NASA SBIR 2017 Phase I Solicitation

H9.02 Intelligent Communication Systems

Lead Center: GRC

Participating Center(s): JPL

Technology Area: TA5 Communication and Navigation

NASA's RF and optical systems require increased levels of adaptive, cognitive, and autonomous system technologies to improve mission communication for science and exploration. Goals of this capability are to improve communications efficiency, mitigate impairments (e.g., scintillation, interference), and reduce operations complexity and costs through intelligent and autonomous communications and data handling. Cognition and automation have the potential to improve system performance, increase data volume return, and reduce user spacecraft burden to improve science return from NASA missions. These goals are further described in the TA05 Communications, Navigation, and Orbital Debris Tracking and Characterization Systems Roadmap, Sections 5.2.1, 5.3.1, 5.3.2, 5.3.3, 5.3.4, 5.5.1, 5.5.2, and 5.5.3.

This solicitation seeks advancements in cognitive and automation communication systems, components, and platforms. 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 optimize the communications capabilities and situational awareness for the network infrastructure and/or the mission. Areas of interest to develop and/or demonstrate are as follows:

- *Flexible and Adaptive Space Hardware Systems* - Signal processing platforms (transceivers) with novel (e.g., low power, small volume, high capacity) processing technology, wideband (e.g., across or among frequency bands of interest), tunable, and adaptive front ends for RF (S-, X-, and Ka-bands) or optical communications, and other intelligent electronics/avionics which advances or enables flexible, cognitive, and intelligent operations.
- *System Wide Intelligence* - while much of the current research often describes negotiations and link improvements between two radio nodes, the subtopic also seeks to understand system wide, architectural aspects and impacts of this new technology. Areas of interest include (but not limited to): cognitive architectures considering mission spacecraft, relay satellites, other user spacecraft, and ground stations. System wide effects to decisions made by one or more communication/navigation elements, handling unexpected or undesired decisions, self-configuring networks, coordination among multiple spacecraft nodes in a multiple access scheme, cooperation and planning among networked space elements to efficiently and securely move data through the system to optimize data throughput and reduce operations costs.
- *Network Operation* - Optimization of the various layers of the Open Systems Interconnection (OSI) model has several aspects applicable to cognitive applications. Knowledge from one layer may be useful to optimize performance at a different layer. As the future space communication architecture progresses towards a more on-demand, ad-hoc, network-based architecture for data delivery among user spacecraft and relay satellite or from user spacecraft direct to ground stations new technologies are needed

to securely provide assured data delivery through the network. Areas of interest include intelligent network routing (best route selection) through quality of service metrics and learning, store and forward data protocols over cognitive links, and advanced network management.

- *Node-to-Node Link Adaptation* - New capabilities for communication radios (hardware and software) to sense and adapt to the mission environment (for both RF and optical systems). Areas of interest include interference mitigation, spectrum cooperation, signal identification, maximizing data throughput and efficiency, learned operation between user spacecraft and relay (or ground) or direct to ground station communications.

For all technologies, Phase I will emphasize aspects for technical feasibility, clear and achievable benefits (e.g., 2x-5x increase in throughput, 25-50% reduction in power, improved quality of service or efficiency, reduction in operations staff or costs) and show a path towards Phase II hardware/software development with delivery of specific hardware or software product for NASA. Demonstrate and explain how and where cognitive and automation technologies could be applied to NASA space systems.

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

Phase II Deliverables - Working engineering model of proposed product/platform or software delivery, along with documentation of development, capabilities, and measurements (showing specific improvement metrics). Proposed prototypes (TRL-5) shall demonstrate a path towards a flight capable platform. User's guide and other documents and tools as necessary for NASA to recreate, modify, and use the cognitive software capability or hardware component(s). Commercialization plan.

Software applications and platform/infrastructure deliverables for SDR platforms shall be compliant with 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/standard/nasa/nasa-std-4009 and https://standards.nasa.gov/standard/nasa/nasa-hdbk-4009, respectively.