Coordinated Science Laboratory

2021 Strategic Plan and Visioning Document

Grainger College of Engineering

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Director's Message

This strategic plan will guide the Coordinated Science Laboratory (CSL) in the coming years. CSL is and will continue to be, in the domain of human-cyber-physical systems, the destination for those who want the freedom to discover, create, and innovate in inclusive, collaborative teams at the intersection and cutting edge of computing, communications, control and circuits. CSL seeks to bring the very best talent to Illinois and foster an environment that allows those individuals to reach their full potential. Our mission remains the same: to foster disciplinary excellence in computing, control, communications and information science and build interdisciplinary excellence and leadership with societal and economic impact.

CSL has transformed the world since its inception and early work on radar technology, electrostatic vacuum gyroscopes, and ILLIAC. CSL is celebrating its 70th anniversary this year. Its research endeavors have evolved and grown in step with the growth of the computer stack, and, subsequently, with the emergence and growing sophistication of networks, and on to today's advanced distributed human-cyber-physical systems. Our faculty, staff, and students address current societal problems such as healthcare, AI for social justice, smart manufacturing, security and privacy for cyber-physical systems, automation, human-robot interactions, and other domains in which human-cyber-physical systems (HCPS) play important roles. The rich set of moonshot ideas proposed by our faculty (provided herein) speak to the breadth of the challenges that remain to be addressed, the creativity of CSL's members, and their determination to be at the forefront of providing solutions to pressing technological and societal challenges.

The strategic plan broadly lays out our vision, objectives, and actions to be undertaken over the coming years to strengthen and grow our research enterprise, to augment our interdisciplinary and professional development offerings that complement departmental offerings, and to become a model for diversity, equity, and inclusion. New resources will be required to implement our plan, and we look forward to working with the College, the campus, our alumni and other key stakeholders to secure needed investments in our facilities, staff, processes, and research activities.

CSL has a distinct and important role to play in the Grainger College of Engineering. It brings the very best faculty from across the College and beyond to work together on interdisciplinary research that has, as a core component, a need for advances in computing and information sciences and engineering. The areas impacted that depend on CSL expertise and resources are only growing more complex and more pervasive and far-reaching as the world becomes more digitalized and data-driven. It is imperative for CSL to continue to provide the resources needed for these individuals to work together at the leading edge of their fields. CSL has made and will continue to make significant investments in shared facilities. CSL also has dedicated staff who have the skills, knowledge, and determination to enable faculty to do what has never been done before. Examples of major initiatives fostered by CSL abound, such as the Information Trust Institute, the Advanced Digital Sciences Center, the Center for Networked Intelligent Components and Environments, and the IBM-Illinois Discovery Accelerator Institute. Few units can claim to have the expertise and knowledge to pursue the diversity of funding mechanisms that CSL's faculty and staff choose to pursue. CSL must remain a place where such bold pursuits are possible.

I sincerely thank everyone have contributed to the plan's development. Three workgroups composed of faculty, staff, and students met repeatedly to discuss the research, education, and diversity, equity, and inclusion dimensions of the plan. CSL's research groups all contributed to developing research opportunities and identifying potential collaborators. Many took advantage of the opportunity to provide feedback on initial drafts of the document. The strategic plan is the better for it.

Cultural and Historical DNA of the Coordinated Science Laboratory

The key strengths of the Coordinated Science Laboratory (CSL) are its people, facilities, and a collaborative culture, which together enable excellent innovative interdisciplinary research. CSL's organizational structure of research groups, centers, and institutes enables faculty and graduate students to conduct foundational and transformative research within their own disciplines as well as across disciplines. Shared services, including business office, HR, facilities, communications, and research development support, have enabled and empowered researchers, staff, students, and postdoctoral fellows to go after various and complex funding opportunities. Such opportunities bring together researchers from across many domains of engineering and science to develop transformative solutions to complex challenges enabled by foundational technological advances at the intersection of computing, communication, control, and circuits. Our faculty address current societal problems in areas such as healthcare, AI for social justice, smart manufacturing, security and privacy for cyber-physical systems, automation, human-robot interactions, and other domains in which human-cyber-physical systems (HCPS) play important roles.

CSL's research endeavors have evolved and grown in step with the growth of the computer stack, and, subsequently, with the emergence and growing sophistication of networks, and on to today's advanced distributed human-cyber-physical systems. Senior executives of major software corporations marvel at the deep expertise and the interdisciplinary, cross-layer, multifaceted knowledge and outlook of our students. The development of that knowledge and outlook occurs naturally in CSL. CSL members win major research grants, and receive best paper awards and other recognition, on a regular basis.

CSL also distinguishes itself for its willingness to innovate to deliver transformational systems and take on the development of new major avenues for research leadership. CSL's recent major achievements are quite remarkable and include big firsts, such as:

(i) The launch of the Information Trust Institute (ITI) from a small seed investment to become an entity that has gained national visibility and leadership;

(ii) The creation of the Advanced Digital Sciences Center (ADSC) in Singapore, Illinois' first research center located overseas; and

(iii) The development and fostering of major corporate partnerships, including the ITI-Boeing MRA, the FIT-Illinois Center for Networked Intelligent Components and Environments (C-NICE), the OSF-Illinois Jump ARCHES partnership, and the IBM-Illinois Discovery Accelerator Institute (IIDAI).

All such initiatives require an openness to change, the vibrant exchanges of ideas, a willingness to pursue the unknown, bold and risk-taking faculty leadership, administrative creativity and determination, and ongoing problem-solving. All of those things are in CSL's cultural and historical DNA. To our knowledge, not many units on campus, and indeed across the nation and the world, can attest to a similar record.

The Organizational Structure of CSL

CSL relies on strong core technical research areas to produce the fundamental research results needed to transform application domains through the incorporation of foundational and systems-level innovation. Over time, CSL has developed an organizational structure that is aligned with those mission priorities. Technical themes anchor the intellectual life of CSL members and drive their interactions. Faculty are organized into research groups based on these technical themes. Many faculty are members of more than one group, creating linkages across themes. The themes underlying these groups typically evolve slowly over time to meet research imperatives while staying true to their fundamental nature. After two years of internal discussions facilitated by the CSL director, eight themes and corresponding groups are in place at the end of 2021: (i) Circuits; (ii) Computational and Physical Electronics; (iii) Computer Systems and Architecture; (iv) Decision and Control; (v) Intelligent Sensing, Networking, and Cyberphysical Systems; (vi) Security & Privacy; (vii) Signals, Inference, and Networks; and (vii) Technology and Societal Impacts. A representative from each of seven of these research groups and four at-large faculty members are elected for two-year terms to serve on CSL's Policy and Planning Committee[1]. Members of this committee advise the Director and serve as liaisons back to their respective groups and other members of the CSL community. The Director oversees the operations of CSL and reports to the Dean. The Director also interfaces regularly with fellow IRU directors and the heads of departments with major faculty membership in CSL.

Application domains are pursued in centers and institutes in which members of research groups come together and with other colleagues to tackle complex technological and societal challenges. Application domain examples include healthcare systems and informatics, smart manufacturing, autonomy and robotics, advanced electronics and device development, and cybersecurity and trust. The CSL organizational structure, as described above, is designed to allow CSL to expand its research portfolio. For example, the IBM-Illinois Discovery Accelerator Institute includes a research cluster focused on Hybrid Cloud applications.

Researchers from the research groups come together to create initiatives for 1–2 years (usually supported by Grainger College of Engineering Strategic Research Initiatives (SRI) seed funding and/or other seed grants). If the initiative gets longer-term funding, perhaps through an NSF Engineering Research Center (ERC) or Science and Technology Center (STC), an Office of Naval Research Multidisciplinary University Research Initiative (MURI), or a corporate partnership, the researchers create a center for 5–10 years. If the center lasts longer and has continuous funding, the faculty can elect to create an institute, e.g., the Information Trust Institute. However, many centers come and go after a certain number of years. For example, the SRC-funded SONIC center ceased to exist after 5 years when funding expired, and all its researchers went back to pursue their own research and new fundamental advances. Typically, such individuals will be on the lookout for new opportunities to create new partnerships that can lead to new initiatives and center(s).

CSL is and will continue to be vital to Grainger Engineering's ability to grow its research enterprise, both in size and reputation. CSL will do so through its ability to initiate and support major research initiatives in the digital domain, a domain that continues to be of vital importance to a knowledge-based economy and society. At the same time, CSL's enduring success is dependent on the ability of faculty, immersed in a collaborative, resource-rich environment, to advance fundamental knowledge. Thus, while CSL seeks to inspire, create, launch, and support large numbers of centers and institutes, the number of ongoing grants in CSL, many of which are for single or small groups of faculty, is typically well over 300 at any given time. All of those awards represent faculty pushing knowledge and innovation that advance fundamental and applied knowledge, and can lead to new ideas for centers and major initiatives. That creates an avenue for both stability and renewal, since funding for centers comes and goes, and not every faculty member is actively involved at any given time in a center or institute.

[1] The Computational and Physical Electronics research group, composed of emeritus faculty do not elect a representative on the P&P Committee.

Looking at the Future: Engineered Human-Cyber-Physical Systems

The field of systems research in engineering will evolve dramatically with the introduction of cyber-components in every engineered physical system and the digitalization of all fields in the Grainger College of Engineering and beyond. Even as the development of digital twins makes simulations of systems more accurate and easier to modify in quasi-real time, operational and management decisions will shift to massive empirical data gathering and analysis, driven by machine learning (ML) and artificial intelligence (AI). It is clear that in 5–10 years, the workforce of all engineering (and social) disciplines will need to have substantial knowledge about computer systems. Digitalization, AI, and ML will be integral to engineered systems, whether for smart materials, smart aero-systems, smart mechanical systems, smart bioengineering systems, or smart civil engineering systems. The boundaries between engineering fields will blur and, like mathematics, computer science will be taught and embedded in every engineering discipline to enable progress and innovation.

Traditional research innovation is accelerating and will increasingly be focused on addressing societal challenges. The emergence of COVID-19 testing techniques and vaccines is but the latest example. The field of materials science is being pushed to cut the time needed to bring innovations from discovery to the marketplace by half, if not more. Such innovations have the potential to transform the very nature of electronic devices, likely requiring a complete redefinition of the entire computing stack and distributed network systems. It will be important for CSL to imagine and lead that future. It will also be important for CSL to bring value to major corporate partners, agency stakeholders, and aspiring student researchers in order to stay relevant and have impact.

CSL is well positioned to play a vital role in ensuring Illinois' prominence in the above areas, given its excellence and breadth across computing, communications, control, and circuits as foundational elements of the emerging areas. CSL will continue to assist and rely on departments to recruit stellar faculty, students, and postdoctoral fellows.

Operational Challenges

Current CSL operational challenges include:

(1) The recent acceleration of staff departures due, in no small part, to the COVID-19 pandemic.

(2) The need to find a balance between educational and research activities in CSL given that several research testbeds are now being partially utilized for educational purposes. An example is the use of the autonomous GEM car for both classes and research within the Center for Autonomy (CfA).

(3) The need to reach a consensus on how to support interdisciplinary educational activities and distribute tuition revenues to ensure the long-term sustainability and fiscal health of CSL. This needs to include appropriate consideration of the cost, safety, and maintenance of facilities and equipment, and the revenues needed to cover CSL operational overhead.

(4) The need for additional space driven by rapid growth and demands for storage space and testbeds.

In next 5 years, CSL anticipates that challenges will include:

(1) Providing additional space for the Center for Autonomy (CfA). This center is receiving offers for new autonomous vehicles and UAVs, and we do not have enough space to accommodate the new cars and UAVs in our current labs. Longer-term needs speak to the benefits of seeing the I-ACT developed at the Illinois transportation center in Rantoul.

(2) Providing promised headquarters and advanced digital smart manufacturing research and experimental space for C-NICE in a new building. CSL does not have the space to accommodate this demand.

(3) Finding space for large new interdisciplinary centers, institutes, and corporate partnerships to accommodate growth in the IBM-Illinois Discovery Accelerator Institute, the Information Trust Institute, the Health Care Engineering Systems Center, and future major centers. The need for significant new space to enable growth of CSL's research enterprise will become acute.

(4) Adapting to or implementing cultural changes in the nature of work and space post-pandemic, including (i) a culture change in office space allocation (dynamic space allocation, hoteling, and space sharing), and (ii) a cultural change in the commitment of space as part of faculty recruitment activities.

(5) Optimizing operations based on new budget models and cost attributions related to both office and lab space allocation. We should strive to ensure that IRU participation continues to be supported by departmental units. It will be important to work with the College to provide clear guidelines and policies in terms of space cost and space allocation across departments and IRUs in GCOE.

(6) The need to ensure safe operations of human-cyber-physical shared facilities across multiple buildings.

Major Strategic Plan Focal Points

The Coordinated Science Laboratory sought the input of its faculty, students, postdoctoral fellows, and staff in three major strategic directions for the Grainger College of Engineering, namely (i) research, (ii) education, and (iii) diversity, inclusion, and equity (DEI). All of the research groups were invited to provide input on future priorities. Strategic planning workgroups were organized for each of the three major strategic directions and met several times to develop initial proposals. These were in turn summarized, synthesized, and shared with the larger CSL community for additional comments and suggestions.

Research

The Coordinated Science Laboratory (CSL) is the oldest interdisciplinary research unit (IRU) on the Illinois campus. CSL is now celebrating its 70th anniversary and continues to flourish through a process of reinvention enabled by the excellence of its faculty, students, postdoctoral fellows, and staff. CSL's history follows the growth of the computing and networking hardware and software stacks, starting with initial breakthroughs in electronic semiconductor materials and radar technology, to current innovations in artificial intelligence, machine learning, and automation security, to the optimization of tomorrow's hybrid cloud infrastructure. The availability of massive Internet of Things (IoT) data, the development of smart and flexible electronic materials, new autonomy and robotics capabilities, advances in machine learning and artificial intelligence, bio-inspired neuromorphic computing, and quantum information science, to name a few emerging transformational developments, are poised to usher in a new era of interdisciplinarity in computing, communications, control, and circuits. This marks a new point of inflection that CSL can leverage to renew itself in order to maintain its leadership in computing, communications, control, and circuits areas.

CSL must be responsive to industry, foundations, and government funding agencies, placing more and more emphasis on the rapid translation of innovations to address pressing problems and ensure U.S. economic competitiveness. CSL's ability to attract the very best students and faculty by providing them with high-quality facilities and resources is also an important factor in CSL's success. CSL's research capabilities and reputational profile must be strengthened, and its interdisciplinary and translational networks expanded.

CSL is well-aligned with the Grainger College of Engineering's (GCOE) vision to grow the research enterprise through major partnerships and transformative initiatives. In recent years, CSL's research and operational expertise enabled the launch of major, long-term, well-funded partnerships such as the FIT-Illinois Center for Intelligent Networked Components and Environments (C-NICE) and the IBM-Illinois Discovery Accelerator Institute (IIDAI). The Health Care Engineering Systems Center (HCESC) has seen its research endowment grow significantly. The Center for Autonomy (CfA), seeded by bold investments in shared robotic laboratory infrastructure[2], has rapidly transformed Illinois' capabilities and reputation in autonomy at a time when this field is transforming the world. Our researchers' work in AI and ML with valued partners is leading to remarkable advances in semiconductor manufacturing, device development, and medicine. The nation's power grid is more secure because of the Information Trust Institute (ITI). It will be important for CSL to implement a process for prioritizing among numerous "moonshot" ideas proposed by our research groups. That will depend on our ability to leverage emerging funding opportunities and make judicious investment choices in the coming years. Further development of CSL's capabilities to create and manage large centers will be another priority.

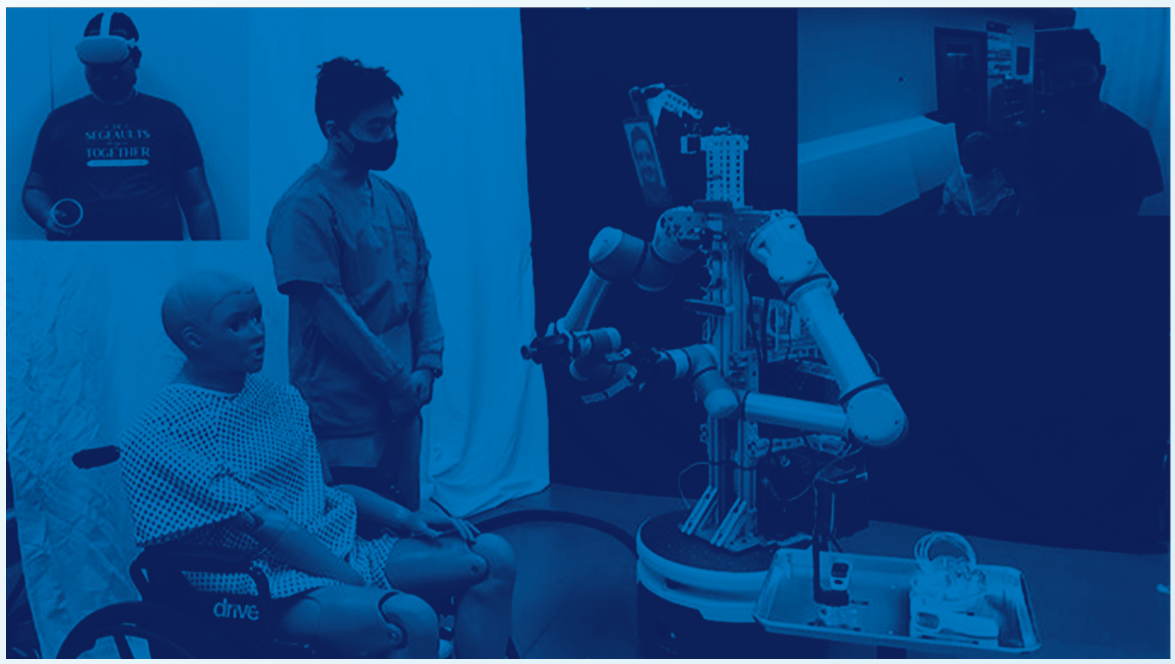
[2] Bold investments have come from CSL, the departments of Computer Science, Electrical and Computer Engineering, Mechanical Science and Engineering, Industrial & Enterprise Systems Engineering, and Aerospace Engineering, as well as the Grainger College of Engineering and the Provost's Office through its Investment for Growth Program.

Avenues of Future Research and Breakthrough Ideas (Moonshots)

The breadth of research undertaken by CSL faculty is significant. The impact that CSL's advances have had on society, defense, and industry is equally broad. Each CSL research group has identified transformative societal and/or technological advances within its field, or that could be enabled within CSL, across the campus, and with external partners. Moonshot ideas are defined as bold ideas that may not come to fruition but would result in major advances if pursued with determination and the availability of plentiful resources. Equally important are breakthrough ideas that leverage CSL's excellence to address foreseeable needs. Both moonshot and breakthrough ideas must be further refined. The benefits of pursuing such ideas must be compelling. Leaders must be identified who are willing to articulate and realize their benefits. These ideas must also have the chance to secure the resources they need to succeed. Ideally, the development of proposals that articulate such ideas should be coupled with known or anticipated emerging funding opportunities.

A non-exhaustive listing of proposed moonshot and breakthrough ideas emerging from our research groups and strategic planning workgroup includes the following:

1. **Sociotechnical systems** research at the intersection of computing systems and social sciences. A natural step would be to leverage CSL's interdisciplinary faculty and, through the C3.ai Institute and other units and organizations, form top-tier interdisciplinary teams to formulate the best ideas for advancing sociotechnical systems. CSL will pursue further collaborations with the iSchool, the College of Liberal Arts & Sciences, the Gies College of Business, the College of Law, and others to pursue interdisciplinary opportunities in this domain. A specific example is the investigation of AI for social good in various societal domains such as healthcare settings, smart cars, smart cities, and smart manufacturing. In all those domains, AI is used for data analytics, yet there are issues with potential biases, misunderstanding, and inaccuracy, with the implication that users can be harmed. AI systems should be able to not only analyze, classify, infer, predict, and detect, but also to reason about outcomes and explain themselves to users.
2. Research driven by **future space systems**. To revitalize CSL's role in space information technology, we will take advantage of the creation of the Space Force military branch and growing calls for major investments to maintain America's leadership in space exploration and the protection of space assets. The goal would be to secure large grants that would rival CSL's block grants in the 1960s and 1970s.

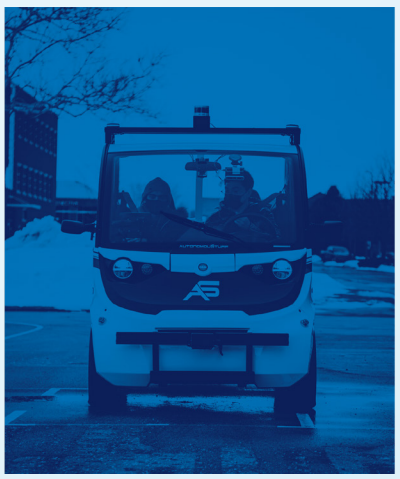


3. **Semiconductor electronics and manufacturing** research. Intel, TSMC, and Samsung are making multibillion-dollar investments in U.S. semiconductor manufacturing facilities. Congressional interest in some version of the CHIPS act promises major new research funding in this area. CSL should proactively leverage its faculty expertise to develop a compelling CSL angle for securing a substantial portion of new research funds. The goal would be to leverage the nationally recognized work of our faculty to carve out a major role in future U.S. research investments in this area; CSL should also work closely with the Holonyak Micro & Nanotechnology Lab (HMNTL) and the Materials Research Laboratory (MRL) to formulate a global vision for this area. Silicon photonics and the resulting need for a new computing stack may be important in this regard; success here could transform the dynamics of a world still reliant on copper-based connectivity.

4. **AI and ML as crosscutting enabling technologies** across real-world human-cyber-physical systems. There is specific interest in physics-aware machine learning, i.e., tying computing with the physical laws of realworld systems. Another direction is the exploration of avenues through which AI- and ML-based systems could materially impact key environmental concerns, like ones related to the nitrogen cycle and climate change. Two other real-world dimensions that are not now adequately addressed are time and uncertainty: the development of algorithms that self-evolve and self-heal is an open problem.

5. **Health-centric computing** to improve the human condition. We will advance AI, data science, and bioinformatics to address health disparities, brain modeling that improves our understanding of neurodegenerative diseases, detection and treatment of mental health issues, and other health-related challenges.

6. **Computing + X:** We intend to be ready to pursue any and all forms of computing platform revolution enabled by new materials, whether this proves to be through quantum computing, biological computing, neuromorphic computing, or something else altogether. CSL can lead new initiatives for future computing technologies in collaboration with other IRUs and departments. Hybrid new computing platforms that consist of quantum computing, optical computing, ambient computing, and biological computing could be the next moonshot projects. A new ILLIAC-like project to build a new computing environment could result, creating a computing solution that can morph from one form to another depending on usage, users, applications, and environments.



7. Remaining at the forefront of **wireless data communications**. This will require us to anticipate what advances are needed for future 6G to 9G wireless ecosystems, from the physical layer to application layers. New AI and ML distributed computing platforms, and richer, natural computer-network-enabled human and human-machine interactions (including brain-computer interfaces for human-robot collaboration and control), and the emergence of digital twins for faster configurability of cyber-physical systems ranging from autonomous vehicles to smart manufacturing platforms will shape future generations of wireless networks.

8. Development of a smart city infrastructure for **Chicago 2050**. To enable it, CSL, working with the Discovery Partners Institute (DPI), would lead an effort involving multiple departments and academic partners to prepare Chicago's critical infrastructure to address climate change stresses (such as water runoff operations), taxiways, and traffic management systems for thousands of drones and autonomous air taxis, and integrated AI systems for indoor climate control and in-city greenery.

9. **AI for education**, leading to powerful new professional development tools and services that bring cost-efficient and effective upskilling and reskilling opportunities to diverse populations.

10. **Advanced enhanced reality immersive environments** that enable the metaverse. Augmented, virtual, and mixed reality (AR, VR, and MR), collectively referred to as *extended reality* (*XR*), has the potential to transform most aspects of our lives. Multiple dimensions of performance and technology must be improved by orders of magnitude. Various areas of CSL expertise can be brought together to address computer vision, machine learning, graphics, optics, haptics, acoustics, and more; the creation of end-user applications (software, computer systems, and middleware) will require interdisciplinary advances.

Adding Skilled Personnel to Grow the Research Enterprise and Its Impact

CSL will seek to transform its ability to support research with an emphasis on advanced planning and real-time responsiveness. Of particular interest is the ability to deliver on both foundational and translational research. CSL also believes that it is imperative for faculty who wish to pursue bold new initiatives, large or small, to be well supported. To move forward in this respect, CSL intends to:

1. Put in place **personnel to facilitate translational research**. Ideas of particular interest are provided in Appendix A. An example is the development of a pool of professionals to support major translational activities.
2. Put in place flexible, dynamic, and detailed **operational and growth models** to more effectively plan for and manage future CSL personnel, facilities, and equipment.
3. Hire a **facility safety officer** to ensure the safety of a growing list of complex human-cyber-physical systems and testbeds.
4. Work closely with the GCOE to develop the next generations of **future faculty leaders**.
5. Advocate for a **philanthropic push** to gather resources to seed truly "out-of-the-box" research through postdoctoral and student fellowships[3].

[3]Agencies and peer-review panels tend to be conservative and require evidence of past performance. Ph.D. Fellowships, for example, would allow faculty to pursue truly new directions..

Plans for Moving Forward

CSL will proactively pursue transformative ideas that could bring significant resources and renown to CSL. To move forward, CSL intends to establish an advisory committee or committees to the director on transformative research activities and pursuits. At its core, the committee(s) is/are expected to facilitate alignment and coordination across CSL and open up new avenues in the pursuit of research excellence. The charge of the committee is expected to focus on three dimensions[4]:

1. Evaluating future research directions and advising on future investments.
2. Advising the director on growing industry interactions and partnerships.
3. Advising the director on how to reestablish CSL's ability to secure major block grants from mission-driven agencies.

[4] Additional details on the three core charges are provided in Appendix A.

Education

The Coordinated Science Laboratory (CSL) is the home of several centers and institutes that incorporate education as well as research. CSL, as a result, already plays a significant role in education[5]. CSL can assist departments by providing an ecosystem and infrastructure that facilitate interdisciplinary education. One of the more important dimensions is the need for CSL to develop staff, expertise, and processes to make the creation and deployment of net revenue-generating workforce development programs as easy as possible. Professional workforce development, especially in human-cyber-physical systems, is expected to be vital to the vibrancy of the Illinois and U.S. economies. CSL industry partners increasingly discuss professional development in tandem with research; likewise, NSF and other U.S. government agencies are increasingly placing priority on professional development activities. CSL sees it as imperative to address this emerging need and opportunity, both to maintain its research programs and to maximize its benefit to society and its stakeholders.

CSL faculty and staff have pushed the bounds of what is possible in research, even when it involved overcoming perceived and, at times, real bureaucratic barriers through creativity and persistence. The launch of the Information Trust Institute (ITI) and the creation of the Advanced Digital Sciences Center (ADSC) in Singapore are examples of success made possible only through determined CSL faculty leadership, creative and determined staff, and College and campus leadership support. All of those elements were needed to overcome resistance to change and to establish new processes and organizational structures that enabled such transformative capabilities while at the same time removing barriers to change. Delivering new professional and workforce development programs will require a similar concerted effort, and CSL now looks to transform the ability of its centers and institutes to deliver bottom-up multidisciplinary cyber-physical systems workforce development programs.

[5] Please see Appendix B for a listing of current and planned CSL educational programs.

Looking ahead, CSL faculty and staff have identified several ways to fill gaps in the interdisciplinary educational offerings of the College while at the same time complementing and supporting the needs of departments:

- Providing access to hands-on educational experiences by leveraging specialized human-cyber-physical system testbeds, equipment, and staff.
- Facilitating the creation of multidisciplinary educational programs driven by CSL centers and institutes that require cross-pollination across departments.
- Facilitating the development and delivery of reskilling and upskilling short courses, micro-certificates, and other nondegree programs to industry partners.
- Leveraging connections into industry and industry sectors to deliver popular net revenue-generating professional development programs tailored to specific industries, industry domains, and environments. It will be equally important to put in place processes and structures that make it easy to close programs that prove not to be successful.

[6] Additional details on each of these pursuits are provided in Appendix C.

[7] For example, CSL's room 301 could be upgraded to have auto-focusing cameras for hybrid course delivery. CSL could also look to incorporate a state-of-the-art multimedia recording facility with the dual purpose of advancing multimedia research and educational content excellence.

To move forward, CSL will pursue the following[6]:

1. Inviting key CSL centers and institutes to form a **professional program development planning committee** charged with assessing what resources, staff, and organizational structure would be needed for CSL to best support its centers and institutes in the delivery of professional education (social media, pricing, marketing, hosting, delivery) in all its forms.
2. Supporting the development of **interdisciplinary MS/MEng degree-granting programs.**
3. Focusing on **workforce development nondegree professional education** to meet upskilling and reskilling needs of the human-cyber-physical systems industry.
4. **Incorporating education delivery in its design and upgrade of shared space** (i.e., conference rooms and recording capabilities).[7]
5. Continuing to support centers and institutes that offer **Research Experiences for Undergraduates (REU) programs.**

[6] Additional details on each of these pursuits are provided in Appendix C.

[7] For example, CSL's room 301 could be upgraded to have auto-focusing cameras for hybrid course delivery. CSL could also look to incorporate a state-of-the-art multimedia recording facility with the dual purpose of advancing multimedia research and educational content excellence.

Diversity, Equity, and Inclusion (DEI)

The Coordinated Science Laboratory (CSL) can and should be a model of equity and inclusion. There is overwhelming evidence that diverse teams are far more likely to deliver the transformative breakthrough solutions to the complex interdisciplinary societal challenges that CSL looks to address. Yet diverse teams are only able to deliver breakthrough solutions if they exist within an organization where diversity and inclusion are truly embraced and where everyone is respected and able to contribute to their fullest. Fostering a welcoming culture for all, regardless of race, ethnicity and national origins, gender and gender identity, sexuality, disability status, class, age, or religious beliefs (among other factors) is central to CSL's success. It will also result in a positive experience for all who work in CSL and impact the manner in which students, as future professors and industry leaders, conduct themselves and, in turn, positively impact others. As a result, CSL will be, in the domain of human-cyber-physical science, engineering, and systems, the top destination for those who want the freedom to discover, create, and innovate in inclusive, collaborative teams at the cutting edge of knowledge and technology.

CSL believes that the development of a welcoming culture requires multiple engagements with its personnel that place emphasis on the benefits and importance of equity and inclusion. Over the past six years, a number of activities and policies have been instituted to advance DEI issues. For example, the Director holds regular luncheons with female faculty and regular luncheons with female graduate students and postdocs. The famed R.T. Chien Distinguished Lecture Series now alternates between male and female speakers. A microaggression workshop has been conducted, and there has been high interest in repeating it. Communications seminars have been conducted to reduce problems between mentees and mentors, and the CSL Director holds open office hours during which anyone can bring forth any issue or concern. Much remains to be done, however, especially with respect to gender identity and ethnic and racial diversity.

Diversity, Equity, and Inclusion (DEI)

DEI ideals and norms of behavior need to gain their own place in the minds of our faculty, students, and staff. This can be achieved through creation of mechanisms and programs that allow our members to be exposed to DEI concepts on a regular and continuous basis through varied and diverse interactions with messaging from colleagues and peers, as well as from administrative leaders. With this idea in mind, we intend to take numerous steps within CSL and to support the Grainger College of Engineering strategic plan and the mission of the Institute for Inclusion, Diversity, Equity, and Access (IDEA). The steps CSL plans to undertake to develop a more inclusive and equitable environment are as follows[8]:

- Educate faculty, postdocs, and senior personnel on DEI issues.
- Make it as easy as possible for CSL students, staff, postdocs and faculty to be informed of DEI issues and actions they can take to make a positive contribution to creating a welcoming environment for all.
- Incentivize CSL participants to incorporate DEI in their thinking.

CSL looks forward to advocating for DEI initiatives that, in our view, would best be offered at the College level[9]. CSL seeks to bring the very best talent to Illinois and foster an environment that allows those individuals to reach their full potential. The evidence shows that units like CSL can become beacons of success in addressing DEI. CSL therefore intends to advance Campus and College DEI goals and emerge as an exemplar of the successful, creative and welcoming environment that can result. The actions proposed above require resources, and CSL will work with its stakeholders (alumni, agencies, and foundations) and the Grainger College of Engineering Advancement office to secure these resources.

[8] Details on how these plans are to be implemented are provided in Appendix D.
[9] Such initiatives are discussed in Appendix D.

Appendix A: Details on Research Plans

Adding Skilled Personnel

Below are additional details on CSL plans for putting in place personnel to facilitate translational research.

1. Developing a **pool of professionals** (programmers, project managers, and other engineering staff) to support major translational endeavors that are expected to be an integral component of major centers and industry partnerships[10].

2. Developing a **postdoc/industrial fellowship program** geared toward applied research, and seeking an endowment or other source of funding to support it.

3. Working with GCOE and departments to develop a **visiting researcher program for industry R&D employees and industry-sponsored PhD students** (employees given paid leave + company fellowships). The program must include frameworks for IP, co-advising, and mentorship.

4. Developing mechanisms for **combining transformative research with professional development** to facilitate the transfer of technological innovations to industry partners and key stakeholders.

Improving Facilities

New investments in facilities should focus on giving our faculty the resources and capabilities they require to make major technological and societal contributions in areas that depend on CSL expertise. In terms of facilities, a number of important investments should be undertaken.

1. Adding **office space, storage space, and contiguous and reconfigurable research space** and upgrading existing facilities. CSL has invested significantly in making its use of space more efficient by increasing the density of graduate students per office and developing shared facilities for robotics and cyber grid research. However, even as efficiencies have been gained, estimated research-expenditures-per-square-foot benchmarks have led to the conclusion that any significant growth in research expenditures will lead to increased space requirements. A new building that includes space for the C-NICE headquarters would help. In a parallel vein, CSL will invest in the maintenance and upgrade of its existing facilities to provide a top-tier working environment.

2. **Reconfiguring lab spaces located in the CSL basement**. This could include the removal of walls to create a more open and reconfigurable floorplan that is more conducive to interdisciplinary research and intergroup communications. Faculty view the existing space as encouraging siloed research and preventing interactions among students.

3. Investigating whether conversion of windowless student offices into **hybrid office/experimental spaces** should be allowed, and the implications of such changes. Even as we push to have these rooms remain student spaces, several faculty are pushing to convert them into living experimental environments for smart homes and smart office technologies.

4. Identifying **the next major shared facilities investment** to be made. Prime candidates include spaces that would support state-of-the-art AV/AR research, 5G-6G anechoic chambers for IoT devices and audio acoustics, and state-of-the art professional development.

[10] The pool could be developed in partnership with the Applied Research Institute (ARI), the Information Trust Institute (ITI), and the National Center for Supercomputing Applications (NCSA).

5. Working with the Grainger College of Engineering and campus to establish transformative capabilities, including:

    a. Encouraging the campus to add major data storage and processing capabilities that CSL faculty could use to advance AI/ML and other data-intensive research.

    b. Continuing to support the efforts of Grainger Engineering to implement the **Illinois Autonomous and Connected Track (I-Act)** in Rantoul with a state-of-the-art IT infrastructure. Such a facility would enable continued research in autonomous vehicles and logistics development that goes beyond ground transportation to include a future of fully integrated rail, air, and ground systems as well as urban areas filled with UAV delivery and monitoring vehicles and air taxis.

    c. New research facilities for **urban renewal and outdoor UAV research**, joint with Civil Engineering and the Illinois Transportation Center.

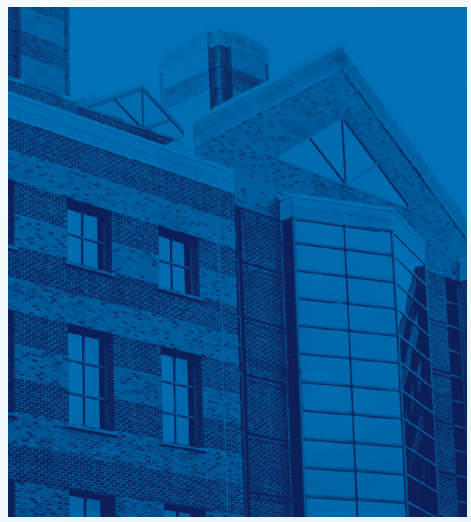
    d. Working with GCOE and the campus to develop **unique experimental facilities in areas of critical importance to U.S. competitiveness and defense**. In particular, CSL proposes the development of unique human-cyber-physical system research facilities that take advantage of one of the University's critical advantages over many of its competitive peers, namely the availability of open spaces for development. Examples include:

- Working with NASA and/or one of the other mission-driven agencies to establish a **national shared facility for satellite constellation research** that could span distributed control, edge computing, and space cybersecurity and trust. One can imagine major anechoic chambers with multiple dynamic 3D mobile platforms that could be used to simulate movement in space to study satellite-to-satellite communications, and also satellite-to-ground robot communications, for both earthbound and space-bound (lunar, asteroid belt, and Mars) assets.
- A similar facility focused on developing advanced wireless communications and acoustics for the control of autonomous vehicles, and developing novel environmental sensing and AR/VR in dynamic environments.



Plans for Moving Forward

CSL will proactively pursue transformative ideas that could bring significant resources and renown to CSL. To move forward, CSL intends to establish an advisory committee or committees to the director on transformative research activities and pursuits. At its core, the committee(s) is/are expected to facilitate alignment and coordination across CSL and open up new avenues in the pursuit of research excellence. The director may ask the committee(s) to form ad hoc subcommittees as needed to explore various aspects of its charge. Alternatively, the director may elect to form a number of ad hoc committees to pursue the work proposed for this committee and decide later, in consultation with the Policy and Planning Committee, if a standing advisory committee needs to be established. Dimensions of the charge are as follows:



1. Evaluating future research directions and advising on future investments. To serve in this capacity, the committee will:

    a. Benchmark characteristics of past major “moonshot-like” initiatives: what has worked, what has not?

    b. Put together teams that can develop white papers outlining major initiatives and moonshot ideas. These white papers will effectively communicate the potential for the ideas to have major societal impact and/or to enable deeply transformative capabilities for humanity, science, and/or engineering.

    c. Identify, develop, and prioritize plans for the next transformative major shared laboratory space, in consultation with GCOE unit leaders.

    d. Increase our efforts to connect with MRL and HMNTL to position Illinois to dominate the coming new materials-based computing revolution.

    e. Identify mechanisms for lowering barriers to interdisciplinary research collaborations.

    f. Stimulate and/or support discussions on major anticipated funding opportunities, in partnership with the Grainger College of Engineering Office of Research.

2. Advise the director on growing industry interactions and partnerships. The advisory panel will look into:

    a. Developing more uniform understanding and guidance regarding types of research (fundamental, applied, translational) from different stakeholder perspectives and training faculty on relevant issues, limitations, and benefits of pursuing each type.

    b. Identifying and prioritizing industries that should be targeted.

    c. Identifying personnel needed and how best to leverage personnel in place.

    d. Recommending processes and techniques for minimizing barriers and delays in the establishment of industry partnerships.

    e. Working with the College, departments, and faculty to reward translational research.

    f. Devising strategies for pursuing centers that incorporate both fundamental and translational research and that advance the careers of both senior and junior faculty.

3. Advise the director on how to reestablish CSL's ability to secure major block grants from mission-driven agencies. This will include looking into:

    a. Identifying and prioritizing mission-driven agencies that should be targeted.

    b. Developing effective and efficient processes to raise CSL's profile with selected agencies, including:

        i. Proactively understanding mission-driven agencies' needs and their cultures; subsequently disseminating such understanding to the broader faculty.

        ii. Presenting CSL's record of accomplishments and current excellence.

        iii. Formulating plans for regular interactions with such agencies.

    c. Devising strategies for securing major grants that deliver solutions to mission-driven agencies while embedding opportunities to define the future through radical innovation. This will include:

        i. Optimizing processes for securing knowledge of agency interests and communicating new ideas to address such interests.

        ii. Working with the campus, GCOE, departments, and faculty to raise awareness of CSL's expertise, both technical and administrative, with mission-driven agency administrative leaders and key government stakeholders.

        iii. Educating faculty on the best practices for pursuing and conducting research from such sources.

Appendix B: Existing and Planned Educational Programs within CSL

HCESC and Jump Simulation Center Educational Activities

Current and Ongoing	Planned*
Yearly HCESC-ARCHES Symposium	Simulation Fellowship Program (yearly)
Yearly HCESC Health Data Summit	Simulation Curriculum Development
Monthly ARCHES Seminars	Simulation Training Courses for Health Care Personnel**
Biannual ARCHES OTM Information Sessions	Simulation Micro-certificate for training modules (2–3 day courses)***
Simulation Training for CI-MED	
Summer ARCHES Undergraduate Internship Program	
Participation in the Masters for Health Technology	

* We plan to generate revenue for the Jump Simulation Center and HCESC through our Investment for Growth award. The effort is targeted at meeting the needs of the healthcare industry. The proposed programs are expected to generate enough revenue by 2022 to offset the operating costs of the Investment for Growth award and the Jump Simulation Center.

** MD specialists, nurses, hospital technicians, etc.

*** Industry-specific personnel (paramedics, firefighters, etc.) can train using recent innovations in educational methodology.

National Center for Principled Leadership and Research Ethics (NCPRE) Education Programs

Current and Ongoing	Planned
Excellence in Academic Leadership • Academic-year online leadership development cohorts for emerging and established leaders	• In-person (Chicago) 2-day academic leadership workshops
HHMI Labs That Work...For Everyone • Lab-based leadership curriculum for HHMI researchers and beyond, centered around nuanced filmed narratives, expert interviews, and professional development activities	International in-person leadership academies: • GB Pant University (India) on hold for COVID • Working with Alex Winter-Nelson's ACES International office more broadly
NTU Leadership Academy • Year-long program; sixth cohort starting this year	• Resources for Research Integrity officers
Leadership Collection • Online collection of free leadership development resources, including quick tips, executive briefings, and expert interview videos	
CCAU consortium • Annual meeting providing strategies for addressing challenged academic units	
Business Officers skills development program, with Office of the Provost • Online programs developed by and for campus business officers, with guidance and advice by NCPRE leaders, using Leadership Collection	
Mentoring for Excellence • Online, asynchronous program for senior faculty who are mentoring early-career faculty	
Professional development presentations and resources; Creation of public access video resources (TRAGEDIES, etc.)	
AGU-Sloan • AGU videos for DEI education	
High school ethics outreach program (on hiatus)	

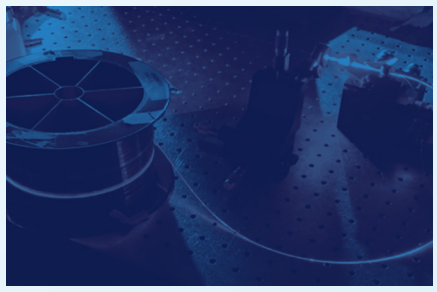
Information Trust Institute (ITI)/Critical Infrastructure Resilience Institute (CIRI) Workforce Development and Educational Activities

Current and Ongoing	Planned
DHS/CISA national Hub & Spoke network and curriculum development.	Funded network plan and curriculum development program, led by CIRI, intended to stimulate increase of the cyber-focused workforce.
Partnership with Federally Funded Research and Development Centers (FFRDCs) to deliver cybersecurity training focused on critical infrastructure support. Undergraduate Cybersecurity Certificate program hosted and managed by ITI, for students who complete a defined program of study that emphasizes cybersecurity from existing CS, ECE, and iSchool course offerings.	Graduate Cybersecurity Certificate programs hosted and managed by ITI, for students who complete a defined program of study that emphasizes cybersecurity from existing CS, ECE and iSchool course offerings.
Support of programs such as the Illinois Cyber Security Scholars Program (ICSSP) and new curriculum that promotes and supports increased interest in cybersecurity-related studies.	Simulation training courses in operational technology and critical infrastructure

ITI plans to generate revenue through the creation and delivery of in-person, hybrid, and virtual course material for nondegree programs in partnership with industry and associations focused on cyber risk in critical infrastructure. It also plans to generate revenue through the creation of online curriculum/content for degree and nondegree programs for a wide audience, focusing on cybersecurity risk in critical infrastructure.

Center for Autonomy

The CfA is now offering a Master of Engineering in Autonomy & Robotics. This fast-paced, one-year professional Master's degree prepares students for leadership in the fields of robotics and autonomous systems. Designed for those looking for a stepping-stone to technical and managerial careers in the autonomy and robotics industries, the program harnesses the strength of several leading academic departments in The Grainger College of Engineering to provide students with an in-depth, interdisciplinary program. Details are provided at https://autonomy.illinois.edu/meng/academics.



Appendix C: Details on Education Implementation Plans

This appendix first provides some of the context behind some of CSL's planned educational objectives and activities, followed by details on implementation plans.

In facilitating the development and delivery of reskilling and upskilling short courses, micro-certificates, and other nondegree programs to industry partners, a number of considerations are noteworthy.

- Of particular interest is the possibility of identifying or developing skilled professional trainers (non-faculty), perhaps even among CSL alumni, to deliver nondegree offerings, even when the nondegree offerings have been developed by faculty or modified from regular faculty materials.
- CSL is becoming increasingly aware that its corporate partners are seeking ways to upskill or reskill their existing workforce rather than simply replenishing their ranks with recent graduates. Many companies and millennials are not looking for traditional full courses and degrees, but instruction delivery tailored to what they need and only what they need. Figuring out how to deliver on this could be a source of significant revenues and tighter connections with corporate partners.
- CSL is also interested in understanding how to incorporate these efforts into an integrated, holistic "lifelong learning" paradigm that would support Illinois graduates as they make their way in their careers.

As noted in the main text, CSL is interested in leveraging connections into industry and industry sectors to deliver popular, net revenue-generating professional development programs tailored to specific industries, industry domains, and environments. In our view, this includes developing capabilities, perhaps in partnership with other organizations like Illinois Business Consulting (IBC) and the Discovery Partners Institute (DPI), in market intelligence and educational program deployment.

The following are details on each of the major initiatives CSL intends to pursue:

1. Inviting key CSL centers and institutes to form a **professional program development planning committee** charged with assessing what resources, staff, and organizational structure would be needed for CSL to best support its centers and institutes in the delivery of professional education (social media, pricing, marketing, hosting, and delivery) in all its forms. This committee would be tasked with assessing whether to recommend:
    a. The **addition of staff and/or creation of teams** with a mandate to support the launch of novel teaching and learning initiatives. These Individuals would, in particular, have a mandate to overcome hurdles to out-of-the-box initiatives.
    b. The development of a cadre of **specialized administrators and education specialists** to manage and deliver professional development programs.
    c. The development of a **capacity for scaling up the deployments of programs** in all their forms and delivering them at scale. Of particular interest would be the potential for working with third parties to meet this need.

2. Supporting the development of **interdisciplinary MS/MEng degree-granting programs**.

    a. Encourage CSL centers, institutes, and faculty to **proactively identify opportunities that transcend specific domains** and thus complement departmental offerings.

    b. Adopt an approach that **lowers barriers to new programs** but includes plans that allow for sustainability and viable ongoing CSL operations in the longer term.

    c. Focus on **mechanisms for providing access to shared testbeds and equipment** for graduate degree programs developed in partnership with faculty and their departments.

    d. Develop **MOU education program templates** for space, resources, and revenue-sharing terms that are fair yet transparent and simple to implement.

3. Focusing on **workforce development nondegree professional education** to meet upskilling and reskilling needs of the human-cyber-physical systems industry. CSL anticipates that:

    a. Programs will include, but will not be limited to, **micro-certifications, short courses, massive open online courses (MOOCs), onsite delivery, online offerings**, etc.

    a. CSL will largely rely on its faculty, centers, and institutes to secure the funding needed to develop and regularly update **top-tier workforce development programs**. CSL would welcome, in this regard, the formation of a seed program at the College level for professional program development, similar to the Strategic Research Initiative (SRI) program.

    b. CSL will develop better connections to DPI, the Applied Research Institute (ARI), the Graduate College, and the Grainger College of Engineering Office of Graduate, Professional and Online programs (GPO) to **form a smoothly functioning professional education ecosystem**. This is intended to include capabilities for assessing market demand for proposed programs, developing targeted marketing plans, and delivering programs. Of high interest is the ability to put in place mechanisms and networks to secure access to the resources, facilities, and personnel needed to deliver the materials, possibly through third parties, alumni, etc.

4. **Incorporating education delivery in the design and upgrade of shared space** (e.g., conference rooms and recording capabilities).[11] These spaces might serve as live experimental testbeds for augmented reality/virtual reality (AR/VR) and other multimedia and learning systems research.

5. Continuing to support centers and institutes that offer **Research Experiences for Undergraduates (REU) programs.** REU programs are fully funded extensions of existing centers and institutes. CSL will seek to provide the space, and access to other resources, that such programs require.

[11] For example, CSL 301 could be upgraded to have auto-focusing cameras for hybrid course delivery. CSL could also look to incorporate a state-of-the-art multimedia recording facility with the dual purpose of advancing multimedia research and educational content excellence.

Appendix D: Details on DEI Implementation Plans

This appendix provides additional details on how CSL plans to address diversity, equity, and inclusion.

Educate faculty, postdocs, and senior personnel on DEI issues:

- **Train faculty and senior personnel in** Team Science[12]. This will strengthen CSL's position in leading centers being proposed to the federal government, where *Team Science* has gained favor; it must be explicitly addressed in major NSF Center proposals. Team Science embraces DEI.
- Get faculty, staff, and students to undergo **"Safe Zone"[13] or similar training**. This will begin with a small cohort to assess its impact and reception. If results are positive, CSL will communicate findings to the College and campus and seek to expand the program if resources can be provided to support the program.
- Encourage the CSL Social Hour student organizing team to use the CSL Social Hour to celebrate the different cultures that exist within CSL.
- Recommend to the CSL Social Hour student organizing team that they host IDEA, asking IDEA to present on the relationship among DEI, identity diversity, cognitive diversity, and impactful breakthrough innovations.
- Encourage all CSL members to become familiar with the IDEA Institute and invite all CSL members to consider joining IDEA.
- Promote and host DEI talks and workshops in partnership with the IDEA Institute and other organizations

[12] The Science of Team Science is a new interdisciplinary field that empirically examines the processes by which large and small scientific teams, research centers, and institutes organize, communicate, and conduct research. This includes understanding how teams connect and collaborate to achieve scientific breakthroughs that would not be attainable by individual or simply additive efforts. For example: https://www.nationalacademies.org/ourwork/the-science-of-team-science.

[13] The Safe Zone Project (SZP) is a free online resource providing curricula, activities, and other resources for educators facilitating Safe Zone trainings (sexuality, gender, and LGBTQ+ education sessions), and learners who are hoping to explore these concepts on their own. https://thesafezoneproject.com/.

Make it as easy as possible for CSL students, staff, and faculty to be informed of DEI issues and possible courses of action they can take to make a positive contribution to creating a welcoming environment for all:

- Create a Broadening Participation Plan for CSL. Its development and plans of action should actively engage CSL students and postdoctoral fellows and include actions in which they can actively participate.
- Ask IDEA, possibly by collaborating with the ASEE[14] Commission on Diversity and Inclusion, to provide access to the most relevant and accessible papers, articles, and books on DEI (e.g., to provide links to facilitate such access).
- Make proactive efforts to inform students and postdocs of organizations that can be leveraged for support and that can provide an increased sense of belonging. Organizations to be considered include Women in Engineering, Women in Computer Science, Graduate Society of Women Engineers, National Society of Black Engineers, Society of Hispanic Professional Engineers, Graduate Engineers Diversifying Illinois, and others as appropriate.
- Encourage the formation of one or more book clubs, discussion groups, and/or other forums to discuss relevant DEI pieces of literature per IDEA recommendations.
- Take concrete steps to explore the possibility of converting some restrooms into gender-neutral facilities that anyone can use.

Incentivize CSL participants to incorporate DEI in their thinking:

- Encourage postdoc and student participation in DEI activities to strengthen their credentials for future employment (i.e. stronger diversity statements when applying for faculty positions and industry posts).
- Be willing to advocate for a measure to require postdoc applicants to provide a diversity statement as part of the hiring process. Be willing to advocate for requiring applicants to senior CSL administrative and communication positions to provide a diversity statement.
- Encourage faculty to participate in DEI activities as a means of strengthening their credibility in pursuing NSF and industry funding, given the expectation that this will become an increasingly important selection criteria. This will have the additional benefit of strengthening their biodata form bona fides. The CSL Director will commit to communicating DEI participation to department heads as part of the CSL Director's contribution to annual faculty reviews.

[14] American Society for Engineering Education.

- Incorporate, where possible, a prompt for information on DEI activities as part of gathering information for the application or nomination process for CSL awards such as the R.T. Chien Civil Service and Academic Professional Awards, the CSL PhD Thesis Award, etc.
- Work with the College to secure funding that might provide the means to remove barriers to equity and inclusion via universal programs[15]. Given that CSL's biggest hiring role is in hiring administrative support staff, CSL intends to place emphasis on hiring and retention of a diverse staff pool.

In addition, CSL looks forward to advocating for the following initiatives that, in our view, would best be offered at the College level, and thus could be undertaken by the IDEA Institute and/or Grainger College of Engineering (GCOE).

- Develop a comprehensive contact plan to expose a large majority of faculty, staff, and students for them to develop a "DEI presence in the mind"- an instinctive consideration of DEI in these individuals in the manner they conduct themselves and relate to their colleagues.
- Get speakers on IDEA topics to give talks on DEI that CSL could promote.
- Develop a cadre of trusted facilitators and points of contact that individuals from different categories of minoritized individuals would feel safe in approaching to discuss issues of concern. The hope is that groups could work together to develop solutions and advocate for change. [16]
- Establish diverse workgroups to identify systematic discriminatory policies and processes and identify symbols that reinforce discrimination and inequality, even if unintentionally[17].

[15] "Universal programs" are non-targeted programs that do not require children or families to meet specific eligibility criteria and are financially accessible. Examples would include provision of laptops to all incoming students.

[16] CSL believes it would be beneficial to create safe environments in which individuals from across multiple units (who belong to minoritized groups that have few members within any one unit) to be able to share their experiences and seek support. This could include staff groups, postdoc groups, and student groups, for example.

[17] An example of symbols that unintentionally reinforce inequality include photos of white men who were past recipients of an award at a time when such awards were simply not given to others.