PHYSICS OF THE SAL-START

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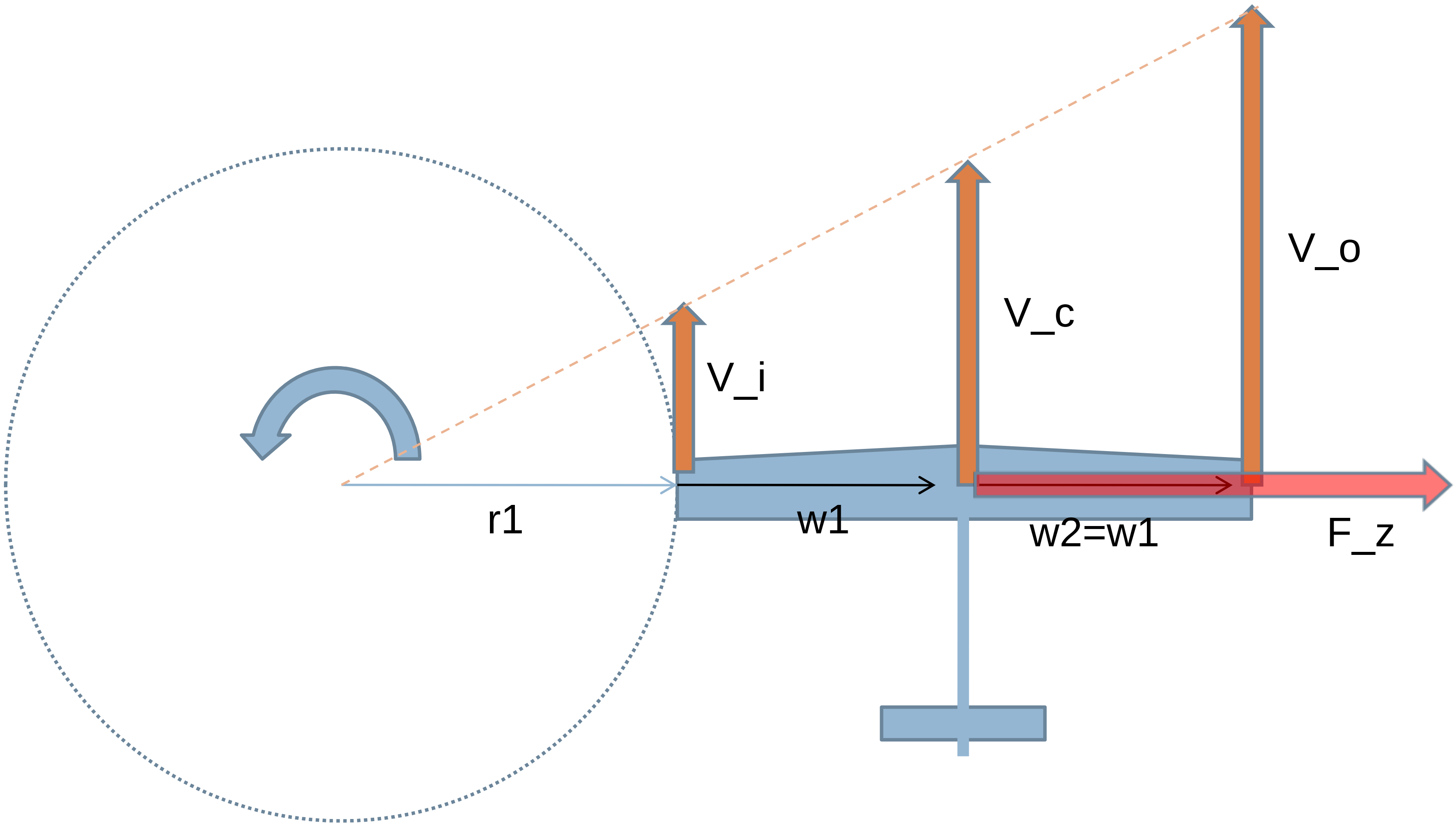
The start setup



Doing some math...

- Angular Speed: $V = 2*PI*r / t = const*r/t$
  - **$V_i = 2*r1*PI / t$**
  - **$V_c = 2*(r1+w1)*PI /t$**
  - **V_o** $= 2*(r1+w1+w2)*PI /t$ = **$2*(r1+2*w1)*PI/t$**
- Angular Force: $F= m*v^2 / r$
  - $F_z = m* V_c^2 / (r1+w1) = m* (2*(r1+w1)*PI/t)^2/(r1+w1) = m*4*(r1+w1)^2*PI^2/t^2 /(r1+w1) \rightarrow$
  - **$F_z = 4*m*(r1+w1)*PI^2 / t^2$**

Doing some physics

- Classic speed to reach a hight of H meters (or speed when falling from that hight):
  - V = SQRT(2*g*H)
- Asume we throw a „stone“ straight up in the air and we want to reach H=30m → V ~= 24.3m/s
- Re ~= v*chordlength*70000
- Time for falling from H meters:
  - T = SQRT(H*2/g) → 2.4s

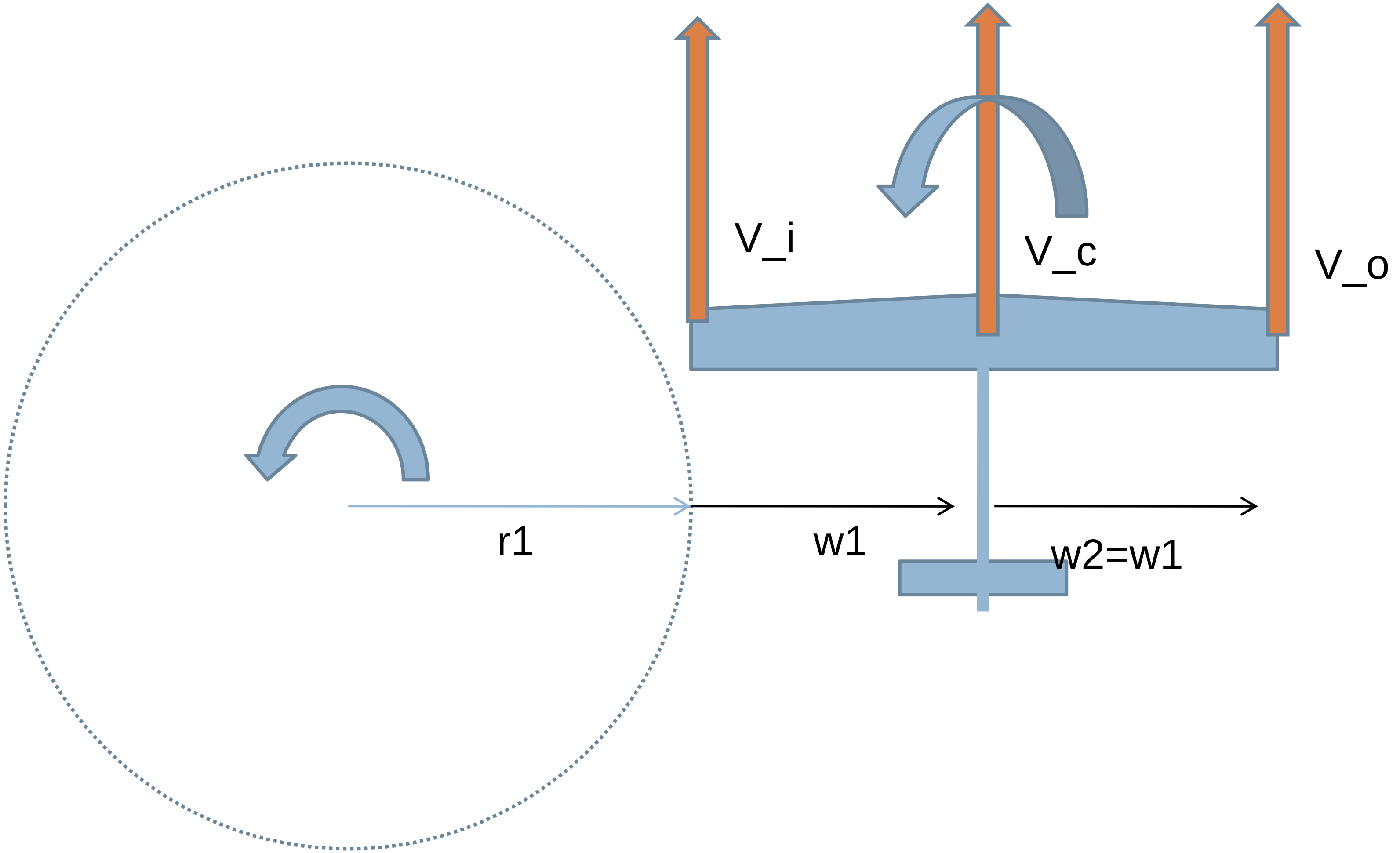
Dimensions

- Arm length r1 = 1m
- Wingspan = 1m → w1 = w2 = 0.5m
- Weight = 0.3kg
- Duration for one 360° turn = 0.5s
- Chord lenght at root = 0.25m
- Chord lenght at tips = 0.20m

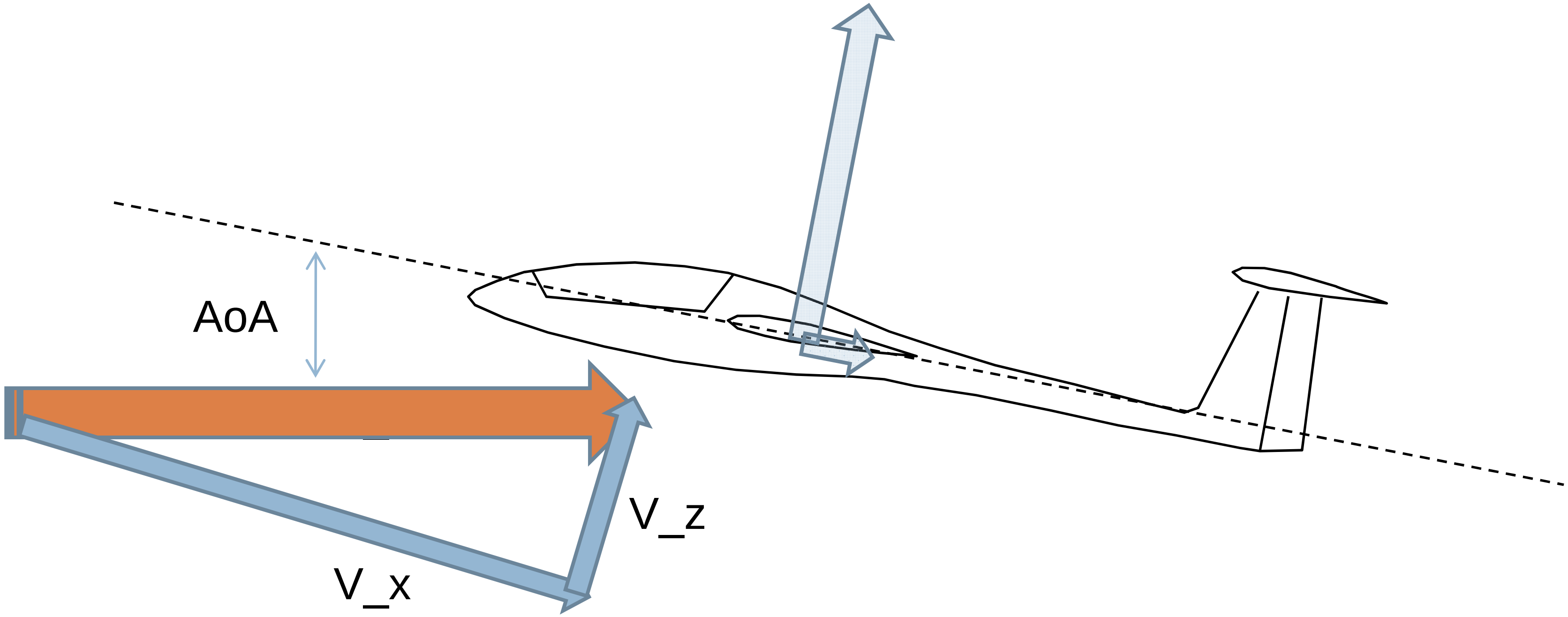
Calculation

- V_i = 12.56 m/s
- V_c = 18.84 m/s = 1.5 * V_i
- V_o = 25.12 m/s = 2* V_i
- F_z = 71N = m*g → 7.23 g (g-force) „virtual“ model weight is 2.1kg during launch!
- Re_i = 175840
- Re_c = 329700 = 1.5 * R_i
- Re_o = 351680 = 2 * R_i

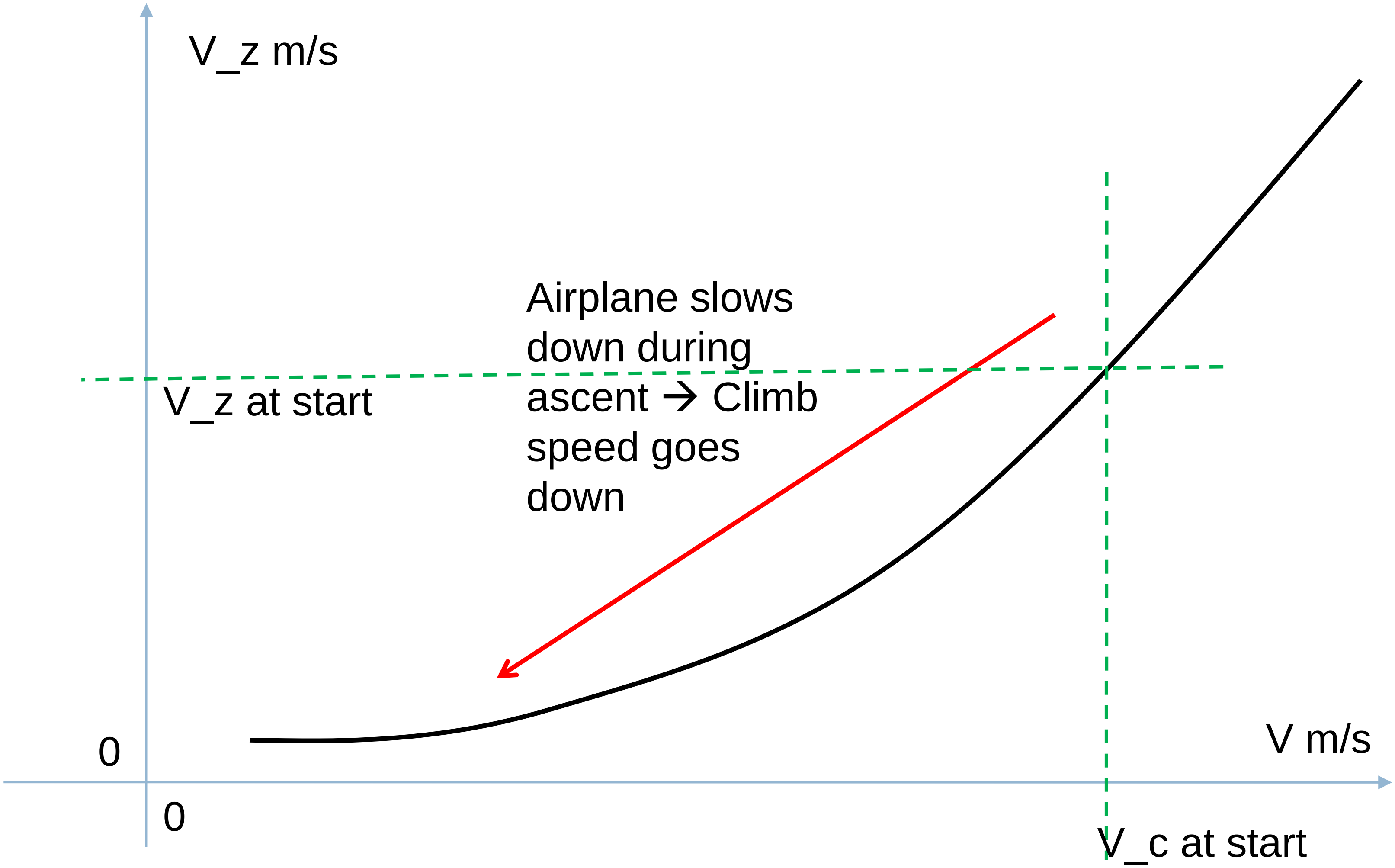
One moment after the start



Going up!



Vz vs V



V_z m/s
Airplane slows down during ascent → Climb speed goes down
V_z at start
0
V m/s
0
V_c at start

$V_z = V_z(V(t))$

- Climb speed is a function of V
- V is a function of time t
- → $V_z = V_z(V(t))$
- → $H(t) = V_z(V(t))*t$
- **Lets asume a linear $V_z(V) = 4*V-20$**
- $V = V(t) = g*t$
- → $V_z(t) = 4*g*t-20$
- → Integrate over time: $\int V_z(t)\, dt$
- → $2*g*t^2-20t$
- Boundary condition: t [0, 2.4s] → **65m! (overestimated due to linear asumtion!)**
- Normal throw straight up: **28.25m!**

So what?

- Implicit asumtions: The AoA changes with respect to the speed correctly.
- Since Cl/Cd has a maximum you should try to „level“ out the airplane during launch at the specific speed to make progress in the air
- Launching with high AoA is bad → AoA must „fit“ to the speed to produce the best lift!