Smart and Autonomous Systems (S&AS)
NSF 18-557

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CISE/IIS

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Webinar

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The S&AS Team

Division of Information and Intelligent Systems (IIS)

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Welcome

- **Erwin Gianchandani** – Deputy Assistant Director and Acting Assistant Director.
  Computer and Information Science and Engineering

Outline

- Overview of S&AS Program

- Solicitation

- Program Scope

- Submitting Proposals

- Questions

Autonomy: Definitions

- Independence in one's thoughts or actions, especially moral independence

- Autonomous systems can make choices free of outside influence

- *Autonomy* refers to the ability of a system to operate and adapt to changing circumstances with reduced or without human control
  - From: "Preparing for the Future of Artificial Intelligence"

Need

- Increasing interest and need for autonomous systems
  - Robots, vehicles, sensor networks, smart infrastructure, ...
  - Manufacturing, health-care, service, exploration, monitoring, sustainability,…
- Need to **minimize human intervention**
  - Systems should self-monitor and report problems
  - Note: *intervention* distinguished from *interaction*
- Need for **adaptation**
  - Deal with new problems and opportunities
  - Deal with changes to system hardware and environment, over time
- Need to consider and maintain **social good**
 - Ethical behavior in the face of conflicting mission and societal goals
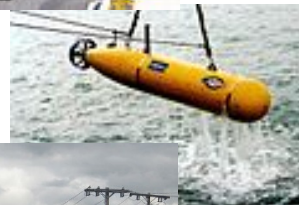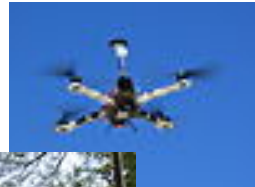
Need

- Recent reports highlight the need for autonomy and ethical behavior in intelligent systems
  - NSF Workshop on Future Directions in Cyber-Physical Systems, Robotics, and Autonomy
    - http://dl.acm.org/citation.cfm?id=2904482
  - OSTP reports: "Preparing for the Future of Artificial Intelligence" and "National AI R&D Strategic Plan"
    - https://www.whitehouse.gov/blog/2016/10/12/administrations-report-future-artificial-intelligence
  - One Hundred Year Study on Artificial Intelligence
    - https://ai100.stanford.edu/

Why True Autonomy is Hard

- The real world is highly uncertain and changing
  - "There are *known knowns*. There are things we know that we know. There are *known unknowns*. That is to say, there are things that we now know we don't know. But there are also *unknown unknowns*. There are things we do not know we don't know." *Donald Rumsfeld, 2002*

- The real world is a heavy-tailed distribution
  - High probability of encountering unexpected events when operating for long duration


- All models are approximations
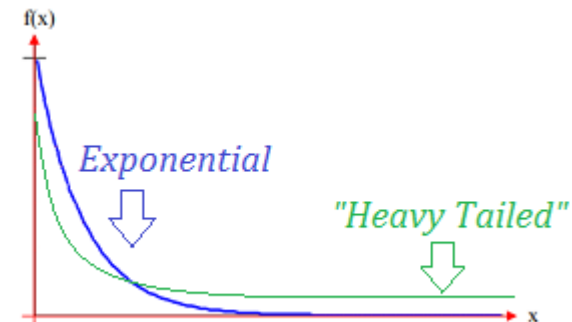
Goal

- Promote fundamental research into **Intelligent Physical Systems** (**IPS**)
  - Focus on *autonomy*

- **IPS**: Integrated hardware and software systems that interact with physical environments and exhibit **four** identifying characteristics
  - **Cognizant**
  - **Taskable**
  - **Adaptable** *change from FY2017 solicitation*
  - **Ethical**

  These characteristics are the *research themes* of S&AS

  Each theme requires IPS to be *knowledge-rich*

Cognizant

- IPS that are aware of their capabilities and limitations
  - Anticipate, diagnose, and recover from failures
  - Act reliably despite uncertain or inaccurately modeled situations
  - Act predictably and be self-explaining

- Example (IIS – 1723924)
  - unmanned marine vehicles adapt to changing conditions, mission objectives, and operator guidance. On-vehicle intelligence facilitates failure recovery and introspection
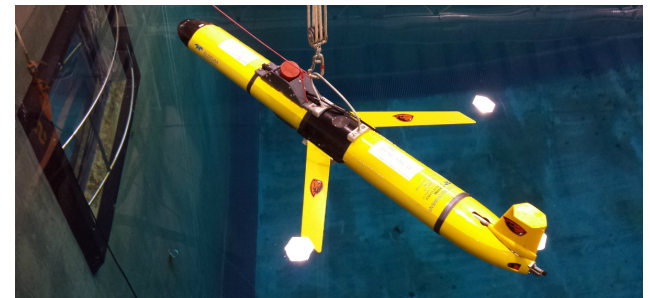
Taskable

- IPS that are versatile
  - Plan and execute diverse tasks in many different situations
  - Translate high-level, often vague, instructions into suitable plans for sensing, reasoning, communicating, and acting
  - Accept instructions through various modalities
    - Natural language dialog, gesture, sketches, multi-modal, …
  - Be interruptible
- Example (IIS – 1723381)
  - enabling high-level commands to a household robot resulting in rational system behavior over long periods without constant supervision

Adaptable

- IPS that optimize, reconfigure, and repair autonomously
  - Improve their behaviors over time, including acquiring, modifying, and transforming their skills by augmenting their knowledge on how to perform tasks
  - Improve the models they use to perceive, plan, and act
  - Continually adjust their behaviors and respond to the particular contexts in which they are operating

- Example (IIS – 1724157)
  - Interactive robots in a public space that can improve over time based on continual interaction with people and environment
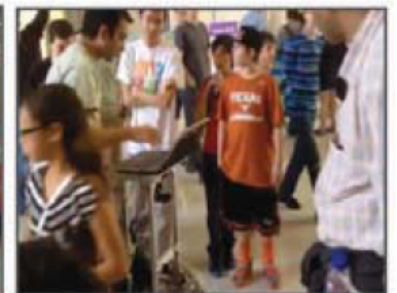
Ethical

- IPS that adhere to an ethical system of societal and legal norms
  - Capable of incorporating societal values into their reasoning
  - Recognize moral imperatives, and avoid commands and actions that violate those dictates
  - Correctly apply ethical decision making when multiple goals are in conflict

- Example (IIS – 1723963)
  - Development of representations and algorithms that enable autonomous systems to recognize and observe human normative expectations and demands.

Knowledge-Rich

no longer a distinct theme, but a critical component of IPS

- Each of the four research themes of this program requires IPS to be **knowledge-rich**, employing a variety of representation and reasoning mechanisms, such as semantic, probabilistic, commonsense, and meta-reasoning.

- Example indicators of knowledge-rich systems:
  - IPS that reason over a diverse body of knowledge
  - Consideration of quantitative and qualitative reasoning, using high-level semantics
  - Reasoning using multiple models, including symbolic, ontological, probabilistic, mixed, and commonsense reasoning models

Project Classes

- **Foundational**:
  - Research fundamental techniques, theories, and technologies that contribute to the development of IPS
  - Must focus on at least one of the four research themes
  - Not required to use a physical testbed, but must clearly demonstrate relevance to some IPS

- **Integrative**:
  - Research into novel integration of two or more components of IPS into increasingly smart and autonomous systems
  - Required to evaluate on a physical testbed
  - Evaluation must be scientifically rigorous

What Proposals are Good Fits for S&AS

- The focus of this solicitation is on **fundamental research on enabling systems to robustly handle uncertain, unanticipated and dynamically changing situations** through high-level cognition, self-awareness, and adaptation.

- Proposals must:
  - Address at least one of the four research themes
  - Demonstrate clear relevance to IPS
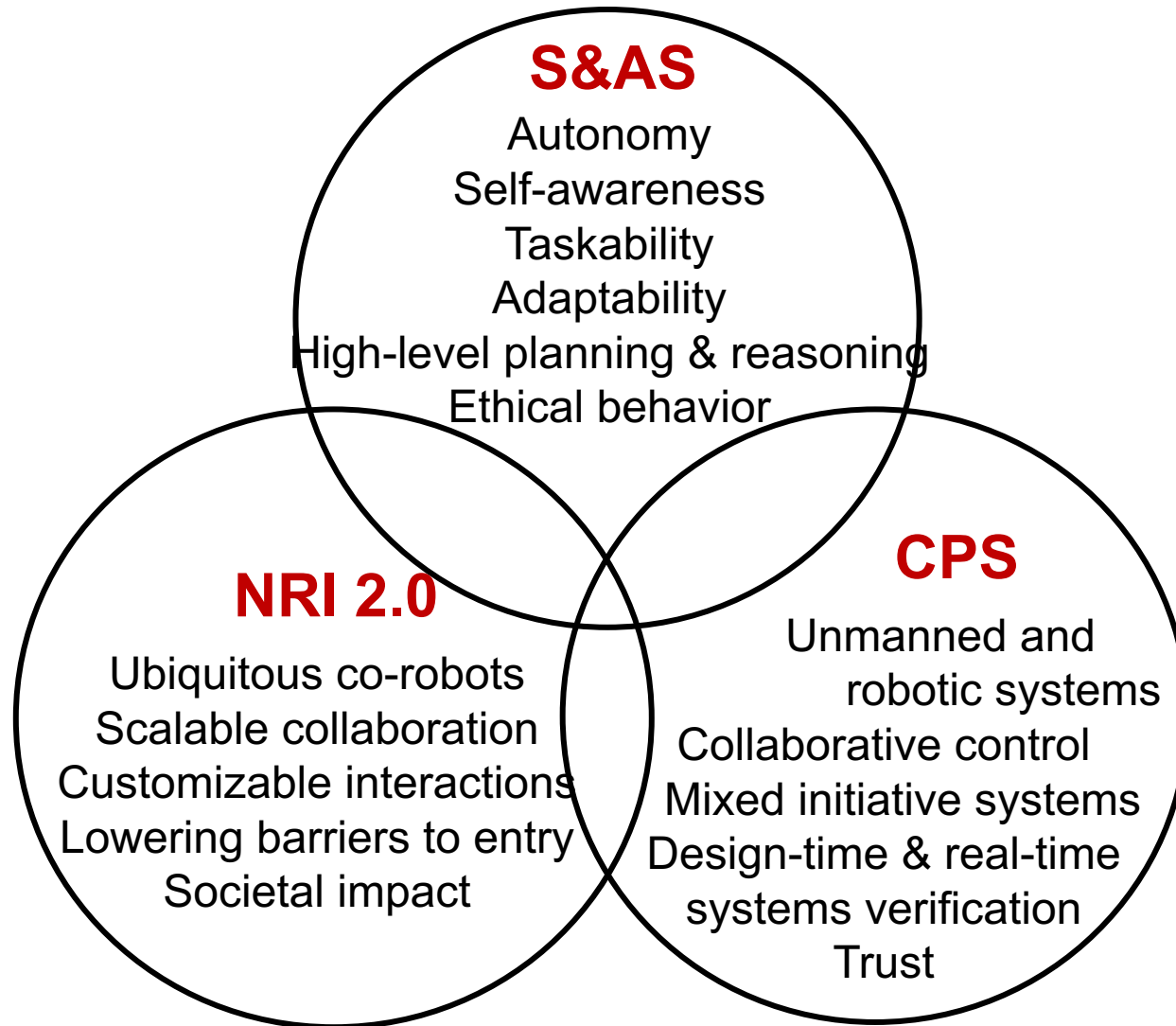 - Integrative projects must include rigorous evaluation

What Proposals are Not Good Fits for S&AS

- Proposals that focus primarily on
  - Advancements in cyber-physical systems lacking a primary research focus in S&AS goals and themes
  - Cooperative robots, human-robot interaction, self interaction, collaboration, and augmentation
  - Purely software (non-embodied) agents
  - System components including hardware design and development, low-level control, formal verification and validation, and security

Proposals focused on these topics may be addressed to the appropriate funding opportunities

Relationships to Other Programs

S&AS
Autonomy
Self-awareness
Taskability
Adaptability
High-level planning & reasoning
Ethical behavior

NRI 2.0
Ubiquitous co-robots
Scalable collaboration
Customizable interactions
Lowering barriers to entry
Societal impact

CPS
Unmanned and robotic systems
Collaborative control
Mixed initiative systems
Design-time & real-time systems verification
Trust

Eligibility Requirements

- Universities and Colleges
  - Including community colleges
  - Accredited, and having a campus located, in the US
- Non-profit, non-academic organization
  - Independent museums, observatories, research labs, professional societies and similar organizations in the U.S. associated with educational or research activities

- At most two (2) S&AS proposals for any PI, co-PI, or Senior Personnel in a given year

Proposal Submission

- Proposal deadline: July 31, 2018 (due 5pm local time)
  - Refer to the solicitation
  - https://www.nsf.gov/pubs/2018/nsf18557/nsf18557.htm
  - Refer to "Proposal and Award Policies Procedures Guide"
  - https://www.nsf.gov/publications/pub_summ.jsp?ods_key=papp

- Yearly PI meeting in Washington, DC
  - Account for travel in budget

Award Information

- Anticipated Funding of $12M in FY 2019
- Foundational Projects
  - $300K–$600K **total costs**; up to three years
  - Expected to award 10–15 projects
- Integrative Projects
  - $500K–$1M **total costs**; up to four years
  - Expected to award 5–10 projects

Budget ranges modified from previous solicitation
These ranges <u>overlap</u> – do <u>not</u> choose project class driven principally by budget preferences

Supplementary & Single Copy Documents

- Data Management Plan

- List of Project Personnel and Partner Institutions
  - List PIs, co-PIs, senior personnel, consultants, collaborators, subawardees, postdocs, advisory committee members
  - **Lead PI submits**

- Collaboration Plan
  - Any project with **more than one** (1) PI
  - Length commensurate with complexity of project

- Postdoctoral Mentoring Plan (if applicable)

- Collaborators and Other Affiliations (COA)
  - Single copy document for *each* PI, co-PI, senior personnel
  - **Use Excel template as required in the PAPPG**

Review Criteria

- *For All Projects:* **Intellectual Merit**
- *For All Projects:* **Broader Impact**

- *For All Projects:* **Program Relevance**
  - address IPS that exhibit long-term autonomy in the face of uncertain, unanticipated, and dynamically changing situations, while requiring minimal human intervention; relevance to program themes
- *For Integrative Projects*:
  - **Innovation** in the integration of the system
  - **Evaluation** plan, including testbed(s), proposed experiments, and evaluation metrics

Direct questions to S&AS@nsf.gov   S&AS Webinar

Thanks!

- Please send questions via email: S&AS@nsf.gov

- Presentation and FAQ will soon be made available on program website: https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=505325