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ARTICLE

The NSF Convergence Accelerator program

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Abstract

The National Science Foundation's Convergence Accelerator is a unique program offering researchers and innovators the opportunity to translate research results into tangible solutions that make a difference for society. Through an intense innovation curriculum and a mentorship program, researchers gain skills and experiences that are of use not only during this program but throughout their careers. This article describes the NSF Convergence Accelerator program and its initial funded convergence research topics—or "tracks"—funded in 2019 and 2020. In almost every track and NSF-funded project, artificial intelligence and machine learning (AI/ML) approaches and methods are playing an essential role.

INTRODUCTION

As a funder of research and education across all science and engineering fields, and with well-established relationships with global universities and funding agencies, the National Science Foundation (NSF) is uniquely positioned to accelerate discovery and innovation for societal impact. In early 2019, the NSF launched a unique program, the Convergence Accelerator to build upon basic research and discovery and accelerate solutions toward societal impact. The goal of the Convergence Accelerator is to serve as a platform for transformative cross-cutting partnerships that bring together stakeholders from different disciplines, expertise, and organizations to solve national-scale challenges. While the main focus is to enable long-lasting societal impact, results from each solution will vary and may include hardware prototypes; new functions and capabilities integrated into existing systems; open-source tools, data, and knowledge products; expansion of tools and services into new markets, for new audiences—keeping in mind, in all cases, the sustained impact beyond the duration of the particular project itself.

The program is founded on the fundamentals of convergence research—requiring a deep integration across disciplines and expertise to address specific challenges or opportunities arising from pressing societal and national needs (NSF 2016)—and acceleration. Acceleration is key to ensuring that teams deliver impactful results to an identified community of users within a 3-year time frame. To achieve these objectives, the program requires partnerships from industry, academia, nonprofits, government, and other communities of practice to support the

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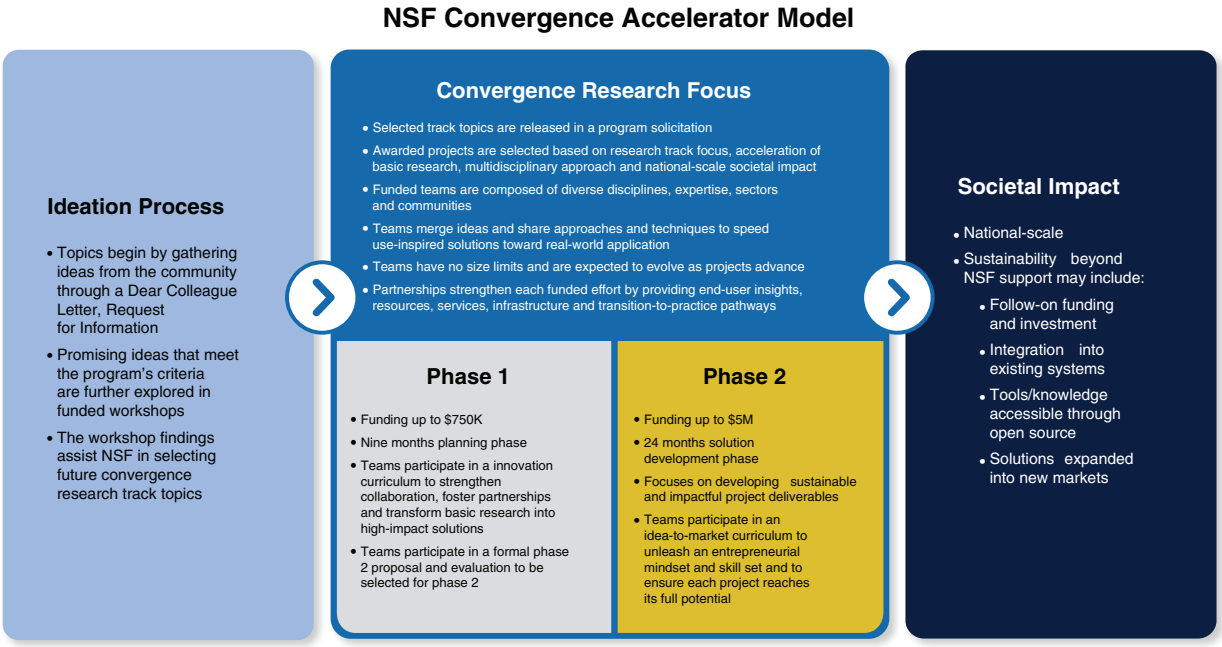

FIGURE 1 The National Science Foundation (NSF) Convergence Accelerator program

teams and strengthen the solutions. Partners may provide end-user insights, resources, services, infrastructure, and transition to practice pathways.

PROGRAM MODEL

The Convergence Accelerator program model has three phases: topic identification; convergence research phase 1; and convergence research phase 2. At the completion of the convergence research phases teams are expected to deliver high-impact solutions that meet societal needs and continue to have an impact after NSF support ends. Figure 1 provides an overview of the program model, from ideation to convergence research phases 1 and 2, and anticipated societal impact.

Ideation process: Topic identification

Convergent research topics emerge during the ideation process. Each year, the program issues a Dear Colleague Letter, Request for Information (DCL/RFI) to gather ideas for potential track topics, such as the ones for FY 2021 and FY 2022, respectively (NSF 2020a; NSF 2020b). Ideas must be built upon foundational research; require convergence and a multidisciplinary approach; and be sufficiently broad in scope to address large-scale societal challenges. Ideas that meet the program's criteria are funded by NSF to organize community workshops. An estimated 10–15 workshops are funded each year to explore potential track topics that incorporate convergence research. A successful workshop would bring together a multidisciplinary group that spans a wide range of disciplines and sectors; focuses on outcomes and deliverables feasible in a 3-year time frame; and considers how the set of projects within the track might work together to deliver successful results. The findings of these workshops assist NSF in developing the final track topic to be funded in the next year.

Convergence research phases 1 and 2

A solicitation is issued each year by NSF with the identified convergence research track topics to solicit proposals from multidisciplinary, multisector teams to develop solutions aligned to these topics, as exemplified by the FY2021 solicitation (NSF 2021a). To encourage submissions from industry and nonprofit submitters, the solicitation is released through a Broad Agency Announcement (BAA), in addition to the standard NSF research solicitation.

In addition to the key NSF criteria of *intellectual merit* and *broader impact*, phase 1 proposals are also assessed based on the extent of their multidisciplinary approach to the problem; identification, or potential to identify, multisector partners for the team; clearly articulated *deliverables* and the likelihood of achieving those in the 3-year time frame; and how well the project goals are aligned with the theme of the track.

Convergence research phase 1: Planning

In the Convergence Research phase 1, teams may receive up to $750,000 for a 12-month duration. During this

phase, teams develop their initial idea into a proof of concept while refining team composition, including adding new team members and partners, if and as needed. Teams participate in an intense hands-on 9-*month Innovation Curriculum* designed to help transform their ideas into proofs of concept, including refining the composition of end-user communities, understanding their requirements, and identifying key partners vital to phase 2 success.

Innovation curriculum

The Convergence Accelerator's *Innovation Curriculum* is a critical aspect of the program and phase 1 activities. The curriculum is delivered through a hybrid model that includes content delivered asynchronously by online video modules and supplementary activities, as well as synchronous live sessions. Members from all teams participate in the curriculum. "Core members" from each team are required to participate in the live sessions.

In addition to regular engagement with the NSF program, each team in phase 1 is also assigned a coach to help navigate through the Acclerator program, develop pitch presentations to diverse audiences, prepare phase two proposals, and develop strategies for creating a sustainable solution beyond phase 2 NSF funding and support. Coaches participating in the Convergence Accelerator program have seasoned entrepreneurial backrounds and are experienced in mentoring early stage startups and transitioning solutions to the marketplace.

The innovation curriculum consists of *team science*, *human-centered design*, *user discovery*, *early-stage prototyping, communications*, *storytelling*, *and pitching* and is designed to position teams for success in accelerating their solution forward and preparing them for phase 2.

- *Team science* – helps teams develop an internal dynamic that supports effective engagement focus on a unified project vision and common goals.
- *Human centered design* – teaches how teams can leverage a collective process to produce tangible outputs rooted in the needs of people who will use the solution. Through this process, teams are able to identify end-users and key stakeholders, conduct user interviews to glean new insights, and build low-fidelity prototypes to elicit feedback.
- *Communications, storytelling, and pitching* – communication is critical to getting the team's ideas in front of various stakeholders including potential partners, investors, and end-users. Teams learn how to effectively communicate about their project; its value proposition, and the challenge the solution is addressing. This includes developing a *Public Executive Summary*.

The experience thus far has demonstrated that teams benefit greatly from this innovation curriculum. Teams have applied the curriculum to modify their original approach and plan, form new partnerships, interview larger numbers of diverse stakeholders—all of which have greatly assisted them in refining project goals and deliverables.

Preparing phase 1 teams for phase 2

All phase 1 projects are eligible to submit a phase 2 proposal for up to $5 million over 2 years. The review process at the end of phase 1 includes a formal proposal evaluation and an oral pitch.

The phase 2 proposal is a traditional NSF proposal that is evaluated by an NSF peer review panel. The review criteria for phase 2 are similar to phase 1, but include an emphasis and focus on *convergence research*, *partnerships*, *deliverables*, and *track alignment*. It is expected that phase 1 activities and experiences would influence the project's direction for phase 2.

Proposals are required to describe the impact of their phase 1 activities on their strategy and tactics going forward including modifications, if any, to their original project plan. The proposals are expected to provide a detailed timeline of phase 2 milestones and deliverables, along with a project coordination and management plan to help ensure that projects are realistically able to achieve their goals and objectives over the 24-month duration.

Projects are also evaluated on an *oral pitch* made to a separate *pitch panel*, which includes panelists with technical expertise as well as expertise in entrepreneurship and industry technology transfer. The pitch panel receives only a 2-page *Public Executive Summary* in advance. Each team is given 10 min to communicate information about the project, such as phase 1 key activities and outcomes and the team's phase 2 plan. This is followed by a 20-min Q&A session.

Proposals are evaluated based on the outcomes from both the NSF peer review and the pitch review and selected teams advance to phase 2.

Convergence research phase 2: Implementation

Throughout the 2-year phase 2 effort, teams continue to work on their solutions while also participating in an entrepreneurial curriculum. By the end of phase 2, each

solution is expected to have found a path to sustainability beyond NSF support.

Entrepreneurial curriculum

The entrepreneurial curriculum in phase 2 is based on the Idea-to-Market curriculum (I2M 2021) supported by Global Innovation Catalyst (https://globalinnovationcatalyst.com/) consisting of modules in *product development*, *intellectual property*, *financial resources*, *sustainability planning*, and *communications and outreach*. It is a structured approach designed to assist teams in defining and developing an execution roadmap and sustainability plan and to help push the projects in reaching their full potential.

Track integration

To ensure that each track outcome is greater than the "sum of its parts," phase 2 teams also work together on *track integration* to try to create solutions that are more than what may be produced by each individual project. Up to 5% of each team's phase 2 budget/effort is set aside for this integration activity.

Convergence accelerator expo

All teams participate in an annual *Convergence Accelerator Expo* that is typically held in July featuring the program's full portfolio. The *Expo* provides teams the opportunity to showcase their solutions to a wide range of stakeholders. Teams may find new users, customers, and partners to assist in accelerating solutions forward, and/or even investor prospects. This outreach event is an opportunity for teams to highlight their project deliverables and achievements and also help teams prepare communication and marketing products that can be used well beyond the event per se.

Due to the pandemic, the 2020 and 2021 expos were virtual. In 2020, the *Expo* featured 43 phase 1 booths (21 in track A and 22 in track B). In 2021, *Expo 2021* (https://nsf-ca.vfairs.com/) featured 40 booths, which included 10 phase 2 booths (five in track A, three in track B, and two track integration booths); 29 phase 1 booths (11 in track C and 18 in track D), and one Convergence Accelerator program booth. *Expo 2022* will also be virtual and is scheduled for July 27–28, 2022. At *Expo 2022*, participants will have the opportunity to see novel solutions across six convergence research track topics, including 18 phase 2 booths from tracks A, B, C, and D and 28 phase 1 booths for track E: Networked Blue Economy and track F: Trust & Authenticity in Communication Systems (see Table 1).

PROGRAM STATUS

The Convergence Accelerator program is currently composed of three cohorts, started in 2019, 2020, and 2021, respectively. Each cohort focuses on two research track topics. The 2019 cohort is in year 2 of phase 2; the 2020 cohort is in year 1 of phase 2 and the 2021 cohort is in its phase 1. Table 1 shows the status of the program's portfolio.

Themes for the two inaugural tracks in the Convergence Accelerator—track A: Open Knowledge Network (OKN) and track B: AI and the Future of Work—were derived from the NSF Big Ideas on Harnessing the Data Revolution and the Future of Work at the Human–Technology Frontier, respectively (NSF 2019a).

As shown in Table 1, in September 2019, 21 projects were selected for track A phase 1 and 22 for tracks B1 and B2 phase 1. Of these, five from track A and three from track B (two B1, one B2) were selected for phase 2, in September 2020. All projects are typically characterized by multisector partnerships involving academia, industry, government, nonprofit, and other sectors; a multidisciplinary project team consisting of a breadth of expertise including subject matter expert as well as technology experts, and, clearly articulated deliverables to be created by the end of phase 2. The following sections provide an overview of track A and tracks B1/B2, as well as a brief overview of the eight projects that entered phase 2. Seven of these projects are described in further detail in separate articles in this special issue. The NSF Program Director for track A is Dr. Lara Campbell and for track B is Dr. Linda Molnar. This special issue also includes an article that provides a brief overview of all phase 1 projects in track D whose theme—data and model sharing to enable AI innovation—is directly related to AI. The NSF Program Director for track D is Michael Pozmantier.

Track A: Open knowledge network

Track A focuses on use-inspired research to create an Open Knowledge Network (OKN) representing information about real-world objects and relationships among objects, as a critical part of a national data and knowledge infrastructure, as originally mentioned in the NSF's HDR Big Idea (HDR 2017). Vast amounts of data are produced daily, yet many organizations lack the tools and resources to draw insights from these data and to make data-driven decisions. Proprietary versions of knowledge

TABLE 1 National Science Foundation (NSF) Convergence Accelerator Portfolio

Cohort year	Track: topic	Projects funded during each convergence research phase	
		Phase 1	Phase 2
2019	Track A: Open Knowledge Networks	21	5
	Track B: AI and the Future of Work	22	3
2020	Track C: Quantum Technology	11	4
	Track D: AI-Driven Innovation via Data and Model Sharing	18	6
2021	Track E: Networked Blue Economy	16	September 2022
	Track F: Trust & Authenticity in Communication Systems	12	September 2022

networks/graphs already power some of today's most powerful applications in web search (for example, Google Search, Bing), dialog-based systems (for example, Siri, Alexa), e-commerce (for example, Amazon), and social media (for example, Facebook, Twitter), while Wikidata provides the most significant example in the open world. Access to an OKN that contains open scientific and government data and information, while also linking to access-controlled information, would open the gates to a new generation of powerful applications serving societal needs. Furthermore, researchers would be able to develop expressive frameworks to capture knowledge and design user-centered interfaces to access knowledge at scale for real applications. Organizations—regardless of their size or sector—would be able to take advantage of this networked infrastructure to provide better services and products.

In a workshop organized in October 2017 by the *Big Data Working Group* of the Federal Networking and Information Technology Research and Development Program, stakeholders from Federal agencies, industry, and academia concluded that an open, community-driven OKN effort would enable stakeholders from all sectors—government, industry, academia, nonprofits, and others—to share the effort and cost of developing this framework and infrastructure (NITRD 2017). This OKN would be an essential component of AI-based solutions by adding context and world knowledge to machine learning systems, enriching data with extensive information about the underlying objects, and enabling natural language systems to link words and sentences to descriptions meaningful to human users. Workshop breakout sessions discussed cross-cutting "horizontal" topics in technology as well as domain-based "vertical" issues. The need for this impactful new mode of data-driven discovery was further endorsed by the NSF Big Idea on Harnessing the Data Revolution.

Key characteristics of this OKN would include (a) *dynamic structure*, reflecting real-world information updates and changes as they occur, (b) *open system*, to accommodate input from a variety of sources, (c) *linkages among entities*, to enable linking across disparate information via link traversal and also enabling deducing of linkages among entities, and (d) "*horizontal*" and "*vertical*" elements. Horizontal elements and activities would support development of a common technological infrastructure, regardless of the knowledge domains, such as data curation/refinement services, data provenance, data integration services, and user-friendly tools, applications, and interfaces. Vertical elements and activities would encompass ingestion and curation of content for a wide variety of information domains with activities such as extraction of information from structured/unstructured sources, defining ontologies, and mapping across ontologies, supporting applications in many different domains.

A report released in March 2021 by the US National Security Commission on AI noted that, "OKNs (or repositories) with massive amounts of world knowledge could fuel the next wave of AI exploration, driving innovations from scientific research to the commercial sector" (NSCAI 2021). It went on to encourage "A vision to create an open knowledge graph of all known entities and their relationships, ranging from the macro (for example, have there been unusual clusters of earthquakes in the US in the past 6 months?) to the micro (for example, what is the best combination of chemotherapeutic drugs for a 56-year-old female with stage 3 brain cancer?). The OKN is meant to be an inclusive, open, community activity resulting in a nonproprietary knowledge infrastructure that could facilitate and empower a host of applications and open new research avenues, including how to create trustworthy knowledge networks and graphs."

Track B1 and track B2: AI and future jobs and national talent ecosystem

Track B focuses on the convergence of AI technologies across a wide range of future of work issues including workforce training and education, curricula and skills training development, and worker-work matching. The landscape of jobs and work is changing at unprecedented speed, enabled by advances in many areas including

computing technologies (for example, AI and robotics); deeper understanding of societal and environmental change; advances in the cognitive and learning sciences; the development of pervasive, intelligent, and autonomous systems; and new concepts of work and the workplace. The ongoing COVID-19 pandemic has brought about even more change and more urgent need to address work—how and where it is done and, importantly, the workers who are doing it. Many American organizations currently suffer from a talent gap. Not only do current workers lack the requisite skills to perform 21st century work but many new graduates moving into the marketplace also lack those skills. In addressing these Future of Work issues, the goals and objectives of track B are in line with NSF's R&D priorities in ensuring accessibility and inclusivity; securing global leadership; and advancing the frontiers of research into the future (FWHTF 2020).

Track B1 on *Artificial Intelligence and Future Jobs* focuses on R&D leading to technological tools to connect individual workers with jobs, and on providing periodic retraining and reskilling outside of traditional educational settings, which will be increasingly necessary and integral to successful lifetime careers. Ensuring fair, ethical, and equitable treatment of workers is a key guiding principle in the creation of tangible deliverables. Projects may consider a broad range of factors impacting employment and training, such as intersectional identities (for example, gender, race, ethnicity), disabilities, socio-economic status, and contextual factors (for example, family responsibilities, as well as access to education, and technology). Projects may focus on particular industries or regions, specific populations such as veterans and autistic/neurodiverse individuals, or particular workplace types such as small businesses, decentralized manufacturing, medical facilities, or K-12 schools. AI technologies utilized may include NLP and understanding; machine-learned models for matching skills with training; and an intelligent coach "virtual teaching assistant" to gain trust and encourage engagement.

Track B2 supports convergence R&D leading to innovative approaches for employers to support their workers seeking the skills required for 21st century work and technologies of the future. Track B2 efforts may devise R&D plans addressing multiple approaches toward re-envisioning the concepts, structures, and technologies needed for employers to support continuous learning for dynamic, digitally intensive work, and provide access to skilled talent pathways, mentors, and authentic workplace experiences. Projects are informed by research on STEM learning, engagement, and its social context, as well as research on organizations and collaboration. Projects may focus on prototyping innovative approaches such as learning environments, platforms, interfaces, or simulations, tools for analysis, assessment, or prediction, and vehicles for recruitment and engagement, with the potential for wider implementation by industry, educational institutions, and other stakeholders engaged in the cocreation of a national talent ecosystem. AI convergent research efforts may include leveraging AI to adaptively personalize the learning content and learning experiences, including AR-based learning applied to fields such as emergency response (ER).

Track A phase 2 projects

A brief outline of the five track A phase 2 projects is provided. Specific issues related to each project are further discussed in separate articles in this issue.

The Open Knowledge Network Infrastructure project (Cafarella et al. in this issue) is developing software to support all phases of the lifecycle of knowledge network creation and use, addressing the lack of an efficient and easy data-oriented programming environment for this purpose. Tools and capabilities are being developed for data ingestion, data curation and knowledge graph refinement, provenance tracking, and development of applications that use knowledge networks. The CORD-19 dataset on COVID-related publications (CORD 2019) provides one application domain. The project is also working with the SCALES project on court records data.

The *KnowWhereGraph (KWG)* project (Janowicz et al. in this issue) is addressing the need for efficient representation and use of spatial information in knowledge graphs while also developing tools to provide geospatial data ("enrichment") that can be tailored to a broad range of applications. Spatial information is "semantically lifted" and representing in the knowledge graph to enable answering questions about spatial properties of entities, and spatiotemporal relationships among them, such as "What entities are located here?," "What events occurred here in the past?," and "How does region X compare with region Y?" for any given region on earth. The project is focusing on applications in disaster relief and supply chain management.

The *Systematic Content Analysis of Litigation EventS Open Knowledge Network (SCALES)* project (Amaral et al. in this issue) is a "vertical" project in the judicial records domain. It seeks to transform the transparency and accessibility of court records by making federal court records information easy to access and query. Current court recordkeeping practices produce rich but largely unstructured text data, the study of which is further complicated by being behind a paywall (Sanga and Schwartz 2020). The project has developed AI techniques for computational understanding of the free text of docket entries,

that allows records to be understood through the different practices employed by each jurisdiction, judge, clerk, and involved party. The team is already answering questions for the courts themselves, and as they build their corpus of data is also focusing on users including legal scholars and researchers, journalists, and policymakers. The project is developing their *Satyrn* platform to integrate natural language querying and visualization in a notebook-style interface and make it easy for nontechnical users to effectively explore, query, and analyze the court records knowledge network.

The Biomedical Open Knowledge Network (SPOKE) project (Baranzini et al. in this issue) is developing an OKN in the precision human health domain. The foundation for this is a large property graph that integrates approximately 40 data sources to date covering a broad spectrum of biomedical data. As part of the data ingestio and curation process, SPOKE uses established ontologies to markup data to enable consistent linking across the knowledge graph. The project is exploring development of visual interfaces for easy navigation of the complex graph and a "neighborhood" explorer to enable analyses that approach the data from different users' perspectives (for example, diseases vs. genes). Specific tools are being explored for biomedical researchers, the pharmaceutical industry (for example, drug repurposing), and clinicians to apply the insights of this knowledge network. SPOKE is also striving to align with Biolink, a biomedical semantic standard currently being established by the NIH/NCATS Biomedical Translator Consortium (BDTC 2019).

The Urban Flooding Open Knowledge Network (UFOKN) project (Yeghizarian et al. in this issue) is developing flood forecasting and response capabilities by integrating data across the *urban multiplex*. The general approach is broadly applicable to the natural disaster "vertical" domain. The approach is to integrate the Urban Multiplex Inventory (UrMI) of multiple linked knowledge graphs (for example, building structures, transportation networks, power resources, utilities) with flood model data across the continental US, incorporating local flood models and tools where available, and socio-economic data (for instance from the US Census' American Community Survey). The project is working closely with local and regional governments in pilot municipalities in Florida, North Carolina, Ohio, Virginia, and Minnesota as they work toward a national rollout of this OKN.

Track B phase 2 projects

The *SkillSync* project (Robson et al. in this issue) is creating AI-based tools to develop an understanding of job postings, work requirements, and training opportunities in terms of the underlying knowledge, skills, and abilities (KSAs) required, or offered, to match training opportunities with skills needs in an efficient, effective, and equitable manner. A "virtual coach" uses human-centered AI to answer questions about SkillSync's own operation, and reasoning functions, to improve usability. The project is creating "Intelligent Links," which are AI-supported connections between Employers and Colleges for training and skills development. The project is run by Eduwork with their partners at Georgia Tech.

The *Learning Environments with Augmentation and Robotics for Next-gen Emergency Responders (LEARNER)* project (Mehta et al. in this issue) is developing an accessible, modular, personalized, and scalable mixed-reality, cloud-based learning platform for ER use to accelerate skilling and reskilling of ER workers, particularly on nascent augmentation technologies, such as powered exoskeletons and head-worn augmented-reality interfaces. These new approaches have the potential to change the very nature of work in this domain, and improve efficiency, health, and well-being of workers. A unique human-centered adaptive training framework is being developed which incorporates physiological, neural, and behavioral markers of learning into real-time AR and virtual reality (VR) and force feedback-based exercise delivery, along with user preference and past training history.

Track integration

As described earlier, projects within each track are also required to work together on "track integration," to endeavor to create an overarching outcome that is greater than simply the sum of the individual efforts. The five track A phase 2 projects are developing a *Data2Knowledge Consortium*, described below, to provide resources and insights drawn from the individual projects' tools and efforts, as well as from cross-project connections, to support other efforts to embrace the significant promise of knowledge graph and OKN approaches.

The track B phase 2 projects are developing a *Skills-based Talent Ecosystem Platform for Upskilling—STEP UP* to help develop evidence-based *guidelines* for selecting the best type of training for acquiring a given set of skills in a multireality environment. In parallel, STEP UP is developing *skills frameworks* and associated *skills-based credentials* for technical areas covered by the LEARNER project and for first-line management leadership training, which is a steppingstone to jobs that provide a living wage and an upward career path. These will be used in a proof-of-concept STEP UP portal scheduled for release by the end of 2022.

Track A: The Data2 knowledge (D2K) consortium

Projects within the track are working together to identify specific areas of mutual opportunity. For example, the OKN Infrastructure and SCALES projects are working on common tools and technical capabilities for information extraction from and understanding of documents. The KWG and UFOKN projects are working together on spatial representation of information and the Biomedical OKN and OKN Infrastructure projects are working on use cases connected to COVID-related information, which can also draw in the KWG and UFOKN projects (for example, compounded effects of flooding during a pandemic) and the SCALES project (for example, impact of pandemic on court cases broadly, but also characteristics of cases related to vaccination and mask mandates).

These projects have identified a set of broad cross-cutting themes across all OKN efforts such as: the importance of tools and well-defined processes for ingestion of new data into knowledge graphs and networks. This includes tracking provenance of data; understanding the role of the human-in-the-loop—how far can an OKN go in providing automated responses using inferencing and other AI techniques and at what point does the human-in-the-loop need to come into ensure accurate data ingestion side as well as effective and fair interpretation, and, provisioning of core infrastructure, that is, what types of computing and data platforms need to be readily available to ensure effective end-to-end applications and maximize benefits to society broadly.

Track B: STEP UP—skills-based talent ecosystem platform for upskilling

STEP UP is a collaboration among the track B phase 2 projects with the long-term vision of providing a translational platform and a transition-to-practice ecosystem not just for the NSF Convergence Accelerator efforts, but to all fundamental researchers and stakeholders involved in Future of Work, including researchers in the NSF FW-HTF (Future of Work at the Human Technology Frontier) core research program and those working in this area with other federal agencies. The goal of STEP UP is to not only transition use-inspired research to practice to have positive and lasting impact on American workers but also to create a virtuous cycle of fundamental research and transition to practice. STEP UP especially focuses on underserved groups and the missing millions in parts of the country that are often overlooked.

STEP UP will provide a platform with a set of capabilities that will (a) allow employers to create job profiles that identify the skills needed for in-demand jobs; (b) enable individuals to create (and validate) skills profiles that identify the skills they have; (c) use AI to match skills profiles to job profiles and to identify skill gaps; (d) enable individuals to find and enroll in training to fill skills gaps; (e) issue skills-based credentials that validate newly acquired skills; and (f) enable individuals to provide existing or potential employers with those credentials. All of these functions will be supported by AI-based techniques that extract skills information from unstructured data for use in job matching and recommendation algorithms using well-validated AI de-biasing techniques. A special focus is on ensuring that research in this area is well-connected to all segments of the population, especially those that have been traditionally underrepresented and historically excluded as part of research focus and case studies. It is envisioned that new workforce technologies and associated skills can be added to the STEP UP platform providing new skills-based credentials, training profiles, worker profiles, and job profiles thus creating more opportunities to support different types of learning that are no longer served by a standard resumes and cover letters (Cardenas-Navia and Jyotishi 2021).

New tracks

Tracks in the Convergence Accelerator are selected through an NSF *RFI* workshop process (other than first two inaugural tracks in the 2019 cohort, which were selected by NSF). The 2019 cohort included tracks A and B, which are in year 2 of phase 2; the 2020 cohort included track C on Quantum Technology (program director Dr. Pradeep Fulay) and track D on Enabling AI Innovation via Data and Model Sharing (program director Michael Pozmantier), which are in year 1 of phase 2. This special issue does not include an article on track C since there are no strong linkages to AI in that track. The article by Baru et al., on Enabling AI Innovation via Data and Model Sharing, provides an overview of all 18 projects in phase 1 of track D. Brief descriptions of projects currently in the 2019 and 2020 cohorts are available in the 2021 Convergence Accelerator Portfolio Guide (NSF 2019b).

Tracks in the 2022 cohort are track E: Networked Blue Economy (program director Dr. Aurali Dade) and track F: Trust and Authenticity in Communications Systems (program director Michael Pozmantier) (NSF 2021b). Tracks in the 2023 cohort have been announced. They are, track G: Securely Operating Through 5G Infrastructure (NSF 2022a) and track H: Enhancing Opportunities for Persons with Disabilities, Track I: Sustainable Materials for Global

Challenges, and Track J: Food & Nutrition Security (NSF 2022b).

Lessons learned

The Convergence Accelerator program has taken off extremely quickly on a steep trajectory. Indeed, the program team likes to say, "We are building the plane as we are flying it!" With the first two tracks (tracks A and B) not yet completed, it is too early to comment on the program's impact. However, one measure of success is the enthusiasm that the researchers have shown for this program, its approach, and its curriculum. Based on community response to the program and informal researcher feedback, the program appears to be addressing important needs in the research community. The program team has learned that not all research areas and topics are necessarily suitable for track topics—each research area needs to be at the right level of maturity to admit multidisciplinary convergent approaches, attract multisector partnerships, and identify tangible deliverables that can be delivered in a 3-year time frame. While the funded researchers have been enthusiastic about the program, the program also resonates best with researchers interested in making an impact via "deliverables" in a relatively short term. The program also offers an exciting learning platform for graduate students and postdocs interested in translational research and transition to practice, that is, those interested in working on use-inspired research and working toward deliverables. Unlike a more "traditional" postdoc mentoring plan, the mentoring plan for Convergence Accelerator projects is expected to emphasize training of postdocs in the areas of translational and use-inspired research, team science, and project management for deliverables.

The program's innovation curriculum and the mentoring provided by coaches have been very popular with the teams—providing effective paths to bringing the teams up to speed on issues related to translational research and transition to practice. Importantly, the Convergence Accelerator program is not a competitor to the long-running NSF Innovation Corps (I-Corps), Small Business Innovation Research (SBIR), and Small Business Technology Transfer (STTR) programs. On the contrary, it complements those programs by being situated earlier in the research development path toward practice. Unlike those other programs, success in the Convergence Accelerator program is not necessarily about commercialization—although commercialization may be a perfectly good and useful outcome. Projects can have an impact without becoming commercial enterprises, such as open-source efforts, nonprofits, acquisition by a forprofit or nonprofit organization, and other avenues. In addition to the requirement for multidisciplinarity and partnerships, the track-based structure of the program also makes it different. The notion of "track integration," where all projects within a track work together to address the larger national or societal challenge to make the whole greater than the sum of parts, is yet another new aspect of the program whose impact is also closely being followed and monitored.

Looking ahead

The Convergence Accelerator is on an exciting path. It is a unique, young NSF program focusing on translational and use-inspired research and accelerating solutions toward societal impact. This is an approach to which NSF is committed. NSF has long supported all facets of fundamental resarch, from foundational, curiosity-driven research to use-inspired, solution-oriented research, and translational research. NSF is actively learning from experiences in the first few years and using those experiences to continuously refine and enhance the program.

So far, more than 400 organizations from academia, industry, government, nonprofit, and others have engaged in the program, including those represented by the project Principal Investigators (PIs), co-PIs, and Senior Personnel, and partner organizations; and interest continues to grow about the program. The first few tracks—A, B, and D—are directly related to AI. Track F focuses on misinformation/disinformation and includes a number of projects that are using AI as a tool. As the program proceeds ahead, NSF anticipates almost every future track topic will have a strong connection with AI, given the ubiquity and importance of AI in nearly every science and engineering field and topic area.

CONFLICT OF INTEREST

There is no conflict of interest.

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