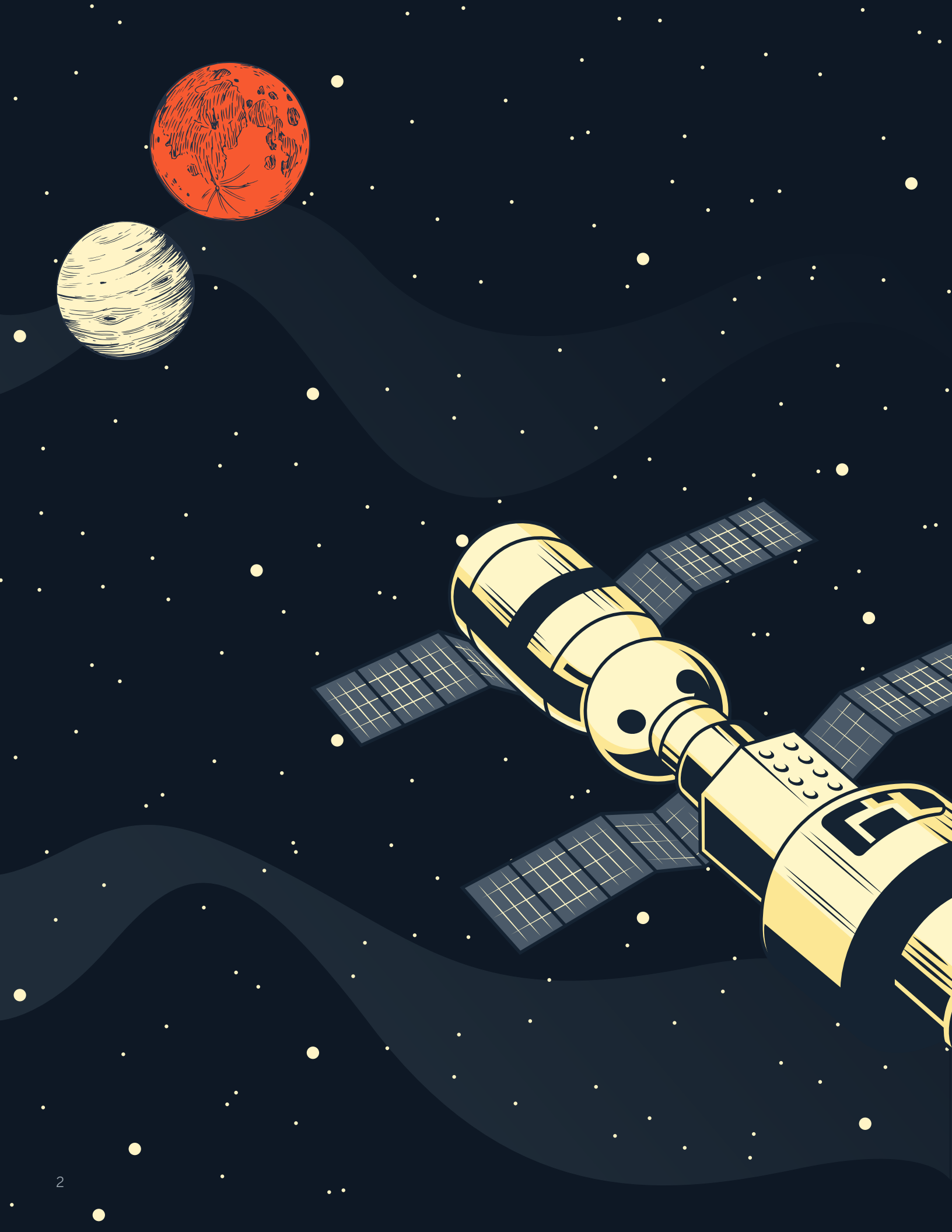


IMPACTS

Strengthening research at
IU and throughout the world



Research Technologies Annual Report 2022

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Research Technologies has had amazing achievements over the past year as we worked through the lingering pandemic. We've learned a lot about ourselves and about the IU research community, and as a group we've grown even stronger. We continue to offer unprecedented research services to IU's students, faculty, and staff, powering not only student success but also important discoveries, grant competitiveness, and a better life for all Hoosiers.

From high performance systems such as Big Red 200, to cloud computing on Jetstream2, to storage systems that can handle massive amounts of data, to digitizing and visualizing IU's research and cultural assets across all campuses, we're providing the technology that makes research at Indiana University not only possible, but accessible to everyone—including undergraduate students—at no cost. This is unique among our peers, and we're honored to be able to deliver these services to the IU community.

Of more than 3,900 U.S. institutions in the Carnegie Classification of Institutions of Higher Education, only 146—including Indiana University—are ranked as R1, or *Doctoral Universities: Very High Research Activity*. Enabling research at a prestigious R1 institution is vital to forward progress, and we're grateful to have the privilege of serving the IU family.

I'm proud of Research Technologies and of University Information Technology Services. We've successfully supported the IU community through challenging times. We survived and thrived, and—most importantly—so has our research community. We will remain focused on continuing our positive approach and doing many more impactful projects in the coming year.

Matt Link
Associate Vice President, Research Technologies
University Information Technology Services
Director, Pervasive Technology Institute
Director, Crisis Innovation Technologies Lab





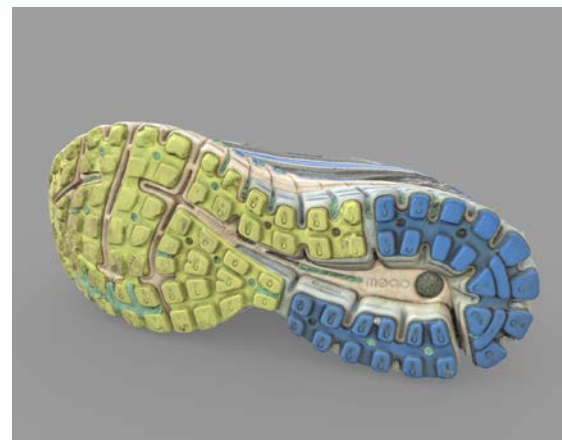
Comprising nearly
30% of all accounts,
undergraduate students are the
 largest single population taking advantage of
 HPC resources at IU.

Powering student success

RT has a proven track record of providing leading-edge high performance computing and storage systems to the university community at no additional cost, making it unique among peer institutions.

Creating detectives with advanced visualization

The Forensics and Investigative Sciences Program in the IUPUI School of Science collaborated with the RT Advanced Visualization lab on a novel online learning program. Students used interactive 3D models to learn forensic evidence identification techniques.



Raising the IQ on all campuses

Through the Advanced Visualization Lab, we have installed 20 IQ-Walls on all seven IU campuses. Most are in public areas and are available to any faculty, staff, or student with a network ID. These systems bring ultra-resolution visualization, interaction, and collaboration capabilities to large segments of the IU population.



“The IQ-Wall provides our artists an impressive new platform on which they can showcase their new multimedia performance works. This year, we were able to show seven works throughout the week of our annual Performing Media Festival here at IU South Bend.”

—**Ryan Olivier**, assistant professor of music, Ernestine M. Raclin School of the Arts, IU South Bend

Improving decision making predictions

As retail environments become more complex, so do computational models suggesting future options in a customer's shopping algorithm. Cognitive science Ph.D. student Gunnar Epping used Carbonate to compare and combine decision making models to analyze patterns like choice and response time in online shopping.

“Without Carbonate, I would not have been able to carry out my research using state-of-the-art cognitive models due to their computational complexity.”

—Gunnar Epping



Connecting through virtual events

The Advanced Visualization Lab collaborated with multiple IU units to imagine and implement a range of technologies to increase engagement, especially during COVID restrictions. Examples include virtual and technology-enhanced components for the Little 500 bike race, graduation ceremonies, BFA & MFA gallery exhibits, and end-of-semester project demonstrations.

“Your work with us helped the school navigate a very challenging time by providing solutions that we will carry forward as best practices even after the pandemic is a thing of the past. Thank you for everything you've done to support us...”

—Greg Hull, dean of the Herron School of Art and Design



Advancing research careers

Now a postdoctoral student in Wisconsin, Maryam Zahedian completed her doctorate in philosophy at IU while minoring in chemical physics under IU chemistry Ph.D. advisor Bogdan Dragnea. She used the Karst and Carbonate supercomputers with high performance storage systems to help overcome anomalies in her research.

“I highly recommend IU's research supercomputers. They are powerful and I received so much assistance from IU's research supercomputer team to run my simulation on these clusters. In simple words, HPC has enabled me to conduct two of my main projects which otherwise would lack enough accuracy to be completed and published.”

—Maryam Zahedian





Strengthening creative research in the university community

Indiana University has long been a national leader in high performance computing for research. IU faculty and student researchers in areas from astronomy to the arts and humanities have no-cost access to powerful supercomputers and massive data storage critical to their research.

RT staff strive to enable researchers to reach discovery faster with low barriers to their research. From education and outreach to tools like Research Desktop (RED) and the first NSF-funded cloud for science and engineering research, Jetstream, we make it easier to access vast amounts of storage, research software, and fast calculations on IU's supercomputers.

Science gateways on Jetstream served more than **100,000** researchers and students as of June 1, 2022.



Jetstream2 began early operations in February 2022 with **8 petaFLOPS** of virtual supercomputing power and **17 petabytes** of storage.



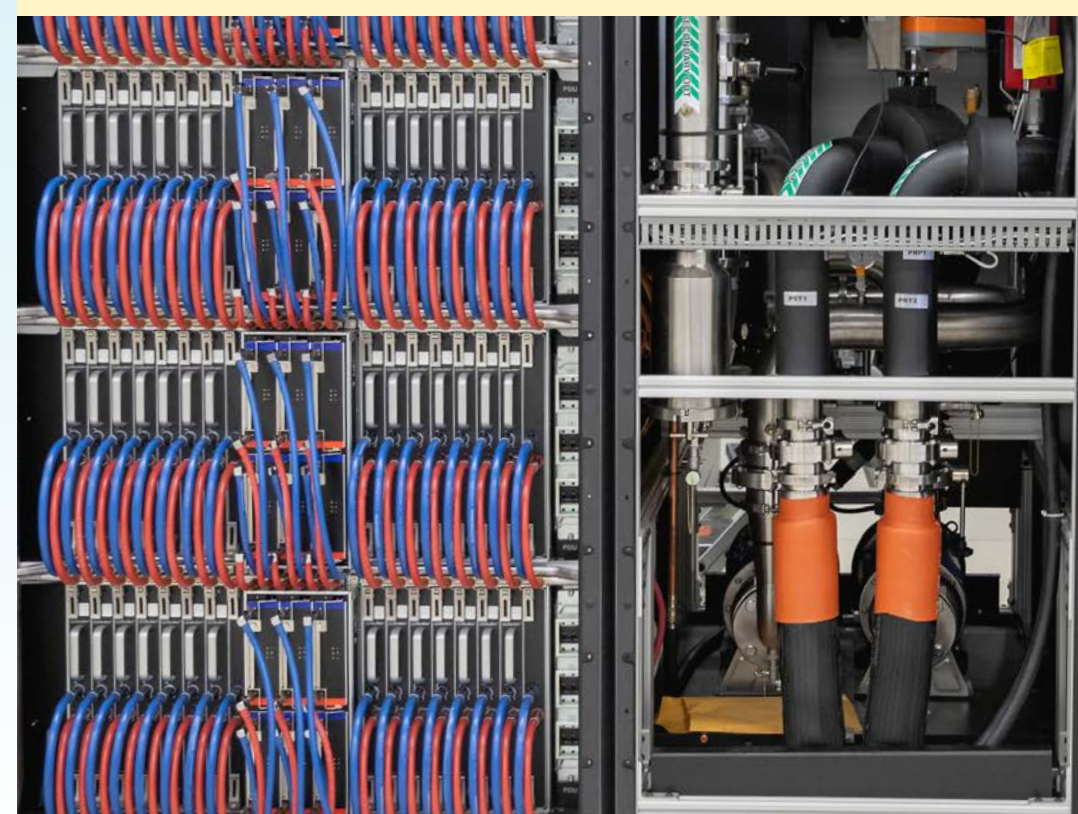
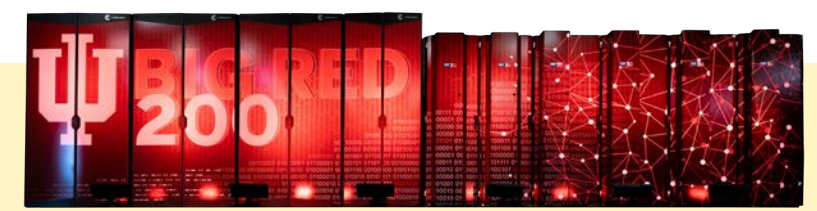
The Scholarly Data Archive can hold enough data to fill about **225 tons** of DVDs.



The Slate high performance file systems received **100 petabytes** of data last year from Big Red 200—a constant transfer rate of **3 gigabytes per second** for **365 days**.



Researchers have run **508,811 jobs** on Big Red 200 since it was made available in spring 2022, using **197,336,920 core hours**.



In 90 seconds, Big Red 200 could ...

- Do more calculations than there are stars in the Milky Way (10^{11} - 10^{12} stars).
- Complete 2.7 million years' worth of credit card transactions.
- Figure about the same number of calculations as there are unique NCAA tournament brackets (2^{63} or 9.2 quintillion).
- Perform the number of operations that, if each operation were a kernel of corn, would take the state of Indiana 12,000 years to produce.

Streamlining genomics data management

The IU School of Medicine Center for Medical Genomics and the RT Scalable Compute Archive (SCA) team collaborated to lower the barriers of complicated information technology systems and workflows.

“The solutions of the SCA allow us to enhance our data management practices by streamlining the data processing, data dissemination, and data backup with just a few clicks. In addition, the users can also easily share their data with partners within the system, which enables collaboration.”

—Yunlong Liu, director, Center for Medical Genomics, Indiana University School of Medicine



Helping IU researchers leverage cloud computing

Research Data Services partners with multiple IU research groups leveraging commercial and on-premises cloud computing resources. These groups include researchers from the Luddy School of Informatics, Computing, and Engineering; the Kelley School of Business; the IU Network Science Institute; SPEA; and the IU School of Medicine. These partnerships include implementations on Jetstream as well as integrations on all three major commercial cloud platforms.

“The Alcoholic Hepatitis Network consortium, with its 10 institutional partners, is counting on us to make the ARDaC cloud platform work—and RDS made it happen.”

—Jing Su, assistant professor of biostatistics & health data science, IU School of Medicine



Supporting data collection and management

IU's Research Electronic Data Capture (REDCap) is a secure, web-based platform that enables researchers to build and manage online surveys and databases with no programming experience. Researchers across the state have used REDCap to:

- Collect and store data about Indiana homes affected by lead.
- Design and build behind-the-scenes research and operations data capture for the IU School of Medicine/AstraZeneca COVID-19 vaccine trial.
- Evaluate the impact of COVID-19 on the mental health, addiction, and help-seeking behaviors of American Indian and Alaska Native young adults.

Understanding the risk of COVID-19 on cancer patients

The biomedical informatics field is under increasing pressure to analyze large-scale health data quickly to inform policy and develop interventions. Researchers at the Regenstrief Institute used Slate-Project to examine data to help them better understand the effect of COVID-19 on immunosuppressed cancer patients in Indiana.

“Social network data are complicated to collect, in general, and in the survey format. We use REDCap because it has the capability of dealing with the challenges of both network generators and name interpreters as well as the novel mental health items on suicide risk and resilience.”

—Bernice Pescosolido, distinguished professor of sociology, Indiana University

“The Slate-Project environment is perfect for analyzing the larger datasets necessary to infer populations trends and outcomes. Storage helps with large datasets and performance helps us do our work quickly and efficiently.”

—Brian Dixon, director of public health informatics, Regenstrief Institute

“ [A]fter a few weeks of intensive use on Big Red 200, my simulations have moved forward significantly at a pace that is unprecedented for what I have seen on IU machines (and anywhere else).”

—**Francesco Calura**, researcher, INAF-OAS, Astrophysics and Space Science Observatory of Bologna: Bologna, Emilia-Romagna, IT

Researching one billion years of cosmic history

Francesco Calura, an IU collaborator from the Astrophysics and Space Science Observatory of Bologna (OAS) used Big Red 200 to model the formation of globular clusters. Big Red 200 has the capability to research approximately a billion years of cosmic history using a set of simulations with unique features.



Cataloging the stars

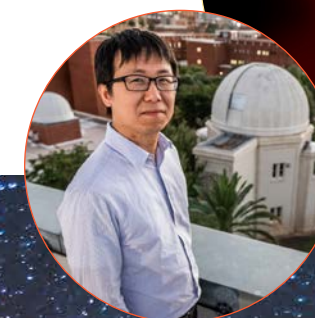
Using the Data Capacitor II high-speed shared storage system and the Carbonate supercomputer, IU astronomy researcher Caty Pilachowski and her team were able to analyze and catalog 70,000 stars in the Milky Way's galactic bulge. The resulting catalog is the largest ever produced and will be made available to astronomers everywhere.

Enabling new black hole research

Astronomers on the Event Horizon Telescope team released the first image of Sagittarius A*, a black hole at the center of the Milky Way. The workflows used to capture the image were prototyped on Jetstream.

“ Jetstream kick-started the EHT's cloud computing effort. The EHT now can survey through hundreds of thousands of imaging parameters because of our initial work with Jetstream.”

—**Chi-kwan Chan**, leader of the EHT Computations and Software Working Group





“The ionized atoms, the electrical fields are very sensitive and the elements want to shoot out in all directions, so if you’re dealing with a wisp of vapor, you can model them as alone in space. But once you start packing them into a dense beam, the interactions multiply—so it very quickly snowballs into a calculation that’s too much for a laptop. Coordinating the simulations, software, and systems is a complex process, and [Research Technologies] did really great work to help us solve really hard problems.”

—Peter Schubert, professor of electrical and computer engineering and director of the Richard G. Lugar Center for Renewable Energy at IUPUI

Transferring power wirelessly

As governments and industry leaders seek alternatives to fossil fuels powering manufacturing and large-scale electric grids, IUPUI Professor and Director of the Richard G. Lugar Center for Renewable Energy Peter Schubert looks to space as a reliable source of solar power. He used Big Red II, Big Red 3, and Carbonate supercomputers to model sending beams of solar power to Indianapolis via satellite.

Managing massive amounts of data

Through our Research Data Services (RDS) group, we are developing and deploying broadly applicable workflows for data and metadata management that are helping individual labs, science departments, and research-intensive schools to manage their research data in consistent, secure, and sustainable ways. These services leverage the excellent resources of RT’s Research Storage and High-Performance File Systems teams.



“RDS helps us manage, store, and process large amounts of imaging data produced in our labs.”

—Hui-Chen Lu, Gill Chair of Neuroscience, Department of Psychological and Brain Sciences

Improving child well-being

Dashboards help community leaders identify adverse trends and address them quickly to improve child well-being. RT’s Crisis Technologies Innovation Lab and IU’s Biostatistics Consulting Center collaborated with The SOURCE, Elkhart County’s system of care, to develop a dashboard that was prototyped on Jetstream. The dashboard provides real-time information about trends and well-being, risk, and protective factors affecting children in the community.



“You have to convince people to share data and then continually reinforce that you’re not going to use that data to point fingers. There’s this continual balance of trust and reinforcing those messages all the time with people.”

—Rebecca Shetler Fast, director, Elkhart County’s system of care, The SOURCE



Enabling new statistical tools

The RT Research Applications and Deep Learning (RADL) team worked with the Bloomington Assessment and Research (BAR) office to create a proof of concept tool and associated test environment to allow BAR to expand opportunities to deploy analytics developed in the R statistical language.

“This application is a prime example of how strategic use of data, software, and analytics can help improve student success here at IU.”

—Sabrina Andrews, associate vice president for institutional analytics

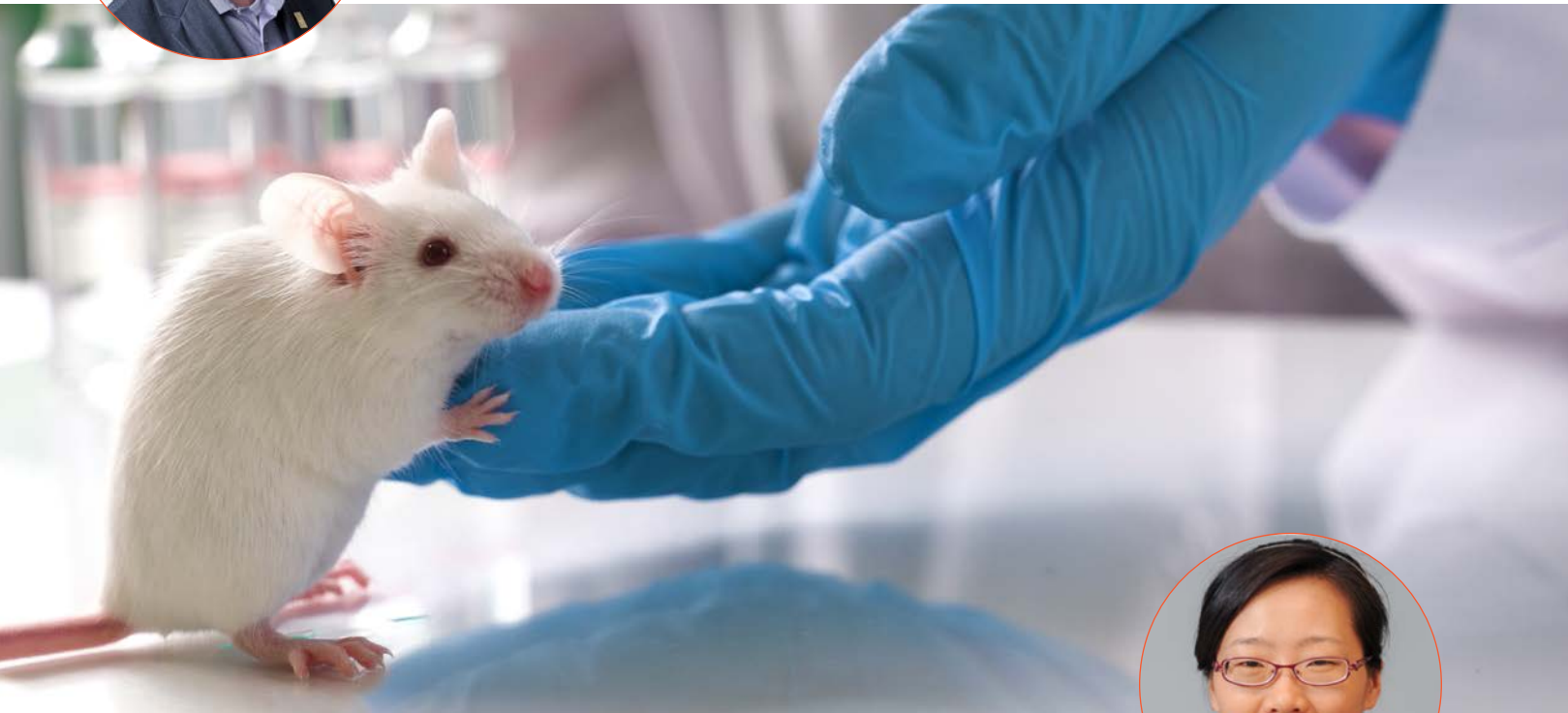


Ensuring ethical animal research

IU Bloomington School of Public Health researchers conducted National Institute of Aging-funded research on the Karst supercomputer to find which test yields optimal statistical results with proper error rates using the least number of animal subjects. The simulations were based on data from real mice to better reflect how real-world data would behave.

“That’s one of the huge benefits of using supercomputers. They enable us to do the calculations more than once in a reasonable amount of time to make sure we’re getting the right answers.”

—Andrew Brown, assistant professor, Department of Applied Health Science, School of Public Health



Innovating information retrieval

Titus Schleyer (Regenstrief Institute) and Xia Ning (The Ohio State University) are using Carbonate and Slate-Project to store and process data for two projects: an innovative information retrieval method for electronic health records using collaborative filtering and a project to characterize COVID-19 patients through a community health information exchange and electronic health record databases. Both projects require access to a large amount of data that contain protected health information.

“The good thing about Carbonate and Slate-Project is that they provide mechanisms to protect sensitive information. They also have ways to monitor for a possible data breach. This is very helpful for us, so we use Carbonate and Slate-Project for both of our research projects.”

—Xia Ning, associate professor for biomedical informatics and computer science and engineering at The Ohio State University



Connecting researchers around the globe

IU Libraries, the IU Network Science Institute (IUNI), and the Big Ten Academic Alliance partnered to create the Collaborative Archive & Data Research Environment (CADRE), an environment where researchers can access big datasets, reproduce shared results, and replicate shared queries. Originally designed and built in Jetstream, CADRE has two components. One is an on-premises system, which works on local Carbonate nodes, but the majority of CADRE is in a cloud-based gateway.

“By encouraging these types of collaborative relationships, we’re not duplicating work and we’re creating a more open environment and encouraging more data to be open so that more researchers can work on it, collaborate, and share work which in turn should increase reproducibility.”

—Jaci Wilkinson, executive director of CADRE

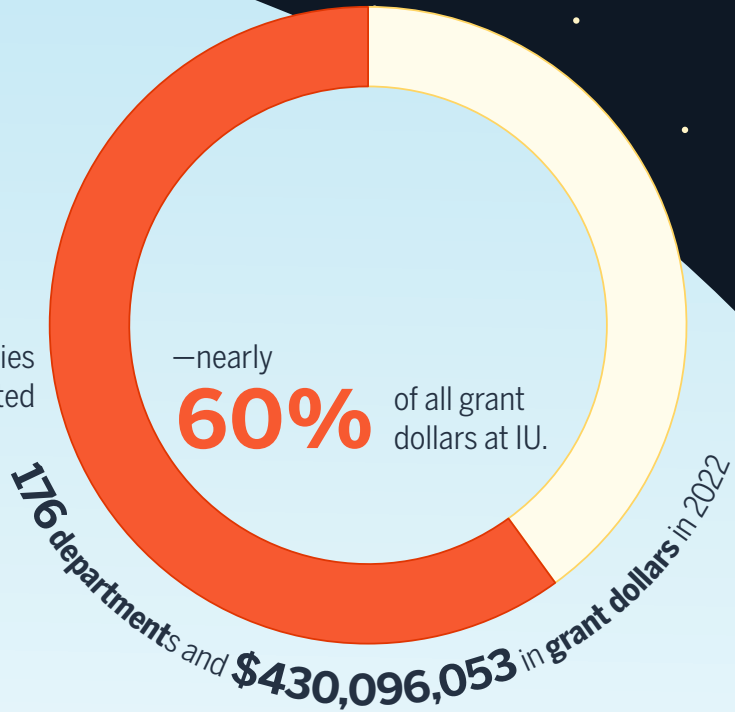


Developing virtual collections

IU3D and the Advanced Visualization Lab have partnered with a variety of IU collection holders to design and implement innovative online and in-person displays for presenting and interacting with digital versions of their physical assets. Partners include Collections @ IU, the new Museum for Archeology and Anthropology, the Eskenazi Art Museum, the Lilly Library, the Sage Costume Collection, the IU Bicentennial, and the Galleries at Herron School of Art + Design.

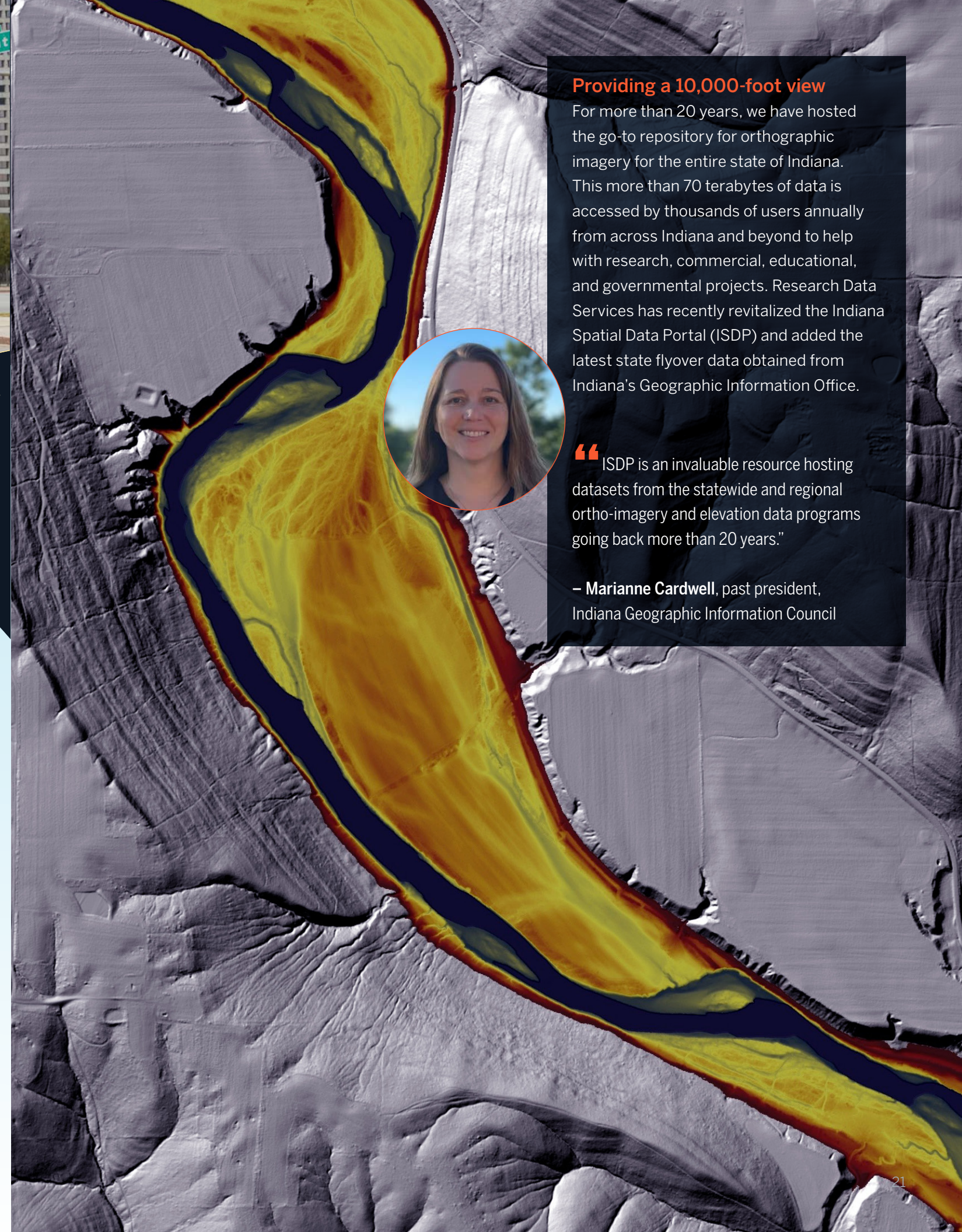


Research Technologies supported



Cultivating the Hoosier economy

More than a service provider, Research Technologies partners with faculty and research labs—providing not only the technology they need, but also the expertise and intellectual contributions that lead to higher competitiveness for grant dollars.



Providing a 10,000-foot view

For more than 20 years, we have hosted the go-to repository for orthographic imagery for the entire state of Indiana. This more than 70 terabytes of data is accessed by thousands of users annually from across Indiana and beyond to help with research, commercial, educational, and governmental projects. Research Data Services has recently revitalized the Indiana Spatial Data Portal (ISDP) and added the latest state flyover data obtained from Indiana's Geographic Information Office.



“ ISDP is an invaluable resource hosting datasets from the statewide and regional ortho-imagery and elevation data programs going back more than 20 years.”

— **Marianne Cardwell**, past president, Indiana Geographic Information Council



Consulting on data collection and management

IU REDCap hosts more than 9,000 projects, putting it in the top 30 worldwide in terms of number of projects and clients. IU REDCap projects have researchers logging in from IU, IU Health, Purdue, the Regenstrief Institute, and locations all over the world. RT staff provide support and consulting for all of these researchers, helping them to design studies and choose the REDCap elements that are most useful to them.



Repurposing technology for education

One IQ-Wall with 16 screens, which began its life in the Advanced Visualization Lab, was moved to a classroom for virtual production and filmmaking classes. The screens facilitate training undergraduate students in methods of virtual production for the Media Arts and Science program.

“The project [using the IQ-Wall] taught me a lot about filmmaking and the innovative technology entering the workforce. I can easily use these skills in my future career.”

—**Kayleigh Jones**, graduate research assistant, IUPUI School of Informatics and Computing



Bringing digital spaces to virtual audiences

Through the IU3D initiative, we have digitized over 100 spaces—including historic buildings, rotating gallery exhibits, research facilities, and schools of study—at five different IU campuses and multiple external collaborators from across Indiana. These digital spaces are being used for student recruitment, virtual exhibits, construction project management, fundraising, fostering cultural understanding, and connecting with alumni.



Advancing granting activities

Over the past decade, we have brought in more than \$65M in external grant funding from federal, commercial, and nonprofit agencies. We continued our success in 2022 with new awards, expanded availability of funded systems, and more.



CONNECTing researchers with next-generation cyberinfrastructure

Collaboration among leaders in RT, UITs Networks, IU's Center for Applied Cybersecurity Research, and the Pervasive Technology Institute at IU is key to the \$20M CONECT project, funded by the National Science Foundation as part of Advanced Cyberinfrastructure Coordination Ecosystem: Services & Support (ACCESS). CONECT will make novel resources accessible to national educators, students, and researchers—particularly those from traditionally underserved audiences.



Broadening access to supercomputing

Big Red 200 became available to all IU researchers in spring 2022. It's intended to be IU's premier system supporting hundreds of millions of dollars in grant-funded research annually. With Big Red 200, IU's research community will be able to do research at a scale and speed that was previously impossible, empowering student success and helping IU to continue as a cutting-edge leader in research and discovery.



Partnering for grant competitiveness

RT maintains cooperative partnerships with higher education institutions providing cyberinfrastructure sites and services, including University of Hawai'i, Cornell University, Johns Hopkins University, Arizona State University, University Corporation for Atmospheric Research, University of Arizona, and University of Texas at Austin.



Saving lives in emergencies

In March, the Crisis Technologies Innovation Lab launched the National Institute of Standards and Technology-funded \$8M First Responder Smart Tracking Challenge (FRST). FRST is a national innovation challenge that brings together technical teams and first responders to develop technologies to locate first responders inside structures with a high degree of accuracy.



“We are increasingly seeing new Internet of Things and tracking technologies emerging on the market and maturing in research labs around the world. Our goal is to create an environment to accelerate innovations that revolutionize location tracking indoors.”

—Sonny Kirkley, FRST project director



Democratizing artificial intelligence

RT is home to Jetstream, the first NSF-funded cloud system for science and engineering research. Jetstream was awarded more than \$14M. Its follow-on, Jetstream2, was funded at \$25M with the option for a five-year noncompetitive renewal for an additional \$22M. These high-performance systems provide anytime, anywhere access to researchers in the United States.

“The worldwide OpenMRS community—a collection of health information technology experts working together to support the development and implementation of a leading open-source medical record system for resource-constrained environments—depends on cloud infrastructure to support forums, wikis, single sign-on, continuous integration, and development and demonstration environments. Jetstream, and now Jetstream2, not only allows us to host the OpenMRS infrastructure, but also maintain it and adapt it with a small group of volunteers using DevOps best practices.”

—Burke Mamlin, co-founder and chief software architect of OpenMRS, associate professor of clinical medicine at the Indiana University School of Medicine, and investigator at the Regenstrief Institute



We advocate for better communities

In their personal time, staff help improve quality of life through activities such as advocating for solar energy, maintaining a genealogy website, running a local minority- and women-owned benefit corporation that recycles organic waste into compost, and helping to build homes in Mexico. Some volunteer for their children's schools. Others help with Makevention, an annual family-friendly celebration of the DIY spirit.

Building a better world

It's not all about the technology. RT staff work diligently to ensure that humanity has a bright future, whether through the research they support or the professional and personal activities they pursue.

We promote diversity, equity, and inclusion (DEI)

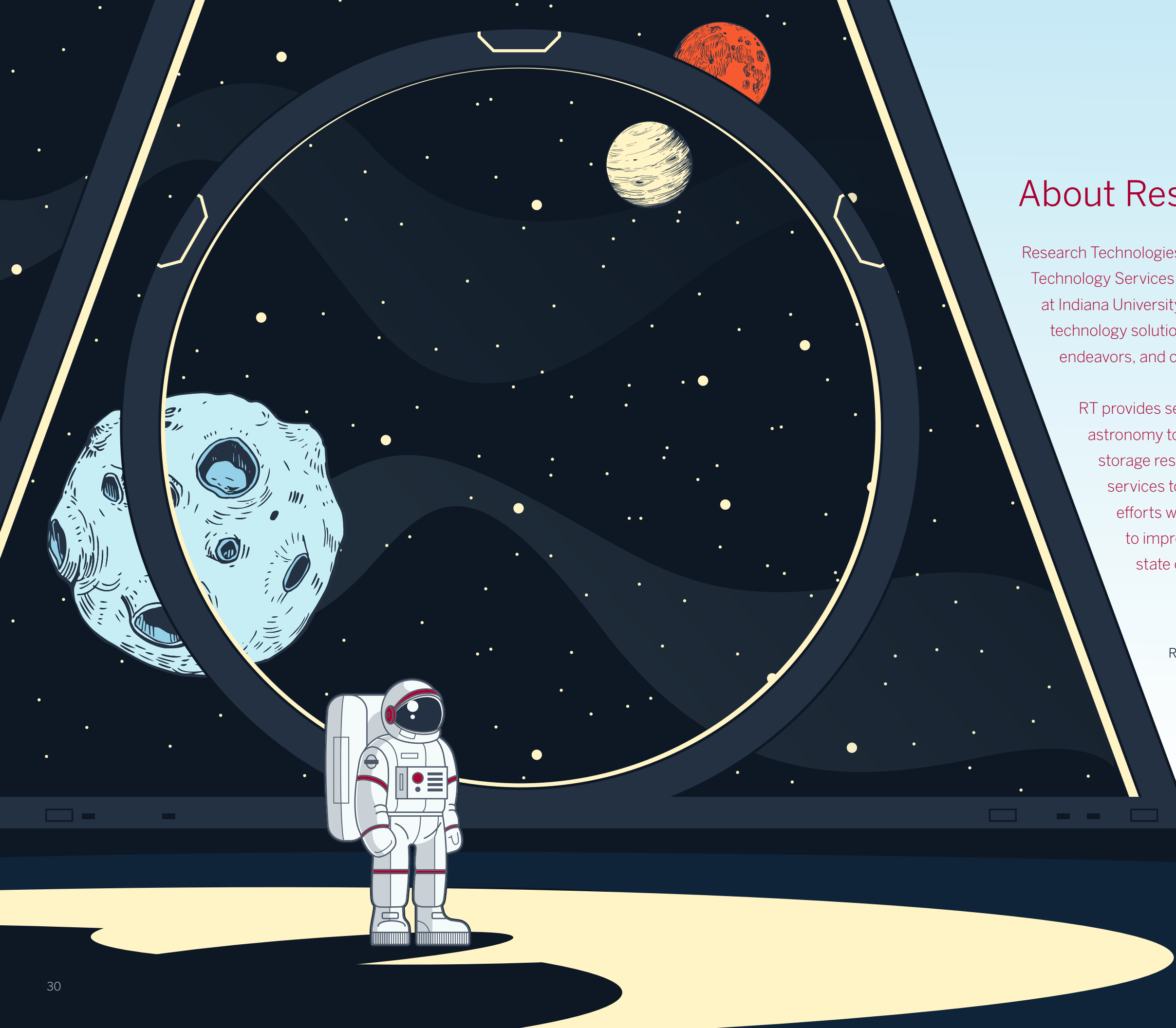
We are proactive when it comes to DEI education and activism. As a panelist, one staff member shared how IU's policy changes during the pandemic helped them to balance caregiving an ailing parent while still being productive at work. Another speaks with IU classes about sexual orientation, knowing that research has shown that meeting someone who is LGBTQ+ is the best way to influence their attitudes about the population. Others help refugees and immigrants feel welcome, serve on the Indianapolis Hebrew Congregation's social justice team, and raise money for local charities in areas including HIV awareness and research, homelessness, mental health stigma, and suicide prevention and awareness.

We share knowledge

We are engaged in leadership positions in national and international IT organizations, ensuring that IU stays at the leading edge of information technology and can deploy technology to improve research at local, state, and national levels. Many serve as panelists and presenters around the world, educating—and learning from—the research community. We have numerous conference organizers and members of communities of practice on staff. And multiple RT staff members hold teaching appointments in academic departments where they regularly share their expertise with IU students by teaching full-semester, for-credit classes.

In February 2022, Research Technologies' Manager of Virtual Platforms Stephanie Cox was named a Fellow in the inaugural 12-member Next Leaders Fellowship (NLF) cohort. NLF is a program designed to identify, develop, and advocate for IT professionals in higher education—particularly those who identify as Black, Indigenous, people of color (BIPOC).





About Research Technologies

Research Technologies (RT), a division of University Information Technology Services and a center in the Pervasive Technology Institute at Indiana University, develops, delivers, and supports advanced technology solutions that enable new possibilities in research, scholarly endeavors, and creative activity at Indiana University and beyond.

RT provides services that benefit those in fields ranging from astronomy to zoology. RT offers expert consulting, compute and storage resources, research software, and visualization and data services to meet researchers' needs. RT complements these efforts with education and technology translation activities to improve the quality of life for people in the IU community, state of Indiana, the nation, and the world.

Read extended versions of these exceptional highlights at go.iu.edu/3X0g. For a complete list of RT services that can help you advance your research and academics, see kb.iu.edu/d/iurt.



UNIVERSITY INFORMATION TECHNOLOGY SERVICES RESEARCH TECHNOLOGIES

First Responder Smart Tracking Challenge (FRST)

This work was performed under the following financial assistance award 70NANB21H022 from U.S. Department of Commerce, National Institute of Standards and Technology.

Jetstream

This material is based upon work supported by the National Science Foundation under Grant 1445604. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

Jetstream2

This material is based upon work supported by the National Science Foundation under Grant 2005506. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

COre National Ecosystem for CyberinfrasTructure (CONNECT)

This material is based upon work supported by the National Science Foundation under Grant 2138307. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

A stylized illustration of a futuristic vehicle or helmet, rendered in shades of blue and white, positioned in the bottom left corner of the page. The background is a dark blue space with scattered white stars and a large, wavy, light blue shape that resembles a nebula or a stylized wave.

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