Development of a 3D Printed 300W Micro Gas Turbine

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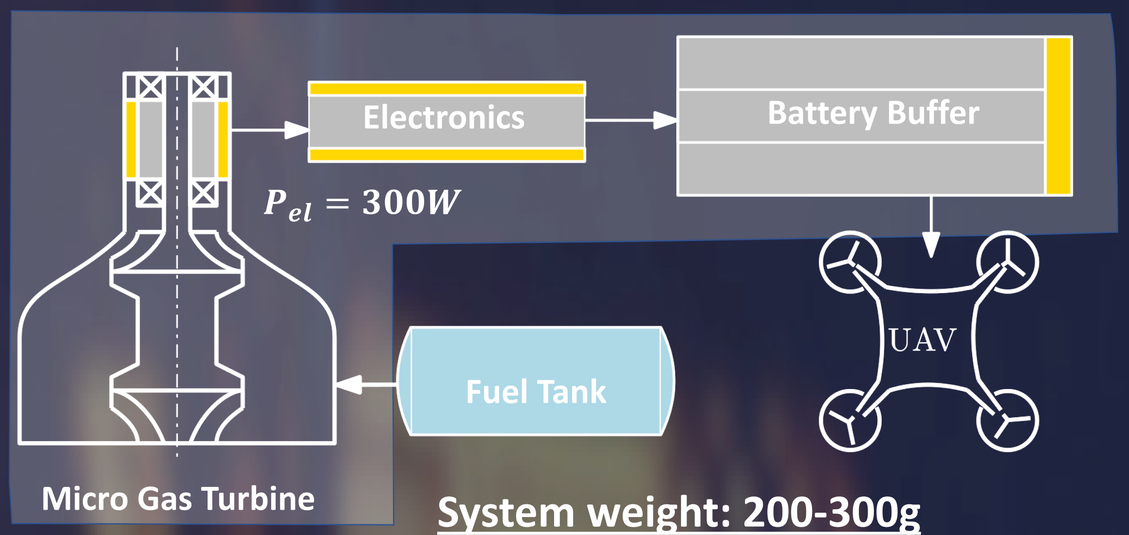
RESEARCH GOAL: MICRO TURBINE GENERATOR FOR UAVs

- Hybrid energy supply system: battery buffer charged by micro gas turbine
- Energy density of up to 1200 kWh/kg due to high kerosene energy density
- Flight time increased 4-6 times compared to Lithium Polymer batteries

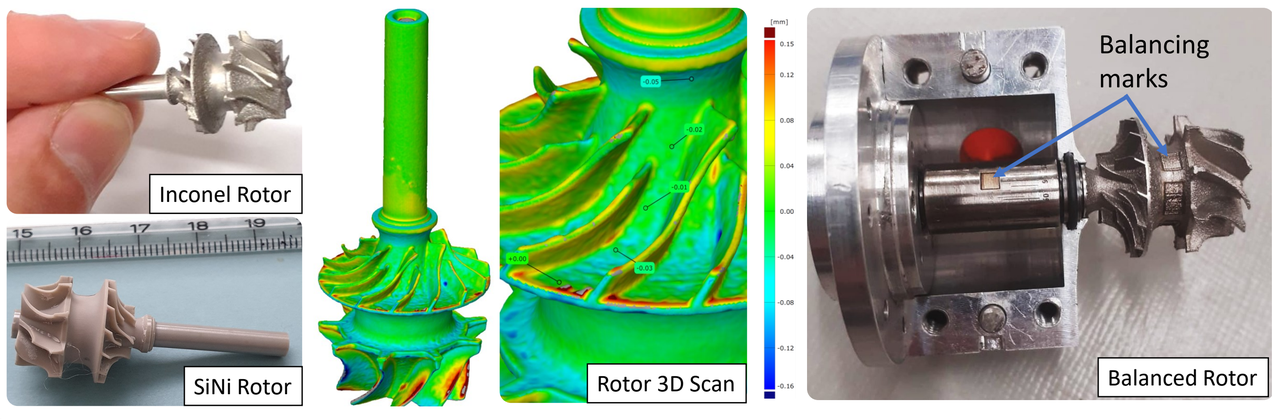


System weight: 200-300g

ROTOR ADDITIVE MANUFACTURING

High-speed rotors have been manufactured using different materials and manufacturing technologies:

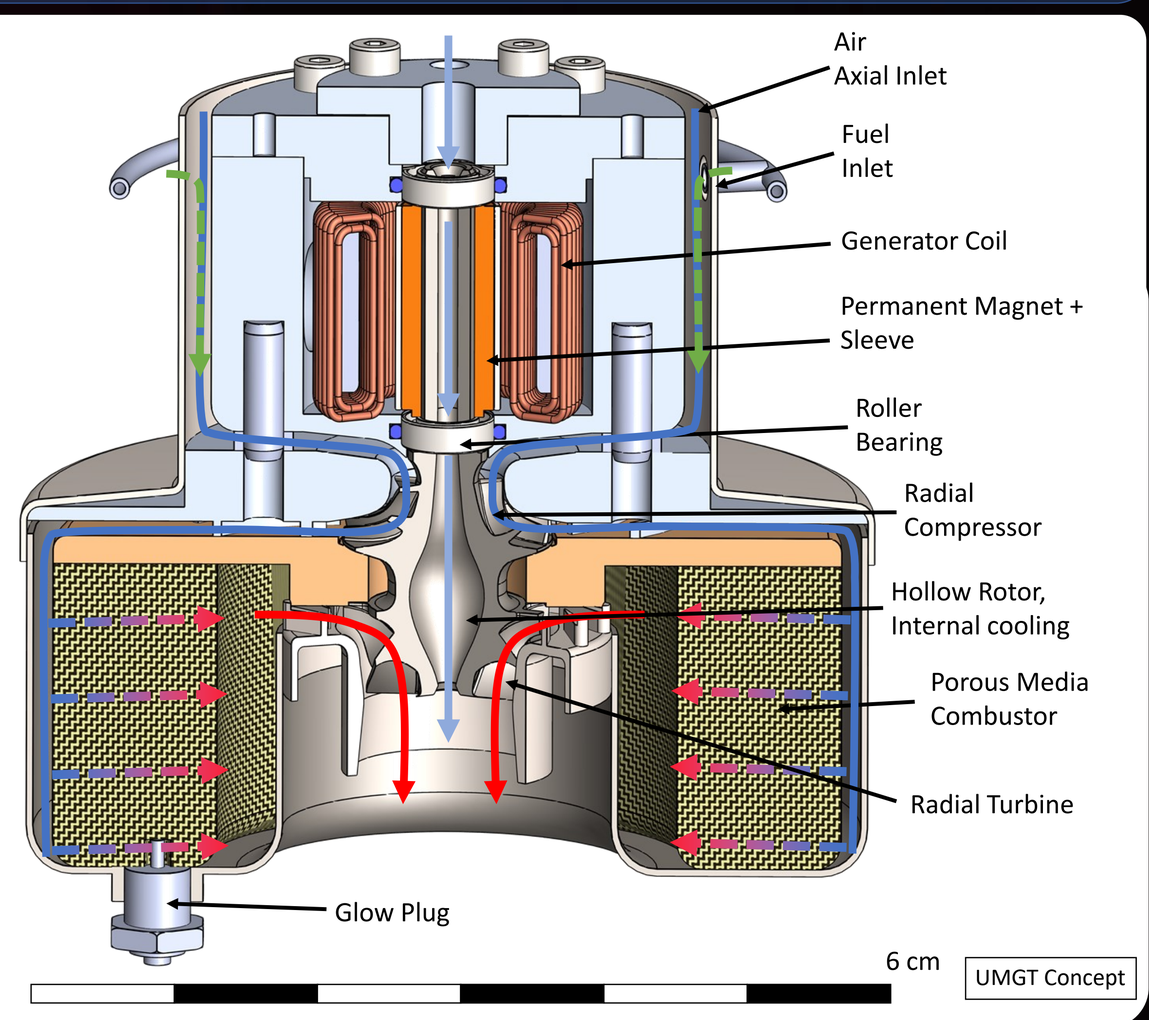
1. Inconel 718: High temperature capable nickel alloy
2. Silicon Nitride: Excellent ceramic for temperatures above 1000°C
3. Alumina: Easy-to-manufacture ceramic for high temperature applications



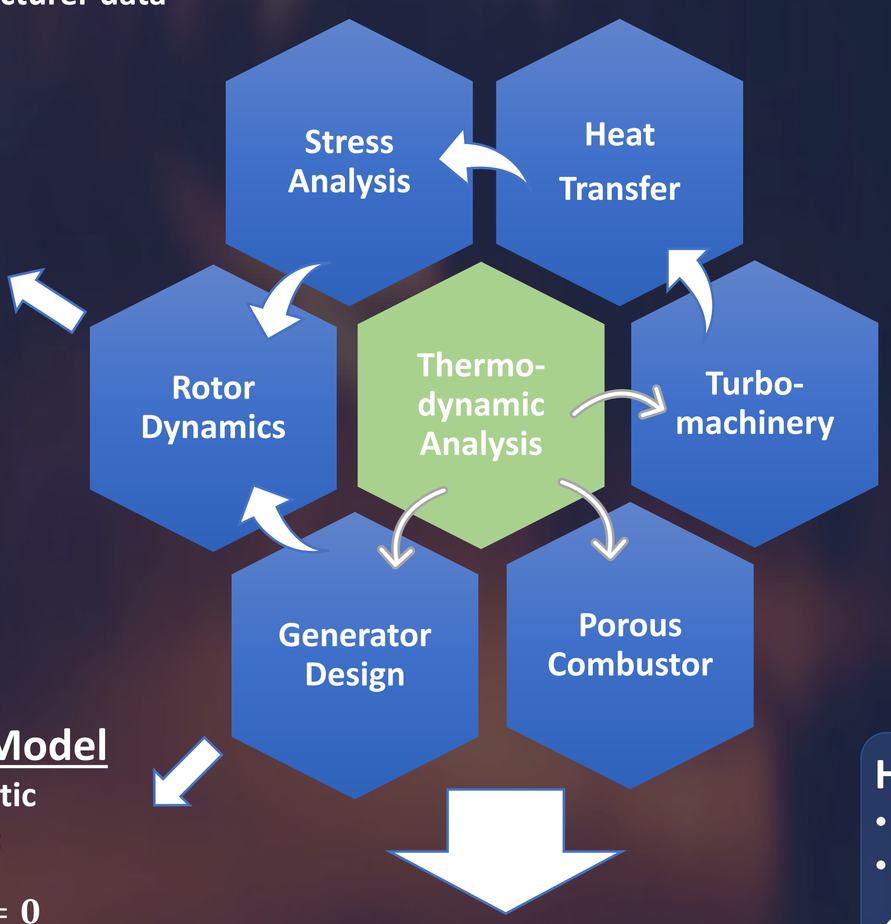
CHALLENGES AND PROPOSED INNOVATIONS

The main obstacles to successful UMGT development were manufacturing constraints, heat transfer management and air bearing instability. These will be overcome by the following innovations:

- Additive Manufactured High-Speed Rotors
  -> geometrical flexibility, high TIT
- Hollow rotor
  -> reducing material agglomeration, heat transfer to compressor, turbine surface temperature
- High-speed hybrid ceramic bearings instead of air bearings
  -> reliability, no whirl instability, high stiffness, off-the-shelf components

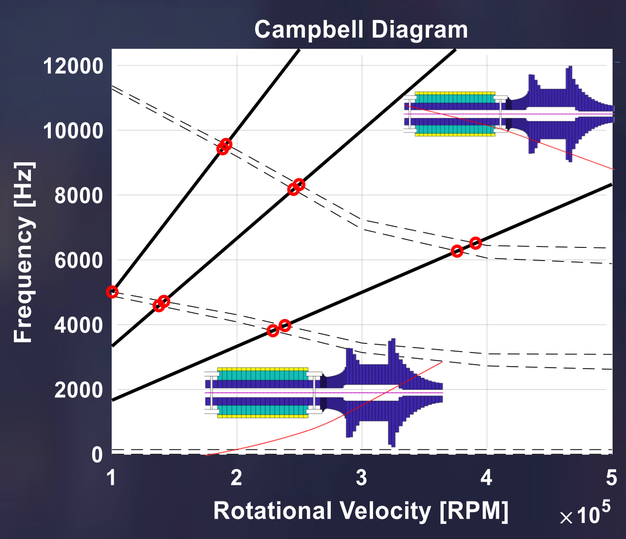


REDUCED ORDER ENGINE MODEL



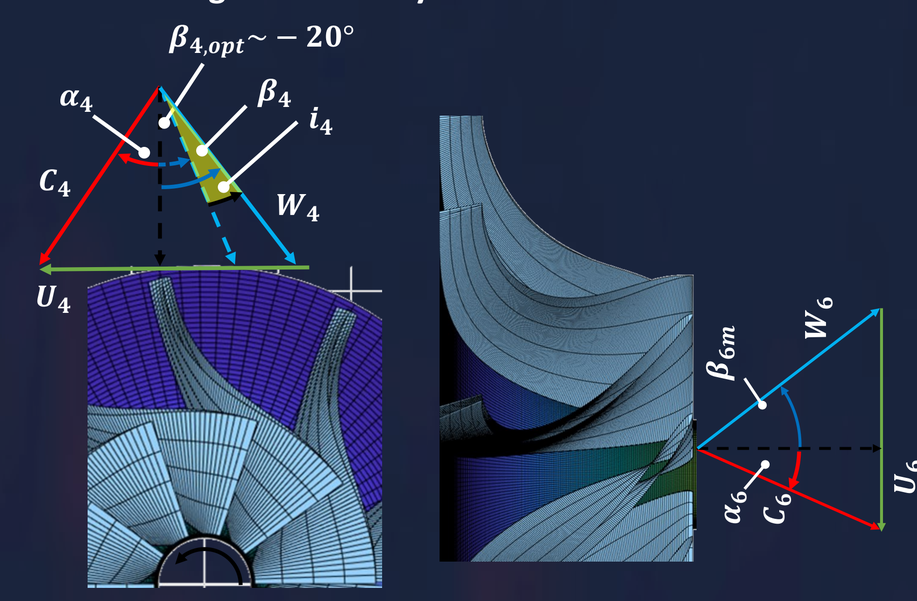
Rotordynamic Model

- Axisymmetric modelling
- Bearing stiffness according to manufacturer data



Compressor and Turbine Models

- Meanline design based on non-dimensional parameters
- Automatic 3D geometry generation
- Loss modelling for efficiency estimation



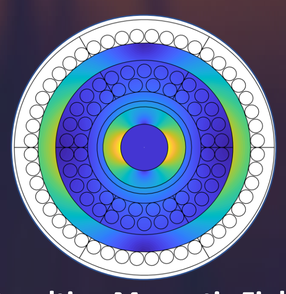
Radial Turbine Velocity Triangles

Generator: 2D Magnetostatic Model

- Solving Laplace's equation for magnetic vector potential in polar coordinates:

$$\frac{\partial^2 A}{\partial r^2} + \frac{1}{r}\frac{\partial A}{\partial r} + \frac{1}{r^2}\frac{\partial^2 A}{\partial \theta^2} = 0$$

- Loss modelling
  - Stator Iron Losses
  - Copper Losses
  - Air friction Losses



Resulting Magnetic Field

INTERDISCIPLINARY ENGINE OPTIMIZATION

NEXT STEPS

- Finalize engine model
- Hot gas testing
- Prototype design and testing

HIGH SPEED TESTING AND MODEL VALIDATION

- Successful testing up to design speed of 500,000 rpm (cold gas)
- Validation of component efficiency, heat transfer models