Request for Information (RFI) on an Implementation Plan for a National Artificial Intelligence Research Resource: Responses

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Introduction – Seizing this Critical Moment

Carnegie Mellon greatly appreciates the opportunity to share perspectives on the development of a National Artificial Intelligence Research Resource (NAIRR). The work of the Task Force will help set the foundation for the United States’ continued leadership in AI research, development and deployment. The high cost of computing for a single large-scale deep learning system can reach into the tens of millions of dollars. This resource will also play a critical role in ensuring that our nation realizes the potential for advances in artificial intelligence to address major challenges and achieve vital national aspirations, and it will inspire and enable the contributions of the broadest, most diverse set of American talent.

Recognizing the significance of this moment, this response seeks to underscore the following underlying tenets:

- The development of a NAIRR should build upon the lessons of successful past federal investments in national computing and science research infrastructure, particularly models that have demonstrated an ability to contribute to goals such as the regional diversification of innovation and which have fostered both strong public/private collaboration and community-building.

- As articulated in the RFI, the NAIRR strategy must consider the multiple national missions that AI is being called upon to help address. They include ensuring sustained U.S. global leadership in critical technologies, meeting the climate challenge, enhancing the resilience of public health and national supply chains, and advancing a more equitable society by restoring the power of innovation as a force for social mobility and opportunity across all communities.

- This effort is vital to ensure access to computing resources, as advancements have increased costs and created barriers that impede research. Computing requirements associated with technologies such as deep learning are massive. Large tech companies have access to computing power that far exceeds resources available to typical academic research groups. An
infrastructure that makes similar resources available to the academic AI community will significantly enhance our national research capability in AI.

- Yet, as the RFI also recognizes, this challenge requires investments in, and strategies supporting, the development of human capital—particularly impactful efforts to foster a more diverse science community.

- Finally, the NAIRR must also be designed to draw upon and catalyze advances at the frontier of AI research, advances that that will shape future computing infrastructure demands and innovations.

The creation of a National AI Research Resource comes at a critical inflection point in the evolution of strategies to shape the future of America’s scientific research infrastructure. It also coincides with bipartisan support for historic investments in science, including basic and mission focused research and the development of testbeds and other infrastructure designed to accelerate the pace of innovation. Perhaps most profoundly, it coincides with advances in AI that hold the potential to transform the research enterprise itself through automated and AI-enabled scientific discovery.

**Thoughts and Recommendations**

The following recommendations reflect the view that the development of an effective NAIRR involves building cohesive and appropriate strategies at three key layers. In addition to its primary focus on computing infrastructure the NAIRR will need services and capabilities at data and human capital layers.

**Question One: Building the Roadmap for NAIRR**

*Capitalize on the National Science Foundation’s Legacy of Leadership and Emerging Capabilities.*

We embrace the focus of the National AI Innovation Initiative and recommend capitalizing on the strengths of the National Science Foundation to serve as the lead agency for the NAIRR. NSF has a history of aligning investments in infrastructure with initiatives to support career development and broad engagement. NSF has also advanced model public/private collaboration in supporting both research and advanced scientific infrastructure. This lead role will also strategically align with initiatives to advance mission related research at NSF and more focused initiatives in diversity, equity and inclusion and a more comprehensive focus on STEM education.

Leadership of the NAIRR will also demand strong inter-agency coordination. NSF has also advanced successful models of multi-agency engagement, such as the National Robotics Initiative (NRI), upon which it can draw to help inform strategies for the NAIRR. Building upon the NRI model, NSF could structure a multi-agency coordination team to help guide the NAIRR that will facilitate shaping a shared national vision and strategy while also ensuring that the distinct missions of each agency are advanced.

*Draw upon Successful Models of Building Regional Hubs*

Important lessons can also be drawn from an earlier generation of investments in advanced computing infrastructure. While the technical challenges and critical mission objectives are distinctly different and will be supported with a cloud-based infrastructure, the creation of NSF’s original network for
supercomputing centers offers important insights of value to the NAIRR effort. There, the creation of a network of competitively awarded regional centers fostered the emergence of a diverse set of technical and research management capabilities that included the rise of complementary areas of specialization in different centers. This network of centers also accelerated the development of university partnerships with industry while encouraging advances innovation driven by competition. Additionally, these centers can serve as a focal point for outreach and diversity, offering grants and educational experiences to those who otherwise would not have easy access.

The network of supercomputing centers approach also leveraged state and local investment, enhanced the linkage between advanced computing capabilities and primary and secondary STEM education. This network model enabled NSF to advance a national mission and vision for these computing resources while capitalizing on local governance and operational innovations—including multi-institutional collaborations and industry partnerships. This network model will also lend itself to fostering multi-agency collaborations that align with the unique specializations of different centers to enhance innovation.

Finally, the regional nature of the centers contributed to expanding the geography of innovation. In the case of Pittsburgh for example, the award of one of the original supercomputing centers (the Pittsburgh Supercomputing Center) to an entity created by Carnegie Mellon and the University of Pittsburgh was an early catalyst to the growth of university based economic development in the region.

A NAIRR initiative will involve distinct technical challenges and investments and will necessitate the development of a broader and more complex set of support and operational services, but the model of creating a network of competitively awarded hubs will provide a valuable starting point for the NAIRR.

**Question Two: Recognizing the Need for a Diverse Set of Services.**

*Provide Support Across the Project Continuum and Build a Broad Base of Services*

The focus of the NAIRR is to advance access to resources needed for large scale computing research initiatives. In structuring services, the program should recognize that these research projects evolve along a continuum. Services should both support early stage and exploratory research activities and be capable of supporting long-term developmental engagements. While these early-stage projects do not demand the same level of support, they are still often impacted by difficulty accessing resources.

*Build Services that Focus on Critical Challenges – Privacy, Ethics, Talent and Workforce Development and Democratization of Data*

In addition to broadening access to computing resources and expertise in the management of deep learning applications, the NAIRR must provide a mix of services to support its mission of broadening access to AI research capabilities. These services should include advanced resources for the identification and proper acquisition of data, data curation, security, privacy and bias expertise. This focus should include expertise and provide technical assistance support to help institutions clarify and update IRB requirements and procedures.

The NAIRR should also build a network of collaborating institutions to assist in advancing education and training initiatives. Models for such collaborations that blend professional development, certificate and shared curricula across institutions have been developed in areas ranging from AI to cybersecurity and
defense engineering. A focus on building strong and broad collaborations in education and training can also enhance the mission of the NAIRR to democratize access to AI resources by enhancing capacity development.

A workforce strategy should also include a focus on helping advance models for building communities or networks of federal data users. These networks can enhance data access and security applications. One model that the NAIRR could build upon is the Coleridge Initiative, a not-for-profit organization bringing together researchers and government agencies to improve access, security and privacy and enhance the development of research initiatives. This model could be expanded to enhance data sharing with the private sector. Activities in this service area will require close coordination with the emerging data democratization initiatives of the White House Office of Science and Technology Policy and the work of United States Digital Service.

Finally, the democratization of access to computing capability should also provide a catalyst to accelerating AI innovation and entrepreneurship. Building collaborations with university tech transfer ecosystems and the emerging investments in regional innovation capabilities could facilitate the ability for the NAIRR to be resource for supporting both entrepreneurship initiatives and regional testbed developments.

**Contribute to Advancing the Frontiers of AI**

As the pace of innovation in emerging technologies continues to accelerate, it is critical to ensure that NAIRR AI infrastructure investments not only support the current application of AI to scientific problems and domains, but also accelerates the development of Distributed AI capabilities to further democratize access to AI data and resources across the United States. Carnegie Mellon has launched a strategic research initiative called *AI Fusion* that is focused on accelerating advances in Distributed AI to overcome the traditional AI paradigm which requires massive data sets to be aggregated and engineered centrally to have access to the most comprehensive AI algorithms and high-performance computing resources that enable AI and machine learning processing. Instead, AI Fusion interconnects multiple, disparate systems and AI resources as part of an immersive *AI Fabric* which then enables the fusion of data sets, compute resources, and AI processing distributed across the country. AI Fusion augments traditional AI capabilities by enabling a more robust and scalable nationwide AI infrastructure that is highly responsive and adaptive, providing much more capability at the ‘point of need’ while still ensuring synchronization and properly structured information sharing. Prioritized investment in AI Fusion and the accelerated development of Distributed AI are pivotal frontier investments in our future AI infrastructure.

This focus on distributed AI should be complemented by coordinated research initiatives that seek to directly address the critical factors impacting the growing cost, complexity and energy impact of deep learning. These targeted areas include a focus on Synthetic Data and initiatives to advance the generation of high-quality labeling.

The NAIRR should also focus on building the intellectual and technical infrastructure to advance multiple solutions for cloud interactions. An example of research in this area is the Army’s Project COEUS. The project is building an AI ecosystem—a virtual location for users to gather for the optimization of sharing algorithms, uniformly stored and organized for accessibility. This ecosystem will provide tools to enable users to more rapidly integrate AI.
Contribute to Advancing the discipline of AI Engineering

AI Engineering is an emergent discipline focused on developing tools, systems, and processes to enable the application of artificial intelligence in real-world contexts. AI Engineering is a field of research and process development that combines the principles of systems engineering, software engineering, computer science, and human-centered design to enable researchers and practitioners to methodically develop AI systems that are robust, secure, scalable, and human-centered. To fully reap the benefits of the National AI Initiative and to bring the power of AI to our most critical national needs and our most exciting opportunities, development of the methodologies of AI engineering must be a core element if the NAIRR. Carnegie Mellon’s Software Engineering Institute is focused on building models, tools and practices to advance this discipline. The NAIRR should build formal relationships with both academic institutions and Federally Funded Research and Development Centers to integrate AI engineering resources into its core capabilities.

Finally, the NAIRR should be focal point for accelerating the development and deployment of advances to improve the energy efficiency of computing. By helping foster distinct models of industry and university collaborations a network of regional resources centers may also help advance these innovations. This focus will necessitate collaboration across multiple agencies and engage academic talent across the nation.

The points outlined above highlight the extent to which the NAIRR must be able to galvanize and engage collaboration across the broader AI community. Recent AI initiatives have created mechanisms to help facilitate community engagement to advance strategic planning and initiatives. One approach would be to consider establishing an Academic Innovation Council. This model, which has been developed for DoD AI initiatives, has proven effective at drawing talent from across the nation to develop roadmaps to help inform future research initiatives.

Question Three: How can the NAIRR and its components reinforce principles of ethical and responsible research and development of AI, such as those concerning issues of racial and gender equity, fairness, bias, civil rights, transparency, and accountability?

Build a Comprehensive Capacity to Integrate a Focus on Ethics and Privacy

In focusing on issues of security, privacy and bias, the NAIRR will have the opportunity to coordinate with and leverage NSF initiatives created through the enactment of the National AI Innovation Initiative and, potentially the final legislation emerging from the US Innovation and Competition and the NSF For the Future acts. In particular, the provisions of these measures focus on ethics training and the development of ethics impact statements as part of AI research proposal development can be integrated into initiatives of the NAIRR.

The NAIRR can contribute to these existing measures by creating a nexus for community engagement on these critical issues. The NAIRR could incorporate grand challenges and other programs that focus on innovations in tool development, curricula and community building into its service portfolio to contribute to and elevate engagement with broader federal policy efforts. Another approach that can reinforce principles of ethical and responsible research and development of AI is incorporating AI ethics into the curriculum of academic institutions. This could include catalyzing a national effort encouraging K-12--more schools to add AI & ethics into their programs. This can train knowledgeable future AI
researchers & developers who are equipped with the right tools to tackle potential ethical challenges of AI in their work. Finally, the NAIRR could work with the academic research community to develop model approaches for engaging broader community stakeholders in helping assess the potential impacts of AI research.

There is an urgent need to clarify and update the interpretation of IRB requirements in light of the collection and mining of human subject data and to ensure adequate awareness and training of AI researchers and IRB offices at universities. The NAIRR could take a leading role in coordinating this process, producing and possibly delivering relevant and effective training material, and being a central node for sharing best practices. The same applies to other ethical considerations, including issues of racial and gender equity, bias, civil rights, transparency and accountability - as well as issues of safety and security.

Another critical dimension of effective ethics and responsible research strategies is to advance capabilities for anonymization. Privacy and ethical concerns currently make providing high quality and representative datasets quite challenging. While different sectors, including private, academic, or public, rely on such datasets to train their AI models, they cannot share many of those datasets publicly as most of the anonymization procedures cannot completely remove the connection between the data and users. This requires thorough investigation of each dataset, reflecting on potential privacy issues, and coming up with mitigation plans. The NAIRR should be a focal point for advancing strategies to address these concerns.

**Question Four: What building blocks already exist for the NAIRR, in terms of government, academic, or private-sector activities, resources, and services?**

With the accelerating pace of innovation in AI, it is critical for the NAIRR to not only provide individual researchers access to critical research infrastructure and resources, but also to facilitate collaboration of the best and brightest researchers across the country. As part of Carnegie Mellon’s long-standing and strategic relationship with the Army Research Laboratory (ARL), we worked closely with ARL to develop a collaborative portal that will dramatically enhance collaboration with the best and brightest researchers across the United States while also giving them secure access to tools and resources, and a virtualized computing environment to accelerate AI research with government trained models or data sets. ARL worked closely with Carnegie Mellon to develop an on-boarding process that is academic-friendly and does not restrict access to the collaborative portal based upon citizenship status or require researchers to qualify for a DoD Common Access Card (CAC).

Once on-boarded into the A2I2 Collaborative Cloud, researchers are able to send and receive CUI emails, take part in virtual Microsoft Teams meetings, and collaborate with other researchers, industry partners, and government personnel. The A2I2 Collaborative Cloud allows researchers across the county to have a virtual CUI desktop and research space at a DISA Impact Level 4 (IL4) level using their existing University PC / laptop and network. Enabling US and foreign researchers the ability to have ready access to government data and CUI information, drastically enhances their ability to develop a targeted approach to research with a much better understanding of the problem space, which in turn drastically increases the impact of AI research. This collaborative approach has been leveraged extensively by the private sector as well to accelerate AI research.
Some additional potential resources that the NAIRR can leverage include the existing frameworks and infrastructures some private-sector companies such as Google (People and AI Research: PAIR) and Facebook (Facebook AI Research: FAIR) have built around AI and research. These groups usually have a well-documented structure, guidelines, and resources for researchers who want to do AI work.

The NAIRR can also leverage existing educational frameworks that have been developed to support and enable the future AI U.S. workforce and expose more people at a younger age to research tools. For example, CMU has developed educational infrastructure at the K-12 level through post graduate levels to educate students at scale. Some of the following programs could potentially be leveraged to incorporate curriculum that could expose students to NAIRR through all educational ranges:

K-12:

- Computer Science Academy (CSA) -a free, universally accessible, online, interactive high school computer science curriculum designed and managed by CMU undergraduate students. CSA offers teacher training, an online interactive textbook, and online technical support from undergraduate computer science students, available “24/7”.

- Computer Science STEM Network (CS2N) - The is a collaborative research project between Carnegie Mellon University, including the Robotics Academy, and the Defense Advanced Research Projects Agency (DARPA) designed to increase the number of students pursuing advanced Computer Science and Science, Technology, Engineering, and Mathematics (CS-STEM) degrees.

Community College

- SAIL - an online learning platform that provides college and university instructors with job-focused technology courses created at Carnegie Mellon University that are project-based, collaborative, and use real-time feedback.

Similarly, the NAIRR can also leverage university based models that foster collaboration among researchers from technical, policy, business and the humanities to engage on critical issues related to the development and impact of AI. For example, Carnegie Mellon’s Block Center for Technology and Society brings such an interdisciplinary focus to research on bias and ethics and the use of AI to address major societal issues. Block Center projects also help provide a bridge between the research community and government users of AI applications to foster best practices and build capacity for the ethical deployment of AI.

**Question Six: Where do you see limitations in the ability of the NAIRR to democratize access to AI R&D? And how could these limitations be overcome?**

The democratization of AI is central to the mission of the NAIRR. Thus, many of the comments above focus on elements of this democratization objective. These elements include the imperative of building services and capabilities at the infrastructure, data and human capital layer as well as proposals to create a vehicle for input from a broader stakeholder community and the imperative of building a focus on ethics and privacy that leverages emerging policies and programs at individual institutions and the federal research agencies. A focus on creating regional hubs as a central element of the NAIRR approach can also contribute to this democratization initiative by helping expand the geography of innovation.
Ultimately, a critical variable will be the need to focus on democratization objectives throughout the metrics that will be used to judge the value of the NAIRR operations and outcomes. A focus on metrics will help ensure that the NAIRR is a catalyst to fostering community wide engagement and commitment to this fundamental goal and that this commitment is reflected in all projects and collaborations.

Concluding Thoughts

Carnegie Mellon University is synonymous with the birthplace of artificial intelligence and continues as a critical hub defining the future of AI and, through it, the future of society. Our faculty and students have been at the forefront of the development of AI technologies that have changed how we live—from self-driving cars to personal assistants, robotic surgery, cognitive tutors, AI enabled traffic signals and the applications of machine learning to fight food scarcity. Carnegie Mellon is committed to continuing to advance this frontier of research and education. The development of a National AI Research Resource is a vital step to ensure that the U.S. leads the development of AI and that Americans in all communities benefit from the potential of these advances to expand economic opportunity and improve the quality of life.