Smart Variable Pitch Turbine Blades

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Problem Statement

Background

- A challenge for VTOL design is the need to vary the speed from 100% at take off to 50% at cruise to improve fuel economy.
- **Maintaining flow incidence angles** within an optimum range can prevent flow separation and reduce thermal stresses.
- **Articulating the turbine blades**, using smart materials, provides a novel solution to enable **high-efficiency variable speed gas turbine engine for FVL**.

Past/Current Technologies

- Variable stator vanes limited in extending efficient operation under off-design conditions.
- Variable speed power turbine blading (ARL/NASA developed) with larger radius leading edge limited in the extent of incidence tolerance range and off-design operational speed range.

Technical Challenges

- **Current gas-turbine technology** is optimized to operate at a **fixed-speed** (100%) with **fixed blade** geometries.
- Operation at **off-design** conditions disrupts the aerodynamic flow and **significantly degrades performance**.

Analysis shows well attached flow resulting in optimal flow field with less aerodynamic losses by synchronously pitching stator and rotor blades.

Before pitching vs. After pitching predicts significant improvement in stage efficiency (by 5% for 10° pitching)
Uniqueness

Coordinated articulation of stator and rotor blades efficient aerodynamic performance (conceptual)

Velocity triangle at design condition  Velocity triangle at off-design condition

Articulating blades design concept
Help the audience understand potential applications for your innovation, beyond the specific military use:

- Adaptive gas turbine blade technology insertion for optimized engine performance.
- Mitigate Engine Stall and flow separation during extreme off-design operating conditions.
- More efficient power generation (Power Turbine for a turbo-shaft engine)
- Improved Compressor stall margin and stability.