OPTIMUM CRUISE CONDITIONS FOR HIGH-SUBSONIC AIRCRAFT

EGBERT TORENBEEK

SAMARA STATE UNIVERSITY

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SPECIFIC RANGE

The *range*, R, is the distance that an aircraft can fly horizontally with a given amount of fuel. It is found from integration of the *specific range*,

$$\frac{V}{F} = \frac{\mathrm{d}R}{\mathrm{d}W_{fuel}} = \frac{\mathrm{d}R/\,\mathrm{d}t}{\dot{m}_{fuel}\, g}, \tag{2.9}$$

or in terms of total propulsive and aerodynamic efficiencies,

$$\frac{V}{F} = R_H \frac{\eta_{tot} L/D}{W}. \tag{2.10}$$

This equation forms the basis for most of the theory presented in this chapter. In terms of the PSFC for propeller aircraft the specific range reads as follows:

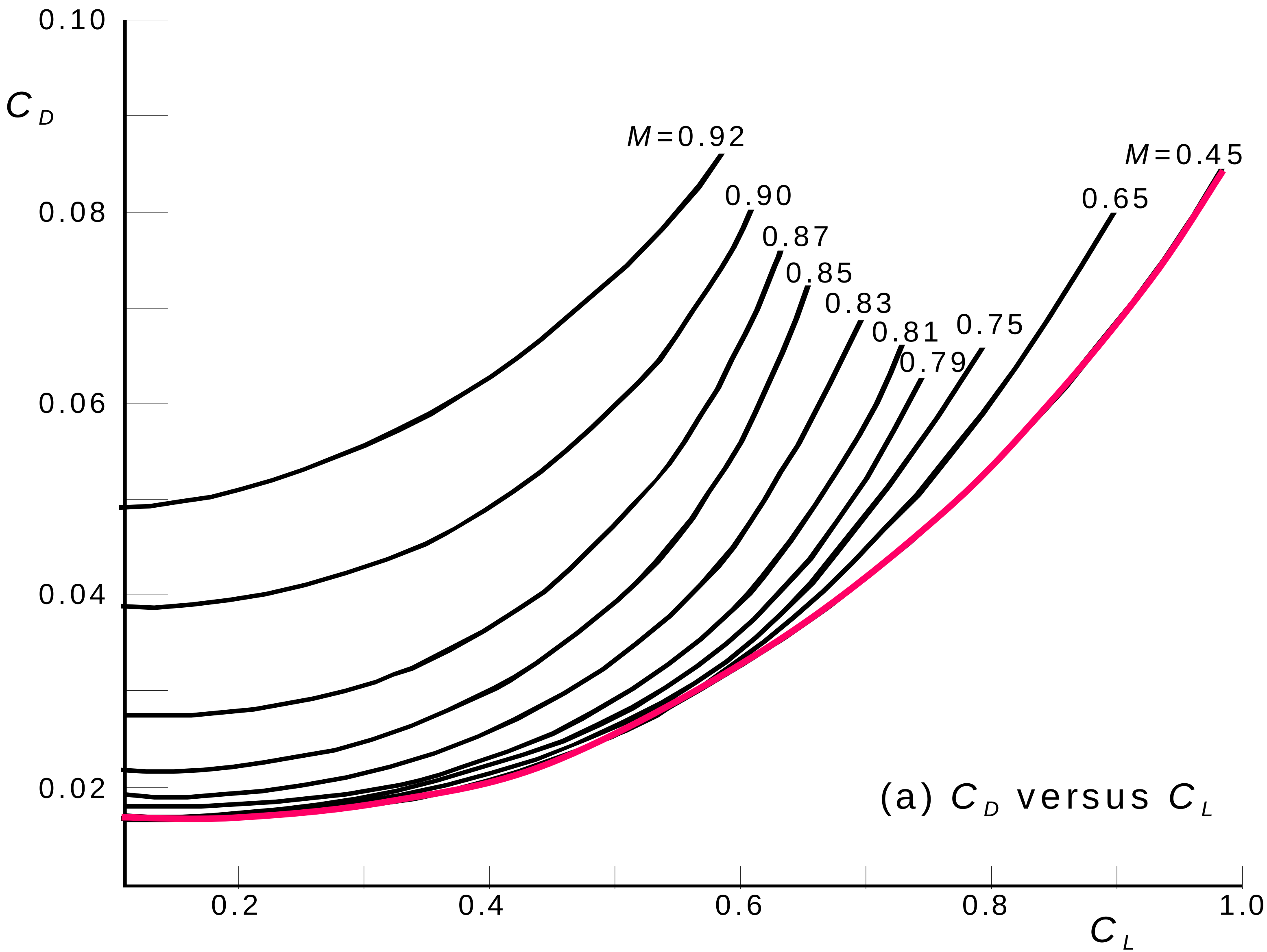
$$\frac{V}{F} = \frac{\eta_{prop}}{C_P} \frac{L/D}{W}, \tag{2.11}$$

while for jet aircraft the use of TSFC yields

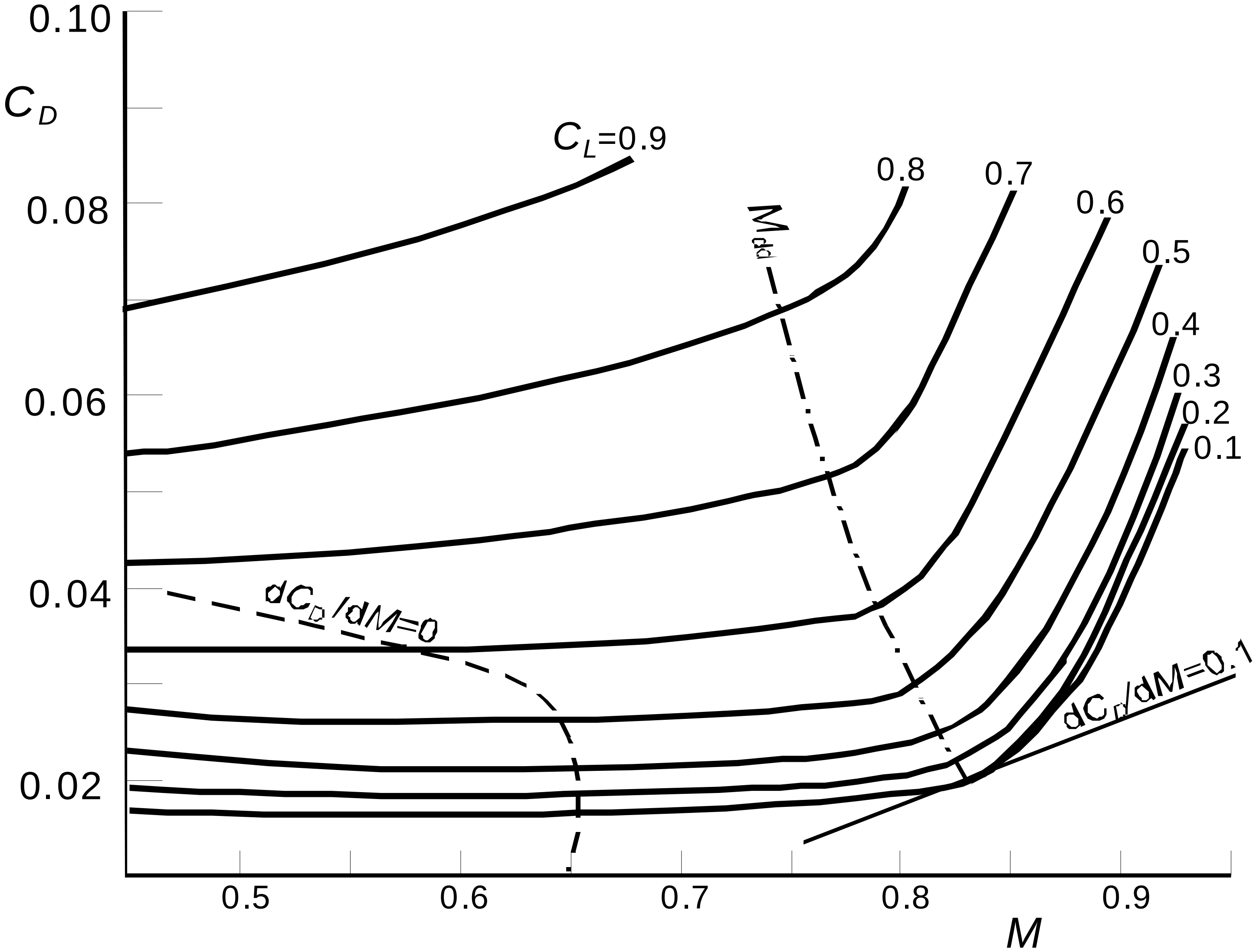
$$\frac{V}{F} = \frac{VL/D}{C_T W} = \frac{a_{sl}\, ML/D}{WC_T/\sqrt{\theta}}. \tag{2.12}$$

Classical analysis of cruising flight is based on the assumption that for jet aircraft TSFC is independent of flight conditions and the specific range is maximum for $(VL/D)_{max}$. A refinement is the assumption of constant corrected TSFC[2], which leads to $(ML/D)_{max}$ as the criterion for maximum specific range. For modern turbofan engines, however, TSFC varies appreciably with Mach number and the use of Eq. 2.10 is to be preferred as the criterion for optimum cruising.

DRAG POLAR CURVES OF HIGH SPEED AIRCRAFT

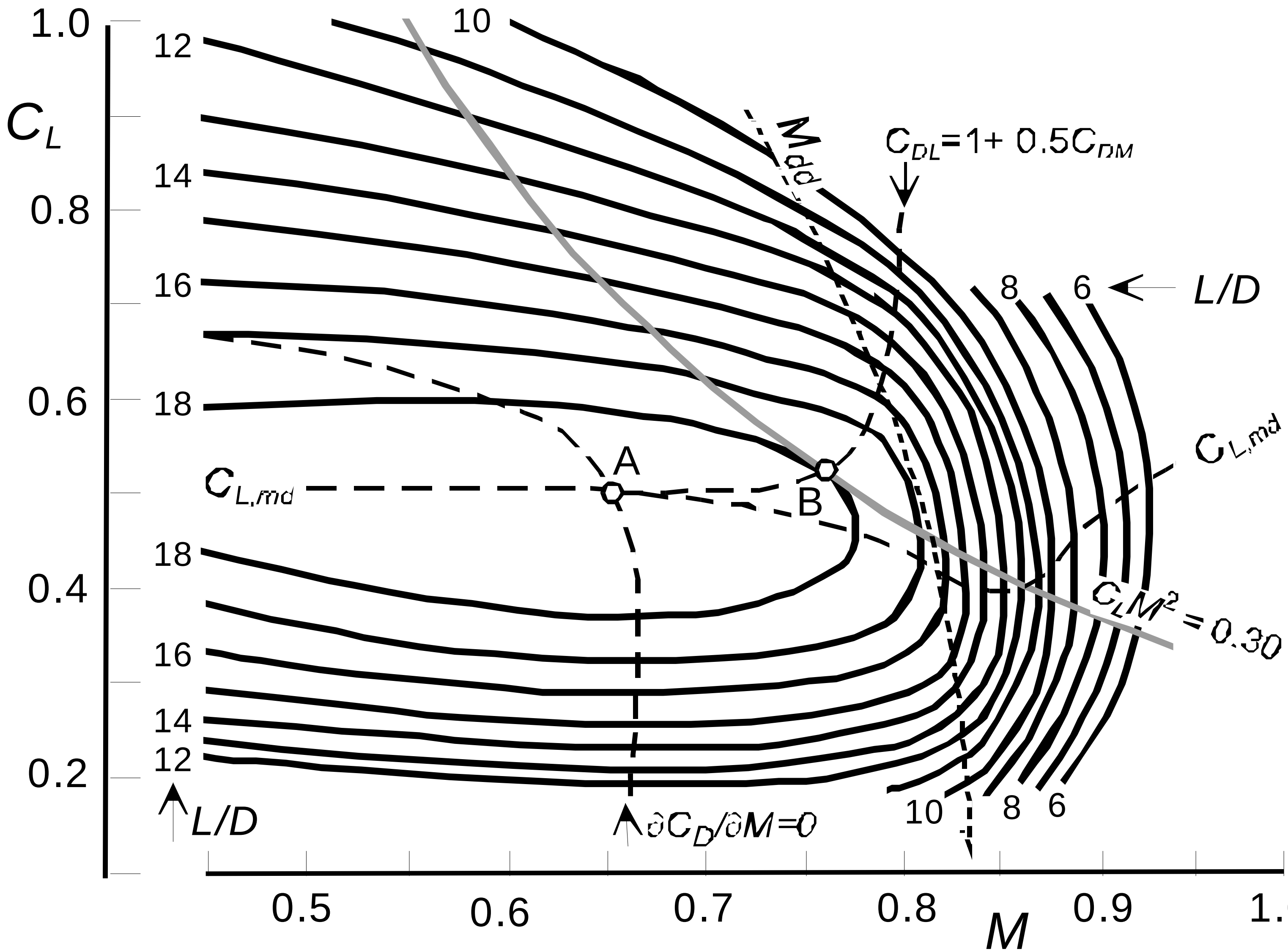


DRAG POLAR CURVES – ALTERNATIVE REPRESENTATION

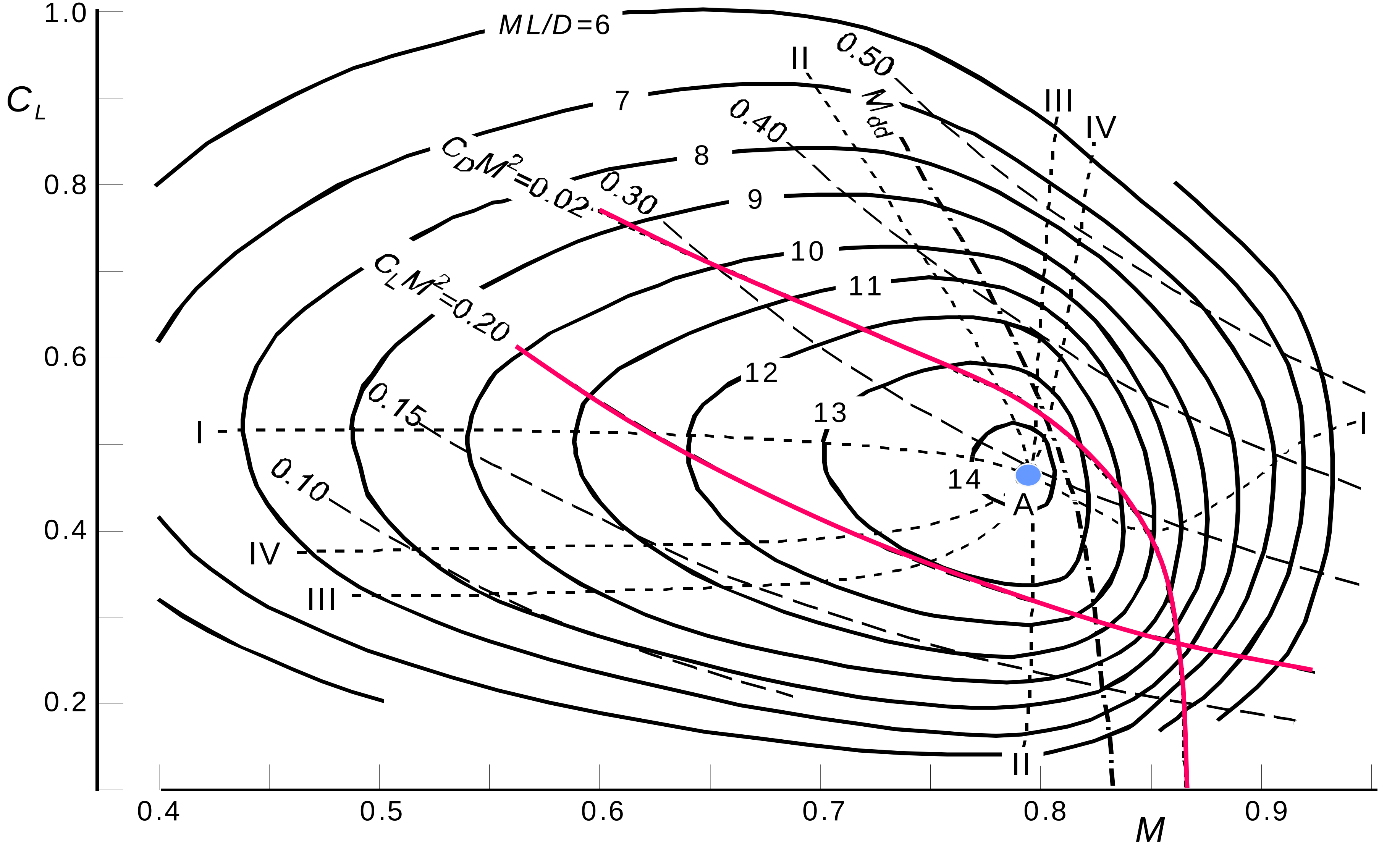


(b) C_D versus M

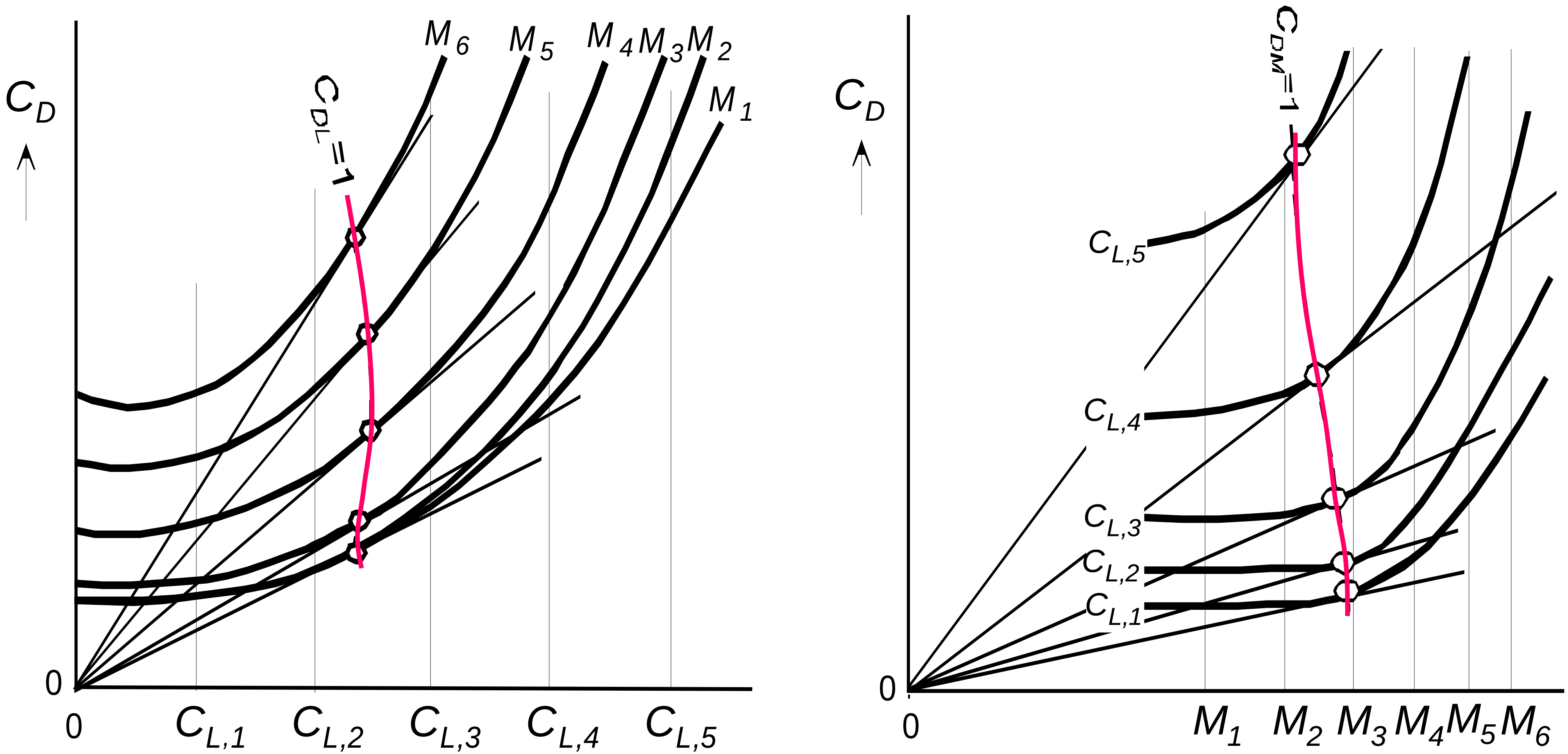
LIFT TO DRAG RATIO VERSUS C_L AND MACH NUMBER



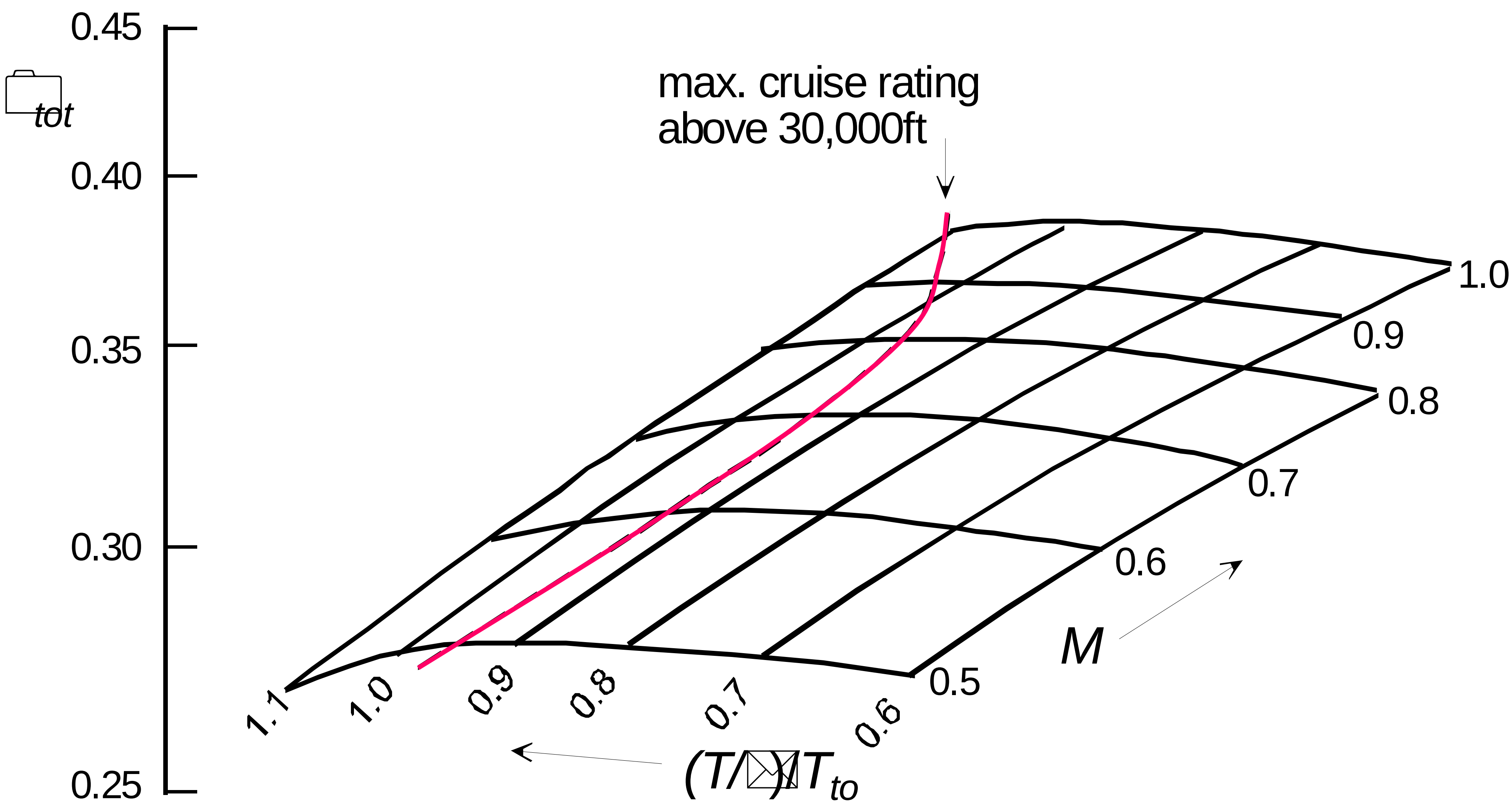
THE PARAMETER ML/D



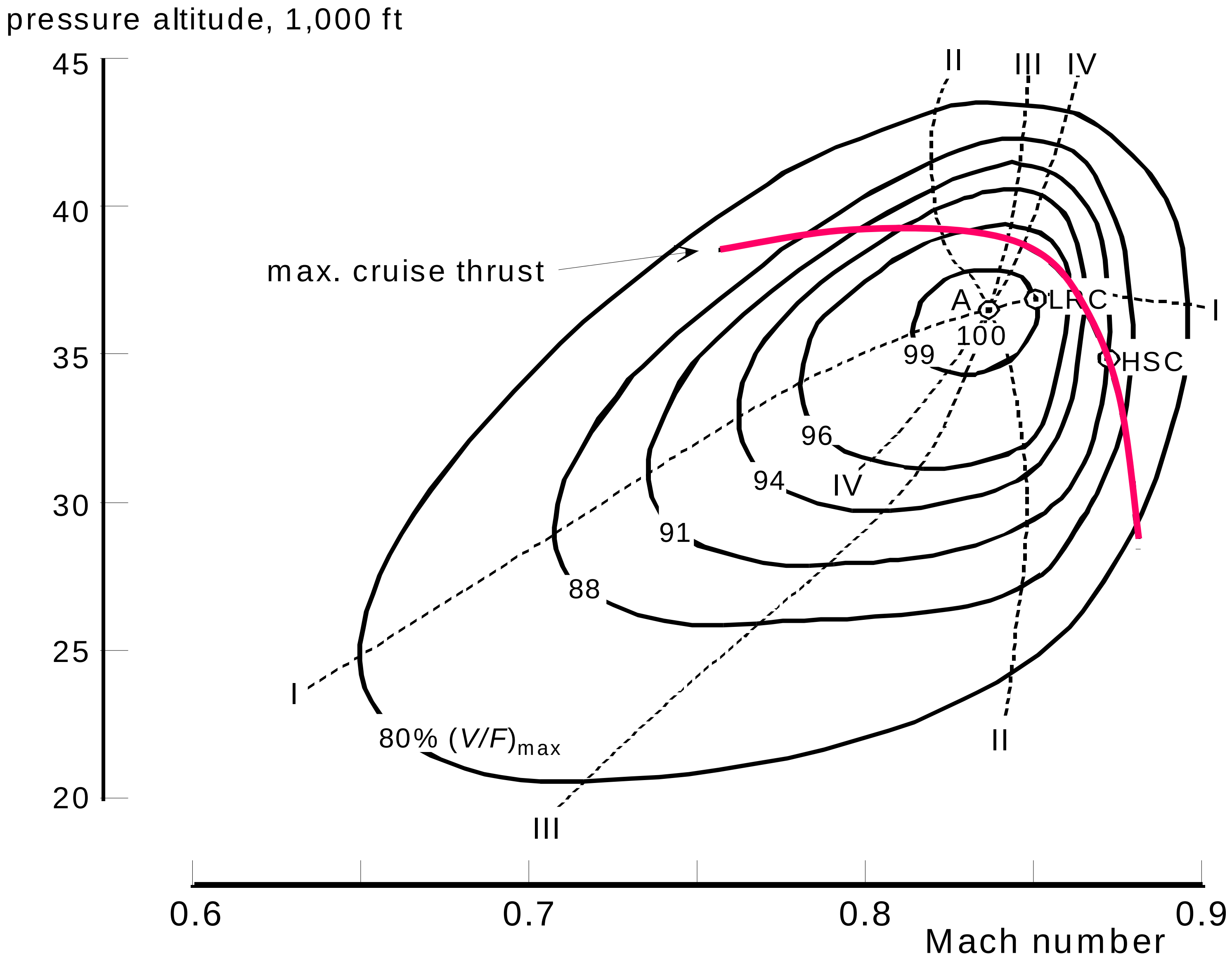
CONDITIONS FOR MAXIMUM ML/D



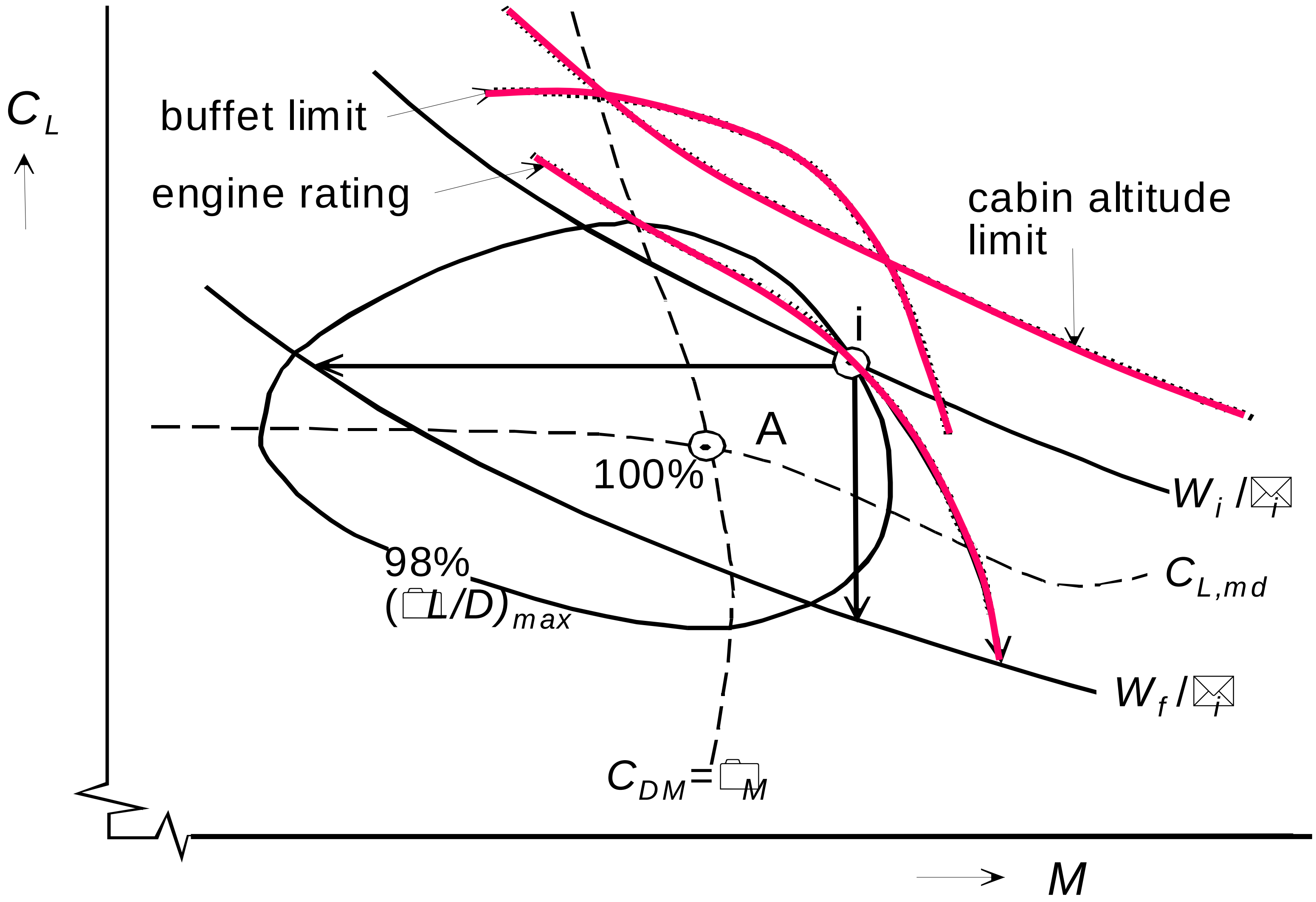
OVERALL PROPULSIVE EFFICIENCY



SPECIFIC RANGE FOR GIVEN ALL-UP WEIGHT



SCHEDULES FOR CRUISING FLIGHT



CRUISING SCHEDULES

(a) In a *constant speed horizontal cruise* the all-up weight decreases to the final value W_f, while the ambient pressure remains constant ($p_f = p_i$). The gradually decreasing lift coefficient allows the range parameter to remain "close to the top". In the present example this schedule is superior to a continuous cruise/climb in point i.

(b) In a *horizontal cruise with constant lift coefficient* the Mach number decreases, the specific range varies "close to the top" and yields a good range. However, the speed variation during the flight is likely to be objectionable in practical operation.

(c) A *maximum thrust horizontal cruise* penalizes the range significantly because the drag rise is penetrated. For a reduced (but constant) engine rating, with point i moved to the left and/or downwards, good range performance will be combined with the drawback of a varying speed with a reduced mean value.

(d) In a *stepped cruise/climb* the lift coefficient varies down from and up to point i and the continuous cruise/climb is closely approximated, dependent on the number of altitude steps[12].