Comparison of Aerodynamic Simulations using *Aeolus ASP* with OEM Specifications and Flight Test Data for the DJI R3390 Propeller

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Uwe Schuster
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Revisions

Revision	Date	Description
-	September 23, 2021	Initial version

Contents

1 Introduction

The flow solver *Aeolus ASP* is used for the numerical simulations. It is based on potential flow and has been developed to predict the aerodynamic performance of lifting bodies, such as fixed wings and propellers. This report shows a comparison of the aerodynamic properties predicted by numerical simulations using *Aeolus ASP* (`https://www.aeolus-aero.com/`) with OEM specifications, and flight test data. The reference is the R3390CW blade (P/N H9NA020154) from DJI on a $33in$ propeller using the hub of DJI's E7000 propulsion system.

2 Methodology

Based on a 3D photogrammetry scan (Fig.2.1), the blade has been discretized into 11 sections as shown in Figure 2.2, which are used as input for *Aeolus ASP*. These sections are highlighted in red in Fig.2.3. For blade positioning, the bolt centerline and the two planes at the hub have been approximated from the STL mesh. The largest angle between the two face normals and the bolt centerline is less than $0.5°$. The bolt centerline has been aligned parallel with the motor axis. The distance from centerline to centerline is $80mm$. The aerodynamic model (blue) matches the original CAD model (yellow), which is shown for reference and sanity check only. That is, the yellow model is not part of the aerodynamic analysis. Note, that the innermost section's trailing edge is originally blunt. As *Aeolus ASP* requires sharp trailing edges, a sharp trailing edge was achieved through extrapolation.

Figure 2.1: 3D Scan of the R3390 blade. Courtesy of wescan.ch.

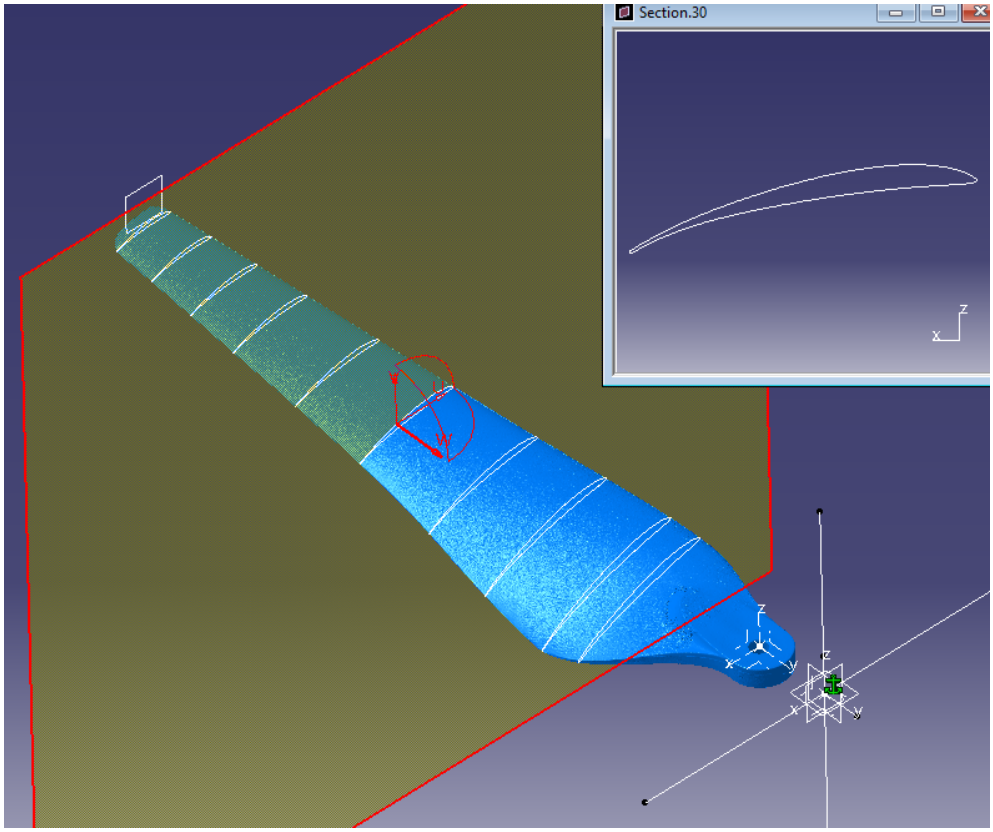

Figure 2.2: Discretization of the scanned blade into 10 sections.

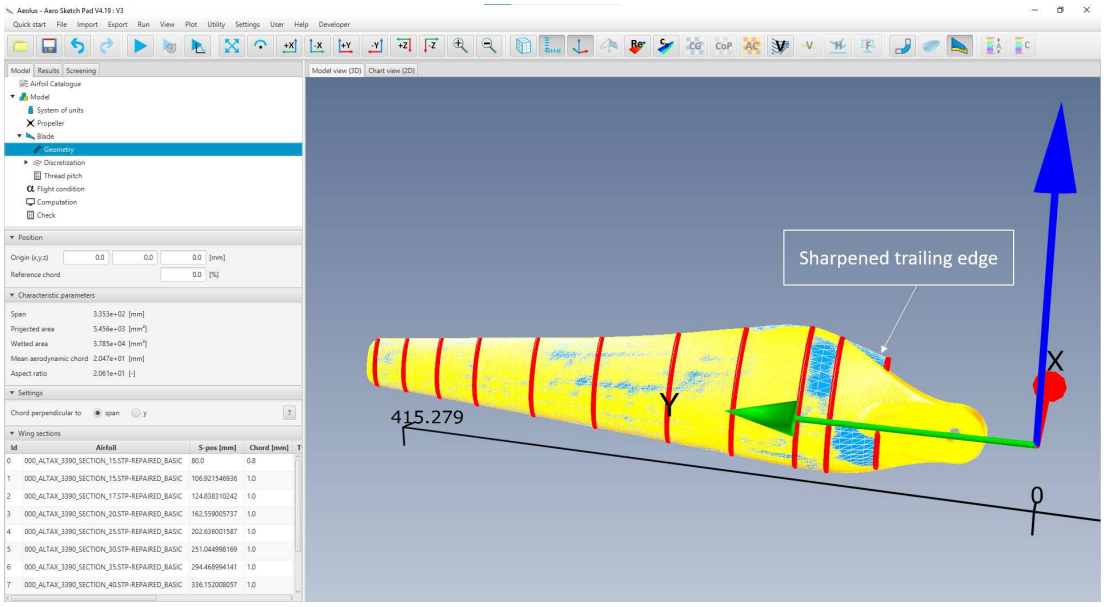

Figure 2.3: Modelling in *Aeolus ASP*.

3 Results

Figures 3.1 and 3.2 show the comparison of thrust and shaft power between *Aeolus ASP* and the OEM specification [1]. The maximum error is 6.6% on thrust, and 2.9% on shaft power. Figure 3.3 shows the same data plotted as Thrust against Shaft power. Also, flight test data from [2] have been added for comparison. These flight tests have been carried out by *Freefly Systems* using their *AltaX* aircraft. Thrust values have been derived from hover data and the measured vehicle weight, and shaft power was computed from averaged battery voltage and current, reduced by an assumed 84% motor efficiency as per [1, p.10]. Note, that the flight test data refer to a 85mm hub (bolt-to-bolt), whereas the OEM specification and the simulation refer to 80mm. However, this 0.6% difference in diameter is negligible for the present comparison.

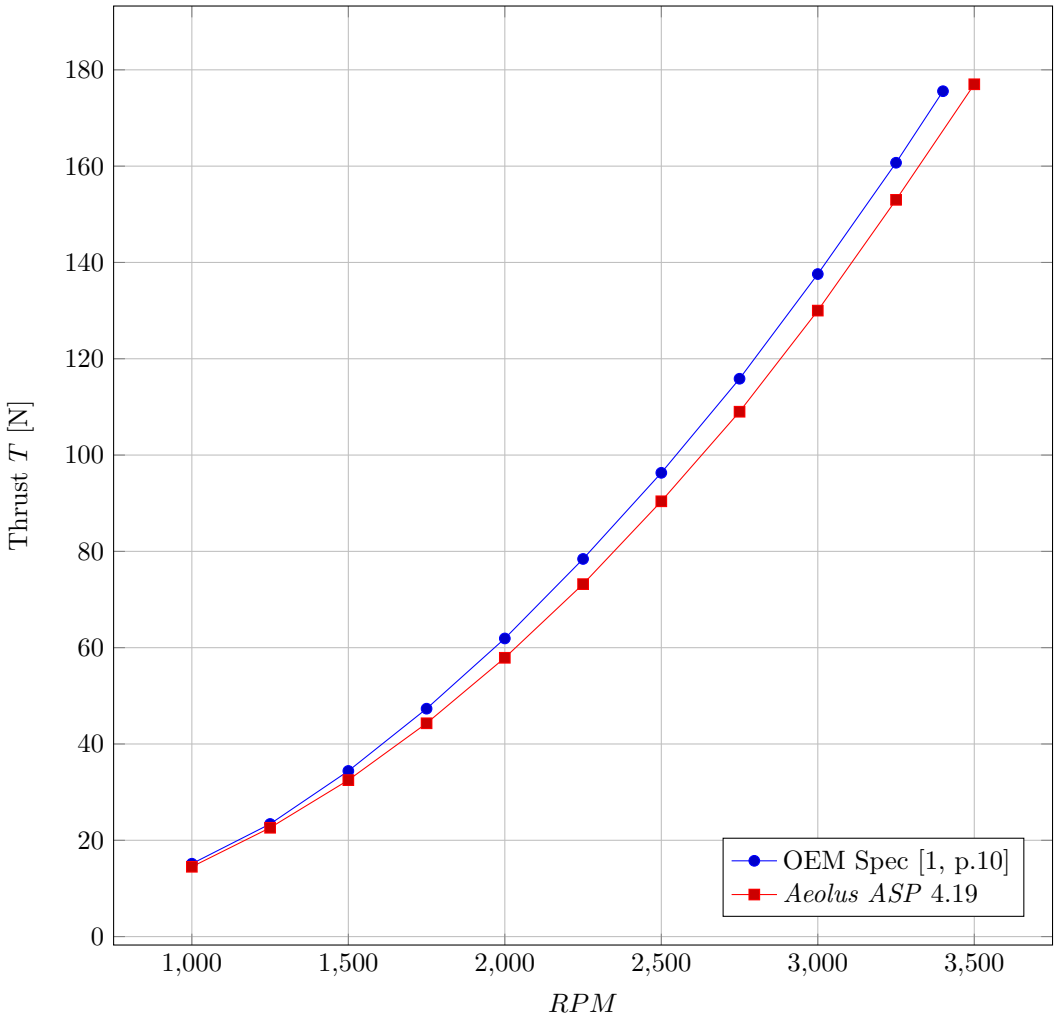

Figure 3.1: Comparison of Thrust T

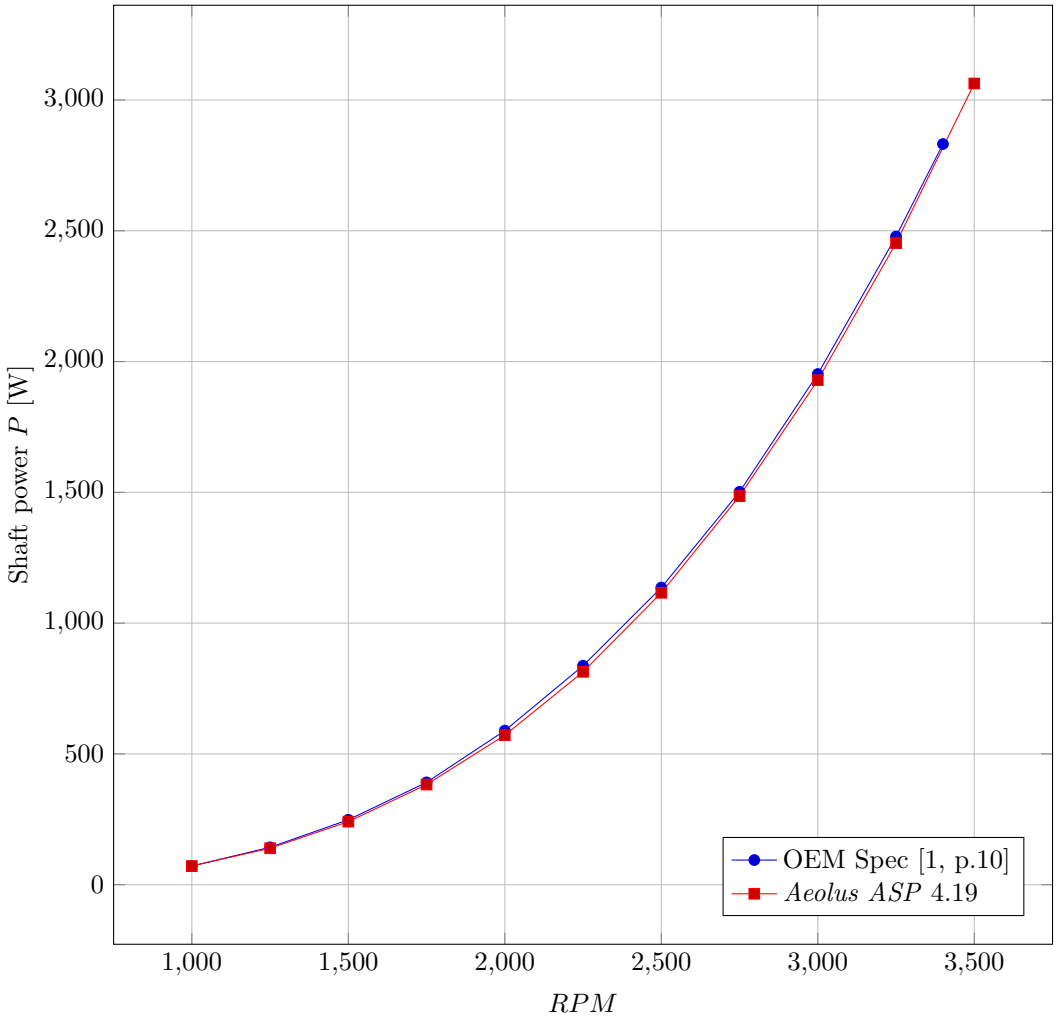

Figure 3.2: Comparison of Shaft Power P

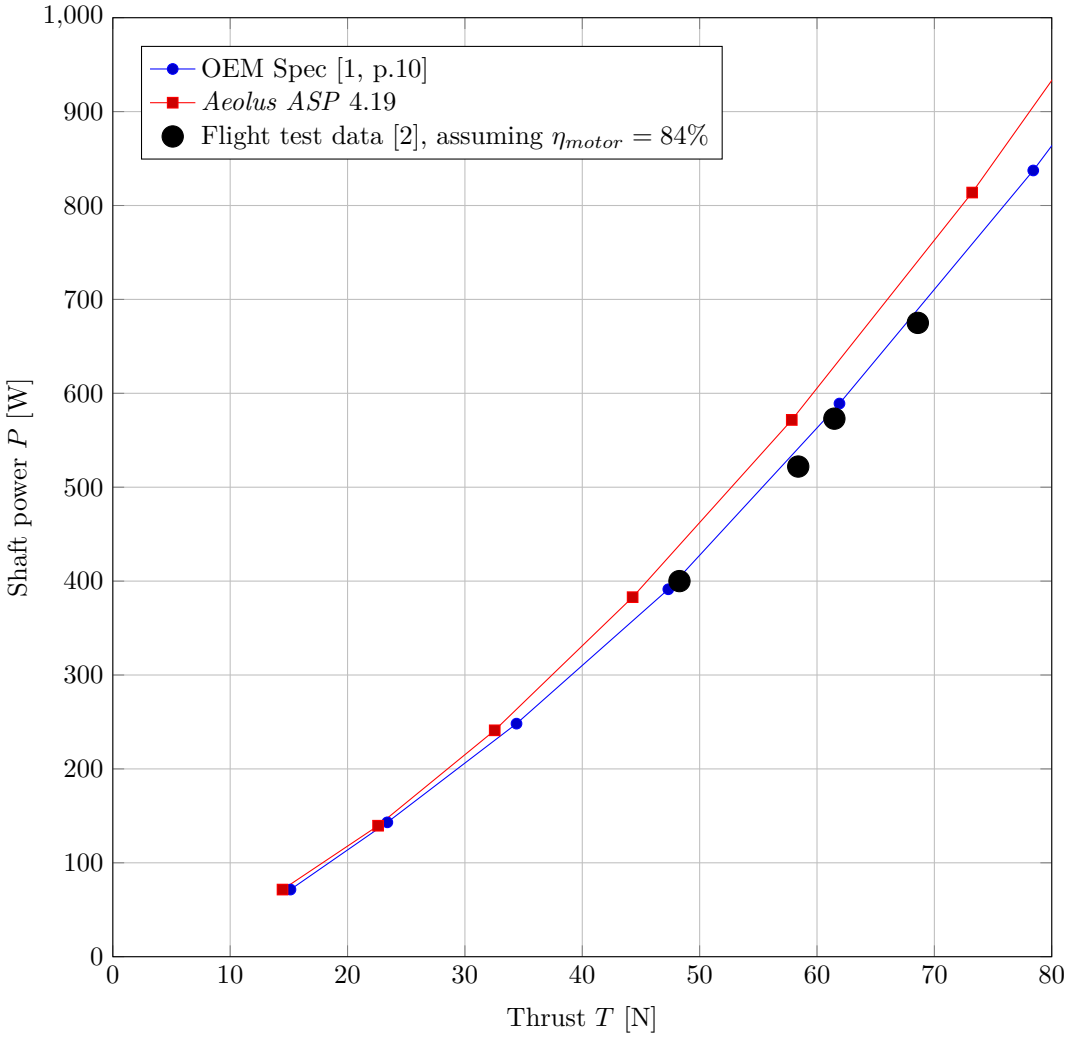

Figure 3.3: Comparison of Analysis Results, Flight Test Data, and OEM Specifications

References

[1] DJI (Hrsg.): *E7000 Tuned Propulsion System - User Manual*. Shenzhen, China: DJI, 2018. – Version 1.2

[2] Henley, Adam ; King, William: *Flight test data logs from AltaX (10_33_32, 10_22_15, 11_05_39, 11_18_25)*. Woodinville (WA), USA: Freefly Systems inc., 2021