AIAA Hover Prediction Workshop

Chairman: Nathan Hariharan

Jennifer Abras, Rohit Jain, Robert Narducci, Brian Wake

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https://www.aiaa-hpw.org/
Welcome

Our vision is to inspire collaboration among industry, governments, and academia for the development of computational methods to predict all aspects of hovering flight efficiently, practically, and accurately.
The Hover Problem

Simulation of self-induced flow fields in near-zero winds to accurately predict rotor performance, loads, download, and acoustic signature of rotorcraft.
Contributions have occurred in 3 areas

- Fundamental process development
- Verification and validation
- Applications
2021 Challenge

- Perform blind calculations of the HVAB rotor; SLS, Mtip = 0.65, \( \theta_{75} = 6 \) to 10°
  - CT, CQ, FM
  - Spanwise thrust and torque distributions
  - Chordwise pressures distributions
  - Vortex size, strength, position
  - Boundary layer transition
  - Blade deformation
Tom Norman

HVAB Rotor Test Status
Time for Something New

- High quality, real-world, detailed data sets are not widely available to the general public… so let’s make some ourselves!

- The HPW steering committee will be inventing a series of hover problems for enthusiasts to solve using their best practices

- Results are intended to be shared for code-to-code comparisons
Hover Focus Problem 1: Overview

- Hover Focus Problem #1 is a deep-dive into “real” hover simulations of a rotorcraft in the proximity of a ground plane.

- Several aspects of the problem are described in 7 sections

- The intention is for practitioners to work through sections of their interest – 1 or more at a time – but not necessarily all at once!

- Practitioners are encouraged to share results for comparison with helicopter enthusiasts across the globe
Hover Focus Problem 1: Overview (Continued)

• For these simulations, utilize the 4-bladed HVAB rotor with the following assumption for cone and lag angles:
  ▪ Cone: \[ \beta = 0.0056 \theta_{75}^2 + 0.1139 \theta_{75} - 0.6094 \]
  ▪ Lag: \[ \zeta = 0.0314 \theta_{75}^2 - 0.1299 \theta_{75} + 1.5425 \]

• Use the following definitions:
  ▪ Gross Weight: \[ GW = T_{\text{installed}} - DL \]
  ▪ Vertical Drag Ratio: \[ DV = \frac{T_{\text{isolated}} - GW}{GW} \]

• Assume sea level standard atmosphere and a rotor speed of 1250 RPM.
Hover Focus Problem 1: Overview (Continued)

• Utilize the Robin-Mod7 fuselage as integrated by Overmeyer and Martin (AIAA 2017-1872) *without* the main rotor pylon

Hover Focus Problem 1: Overview (Continued)

- Step 1: HOGE Assessment
- Step 2: HIGE Assessment
- Step 3: Groundwash Assessment – Part 1
- Step 4: Groundwash Assessment – Part 2
- Step 5: Impact of Headwinds
- Step 6: Generalized Impact of Wind
- Step 7: Descent Simulation
Hover Focus Problem 1: Step 1

HOGE Assessment

- For the isolated HVAB rotor, run a thrust sweep (suggest $\theta_{75} = 6^\circ, 8^\circ, 9^\circ, 10^\circ, 11^\circ$) to determine thrust, power, distributed thrust $\partial T / \partial r$, distributed torque $\partial Q / \partial r$, and pressure coefficient at radial stations $r = 0.875, 0.900, 0.973, \text{ and } 0.990$
- Repeat the calculation for the installed rotor case for $\theta_{75} = 10^\circ$
- Compute the augmented thrust, the added thrust produced by the rotor as a result of the presence of the fuselage (use the power produced by the rotor of the installed case)
- Compute the download acting on the aircraft due to the rotorwash. Report the download as a percentage of the thrust; report the augmented thrust as a percentage of the download.
- Extra credit: Repeat the installed calculations for ($\theta_{75} = 6^\circ, 8^\circ, 9^\circ, 10^\circ, 11^\circ$) and find $DL = f(T)$ and $\Delta T = f(T)$
Hover Focus Problem 1: Step 2

HIGE Assessment

- For a flat ground plane, compute installed hover performance for a gross weight of 1,000 lbf. Consider rotor height above ground from \( h/D = 0.5 \) to 3.0. Find thrust, power, distributed thrust \( \partial T / \partial r \), distributed torque \( \partial Q / \partial r \), and pressure coefficient at radial stations \( r = 0.875, 0.900, 0.973, \) and 0.990.
- Find \( DL = f(h/D) \).
Hover Focus Problem 1: Step 3

Groundwash Assessment – Part 1

- For a flat ground plane, compute the ground wash for installed hover performance for a gross weight of 1,000 lbf and a rotor height above ground of $h/D = 0.5$. Note: this is one of the cases in Step 2A.

- Plot the ground velocity profile at azimuth locations of 0, ±45°, 90°, ±135°, and 180°, and radial locations of 0.5D, 1.0D, and 1.5D.

- Extra Credit: How do the results of Step 3A differ for an isolated rotor?
Hover Focus Problem 1: Step 4

Groundwash Assessment – Part 2

• Repeat Step 3 with the hillside ground plane
Hover Focus Problem 1: Step 5

Impact of Headwinds

- Repeat Step 3 with 3- and 6-knot headwinds. For this exercise, do not consider changes to rotor flapping or add cyclic for rotor trim. Instead, report changes to rotor forces and moments.
Hover Focus Problem 1: Step 6

Generalized Impact of Wind

- Repeat Step 5 with 3- and 6-knot winds from $\pm 45^\circ$, $90^\circ$, $\pm 135^\circ$, and $180^\circ$
Hover Focus Problem 1: Step 7

Descent Simulation

- Consider a descent from $h/D = 2.0$ to $h/D = 0.5$ following the velocity profile described by:

$$V = 6.9271 - 6.9271 \times \cos(\pi/1.2 \times t)$$

- Keep gross weight constant (1,000 lbf) and find $T = f(t)$, $P = f(t)$ and $DL = f(t)$. The simulation is 2.4 seconds long requiring 50 rotor revolutions.
Write a paper, share your results… see you at SciTech 2023