NASA SBIR 2015 Phase I Solicitation

H9.02 Intelligent Communication Systems

Lead Center: GRC

Participating Center(s): JPL

NASA seeks novel approaches to improve mission communication and navigation capabilities for science and exploration through advancements in cognitive systems and automation. Over the past 10 years software defined radios and their applications have emerged and demonstrated the potential and applicability of reconfigurable platforms and applications to space missions. The SCaN Testbed launched in 2012 demonstrated software defined radio applications capable of sensing and reacting to environment conditions. Building on this foundation, cognition and automation have the potential to improve system performance, increase data volume return, improve data transmission efficiency, and reduce user spacecraft burden to improve science return from NASA missions. Understanding how and where to apply cognitive and automation technologies is critical and should be discussed in the proposal.

This solicitation seeks advancements in cognitive and automation systems and components as applied to communication and navigation capabilities. While there are a number of acceptable definitions of cognitive systems/radio, for simplicity, a cognitive system should sense, detect, adapt, and learn from its environment to improve the communications or navigation capabilities for the mission. The goal is to improve the state of the user spacecraft system to maximize science data return, enable substantial efficiencies, or adapt to unplanned scenarios. While much interest in cognitive radio entails dynamic spectrum access, this subtopic is also interested in other ways to apply cognition and automation. Areas of interest to develop and/or demonstrate are as follows:Â

- *Cognitive engine (algorithm) and component development* - to demonstrate new capability in sensing and adapting to the radio/mission environment. Technologies may include changes in physical (PHY) layer data rate, modulation, and coding, medium access control (MAC) layers for new protocols, and cognitive engines to negotiate changes between nodes and throughout the network, learning opportunities and techniques, and networking and application layers (and across layers) to adjust to signal conditions, efficiently using links for different data types (e.g., telemetry v. video), adaptive and intelligent routing, etc.
- *System wide distributed intelligence of cognitive and intelligent applications* - while much of the current research often describes negotiations and improvements between two radio nodes, the subtopic seeks solutions to understand system wide aspects and impacts of this new technology. Areas of interest include (but not limited to) system wide effects (e.g., protocols) to decisions made by one or more communication/navigation elements, how to handle unexpected or undesired decisions, how changing data rate, modulation, or frequency between nodes effects data distribution through relay satellites, and throughout space and ground network and multiple access techniques that optimize connectivity and throughput while minimizing onboard data storage and interference.
- *Flexible and adaptive hardware systems* - (e.g., signal processing platforms, adaptive front ends for RF or optical communications, and other intelligent electronics) which directly implements or demonstrates cognitive or intelligent applications as an alternative to more general software-based intelligent systems.

Systems should highlight advancements to provide needed capability while minimizing on-board resources and cost.

- *Autonomous Ka-band and/or optical communications antenna pointing on mission spacecraft within intelligent multiple access systems* - Future mission spacecraft in low Earth orbit may need to access both shared relay satellites in geosynchronous orbit (GEO) and direct to ground stations via Ka-band (25.5-27.0 GHz) and/or optical (1550 nm) communications for high capacity data return. To maximize the use of this capacity, user spacecraft will need to point autonomously and communicate with both the relays and ground terminals on a coordinated, non-interfering basis along with other spacecraft using these same space- and ground-based assets. Areas of interest include (but are not limited to): autonomous navigation and pointing techniques with sufficient precision to minimize pointing loss; techniques to coordinate multiple autonomous activities and adaptive or cognitive radio systems that can continuously maximize data return via both multiple beam GEO relays and direct to ground links.

For all technologies, Phase I will emphasize research aspects for technical feasibility, clear and achievable benefits (e.g., 2x-5x increase in throughput, 25-50% reduction in bandwidth, improved quality of service or efficiency) and show a path towards Phase II hardware/software demonstration with delivery of a demonstration unit or software product for NASA testing at the completion of the Phase II contract.

Phase I Deliverables - Feasibility study and concept of operations of the research topic, including simulations and measurements, proving the proposed approach to develop a given product (TRL 3-4). Delivery of the simulation or demonstration software and/or platform(s) to NASA. Plan for verification of specific measurements or capabilities to be performed at the end of Phase II.

Phase II Deliverables - Working engineering model of proposed product/platform or software, along with full report of development, capabilities, and measurements (showing specific improvement metrics). Userâ€™s guide and other documents as necessary for NASA to recreate and use the demonstration capability or hardware component(s). Opportunities and plans should also be identified and summarized for potential commercialization.

Depending on the status at the time, there may be opportunity to port software (cognitive engines and applications) to the SCaN Testbed software defined radio ground and/or flight system on International Space Station (ISS) for demonstration and/or test in the actual space environment. At a minimum, the SCaN Testbed ground system radio testbed will provide an ideal cognitive application test environment, as user spacecraft, relay satellites, and control centers are all emulated in hardware. Software applications and infrastructure should consider the NASA standard for software defined radios, the Space Telecommunications Radio System (STRS), NASA-STD-4009 and NASA-HNBK-4009, found at (https://standards.nasa.gov/documents/detail/3315910).Â Â Â