Readme
HVAB Photogrammetry

Tom Norman
NASA Ames Research Center
September 2023

Version History
9/28/23 Initial Release

This document summarizes the test conditions during which photogrammetry data were acquired and describes the data provided as part of the HVAB data release.

Photogrammetry data were acquired as part of the HVAB hover test to measure the blade deformations (bending and elastic twist) of the 4-bladed HVAB rotor. A summary of the entire test program can be found in Ref. 1. Significantly more detail on the photogrammetry approach, including data reduction and error analysis, is provided in Ref. 2. The abstract from Ref. 2 is provided below to summarize the effort:

> Bending and elastic twist of blades of a four-bladed rotor in hover were measured by stereo photogrammetry as part of the test campaign of the Hover Validation and Acoustic Baseline (HVAB) rotor in the National Full-Scale Aerodynamic Complex at NASA Ames Research Center. The rotor blades were imaged from below by two scientific digital cameras mounted on the floor of the test section 46 feet apart and 40 feet below the rotor plane. Retro-reflective targets were placed in rows of four at 20 radial stations on the lower surface of each blade and were illuminated by flash-lamps co-located with the cameras. Bending and elastic twist were computed by comparing target locations measured at loaded and unloaded conditions after accounting for differences due to rigid-body displacements and rotations. Differences between repeated measurements of bending and elastic twist at ostensibly the same test conditions were larger than expected probably due to unsteady recirculation in the test section. These effects were mitigated by averaging five repeated measurements at each test condition and by averaging measurements of all four blades. The data averaged in this way showed smooth increases in bending and nose-down elastic twist as the collective pitch set point was increased.

Photogrammetry Test Conditions
Photogrammetry data were acquired early in the test program so that the required retroreflective targets could be removed prior to the research-quality performance runs. Table 1 provides a summary of the photogrammetry test conditions, including Run and point numbers.

Table 1. Photogrammetry Test Conditions

Run Numbers	Pt Numbers	RPM	Collective
30	6-125	1250 RPM	4, 6, 8, 10, 12, 13
34	6-110	1310 RPM	4, 6, 8, 10, 12, 14
36	7-106	1160 RPM	4, 6, 8, 10, 12
36	151-170	1250 RPM	14

Description of Spreadsheet Data

Three spreadsheets are provided, one for each of the data runs/RPMs. Each spreadsheet contains 5 tabs, each of which shows the vertical blade bending (DZ) and elastic twist as a function of r/R for all measured values of collective pitch. The first 4 tabs provide the average deformations for the individual blades and the last tab ("Ave sweep") provides the averages for all 4 blades together. It is recommended that the data in the last tab be used for correlation with analysis.

To maintain consistency across the different data types acquired during HVAB testing, a common identification scheme is used for the various test conditions. These conditions are identified as follows:

RxxMxxxTHxx

where Rxx is the run number during which the data were acquired (xx between 30 and 36), Mxxx is the tip Mach number for the condition (xxx = 600, 650, or 675), and THxx is the nominal collective setting from the control console (xx between 4 and 15). Note that for the photogrammetry runs, the Mtip numbers are approximate since the rotor was set to RPM instead of Mtip during operation.

References

1. Norman, T.R., Heineck, J.T., Schairer, E.T., Schaeffler, N.W., Wagner, L.N., Yamauchi, G.K., Overmeyer, A.D., Ramasamy, M., Cameron, C.G., Dominguez, M., and Sheikman, A.L., "Helicopter Rotor Boundary Layer Transition Measurement in Forward Flight Using an Infrared Camera," VFS 75th Annual Forum Proceedings, Philadelphia, PA, May 2019. https://rotorcraft.arc.nasa.gov/Publications/files/79-2023-1166-Norman.pdf
2. Schairer, E.T., Heineck, J.T., Dominguez, M., Norman, T.R., "Blade Deformation Measurements of the HVAB Rotor in Hover by Stereo Photogrammetry," NASA TM-2023-0009506, July 2023. https://rotorcraft.arc.nasa.gov/Publications/files/HVAB%20Blade%20Deformation%20TM.pdf.