NASA SBIR/STTR — Small Business Innovation Research / Small Business Technology Transfer

NASA SBIR 2016 Phase I Solicitation

A1.07 Propulsion Efficiency - Turbomachinery Technology for Reduced Fuel Burn

Lead Center: GRC

System and technology studies have indicated that advanced gas turbine propulsion will remain critical for future subsonic transports. Turbomachinery includes the rotating machinery in the high and low pressure spools, transition ducts, purge and bleed flows, casing and hub. We are interested in traditional gas turbine turbomachinery, as well as in innovative concepts as exo-skeletal engines, intercooled gas turbines, cooled cooling air, waste heat recovery, and other concepts.

NASA is looking for improvement in aeropropulsive efficiency. Areas of interest include: Improved components of current architectures and cycles, novel components and cycles to improve cycle limits, and novel architectures to improve mission efficiency limits.

In the compression system, advanced concepts and technologies are required to enable higher overall pressure ratio, high stage loading and wider operating range. In the turbine, the very high cycle temperatures demanded by advanced engine cycles place a premium on the cooling technologies required to ensure adequate life of the turbine component. New capabilities as well as challenges are provided with expected increased use of ceramic matrix composites (CMC's). Reduced cooling flow rates and/or increased cycle temperatures enabled by these technologies have a dramatic impact on the engine performance. Such improvements will enable reduced fuel burn, reduced weight and part count, and will enable advanced variable cycle engines for various missions.

Innovative proposals in the following turbomachinery and heat transfer areas are solicited:

- *Small core turbomachinery* - Higher fan Bypass Ratio (BPR) will require more compact engine core sizes rather than by growing the fan diameter, resulting in large tip/endwall and purge flow losses. Tip-leakage mitigation technologies for small-core turbomachinery and concept for circumvent the issue via innovative gas turbine designs. Desensitizing to losses due to tip leakage, secondary flows, seals, purge flows, and cooling air. Shorter transition ducts.
- *Optimized integrated combustor – turbine systems* - Integration concepts of combustor and turbine for improved overall and component performance are being sought.
- *Flow control in turbomachinery* - Advanced turbomachinery active and passive flow control concepts to enable increased high stage loading in single and multi-stage axial compressors while maintaining or improving aerodynamic efficiency and operability. Technologies are sought that would reduce dependence on traditional range extending techniques (such as variable inlet guide vane and variable stator geometry) in compression systems. These may include flow control techniques near the compressor end walls and on the rotor and stator blade surfaces. Technologies are sought to reduce tip clearance leakage as well as rapid acting tip clearance control in compressors and turbines. Technologies are sought to eliminate flow separation in low pressure turbines and transition ducts, improve off-design operation and enable variable cycle operation.
- *Cooling and thermal management* - Novel turbine cooling concepts are sought to enable very high turbine cooling effectiveness. The concepts are mainly for ceramic-based turbine materials such as ceramic matrix

composite (CMC) vanes and blades. The availability of advanced manufacturing techniques may enable improved cooling designs beyond the current state-of-the-art. These concepts may include film cooling concepts, internal cooling concepts, and innovative methods to couple the film and internal cooling designs. Innovative high performance heat exchangers to cool the cooling air and for intercooling cycles are sought.

- *Computational technologies for turbomachinery* - Computational technologies allowing accurate predictions of turbomachinery flows and heat transfer including active and passive flow control features and flow structures. Advanced turbulence and LES models that can account for complex three-dimensional flows common in turbomachinery. Models of flow control devices that enable incorporating them in RANS based CFD codes. Particular interest is in CFD method based on overset moving grids that will enable flexibility in studies of small features as cooling holes and active and passive flow control devices. Interfacing LES and RANS codes for unsteady rotating bounded flows. As engines get smaller, interaction issues dominate and CFD methods to enable simulation of the interactions are needed.