Rules of Thumb

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1 Rules of Thumb

This section contains the listing of useful rules of thumb.

1.1 True Airspeed (TAS)

$$TAS \approx CAS + 2 \cdot \frac{FL}{10} \qquad if\ TAS \leqq 150\,kt.$$
$$TAS \approx CAS + 3 \cdot \frac{FL}{10} \qquad if\ TAS > 150\,kt.$$

where

$$CAS \approx IAS$$

1.2 Standart Rate Turn (SRT)

In a SRT the RoT is $3 \frac{o}{sec}$. Therefore a 360^o-Turn takes 2 minutes. So, the circumference U of the 360 in time distance is

$$2min = U = 2\pi\, R$$
$$\Rightarrow R = \frac{120\ sec}{2\pi} \approx \frac{120\ sec}{2 \cdot 3} = 20\ sec$$

The radius R of a SRT in time distance is

$$R\ =\ 20\,sec$$

1.3 Wind Correction Angle (WCA), Ground Speed (GS) and other Components

Wind Angle wa:

$$wa = W - TC$$

Crosswind Component CWC:

$$CWC = V \cdot sin(wa)$$

Wind Component WC:

$$WC = -V \cdot cos(wa)$$

where the WC is a negative Headwind Component (HWC) or a positive Tailwind Component (TWC).

Another way to calculate the WC is

- Calculate $110 - wa$. This is the percentage of the wind speed V which is the WC.
- For $wa = 80^o$ use 20% instead of 30%.
- For $wa = 90^o$ WC = 0 kt.
- For $wa = 0^o$ WC = V.

Effective true airspeed:

$$TAS_{effective} = \sqrt{TAS^2 - CWC^2}$$

or, if the WCA is already known

$$TAS_{effective} = TAS \cdot cos(WCA)$$

Groundspeed GS:

$$GS = TAS_{effective} + WC$$
$$GS \approx TAS + WC$$

Wind Correction Angle WCA:

$$WCA = arcsin(\frac{CWC}{TAS}) = arccos(\frac{TAS_{effective}}{TAS})$$
$$\Rightarrow \frac{CWC}{TAS} = sin(WCA) \approx \frac{WCA}{60}$$
$$\Rightarrow WCA \approx \frac{CWC}{\frac{TAS}{60}} = \frac{V}{\frac{TAS}{60}} \cdot sin(wa) = WCA_{max} \cdot sin(wa)$$

where the maximal WCA is

$$WCA_{max} = \frac{V}{\frac{TAS}{60}}$$

and $\frac{TAS}{60}$ are the airmiles per minute.

1.4 Bank Angle (β)

Gravitation:

$$F_G = m \cdot g$$

with acceleration g due to gravitation.

Centrifugal force:

$$F_Z = m \cdot \frac{v_T^2}{r}$$

with turning radius r.

Tangential velocity:

$$v_T = \frac{2\pi r}{T}$$

with period: T.

$$v_T = \frac{2\pi r}{T} = \frac{2\pi}{T} \cdot r = \omega \cdot r$$

Angular velocity SRT: $RoT = \omega = 3[\frac{o}{s}]$, velocity: $v_T = TAS[kt]$

$$tan\beta = \frac{F_Z}{F_G} = \frac{m \cdot \frac{v_T^2}{r}}{m \cdot g} = \frac{v_T^2}{r \cdot g} = \frac{v_T}{r} \cdot \frac{v_T}{g} = \omega \cdot \frac{v_T}{g} \qquad because \quad \omega = \frac{v_T}{r}$$

or

$$tan\beta = \frac{RoT \cdot TAS}{g}$$

$$tan\beta = \frac{3[\frac{o}{s}] \cdot \frac{\pi}{180^o} \cdot TAS[kt] \cdot \frac{\frac{1852[m]}{3600[s]}}{[kt]}}{9.91[\frac{m}{s^2}]}$$

$$\Rightarrow \quad tan\beta = 0.00275_{[\frac{1}{kt}]} \cdot TAS_{[kt]}$$

$$\Rightarrow tan\beta \approx \frac{\beta}{60} \approx 0.00275 \cdot TAS$$

$$\Rightarrow \beta \approx \frac{TAS}{10} \cdot 0.0275 \cdot 60 = \frac{TAS}{10} \cdot 1.65 \approx \frac{TAS}{10} \cdot 1.5$$

or

$$\beta \approx \frac{TAS}{10} + 50\%$$

which formula fits low speed turns better than high speed turns.

Maneuvers are performed with a TAS between 100 kt and 200 kt.

Average maneuver TAS 150 kt:

$$\Rightarrow \beta \approx \frac{150}{10} \cdot 1.5 = 22.5^o = \frac{TAS}{10} + 7.5^o \approx \frac{TAS}{10} + 7^o$$

Lufthansa therefore uses

$$\beta \approx \frac{TAS}{10} + 7^o$$

which formula fits high speed turns better than low speed turns.

1.5 Rate of Descent (RoD)

$$\frac{3}{60} \approx tan(3^o) = \frac{RoD_{[kt]}}{GS_{[kt]}}$$

$$\Rightarrow \qquad RoD_{[kt]} \approx \frac{3}{60} \cdot GS_{[kt]}$$

with

$$1kt = 1\frac{NM}{h} \approx \frac{6000\,ft}{60\,min} = 100\,fpm$$

follows

$$RoD_{[fpm]} \approx \frac{3}{60} \cdot GS_{[kt]} \cdot 100[\frac{fpm}{kt}]$$

$$\Rightarrow \qquad RoD_{[fpm]} \approx 5 \cdot GS_{[kt]}.$$

So, the relation is

$$\frac{GlideSlope\;3^o}{Factor\;5} = 0.6 \approx 0.5 = \frac{1}{2}[\frac{^o}{\Delta Factor\;1}]$$

or the other way around:

$$\frac{Factor\;5}{GlideSlope\;3^o} = 1.\overline{6} \approx 2[\frac{\Delta Factor}{1^o}] = \frac{2}{10}[\frac{\Delta Factor}{0.1^o}]$$

1.6 Top of Descent (d_{TOD})

$$\frac{3}{60} \approx tan(3^o) = \frac{\Delta ALT_{[NM]}}{d_{TOD[NM]}}$$

$$\Rightarrow \qquad d_{TOD[NM]} \approx \frac{60}{3} \cdot \Delta ALT_{[NM]}$$

with

$$1\,NM \approx 6000\,ft$$

follows

$$d_{TOD[NM]} \approx \frac{60}{3} \cdot \Delta ALT_{[NM]} \approx \frac{60}{3} \cdot \Delta ALT_{[NM]} \cdot \frac{1}{6000}[\frac{ft}{NM}] = \frac{\Delta ALT_{[ft]}}{300}$$

or with

$$1\,FL = 100\,ft$$

$$\Rightarrow \qquad d_{TOD[NM]} \approx \frac{\Delta FL}{3}$$

This is the formula in use by LH and the LBA.

On the other hand

$$d_{TOD[NM]} \approx \frac{\Delta ALT_{[ft]}}{300} = \frac{1}{3} \cdot \frac{\Delta ALT_{[ft]}}{100} \approx \frac{3}{10} \cdot \frac{\Delta ALT_{[ft]}}{100}$$

because

$$\frac{1}{3} = 0.333... \approx 0.3 = \frac{3}{10}$$

Therefore ATCA uses

$$d_{TOD[NM]} \approx \frac{\Delta ALT_{[ft]}}{1000} \cdot 3$$

1.7 Distance of Lead (DoL)

$$DoL = GS \cdot R$$

where R = 20[sec] is the SRT radius in time distance.
Because

$$20[sec] = \frac{1}{3}[min] \approx \frac{3}{10}[min] = \frac{3}{10} \cdot \frac{1}{60}[h] = \frac{1}{200}[h]$$

$$\Rightarrow \qquad DoL_{[NM]} \approx \frac{GS_{[kt]}}{200} = \frac{GS_{[kt]}}{2} : 100$$

or: The DoL in NM is approximately a $\frac{1}{2}\%$ of the value of the GS in kt.

2 Quellen

References

[1] Wolf Scheuermann
Lufthansa Flight Training (LFT) GmbH
(Preliminary Text) Instrument Flight Procedures
v1.3, BW and other remarks included
Bremen April 2015