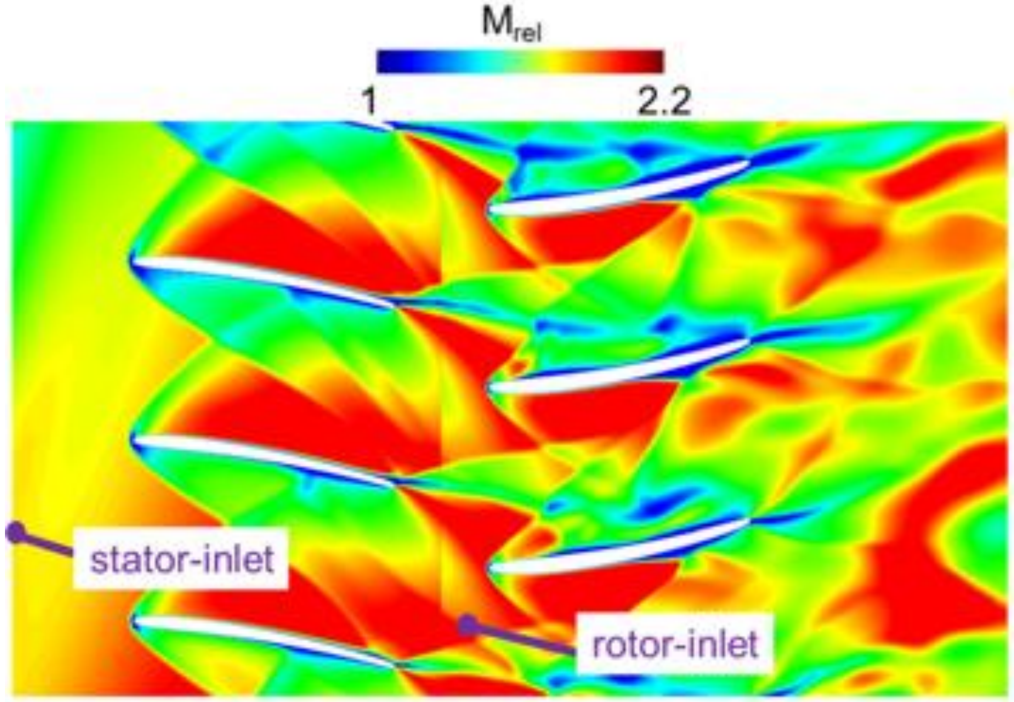
# DEVELOPMENT OF NOVEL TURBINE DESIGNS @ PURDUE UNIVERSITY

## Escuela Politécnica de Ingeniería de Gijón (EPI-Gijón)
## Sala de juntas del Aulario Sur, 28 de mayo de 2019, 10:00 h





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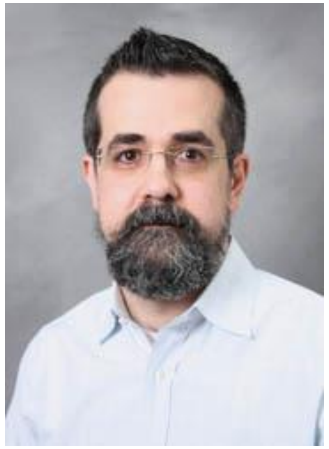

*Research Interests*
- Compact high speed turbines
- High speed propulsion
- Development of measurement techniques and data processing

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**ABSTRACT.** The presentation will begin describing some design challenges for future turbines, related to conventional gas turbines, pressure gain combustion and alternative green cycles. Regarding pressure gain combustion, the harsh flow conditions delivered by the combustor require alternative designs. We will review several strategies developed by the Purdue Experimental Turbine Aerothermal Lab: subsonic inlet, supersonic inlet and bladeless turbine. The subsonic inlet enables high efficiency and high power extraction, as well as acceptable pressure flections to the rotor. The turbine endwalls were parametrized and optimized with a multistep approach first using a steady approach with a wide range of parameters, and then with a narrower range using unsteady evaluations using a commercial 3D Reynolds-Averaged Navier-Stokes solver. Finally, an overall engine analysis of the gas turbine with conventional and pressure gain combustion demonstrates the superiority of pressure gain combustion integrated with the optimized turbine. A reduced-order model of the gas turbine models the the combustion process of the rotating detonation combustor, losses through the diffuser, and turbine losses. We will also present the bladeless turbine to harness power from supersonic axial inflow without inlet swirl, allowing for power extraction from harsh environments with minimal maintenance costs.

The computational work is integrated with a detailed experimental campaign performed at the **Purdue Experimental Turbine Aerothermal Lab (PETAL).** This experimental tri-sonic facility can operate continuously and also perform transients, suited for precise heat flux, performance, and optical measurement techniques. PETAL owns two modular wind tunnels, with two separate settling chambers and two sonic valves. The two different wind tunnels have three different test sections: LEAF (Linear Experimental Aerothermal Facility), BRASTA (Big Rig for Aerothermal Stationary Turbine Analysis), STARR (Small Turbine Aerothermal Rotating Rig) to service both fundamental and applied research. LEAF is completely transparent for optical imaging, and detailed calibration of both intrusive and optical diagnostics, aimed at technology readiness levels (TRLs) of 1–2. BRASTA was designed with multiple optical access to perform proof of concepts as well as validation of turbine component performance for relevant non-dimensional parameters at TRLs of 3–4. STARR comprises a two-stage turbine module, specifically designed to ensure accurate efficiency measurements, with a direct drive (no gearbox) high speed AC electric motor, enabling engine representative transient operation. The test section Reynolds number (Re) extends from 60,000 to 3,000,000, based on a characteristic length of 0.06 m. The adequate setting of the inlet massflow and sonic valve position enables a very wide range of inlet Mach number, from Mach 0.1 to Mach 6.5, with massflows up to 30kg/s.

**Finally we will discuss how research and education is coupled by the PETAL group, and what Purdue University can offer to you.**