FAKULTÄT TECHNIK UND INFORMATIK
Department Fahrzeugtechnik und Flugzeugbau

HAW HAMBURG

Preliminary Sizing and Optimization of Propeller Aircraft (Part 25)

Large propeller aircraft will be the choice for the next generation and will replace current passenger jets.

Propeller driven aircraft (Figure 1) have a higher propulsive efficiency, less drag, less Direct Operating Costs (DOC), and much less equivalent CO2 due to contrail avoidance at lower cruise altitude compared to traditional passenger jet aircraft. At HAW Hamburg we teach such designs based on our PhD-level research.

PURPOSE

This project incorporates methods for propeller efficiency estimation into a preliminary sizing (and optimization) tool for large aircraft certified for CS-25 respectively FAR Part 25.

METHODOLOGY

Variable pitch propellers are considered. For them, previously collected methods for propeller efficiency estimation are evaluated and used. The resulting preliminary aircraft sizing tool is evaluated with a redesign of the ATR72-600.

FINDINGS

Propeller efficiency estimation methods are based on experience or theory and are defined in diagrams or equations. The main parameters with an influence on propeller efficiency are cruise speed, air density and propeller disc diameter. Furthermore, friction and shock waves (occurring at high Mach numbers) have a large influence on the propeller efficiency. When aerodynamic effects at high Mach numbers are not considered, estimation methods yield maximum propeller efficiency at maximum speed (which may be unrealistic).

RESEARCH LIMITATIONS

The influence of high Mach number on propeller efficiency needs to be evaluated further. Propeller efficiency methods are referenced and explained, but not derived.

PRACTICAL IMPLICATIONS

Aircraft preliminary sizing works with automatic calculation of propeller efficiencies. User look-up of efficiencies from diagrams is not required anymore.

SOCIAL IMPLICATIONS

The preliminary sizing tool for large propeller driven aircraft is openly available. Therefore, the potential of future propeller driven aircraft can be discussed by the public.

ORIGINALITY

A didactically enhanced design, redesign, and optimization tool (on preliminary sizing level) for large propeller driven aircraft is made openly available. It is especially suited for students and fills a perceived gap (Figure 2 and 3).

Figure 1: "Smart Turboprop" from the project "Airport 2023" (http://Airport2030.ProfScholz.de).

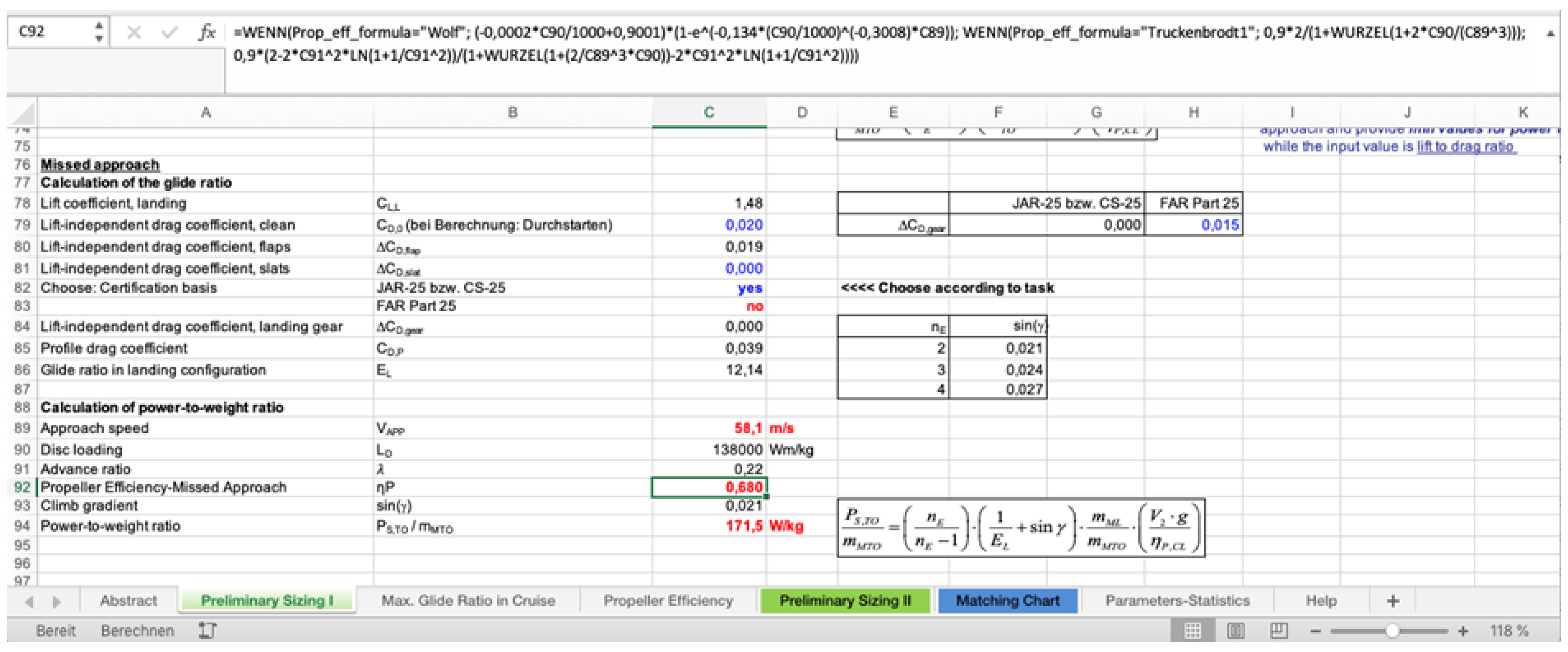

Figure 2: Sizing: Detail of the Excel tool "PreSTo-Classic-Prop" (http://PreSTo-Classic.ProfScholz.de).

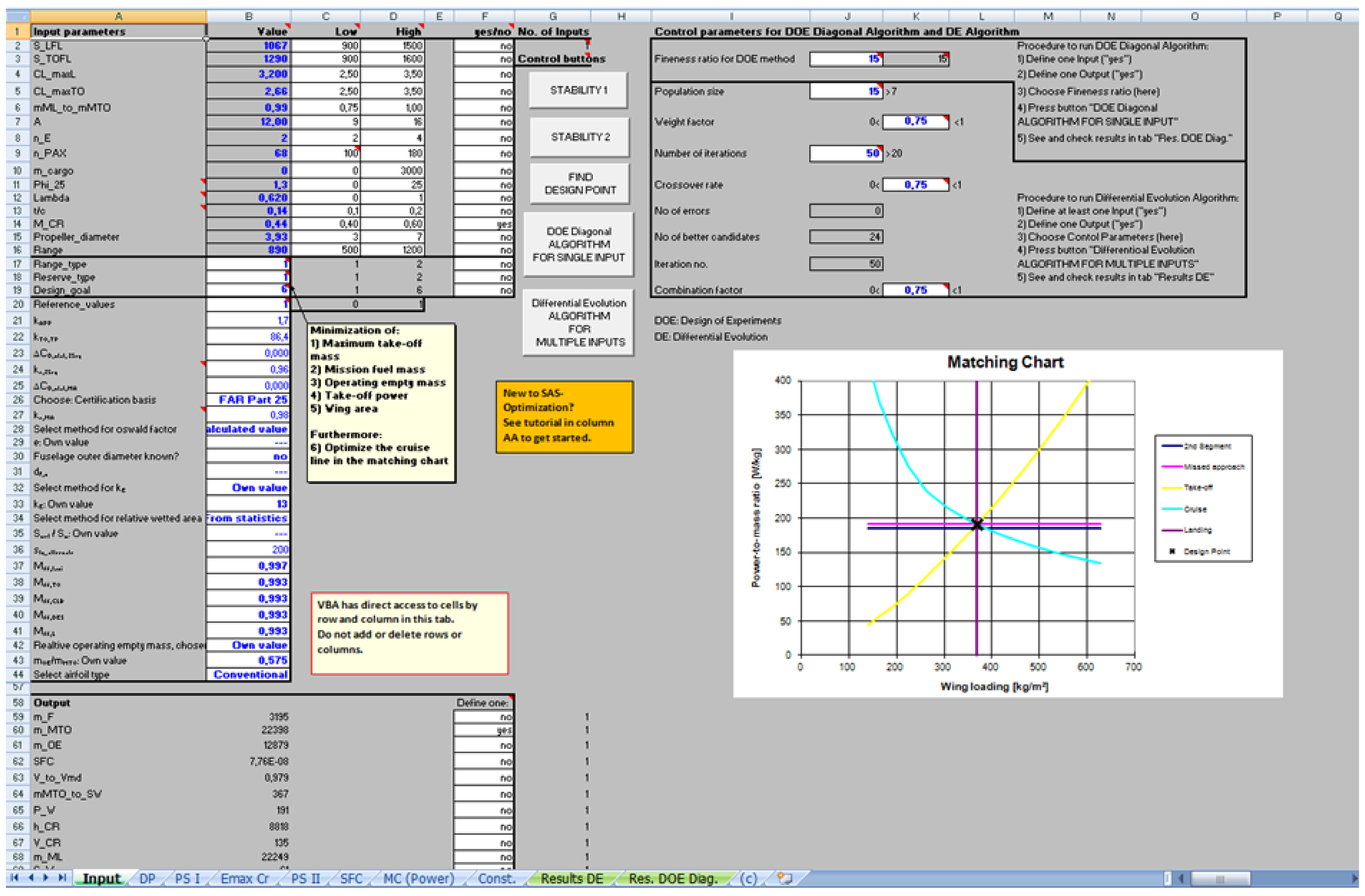

Figure 3: Optimization: Detail of the Excel tool "SAS-Part25-Prop" (http://SAS.ProfScholz.de).

All details in the Bachelor Project of Krull (2022):
https://nbn-resolving.org/urn:nbn:de:gbv:18302-aero2022-04-29.012

Associated research data (Harvard Dataverse):
https://doi.org/10.7910/DVN/ET4ZKV

Marlis Krull

Prof. Dr. Dieter Scholz, MSME

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