Hochschule für Angewandte Wissenschaften Hamburg
Hamburg University of Applied Sciences
Department Fahrzeugtechnik und Flugzeugbau

Flight test planning and data extraction

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Introduction

Motivation:

Subscale flight testing offers:

- **Cost efficiency**
- **Safety – investigations of the aircraft's behaviour in extreme portions of the flight envelope**
- **Identification of important aircraft flying qualities prior to building a full-scaled model**

However:

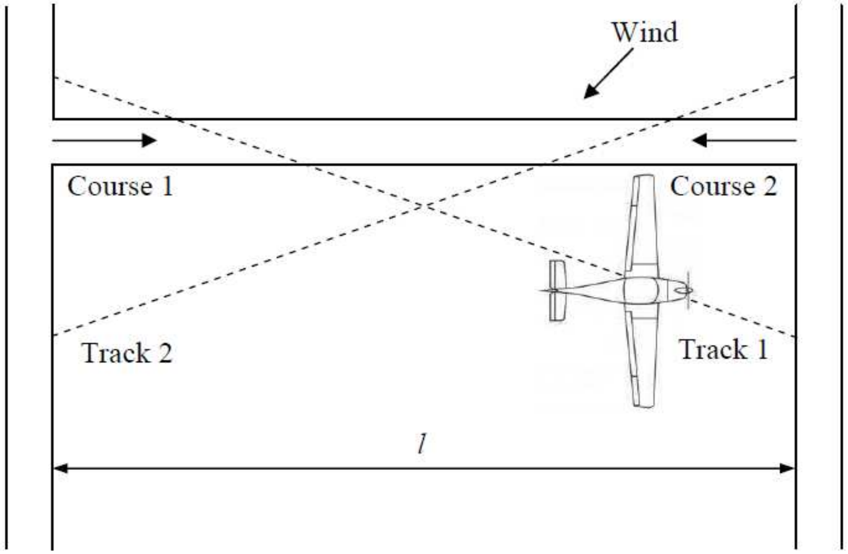
Concept has to be completely understood!

Raven – basic information

Raven design:

- Conventional tail aft aircraft
- T-shaped tail section
- Low wing configuration
- Forward sweep
- Small nose boom for pressure and angle of attack and sideslip angle measurements
- Dimensions: 1,74 m x 2,0 m; Aspect ratio 10
- Weight (w/o fuel) 9,75 kg; max. Endurance: 20 min

Calibration methods



Speed Course Method:

- 2 courses with reciprocal headings over the same measured distance *l*
- Speed and heading are to be maintained constant with inputs on the controls
- *Advantage*: simple instrumentation required
- *Disadvantages*: → Constant heading
  → Less accurate results

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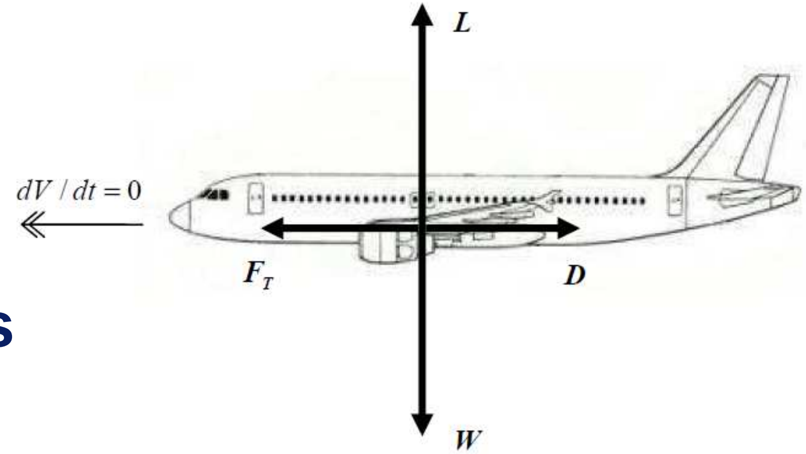
Lift and drag determination



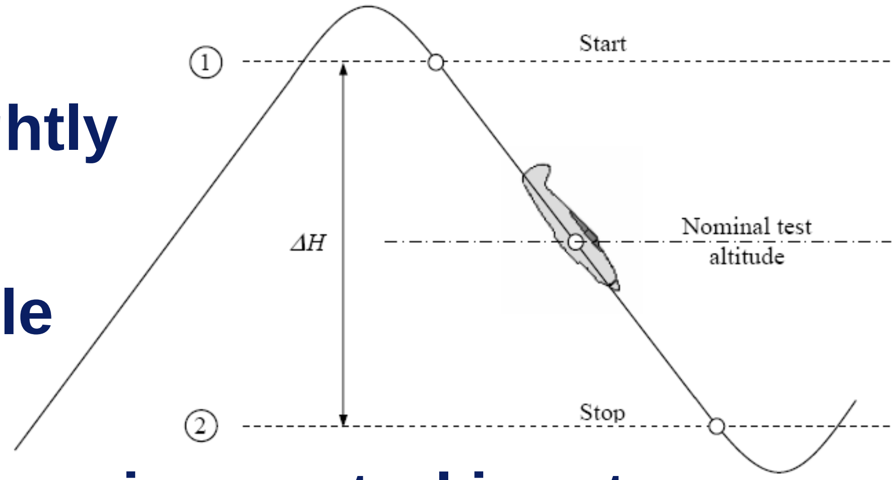
Steady level flight:

- Lift = Weight ; Drag = Thrust
- Aircraft is trimmed at various angles of attack
- Drag is obtained using a turbine thrust model
- Weight is calculated using fuel flow indications
- *Advantages*: → *L* and *D* directly as functions of AOA
  → No data corrections
- *Disadvantages*: → Turbine thrust model not verified
  → At high α: thrust not in flight path

Lift and drag determination

<u>Steady glide method:</u>

- Nominal altitude and an altitude band ΔH of approx. 300 m is chosen
- Aircraft is climbed slightly above Point 1
- Engine power set to idle
- Speed is maintained constant very precisely using control inputs
- Manoeuvre repeated for a range of constant speeds



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Lift and drag determination

Data reduction for a single glide:

- ΔH is corrected for:
  - Non-standard surface temperature
  - Occurring acceleration due to constant indicated airspeed
  - Non-standard weight
- *ROD* is calculated with the corrected ΔH and Δt
- C_L and C_D are obtained using γ, W_{avg} , V_{avg}
- *Disadvantages:* → Thrust forces are not zero
  → Drag polar; no AOA dependency
  → Short flight operational time

Stall speed flight tests

Power-off gradual deceleration technique:

- **Chosen altitude – sufficient to gain back control**
- **Aircraft is trimmed at approx. 1,2 the predicted stall speed; $\rightarrow$ engines to idle**
- **α is slowly increased until stall occurs; pilot uses pitch control to maintain small deceleration rate**
- **Indication of stall – a nose pitch down; plunge down**

Data reduction:

Calculated V_S is corrected for non-standard weight

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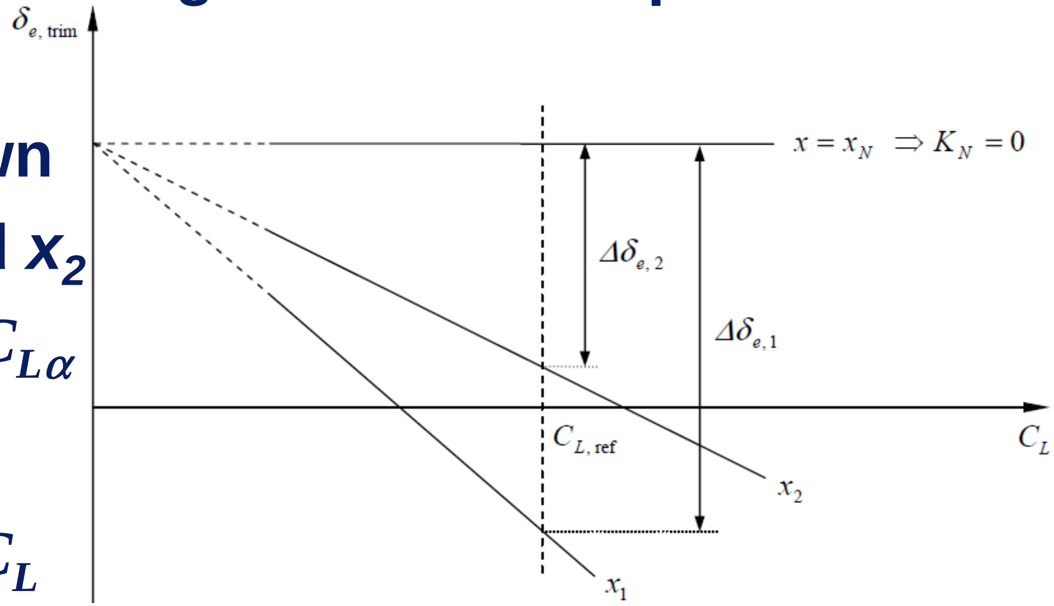
Longitudinal static stability

- Change of $C_{M,\,c.g.}$ with C_L is linear; slope depends on the CG position; $dC_{M,\,c.g.} / dC_L = -K_N$ (static margin)
- Aircraft trimmed for a range of V at 2 CG positions
- x_N calculated using $\Delta\delta_{e,1}$, $\Delta\delta_{e,2}$ and known CG positions x_1 and x_2
- $dC_{M,\,c.g.} / d\alpha = -K_N \times C_{L\alpha}$
- If non-linear:
  $\rightarrow$ x_N varies with C_L



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Lateral static stability

Steady heading sideslips:

- **Trim aircraft at nominal altitude and test airspeed**
- **Sideslip is entered with a small rudder input**
- **Aircraft is trimmed using lateral controls and data is recorded; rudder and aileron should be applied simultaneously $\rightarrow$ cross-coupled controls**
- **Repeat in steps of 0,25 full δ_r for opposite β**

Data reduction:

- **Control surface deflection plotted versus recorded β**
- $C_{Y\beta} = -\partial\phi / \partial\beta \times C_L$; $\partial\phi / \partial\beta$ **at zero β**

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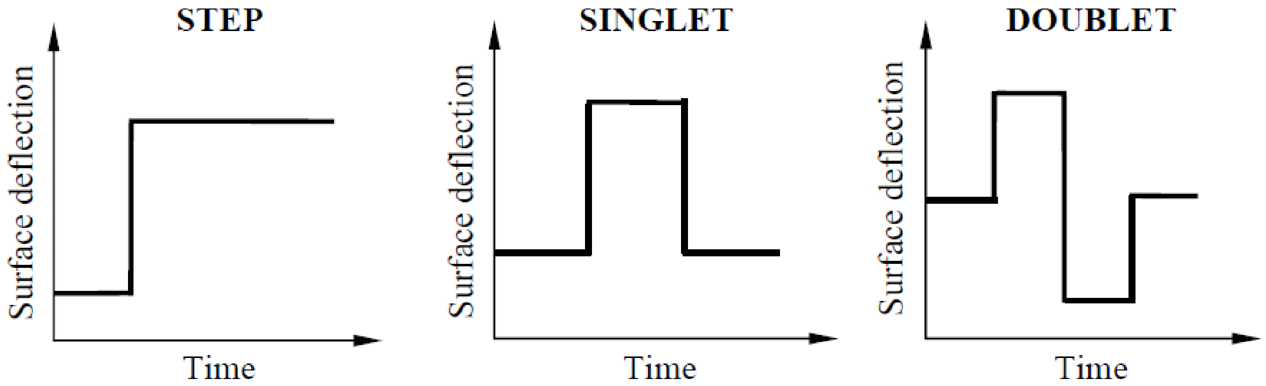
Dynamic stability flight tests

Types of control inputs for dynamic stability tests:



Short period mode: doublet ; singlet ; 2-g pull-up

Data reduction methods:

- Maximum Slope method
- Time-Ratio method

Dynamic stability flight tests

- **Phugoid mode:** singlet of fairly long duration
  - Transient Peak Ratio method
  - Numerical approximation of the phugoid motion
- **Spiral mode:** trim, roll to 10° bank, trim, release
  - time to double / half the bank angle
- **Roll mode:** step or singlet aileron input
  - τ_r : time to reach 63,2% of the steady-state roll rate
- **Dutch roll mode:** rudder doublet ; aileron singlet

Lateral-directional dynamic stability data reduction:

- Graphical method applying superposition of all 3 modes

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Questions?

The End

Thank you for your attention!