NASA STTR 2017 Phase I Solicitation

T15.02 Bio-inspired and Biomimetic Technologies and Processes for Earth and Space

Lead Center: GRC

Participating Center(s): ARC, LaRC

Technology Area: TA15 Aeronautics

Biomimicry is the imitation of life, natural systems and life's principles characterized by reduced use of energy, water and raw materials. Energy and material use is minimized through information and structure. The goal of this topic is to focus efforts on system driven technology development that draws from nature to solve technical challenges in aeronautics and space exploration. While most of the areas described here pertain to aeronautics, biological models have multiple applications and cross cutting solutions are also welcomed that apply to space technology.

Proposals must demonstrate that the proposed technology complies with natural principles, patterns and mechanisms.

Some resources are provided here: NASA workshop: https://www.grc.nasa.gov/vibe; www.asknature.org; http://toolbox.biomimicry.org/.

Technology is sought in the following areas:

Bio-inspired air breathing propulsion technology to mitigate engine and airframe icing, to reduce fuel burn, noise and emissions (ARMD Strategic Thrust 3)

Community performance goals for subsonic transports include specific levels of reduction in energy consumption, emissions of nitrogen oxides (NO), and noise, represented as N+1, N+2, and N+3 performance levels. These goals support reductions in carbon emissions expressed in an IATA resolution that calls for a 1.5% average annual fuel efficiency improvement between 2010 and 2020, carbon neutral growth from 2020 onward, and a reduction of 50% in net emissions by 2050 compared to 2005 levels.

This subtopic calls for proposals to reduce fuel burn, noise and emissions through bio-inspired propulsion system technology including but not limited to blade design, coatings, combustor lining, fuel injectors. Some areas of interest are:

- Management of 'leakage' flow (over blade tips and from purge cavities) in engines that becomes increasingly significant as engine core sizes decrease below 2.5lbm/s compressor exit corrected flow.
- Cooling technology for turbines that must withstand 3000° F inlet temperature. More generally, technology that can enable OPRs (Overall Pressure Ratios) higher than 60 are sought with linkages clearly demonstrated.
- Acoustic liners and turbomachinery concepts to reduce engine noise to reach ARMD's targeted 52dB

reduction by 2025 (TRL 4-6 in 2025).
- Some common biological models are shark skin, owl wings and nautilus shell.

- Bio-inspired icephobic materials and structures for aeronautics (ARMD Strategic Thrust 1). ARMD plans for continued research in engine and airframe icing to enable air vehicles to safely fly into various types of icing environments. This research will include validated computational and experimental icing simulations, as well as complementary on-board icing sensing radar to enable avoidance of icing conditions and to facilitate safe operation of current and future air vehicle concepts. Icing mechanisms on airframes and in engines differ significantly from each other. Icing is also dependent on flight speed and atmospheric conditions. Thus, methods used for refrigerators may not be applicable to aeronautics. Proposals sought include materials or structures that delay ice formation relative to state of the art, that are relatively low energy to de-ice and multifunctional de-icing or icephobic systems. Well known biological systems or models should not be proposed unless the technology proposed is using a known biological model in a novel way. Examples of such models include shark skin, lotus leaves, pitcher plants.

Bio-inspired power generation, energy storage, power management and distribution

The NRC has identified a NASA Top Technical Challenge as the need to "Increase Available Power". Additionally, a NASA Grand Challenge is "Affordable and Abundant Power" for NASA mission activities. It is essential to be able to harness, store and distribute energy while maintaining minimal system mass and complexity. Biological models such as the oriental hornet or electric eel may be obvious candidates. Methods to improve solar cell efficiency or to create structural solar cells are of interest. Goals of this subtopic overlap with subtopic T3.01 Energy Transformation and Multifunctional Power Dissemination.

Power generation and management systems are also of interest to the growing Hybrid Gas Electric Propulsion Project under ARMD. There is specific interest in motor thermal management and low loss power distribution and storage. New concepts for electric motors and hybrid systems are desirable.

Cross cutting technology making use of bio-inspired processes in conjunction with 1 or more of big data analytics, synthetic biology and additive manufacturing.

Specific areas of interest include:

- Demonstrations of advantages in mass savings made possible through bioinspired topologies enabled by additive manufacturing methods.
- Controlled synthesis of lightweight engineering materials due to bioinspired synthesis methods.