

NSF Cyber Physical Systems

CPS-IoT Week 2023

San Antonio, TX



In a few words...

Advances in **Cyber-Physical Systems** are reshaping our relationship to technology, our world, the environment, and cyberspace

- **Transforming** the way that we live
- **Driving** scientific discovery & technology innovation
- **Making** our economy prosperous
- **Supporting** our national security
- **Enhancing** our health and societal well-being
- **Educating** future CPS researchers, leaders & workforce



Cyber-Physical Systems

Deeply integrating computation, communication, and control into physical systems everywhere

Characteristics of CPS

- Pervasive computing, sensing, control
- Networked at multi-&-extreme scales
- Dynamically reorganizing/reconfiguring
- High degrees of automation
- Dependable trustworthy operations
- High assurance and formal verification
- Scalable, interoperable, safe, secure, resilient, usable
- Autonomy & human-in/on-the-loop
- Conventional and unconventional substrates / platforms

Application Domains



Autonomous Systems



Civil Infrastructure / Energy



Agriculture / Healthcare

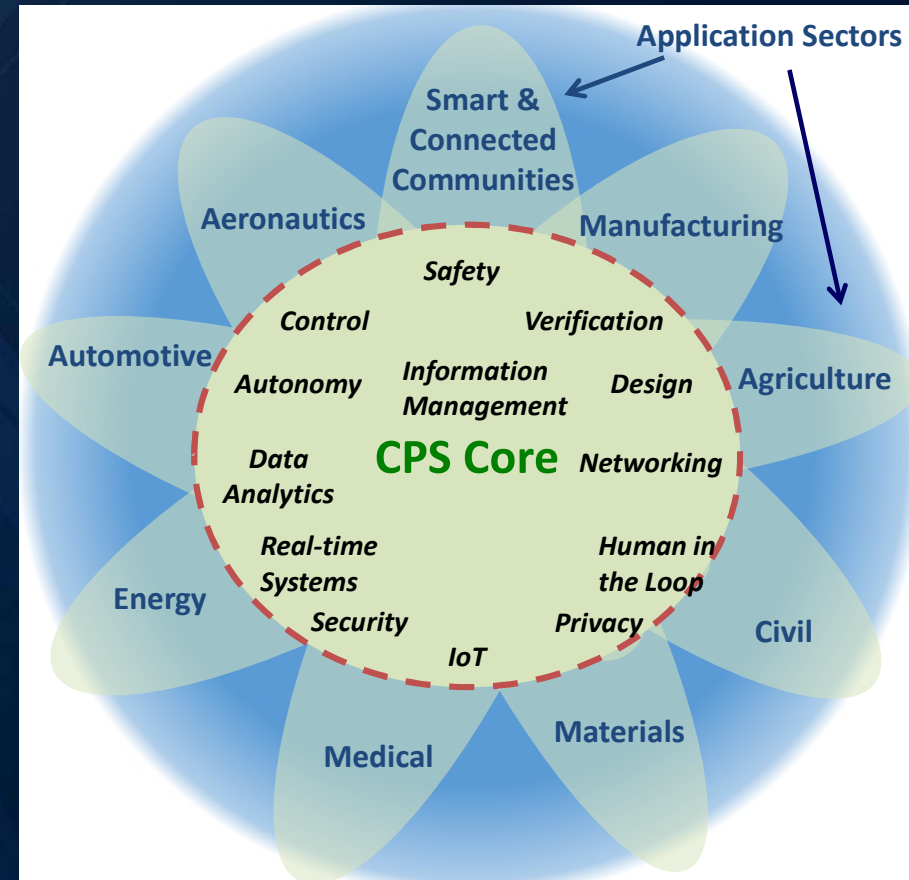


Transportation / Manufacturing



Overview of the CPS Program

- The **goal** of the CPS program is to develop the core system science needed to engineer complex cyber-physical systems upon which people can depend on with high confidence
- Reveal cross-cutting fundamental scientific and engineering principles that underpin the integration of cyber and physical elements across all application sectors
- Multi- agency: DoT, DHS, NIFA, NIH



CPS Project Classes

- **Small** – Budget \leq \$500,000, typically single investigator. Frequently more focused research and sometimes higher risk
- **Medium** – Innovation at the intersection of multiple disciplines, to accomplish a clear goal that requires an integrated perspective. Budget between \$500,001 and \$1.2M
- **Frontier** – Critical CPS challenges that cannot be achieved by multiple small projects. Budget $<$ \$7M
- **Transition to Practice** – Leverage research for accelerated maturation and implementation – we're serious about these --- you need a strong story – not just hope. Are there partners?
- Also – **CRII and CAREER** for CPS program
- Also – **REU and RET** supplements



We are looking for **creative** ideas



CPS Research Themes – Mining Past Awards

Autonomous Systems

Complex Systems

Real-time Systems

Medical CPS

Energy Grid

Cyber Infrastructure

Mobile Agents

Multi-agent Systems

Wearable CPS

Manufacturing

Intelligent Transportation

Agriculture Systems

Robust Control

Coordinated Control

Event-triggered Control

Supervisory Control

Predictive Control

Optimization

Formal Methods

Verification

Situation awareness

Time Synchronization

System Integration

Resilience

Game Theory

Cyber Security

Intrusion Detection

Privacy

Safety

Autonomy

Machine Learning

Human-in-the-loop



What's in a CPS Proposal



Guiding Principles for CPS Proposals

Cyber-Physical Systems – systems in which the cyber and physical components are tightly integrated at all scales and levels. Problem space includes computation, sensing, control, networking for the physical world

- What makes this CPS?
 - How does the research integrate cyber and physical components? How does it go beyond sensing --- and **“close the loop”**
- How does this go beyond a difficult domain problem?
 - What are **the core CPS research areas** being addressed? How are the research outcomes translational to other application domains?
 - What are the technical challenges that drive the research problem?
- How will the **project demonstrate and validate** research concepts?
 - What is success? What are the metrics?
 - What experiments will be conducted? Data collected?
- What are the major project activities? Are they integrated tasks?
- What are the team collaboration plans?
- What are the tasks and how are they integrated? Who is responsible?



Intellectual Merit for CPS Proposals

- **Research Description:** Technical rationale and technical approach of the CPS research
- **CPS Research Focus:** Core CPS research areas where the novel and foundational research contributions are being made
- **Evaluation/Experimentation Plan:** How proposed concepts will be validated and the metrics for success
- **Project Management and Collaboration Plan:** How the project team is ideally suited to realize the project goals and how the team will assure effective collaboration



Broader Impacts for CPS Proposals

- How does the research **impact society**? Who – outside the project - will care if the project is funded? What impact will the research have on the greater field of CPS?
- Describes how the research will be disseminated to a broad and diverse audience
 - Beyond traditional academic publications and include education and outreach from the research team spanning multiple levels of engagement
 - How the research and education outcomes will be disseminated in a manner that enables the CPS research community and others to use the results in ways that go beyond traditional academic publications



BPC/BPE Plan for Medium & Frontier Proposals

CISE strongly encourages meaningful and **intentional** actions that address the longstanding underrepresentation of various populations— including women, African Americans, Hispanics, American Indians, Alaska Natives, Native Hawaiians, Pacific Islanders, and persons with disabilities— in computing and closely-related discipline.

<https://www.nsf.gov/cise/bpc/>

CONTEXT: Does the proposal identify a specific problem or need to be addressed? What are the goals of the plan and rationale?

TARGET: Who is the intended population for the BPC plan? Provide some clear demographic data on the intended population

STRATEGY: What are the specific activities to be undertaken and resources required to ensure the project is viable and responsive to the needs and strengths of the target audience

MEASUREMENT AND DISSEMINATION: How will you measure progress? What are the metrics? How will you share the results?



TTP Option

- Transition-to-Practice is an option ---- proposal must be able to stand on its own without it
- Evaluated separately from the proposed project – discussed only if Competitive or Highly Competitive
- Does the addition of a TTP option
 - Bring more impact on the field?
 - Add a new capability?
 - Open up partnering with an industry that will use the technology?
 - Have well-stated goals and milestones, metrics, and evaluation of a working system to be deployed?
 - Have steps to take the prototype system to the next level for industry use?



Words of Advice



Words of Advice

- Think about the **Heilmeier questions**
- Look at your proposal from the perspective of a reviewer ---- what makes it different? Too many proposals all seem the same and need to look at what makes your proposal unique.
- Write legible and understandable proposals ---legible from the point “don’t cheat on formatting”, make your tables and graphics readable, don’t submit unless you think its ready, don’t ask the question – is this a good topic for CPS? ----- it shows you don’t know anything about the program ---- and it may be a great topic – but the proposal is what matters.



The Heilmeier Catechism for CPS

George H. Heilmeier, DARPA director (1975-1977), crafted a set of questions known as the "Heilmeier Catechism" to help evaluate proposed research



- **What are you trying to do?** *Articulate your objectives using absolutely no jargon.*
- **How is it done today, and what are the limits of current practice?** *Your proposal not only has to go beyond the state of practice ---- but beyond the state of the art*
- **What is new in your approach and why do you think it will be successful?** *Think carefully to define what is success?*
- **Who cares? If you are successful, what difference will it make?** *Can you go beyond "it will be better" or "it will improve"?*
- **What are the risks?** *We in CPS anticipate that there should be risks – otherwise not enough research, but do you understand what the risks are?*
- **How much will it cost?** *Top line is fixed for proposal categories – but is the research benefit commensurate with the cost and is it realistic?*
- **How long will it take?**
- **What are the mid-term and final "exams" to check for success?** *What are the critical experiments you will do to demonstrate your hypotheses?*



Some considerations for CPS CAREER Proposals

- **Should a CPS CAREER proposal be your first exposure to the CPS program or even your first NSF proposal?** *You only have three tries. You may want to speak with a CPS Program Officer at NSF before submitting a CPS CAREER proposal.*
- **Why CPS?** *Go beyond sensors and sensor processing. CPS need to tightly integrating computing, control, networking, and sensing of the physical world. Does the system close the loop?*
- **Address core areas of CPS research.** *CPS is not just an application. What are the research questions? How does this go beyond today's state of practice and the state of the art? Is the fundamental research applicable to several CPS domains – or is it a point solution for one domain?*
- **Make sure your proposal can be understood and appreciated by CPS researchers who are not specialists in your area.**
- **CAREER is a 5-year CAREER plan, not a CPS 3-year project that you would submit to the CPS Solicitation.**
- **How will the research impact society?** *Broader impact should go beyond dissemination.*
- **How will your research be integrated into education?** *Give this some real thought.*
- **Be realistic of what can be done.**
- **Participate on CPS panels.**



Quick Introduction to Smart & Connected Communities Program and CIVIC Innovation Challenge Program



Smart & Connected Communities

- Use-inspired, community-focused research to improve quality of life
- Fundamental technological and social science dimensions of smart and connected communities
- Pilot research activities together with communities
- Scalability and transferability of research outcomes; sustainability beyond the life of the NSF award
- 1 year, 3 year, 4 year grants
- sccvo.org



CIVIC Innovation Challenge

- Two themed tracks
- Strong civic-academic partnerships
- Fast-paced pilot project
 - Stage 1 for 6 months
 - Stage 2 for 12 months
- Transferrable, scalable, sustainable
- Communities of Practice
- nscivinnovation.org



Address local priorities and challenges by **piloting research-based solutions** co-created by academics, community partners, and stakeholders



Accelerate transition to practice of foundational research and emerging technologies **into local government and community organizations**



Explicit emphasis on projects that can be **scaled and sustained** in their pilot communities, with potential for **transfer across the US**



Joint federal investments in national priority areas, engaging vulnerable **populations not typically involved** in innovation and research activities



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Q & A

Thank you!

