# P­ropeller Performance Modelling Using BEMT

Chapter 14 of the aircraft design book by Gudmundson provides an array of techniques to model the performance of propellers. Among them was the Blade Element Momentum Theory which was the highest fidelity method among all methods provided. The Blade Element Theory attempts to estimate the performance of a propeller by dividing the blade into small sections called blade elements and then treating each element as a separate 2-D airfoil. The aerodynamic characteristics of each element are calculated based on the local flow conditions and they are summed up in the end to give the performance of the complete propeller. The Momentum Theory is used to estimate the induced AOA which results from the induced velocity of air; effectively making BET into BEMT. BEMT was implemented in a MATLAB code and the verification of the code was possible thanks to the propeller databases made available by UIUC (University of Illinois Urbana Champagne) and APC propellers. The geometry file of a propeller was used to populate the MATLAB code and the results were compared to the corresponding performance file.

## Integration of XFOIL

A challenge with the BEMT code is that although the determination of aerodynamic characteristics of each section individually based on local flow conditions and AOA allows for high fidelity, the accurate determination of these characteristics using a singular lift drag equation renders the solution inaccurate since the lift and drag equation is specific to the Reynolds number which changes along the blade span with increasing tangential velocities.

XFOIL is a well-known panel method solver for determining the airfoil aerodynamic characteristics and since it is a small application, it was quickly automated into the BEMT code using the expertise of the automation team such that it could be called for each iteration of every segment of the propeller. The problems began to occur after the code was fully developed i.e. anytime there was a convergence error in XFOIL, the whole execution would stop; this problem would especially occur for the inner segments with lower Reynolds numbers for reasons yet to be found. An entire day was exhausted in the effort to remedy this situation by applying different panelling schemes for the airfoil but to no avail; XFOIL integration has since then been abandoned.

## Integration of VSPAERO

Although VSPAERO has been developed for aerodynamic analysis of 3-D bodies, airfoil analysis can be made possible by making a pseudo-infinite wing i.e. a wing with a very large span. Such a wing which sports the airfoil in question would allow the 3-D panel code in VSPAERO to approximate the aerodynamic performance of the 2-D airfoil. The automation of VSPAERO into the BEMT code is still in progress and will hopefully bring the expectations of a high fidelity propeller performance tool into fruition.

For now, we are certain that the BEMT code is valid from an algorithm standpoint since even with the same two equations for lift and drag at each segment, we get a result which resembles the actual performance data which is a good indication of success once VSPAERO is integrated in the BEMT code.

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| Propeller Efficiency Comparison | |
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| Propeller CT Comparison | |
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