IOWA STATE UNIVERSITY
Department of Electrical and Computer Engineering

$16 million ARA project grows rural wireless internet access

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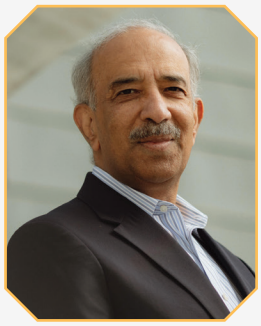
IMPACT REPORT 2023

The Future is What We Do.

Dear Friends,



We are excited to bring you this impact report with a summary of remarkable achievements and advancements made by the Department of Electrical and Computer Engineering (ECpE) at Iowa State University over the past year. We proudly showcase the innovative work and contributions that have shaped our department's journey.

The year has been filled with excitement as we celebrated successes and confronted new challenges. Notably, we commemorated the 60th year of the Electric Power Research Center (EPRC), marking a significant milestone in our commitment to advancing research in electric power. In addressing the evolving landscape of energy future, our ECpE faculty have been at the forefront of impactful research in diverse areas such as renewable energy, grid resilience and reliability, and secure energy systems. We are actively engaged in pioneering efforts to shape the energy trajectory of our state and the U.S., reflecting our commitment to driving positive change.

Another noteworthy achievement is the progression of the ARA Wireless Living Lab for Smart and Connected Rural Communities, which successfully transitioned to a public testing phase. It is a one of its kind living lab that underscores our dedication to creating real-world solutions for smart and connected rural environments.

Amidst these achievements, we are proud to announce the addition of three new faculty members to our esteemed department. Furthermore, we are dedicated to fostering diversity within our faculty, actively working to increase female representation and create an inclusive academic environment.

Our research endeavors continue to encompass a wide spectrum, ranging from smart sensors, energy storage, and cybersecurity to innovations in the agriculture industry, next-generation computing and advancements in biomedicine. This comprehensive approach reflects our commitment to addressing multifaceted challenges and contributing to diverse fields of study.

At ECpE, innovation is at the heart of what we do. Our cutting-edge solutions aim to tackle some of the world's most pressing problems, and this year has been no exception. We invite you to explore our 2023 Impact Report and learn how we live up to our ECpE motto, "The Future Is What We Do!"

If you have any questions or require further information, please do not hesitate to contact us. We appreciate your ongoing support and look forward to sharing more exciting developments in the future.

Ashfaq Khokhar
Professor and Palmer
Department Chair in Electrical
and Computer Engineering

NEW FACULTY

Bai Cui

Assistant Professor

Research focus: Application of optimization and control techniques in power system studies.

Esmat Farzana

Assistant Professor

Research focus: Investigating the existing challenges of emerging ultrawide-bandgap semiconductors (UWBG), including their device design, fabrication and advanced defect characterization, which aims to improve their material properties, device performance and extreme environment tolerance.

Shuang Li

Assistant Professor

Research focus: Signal processing and machine learning—specifically, leveraging low-dimensional structures such as sparsity, low-rankness and smoothness existing in high-dimensional data to develop optimization-based techniques.

2022-23 BY THE NUMBERS: **STUDENTS**

2,117
Total Students

1790 Undergraduate Students

327 Graduate Students

115 Masters Students

212 Doctorate Students

464 Computer Engineering Students

478 Electrical Engineering Students

662 Software Engineering Students

186 Cyber Security Engineering Students

382 B.S. degrees awarded

77 M.S. & M.Eng. degrees awarded

29 Ph.D. degrees awarded

2022-23 BY THE NUMBERS: **FACULTY**

179 Journal Publications

166 Conference Papers

5 Books

2,644 Citations

1 NSF CAREER Award

16 IEEE Fellows

20 Endowed Professorships

53 Total Faculty

49 Tenure / Tenure Track

10 Women

RESEARCH EXPENDITURES

Strategic Areas

Bioengineering | Cyber Infrastructure
Data, Decisions, Network & Autonomy
Energy Infrastructure | Materials, Devices & Circuits

New Awards (CY2022):

$10.6M

Expenditures (FY2023):

$18.7M

Planning Iowa's energy future

Anson Marston Distinguished Professor **James McCalley** leads a state-funded project to fortify Iowa's power grid. McCalley and his team aim to present five visions for Iowa's energy future. These include varying emphases on cost minimization, CO_2 reduction, energy export expansion, and grid resilience, all while providing a balanced approach to executing each one of these visions. The project hopes to provide a 25-year strategy for Iowa's low-carbon infrastructure, empowering informed decisions on the state's energy future.

Cattle health app to detect lameness

Associate professor **Santosh Pandey**, with collaborators in Iowa State's College of Veterinary Medicine, is developing a user-friendly app to identify early signs of cattle lameness at the herd level. Using smartphone cameras, the prototype system analyzes mobility parameters, notifying farm operators about cattle requiring attention. The goal is to provide an accessible tool for cattle producers to detect lameness early, conserving resources and enhancing cattle welfare.

Doug Jacobson awarded the Sunil & Sujata Gaitonde Professorship in Cybersecurity

Doug Jacobson, University Professor of electrical and computer engineering and director of Iowa State's Center for Cyber Security Innovation and Outreach, was awarded the Sunil & Sujata Gaitonde Professorship in Cybersecurity.

Electric Power Research Center: Sixty years of aiding industry, preparing students, inventing solutions

"To us, right now in this moment of history," said **Anne Kimber**, the director of Iowa State's Electric Power Research Center (EPRC). "It's the most exciting time in the world."

The EPRC, now in its 60th year, is all about supporting research, connecting university researchers with industry engineers and launching students into electric power careers.

The Electric Power Research Center began in 1963 as the Power Affiliates Program. Its mission was to "advance research and graduate education in electric power systems and strengthen industry ties."

That mission still holds. The center has 10 industry members and three collaborators – including city utilities, power cooperatives, utility companies, a manufacturer of electrification equipment, a transmission company and a grid operator.

The EPRC's work is also supported by **Ian Dobson's** Arend J. and Verna V. Sandbulte Professorship, **James McCalley's** Jack London Chair in Power Systems Engineering, **Venkataramana Ajjarapu's**Thomas Whitney Professorship, **Manimaran Govindarasu's** Harpole Professorship, **Zhaoyu Wang's** Northrop Grumman Professorship, and **Hugo Villegas-Pico's** Harpole Pentair Professorship.

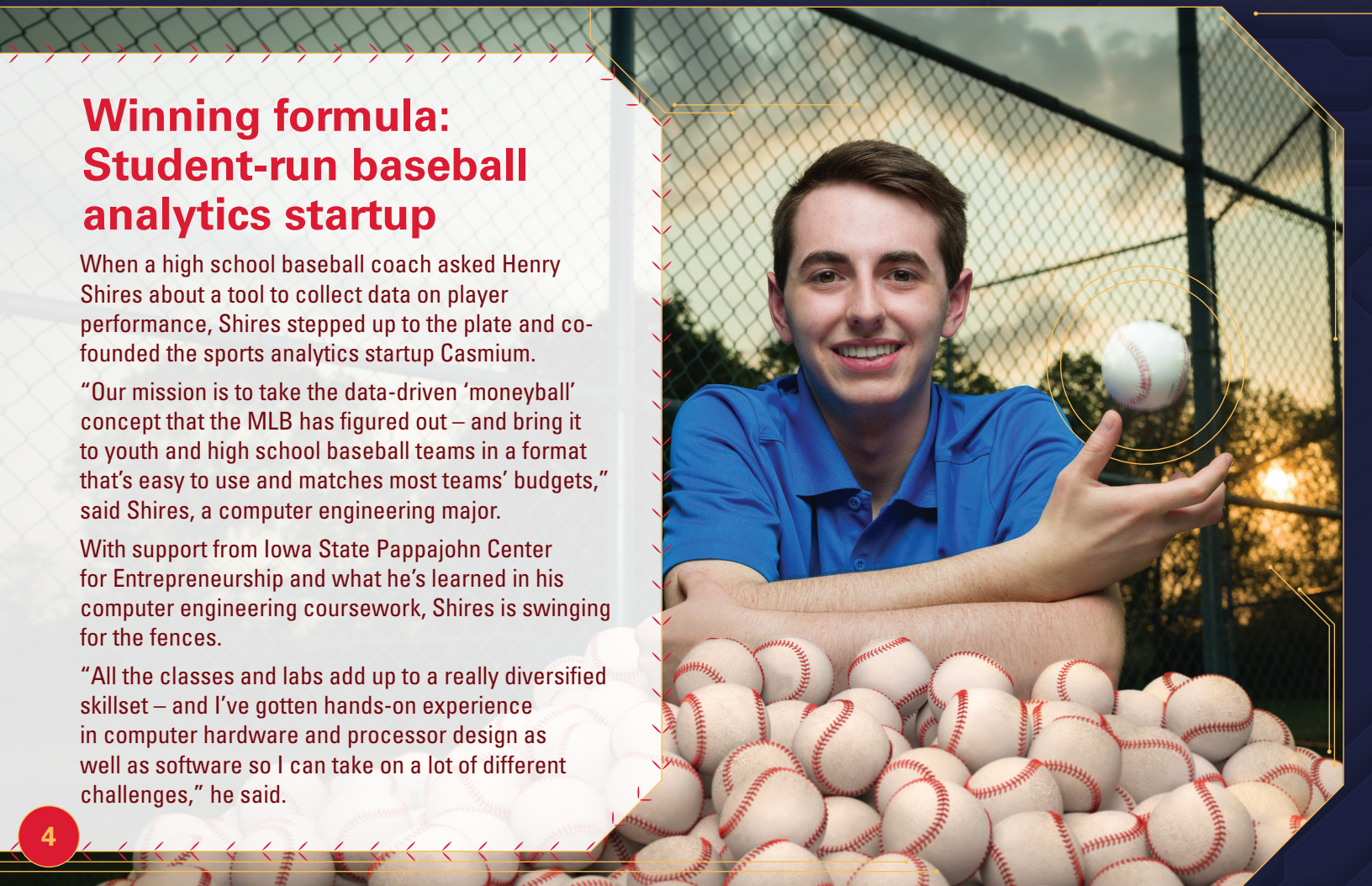
Winning formula: Student-run baseball analytics startup

When a high school baseball coach asked Henry Shires about a tool to collect data on player performance, Shires stepped up to the plate and co-founded the sports analytics startup Casmium.

"Our mission is to take the data-driven 'moneyball' concept that the MLB has figured out – and bring it to youth and high school baseball teams in a format that's easy to use and matches most teams' budgets," said Shires, a computer engineering major.

With support from Iowa State Pappajohn Center for Entrepreneurship and what he's learned in his computer engineering coursework, Shires is swinging for the fences.

"All the classes and labs add up to a really diversified skillset – and I've gotten hands-on experience in computer hardware and processor design as well as software so I can take on a lot of different challenges," he said.



Ultra-powered ultrasound: Breaking biofilms on medical implants

Millions of medical devices are implanted in patients each year, and while the majority are successful procedures, some can become infected with bacteria. The type of bacterial infection involving a medical implant can create a biofilm that is extremely hard to kill, thus causing the patient to likely have to remove the device, take the time to heal and get it re-implanted.

Associate Professor **Timothy Bigelow** plans to use ultrasound therapy to combat these biofilms on medical devices and has chosen hernia mesh as a good candidate for a proof-of-concept example.

"The hernia mesh will be targeted with very high intensity ultrasound that creates kind of a bubble cloud right at the focal regions," Bigelow said. "And we will show this therapy can break up the biofilm; get it back to free-floating bacteria, where antibiotics and the immune system can take care of it."

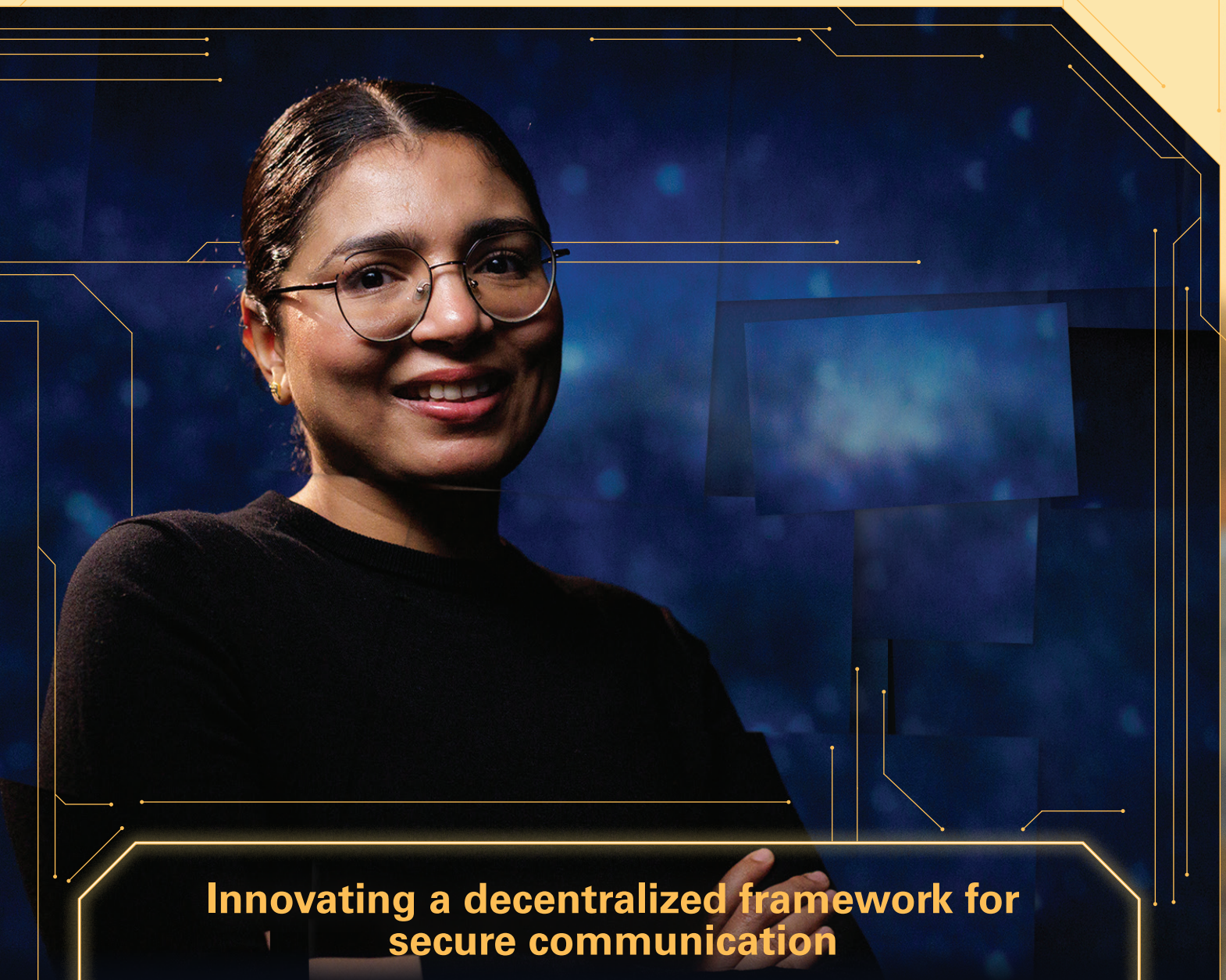
Another aspect of his National Institute of Health funded project is developing a surgical mesh material that is easily viewable by CT and ultrasound imaging.

Vessel-on-a-chip: Understanding blood clot formation

Cardiovascular diseases are the major cause of death around the world and accounted for 31% of all global deaths in 2015. Thrombosis, or blood clots, are the most common pathology leading to these life-threatening conditions.

Professor **Long Que** has been developing a blood vessel mimicking platform with quantitative flow control, both flow rate and flow direction, quantitative control of pharmacological agents on platelets and the ability of monitoring the behaviors of platelets at a single-cell level.

"Our long-term goal is to lessen the severity of thrombosis, and eventually other cardiovascular diseases," Que said. "Local blood flow and shear conditions are important mechanical factors initiating platelet adhesion and activation, studying platelet functions under controllable flow conditions and under controllable pharmacological agents' treatment is critical for the understanding of the mechanisms of thrombus formation and therapeutics."



Innovating a decentralized framework for secure communication

Millions of terabytes of information traverse the globe daily, constituting a scale of communication unprecedented in human history. As our exploration extends beyond Earth, the significance of images and data from satellites and space missions becomes increasingly profound.

The intricate transfer of such crucial imagery and diverse data for practical applications relies heavily on a federated system. This intricate system involves breaking down information into smaller, compressed segments, subsequently encrypting them for secure transmission and decoding upon arrival.

At the forefront of advancing a decentralized framework for reconstructing data from under sampled and noisy signals is assistant professor **Shana Moothedath**. Her research not only delves into the complexities of efficient data reconstruction but also prioritizes the security of this process. In the face of an evolving threat landscape, Moothedath directs her efforts toward safeguarding against potential risks posed by malicious actors who may seek to compromise or manipulate data. This security emphasis holds particular significance in contexts vital to national security, where the integrity of information is of utmost importance.

"Our primary contribution lies in demonstrating the high success rate of our approach to fully decentralize the communication decoding process," Moothedath said. "Simultaneously, we aim to excel in identifying and thwarting fraudulent activities perpetrated by malicious actors, thereby ensuring the resilience and dependability of our decentralized framework, especially in critical applications."

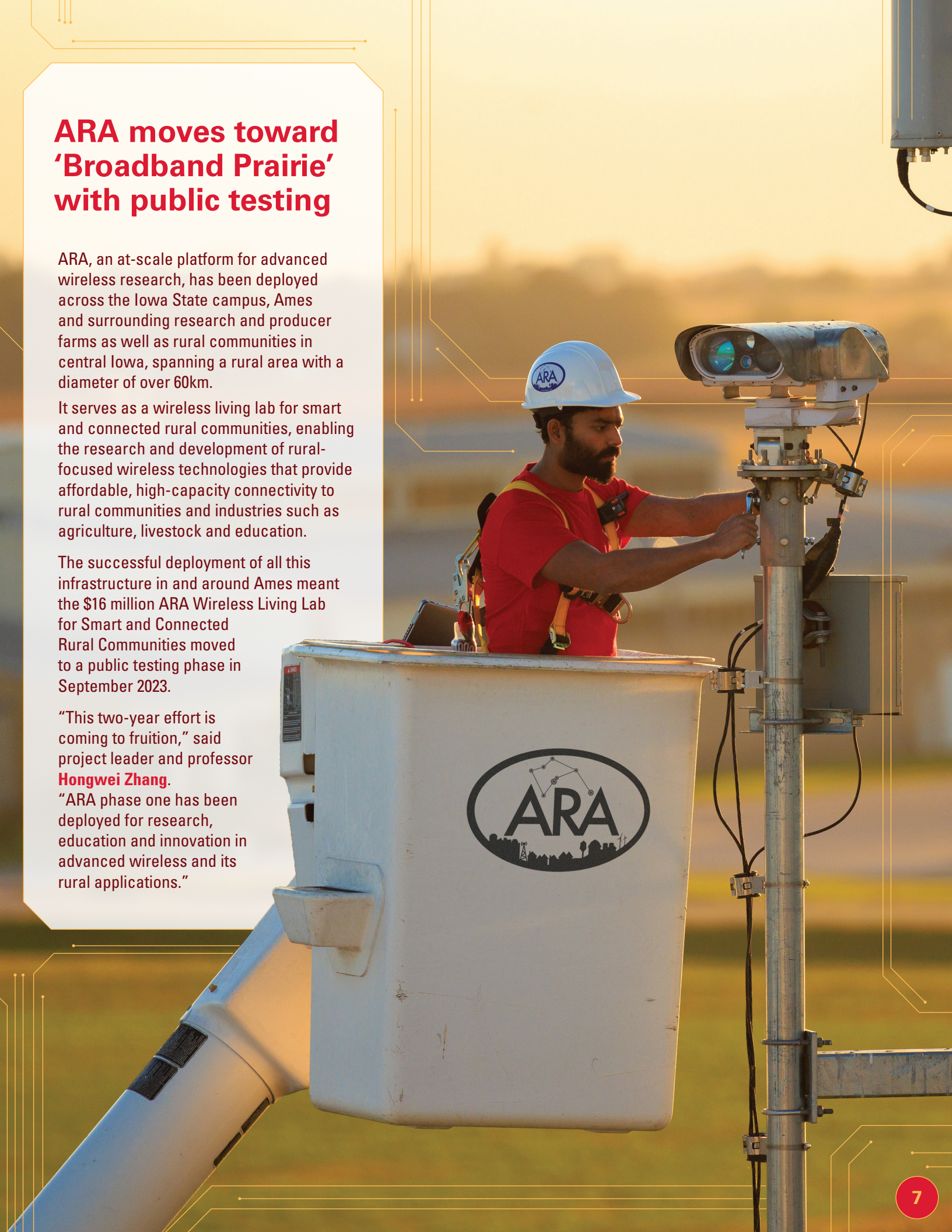
ARA moves toward ‘Broadband Prairie’ with public testing

ARA, an at-scale platform for advanced wireless research, has been deployed across the Iowa State campus, Ames and surrounding research and producer farms as well as rural communities in central Iowa, spanning a rural area with a diameter of over 60km.

It serves as a wireless living lab for smart and connected rural communities, enabling the research and development of rural-focused wireless technologies that provide affordable, high-capacity connectivity to rural communities and industries such as agriculture, livestock and education.

The successful deployment of all this infrastructure in and around Ames meant the $16 million ARA Wireless Living Lab for Smart and Connected Rural Communities moved to a public testing phase in September 2023.

“This two-year effort is coming to fruition,” said project leader and professor **Hongwei Zhang**. “ARA phase one has been deployed for research, education and innovation in advanced wireless and its rural applications.”



IOWA STATE UNIVERSITY
Department of Electrical and Computer Engineering

- **$18.7M in research expenditures**
  in FY2023
- **327 graduate students**
  All-time high number PhD students
- **Leaders in power systems research**
  Renewable energy and grid resilience

Ashfaq Khokhar
Professor and Palmer Department Chair in
Electrical and Computer Engineering

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