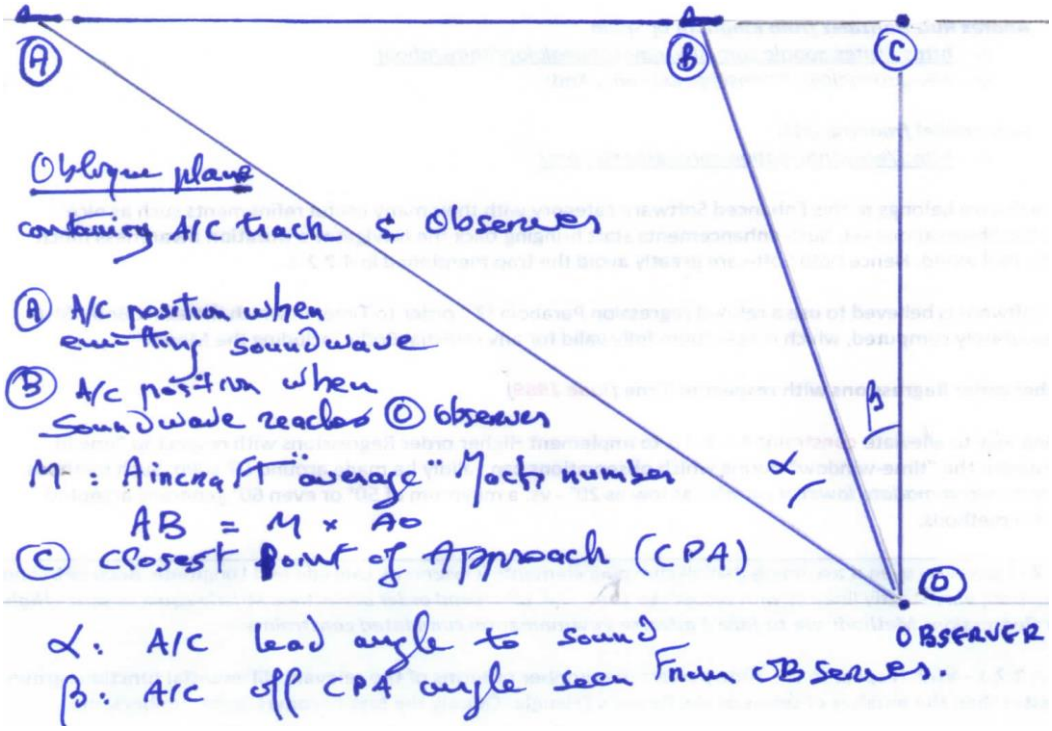
211015 - Aircraft lead-angle and lead-distance to its sound

The **A/C** flies level at a **given Subsonic Mach** and the **sound velocity** remains **constant at all altitudes**.



The aircraft lead-angle "**α**" and lead-distance "**AB**" to its sound are defined by the following 3 parameters measured in the **plane** containing the **Observer** Ⓞ and the **A/C track** (generally *an oblique/slant plane*):

AO : *Slant* distance covered by the sound wave from A/C initial position Ⓐ to **Observer** Ⓞ

OC : **A/C track CPA** (Closest Point of Approach) to **Observer** Ⓞ, generally a *slant* distance.

M : **A/C Mach Number**.Then:

(1): AB = AO x M **(2): (α + β) = acos (OC/OA)** **(3): AC = AO sin (α + β)**

(4): BC = AC - AB **(5): β = atan (BC/OC)** **(6): α = (α + β) - β**

A FEW EXAMPLES

All distances in the ***same units***, *here in km* with FL330 overhead: CPA=10.058 km, and FL330 with 10 km offset : CPA=14.183 km

For a given geometric configuration, results are irrespective of actual speed of sound and depend only on Mach Number.

M : Mach = 0.6 (asin Mach = 37°)				**Mach = 0.7 (asin Mach = 44°)**			
	⇤ ← ← ← ← Max hearing range → → → → ⇥				⇤ ← ← ← ← Max hearing range → → → → ⇥		
↓CPA↓	**20**	**15**	**10**	**↓CPA↓**	**20**	**15**	**10**
15	AB=12.0, α=37°, β=-5°	AB=9.0, α=31°, β=31°	-------	**15**	AB=14.0, α=44°, β=3°	AB=10.5, α=35°, β=35°	-------
14.183	AB=12.0, α=36°, β=-8°	AB=9.0, α=35°, β=16°	-------	**14.183**	AB=14.0, α=44°, β=0°	AB=10.5, α=41°, β=22°	-------
10.058	AB=12.0, α=32°, β=-28°	AB=9.0, α=36°, β=-12°	-------	**10.058**	AB=14.0, α=42° β=-18°	AB=10.5, α=44°, β=-4°	-------
8	AB=12.0, α=28°, β=-38°	AB=9.0, α=33°, β=-25°	AB=-6.0, α=37°, β=0.0°	**8**	AB=14.0, α=38° β=-28°	AB=10.5, α=42°, β=-15°	AB=7.0, α=44°, β=7°
5	AB=12.0, α=20°, β=-56°	AB=9.0, α=25°, β=-46°	AB=6.0, α=32°, β=-28°	**5**	AB=14.0, α=29° β=-47°	AB=10.5, α=34°, β=-36°	AB=7.0, α=42°, β=-18°
M : Mach = 0.8 (asin Mach = 53°)				**Mach = 0.9 (asin Mach = 64°)**			
	⇤ ← ← ← ← Max hearing range → → → → ⇥				⇤ ← ← ← ← Max hearing range → → → → ⇥		
↓CPA↓	**20**	**15**	**10**	**↓CPA↓**	**20**	**15**	**10**
15	AB=16.0, α=52°, β=10°	AB=12.0, α=39°, β=39°	-------	**15**	AB=18.0, α=59°, β=18°	AB=13.5, α=42°, β=42°	-------
14.183	AB=16.0, α=52°, β=8°	AB=12.0, α=46°, β=27°	-------	**14.183**	AB=18.0, α=60°, β=15°	AB=13.5, α=50°, β=31°	-------
10.058	AB=16.0 , α=53°, β=-7°	AB=12.0, α=53°, β=5°	-------	**10.058**	AB=18.0, α=64°, β=4°	AB=13.5, α=61°, β=13°	-------
8	AB=16.0, α=50°, β=-16°	AB=12.0, α=53°, β=-5°	AB=8.0, α=51°, β=14°	**8**	AB=18.0, α=64°, β=-2°	AB=13.5, α=64°, β=6°	AB=9.0, α=57°, β=21°
5	AB=16.0, α=42°, β=-34°	AB=12.0, α=47°, β=-23°	AB=8.0, α=52°, β=-8°	**5**	AB=18.0, α=60° β=-15°	AB=13.5, α=63°, β=-7°	AB=9.0, α=64°, β=4°

Remark: As we could expect, when A/C is close from abeam position - i.e. **|β|<12° -** , then **α ≅ asin (Mach)**

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