Parameter Optimization for an Interactive Aircraft Design

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General

Background: At Hamburg University of Applied Sciences an EXCEL/VBA tool called **PreSTo - Preliminary Sizing Tool** was developed. PreSTo is divided into several modules that deal with every step in aircraft design: preliminary sizing (discussed hier), cabin and fuselage, wing, high lift, empennage, landing gear, mass and CG, drag and DOC calculation.

The Problem: Design parameters (aspect ratio, maximum lift coefficients, ...) are the engineer's choice. Especially for inexperienced students it is difficult to choose all required design parameters. The best *combination* of design parameters leading to a good design needs to be found.

The Solution: To formally optimize the aircraft design parameters and present these optimized values to the student as a starting point. To combine formal optimization with a subsequent interactive and experienced driven aircraft design.

Starting Point

The Matching Chart: Two-dimensional optimization problem: thrust-to-weight ratio versus wing loading for five requirements (see Fig. 1).

Application of a formal optimization program: OPTIMUS was connected to the Excel preliminary sizing sheet from PreSTo. This made it possible to optimize any design output parameter for any combination of design input parameters. The original tool was extended in order to incorporate both benefits (L/D, SFC...) and penalties (structural mass, drag...).

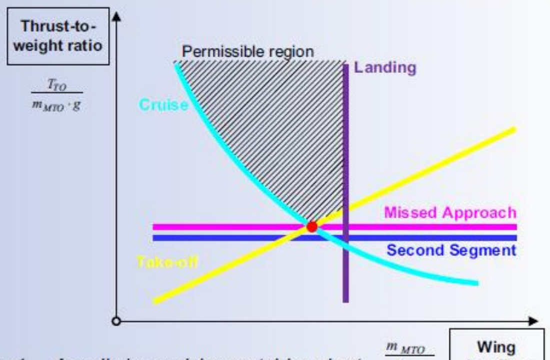

Fig. 1 A preliminary sizing matching chart

Selected Results

Tests were performed starting from the parameters of an Airbus A320 redesigned as closely as possible to the real aircraft. The objective was to see which combination of new parameters minimizes the maximum take-off mass. First the maximum lift coefficient for landing (C_{LmaxL}) was varied, while the one for take-off (C_{LmaxTO}) was set to 80 % of C_{LmaxL} (Fig. 2, 3, 5, 6). The cruise line is always matched by modifying the ratio V/V_m. The kink in Fig. 2 and 5 indicates the moment when the second segment line moves above the take-off line in the matching chart. The maximum L/D is found for a C_{LmaxL} of about 2.8 (Fig. 3).This corresponds to $V/V_m = 1$ (Fig. 6). An optimum C_{LmaxL} reduced the maximum take-off mass by 13.41 % compared to the original A320. The variation of m_{ML}/m_{MTO} ratio (Fig. 4), confirms that a small mass ratio allows a high wing loading at take-off. This has the potential of a smaller and lighter wing. It however requires a higher thrust-to-weight ratio, T/W and a bigger and heavier engine. When varying both C_{LmaxL} and m_{ML}/m_{MTO} (Fig. 7), m_{MTO} is optimized for the values 2.6 and 0.95 respectively. The take-off mass is reduced by 17.94 % compared to A320.

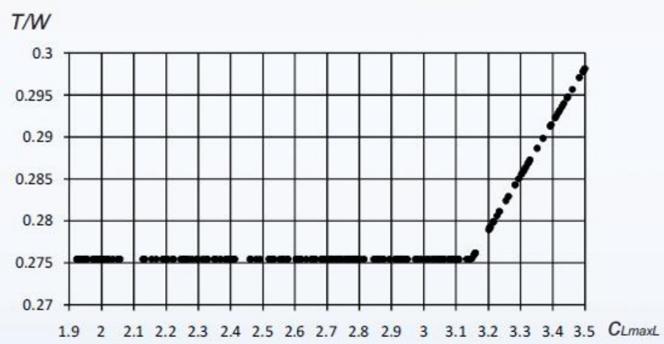

Fig. 2 Thrust-to-weight ratio, T/W as a function of maximum lift coefficient for landing configuration, C_{LmaxL}

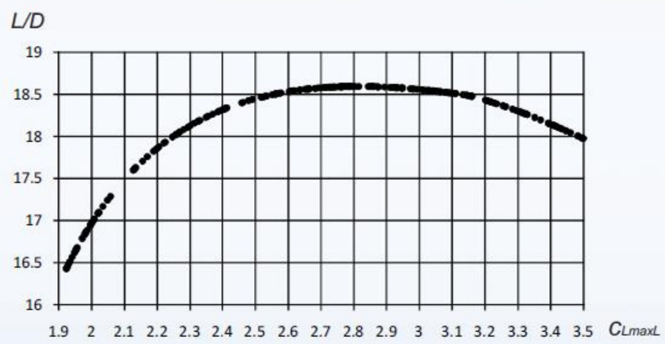

Fig. 3 Lift-to-drag ratio, L/D as a function of maximum lift coefficient for landing configuration, C_{LmaxL}

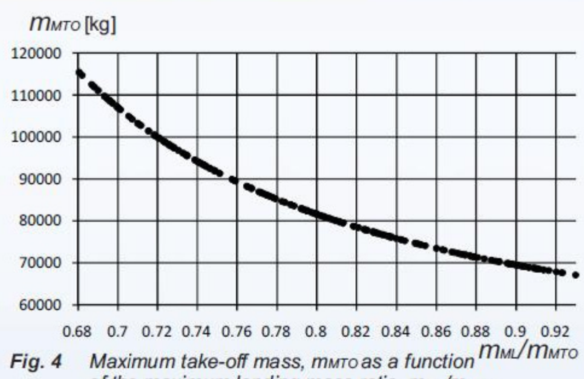

Fig. 4 Maximum take-off mass, m_{MTO} as a function of the maximum landing mass ratio, m_{ML}/m_{MTO}

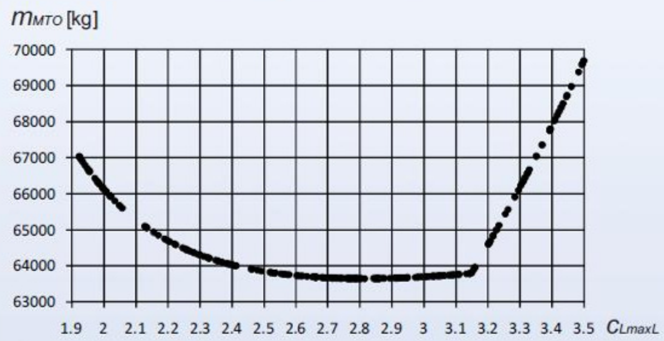

Fig. 5 Maximum take-off mass, m_{MTO} as a function of maximum lift coefficient for landing configuration, C_{LmaxL}

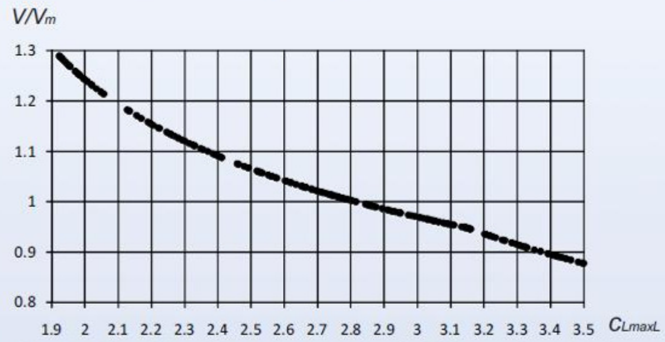

Fig. 6 Speed-to-minimum drag speed ratio, V/V_m as a function of maximum lift coefficient for landing configuration, C_{LmaxL}

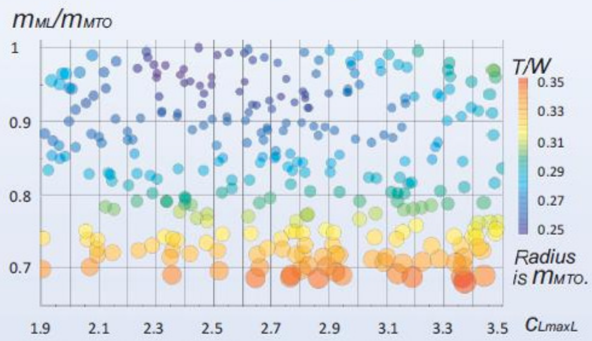

Fig. 7 Variation of m_{ML}/m_{MTO} and C_{LmaxL}. Results shown are m_{MTO} (bubble diameter) and T/W (color).

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