# Reinforcement Learning Based Control Agent for Rotorcraft Applications

**About DEVCOM ARL:**

The DEVCOM Army Research Laboratory conducts basic and applied research for the Army. Its mission is to operationalize science for transformational overmatch. The basic research conducted at the laboratory leads to capabilities for soldiers to fight and win on the battlefield. The Vehicle Applied Research Branch specifically conducts experimental and computational research in rotary-wing and other vertical lift technologies at both the manned and unmanned scales.

**RESEARCH LOCATION:** Aberdeen Proving Ground, MD

**PROJECT DESCRIPTION:**

Reinforcement learning based control agent will be developed to provide trim capability for rotorcraft simulations using the CREATE-AV Helios software. A number of strategies to develop the reinforcement learning control agent will be explored including off-line and on-line trainings with single/multi-fidelity training datasets/models. Different reinforcement learning algorithms will be evaluated to provide understanding and insight into their effectiveness, robustness, reliability. Especially, those reinforcement learning algorithms will be subjected to modeling and simulation condition uncertainties.

A plugin will be developed for CREATE-AV Helios that enables RL models to be used for trim control. The plugin will facilitate data transfer between HELIOS and the RL control agent, extracting appropriate model inputs from HELIOS (rotor loads, vehicle states, etc.), and applying corresponding control inputs from the RL model (blade pitch, aircraft orientation, etc.). This will allow the control model to stabilize the simulated aircraft and for the controller's effectiveness to be evaluated. To build this plugin, the intern will:

- Design a hovering rotor test cases in Helios and implement a plugin that can - a) track rotor loads and other relevant aircraft states, and b) apply control inputs back to the Helios model.
- Integrate these plugins into a simple proportional controller for rotor thrust control 3. Develop RL control agents (2~4).
- Replace the proportional controller with RL control agents.
- Develop plans for off-line versus on-line trainings with Helios and/or low-fidelity models.
- Evaluating different RL algorithms for effectiveness, robustness, and reliability with modeling uncertainties.

Under the guidance of mentors, the intern will learn how to perform Helios simulations using a variety of HPC tools including Helios (CREATE-AV) and Capstone (CREATE-FT). The intern will attend Capstone and Helios trainings if offered by the CREATE program. The intern will learn how to write plugins for Helios, how to track and process aerodynamic loads, how to control rotor states to achieve the desired response, how to train RL models, and how to use RL models for control.

At the conclusion of the project, the intern will present their findings to researchers in the mentor organization. In the first two weeks of the internship, the mentor will train the intern on software, methods, concepts related to the research (Helios, Capstone, RL modeling for control). The intern will learn how to perform Helios simulations on the HPC systems and introductory RL control.

Throughout the 10-week period, a daily informal meeting will be scheduled to assess the intern progress and fill in any knowledge gaps. The intern and mentors will be co-located in the same building which allows for convenient formal and informal daily interactions.

Tentative program schedule (10-weeks):

Weeks 1-2: Training on software, CFD model setup, Helios plugin architecture, TensorFlow, proportional control, RL control agent.

Weeks 3-5: Develop basic Helios control plugin (proportional controller for rotor thrust control) and develop/train RL control agents on linearized models of rotor in hover.

Weeks 6-8: Integrate the RL control agents into the Helios plugin (off-line vs on-line training for RL agents).

Weeks 9-10: Assess the performance/robustness/reliability of the RL control agents in Helios.

**ANTICIPATED START DATE:**

May 2025– Exact start dates will be determined at the time of selection and in coordination with the selected candidate.

**QUALIFICATIONS:**

The ideal candidate would be a master's or doctoral student in aerospace engineering or computer engineering sciences education or experience in:

- CFD
- Surrogate modeling
- Control experience
- Machine learning/surrogate modeling experience
- Python
- TensorFlow

**ACADEMIC LEVEL:**

Degree received within the last 60 months or currently pursuing:

- Master’s
- Doctoral

**DISCIPLINE NEEDED:**

- Computer, Information, and Data Science
- Engineering
- Science & Engineering-related