NSF S&CC Visioning Workshop Report

February 2024

The Smart and Connected Communities (S&CC) program, launched by the National Science Foundation (NSF) in 2016, aims to advance research in smart communities through interdisciplinary research projects that are motivated by community-driven challenges. The program's mission and goals are being reevaluated in light of advancements in computing, engineering, social sciences, and the evolving needs of communities. This includes clarifying the program's scope in relation to other NSF initiatives with synergistic themes and considering adjustments to encourage more exploratory and ambitious research.

In February 2024, the program held a visioning workshop alongside its annual S&CC PI meeting, to engage researchers and practitioners in discussing future priorities for the S&CC program. The goals of this workshop were to advise the S&CC program on how it can best support the latest scientific advancements and be responsive to the emerging needs of communities. This report summarizes the visioning workshop along the following dimensions:

- High Priority Areas for the Future of S&CC **(Section 2)**
- Methods to encourage high-risk high-reward research **(Section 3)**
- Approaches for use-inspired high-reward research **(Section 4)**
- Changes to allowable budgets and considerations for supplemental funding to enable transition to practice activities **(Section 5)**

1 Background on Program

The Smart and Connected Communities Program agenda was formulated in 2015 and launched in 2016 to develop novel intelligent technologies and concepts that address long-standing societal-scale challenges. The program made its first awards in 2017 and has since funded both planning grants (small developmental grants) and integrative research grants (full awards). The program's unique structure made it well suited to fund projects combining social sciences with cyber-physical systems and technical research ("sociotechnical research"). A strong emphasis was placed on use-inspired research with real-world pilot implementations on timescales of approximately 5 years. This focus on pilot implementations over a 5 year time horizon situated the program to think critically about the types of impact that are achievable on a 7-10 year time horizon.

Since the program's inception, S&CC has invested in projects spanning over 40 states, with communities ranging from large cities (e.g., Seattle and Los Angeles) to rural communities (e.g., Platte County, NE) to tribal communities (e.g., Sitka, AK), and has involved a range of community stakeholders including local and state governments, non-government organizations, utility providers, faith-based organizations, and neighborhood advocacy groups. These project have typically been supported either at the 1.5-2.5M$ track (up to 4 years), or the 0-1.5M$ track (up to 3 years). In addition to these two research tracks, the S&CC program offers planning grants at 150K which allows researchers to explore early-stage research ideas with the goal of preparing the teams to submit future IRG proposals. Typically, the S&CC program funds 8-12 IRG projects a year as well as 20-30 planning grant projects. Since 2018, the program began awarding *transition to practice* (TTP)

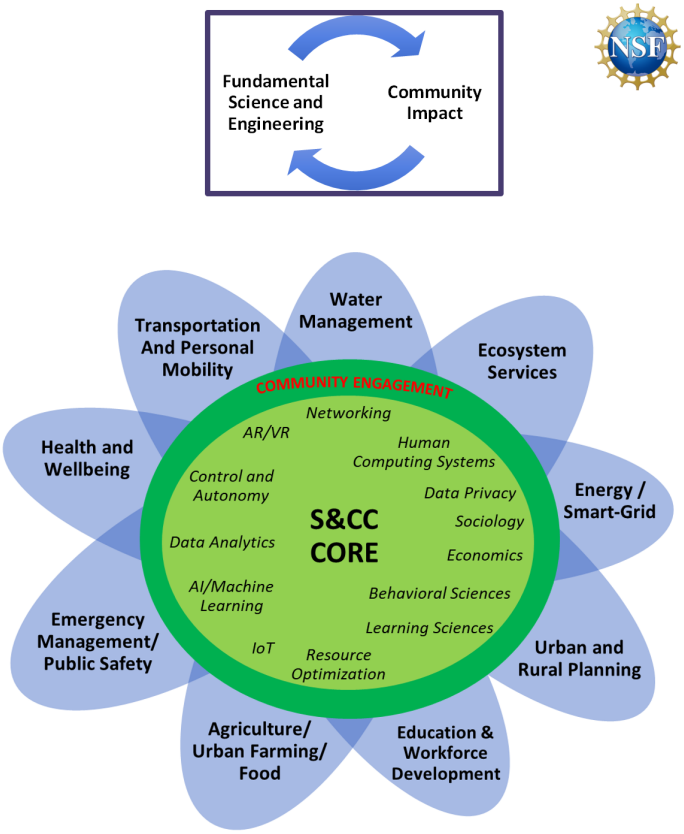

Figure 1: (top) The high-level goal of the Smart and Connected Communities program is to encourage a virtuous cycle where researchers can innovate on new and specific challenges, and community stakeholders guide the project in the most impactful directions while providing vital and context-specific information to researchers.(bottom) As envisioned by the program solicitation, core computer science, engineering, and social science insights are applied to domain specific applications by engaging community stakeholders to inform and shape each approach.

supplemental awards on a limited basis to provide additional funding for projects with promising pilot phases.

The S&CC program solicitation (NSF 22-529) has a scheduled expiration date of April 1 2024, which provided an incentive for reflection on the future of the program and its continuing potential for impact moving forward.

1.1 A changing funding landscape

Since the program's inception, a number of other funding opportunities from NSF have emerged as funding sources for projects in similar cutting-edge technology-meets-community spaces.

- NSF 22-565: Civic Innovation Challenge - accelerates the transition to practice of foundational research and emerging technologies into communities by funding projects that pilot state-of-the-art solutions over 12 months, following a six-month planning phase, that have the potential for lasting impact in the partnering community as well as the potential to be scaled and implemented in other communities. Due to the short timeline and $1M budget, the program funds projects that have a reasonable chance of success within 1 year. This is in contrast to SCC-funded projects, which are expected to take on higher risk projects commensurate with the longer time horizon.
- NSF 24-519: Strengthening American Infrastructure (SAI) - seeks to stimulate human-centered, use-inspired, fundamental and potentially transformative research aimed at strengthening America's infrastructure. Proposals to this program must bring deep leadership expertise in at least one Social, Behavioral and Economic Sciences (SBE) disciplinary program area, and provide details on how such SBE disciplinary expertise and leadership will contribute to strengthening American infrastructure.
- NSF 23-624: Research on Innovative Technologies for Enhanced Learning (RITEL)- supports early-stage research in emerging technologies for teaching and learning that respond to pressing needs in authentic (real-world) educational environments. Because this program is led from the Directorate for STEM Education, projects funded by RITEL must have a strong focus on expanding teaching/learning research as well as technology.

The diversity of programs in this area demonstrates the growing interests of researchers and government agencies in supporting work to address the increasing prevalence of emerging technologies and their transformative potential when developed and applied to solving tough community problems.

Moreover, in light of the growing interest in this research space, a number of structural goals are proposed for the S&CC program to ensure it remains well poised to fund a visionary set of high-impact community driven research projects in the future, while reducing overlap with other use-inspired research programs at NSF or elsewhere. Each is detailed in the following sections.

2 The Future of S&CC

The following areas represent the breadth of priorities identified at the Visioning Workshop. The numerous priorities have been divided into two large groups, priorities for (a) new solicitations, and (b) S&CC research themes

2.1 Research Priorities

The research priorities discussed at the workshop highlight some of the key areas for exploration, including the challenges of community-engaged research in the age of generative AI, embodied intelligence on a community scale, privacy in smart communities, real-time decision-making support, and community resilience to rapidly evolving cyber, physical, and social threats. These topics are not exhaustive but represent a subset of relevant areas for the program. The program will support

research that broadly addresses emerging challenges to advance community-driven solutions through technology, including on topics not mentioned during the workshop.

2.2 Solicitation Features

- Relative to other, synergistic NSF programs, a strength of S&CC is its focus on motivating innovations in intelligent technologies through use-inspired, community engaged research over 3-4 year projects, with 7-10 year impact horizons for project outputs.
- Addressing societal challenges within a well-defined community - responsive to larger national priorities (e.g., recommendations from PCAST reports).
- Support for more exploratory research that develops novel computational and engineering tools for communities that go well beyond today's state-of-the-art .
- Evaluating research through controlled experiments via simulations and/or testbeds
- Considering the generalizability of the research and developed technologies beyond the NSF award to a broader set of communities.
- Growing the program through opportunities for collaboration and co-funding with other federal agencies and NSF directorates.
- Re-defining the role of communities in aligning research aims to their needs and encouraging both communities and researchers to jointly undertake projects with potential for high societal and scientific impact.

3 Encouraging Bold Research Agendas

To distinguish itself from other complementary research programs, S&CC seeks to encourage bolder, "high-risk, high-reward" projects (See 4.1).

Such projects should:

i.) address inherently difficult problems, for which existing technologies are not sufficient.

ii.) involve non-trivial technical advances in the state of the art, where risk of research failure is high

iii.) The high risk of research failure must be balanced by the potential for significant community impact over a 5-10 year horizon if the project is successful.

iv.) require buy-in from communities and their active involvement in the design and iterative evaluation of research aims and goals.

Research funded by S&CC will affirmatively answer the questions:

- What is the current approach and state-of-the-art to addressing the challenge motivating the research, and what are the limits of current practice?
- How does your approach go beyond the state-of-the-art and why do you think it will be successful? How will you define and measure success?
- Who will care if you are successful? If you are successful, what scientific and social impact will it make? Will the impact go beyond addressing the identified community-challenge?

The language of the program solicitation should challenge researchers to get outside of the comfort zones of well established fields and embrace risk. The program should be written to encourage projects with a smaller chance of success, but a with a larger scientific and community impact payoff if they are successful. Projects should also be assessed in terms of their ability to identify and begin to

address potential sources of risk to the success of the project (i.e. quickly engaging with community stakeholders to identify potential resistance and quickly developing technical proof-of-concepts to assess technical feasibility).

In summary, the program should strengthen requirements for contributions in computing and engineering that go beyond the state of the art - projects that are simply applications of existing approaches to domain problems or incremental in technical advancement should fall out of scope for the S&CC program.

4 The Use-Inspired Approach to Bolder Research

A core tenet of the S&CC program has been the connection of advancing fundamental computational science and engineering research through use-inspired community engaged research, as in the top of Figure 1. The sociological and behavioral components of S&CC research need to be tied to the technological research goals, and the technological research may require dependency on sociological and behavioral research questions. Primarily socially-focused research may be appropriate for complementary programs such as SAI, and RITEL.

Making communities "smart" is not the goal of the research, but rather a tool to enable solutions to community problems pertaining to attributes like resilience, efficiency, sustainability, and adaptability. There are many communal challenges which are in need of visionary transformative research solutions. However, prospective transformative research impacts require more risk-tolerance in the research approach. To enable more exploratory and 'risky' research, proposed S&CC approaches may not necessarily include as deep community partnerships as may be necessary in programs such as the Civic Innovation Challenge. Similarly, while the sustainability and transferability of the work remain important, expectations for S&CC projects may be set to account to enable ambitious research approaches without guarantees of future success.

4.1 Dimensions of Risk

The concept of 'high-risk' research may pertain to the domains of the technological advancements, the social or behavioral science, or the realized large positive impacts of the technology on the community. High-risk S&CC projects refer to the research risk, for example because the hypothesis may be incorrect, or the research proves to be too difficult, and not risk to the community. Risk is not considered to ever cross the rubicons of safety, consent, and privacy of the impacted communities. Riskier research can provide a high value proposition to communities, where the potential benefits are much greater. A more risk-tolerant research approach to community problems gives space to researchers to be more ambitious and creative in the kinds of community problems to take on.

These risks should be high-reward projects are the significant improvements to quality of life in the community that are enabled by the research.

4.2 The Role of Communities

The *status quo* defining communities includes specific geographic constraints. During the workshop, there was some consideration of how this requirement could be relaxed in the future of the program. Ideas brought to light included the merits of growing strength in virtual organizations and communities, and other networks of small communities empowered by emerging telecommunication technologies. Workshop attendees did not explicitly or strictly define 'communities'. However, it remained very clear that the S&CC research directions should be oriented from the community (by any definition) at its roots. Further, the consensus held that communities' autonomy should be respected, and the research solutions should honor this by enabling their recognized wants/needs.

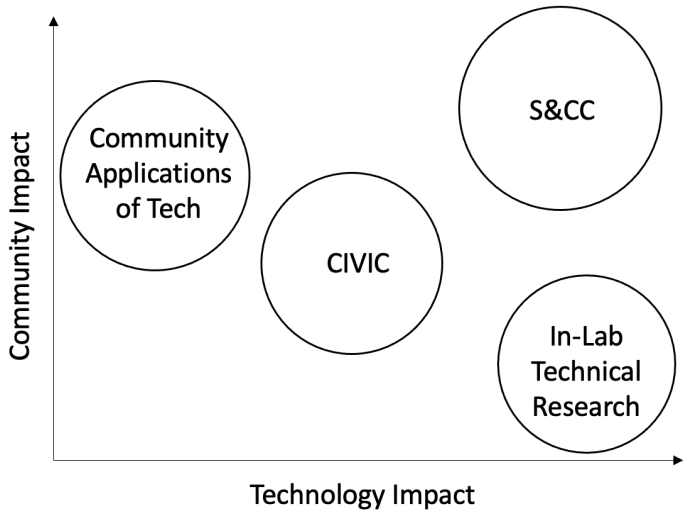

Figure 2: **Dimensions of Rewards**: The S&CC program is positioned to fund bold research plans which are oriented to make both fundamental technological impacts, and take on large community-driven problems.

5 Changes to Budgets, and Supplemental Funding for Transition to Practice

The following changes to the S&CC Funding structure and budget were also discussed.

- To support transformative, bold, flagship ideas in S&CC that go beyond traditional existing project scopes and scales, there is a desire to create a larger *Frontier* category of projects with a commensurate budget maximum. S&CC Frontier projects will address clearly identified critical S&CC challenges that cannot be achieved by a set of smaller IRG projects. Furthermore, Frontier projects should also look to push the boundaries of S&CC well beyond today's systems and capabilities.

- To keep initial investments on higher risk research smaller, it may be necessary to adjust the budget size of the Track 1 ($1.5-2.5M) projects. It was noted that the average funding for FY23 S&CC awards was approximately $1.7M, and other NSF programs with similar requirements have a budget maximum of $1.2M.

- Accounting for the proposed smaller initial investments, projects with demonstrated success should be encouraged to procure additional supplemental funding for the project through *transition to practice* (TTP) awards. Supplemental funding requests are appropriate when the principal investigator has made significant progress on the basic grant to establish feasibility. The limited funds request should be used to transition the research to practice in the community or to enable a rapid acceleration of maturity.

- It was also recommended to encourage projects to transition to other program funding opportunities, such as the Civic Innovation Challenge, which support piloting and translational activities, at the end of the S&CC project timeline.

6 Acknowledgements

Visioning Attendees: Vishal Sharma, Payman Arabshahi, William Barbour, Linda Bushnell, Matt Carroll, Cynthia Chen, David Corman, Abhishek Dubey, Chen Feng, Derek Gloudemans, Panagiota Karava, Jacob Kravetz, David Kuehn, Daan Liang, Neda Madi, Ayan Mukhopadhyay,

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Appendix A: Agenda

Workshop Agenda

9:00 am - 9:15 am	**Welcome and Introductions**
9:15 am - 10:00 am	**NSF Overview of Proposed Changes to S&CC** The S&CC Program Team will provide an overview to workshop attendees on its high-priority goals for revising the program's goals and solicitation. (15 minutes) **Comments on the Future of Smart Communities:** Dr. Tho Nguyen, Senior Officer on the Computer Science and Telecommunications Board (CSTB), National Academy of Sciences (10 minutes) Open Q&A between workshop attendees and NSF staff (20 minutes)
10:00 am - 12:00 pm	**The Future of Smart Communities** A mini-workshop style activity that will ask workshop attendees the following two questions: 1. What is the current state-of-the-art in smart communities across a range of application domains (e.g., transportation, public safety, disaster resilience, public health, etc.)? 2. When we envision a "smart community of the future", where do we want to be in 10-15 years? What do we need to do over the next several years to realize this future?
12:00 pm - 1:00 pm	Lunch Break
1:00 pm - 3:00 pm	**High-Priority Research Areas for Smart Community Futures** Will be a continuation of the mini-workshop and backcasting activity outputs. Will have two primary goals: 1. Identify high-priority research areas in computing and engineering for the program to consider in a solicitation revision. 2. Address the role of social and behavioral sciences, identifying high-priority themes that would make significant contributions to the human-side of technological advancement.
3:00 pm - 3:30 pm	**Community Informed Research in S&CC** Discussion on the scope and scale of community engagement for the proposed changes to S&CC.

3:30 pm - 4:30 pm	**Proposed Changes to the Budget** Discussion on revising the budget to 3-4 years at $1.5M.
4:30 pm - 5:30 pm	Workshop Reflections and Open Q&A