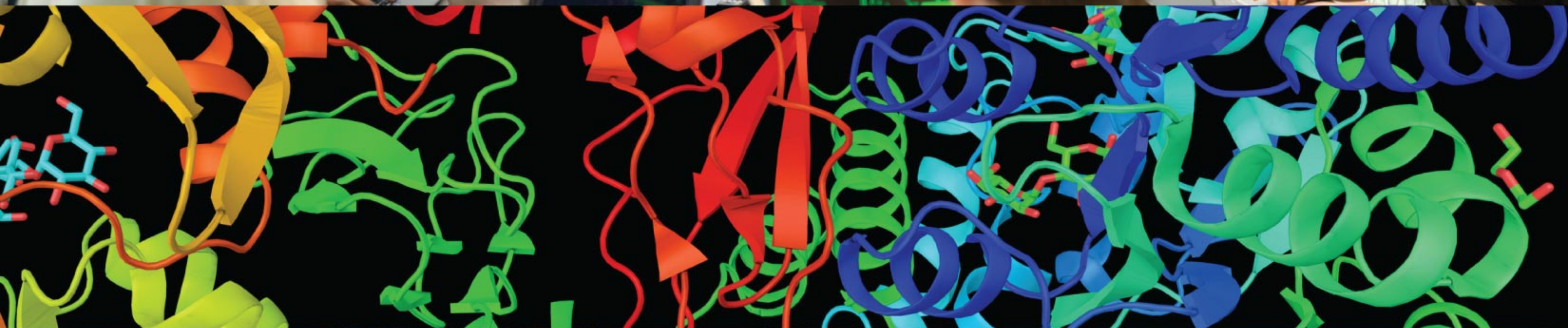




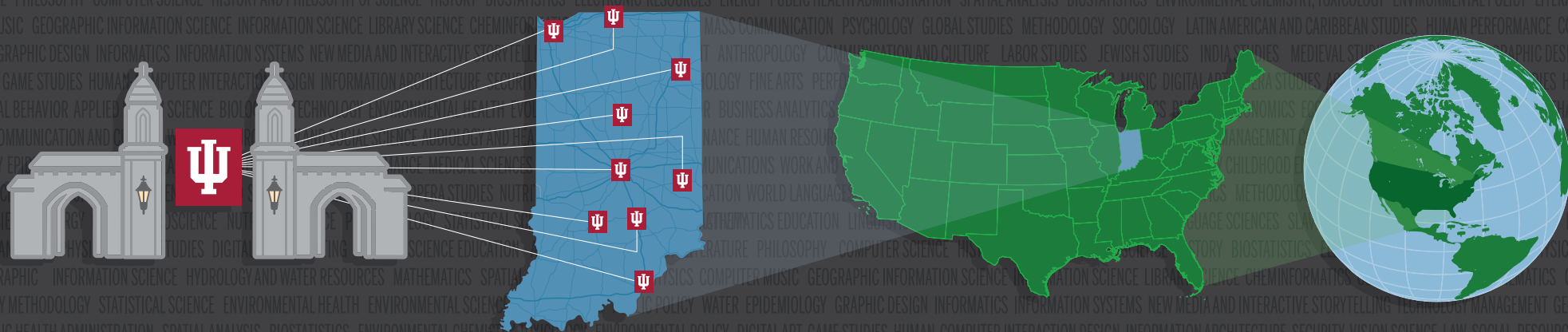
**RESEARCH TECHNOLOGIES**  
UNIVERSITY INFORMATION TECHNOLOGY SERVICES

# IMPACTS

## Annual Report FY2020







## Letter from AVP Matt Link, Research Technologies

### Dear friends and colleagues,

It has been a remarkable year for UITs Research Technologies (RT), marked equally by enthusiastic celebration and by sober reflection in these extraordinary times. Our mission, as one of the IU Pervasive Technology Institute's centers, is to provide systems, tools, and services that open new possibilities for intellectuals and innovators within and beyond the IU community. With specializations in consulting, storage, research software, data visualization, and training, RT has fostered collaborations across disciplines and campuses, some of which are highlighted in the following pages.

Last summer, RT teams geared up for IU's Bicentennial. The Advanced Visualization Lab found creative ways to transport the university's famous artifacts and experiences throughout the state on the "All for You" tour. This team also set up the breathtaking Crystal Wall—the largest curved, mobile CLED display in the world—in Wrubel Commons, where its unparalleled technical capabilities will enable scientific research and enhance the many lectures, presentations, and classes offered in that space.

In 2019, Big Red II was succeeded by Big Red 3, and in January of 2020, Big Red 200 was dedicated as part of IU's Bicentennial event. More than 300 times faster than Big Red II, the new supercomputer will enable as-yet-unimaginable research. These resources will, undoubtedly, enhance the kinds of partnerships that are essential to solving our most pressing research challenges in Indiana, the United States, and the world.

In June, Jetstream, the National Science Foundation's first cloud-computing environment, announced that Jetstream2 was funded through a new \$10M grant. Jetstream has enjoyed a reputation for making high performance computing resources accessible to researchers with limited experience in the field. Jetstream2 will continue along these lines, with increased support for data analysis, on-demand research, and artificial intelligence.

This spring, IU made the prudent decision to move essential operations online. The UITs team in general, and several RT areas specifically, have helped the university stay up and running—from enhancing work-from-home capabilities to making eLearning work for our sizable student body—during the pandemic crisis. Jetstream has made its considerable resources available to the global research community for COVID-19 research.

As an organization, we remain committed to improving our services through communication and innovation. I am very proud of our team's creative activities in furthering research. I am pleased to share these examples of our work with you, and hope that we can continue to collaborate and support research across the university during these challenging times. I look forward to the day that we can all be together again!

**Matt Link**

Associate Vice President  
Research Technologies, Pervasive Technology Institute  
University Information Technology Services

## Introduction

Research Technologies, a division of University Information Technology Services (UTIS) and a center in the IU Pervasive Technology Institute, 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. We offer expert consulting, compute and storage resources, and research software, as well as 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.

### KEY NUMBERS

**\$351,632,947**

FY20 grant dollars  
supported by RT

**\$854,478,824**

FY20 grant dollars  
for all IU

**181**

Departments supported  
in FY2020



The Research Technologies staff in front of the Supercomputing for Everyone bus at the Cyberinfrastructure building on IU Bloomington campus.

## Research Technologies support

We provide A to Z services in five major categories. No matter the tool, service, or support application, our goal is to benefit the entire IU community.

### COMPUTE & STORAGE RESOURCES

Enabling fast calculations, advanced simulations, and massive secure storage

### EXPERT CONSULTING

Connecting researchers with software, computing, tools, and other resources to advance their work

### RESEARCH SOFTWARE

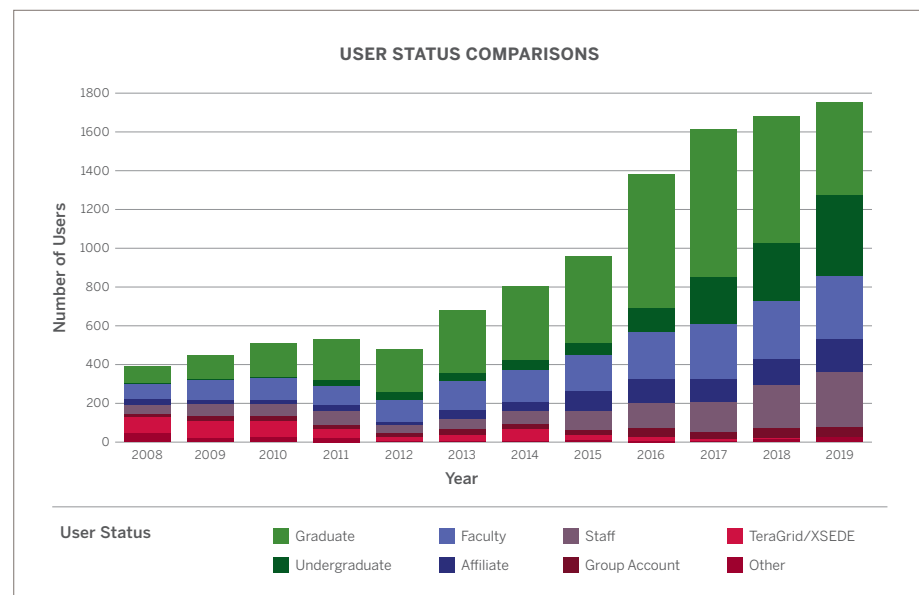
Delivering tools for analytics and big data research; distributing stat/numerical and open-source software

### VISUALIZATION & DATA SERVICES

Promoting interactive models, virtual and augmented reality, advanced digital arts and media, and secure data analysis

### TRAINING & OUTREACH

Connecting researchers with the services they need to reach discovery through targeted training, seminars, workshops, and tours



This diagram indicates both the increase in individuals using HPC systems from 2008–19 and a breakdown of those user groups.

### About this report

This report is organized by major areas of IU Research Technologies impact: Indiana University, the state of Indiana, the nation, and the world. Each section highlights RT organizations and support services by providing a brief description, connections to successful use cases, and user testimonials.



RT IMPACT IN FOCUS

# Indiana University

*Strengthening creative research  
in the university community*



Big Red 200 supercomputer at IU Data Center





RT IMPACT:  
INDIANA  
UNIVERSITY

## Supporting research at IU

*Background image: AVP Matt Link gives IU President and First Lady McRobbie a tour of Big Red 200 during the dedication event in January.*

RT SERVICE IN USE

### Big Red 200

With artificial intelligence capabilities and a peak performance rate of more than 6 petaFLOPS, IU's latest supercomputer solidifies its standing as a high performance computing powerhouse.

### IU UNVEILS SUPERCOMPUTER BIG RED 200

Big Red 200 will operate at a peak rate more than six times faster than its predecessor (Big Red II), with greater than 6 quadrillion—or 6 thousand trillion—floating-point operations per second, or petaFLOPS. Named Big Red 200 in honor of the IU Bicentennial celebration, the new system is more than 300 times faster than the original Big Red supercomputer installed 15 years ago. IU dedicated Big Red 200 as part of IU's Bicentennial event, "A Day of Commemoration: IU's 200th Anniversary," on January 20, 2020.



## Supporting research at IU

### RT SERVICES IN USE

#### Big Red II and Big Red 3

2019 saw the retirement of Big Red II, once IU's primary system for high performance parallel computing dedicated to research. In five years, it supported over 1,700 users in 237 academic disciplines, handling more than 2.5 million jobs with over a billion core hours delivered. Its successor, Big Red 3, is a Cray XC40 supercomputer dedicated to researchers, scholars, and artists with large-scale, compute-intensive applications that can take advantage of the system's extreme processing capability and high-bandwidth network topology.

- 930 dual-socket compute nodes equipped with Intel Haswell Xeon processors (22,464 compute cores)
- Theoretical peak performance (Rpeak) of 934 trillion floating-point operations per second (934 teraFLOPS)

*Background image:  
Big Red 3 supercomputer  
at IU Data Center*

#### PHYSICISTS EXPLORE THE NATURE OF QUANTUM PHYSICS WITH BIG RED II AND 3

At Indiana University, physicists are taking a closer look at how electrons behave, with help from hundreds of millions of calculations powered by HPC clusters Big Red II and 3. Their work expands upon recent discoveries that proved the existence of the Hofstadter Butterfly, a fractal pattern that shows the behavior of electrons in a magnetic field. IU physicists are hoping to classify the types of electrons present in a magnetic field.

"In these types of classifications, the discovery is made possible by supercomputers like Big Red II and 3. The intricacies of what is happening in a physical system are too great for us to have any equation we can solve on paper. We need to use the computers to solve and find these values."

**Babak Seradjeh**  
*Associate Professor of  
Physics, IU Bloomington*



## Supporting research at IU

### EXPLORING GENE EXPRESSION THROUGH HIGH PERFORMANCE COMPUTING

R. Taylor Raborn and his colleagues design methods for locating gene promoters. They use Carbonate to develop containerized deployment and application of their analysis software.

#### RT SERVICE IN USE

### Carbonate

Carbonate is a large-memory computer cluster configured to support high performance, data-intensive computing. Carbonate can handle computing tasks for researchers using genome assembly software, large-scale phylogenetic software, and other genome analysis applications that require large amounts of computer memory.

- 72 general-purpose nodes, 256 GB RAM each
- 8 large-memory compute nodes, 512 GB RAM each
- Each node: Lenovo NeXtScale nx360 M5 server with two 12-core Intel Xeon E5-2680 v3 CPUs and four 480GB SSDs

"This wouldn't have been possible without the great resources that UITS provided for us. I don't know if there's any high performance computing center in the country that is as easy to work with and that does as much for the people that work in the university as UITS....It really democratizes the use of resources."

**R. Taylor Raborn**  
*Research Scientist, Arizona State  
University Biodesign Institute*

### IU RESEARCHERS STUDY ROLE OF MICROBIOMES IN HONEYBEE FUNCTION

Eric Smith, a postdoctoral fellow in the IU biology department's Newton Lab, studies how honeybees' microbiomes support and influence their function. Smith explores the specifics of these symbiotic relationships using computational biological methods. He uses IU's large-memory computer cluster Carbonate to write and run computational programs to analyze DNA sequences.

"Carbonate provides the computational infrastructure necessary to perform large amounts of data simulation to test computational pipelines and eventually analyze DNA sequencing data."

**Eric Smith**  
*Postdoctoral Fellow in Biology, IU Bloomington*



Background image: Detail  
of Carbonate supercomputer  
at IU Data Center



RT SERVICE IN USE

## Carbonate deep-learning nodes

Starting in June 2019, the Carbonate Deep Learning resource delivered 759,688 core hours and 92,783 GPU hours to users conducting research in disciplines including medical image segmentation, video classification, cybersecurity, genomics, and natural language processing.

### IDENTIFYING NEUTRINOS WITH MACHINE LEARNING

Mark Messier, Micah Groh, and Ryan Murphy of the IU physics department measure the rates at which neutrinos change their type, or flavor. By looking at the particles' patterns, they hope to determine if matter and antimatter neutrinos follow the same pattern, or if they differ from each other. The team uses Carbonate to process examples of neutrino interactions, feeding them through an algorithm so that it can learn each flavor's identifying characteristics.

"The Carbonate computer cluster here at IU has top-of-the-line GPU processors, which are perfect for processing these examples quickly. Having this resource readily available at IU allowed us to try lots of ideas out so we could find the best ones."

**Micah Groh**  
*Graduate student in  
Physics, IU Bloomington*

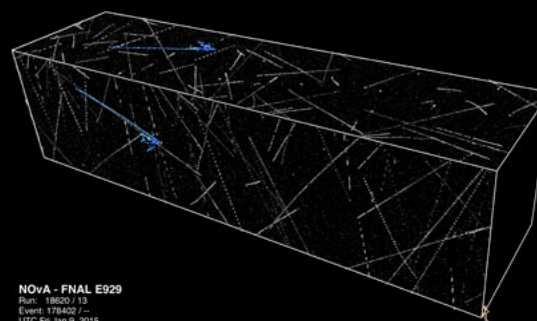
"In its first year, the Deep Learning expansion of the Carbonate system enabled research in over 130 projects. With its uniquely capable V100 GPUs, this resource gives IU's researchers the ability to get ahead of the curve with their research using AI techniques."

**Scott Michael**  
*Manager, Research Applications  
and Deep Learning, IU Research  
Technologies*

RT IMPACT:  
**INDIANA  
UNIVERSITY**

## Supporting research at IU

*Background image: Detail  
of Carbonate supercomputer  
at IU Data Center*





## HPC resources support projects of any scale

Background image: Research  
Desktop interface in use

### RT SERVICE IN USE

#### Research Desktop

Research Desktop (RED) provides a user-friendly graphical user interface (GUI) for researchers unfamiliar with command-line coding who want to use HPC resources. Research Software and Solutions (RSS) Director Robert Henschel says increasing accessibility diversifies the research projects that use IU's HPC resources beyond the computer sciences.

#### IMPROVING HOW SCIENTISTS MEASURE AIR POLLUTION

IU environmental science Ph.D. candidate Colleen Rosales uses RED to power complex air pollution measurements. RED allows her to share her work without her colleagues having to install programs on their own computers or learn UNIX terminal commands. She uses her research as a digital teaching tool.

"The graphical interface of RED helps me easily share and show people how to use IU's supercomputers, from colleagues to undergraduate students."

**Colleen Rosales**  
*Graduate student in  
Environmental Science,  
IU Bloomington*

#### IU STUDENT RESEARCHER WINS AWARD FOR POSTER ON ADVANCED COMPUTING

Student researcher John Clere (shown far right) documents Indiana history using hundreds of images, processed through Karst, to make 3D-printed models of artifacts from Floyd County. His poster, titled "Floyd County history now in 3D: Supercomputing and photogrammetry increase understanding of artifacts" won "Best Overall Poster" at the Student Poster Expo.



### RT SERVICE IN USE

#### Karst

A high-throughput computing cluster designed to deliver large amounts of processing capacity over long periods of time, Karst provides batch processing and node-level co-location services, making it especially suited for high-throughput, data-intensive parallel computing jobs.

- Remote access from Karst Desktop
- 228 general-access compute nodes
- 28 condominium nodes
- 16 dedicated data nodes, each with 64 GB RAM and 24 TB local storage
- Each node: IBM NeXtScale nx360 M4 server with two Intel Xeon E5-2650 v2 8-core processors, 32 GB RAM, 250 GB local disc storage



## New perspectives with visualization tools

*Background image: Crystal  
Wall at the CIB displaying  
3D medical imagery*

### RT SERVICE IN USE

#### IQ-Walls

IQ-Walls are a next-generation planning tool for Indiana University and its partners. They combine large-format, ultra-high resolution video display systems with applications developed by the UITS Advanced Visualization Lab (AVL) that support 3D holographic miniatures and augmented reality.

Hubs for collaborative research, teaching, and creative activities, the AVL has installed more than 18 IQ-Walls across IU. This includes a mobile IQ-Wall that allows users to move each column of displays depending on the environment.

#### REPURPOSING TECHNOLOGY ACROSS IU CAMPUSES

Summer 2019 saw the AVL engaging in a “technology trickle-down” with its IQ-Walls. An interactive 4x2 multitouch wall was relocated from IUPUI’s Informatics and Communications Technology Complex to the Scholars Commons in the Wells Library at IU Bloomington. The Wells Library’s 4x4 stereoscopic 3D IQ-Wall was moved to the Mathers Museum, and part of the museum’s old IQ-Wall was put into service as a mobile display column to welcome visitors.

#### CRYSTAL WALL

Debuting in January, the Crystal Wall, located in the Cyberinfrastructure Building’s Wrubel Commons, is the largest curved, mobile CLED display in the world. With a resolution above 4K, this display highlights scientific, data, and artistic visualizations with stunning clarity and brightness. Nearly 28 feet wide and 10 feet tall, with 108 panels, it enables HPC interaction, videoconferencing, and stereoscopic 3D and spatial tracking for virtual reality applications.

“The Crystal Wall is truly breathtaking. It has already received national attention from commercial media studios seeking to duplicate the installation, and will be a strong contender for international engineering awards for visual display systems. The AVL is honored to share this gem with the IU community.”

**Scott Birch**  
*Manager, Advanced Visualization Lab, IU Research Technologies*



## Supporting research communities

*Background image: A CAAV conference attendee takes the virtual reality demo for a spin in IU's Alumni Hall.*

### HUF19 AND THE CAAV CONFERENCES

In October, RT hosted two conferences in the same week: the High Performance Storage System (HPSS) User Forum, or HUF19, and the Campus Alliance for Advanced Visualization, or CAAV. HUF19, with 77 attendees from 11 states and 6 countries, explored the importance of HPSS around the world, IU's 20-year history of HPSS, and the HPSS issues faced by different organizations. CAAV, which includes both academic and industry members, boasted a range of workshops on everything from virtual reality to sustainability.

### RT SERVICES IN USE

#### Training & outreach

Research Technologies strives to serve both IU and the local community by providing training and outreach programs. Programs focused on teaching, informing, and conveying the roles that technology can play in research and discovery continue to evolve. In the coming year, RT will extend its outreach to local educators by providing more hands-on technology experiences for young students. RT will also engage directly with the IU community to expand its reach, building partnerships with faculty and researchers to support them in their quest for new knowledge.

#### READY, SET, ROBOTS!

This two-day summer camp requires no pre-requisites, just a curious mind and an interest in technology. Kids grades 7-12 tour the IU Data Center and learn basic computer programming skills as they work in teams alongside RT staff to command LEGO Mindstorms® robots, simulating a Mars rover mission. The camps end with a Robot Grand Challenge, where parents and friends gather to see the kids' newly acquired skills.

"The real strength of the CAAV is the diversity of who comes and what's presented. Sometimes we can have a technically heavy, pretty intense presentation that might have information to do with mathematics, graphics, compute, and computing architecture, and different methods of rendering. And the next presentation might be someone talking about how to make a multimillion-dollar facility sustainable."

**Emma-Jane Alexander**  
Manager, Shell 3D Visualization Center, University of Wyoming



RT IMPACT IN FOCUS

# State of Indiana

*Serving Indiana through  
technological innovation*



Throughout IU's bicentennial, the Big Red Bus toured the "All for You" exhibit around the state of Indiana.



## Advanced Visualizaton Lab

The UITs Advanced Visualization Lab (AVL) promotes and supports the innovative application of visual technologies to enhance research, education, creative activity, and community outreach within and beyond Indiana University. The AVL also provides expert consulting services, training opportunities, and learning resources related to visualization.

## THE “ALL FOR YOU” TOUR

From September 2019 through early 2020, IU’s traveling exhibit, “All for You,” toured Indiana, bringing the IU Bicentennial to the state’s many counties. This interactive exhibit explored IU’s impact on the state. The exhibit featured content from each campus in various mediums, including virtual reality, 3D prints, physical objects from IU’s collections, videos, and historic images. A virtual tour is available on the Bicentennial website (200.iu.edu).

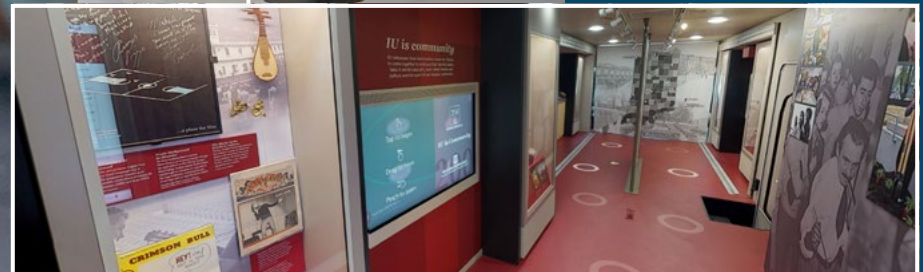
## RT IMPACT: STATE OF INDIANA

## Picturing tomorrow

*Background image:  
Element from 3D printed  
Showalter Fountain*

## 3D PRINTING IU LANDMARKS IN HONOR OF THE IU BICENTENNIAL

In honor of IU’s Bicentennial, Scott Birch and the Advanced Visualization Lab (AVL) digitized and 3D printed a series of renowned IU monuments and artifacts, including the Old Oaken Bucket and a striking version of the Showalter Fountain, in miniature. The Bicentennial Bus traveled all over the state with these objects inside, allowing the team to highlight this and many other technologies the AVL promotes and supports. The bus included two custom touchscreen kiosks loaded with virtual tours of beautiful locations on all IU’s campuses with Campus Quest. The Digital Diorama Viewer was also on board, allowing visitors to dive deeper into shipwrecks and other historically significant sites.



“The IU Bicentennial provided a unique opportunity to share the expertise of RT in a way that was extremely accessible and meaningful to all Hoosiers. The traveling exhibit was a literal and figurative vehicle for showcasing why IU matters to the state, and why RT matters to IU.”

**Eric Wernert**  
*Director, Visualization and Data Services*



## Enabling data-driven insights

### IUSM RESEARCHERS STUDY IMPACT OF VIRAL INFECTIONS IN INFANTS WITH CYSTIC FIBROSIS

Researchers at the Indiana University School of Medicine, led by Drs. Stephanie Davis and Ashley Deschamp, are seeking to improve understanding of respiratory disease in infants born with cystic fibrosis. The study enrolled 70 infants between the ages of 3 and 5 months to participate in the observational study at four centers, and used REDCap to collect data through clinic visits and weekly phone calls over the course of a year.

“Creating a REDCap database and enabling it to do a myriad of different things for the research team (e.g., sending out study reminders and/or questionnaires automatically, displaying questions that need to be answered only when very specific conditions are met, etc.) is extremely easy and can be done by a research coordinator, an investigator, or another member of the study team without any coding experience.”

**Joseph Hatch**  
*Research Specialist, Cystic Fibrosis Research Center,  
University of North Carolina-Chapel Hill*

### REDCap

IU's Research Electronic Data Capture (REDCap) is a secure web-based platform designed to support data collection and data management for research, operations support, and quality improvement projects. Easy-to-use, intuitive features allow REDCap users to build and manage online surveys and databases with no programming experience required.





## Enabling data-driven insights

### RT SERVICES IN USE

#### REDCap

REDCap is available to Indiana University researchers as a result of IU's partnership in the REDCap Consortium. Sponsored by the UITs Research Technologies Advanced Biomedical IT Core (ABITC), IU REDCap is one of several research-related collaboration tools offered by the Indiana Clinical and Translational Sciences Institute (Indiana CTSI).

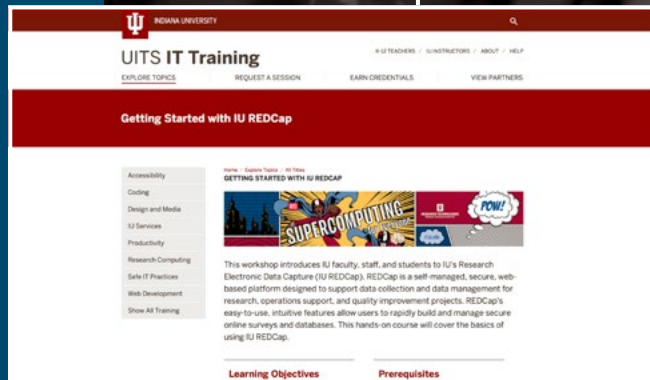
#### SECURE ACCESS TO REDCAP DATA THROUGH THE API TOKEN VAULT

Until recently, the process of obtaining a REDCap API involved a twelve-page report to create and use a REDCap token. Understandably, this document was a deterrent for many potential users. Bob Davis, director of clinical data management at the Indiana University School of Medicine Department of Biostatistics, and his team (shown from left to right: Steve Brown, Greg Puetz, and Larry Rikken) created a technological solution, the API Token Vault. To meet stringent security requirements, the tokens are encrypted, accessible only through integrated authentication, and visible only to their user-owners.



#### EXPANDING RESEARCH INFRASTRUCTURE WITH REDCAP

From the digital humanities and bioinformatics to data privacy and patient surveys, the Supercomputing for Everyone Series (S4ES) connects IU's research community with the possibilities of REDCap. In addition to in-person training and online courses, IU's REDCap support team develops tools like the REDCap ETL for data extraction, and shares these developments with over four thousand consortium members.



"Supporting over 10,000 total users with over 14,000 projects, IU's REDCap is a popular choice for data-driven research. This year, over 200 people attended the weekly online office hours where REDCap administrators answer questions on how best to use REDCap to maximize data quality and management."

**Catherine Bauer-Martinez**  
*REDCap Application Administrator, Advanced  
Biomedical IT Core, IUPUI*



# Addressing Indiana's toughest challenges

*Background image: Nurse  
running diabetes test on  
expectant mother*

## IU's Grand Challenges Program

IU's Grand Challenges Program is a bold commitment to address the issues that impact Indiana and the world. The challenges are split into three categories: the Precision Health Initiative, Prepared for Environmental Change, and Responding to the Addiction Crisis. As these large-scale programs and projects ramp up in size and scope, Research Technologies at UITS remains committed to providing support to the IU Grand Challenges Program, and stands ready to assist with the high performance computing needs that might arise.

## MONITORING THE HEALTH OF HOOSIER MOMS

Patient surveys powered by Indiana University's REDCap help understand the genetic risks of gestational diabetes in Hoosier moms as part of the Precision Health Initiative. Updates to REDCap's "date calculated" field allow for more accurate tracking of patients' trimesters and improve data collection.

"Patients can answer questions in the comfort of their homes. The ability for research teams to quickly and easily create projects and surveys is invaluable."

**Kathleen Flannery**  
*Study Coordinator,  
Obstetrics and  
Gynecology Research,  
IU School of Medicine*

## ADDICTIONS

Raymond Sheppard of RT has been working with the IU School of Nursing to re-create a Microsoft Windows computational environment in which they can conduct research on Karst without needing to know how to use a supercomputer. Researchers are using this environment on a variety of projects, including one studying the pharmacokinetics of buprenorphine in pregnant women undergoing treatment for opioid use disorder.



## Addressing Indiana's toughest challenges

### Environmental Resilience Institute

Indiana's climate is warming, a development with wide-ranging consequences for our state's economy and health. Funded through Indiana University's Prepared for Environmental Change Grand Challenge initiative, the Environmental Resilience Institute is working to prepare businesses, families, and communities to adapt—and thrive—amid these changes. Research Technologies at UITS is providing research support through resources such as high performance computing.

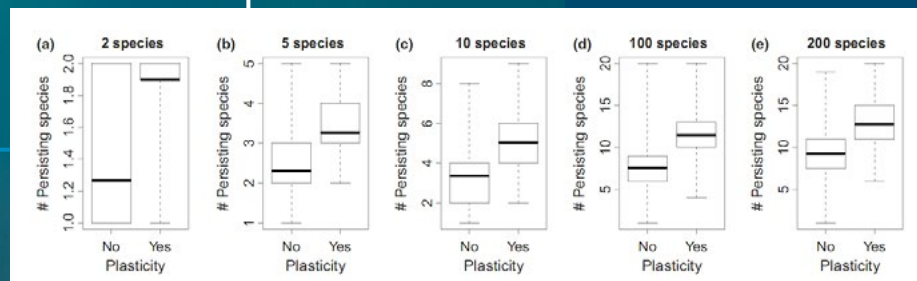
### PREPARED FOR ENVIRONMENTAL CHANGE

Ranjan Muthukrishnan of the IU Environmental Resilience Institute recently published a paper in which he and his collaborators use HPC simulations to offer a new angle on commonly held understandings of the composition-colonization trade-off within ecosystems. Muthukrishnan's simulations explore the influence of species plasticity in this context. Plasticity, when brought into the equation, allows for competitive hierarchies to shift, leading to more coexistence in a broader range of conditions.

"If one were to consider only one set of conditions, this type of simulation would not be overly complex. To play it out in lots of different circumstances, high performance computing resources, like those IU provides through Big Red 3 and Carbonate, are essential. Playing out simulations in a way that includes a whole landscape of possible locations requires a large amount of computer memory. IU's supercomputers give the large-scale simulations ample time to run through different scenarios and show results even when they depend on important, rare events."

**Ranjan Muthukrishnan**  
Research Scientist, Environmental Resilience Institute, IU Bloomington

*Background image:  
Carbonate supercomputer  
at IU Data Center*





RT IMPACT IN FOCUS

# The nation

*Answering the nation's call  
for technological access*



*Researchers use high performance computing  
to aid in 3D protein mapping.*



## High performance computing (HPC) in focus

### Jetstream

Jetstream, the first National Science Foundation (NSF) funded production cloud for science and engineering, began in 2014 with an \$11 million grant, and since then, it has enabled research in fields from bioinformatics to political science. Jetstream's on-demand capabilities give researchers access to advanced cyberinfrastructure from their tablets, laptops, and desktop computers. In 2020, Jetstream had a greater than 99% up-time for the fourth year in a row, and IU gave it a hardware update that expanded its capacity, allowing it to support even more projects.

### EXTERNAL FUNDING

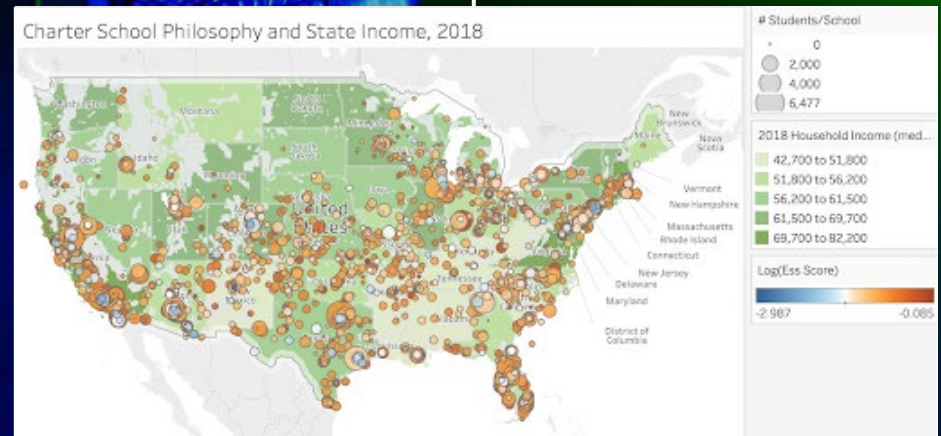
External funding for projects like Jetstream allows RT to extend its reach beyond IU, offering resources to national research communities. That external funding also helps attract talented, technically adept staff to Indiana, filtering those funds back into the state economy.

### SOCIAL SCIENCE RESEARCH IN REAL TIME

Jetstream connects social scientists at the University of California, Berkeley working across informatic research disciplines to map how marketing language used by charter schools may further race- and class-based U.S. educational segregation.

"The stability, scalability, and user friendliness of Jetstream have allowed me to smoothly incorporate new team members on an ongoing basis, and to easily shift resources between tasks as each aspect of the project unfolds."

Jaren Haber  
Graduate student in Sociology, University of California, Berkeley







## Jetstream2

In June 2020, the NSF awarded IU \$10 million to deploy Jetstream2, a distributed cloud computing system intended to support on-demand research, artificial intelligence, and enhanced large-scale data analyses. The NSF's newest supercomputing resource, Jetstream2 is designed especially for researchers who have limited experience with high performance computing and software resources, which allows points of access for small, under-resourced academic communities.

"We intend Jetstream2 to be a democratizing force within the NSF ecosystem, allowing researchers and educators access to cutting-edge resources regardless of project scale."

David Y. Hancock  
*Principal Investigator,  
Jetstream and Jetstream2*

RT IMPACT:  
THE NATION

High  
performance  
computing  
(HPC)  
in focus

## A GATEWAY TO ATMOSPHERIC AND GEOLOGICAL RESEARCH

Jetstream's virtual machines power a collaborative initiative between the Unidata Program Center at the University Corporation for Atmospheric Research and the NSF, for the benefit of the geoscientific community. With these Jetstream resources, Unidata provides a variety of geoscience data to university faculty, researchers, and students. Alongside those short-term archive and near real-time data holdings, Unidata also provides visualization and analysis tools.

"Science students and professionals spend too much time distracted by software that is difficult to access, install, and use. Cloud computing accelerates scientific discoveries and collaborations by reducing research and data friction. We aim to improve 'time to science' for atmospheric science researchers and students with the NSF-funded XSEDE Jetstream cloud."

Julien Chastang  
*Software Engineer, Unidata*



## High performance computing (HPC) in focus

### A COMPUTATIONAL BIOLOGY CLASSROOM IN THE CLOUD

Through Jetstream's open access for educators and researchers, computational biology and chemistry students at Doane University in Crete, Nebraska have access to supercomputing resources that illuminate the scope of bioinformatics.



"It's important for computational biologists to have some basic coding skills. I can create a virtual machine, and everyone logs into the web browser on their laptops. Jetstream makes it so much easier to get students up and running."

Erin Doyle  
*Professor of Biology, Doane University*

### Jetstream in (and out) of the classroom

One of Jetstream's goals is to increase access to cloud computing resources for researchers in the long tail of science, including social science and humanities research. Jetstream extends this mission through its Research Experience for Undergraduates (REU) program and its many education allocations, giving students early access to advanced cyberinfrastructure—invaluable experience for future members of the 21st century workforce.

### JETSTREAM REU

Each summer, Jetstream—the NSF's first production cloud computing system—lets undergraduate students from all over the country loose in the cloud. Its REU program involves students in projects that capitalize on IU's leadership in fields like bioinformatics, data visualization, and advanced media.

"Incorporating undergraduate students in large-scale NSF projects is not only rewarding for the students and their mentors, but it also has the practical benefit of helping the Jetstream team refine documentation and teaching practices that make the system more accessible to others. The diversity of the students, and recruiting in non-traditional disciplines, has further enhanced those benefits."

David Y. Hancock  
*Principal Investigator, Jetstream and Jetstream2*



## High performance computing (HPC) in focus

### WILL A POPULAR ANGLING FISH SURVIVE A CHANGING CLIMATE?

JingWei Song, who attended the *de novo* transcriptome workshop held by NCGAS in spring 2019, studies the effects of temperature change on sea trout metabolism as part of his research on climate resilience at the Virginia Institute of Marine Science.



## The National Center for Genome Analysis Support

The National Center for Genome Analysis Support (NCGAS) provides resources for the U.S. biological research community to analyze, understand, and use the vast amount of genomic information now available. A collaborative project between Indiana University and the Pittsburgh Supercomputing Center at Carnegie Mellon University, NCGAS focuses on transcriptome- and genome-level assembly, phylogenetics, metagenomics, transcriptomics, and community genomics. With consulting services for NSF-funded researchers and education and outreach programs on genome assembly and analysis, NCGAS also maintains software on several nationally accessible high performance clusters.

"The SRA is a great resource, but searching these data is challenging because the database is increasing exponentially. These young researchers are improving access to data by learning data mining, in addition to participating in microbiology research."

**Bhavya Papudeshi**  
*Bioinformatics Analyst, NCGAS*

### RESEARCHERS MINE GENETIC DATA FOR MICROBE CLUES

Undergraduate women researchers have been behind some of the latest discoveries within the Sequence Read Archives (SRA) hosted by the National Center for Biotechnology Information team. Researchers' data mining into the genetic dispositions of microbes was recognized by the American Society for Microbiology Microbe Conferences in 2019 and 2020. Their research is the result of collaboration between NCGAS, the Center of Excellence for Women & Technology, and the Jetstream Research Experience for Undergraduates.

"The *de novo* transcriptome assembly workshop greatly reduced the learning curve for my analyses. I couldn't have gotten my preliminary results in time to present at the American Fisheries Society Meeting without the computing resources provided by NCGAS."

**JingWei Song**  
*Graduate student of Biology, Virginia Institute of Marine Science*



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*Delivering transformative technology  
to the global research community*





## Responding to a global pandemic

IU's HPC resources are the infrastructure behind collaborative and cutting-edge research. With COVID-19 infections on the rise, Indiana University is providing services and resources to help understand and contain the pandemic.

### NCGAS OFFERS CONSULTATION TO COVID-19 RESEARCHERS

NCGAS, which helps the U.S. biological research community analyze and utilize genomic information, is offering consultations for biologists and bio-informaticians involved in COVID-19 research.

### JETSTREAM PARTICIPATES IN THE COVID-19 HPC CONSORTIUM

As part of the worldwide effort to understand and contain the COVID-19 pandemic, Indiana University's Jetstream is fast-tracking projects that respond to the crisis.

### REDCAP SUPPORTS GLOBAL VACCINE EFFORT

Indiana University's REDCap will facilitate the Indiana Clinical and Translational Sciences Institute (CTSI) research center's implementation of the AstraZeneca COVID-19 vaccine protocol.

In April 2020, the COVID-19 symptom research initiative was launched by IU, the Regenstrief Institute, and Microsoft News. This anonymous REDCap survey collected COVID-19 data worldwide, with record response rates allowing epidemiologists to use this data to monitor hotspots and predict new outbreaks in areas with limited testing.

### IUANYWARE BRINGS IU'S VIRTUAL CAMPUS TOGETHER

From proctoring exams remotely to maintaining critical research from home, IU's client virtualization service IUanyWare was a critical asset during the spring semester's pivot to virtual learning. Working with IU's Intelligent Infrastructure, UITS Support Center, and Student Technology Centers, IUanyWare also virtualized campus computers that would have sat idle.

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## Partnership on a global scale

"Regardless of what the 2020-2021 school year looks like, the technology and infrastructure is in place, and I feel we are prepared to meet any challenges."

**Stephanie Cox**  
*Manager, IUanyWare, IU Research Technologies*

"Jetstream is proud to be part of the COVID-19 HPC Consortium, putting the power of our collective resources into the hands of scientists who can use them to respond to this unprecedented crisis."

**David Y. Hancock**  
*Principal Investigator, Jetstream and Jetstream2*



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