I am pleased to present this annual report of the Office of Information Technology for the FY18 academic year. The theme for this annual report is Service, and you will see that represented on nearly every page. I hope that you will be able to see the remarkable progress we are making in transforming our department from implementers of technology to partners in the delivery of technology services that are fully aligned with the needs of those that we serve.

During this year, we made important progress in advancing and completing the major initiatives of our long-range plan. This includes continued investment in research computing through our Research Software Engineering program and infrastructure upgrades that include the deployment of the Tiger II cluster. Our Next Generation Network project kicked off this year with the goal of implementing a state-of-the-art network that delivers higher bandwidth for our researchers, and enhanced resiliency and a greater level of security for everyone. As you will read, we also greatly enhanced our capability in the Project and Technology Office (PATCO) to help our campus partners effectively implement new solutions.

This fiscal year marked a major milestone in our Service Management initiative as we implemented both the problem management and asset management processes. With these two processes in place, we completed the original scope of our IT Service Management project and are now well on the way to creating the culture of continual improvement that we strive for. There is much work to be done, for sure, but the foundation is strong.

I hope that you will also see in these colorful pages the passion that our staff bring to their work every day. We all feel the deep responsibility we have to this remarkable institution and it is a joy to be able to work with such extraordinary people. It is their dedication to supporting the mission that makes the Office of Information Technology successful.

Jay Dominick
Vice President for Information Technology
and Chief Information Office
OIT Mission Statement

OIT delivers information technology services and resources that enable Princeton to succeed in its mission to advance learning through scholarship, research, and teaching of unsurpassed quality. We achieve this through continual improvement and by aligning our services to the changing needs of our campus.

Our services are delivered with a commitment to:

- **Enabling innovation and research** at the frontier of discovery through centrally-provided, high-performance computing services and support resources;
- Delivering technology, tools, services, and applications that **support teaching and scholarship in and beyond the classroom**;
- **Supporting the effectiveness of University operations** through IT solutions and processes that align with campus priorities and strategic initiatives;
- **Relentlessly protecting the University's information**, while respecting the privacy of the members of our University community;
- Providing information technology services that **enrich the student learning and living experience**;
- **Delivering next-generation state of IT services** achieved through service management planning and practices that ensure responsible stewardship of University resources;
- **Fostering a diverse workforce and an inclusive culture** that leverages many perspectives in the creation and delivery of technology solutions and services for our campus community.
OIT as IT Services

OIT’s eight departments provide more than 230 services across more than 70 business service collections. The services are represented in 8 major IT categories, including infrastructure, administrative and business, communications and collaboration, security and identity/access services, teaching and learning, research computing, IT professional services and client computing.
OIT’s first priority is to empower our campus partners to address the University’s constant strategic objectives. As our customers’ needs and focus change, OIT must adjust to meet their new demands. Inspired by this IT evolution in progress, OIT took stock in FY18 and considered how to meet the demands of a new technology paradigm. The result is the revitalization of our software strategy with the formation of a new department that builds on a successful track record across IT disciplines: Software and Application Services (SAS). More than an organizational restructuring, SAS represents a modern shift in how OIT will think about code by introducing a transformative development model.

Academic and administrative programming worlds unite

Historically, separate programming groups serviced our academic and administrative partners. This was the norm on college campuses, in part due to a divergence in the code on which academic and administrative systems relied. Yet, as the development standard has advanced, trends such as automation, Software as a Service (SaaS), usability and accessibility, and language-agnostic development are redefining enterprise IT and bridging the gap across programming languages. Bringing development teams together as a single group focused on meeting customer needs creates synergies that render advantages across all technology projects.

This matured development approach is allowing our campus partners to benefit from:

- Universal core principles in integration, security, and interoperability
- Unified design guidelines that amplify productivity and maximize efficiency
- Shared software architecture that reflects the practices that inform our collective work, regardless of the system or code base

While continuing to support a myriad of programming languages, a unified SAS team brings together valuable skills honed across academic, administrative, web development, user experience, and database teams, while introducing game-changing capabilities in the way of software infrastructure services. (More on that below.) In so doing, the team has aligned under a shared mission to provide solutions that keep our campus partners on par with the pace of change through software applications crafted with a human touch.

Within SAS, programming services now reflect a broad continuum of capabilities that together inform superior technology provisions. From system engineers and web developers to data analysts and enterprise resource planning specialists, SAS encourages shared perspectives and promotes a holistic approach to software delivery. This is more than conceptual. Engagement between web and application development broadens perspectives on the power and importance of design. Bringing together programming expertise and applications encourages a needs-based approach to making decisions on where best to develop or house a solution, extending possibilities and promoting creative thinking.

SAS is proof positive of an age-old adage: the whole is greater than the sum of its parts.

Above: A unified Software and Application Services team brings together valuable skills, while introducing game-changing capabilities in software infrastructure services.
Software Infrastructure Services (SIS): A key ingredient

Underlying SAS is a careful reimagining of how OIT builds and delivers its applications. As software transforms the world, it is essential to invest in expertise that bridges the divide between complex systems and the data that gives them purpose. At the same time, new techniques including advanced Application Programming Interface (API) management are altering the relationship between applications and the infrastructure on which they rely, and redefining how development gets done. With that as context, Software Infrastructure Services (SIS) was launched in FY18 as part of the SAS structure. Its charge is to bring a team of system engineers and database architects together who will work to guide an IT culture change.

Increasingly, applications, the networks that host them, and even firewalls are spun up and maintained through software. This frontier requires a new point of view that moves beyond programming languages and servers in favor of a model that prioritizes innovation. SIS will operationalize a horizontal approach to development by inspiring a Development and Information Technology Operations (DevOps) mindset across programming teams, which introduces practices and tools that enable OIT to evolve, improve, and deliver software at a faster pace. DevOps emphasizes continuous integration, wherein real-time feedback ensures continued fitness for purpose wherever and whenever code is checked in. It recognizes the possibilities unlocked by automation when it comes to project timelines. Echoing the service mission noted throughout this report, usability and accessibility are considered from the earliest stages of a project.

This optimization is partly realized through a strategically defined DevOps stack, which is simply a collection of software programs that work in tandem to achieve defined goals. The framework for DevOps was developed in FY18. Based on concepts intuitive to any developer, it incorporates:

- Version control
- Dependency resolution
- Build process
- Unit testing
- Functional testing
- Automated deployments
- Code analysis
- Artifact versioning

Serving as an internal service provider, SIS will introduce new approaches to database administration and agile system integration, while shaping automated software tools and standards. More than advanced IT concepts, these techniques are game-changers. Centralized software delivery will help developers offload low value-adding activities like maintaining infrastructure, bolstering opportunities for creativity and enhancing productivity potential. Code will be leveraged wisely across projects, reducing duplicative work. Real-time feedback on code health and automatic debugging will drive better outcomes.

SIS hit the ground running in FY18, initiating foundational projects that will inspire new heights in productivity throughout SAS in the coming years:

- **Infrastructure as Code:** Application servers depend on many layers of complicated configuration, which was traditionally a frustrating time sink for development teams. SIS collaborated with server infrastructure colleagues to deliver the capability to use code to maintain servers. This new technology allows development teams to manage their systems with full confidence and minimal effort via programmatic control of all configuration tasks.
Automated regression testing: Regression testing ensures code changes do not compromise existing functionality. The SIS team has prototyped a tool to fully test-run an application through multiple browsers and exercise paths without a heavy lift from the developer.

App-to-app API: SIS is guiding the creation of a shared layer through which systems can more easily communicate and share data, which will reveal new potential when it comes to securely harnessing formerly disparate information.

A DevOps foundation: SIS began the effort to automate the processes by which code is propagated from a developer’s workstation through QA and into production. Work is in progress to make tasks like scheduling, code analysis, integration, versioning, and testing largely self-running and seamless. By standardizing this approach, OIT will better surface shared needs and project interdependencies, while freeing development teams to focus on creatively applying their highest-value thinking.

Priming Princeton for the evolving technology landscape

Forward-looking and steeped in best practices, SAS will alter the nature of application development within OIT, promoting a software-savvy development culture that is:

- Data-focused: Data is one of our most important institutional assets. Broad data expertise, guided by industry-leading techniques related to security, authentication, hygiene, and management will prepare the University to achieve new insight, whether managing enterprise applications or modeling best practices in the classroom.

- Automation-informed: By letting code do what it does best, OIT will prepare Princeton to make swift use of new technologies as they emerge.

- Agile: Flexible, dynamic development that leverages automation and real-time feedback results in high-performance applications of maximum utility, even as the nature of technology changes.

- Future-ready: By merging talent geographically and philosophically, SAS will position Princeton to make smart moves into the software-driven future.

- Built to purpose: Campus partners enjoy consistent, reliable solutions that are fully vetted, strategically informed, and achieved at a faster pace than ever before.
Defining the Next Generation Network

Today, it is difficult to recall the nearby past when the Internet was newly born and network connections involved a chorus of beeps, static, and patience. Princeton’s inaugural connection to the National Science Foundation Network (NSFNET), an Internet predecessor that connected universities to regional networks, was made a mere three decades ago. In the late 1980s, it was nothing short of revolutionary, reflecting one of the world’s fastest connections, at a speed of 1.5 million bits of data per second (Mbps). Twelve-plus Internet generations later, Princeton’s 150,000 Mbps network reflects a sharp growth rate, encompassing an order of magnitude increase every five years.

The computational and connectivity needs of the campus continue to expand, from the residence halls to the data center. There, some of the world’s foremost computational researchers rely more and more on data-intensive instruments such as cryo-EM and genomic sequencing devices that have easily displaced video streaming as the driver of network bandwidth demand. At the same time, a planned campus expansion, proliferation of IT-enabled learning solutions, and a rapidly changing technological context will result in a surge in the number of network-enabled devices that is just as steep as that seen for acceleration in networking speed.

In 2018, roughly 300,000 devices used the University’s wireless network. The number of devices that rely on the campus network is expected to grow to one million-plus over the next decade alone.

With that as inspiration, OIT has launched one of its most complex and ambitious projects to date: building Princeton’s Next Generation Network. Borne of the University’s Campus Plan and designed in full consideration of the Infrastructure Master Plan that will bring it to life, this next generation network will deliver greater speed, significantly more capacity, and visionary security protocols to keep Princeton’s data secure. Fully redesigned to reflect the trajectory of a wireless, always-on world, it is the most significant leap forward in the history of networking at Princeton. The goal is to achieve one terabit (Tb) per second of connectivity by 2023. This is nearly seven times the current speed.

A broad horizon

Through the years, Princeton’s existing network, which will be maintained as its replacement is developed, has served the University well. The current iteration, based on best-in-class standards developed during the wired era, has facilitated powerful connections between students, faculty, and their academic partners. It has supported intensive supercomputing, rapid data expansion, and a steady advance into the WiFi era, all while growing progressively more complex, robust, and security-centered.

As OIT looks to the future of the University’s IT needs, however, network demands are steadily expanding. The Internet of Things (IoT), wherein everyday objects send and receive data via the Internet to optimize performance, requires ever-greater capacity to inform a high-performing campus, from heating and cooling to electrical systems. A wireless-first reality has flipped the script on how people access and use the network. Researchers require the ability to move vast amounts of data that would have been head-spinning to those early Internet pioneers. They need to move it securely and faster than ever before. Moreover, campus expansion — with the development of the new Lake Campus, greater emphasis on data science, and growth of the School of Engineering and Applied Sciences — all point to a near future in which more people, more devices, and more applications will rely on and demand reliable network connectivity.

Knowing this future makes now the ideal moment in which to re-envision a future-ready network that will support the University for generations to come. Emphasizing security, resilience, and efficiency, it is nothing less than a paradigm shift. The new network will be:

- **Scalable**: Able to rapidly scale, keeping pace with the data intensivity of modern research and an evolution in the technology that underlies modern life.

- **Wireless and IoT optimized**: It will support the numerous devices proliferating within the campus infrastructure and among our community of students, faculty, and visitors.

- **Primed for automation**: As software infuses the world, the opportunity to take advantage of new efficiencies will be baked into the design from the beginning.

- **High-performing**: Bolstered by projects including network monitoring (see, “Defining the future of technology service monitoring” on page 11), the network will continuously respond to evolving demands, from managing relationships between network devices to routing network traffic strategically during periods of high demand.
Secure: Backed with always-on security informed by the University’s IT Risk Assessment process, OIT will be powered to provide real-time responses to real-time threats. This includes responses to Denial of Service (DoS) attacks, which are rising in number, wherein an attacker overloads a system to prevent legitimate access among authorized users.

While achieving all of the above, the bar for reliability will be set high. This is expressed in factors of nine. For example, certain critical life systems work toward 99.999% uptime, allowing for only 5.26 minutes of downtime annually. While developing against that standard, OIT is aiming to achieve an extra nine across its 10- to 30-year window, which would effectively reduce downtime to 31.5 seconds. To achieve this, OIT will rely on sound underlying architecture and rapid-healing techniques that leverage the network’s own power to correct course in the event of a disruption.

Planning for the network began in earnest in FY17, with a phased rollout planned over the next three-plus years. While accounting for networking demand across a 10-year horizon, the strategy reflects a 30-year context, mirroring the strategic window established by the Campus Master Plan.

Key wins for FY18, which involved thousands of person hours within OIT and beyond, include:

- Peer reviews to assess the state of top-tier university networks
- Initial vendor selection
- Architecture mapping
- Development of a go-forward framework
- Creation of a new wireless visitor network, launched in the fall

Security-infused design

As part of the network overhaul, OIT is taking the opportunity to shore up the network border, reflecting the heightened emphasis on security that infuses every technology initiative on our roster. By engineering redundancies, powerful firewalls, and traffic management into the design, OIT is taking evolving security threats seriously.

As this security-smart network takes shape, thinking anew is allowing us to re-engineer the way buildings “talk” to each other. We are guiding improvements to incident response times using data and automation. The new network will also be privacy-preserving, relying on built-in versus bolted-on solutions that secure our information, and operating across zones with intelligent, role-based permissions that limit access to sensitive portions of the network for non-authorized parties.

Next Generation Network by the numbers

- 2 data centers, 2 network border sites, 3 network core sites, with fiber connectivity
- 200+ buildings, all with fiber connections
- 14,000+ wi-fi access points
- 2,000+ network switches
- Support for 10 Gbps, 40 Gbps, and 100 Gbps
- 5 to 100 Gbps Internet services

At the heart, it is about remembering the humans behind the technology. In the future, network access will be determined based on people’s roles. For example, faculty will have access to the IT services and resources that support their particular teaching and research initiatives.

Designing the future today

Combined with the University’s new data center, a forward-looking software-architecture initiative, and investment in the IT backbone of campus learning spaces, the strategy underlying the network project echoes the Princeton’s mission: to provide unwavering support to students and faculty across their learning and research endeavors. In so doing, it will benefit everyone on campus, from visitors connecting wirelessly while partnering on a research project to the administrators who keep Princeton running smoothly day-by-day.

Looking toward the future, Princeton has ambitious plans that suit its long history of innovation. This includes a legacy of contributions by Princeton researchers to the essential technology on which the world now relies day-to-day—a track record that we expect to continue as OIT activates a “campus as a lab” approach wherein our brightest minds will continue to redefine the networking frontier. Energized by this vital exchange, OIT situates itself firmly in the service of these goals: supporting faculty innovation, delivering world-class education to world-class students, and meeting the technology curve of research across disciplines, wherever that journey may lead.
Defining the future of technology service monitoring

A proliferation of software- and network-enabled applications has changed the nature of higher education. The University is reliant on a well-run, tightly managed set of technology services, from the classroom and residential colleges to the central office. At the same time, potential threats from bad actors grow ever more complex, as does the job of properly meeting emerging technology demands. This makes performance and security monitoring mission-critical for the future of IT service delivery at Princeton.

In FY18, OIT created a service monitoring team. The team’s charge is to establish a framework to revolutionize its service-monitoring approach. Led by a newly appointed associate director and staffed by a team of security and monitoring analysts, the group will work with campus stakeholders to deliver a new model for monitoring that ensures maximum service uptime and performance.

The power of a holistic view

In the past, systems monitoring was based on an “up-down” model, wherein various technologies, such as servers or CPUs, were assessed for out-of-spec performance. This schema is adept at capturing failures in a given system. It is less potent at identifying disruptions in interactions between applications, networks, and servers or even new areas of need. A new customer-centric monitoring approach—seeing how well a service is working from the customer’s device—eliminates blinder-view silos in favor of a horizontal, “end-to-end” view of Princeton’s IT-service landscape.

Making strategic moves to the cloud

As software reshapes the future of IT, smart cloud utilization becomes a key OIT initiative. With the advance of innovative, software-based infrastructure from industry-defining players such as Amazon AWS, MicroSoft Azure, and Google Cloud, everything down to the servers on which developers rely can be spun up through code that is reproducible, testable, and scalable.

Absent these advances, onboarding a server could take a week, from installation and configuration to testing. Today, the same outcome can be achieved with a few lines of script. Employed with intentionality, cloud-based services can offer significant cost and time savings compared to infrastructure maintained onsite, allowing us to redirect limited resources to strategic work on our partners’ behalf.

In FY18, we began advancing the organization’s cloud-readiness and expertise, laying groundwork for a future in which such services become a standard component of the overall OIT infrastructure toolkit.

Preparing for Office 365

Looking toward a horizon wherein Software as a Service (SaaS) becomes standard operating procedure, OIT is taking steps in delivering cloud-based services. In FY18, we dedicated significant effort preparing for a move to Office 365 in the cloud, with the anticipated rollout of faculty and staff email and OneDrive beginning in Spring of 2019. The result of deliberate planning, paired with stringent analysis of vendor terms and data security protocols, the project is already beginning to transform how the team works. Letting the vendor do what they do best, from stabilizing underlying infrastructure to managing change, OIT can better support the campus with efficient, affordable, and secure solutions.

AWS server provisioning pilot delivers proof-of-concept

The advance of the cloud reflects a watershed IT moment. For more than a year, an OIT team has met biweekly to build its Infrastructure as a Service (IaaS) skillset. This culminated in a noteworthy FY18 accomplishment: an OIT server provisioning process that now includes activating
servers on-demand in the Amazon Web Services (AWS) cloud platform.

The benefits are already being seen. One project focused on automating the creation of servers in AWS. This involved establishing a network in AWS, connecting it to Princeton’s network, resolving DNS and routing issues, and extending the existing server provisioning system to now deploy Linux and Windows servers in AWS.

OIT also leveraged AWS for the Thesis Central project. Thesis Central, the system undergraduates use to submit their senior theses, required both a server for running the application and a relational database, which is used to organize data sets. OIT’s server administrators and database architects worked together to automate the creation of the system in AWS such that it can be completely deleted after all theses for the academic year have been collected. Then it can be quickly recreated when submissions begin anew. This is significant for several reasons:

- **Security**: The infrastructure can be quickly eliminated after it has served its purpose, limiting potential breaches by bad actors. The software also remains up-to-date and patched, which reduces risk by eliminating any known security vulnerabilities.
- **Savings**: Servers can be quickly spun up and down as needed, eliminating the costs associated with continually having to maintain software and hardware for on-prem infrastructure.
- **Service**: This IaaS template has resulted in transferable knowledge and a repeatable process that can enable OIT to quickly and adeptly respond to similar server needs and requests in the future.

### Storing backups in the cloud

Maintaining the University’s digital data is vital for ongoing research and administrative functions. To ensure that the data survives any compromise affecting the University’s data centers, backup copies of all data are currently written to tape and shipped to an outside location. With rapid growth in the amount of data, however, this process has become cumbersome. OIT completed a pilot project in FY18 to send backup data over the network to cloud storage located hundreds of miles away from campus. The new process is streamlined, helps protect and preserve University data, and is expected to turn a cost savings as the technology matures.

### Liberating code from servers

In the past, in order to run a piece of code, programmers had to locate or build a server that contained all of the specific versions of software on which the code depended. With the advent of serverless platforms, codes and dependent software can be packaged and deployed together in such a way that the underlying server can be generic. In FY18, OIT deployed Docker containers in AWS. Eliminating server and software version constraints, they package code and its dependencies together, allowing developers to use the programming languages and software libraries best suited to the job at hand. Ideal for schedule-based tasks, these containers are activated only when needed, saving costs between cycles. This makes administrative functions like generating reports and sending notifications both easy and cost-effective.

### Serving our campus stakeholders

#### Expanding support for researchers

From the sciences to the humanities, researchers throughout the University are conducting pioneering work using cloud-based platforms. Many researchers seek OIT’s assistance in making sound use of enterprise license agreements, often to adhere to funding requirements. Recognizing an emerging need, OIT has worked with Microsoft, Google, and Amazon to manage funding and billing for researchers’ work in each platform. OIT has started discussions with the Office of Finance and Treasury to develop and launch Managed Billing for Cloud Infrastructure as a Service, which would enhance administrative efficiency and keep our faculty focused on their groundbreaking work.

#### Keeping campus connected

In the rare cases when the University’s core website goes down, maintaining contact is critical. The University’s website is hosted on a redundant, fault-tolerant infrastructure hosted in multiple data centers in Amazon’s eastern U.S. region. Despite the redundancy, interruptions may still occur due to widespread network outages or extremely high volume of demand. OIT has helped the Office of Communications account for such extreme cases. A simple outage page is now stored in redundant locations throughout the U.S. If the website goes down, that page is cached and delivered via the cloud to a series of nodes distributed throughout the world, and it can be easily updated by Communications staff with any important information. This virtually eliminates the possibility of a total loss of the University’s ability to communicate to the campus community through its website.
Whether appointed to one of the two-dozen-plus departments that leverage centralized research computing infrastructure and services, or situated in a department that maintains infrastructure in-house, OIT’s Research Computing team remains committed to meeting the evolving needs of our faculty and graduate student researcher community.

As the pace of technological change accelerates, this grows ever more important. Computationally intensive instruments like functional magnetic resonance imaging (fMRI), which measures brain activity, and cryo-EM, an advanced electronic microscopy technique that uses electrons to capture 3D images of molecules and other biological phenomena at near-atomic resolution, are surfacing data-rich insights at a level of detail previously inconceivable. This necessitates sophisticated research plans. Optimized computer architectures backed by high-powered processors have become incredibly complex and more opportunity-rich for those who understand how to take advantage of them. As highlighted in this report, new software methodologies from machine learning to cloud computing are also redefining the very nature of high-performance computing.

Guided by University leadership, OIT continues to uphold Princeton’s mission to advance learning through scholarship, research, and teaching in all that we do. This includes the provision of needs-aligned solutions, from systems to training to frontline engineering support, that empower faculty to make transformative discoveries and define the frontier of inquiry in their fields.

Tiger2 gets a boost

In FY17, OIT introduced Tiger2, the most advanced high-performance computing system ever to reside on campus. Launched with 1.5 petaflops of computing speed, it significantly bolstered available power, computational capacity, and throughput—and is already contributing to award-winning faculty work that is changing our understanding of topics as diverse as genetics and machine learning.

As promised, OIT achieved significant additional gains in FY18. Tiger2 launched in FY17 with an impressive 320 GPUs, distributed across 80 nodes. GPU microprocessors have grown ever-more important in modern research. Comprised of hundreds of cores each, they excel in processing many software threads simultaneously. CPUs are comprised of just a few, yet much more powerful, cores that can cache great amounts of data and perform more independent and general operations. Recognizing the diverse needs of our research community, OIT boosted its cluster to include 408 HPE Apollo Intel Skylake CPU nodes with more than 163,000 cores in FY18. Tiger2 is now four-to-five times more powerful than the system it replaced.

Setting sights on a major data storage upgrade

Great leaps in computational potential have resulted in data sets of remarkable scale and complexity. This has led to new initiatives, such as the Princeton Research Data Service, which was envisioned and remains guided by a cross-functional team, including: Dean for Research Pablo DeBenedetti; Robert H. Taylor 1930 University Librarian Anne Jarvis; and Vice President for Information Technology and Chief Information Officer, Jay Dominick. Establishing a new paradigm for archiving data and facilitating open access, the service has revealed strong need for visionary data solutions in the years to come.

This insight planted a seed, and in FY18, OIT began gathering requirements for a proposed solution that will increase departmental and administrative storage by a factor of 10, or a total of 100 petabytes. More than a way to create space, the solution includes a new strategy for organizing data that reduces effort via three levels of organization: working or scratch data that is currently in use; persistent data that is dynamic, but not immediately active; and true archival data, which is static yet important. Using a combination of on- and off-prem infrastructure, the solution that is in progress promises maximum performance, value, and security combined with ease-of-use. Watch for updates in FY19.

Pilot program with the Princeton Plasma Physics Laboratory (PPPL) demonstrates the value-added nature of partnership

Ongoing management of computational and storage hardware can be a demanding task, particularly in an era where data expertise is in high demand. Like other departments that rely on specialized clusters to advance faculty research objectives, PPPL excels at maintaining equipment in their data center. Such systems are mission-critical, facilitating groundbreaking work in topics like fusion. A pilot program in FY18 showed that partnership with central services can yield rewards. With the placement of a jointly managed cluster in the OIT data center, PPPL researchers were able to more efficiently employ OIT data insight throughout the pilot period, which is expected to continue. Such a cluster allows both the University and lab researchers to have access to a broader array of modern, stable computational systems.
For the average person, any rumination on the fruit fly ends with a distracted swat. Yet the hidden world of this diminutive species has potential to reveal surprising insights into the neural-generated behavior of species across the animal kingdom, including our own.

For example, it may surprise the uninitiated to learn that fruit fly mating rituals include elements commonly associated with classic human romance, intricately patterned love songs among them. Smitten by a potential partner, a male plays a song using his fast-fluttering wings. As his prospective female partner responds, moving toward or away, he measures her proximity and speed and adjusts his tune in real time.

If all goes well, he will convince her to become his mate. For Princeton Neuroscience Institute (PNI) Professor of Neuroscience and Molecular Biology Mala Murthy, the neural patterns that spark such songs can unlock insight into how the brain processes sensory information to inform behavior. With the addition of Research Software Engineer David Turner to PNI in 2017, her ability to explore this question has grown by leaps and bounds.

Through a position jointly funded by PNI and the Office of Information Technology, Turner's role points to a wider investment the University is making to bring expert software engineers to disciplines from statistics and machine learning to genomics.

Their task: to bring advanced programming expertise to departments and create new research possibilities in the process.

“The fruit fly, Drosophila melanogaster, is a great model system, because it has a number of genetic tools with which to manipulate the nervous system,” Professor Murthy explains of her work. “You can turn on neurons and turn off neurons. You can record activity from neurons. This allows us to get at what we call neural mechanism: how individual neurons that make up the brain contribute to behavior.”

Romance aside, that query is deeply quantitative, necessitating a highly sophisticated research model. Using advanced microscopy, Murthy examines the fly's brain in response to sensory stimuli, tracking 100s of firing neurons at a time. With Turner on board, Murthy has rapidly refined that methodology — including the recent implementation of a virtual reality experience that approximates the natural experience of males and females during courtship.

“The fly can’t actually walk, because it’s fixed on a microscope,” Turner explains of the challenge on which he focused his attention. Yet motion is central to the experience that drives neural responses. The solution approximates the fly’s motion in a free environment by positioning it on an omnidirectional trackball during research sessions. Stimuli that flies would normally experience during courtship are presented relative to speed on the ball. These experiments will get at cognitive processes like learning and memory, decision-making, and sensory-guided behavior.

“You can’t perform the neural recordings in a freely moving fly,” Murthy says. “This is the next best thing.”

“This is precisely the kind of work that the Research Software Engineering program is designed to deliver,” explains Ian Cosden, manager of HPC software engineering and performance tuning for OIT’s Research Computing group. In the United Kingdom, he says, the pairing of researchers and software engineers has steadily gained steam over the last five years. Princeton is at the leading edge of its adoption in American universities.

For computer scientists like Turner, who has a Ph.D. in mechanical engineering and a master’s and bachelor’s in computer science, it is an emerging career path well suited to those who wish to apply their programming skills in an applied environment. Turner chose to pursue his Ph.D. in mechanical engineering rather than computer science because he was driven to apply his software skills to applied research questions, he says. “As a research software engineer, I can adapt my skills to a different scientific domain.”

At PNI, he contributes directly to Murthy’s work, while exposing the next generation of researchers to new levels of professionalism in software development — though he is quick to note the contributions of postdocs like David S. Deutsch, who built much of the hardware for the project. That’s a significant paradigm shift in an era when programming is fast becoming a core competency in research. It also solves a problem that has long challenged labs like Murthy’s. In the past, programming...
Training the next generation

Building the computational fluency of the rising generation of academic leaders is every bit as central to Princeton’s mission as its promotion of groundbreaking faculty research. As more and more disciplines find value in code for their research, OIT is partnering with University departments to equip their students with the technical and research skills demanded in their fields.

Portal to Python creates new student research possibilities

More and more courses at Princeton include programming on the syllabus. Yet in the past, connecting students with advanced computational tools could be a logistical challenge. In the summer of 2018, Research Computing recognized that need and partnered with the Center for Statistics and Machine Learning (CSML) to create a cloud interface that enabled students enrolled in a summer course to run statistical programming packages using R and Python. Accessible on their laptops via a simple authentication, it vastly simplified the provision of a leading-edge learning tool, eliminating the need for one-by-one installations and keeping the instructor’s focus on teaching. It also gave students the ability to pursue larger, more complex projects than what might be possible on their personal machines. Heading into fall 2018, an additional 420 undergraduates across three courses benefitted from the interface. Plans are in place to partner with the CSML to further develop the program.

Graduate workshop pilot reveals data-management essentials

Anyone who has struggled to find a file in a labyrinthine shared drive understands the importance of defined data structures. This is no less true for the modern Princeton student, whose coursework and research can generate vast volumes of data. With a conviction that data management is now a core competency, a pilot workshop for graduate students was developed by the OIT Research Computing team, in partnership with the University Library and the Princeton Institute for Computational Science and Engineering (PICSciE), for a January 2019 launch with three-dozen participants. Spanning five days and covering topics from data hygiene and curation to analysis and ethics, it is designed to expand student awareness of key data essentials, while illuminating the many helpful resources available to them throughout their tenure with the University. With the onboarding of a training specialist in FY19, plans are in place to formalize and expand the program.
Deepening our bench to create lasting value

Cloud architect to be hired in FY19

As the range of IT-reliant disciplines grows, on-prem cloud technology will continue to play a role across an array of faculty research projects, particularly those involving simulation and modeling across tightly coupled systems. At the same time, maturation in the commercial cloud has introduced new and budget-friendly possibilities. The key to determining the right approach for the work at hand is a deep understanding of the state of the industry. In FY18, OIT hired contract cloud specialists to facilitate the acquisition of high-value cloud software. Building on that success, a search was initiated to hire a permanent cloud architect who will position Princeton to elegantly meet the demands of specialized faculty work and support the development and deployment of emerging research techniques.

Research software engineering program takes a leap forward

Launched in FY16, OIT’s research software engineering program has become an indispensable resource for departments seeking to elevate software performance and create new advantages for their research faculty. Placing Princeton at the forefront of American universities, the program pairs highly skilled research software engineers (RSEs) with co-sponsoring partners who require both software engineering and domain expertise to leverage new technologies and platforms.

This arrangement enables faculty and researchers to devote their focus to their core research objectives, rather than the issues surrounding software implementation. It also elevates the standard for software performance, increasing the likelihood that the resulting code base can be leveraged by peer scientists — an area of focus among sponsors who wish to create lasting value through their investments.

Given the pace of technological change, Princeton’s RSE program marks a new way of thinking about the composition of a research team, bringing expert collaborators into the mix who understand the science through the lens of software performance. The RSE program’s value also exceeds the sum of its parts. Working as peers, the RSEs hone expertise in their sponsoring departments, while sharing insights that activate synergies. Their standing as full-time professionals at the University also helps to preserve critical institutional knowledge that not only ensures the viability of individual projects when key researcher inevitably leave, but has ripple effects beyond any given project.

In FY17, the RSE program included four positions. Funding was secured in FY18 to expand it to eight, including new RSE expertise in politics and sociology, bioinformatics and genomics, and molecular biology. More than a new service, the program is a model for other Universities in the U.S. who wish to pursue a structure that has become quite robust in the United Kingdom over the past five years. By all accounts, it is working. In FY18, code from the Princeton Geoscience Project — led by Jeroen Tromp, Blair Professor of Geology, and professor of geosciences and applied and computational mathematics — was so well-constructed that it was selected to be used as one of the e-benchmarks for Summit at Oak Ridge National Laboratory, the newest and most powerful supercomputer in the world.

A new look for Research Computing

With the launch of Tiger2, OIT was inspired to create a logo that conveys the prowess of the research being conducted on campus. In FY18, it was adopted as the new logo for Research Computing. Echoing OIT’s dedication to supporting and promoting world-class research in partnership with the Princeton Institute for Computational Science and Engineering (PICSciE), it mirrors a forward-looking stance and dynamic support recipe that spans infrastructure services, the provision of technical insight, and ongoing education and training.

In FY18, Research Computing also launched a new website: researchcomputing.princeton.edu. Echoing the themes above, it offers a one-stop shop for all things Research Computing, including emerging news, detailed specifications for on-campus infrastructure, and an up-to-date event calendar.

Research Software Engineer Disciplines

- Physics and Geosciences
- Princeton Neuroscience Institute (PNI)
- Astrophysical Sciences
- Center for Statistics and Machine Learning (CSML)
- Lewis-Sigler Institute for Integrative Genomics and Ecology and Evolutionary Biology (jointly funded)
- Politics and Sociology
- Molecular Biology
Advancing the service paradigm in OIT

The Service Management Office (SMO) was established in FY15 with the charge to transform OIT into a service-delivery organization. Guided by the principles of Information Technology Service Management (ITSM) and with a goal of Continual Service Improvement (CSI), this new model requires the tireless pursuit of a culture change. Operating as a single organization and working across OIT wherever possible, we continue to leverage data to maximize value in support of University strategic and business objectives; proactively manage change; and activate service improvement through everything from automation to self-service to keep customers focused on their business needs rather than their technology.

Along the way, key milestones have included the creation of a service roadmap for OIT and the implementation of ServiceNow and SN@P, the ripple effects of which can be seen throughout this report. From launching new technology applications in the classroom and laboratory, to planning for the campus expansion and a revolutionized network, it is incumbent on each member of OIT to contextualize our efforts in a framework of customer-centricity.

With this as our foundation, in FY18, OIT took the next step in elevating our service approach. That includes continually seeking opportunities to refine ServiceNow workflows to attain the best outcomes, and implementing new processes that deepen our service practice and extend it to others.

Service-lifecycle methodology delivers beginning-to-end value

When it comes to technology, it is natural to be compelled by the next big thing, from emerging automation techniques to cloud-based applications that are changing the way we work. Yet true power is actualized when IT investments are in lockstep with a customer’s strategic needs. In FY18, OIT designed a new methodology for onboarding and upgrading technology services. Organized into a five-part service lifecycle, it emphasizes lasting value creation and the provision of responsive support from request through service retirement.

- **Strategy:** Using industry-standard techniques, OIT works with the service owner or manager to determine where a proposed service fits within the OIT portfolio, assess cost and policy implications, and outline the universe of customers it may serve.

- **Design:** Before technical implementation begins, the team fully documents the scope and requirements, assesses system and application impact, outlines security and support protocols, and ensures stakeholder buy-in.

- **Transition:** Employing the Change Management process launched in FY17, streamlined communications and outreach prepare customers to leverage the new or upgraded service. As it is deployed, clear risk-management plans prepare stakeholders for any impact during roll-out.

- **Operations:** As we enter day-to-day management, training is ongoing and OIT is available to offer end-to-end support. Any incidents are analyzed to ensure swift response and reduce repeat problems.

- **Continual Service Improvement:** Through close analysis of data and metrics, proactive enhancements are made. OIT tracks each service in the context of its prospective retirement date to ensure that new solutions are advanced.

Beyond building a stronger OIT service portfolio that considers each request in the context of the broader technology ecosystem, this methodology encourages customers to think about their services in terms of the more important outcomes, rather than technologies. It also supports sister initiatives within the organization, including service monitoring (see, “Defining the future of technology service monitoring” on page 11). Outlining concrete steps that support a proactive approach, it is one more way that OIT can help our customers achieve their goals.

What is a service?

- Focused on outcomes over tasks
- Activates business processes that create value
- Built from applications and systems, but not of them — customers enjoy a single point of contact within OIT, eliminating the need to balance multiple service-group relationships

OIT service summit empowers service owners

Continual Service Improvement is only as powerful as our commitment to empowering service owners to truly meet the needs of their customers. Building on new operational processes that are fast making CSI standard operating procedure, the SMO hosted a multi-day service summit to celebrate our service culture and offer actionable tools like the lifecycle described above to help teams intensify their practice and attain new levels of productivity, cost-efficiency, and customer satisfaction.

With this understanding and toolset, service owners represent their customers and can assume end-to-end
accountability for their offerings. Throughout the service lifecycle, they work in tandem with OIT service offering managers to ensure that customers’ expectations are met and exceeded. During the summit, the team reviewed the new service lifecycle, along with an array of tools to help them advance a culture of Continual Service Improvement within OIT.

- **Service portfolios:** Smart catalogs that employ customer-centric relational taxonomies help customers easily find services relevant to their needs.

- **Metrics:** Sharp analysis drives both day-to-day work and long-range planning.

- **Service roadmaps:** Clear plans — reviewed annually and inclusive of descriptions, goals, change records, and financials — clarify the overarching service strategy to customers, OIT team members, and unit leaders. This helps OIT identify gaps and better manage the service portfolio by creating a clear understanding of where each service resides within the constellation of OIT’s offerings.

![Core File Storage for End Users Technologies Currently Supported](image)

**Above:** A service roadmap for core file storage shows where central IT file storage services in the lifecycle from evaluate to retire.

### Formalized Problem Management process is launched

When technology problems emerge, a rapid and effective response is essential to delivering the highest level of support for the University’s teaching and research initiatives. Yet especially in the case of complex IT challenges, OIT’s service promise is most clearly realized when strategic operational processes prevent such instances from reoccurring. In August of 2018, the SMO launched a new Problem Management process within ServiceNow to advance that goal.

Rooted in the Information Technology Service Management (ITSM) paradigm, which promotes continual service improvement, problem management involves the investigation and application of root-cause analysis techniques to address issues and their underlying causes and potential ripple effects. Steeped in technology best practices, the power of the approach resides in the use of a defined process to promote critical thinking and proven analysis techniques to solve problems and significantly elevate service delivery and reliability.

FY18 efforts included the design and build of the process, testing, and release to production. Building on the established problem-solving prowess of our technical staff, this fine-tuned process will power high-quality work with fewer errors and less risk. Problem records enable OIT’s support teams to clearly track and document issues through their lifecycle, from initiation through resolution. With problem management, OIT can better gather, clarify, and organize problem data; document workarounds and known errors for future reference; capture root-cause analysis efforts; and assess the risk and impact of potential solutions prior to remediation.

The resulting benefits to the customer are many:

- **Increased service availability and reliability**
- **Reduced business impact when incidents occur**
- **Renewed emphasis on causes versus symptoms**
- **Detections of patterns to prevent future problems**
- **Heightened customer confidence and satisfaction through thoughtful service delivery**
Asset Management transforms service delivery

In FY17, the successful launch of Field Services marked the first implementation of Asset Management in ServiceNow (see “Activating continual service improvement in the field,” on page 20). More than a way to help technicians in Hardware Support and Instructional Support Services better manage requests, the module is poised to unlock new potential across a range of critical projects — from Event Management to the Next Generation Network — by heightening the visibility of Princeton’s end-to-end asset ecosystem.

In the near future, a constellation of wireless devices and an expanding campus will change the nature of IT at Princeton, extending its reach further into the virtual realm. By tying together previously disparate information about a broad array of devices into the system, including details about their status and interrelationships, Asset Management will guide better, faster technology decisions and superior service. It will also heighten the efficiency of upcoming initiatives like the Learning Space Initiative to transform Princeton’s classrooms (see “OIT in the neighborhood: Instructional support takes a local approach,” on page 21).

- **Detailed records**: Asset records include key information about configuration items (CIs) including ownership, support teams, service linkages, and open tickets.
- **Comprehensive inventories**: Offering a full view of devices owned or managed by a particular group, Asset Management streamlines inventorying and response time when a customer request relates to a particular device.
- **Clear linkages**: Relationships between assets, customers, support requests, and OIT-managed services become transparent so that patterns and dependencies can be more easily discerned.
- **Holistic troubleshooting**: Dashboard views of ticket histories, departmental affiliations, operating systems, hard-drive space, financial data, and the asset lifecycle advance OIT’s ability to analyze trends and offer proactive support.

Asset dashboards streamline departmental reporting

Department IT support teams manage a variety of asset portfolios, with differing levels of control and a range of tracking systems. Yet they are often called on by department managers to provide asset data quickly, from device counts to financial and support details. In FY18, OIT partnered with SCAD/DCS department IT representatives to identify their needs, and then created new departmental dashboards. Pulling together key information, they add new ease to overall portfolio management and foster a better understanding of departmental operations.

Service account reports lead to greater security

When an individual leaves the University, assets left in their name introduce a security risk. Yet in the past, it was difficult to ensure that such assets were properly accounted for. In FY18, a dashboard view was created for the Information Security Office (ISO). Crafting a new procedure, the team is working with the SOC to close or transfer these accounts. In addition, a new process has been implemented to automatically disassociate accounts from their phone lines when a person leaves, automating a previously manual process and creating cost savings.

New and improved strategy for asset registration

When new devices are on-boarded, a multi-part process is initiated. SCAD/DCS teams register them in the network registration database, as well as in their in-house tracking system. As the status of the asset changes, data is maintained manually across systems. Not only does this limit visibility within and across departments; without an automated interconnect between the host database and departmental inventories, records can become outdated and out of sync.

In FY18, a project was initiated in OIT to marry network registrations and Asset Management to promote one-stop device management. The premise is simple: Devices are registered once, and through automated processes they are listed wherever needed. Many person hours were dedicated to the project across a number of areas:

- **Strategy**: A comprehensive wired and wireless strategy accounts for an evolving campus and next-generation network in progress.
- **Migration**: More than a million asset records were moved into ServiceNow, with planning in place to move the full scope of network-related assets.
- **Integration**: Work was done to integrate ServiceNow into wired and wireless systems. The CI and asset creation process was refined, with upgraded security protocols.
- **Training**: Documentation, training, and outreach activities were initiated.
- **Pilot**: Wireless registration forms were tested and refined for a November 2018 go-live date. Based on user feedback, including from student technology consultants, the process was further refined and parlayed into a successful campus rollout.

As wireless devices proliferate and the number of assets on our world-class network grows, a strategic management approach is essential. By incentivizing ongoing data maintenance, SCADs have fast access to device information, enabling them to quickly generate reports, better service their teams, and make more astute decisions. Moreover, with a move toward captive-portal technology and self-service, both long-term members of the campus community and their collaborators will be able to get onto the network quickly and get to work, without device limits or registration complications. When this project concludes with the launch of wired registrations in FY19, all wireless and wired registrations will be handled via SN@P, and the legacy host database will be retired.
Activating continual service improvement in the field

When the Field Services module launched within ServiceNow in the fall of 2017, OIT delivered on its promise to continually elevate our service standard, from classroom technology and event support to printer and infrastructure repairs. Activating a truly customer-centric approach, our goal was to modernize not just the system by which requests are received, routed, and resolved—but to rethink and reframe the business processes that guide our work, reaching new levels of efficiency and allowing our administrative staff to take on a more technical role.

After a successful first year, ripple effects from the Field Services project continue to raise the bar in how we meet the high expectations of both our customers and our own teams.

Field Services powers streamlined scheduling and resource allocation, guiding our response to thousands of one-off and term-long requests. Smart forms with built-in workflows have made it easier for customers to request support. Now, submitting a single form informs all IT teams of the request, thereby eliminating the need for the customer to reach out to multiple service groups. Using SN@P, an empowered roster of technicians can easily monitor, dispatch, and track their work, while communicating with both customers and service partners via ever-on mobile devices. Along the way, quotes, inventory management, time-tracking, and billing have become more seamless through the union of data streams formerly housed across disparate systems.

Leveraging new levels of data insight and unlocking potential as mobile and wireless technology redefine what's possible, Field Services serves as a powerful example of OIT's design-into-practice approach to technology provisioning.

Superior customer service

- **Fewer forms, greater detail:** Requests that involve multiple OIT teams, including video production and learning space enhancements, no longer require submission of multiple forms. Greater detail is also captured upon request, reducing back-and-forth communications and allowing the team to hit the ground running.

- **Single stop for service:** Built-in system logic routes requests to the appropriate team, helping projects kick off quickly. SN@P brings together everything related to a request in one place, elegantly tying together complete service details.

- **Continuity of response:** Customers find real-time status information through SN@P and the Support and Operations Center (SOC) regardless of where their ticket has been routed. In addition, technicians can provide customer-facing notes through a dedicated comments field, with optional watch lists for project stakeholders. Whether the team is waiting on parts or anticipates faster-than-expected resolution, the customer remains fully informed.

- **Billing clarity:** Formalized quoting, clear authorization chains, and the FY18 roll-out of upfront chart-string validation inform clarity and ensure accuracy throughout the project lifecycle. Management is able to track labor and material expenses against budgetary thresholds to keep spending in line with expectations or make approved adjustments in the case of scope changes.

An enhanced OIT workflow

- **Mobile-driven productivity:** Field technicians no longer lose time printing work tickets, manually tracking time and parts, punching time cards, and reentering data across systems — tasks that used to consume up to one hour a day. Rather, they can manage their workload from the field while capturing job notes in real time, enhancing accuracy and responsiveness, while tightening the timeline from request to resolution.

- **Stronger collaboration:** Breaking down silos, Field Services creates new value as formerly disparate groups come together as a single team united under a shared commitment to Continual Service Improvement. Shared work notes aid in clarity and shared brainstorming as the task moves between assigned groups.

- **Strategic inventory management:** Assets purchased through Prime used to be manually entered into SN@P, introducing the risk of inaccurate records. With the introduction of a direct feed from the Asset Management module, managers enjoy real-time inventory data. This allows for better budget management and forecasting that indicates shifts in usage or demand. On the job, technicians are able to directly withdraw parts for their jobs, improving accountability and accuracy. (See "Asset Management transforms service delivery," on page 19, for more on Asset Management).

- **Clearer labor accounting:** The days of paper forms and manual time entry are over. The elimination of end-of-day record-keeping in favor of on-the-job tracking ensures that productive hours are kept at a maximum. This data also allows OIT to manage training and staffing initiatives to best meet customer needs.

- **Continual service improvement:** Armed with clear project and inventory data, OIT has a mechanism by which to continue refining our operations to meet the University's evolving needs. As flagship projects such as the Learning Space Initiative and Next Generation Network move forward, strong connections between service and data will only make our value proposition stronger.
Five-year initiative to transform campus learning spaces

As technology evolves, so too do opportunities to modernize the University’s teaching and learning infrastructure. After several years of strategic planning, FY18 marked the first official year of the Learning Spaces Initiative (LSI). Over the next five years, the LSI will revolutionize 240 learning spaces with upgraded features and best-in-class technology. It is a partnership between the Office of Capital Projects (OCP) and the Office of Information Technology (OIT), with guidance from the Office of the Registrar, the Vice Provost for Space Programming and Planning, and the Faculty Committee on Classrooms and Schedule.

Princeton-centric features

Central to the project is a mission to thoughtfully design and implement solutions that can be elegantly supported and maintained across successive, five-year upgrade cycles. Guided by input from faculty, and contextualized within the campus-expansion and Next Generation Network projects, the plan brings best practices in teaching and learning technology to campus, while defining a performance standard aligned with educational macro-trends:

- Evolution toward a learner-centered pedagogy
- Preference for natural, ambient technology systems
- Seamless connectivity to spaces outside of the classroom
- Demand for flexibility
- Reliance on wireless and fast networks to share information in real time

The result of focused planning that kicked off in FY15, the heart of the LSI strategy addresses the demand for continuity in the user experience across spaces. Over time, reliance on outside AV consultants had led to a disparate range of systems from one learning space to the next. Taking this into account, a new, standardized technology approach was introduced in FY17 by OIT to faculty and other campus users, initially hosted with help from the McGraw Center for Teaching and Learning. Feedback from a model classroom informed a refined design paradigm that is now being actualized.

Beginning with the upgrade of 15 classrooms in FY18, supported through Annual Giving Funds, 40 to 50 spaces will be transformed in each of the five project years. They feature in-demand solutions that take the guesswork out of classroom management, including: wireless Apple TVs; new projectors and flat-panel televisions; standard HDMI connections; and intuitive control panels. This isn’t to say that every classroom will be the same. The needs of our departments and educators will inform a variety of additional, pedagogy-driven features, from science labs to language classrooms.

From design to evolution

Building on the success of Field Services (see page 20), the LSI project is yet another example of the amplified benefits of cross-campus teams and shared solutions. The LSI strategy involves a joint effort in shepherding the full lifecycle of a learning space. The OCP is responsible for best-in-class infrastructure, from lighting and flooring to furniture, all of which emphasize accessibility. The OIT Instructional Support Services (ISS) team will maintain the high technology standard, while offering just-in-time support. With this in mind, OIT onboarded an AV Designer and Engineer in FY18 who will help ensure consistency and guide streamlined and responsive AV workflow processes.

At the same time, technology-enabled classroom management will ensure that educators and their students are best positioned to leverage Princeton’s evolving network, from real-time streaming and conferencing to eventual AV over IP. Ultimately, the project’s greatest value proposition resides in its ability to empower new modes of instruction, new paradigms in student engagement, and continual knowledge creation and exchange. The combined forces of the Next Generation Network and Learning Spaces Initiative exemplify the core purpose of the OIT 3.0 framework launched in FY14: A world-class network will provide world-class instruction in world-class classrooms to a world-class academic audience.

New ideas welcome

User input has been central to the LSI initiative from its earliest stages. Have ideas or feedback on an upgraded learning space? We welcome you to contact us via the ISS website: https://iss.princeton.edu/learning-spaces.
OIT in the neighborhood: Instructional support takes a local approach

The life of any given learning space at Princeton is rich and varied. Academic departments employ media technology to create an engaging learning experience for students. At the same time, they rely on fast, often wireless connections to foster new levels of collaboration with global peers. In a given day, a single room might be used to host a class, support student presentations, and serve as a venue for a high-profile public presentation.

Technology is the heartbeat that enables some of the vital work that sets our faculty and students apart. As such, OIT is called on to go beyond the provision of Apple TVs or wireless connections, powerful though they may be. Rather, the team is collaborating with academic partners in new ways to match their evolving vision for the provision of a world-class teaching and research experience.

In FY18, this translated into the addition of a new, neighborhood approach to Learning Space Support. The premise is as simple as it is profound. When it comes to exceeding expectations, OIT understands that true solutions rely on an intimate understanding of what a department is truly seeking to achieve. This led to a revolutionary idea: What if OIT stationed an on-demand audio-visual expert within the community they serve? With that as a premise, the inaugural Sciences and Molecular Biology neighborhood was established in FY18.

“The strategy was for a member of our team to become an in-person extension of our Learning Space Support service, and a liaison to the rest of the team,” explains Richard Bakken, director of Instructional Support Services. Stationed within their neighborhood 85% of the time, liaisons are able to offer a just-in-time service response, while acting as a conduit through which emerging needs can be proactively identified.

Early results have been promising.

“Our large department, as many others, hosts constant presentations, high-profile visiting lecturers, as well as our regular classes,” explains Terry MacFarland, senior operations manager in the Department of Molecular Biology. With two large lecture halls, conference / classrooms, and meeting and presentation spaces in the mix, strategic media support is vital to smooth operations. Yet, demand once outstripped resources. “The key for us, as I assume is the case across campus, was timeliness. Whether a famous scientist came to present a lecture, or a faculty member wanted to start class, a delay in media trouble-shooting was quite unpopular!” MacFarland continues.

With OIT staff on site, that pain point has been eliminated.

“Having a media expert in the neighborhood has mitigated so much frustration for us,” MacFarland shares, citing dramatically reduced response times and the provision of trusted advice. “We take advantage of [our liaison’s] expertise constantly, whether it’s advice on training, purchasing, or basically any issue regarding our media needs. We finally have the customer service that I believe Princeton faculty, staff, students, and researchers have come to expect.”

As FY18 drew to a close, a second neighborhood was in the works to support departments and spaces near 185 Nassau Street, the Friend Center, and the Julis Romo Rabinowitz Building / Louis A. Simpson International Building. Given its early success, OIT expects the program to further expand and evolve in years to come.
Project and Technology Consulting Office (PATCO)

OIT’s campus partners rely on technology to drive performance improvements, foster efficiencies, and attain better value for those they serve. To facilitate their success, PATCO has expanded to three service areas:

- Value-added project consulting
- Process improvement consulting
- Strategic IT project management

With the support of the Provost’s Office and the Strategic Advisory Group on IT (SAGIT), PATCO has deepened its bench to include three professional process improvement consultants. These individuals work with clients across campus to ensure that new IT systems are implemented in concert with streamlined workflows and processes. PATCO has also added five senior project managers who specialize in managing the complexities of large-scale, campus-wide IT projects.

Our focus: Where purpose meets process

Process evolution has been a key FY18 theme throughout OIT and other administrative departments, from aligning internal teams to leverage an increasingly software-driven world to reconceptualizing Princeton’s network on the eve of campus expansion. Yet change is never a goal unto itself. Rather, we are shifting how we work to power new heights of productivity and insight among campus partners. That means asking different questions as new technologies come online. It involves thinking not just about better ways to do what we’ve always done, but thoughtfully analyzing underlying processes and workflows to activate new possibilities.

Underpinning our approach is a shared set of values that reinforce OIT’s commitment to transforming design into meaningful action. Central among them is the tenet that purpose drives design, whether we’re designing a process, an electronic form, or a system.

- Streamlined workflows precede technology design.
- Data flows unlock the potential for process alignment.
- Change is approached with an emphasis on inspiring meaningful outcomes.

Process improvement consultants: Unlocking possibilities

Often, underlying a proposal for an IT project is a desire to streamline work processes and make interactions more convenient for students, faculty, and staff. The question is: How does one best get there, considering the cross-functional nature of many of our processes? With the launch of PATCO’s Process Improvement Consulting service, OIT is able to assist University offices even more in rethinking related work processes and policies as part of pursuing IT solutions.

Since the introduction of OIT 3.0 in FY14, PATCO has been involved in the University’s most strategic and complex IT projects, from supporting campus partners as they craft compelling proposals for SAGIT funding to guiding technical implementations. By infusing process redesign and improvement into a project’s foundation, we are widening the definition of success. In turn, project sponsors attain a higher impact with every technology investment.

- New talent: In addition to staffing the position responsible for oversight of the process improvement consulting service, PATCO onboarded two process improvement consultants. Each is skilled in conducting deep, consultative business process analyses for those who wish to amplify the impact of their technology investments.
- New methodology: A pragmatic, Princeton-ized process improvement methodology was launched in the spring for use in strategic projects targeting process improvement goals, as part of the overall project management methodology. It outlines the stages and activities of process improvement, from planning through implementation and follow-up. As it is tested and refined, it will be rolled out to a broader constituency on demand.
- New training: To share the basic principles of process improvement with the larger campus community, PATCO designed and launched two workshops: “Introduction to Process Mapping” and “Improving Business Processes.” Registration for these is available through the Employee Learning Center.

Strategic IT project managers: Adding value

Each year, 80-90% of Princeton’s IT projects are managed using existing staff from the department that requested the project. Using this approach has accomplished two important objectives. First, it put the “requesting department” in the driver’s seat regarding the direction, scope, and pace of a project to ensure that it fulfills the needs of that administrative unit. Second, it has created a shared sense of project discipline across the campus that has fostered project collaboration and success.
By design, project management is treated more often as a role than a position. While this model works for small-to-medium sized projects (where the management of those projects would represent only part of someone’s workload), it does not scale for the very largest of our IT initiatives, which often require a half or full-time project manager for a year or more. In those cases, Princeton had been contracting project managers at a premium cost, spending time and effort onboarding them to Princeton, and then losing that intellectual capital when the projects end.

New in FY19, SAGIT funded the creation of five, full-time, in-house project manager positions. More than a new capability, this has the potential to create numerous positive ripple effects:

- **Rapid onboarding**: Clients enjoy access to skilled project managers with OIT expertise who are steeped in the University’s culture, operations, and processes.

- **Co-location**: Project managers work with their sponsors as on-site “employees” for the duration of their in-depth campus deployments.

- **Preserved insight**: By creating a permanent talent pool, institutional knowledge is maintained and relationships are deepened over time.

- **Cost savings**: Monetary savings can be considerable compared to outside consultants, who remain in high demand throughout the region.

**Looking forward: Measuring impact**

We are making these investments in Princeton’s most impactful IT-enabled initiatives because we believe in the strategic and operational value they propose to deliver. Over the next year, we will also be creating a feedback loop to look at how well Princeton is realizing the benefits that were articulated in the business justifications for these projects. The results of these assessments will help improve our organizational capability to develop increasingly accurate business cases as we progress.

### Budget planning software to enhance productivity among academic managers

As the work of higher education grows ever more data-intensive, data management can be a time-consuming administrative task. Yet it has also fostered innovation. Disparate groups across campus have devised techniques to lighten the workload, particularly for academic department managers, who rely on data housed across multiple enterprise systems.

In FY17, OIT and the Provost’s Office conducted a joint study focused on better serving departments’ operational needs. Among the discoveries was a need to streamline budgetary planning, while maintaining the flexibility Princeton’s academic units require. Fittingly, inspiration for a solution now in progress was found therein. A variety of budget-planning systems had been developed by academic units that elegantly reduced time demands and streamlined data access.

Using that as a launching-off point, OIT brought together a team of talent from across OIT to conceptualize a centralized budget planning system designed to take the best of each and create a single tool that meets critical needs. Based on input gathered directly from a group of departmental administrative managers, the system will be designed to improve data management, minimize administrative burden, and free up time and resources for strategic planning. Its key features include:

- **Faculty projections**: Availability of cross-system data powers a long-range view of each department’s faculty portfolio.

- **Commitment database**: The system streamlines tracking of interdepartmental commitments, which were often handled through email in the past.

- **Departmental records**: In moving to a central solution, departments can capture key notes and documentation in a single place.

- **Central data repository**: Departmental data is organized, secure, and readily available for multi-year planning.

- **Analytic reporting**: In merging information from multiple sources, departments can attain new levels of insight.

FY18 efforts reflect steady progress toward an FY20 launch, including assembly of the development team, stakeholder ideation, vetting of initial wireframes, and holistic assessment of existing enterprise data systems with emphasis on structure and security. The project has seen early success in extending OIT services to a new campus constituency. Not only has the shared project enabled them to uncover synergies and shared needs in the context of their complex daily tasks; OIT has leveraged direct departmental insights to devise a solution that can be used by central offices to reap shared rewards. Watch for updates in future reports.
Security first: Risk mitigation becomes standard operating procedure

As Princeton architects ambitious future plans, the twin forces of fast-evolving technology and an expanding campus call on OIT to maintain utmost vigilance in safeguarding our critical systems, our infrastructure, and our data. In recent years, the OIT Information Security Office (ISO) has activated a “defense in depth” risk-management approach, partnering with stakeholders to make a security mindset ubiquitous by continuing to emphasize process over technology. As these practices reach maturity, “security first” has transitioned from a guiding principle to an established mantra, infusing every initiative in our organization — and, increasingly, throughout campus.

Recognizing that the work of higher education involves University-created and outside data, the OIT is empowering people to serve as data stewards with legal, regulatory, and moral responsibilities to protect it. Security is also being baked into IT projects, aided by a refined project management methodology and ISO staff, including a security architect tasked with proactively embedding security measures into solutions from their earliest stages.

This evolution is key: Princeton is preparing for an exciting new reality wherein wireless is the norm and technology transforms at lightning speed. A security-first posture reinforces OIT’s charge to activate technology for our customers and prepares the University to leverage emerging opportunities with the full backing of world-class security measures. In FY18, the ISO continued to emphasize information security through outreach and training, while implementing advanced security protocols.

A shared language for enterprise risk management

As Princeton expands its physical footprint, the campus will encompass more people, more devices, more data, and more network-enabled applications. At the same time, an IT evolution including cloud computing and the proliferation of Internet of Things (IoT)-enabled devices will change the way each of us works. While these shifts create compelling new possibilities from the classroom to the back office, they also introduce pathways by which bad actors can attempt to access Princeton’s network and cyberinfrastructure.

Given that context, OIT continues to work with University leadership to refine our approach to risk.

Cybersecurity ranks among the top enterprise risk management priorities. In FY18, the Enterprise Risk Management Plan adopted language parallel to that used in the FY16 University IT Risk Assessment. A shared vocabulary regarding risk measurement, along with streamlined definitions of likelihood and impact, creates a clear understanding of threats and the strategies in place to defend against them. This positions campus leaders to take a holistic view of both longstanding and emerging risks, while promoting efficient communication and the most effective response in the event that a threat emerges.

In FY18, the University also continued to refine protocols and continue initiatives to address the 12 key issues outlined in the University IT Risk Assessment. By treating the assessment as a living document, and revisiting it often, we ensure that our risk posture is proactive, cutting edge, and fully aligned with evolving concerns.

Partnering to mitigate risk

In addition to initiatives that promote a strong security posture, the ISO extended its services to partners interested in empowering their teams and shoring up systems.

Vulnerability scanning continues

Building on success prior to FY18, the ISO expanded the availability of a powerful service wherein campus partners can request a scan of their servers, devices, and applications. Using advanced tools backed by documented processes, ISO teams work to uncover potential threats, share best practices, and minimize exposure to risk.

Campus risk assessments mature

The ISO continues to offer IT Risk Assessments as a service on a request basis. As the process reaches maturity, the team has conducted 10-20 engagements annually, helping campus partners to better understand information security, identify specific risks within their operations, and implement tailored risk-mitigation strategies.

Strong growth in vendor risk assessments

While vendor IT risk assessments have been provided since FY16, OIT is pleased to report a 170% increase in requests over the past two years. As part of its mission to optimize the compatibility of products and services with the University’s information technology and security principles, the Architecture and Security Review Board reviews prospective vendors on a request basis. Other engagements emerge from within OIT, or from documentation provided to PATCO as partners seek SAGIT support. In a growing trend, however, such requests are coming directly from the community, indicating greater awareness of OIT’s security offerings. During vendor assessments, IT experts ask key security questions early, empowering partners to make well-informed decisions regarding technology, whether they are bringing on a new cloud vendor or overhauling a business-critical system.

Given the diversity of technology applications being adopted, the ISO refined its vendor assessments to create needs-aligned support levels. Full assessments include a deep dive into vendor offerings and the security policies that guide them. This level of assessment is designed for enterprise systems and applications that are used by a broad constituency. For products previously vetted or for systems with a limited reach, a light review or security-oriented conversation may be more appropriate. Interested parties are encouraged to contact the ISO for more details.