptionally well in its latest flight test, navigating harsher conditions and aggressive maneuvers better than ever before. It's a key step toward ensuring reliable position, navigation and timing solutions in **GPS-denied** environments.

Our work on quantum entanglement swapping for **Boeing's Q4S satellite mission** continues to push boundaries. We've designed, built and tested a deployable optical system capable of 4-photon teleportation.

We also addressed Boeing's need for low-cost radar solutions. Our **Ultra Low-Cost Sensor** prototype exceeded performance targets during recent radar testing at a Boeing facility, unlocking the potential for new missions on **cost-effective platforms**.

Collaboration is core to what we do. In 2024, we worked with institutions like **UCSB, UCLA and USC** on millimeter-wave phased arrays and power amplifiers under the Department of Defense sponsored **CA DREAMS Electronics and Microdevices hub**, while partnering with the **University of Florida** on a novel detector concept where HRL will develop cutting-edge electrically reconfigurable infrared filters.

Whether it's pioneering quantum networks or breaking fundamental limits for advanced antenna systems, SEL is proud to deliver technologies that are shaping tomorrow's missions today.



VSL VISION SYSTEMS LABORATORY

ADVANCING FOCAL PLANE TECHNOLOGIES



“VSL has built a world-class team and facility that are recognized as a national industrial base asset by the U.S. government. In 2024, we reached key milestones, enabling us to transition advanced research into production-ready products and support proliferated space flight deliveries.”

Raphael Ricardo, General Manager

In 2024, VSL made strides in enhancing our focal plane capabilities and delivering solutions that are already shaping the future for Boeing and the government.

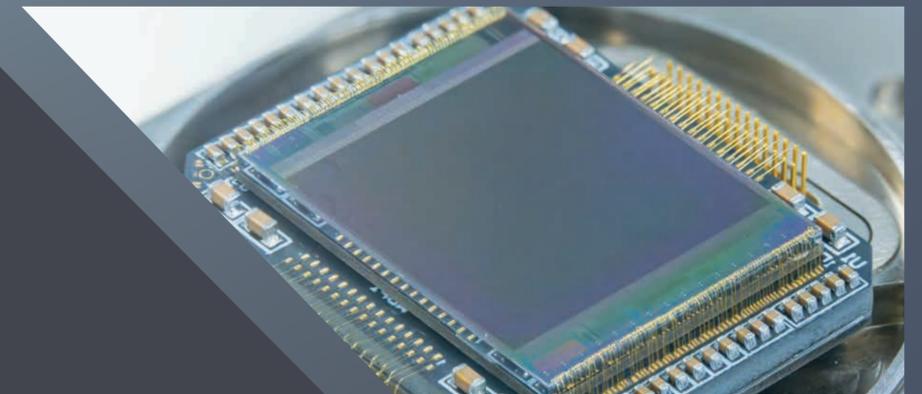
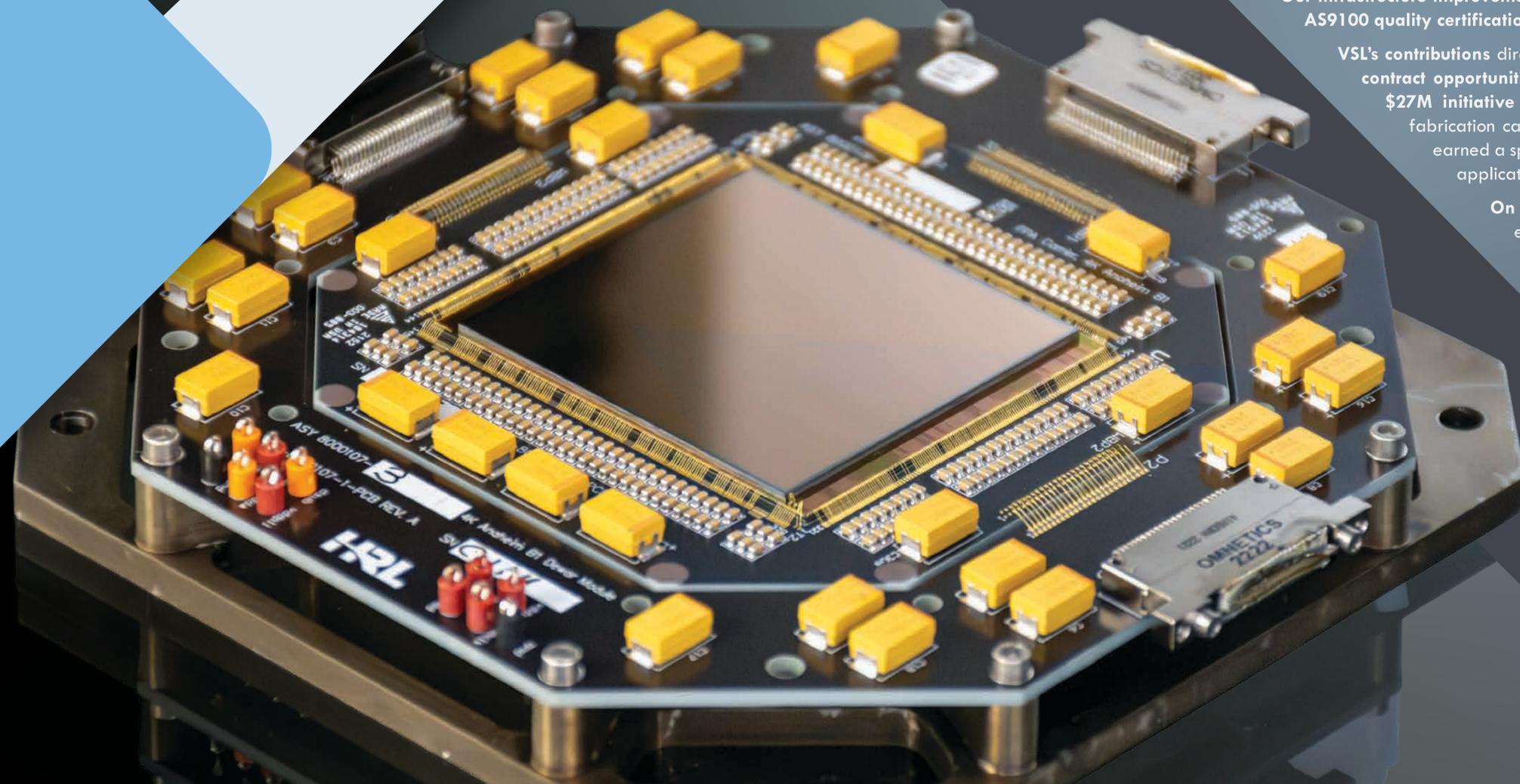
A **standout achievement** was the successful radiation testing of our large-format read-out integrated circuits (ROIC), qualifying them for **space missions**. This underscores our commitment to ensuring our sensors can perform reliably in extreme environments, including **space**.

Additionally, we completed the move to our **new Camarillo Production Facility**, which will increase our delivery capacity from **15 to more than 75 large-format focal planes** per year, supporting growing demand.

Our **infrastructure improvements** also included implementing advanced **enterprise resource planning systems** and securing **AS9100 quality certification**, ensuring we can scale efficiently and maintain high standards in production.

VSL's **contributions** directly support Boeing's success, with our focal plane arrays fortifying **more than \$2B in satellite contract opportunities**. We also partnered with **Air Force Research Laboratory** through the CASTLE program, a **\$27M initiative** aimed at strengthening the U.S. military's industrial base by enhancing and maturing our fabrication capabilities. This program award signifies the government's recognition that HRL's VSL team has earned a spot as one of only three fully capable focal plane suppliers in the U.S. for their space flight mission applications.

On the technical front, we completed design and testing of our upgraded large-format focal plane engineering units, as well as tapeout of a **high dynamic range ROIC**, which is currently undergoing functional testing. **VSL is advancing the future** of infrared sensor technology for both national security and scientific applications.



MTL

MICROFABRICATION TECHNOLOGY LABORATORY RAISING THE BAR IN WAFER FABRICATION

“MTL enhanced its operations to improve data organization, visualization and communication. These upgrades strengthen collaboration with internal customers and help us balance flexible R&D capabilities with improved on-time delivery.”

Franklin Monzon, Vice President

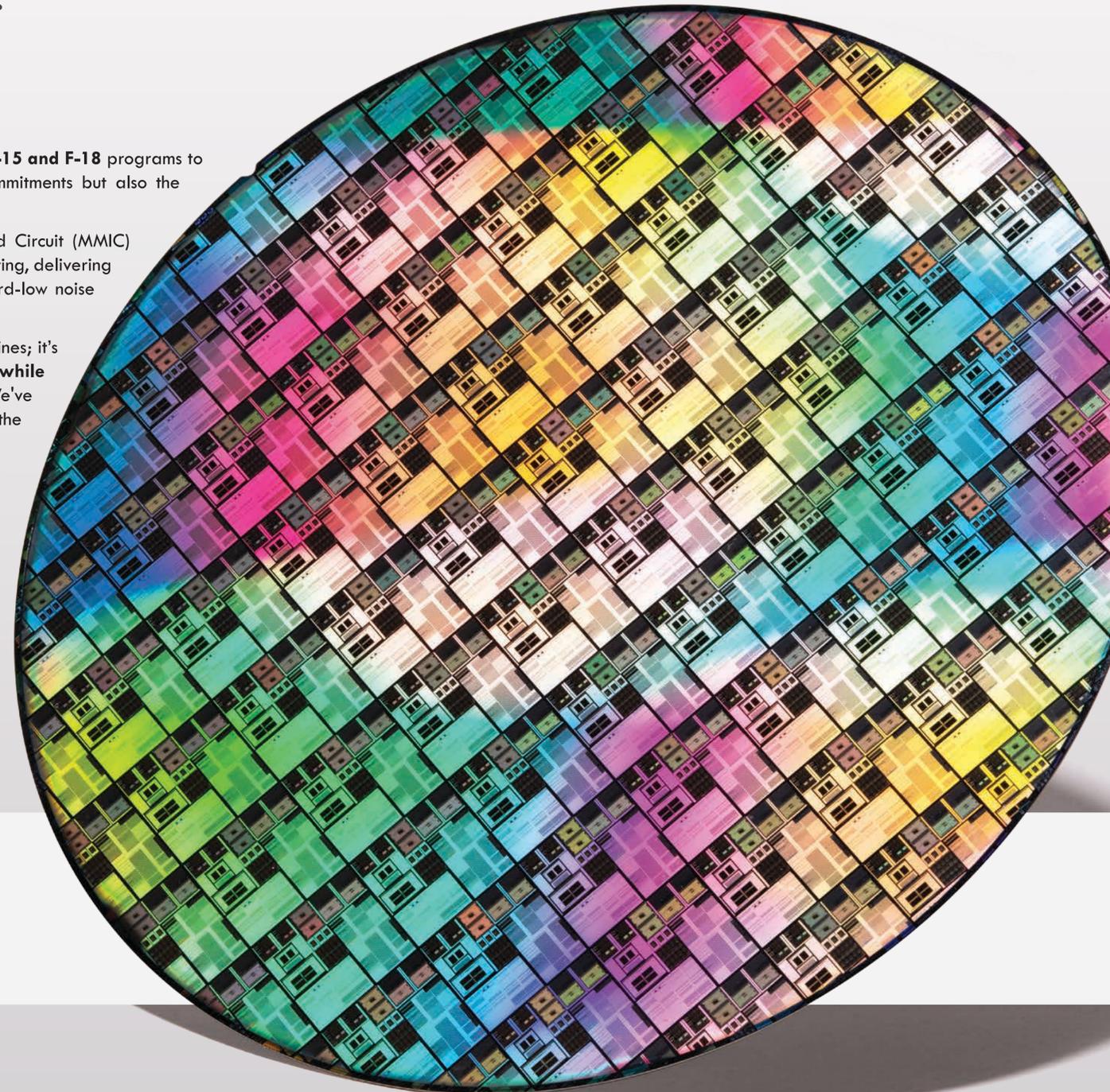
2024 was a year of transformation for MTL. From continuing our long-standing collaboration for **Boeing’s F-15 and F-18** programs to improved **150mm and 200mm wafer processing**, we’ve been pushing not only to meet ongoing commitments but also the demands of future semiconductor research and manufacturing.

The successful maturation of our T3L Gallium Nitride (GaN) Monolithic Microwave Integrated Circuit (MMIC) technology is a major highlight of the year. Our team rapidly moved through fabrication and testing, delivering the parts needed. Boeing validated their exceptional performance - particularly the record-low noise figure, which set a new standard for **GaN MMICs**.

MTL invested more than \$10M in new tools. This isn’t just about bigger, faster machines; it’s about enhancing our ability to handle **larger wafers and mature processes while maintaining flexibility for rapid prototyping**. And, it’s paying off. We’ve improved throughput, lowered costs and most importantly, maintained the quality that our customers expect.

We’ve also deepened our ties with local universities and industry partners through the CHIPS Act’s Southern California Defense-Ready Electronics and Microdevices Superhub (**CA DREAMS**), working alongside some of the best minds in tech to drive innovation.

It’s not just about meeting expectations - it’s about exceeding them and setting new benchmarks for success.



ISC

INTELLIGENT SYSTEMS CENTER

BOOSTING HUMAN-MACHINE TEAM PERFORMANCE



ISC made great strides in 2024, developing intelligent systems capabilities for the automotive, aerospace and defense markets.

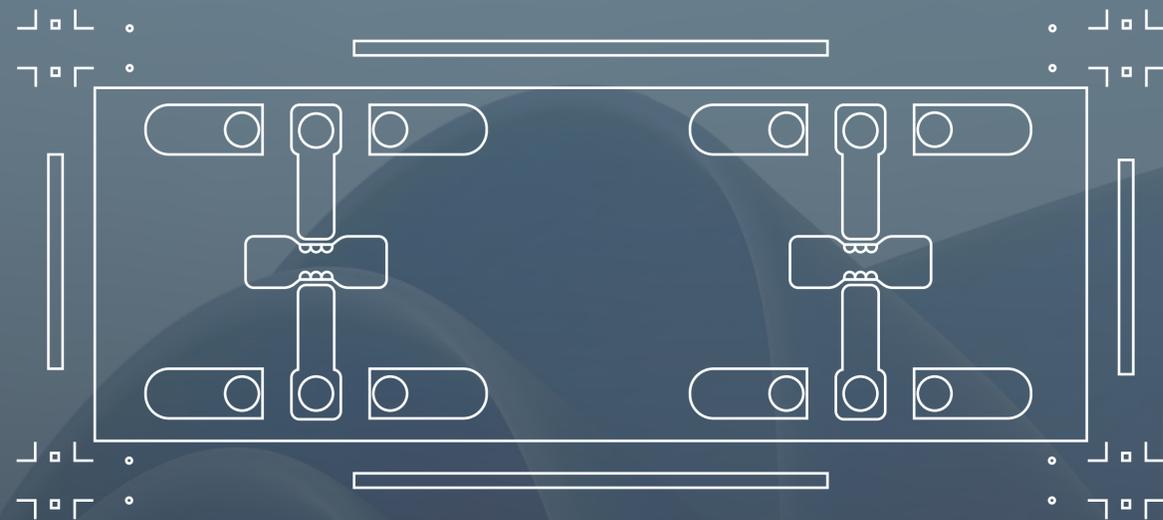
Major achievements included showcasing a robust navigation and **air-to-air refueling system for Boeing** and achieving **closed-loop control of a robotic arm** using speech and gesture commands – setting the stage for a 2025 robot cell prototype for **GM**.

We also introduced the Sensemaking Effectiveness using Neurocognitive Signatures of Efficiency (SENSE) system, which measures how AI tools impact human analysts. The system was demonstrated successfully at the National Geospatial-Intelligence Agency and secured future funding.

In the satellite domain, we developed algorithms to optimize **traffic routing and network topology**, which were successfully transitioned to Boeing. Plus, we created a computer-vision-based tracking system that could enhance Boeing factory operations.

Throughout 2024, we partnered with organizations like Kairos Research, Parallax and Riverside Research on augmented intelligence projects aimed at more effective teaming of humans with artificial intelligence capabilities.

As we move forward, ISC's vision is to mature and missionize intelligent systems by making them more proficient, collaborative and secure.



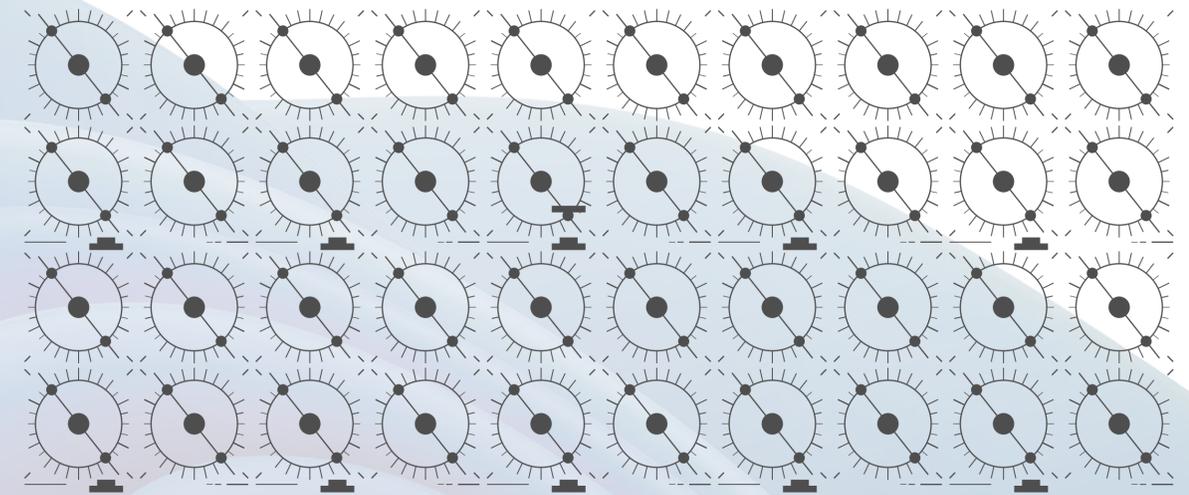
ADVANCING GaN TECHNOLOGY FOR NEXT-GEN SYSTEMS

HRL is driving innovation in Gallium Nitride (GaN) technology, delivering high-performance Monolithic Microwave Integrated Circuits (MMICs) for transmitting and receiving applications up to **120 GHz**. Built on silicon carbide, HRL's GaN technology offers **high bandwidth and high performance**, making it a game-changer for defense and commercial systems alike.

In 2024, our highlights included adopting the **high-linearity GaN device** developed under the **DARPA DREAM** program into a **40nm (T3L GaN) pilot line**. A preliminary Process Design Kit was released, enabling multiple customers to begin designing with HRL GaN. Additionally, the team completed a crucial qualification lot and 900 hours of **High-Temperature Reverse Bias testing—an industry first for sub-100nm GaN** technology.

GaN's superior power-handling capabilities and efficiency make it a strong contender for future **Boeing platforms**, offering better survivability and robustness compared to incumbent technologies. With insertion opportunities already being explored, this technology is poised to enhance **performance-sensitive systems**.

HRL plans to deliver low-noise amplifiers to Boeing, advance process qualification efforts and refine manufacturing readiness to reach **Manufacturing Readiness Level 6** and integrate industry standard packaging interconnect support. A focused business plan will also target commercial MMIC sales while pursuing **transition opportunities**. These efforts **solidify GaN as a cornerstone of HRL's mission** to deliver cutting-edge technologies to our partners.



REVOLUTIONIZING INERTIAL NAVIGATION WITH MEMS-BASED IMUs

HRL's compact, high-performance **Micro-Electro-Mechanical Systems (MEMS) Inertial Measurement Units (IMUs)** are redefining navigation systems by providing reliable guidance in **GPS-degraded environments**. Designed with navigation-grade precision, these IMUs offer a **cost-effective, scalable solution** for automotive, aerospace and other demanding applications where traditional GPS reliance is no longer sufficient.

MEMS IMUs address critical challenges faced by industries that depend on consistent navigation. By leveraging pure inertial sensing, these systems ensure accurate guidance without the risks of **GPS jamming or spoofing**. The technology supports long-duration operations, making it ideal for advanced driver assistance systems, autonomous platforms and aerospace missions.

In 2024, HRL performed **live demonstrations** in both automotive and aerospace environments showcasing our MEMS IMUs' robust performance under real-world conditions. **Key advancements** included mitigating thermal and vibrational noise to maintain navigation-grade accuracy. Additionally, the successful transfer of the **MEMS resonator fabrication process** to a 200mm wafer format highlighted its scalability for **high-volume production**.

Looking forward, our efforts are focused on reducing costs and optimizing packaging to meet mass-manufacturing demands while maintaining performance consistency. These innovations aim to deliver **a first-of-its-kind navigation-grade component**, providing industries with a reliable, economical alternative to traditional IMUs and advancing capabilities for **autonomous systems and precise navigation**.

BOARD OF DIRECTORS



R. Vasquez
President & CEO



S. O'Sullivan
Board Chair



D. Meyerriecks
Independent Board Director



M. Sinnett
Boeing



C. Toups
Boeing



A. Ganguli
General Motors



K. Helfrich
General Motors

QUANTUM

At HRL, we're exploring the incredible potential of quantum technologies to revolutionize computing, communication and sensing. By leveraging quantum effects, we're creating solutions that are faster, more secure and remarkably sensitive. Our work with **Si/SiGe quantum dots** is paving the way for scalable quantum processors that can unlock new quantum chemistry applications, while entangled photons are enhancing the security of critical networks. Integrated quantum photonics are also opening up exciting possibilities for advanced sensing systems.

In 2024, we achieved a key breakthrough by developing and testing 2D arrays of Si/SiGe quantum dots using scalable, microelectronics-compatible processes, a key step towards building practical quantum processors for real-world applications.

And importantly, we began delivering these devices to university and national lab researchers, helping grow the national quantum workforce. On top of that, our team published several important papers under **DARPA's Quantum Benchmarking program**, diving deep into the future of quantum chemistry.

In quantum communication and sensing, we designed the payload for **Boeing's Q45 satellite**, which is set to demonstrate entangled photonic networks in space. We also made strides in integrating quantum photonics with silicon-carbide-on-insulator technology, a big step forward for both sensing and communication applications.

Looking to 2025, we'll build on these achievements by demonstrating the scalability of our quantum dot devices, expanding real-world quantum chemistry applications and validating quantum clocks and communication systems in practical settings.

The future of quantum is bright, and we're proud to be leading the industry.



Left to Right: Dave Chow, Jim Soash, Genny Findlay, Rob Vasquez, Jewel Miller, Seong Kim, Leslie Momoda, Geoff McKnight, Jocelyn Hicks-Garner, Franklin Monzon, Robert Pesceone, Brad Jones, Raphael Ricardo, (Not pictured: William Casebeer)

HRL EXECUTIVE TEAM

Rob Vasquez
President & CEO

Leslie Momoda
Executive Vice President

Genny Findlay
Chief Human Resources Officer

Jewel Miller
General Counsel

Robert Pesceone
Chief Financial Officer

David Chow
Chief Scientific Officer

Franklin Monzon
Vice President MTL

Raphael Ricardo
General Manager VSL

William Casebeer
Director ISC

Jocelyn Hicks-Garner
Vice President Operations

James Soash
Vice President Special Programs

Geoff McKnight
Vice President MML

Seong Kim
Vice President SEL

Brad Jones
Vice President VSL

OUR PEOPLE

BUILDING CAREERS AND COMMUNITIES THAT THRIVE

Our culture thrives at the intersection of innovation, collaboration and a steadfast commitment to execution. With a team of more than **one thousand talented individuals**, including **nearly 200 new hires** in 2024, we've continued to grow while fostering a **supportive and dynamic** work environment.

Our focus on company culture remains strong as we expanded and matured our existing employee resource groups, partnered with inclusive organizations and attended national events to ensure our workforce reflects **a range of perspectives and experiences**.

In 2024, we deepened our commitment to employee well-being. From walking challenges and onsite wellness clinics to maintaining our best-in-class health benefits, **we prioritize the holistic health** of our team.

HRL empowers employees to thrive. To support growth, **we enhanced our** Leadership Development Program and provided education reimbursement opportunities. A new Talent Management program ensures visibility into workforce development and paves pathways for internal promotions, **helping our employees grow** with the organization.

We built a deliberate cultural framework designed to enhance employee experiences across the organization. This guiding framework for **behavior, decision-making and overall workplace interactions** will set a foundation for who we are and who we want to be in the future.

Our mission to combine cutting-edge research with national impact attracts some of the brightest minds in science and engineering, giving our people the chance to tackle complex challenges that matter.

As we look ahead to 2025, we remain committed to driving an inclusive, results-driven culture. A place where innovation, growth and collaboration flourish, **making HRL not just a workplace, but a community.**

HRL HEADCOUNT

