University of Illinois
Year of Cyberinfrastructure

Final Report
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I. Executive Summary

The University of Illinois at Urbana-Champaign is a leader in computing and information technology (IT). Our leadership role has both produced and been produced by a culture of innovation. Many efforts have arisen over the years that have been the product of this culture. While the university's commitment to developing digital infrastructure, resources, and support services has served campus researchers well, it has become clear that a more coherent and unified approach to assessing and addressing the IT services and support needs of campus researchers is imperative.

With the support of the Vice Chancellor for Research and the Chief Information Officer, we embarked on the Year of Cyberinfrastructure (Year of CI). Through this effort, we engaged researchers across disciplines to gain an understanding of the challenges they face in order to inform how we, as a campus, should move together to address these needs.

We confirmed that researchers tend to assemble needed resources and services on their own, often out of necessity. While this practice has allowed those with the ambition or, more frequently, the absolute need, to advance their fields, it has primarily benefitted only those researchers and their collaborators. Providers of resources and services have brought value to the research process, but this value has been accrued in a largely disjointed manner that has tended to favor the power users of technology.

The Year of CI effort has made clear that our research support landscape is not only lacking coherence but is also very uneven across academic and research units. To support modern research practices and to be competitive and preeminent in the academic community and the world, the 21st century research university must provide a foundation of research IT infrastructure and services that are accessible by all disciplines. Our campus needs a strong vision for how IT supports research, along with the ability to realize and evolve that vision in lockstep with the changing needs of the research community and the technologies available to meet those needs.

Based on our findings from the Year of CI, we make the following recommendations:

1. *Develop a single source of information for the campus to document all resources and services available to researchers but make the information in this source available in a multitude of locations where faculty and students are likely to see the information.*

2. *Develop new communications strategies for informing researchers of the technologies, services, and support available to them with an increased emphasis on showcasing how these can support their particular research.*

3. *Improve training opportunities for researchers as well as IT professionals to better enable them to use the technologies, services, and support available to them.*

4. *Provide researchers with access to support staff who have specialized technical skills.*

5. *Make research-critical technologies available to the campus community in a manner that ensures a low barrier to access and use.*

6. *Enhance and expand the scope of efforts of the Research Data Service to address the expanding and evolving needs of researchers with respect to data.*

7. *Develop, deploy, and support solutions that can manage restricted access to sensitive data.*

We also make the following higher-level, meta-recommendations that seek to address concerns expressed by the participants regarding processes for feedback and how this feedback is applied to improving existing services and providing new services:

8. *Establish an ongoing process for engagement with the campus community to continue to solicit feedback that captures their evolving needs.*

9. *Develop a coherent strategy for how feedback will be addressed in a visible and transparent manner.*

As discussed below, the creation of a Cyberinfrastructure Master Plan (CI Master Plan) is the first step toward addressing these recommendations in a holistic, coherent fashion. Clearly, other initiatives will need to move forward in parallel with the development of this plan and need to be refined in light of the emergent CI Master Plan.

Though Illinois faces significant financial challenges, it is time to be bold and make an investment to allow the university to emerge from these challenges as the premier destination for faculty, postdocs, graduate students, undergraduate students, and research staff who seek to work in a world-class modern research environment. It is time to provide the infrastructure that will grow the campus research portfolio to new heights. The Year of CI has provided the initial assessment of the campus and indicates the steps we must take to develop the digital support ecosystem that will allow the campus to realize its vision of preeminence in research.

II. The Year of Cyberinfrastructure Initiative

The Year of CI began in September 2014 with three primary purposes:
- Create a common understanding of which resources are part of cyberinfrastructure
- Highlight how cyberinfrastructure supports research and education across all disciplines
- Develop an implementation plan for additional campus cyberinfrastructure resources.

The term "cyberinfrastructure" was originally used as defined by the National Science Foundation in the report *Revolutionizing Science and Engineering through Cyberinfrastructure,*

"distributed computer, information and communication technologies combined with the personnel and integrating components that provide a long-term platform to empower the modern scientific research endeavor." To make the initiative friendlier and more understandable, Year of Cyberinfrastructure quickly became more commonly referred to as Year of CI and CI was redefined as "whatever information technology you need to accomplish your research and teaching."

The Year of CI formally opened with a symposium on September 30, 2014[1]. A lightning round with four faculty from across campus highlighted the challenges researchers are having today, Professor Sally Jackson gave a keynote on "The Social Side of Cyberinfrastructure" that provided context for the entire initiative, and Professor Roy Campbell closed the symposium with a talk on the impact of CI on education.

The primary activities after the symposium include conducting focus groups and gathering data via survey. A total of twenty-seven (27) focus groups were held with over two hundred (200) participants across campus; more than one hundred and thirty (130) participants were faculty representing twelve (12) of our fourteen (14) colleges. There were one hundred and forty-four (144) surveys completed on paper during focus group sessions. An additional one hundred and eighty three (183) responses were provided to an online version of the survey; these responses were drawn from the entirety of campus. The resounding message received during the focus groups was that participants appreciated being listened to, heard, and understood. Additionally, they also appreciated having some of their concerns addressed immediately; committee members often provided answers to questions and potential solutions to problems during the interaction.

The Year of CI closed with a symposium on October 7, 2015[2]. Another lightning round with four additional talks by faculty, research scientists, and grad students from across campus helped to emphasize and make real the key findings developed by the Year of CI.

III. Realizations and Themes

A significant realization occurred for each of the three original purposes of the Year of CI:
- Create a common understanding of which resources are part of cyberinfrastructure
  - ***All IT resources are part of CI***
- Highlight how cyberinfrastructure supports research and education across all disciplines
  - ***There are CI inadequacies across the board***
- Develop an implementation plan for additional campus cyberinfrastructure resources
  - ***Any CI implementation plan must align with all campus strategic plans***

Illinois has a wealth of CI resources, yet what is lacking is the adequate and broad dissemination to the campus community of what resources are available to researchers. Further, there is evidence on campus that for all its richness, considerable gaps exist that need

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[1] http://cyberinfrastructure.illinois.edu/symposiums/opening-symposium/
[2] http://cyberinfrastructure.illinois.edu/symposiums/closing-symposium/

to be addressed. These realizations came from four major themes identified in the Year of CI feedback:
- Access to Expertise
- Communication
- Data
- Technology

These themes are summarized in a paraphrased quote from a focus group participant:

"Stop building new services if you're not going to support us in using them, provide us training in using them, or make sure we actually know they exist."

Access to Expertise

Access to training is requisite in order to develop needed skills through a broad set of training topics at varying depths of knowledge readiness: from the novice to the expert. Additionally, access to people with specialized technical skills is in high demand. There is a significant need for more consulting access to those with advanced technical expertise and for the ability to hire staff with deeper technical skills for hours or weeks in order to perform specific tasks.

Communication

Common feedback during focus group sessions often included requests for services that already exist on campus. Getting information to those in need is only part of the challenge. There are also many faculty who have heard of particular campus services but do not know enough about what those services can do in order to determine if they are useful. When local IT staff do not know about a service, it is often the case that faculty are unsure whom else to contact for additional information.

Data

Data was mentioned in a multitude of ways ranging from acquisition and analysis through issues with transferring and storing it. In total, data related needs were the most common need mentioned during both focus groups and in the surveys with data related themes appearing in each of the other three key findings.

Technology

Technology, outside of data related technology, was unexpectedly only the fourth most common theme. After data and storage-related technologies, the prevalent technology-related topics were about software and other tools. Even the latter are often mentioned in conjunction with analyzing data. Also noted was the unevenness across campus of access to technology.

In summary, many faculty report not having access to the help or expertise they need – even if they have IT support staff (and many do not). Having someone to fix your desktop is not the same as having someone help you assess and utilize tools or services. The needs go beyond

basic IT support. Faculty need better tangible methods to get connected to the expertise and resources needed.

IV. Theme 1: Access to Expertise

Access to expertise was a major theme from both the focus groups and the survey responses. Not only access to expert staff, but to training, skills, consulting, and support that should be available to various user levels including the novice, intermediate, or expert researcher.

Expert Staff

Even faculty who have direct access to local IT support staff, at times lack sufficient access to needed help or expertise. Expertise needs stretch beyond basic support to encompass help with identifying and using appropriate tools and/or services. Faculty are requesting in-depth expertise on things ranging from common toolsets like Microsoft Office to data cleansing, analysis and management. Many drivers exist for requested expertise. However, the common theme is that local, trusted IT support is needed to help with general consulting, to identify and use new toolsets and instrumentation like high-performance computing resources. Survey results overwhelmingly indicate that faculty prefer a hands-on approach working collaboratively with technology experts.

Figure 1 Research-Based Technical Assistance

Campus IT professionals must increase their focus on engaging students, faculty and staff to enable the core research, teaching and engagement missions of the University. New roles will be needed that have expertise in a wide range of areas IT professionals have typically not served, roles more customer- and solutions-focused.

Training

As needs change, technology is evolving to meet new demands. For all technologies, new and old, there is a need to be trained on how to best use them. Researchers requested opportunities to receive training on a much broader range of tools and services than is available today. They also requested training options to a higher level of expertise than currently available. Although researchers may have heard about a technology that could benefit their research, many currently face steep learning curves in actually using identified technologies. Researchers often do not know how to get started using a discovered technologies, let alone be able to develop significant expertise with them.
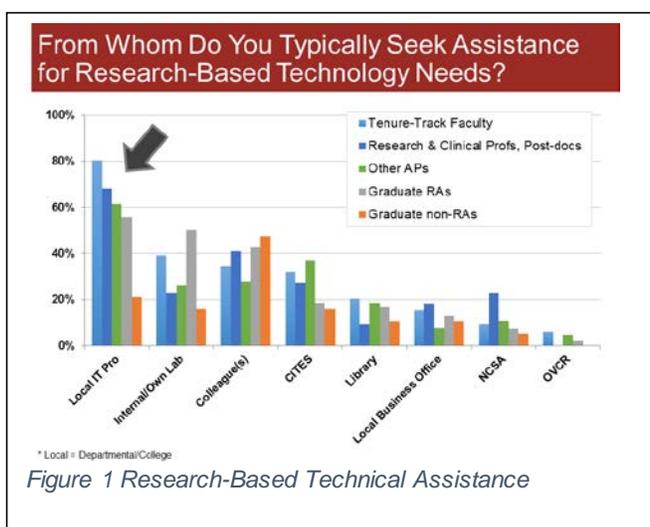
Researchers expressed training needs ranging from Excel use for data analysis to HPC to data visualization to API development. It is important to note that many faculty members rely on their own labs (e.g. graduate students) to both identify trends and to become proficient with technologies. They themselves often have no background with them.

Lack of training leaves a significant gap in both our graduate education and research missions. In direct response to this need, one of the Year of CI committee members (Heidi Imker) serves as a faculty mentor for a Focal Point class that provides graduate students with hands-on basic training in a variety of data science tools. As a testament to the need for such training, the class of nineteen was filled almost entirely by word-of-month and a waitlist had to be established.
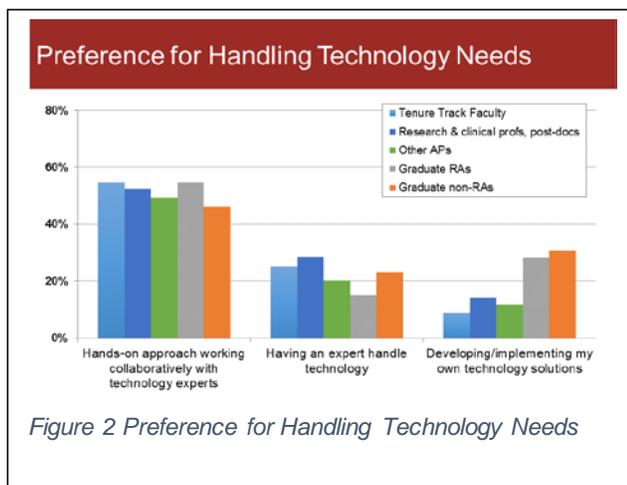

Figure 2 Preference for Handling Technology Needs

Students, faculty and staff should have a superior, seamless experience in being able to utilize the technologies available to them in support of their research, teaching, and learning.

V. Theme 2: Communication

The Year of CI gave researchers an opportunity to share their stories about working with information technologies on campus. Feedback provided from focus group sessions and the survey made clear that researchers feel that some campus technologies do not meet their research requirements. It was also clear that they lacked adequate venues for expressing their frustrations.

Example Concerns

Many focus groups expressed appreciation for allowing their voices to be heard, specifically regarding problems they were encountering. Concerns surround dissatisfaction with current services available to them, access to available services, and unavailable services. Researchers offered U of I Box as an example of an available service that did not meet their needs; stating that, U of I Box was hard to use, slow, unreliable, and the storage quota was too small to be effective.

When researchers cannot access services on campus to do their research, they seek those services off-campus. Frustrations were expressed because the purchasing process is inhibitive. Researchers also expressed frustration at seeing colleagues using the tools and services that they needed for their own research, but discovering that they were unable to use or even acquire the tools themselves. At times, researchers were paying hundreds of dollars out-of-pocket to access needed tools and resources.

Awareness

Lack of awareness, another resounding theme, indicates a gap in both faculty and student engagement. Requests included access to readily available information on resources, tools, training and technology in general. One researcher was surprised to learn that a central high performance compute instrument, Illinois Campus Cluster Program (ICCP), was available. Another post-doctoral student lamented how she used Lynda, an online training tool, when visiting colleagues at other institutions, and was surprised to learn that Lynda is actually available at Illinois.

Data collected from the Year of CI focus groups reveals that faculty and students are asking about availability ranging from common tools and services, such as what software exists in which labs, to specific needs, such as "bleeding edge systems not yet commercially available".

Faculty continue to face unnecessary barriers due to a lack of information about what services, tools, and/or resources exist. A single repository of available resources is not sufficient, and a multi-faceted approach consisting of new staffing roles coupled with various catalogs of information is necessary to map resources to needs.

VI. Theme 3: Data

Data is the foundation of research. As such, it is not surprising that data quickly emerged as a core theme of Year of CI. Almost all participants in nearly all demographics across the disciplines are concerned with data. Focus group conversations readily and repeatedly turned to data. Researchers in particular note that data-related issues constitute their most pressing needs.

Although data needs are diverse, the focus groups and survey results show that researchers are concerned with five data-related topics. These map roughly to the "data pipeline": data acquisition, data analysis, data visualization, data transfer, and data storage.

For example, researchers were presented with a list of seventeen technology resources expected to be most important to a respondent's research in the next few years. Their top three most commonly selected resources are all data-related. These resources are: storage services (35.8%), analysis services (26.9%), and visualization services (22.0%).

The top data concern is storage, which comes up as the single-most common data-related issue across age group, job title, and primary data type (qualitative and quantitative). Storage is also the top or almost the top concern in over half the departmental/unit breakdowns.

We analyzed the focus group results by counting the frequency with which certain activities or resources were mentioned as needs. The twenty-one data-related topics are mentioned four hundred and eleven times. Among these, the top five topics are data transfer (16%), data analysis (15%), data acquisition (13%), data storage (13%), and access control (9%).

After data pipeline needs, participants requested hardware and software resources, and access to expertise, particularly when discussing their data analysis needs. Researchers also requested access to expertise when discussing seemingly mundane activities like data transfer. In the era of Big Data, even basic tasks may require specialized skills. Personnel who can maximize the utility of campus hardware and software resources are a critical component of cyberinfrastructure.

In addition to challenges with respect to the traditional data pipeline, there is a rapidly growing concern about data security. Focus group responses regarding access control show that respondents are particularly concerned with conforming to Health Insurance Portability and Accountability Act (HIPAA) privacy rules. We expect this will be a growing concern as the new College of Medicine is launched on the Urbana campus. Though concerns over other types of sensitive data were expressed, HIPAA-related concerns were most frequently cited in focus group discussions.

Beyond health data, several participants indicate a need to host proprietary data. As research funding shifts to be more reliant on industry, the need for this service seems likely to increase. The survey results support this assumption. 42.8% of respondents reported working with human subject data, which requires a level of safeguarding even in the absence of PHI (Personal Health Information). Less than one third of all respondents (30.6%) report working with no restricted data at all.

VII. Theme 4: Technology

Access to technologies including software, resources, storage, and tools emerged as another important theme through the focus groups and data analysis. In particular, software-related feedback was grouped into three general areas: obtaining, using, and developing.

Software

Obtaining Software

Information on available software for both university and personal systems needs to be significantly better and easier to find, particularly information on software titles used commonly by particular disciplines. Mechanisms to identify common pockets of interest across campus need to be developed. Notably, many focus group participants requested software already available to them. They simply do not know what resources are already accessible and what resources need to be formally requested.

Many barriers exist to gaining access to software even if it is available somewhere on campus. These include unit affiliation, cost, and licensing constraints. Some researchers shared a scenario where the only way they had easy and affordable access to software tools was through their graduate students, who were enrolled in specific classes that granted access to those tools.

Access to many titles depends on unit affiliation or role, something that causes particularly strong difficulties for interdisciplinary researchers. Cost is also an issue in obtaining needed software. Annual licenses are used on campus as a means of reducing software licensing costs but create additional problems such as difficulties with renewal and having licenses expire while researchers are away from campus but still using the licensed software to conduct research.

Even with a valid license, software is often not accessible where it needs to be used (e.g. not installed in a particular computer lab). Many licenses require an active network connection, making them difficult to use from some locations (e.g. in the field or on a plane). Focus group participants want to be able to use more software remotely from a range of devices.

Available or installed versions of software often do not match what is needed. Better mechanisms are needed to allow researcher access to multiple versions of the same title, as some need the latest version and others must continue to use older versions. The need for older versions is particularly important on legacy platforms still in active use.

In general, individuals expressed need for an easier process to install software on their own while being able to request assistance when necessary.

A range of requests were made for more software in the following areas: educational video production; fast signal processing; GIS; molecular modeling for chemistry; online testing; production quality recording; statistical analysis; survey tools; transcription.

Using Software
Campus documentation and training resources for the breadth of software used on a daily basis for research and teaching are lacking.

The Technology Services Training program (FAST3) primarily covers Microsoft Office and Adobe products at the beginner and intermediate levels. Computational Science and Engineering (CSE) has begun offering training for additional scientific packages but is not yet well known. Campus has a site license for Lynda.com, but awareness of this license is not high. Making training and additional documentation available and publicizing its availability is as important as making additional software available.

Often advanced usage requires training at a level beyond what most campus training programs provide. Even with more training and documentation, some software titles require more expertise to effectively use. This expertise could be dedicated staff or a network of faculty and students who share their knowledge. This same group of experts could also provide needed training.

Developing Software
Focus group participants were also concerned with software development. An affordable professional software development service would greatly enhance campus research. While students are able to meet some development needs, they are not always able to reliably

develop and sustain projects, particularly after they graduate. Focus group participants request the ability to promote and support sustainable software in a rapid development environment.

In addition, support and infrastructure for custom development of software and software libraries are needed. Skills with interfacing with existing systems is a natural extension to this need. Many projects are of relatively short duration (weeks or months), making it difficult to hire a full-time developer even when funding is available. Providing a work-for-hire service would help address software development needs that cannot or should not be met with students.

Access to Resources

Researchers are aware there are many resources available at the University of Illinois campus, but they do not have appropriate access to use them. Researchers commented that they were interested in having instant access to campus resources, rather than laboring to gain access to even common resources.

While researchers were pleased with advanced resources such as high performance computing available from NCSA, they expressed concern that access to these great resources is problematic. XSEDE was specifically mentioned by multiple researchers. However, one researcher said they were able to access NCSA resources through an agreement with another institution out-of-state easier than they were able to access them as a University of Illinois researcher. Researchers are drawn to our campus because of excellent resources and yet some cannot actually use them as their research requires.

Storage

Lack of adequate storage was a recurring theme. The available quantity is certainly an issue and there is ample evidence that more storage should be available as a baseline service. The fundamental challenge is ensuring the availability of appropriate storage to meet a range of needs.

The need to access storage both on and off campus, from a range of device types, with the ability to give access to collaborators across the globe drives a desire for cloud storage options with larger quotas and better functionality.

General storage services, while valuable, do not suffice for many specialized needs. Examples heard from faculty included: fast storage used for capturing, editing, and analyzing large multimedia files; storage to support real-time data retrieval and analysis; extra-large temporary storage capacity for intermediate work.

These specialized needs also often involve other constraints that must be addressed. All storage requires adequate networking connectivity to the locations from which it will be accessed. For some services such as high-performance computing and data collection devices attached to instruments, the storage must currently be co-located in order to provide the necessary performance. This often results in ad-hoc or inadequate solutions.

There is also need for secure versions of many of these storage options to allow them to be used with a range of sensitive data. Focus group participants expressed that the need to provide secure data options for researchers has been significantly underestimated.

Regardless of the type of storage, there is a need to have backup options available to protect against data loss caused by hardware, software, facility, and human failures. There appears to be a large amount of important research and institutional data susceptible to loss today because it is on poor storage devices that are not backed up.

There is also significant need for more long-term data storage, both for simply saving data that might be needed again in the future and for formally curated, preserved, and potentially published data. The new funding agency requirements for publication of data are a major driver behind this. The Research Data Service (RDS) is a start in the right direction, but we need to provide even broader awareness of its existence. As people become more aware of RDS, the service will almost certainly require additional resources.

Finally, while robust, professionally managed storage is seen as a value-add, cost nonetheless remains a significant barrier to using storage services. There can be significant risks using cheap storage or a personal cloud storage account.

Nevertheless, faculty regularly make these choices in the absence of storage solutions that meet their needs in a cost-effective manner. Significant attention needs to be paid to determining a baseline amount of storage that is free to faculty, has adequate functionality for most, and is affordable for campus. Similar attention is needed for more advanced storage services that must at least have partial cost recovery.

Tools

Researchers expressed a clear need to have access to tools. They need multimedia tools, collaboration tools, and tools to handle their research data. For the tools available in these spaces, the stated request heard multiple times is that the access needs to be easier.

The prominent message received was the need to have access to a survey tool that can be used campus wide for the collection of research survey data. Although a campus accessible survey tool from the Office of Public Affairs was acknowledged, that survey tool does not meet the needs of many researchers in terms of question types, ease of use, and advanced features. This need has been handled in various ways across campus with some colleges and units maintaining licensed software and services for their colleges. Many researchers have made use of free online survey tools or paid for their use individually. There is a great opportunity to provide access across the campus to survey tools that match the advanced research being done at Illinois.

There are requests for acceptable tools to perform data analysis, mining of data, and data modeling. Some researchers also want access to transcription analysis tools and others tools (or expertise) that assist in determining the quality of collected data. The need for data

visualization tools is important to researchers and reflected in the survey results and in-person sessions. As acknowledged in this report, data is a major theme and it matches the request for tools that handle the data.

VIII. Recommendations

Primary Recommendations

1. ***Develop a single source of information for the campus to document all resources and services available to researchers but make the information in this source available in a multitude of locations where faculty and students are likely to see the information.***
Many of the needs expressed by researchers had solutions available of which they were unaware. Many services that they are aware of are documented to varying degrees, frequently with incomplete or out-of-date information. A well maintained and complete repository of service information is needed and this information source must not only relay what is provided centrally by the campus, but also those resources, services, and support available from local units and from off-campus vendors via existing contracts.

2. ***Develop new communications strategies for informing researchers of the technologies, services, and support available to them with an increased emphasis on showcasing how these can support their particular research.***
Many of the needs expressed by researchers had solutions available of which they were unaware. The development of a solid source of information about services is not sufficient if researchers are unaware of it. This information resource must be well-advertised among researchers as well as IT professionals and the advertising must be done in a variety of locations in order to maximize the opportunities for the information to be found when needed. Further, it is critical that the advertising to researchers focus on helping them understand how the resources can help them with their research rather than be focused on the technical details of the given resource.

3. ***Improve training opportunities for researchers as well as IT professionals to better enable them to use the technologies, services, and support available to them.***
Skills development is critical. Though there are some opportunities today, there needs to be a more comprehensive set of offerings available, in particular those that offer advanced training on various topics.

4. ***Provide researchers with access to support staff who have specialized technical skills.***
This presents a challenge in that many of those with the need to access such experts typically only need that expertise for short durations and they cannot secure the funding to hire such a person. Thus, the mechanism must allow for shared use of these experts allowing those needing their support to be successful while providing job security and professional development for those same experts at the same time. Though the specific needs ranged significantly, there was particular needs raised with respect to interfacing with research instrumentation, software development, and support for use of third party software.

5. ***Make research-critical technologies available to the campus community in a manner that ensures a low barrier to access and use.***
   While part of this echoes the needs for information about available resources and services and the commensurate training being available, there are also needs for access to specific technologies. Though frequently mentioned during the course of focus groups and also indicated in the online survey, data resources and services are not the only technologies in need. Software and other tools were also strong themes and it is anticipated that these needs will evolve as the practice of research evolves. Cost is a definite factor in the ability of researchers to use many needed technologies but so are other issues such as ease and timeliness of being able to procure services.

6. ***Enhance and expand the scope of efforts of the Research Data Service to address the expanding and evolving needs of researchers with respect to data.***
   The need for data resources, services and support was a constant refrain throughout the engagements of the Year of CI. A wide range of needs was expressed, from simple data transfer support to full data lifecycle planning and support. Many of these needs go beyond what the Research Data Service is funded to provide today. It is also recognized that these efforts should take into account the larger issues of data, including non-research data with which the university as a whole is wrestling. Solutions in this space need to at least be cognizant of those efforts and should support leveraging efforts whenever possible.

7. ***Develop, deploy, and support solutions that can manage restricted access to sensitive data.***
   While this might be considered part of the preceding recommendation, given the lost research opportunities and the risk the university is already facing with respect to such data, this is called out as a specific issue with respect to data. This is also meant to address the wide range of such data—not just HIPAA and PHI. There are clear research opportunities that our faculty cannot pursue. There is also clear and present risk to the university in the case of any researcher unwittingly holding such data in an inappropriate way with serious repercussions possible.

Meta-Recommendations

These additional higher-level recommendations seek to address concerns expressed by the participants in Year of CI focus groups regarding processes for feedback and how this feedback is applied to improving existing services and providing new services.

8. ***Establish an ongoing process for engagement with the campus community to continue to solicit feedback that captures their evolving needs.***
   Clearly, the efforts of the past year essentially only provide a snapshot in time of a cross-section of the campus community and their needs. An ongoing process that identifies emerging and evolving needs will be critical to providing ongoing guidance to the efforts of the campus.

9. ***Develop a coherent strategy for how feedback will be addressed in a visible and transparent manner.***

Fundamentally, this is a call for the creation and implementation of the Cyberinfrastructure Master Plan that has been discussed previously. It is clear that researchers, particularly those among the growing group involved in cross-disciplinary research endeavors, want to see consistency in what is available to all on the campus and that the resources, services and support functions are developed in concert with one another.