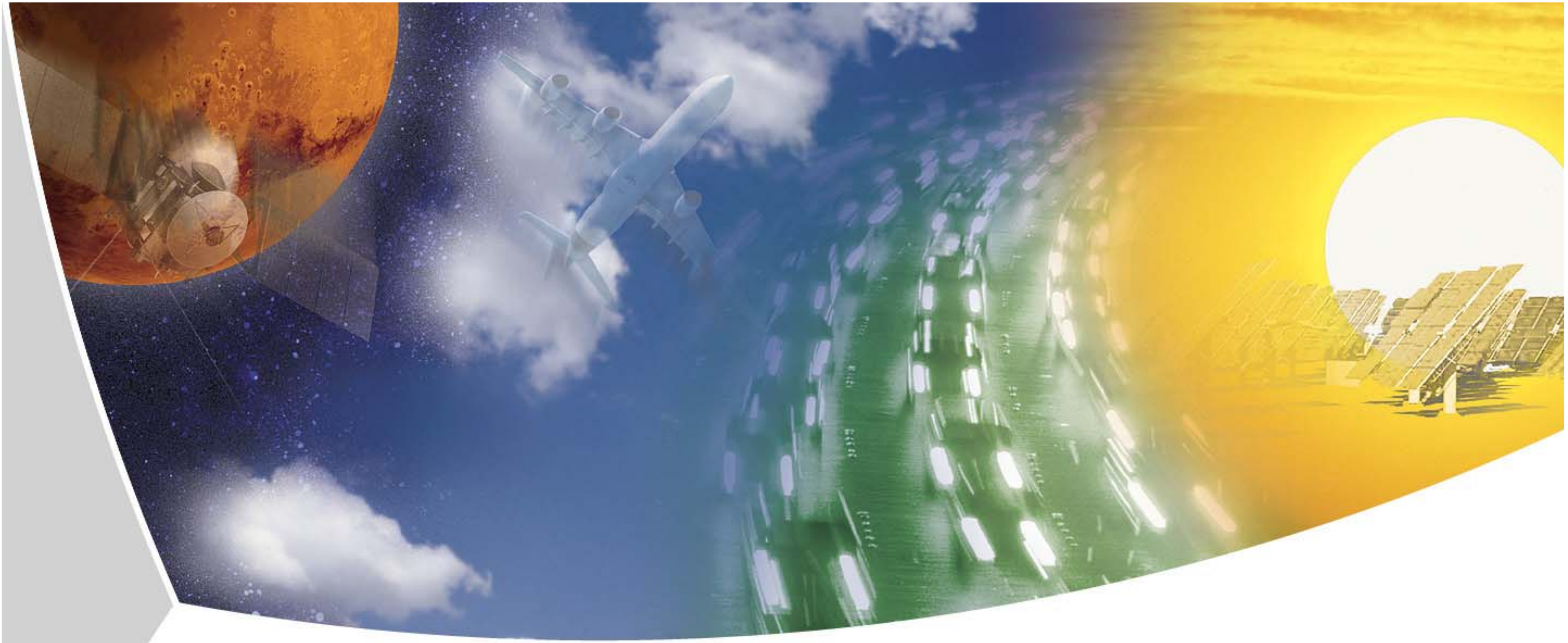

A comparing overview on ECAC Doc.29 3rd Edition and the new German AzB

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Doc.29 Vol.3 vs. AzB- 2008

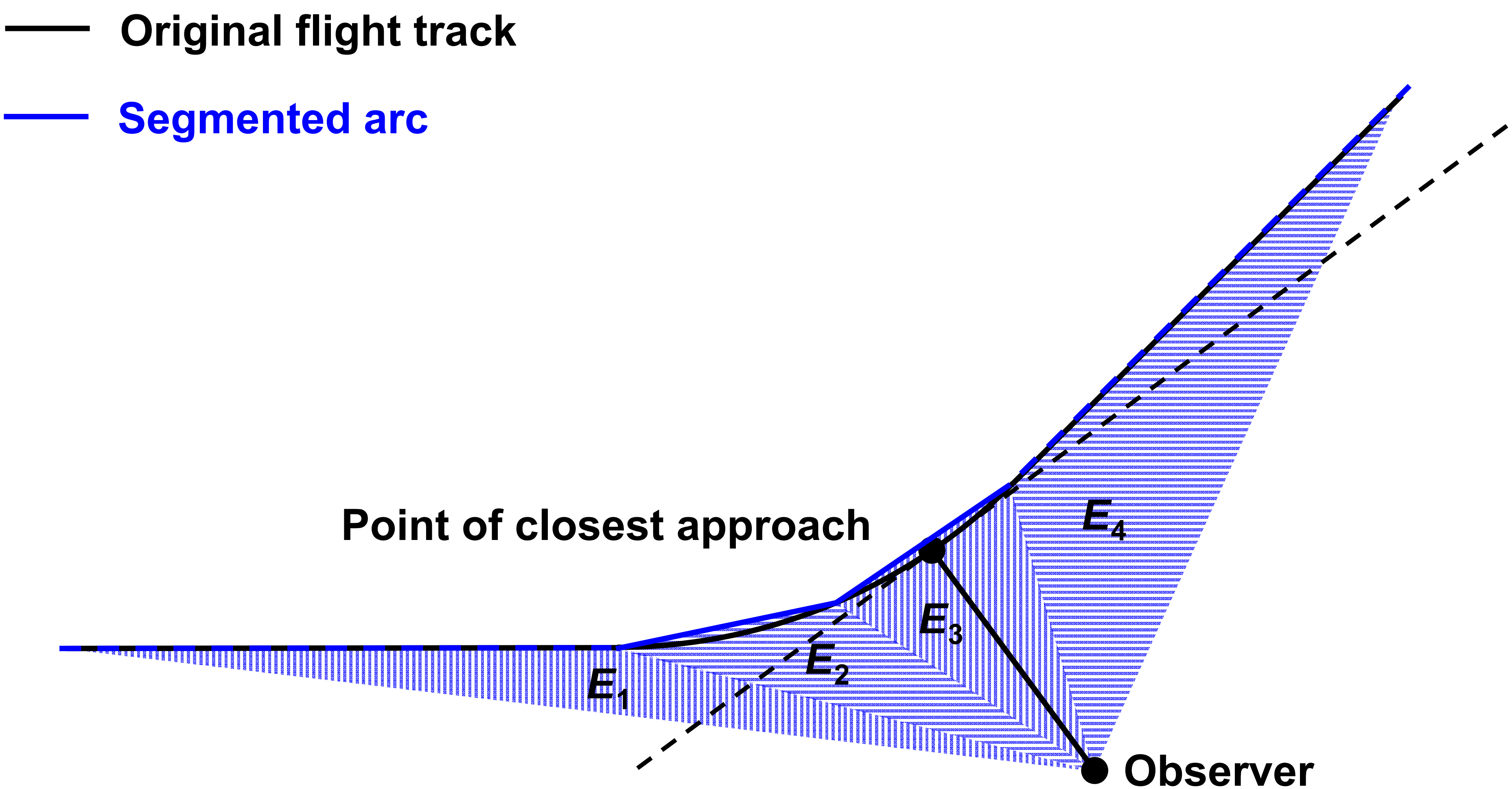
	Doc.29 3rd Edition	AzB-2008
Model Type	Segmentation model with specific improvements	Segmentation depending on receiver location
Emission Data	NPD-data and spectral classes	Octave spectra
Directivity	Semi-empirical dipole model with correction for installation effects	Spectral 2-dimensional directivity function
Aircraft Categories	Airframe/engine combinations	Limited number of aircraft groups
Performance Data	Procedural profiles	Predefined fixed-point profiles
Lateral Spreading	7 subtracks (recommended)	15 subtracks (prescribed)
Receiver Height	-	Solid angle correction (ISO 9613-2)
Topography	Only altitude effect on propagation distance	
Reverse Thrust	AzB adapted the Doc.29 model	
Ground Noise	-	Taxiiing and APU
Field of Application	Civil airports / Flexible	All airports / Primarily Forecast

Segmentation model

AzB: 2-step segmentation with additional segmentation step depending on aircraft-observer-geometry

Doc.29: Classical 2-step flight path segmentation with specific improvements

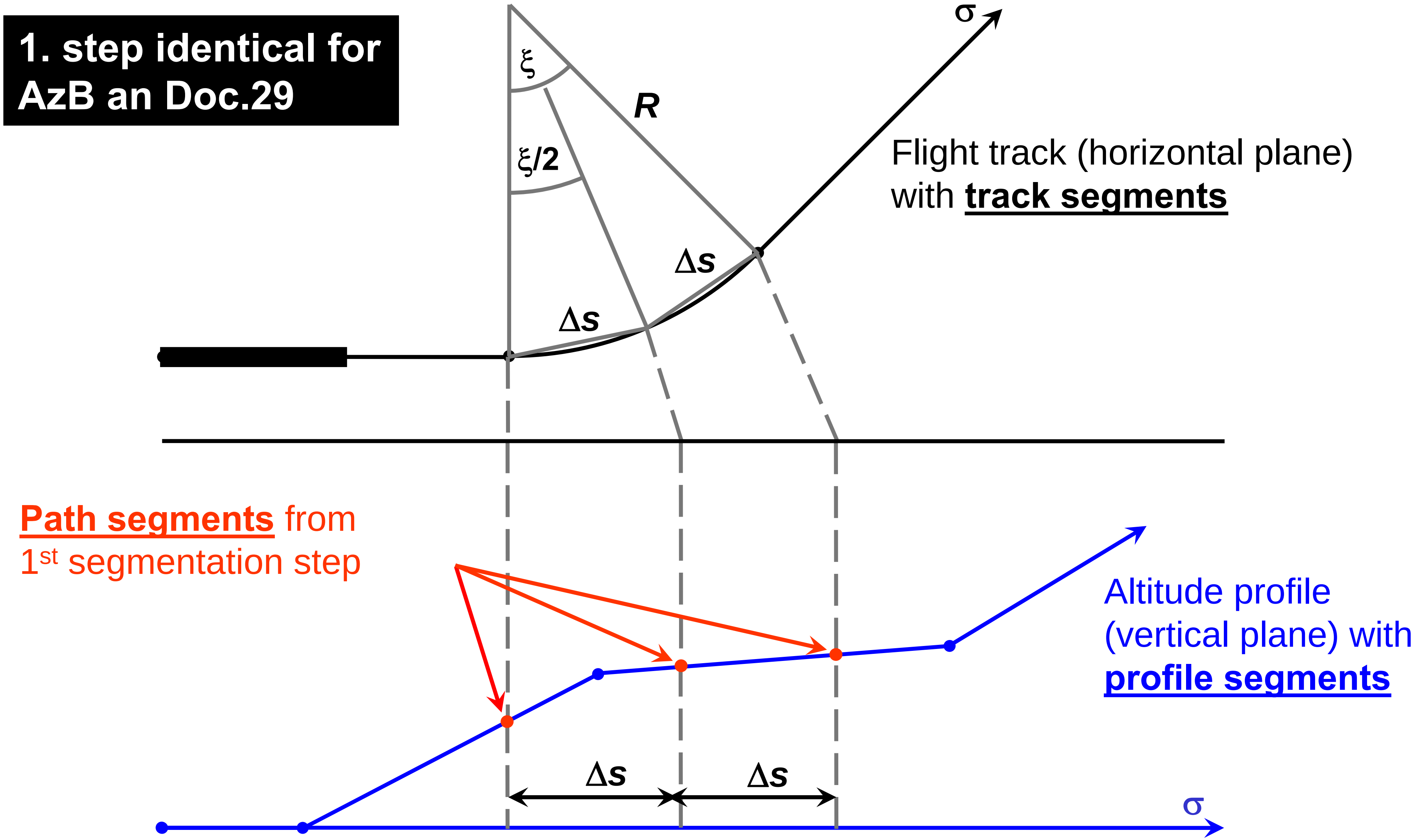
Principle of Segmentation



Total exposition $E = \sum E_i$

Flight path segmentation: 1. Step

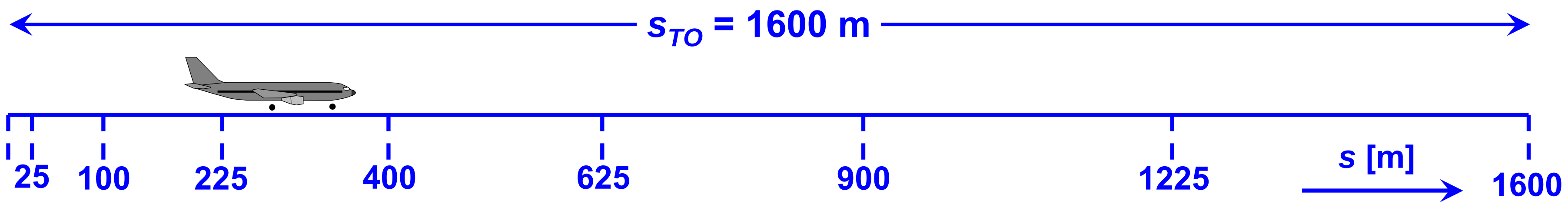
1. step identical for AzB an Doc.29



Flight path segmentation: 2. Step (Doc.29)

T/O-Roll segment :

- Segmentation in fixed time intervals (const. acceleration)
- Improved comparability to simulation



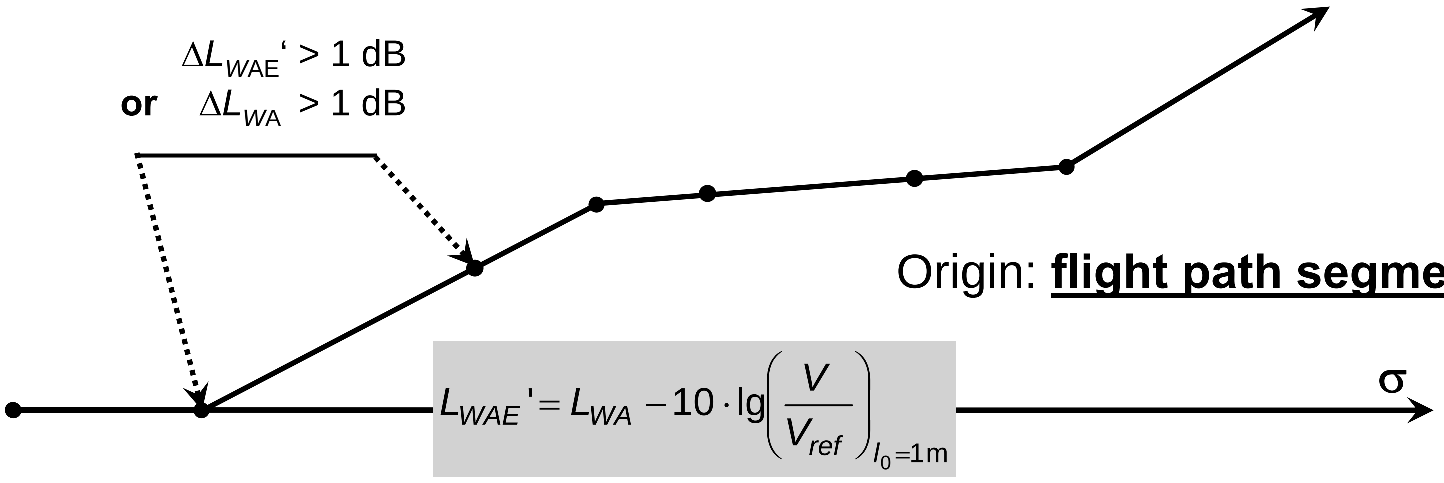
Airborne segments:

- Removal of points located close to each other
- Segmentation of long segments with great changes in aircraft speed

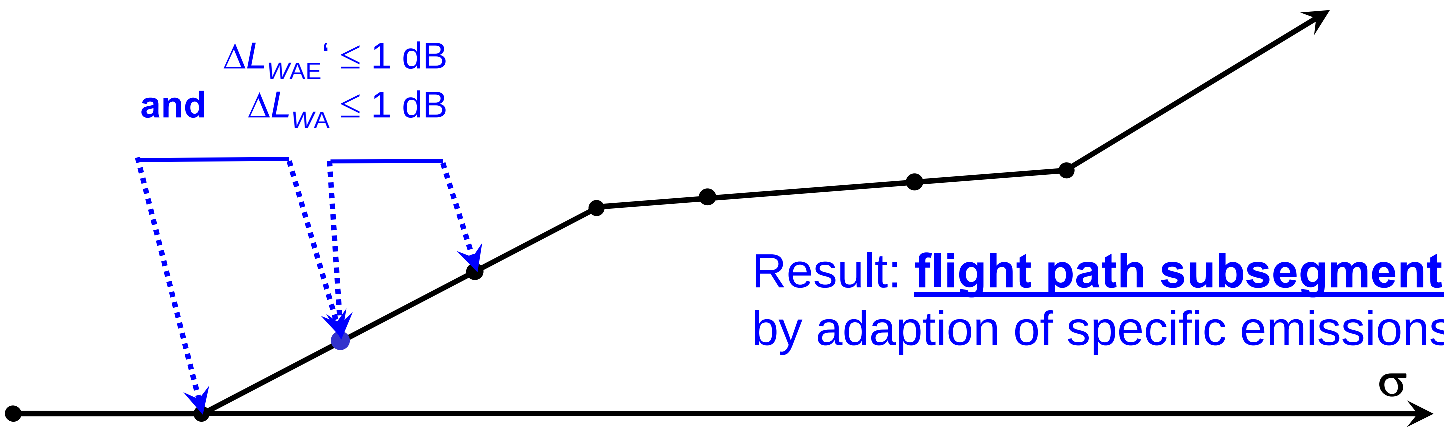
Transition segments adjacent to curved flight tracks

- Removal of discontinuities due to effects of bank angle

Flight path segmentation: 2. Step (AzB)

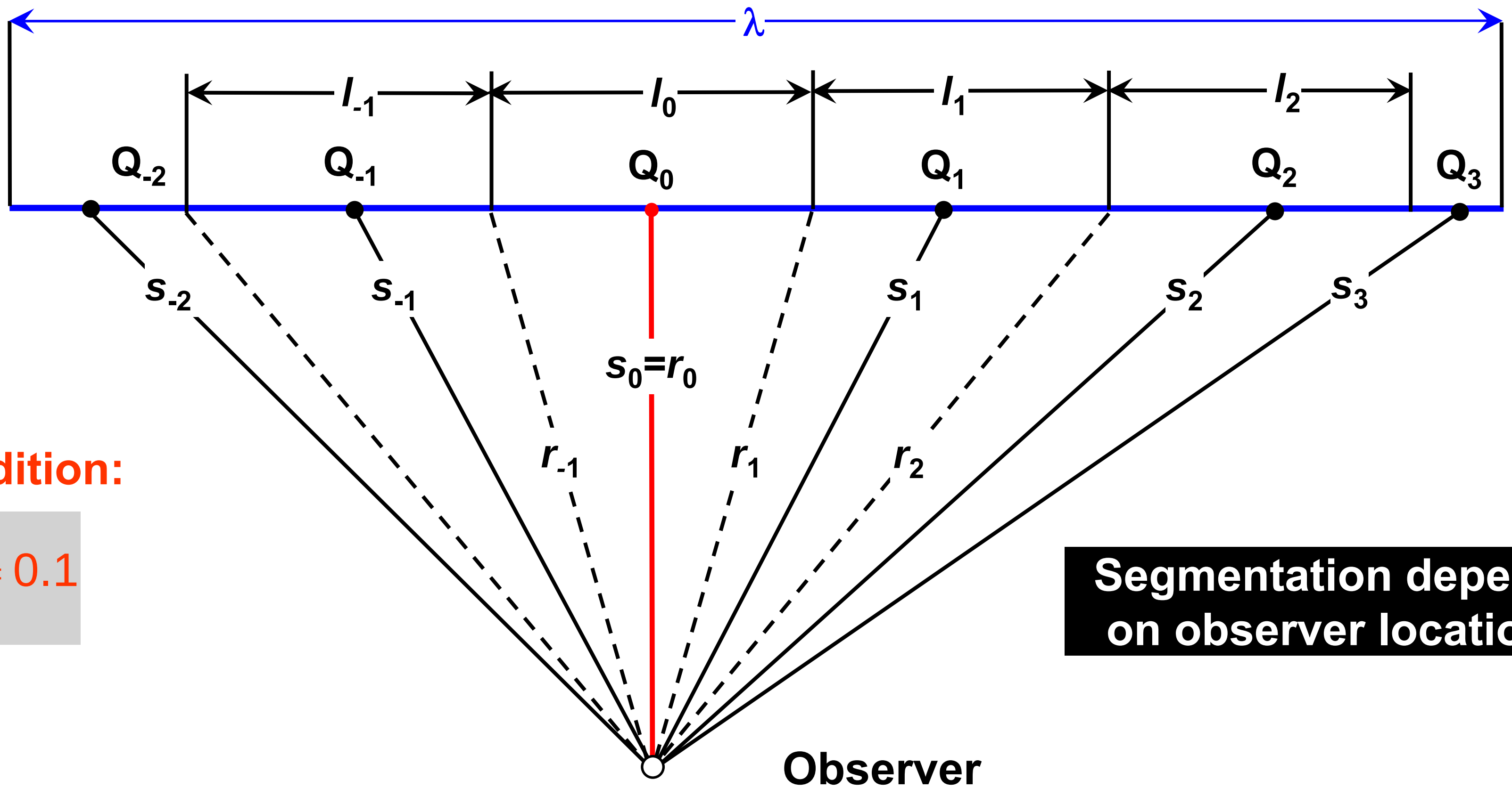


$$L_{WAE}' = L_{WA} - 10 \cdot \lg\left(\frac{V}{V_{ref}}\right)_{l_0=1\mathrm{m}}$$



Flight path segmentation: 3. Step (AzB)

- Flight path subsegment of length λ is subdivided in final segments of length l_i
- Subdivision starts at point of closest approach Q_0
- Final segments are represented by point sources Q_i



Condition:

$$\frac{l_i}{r_i} = 0.1$$

Segmentation depends on observer location !

Source model

AzB: - Octave spectra
- Spectral 2D directivitiy (directivity factors)

Doc.29: - NPD data based on spectral classes
- Semi-empirical 2D dipole model
- Lateral directivity from installation effects

Example of AzB-2008 approach data set

Acoustical data

n	(1) O_n [dB]	(2) R_n
1	68,0	{0,0,0}
2	76,0	{0,0,0}
3	74,0	{0,0,0}
4	75,0	{0,0,0}
5	72,5	{0,0,0}
6	69,5	{0,0,0}
7	70,0	{0,0,0}
8	56,5	{0,0,0}

s_{On} = 300 m

(3) P_F: Landeschwelle

σ' [m]	(4) *Z* [dB]	(5) *V* [m/s]	(6) *H* [m]
-300 - S_V	-10	15	0
-400	5	60	0
-300	0	65	0
7400	0	75	-
X	-1	108	h_0
$X + S_z$	-1	108	h_0
σ' [m]	**d*Z*/dσ' [dB/m]**	**d*V*/dσ' [s^{-1}]**	**d*H*/dσ'**
> $X + S_z$	0	0	tan *w*

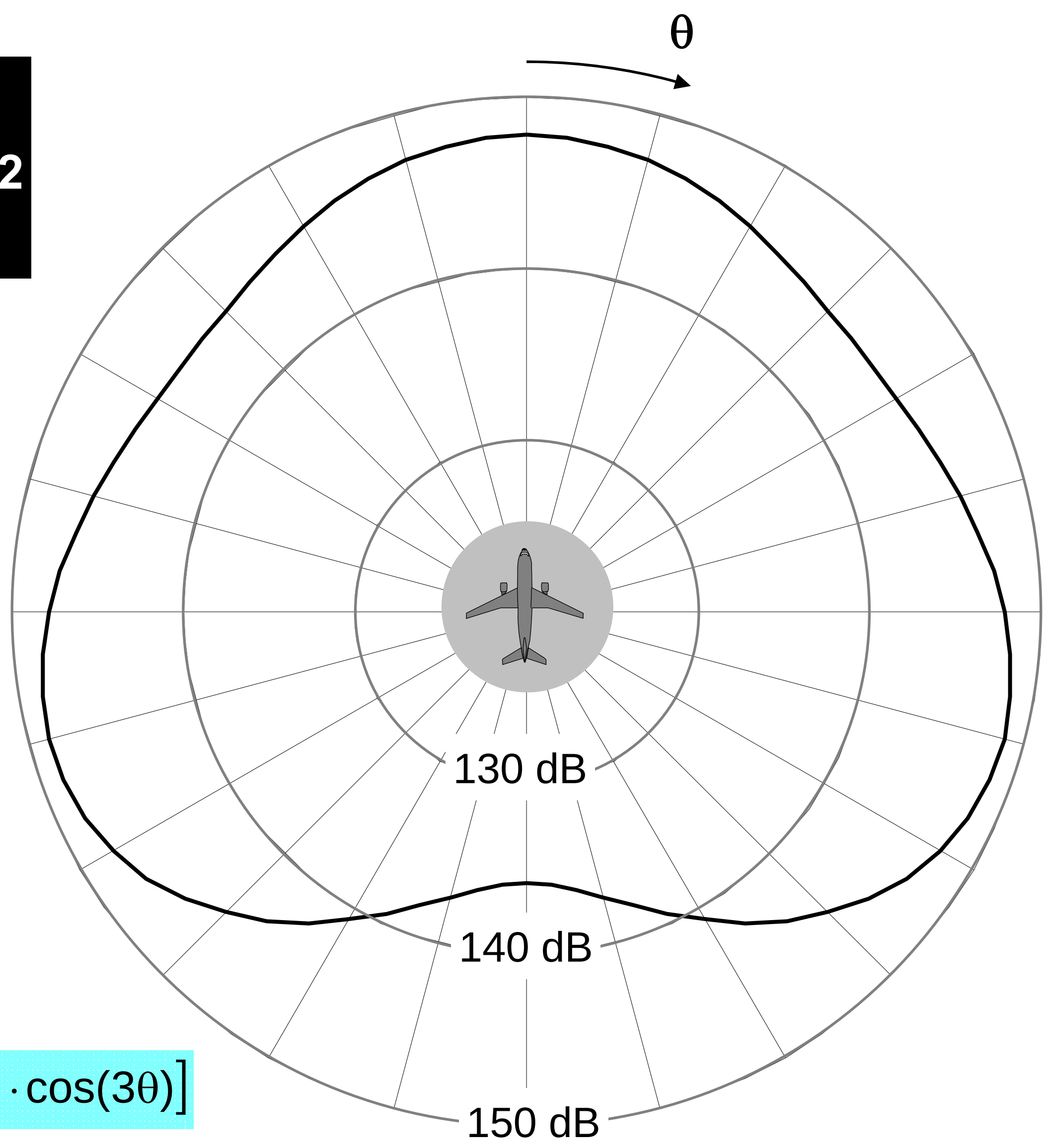
(7) h_Q = 1,4 m
(8) Q_σ = 3 dB
(9) S_V = 900 m

zugehörige APU-Klasse: APU 1 - L

$$X = \frac{h_0}{\tan w} - 300$$

Directivity according to AzB-2008

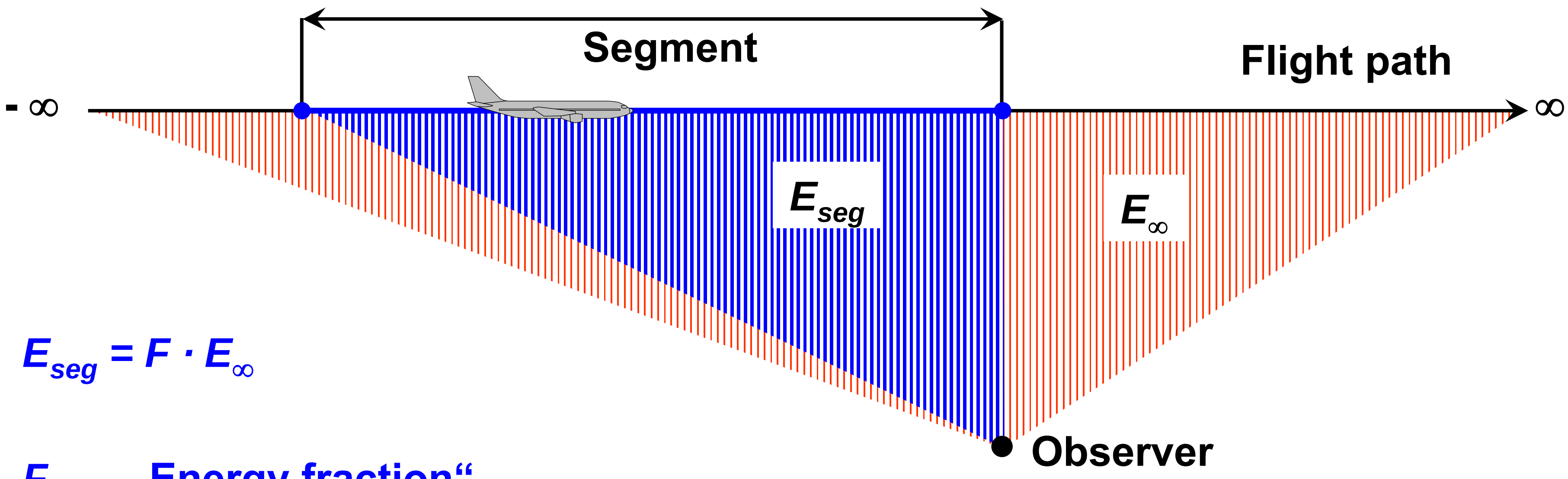
Directivity diagram $L_{WA}(\theta)$ for departure of aircraft category S5.2
R_n = { 1 , -1, 1 }



Representation of spectral directivity by series expansion in cosine of radiation angle θ

$$D^{*}_{l,n}(\theta) = 3 \cdot \left[a_1 \cdot \cos(\theta) + a_2 \cdot \cos(2\theta) + a_3 \cdot \cos(3\theta)\right]$$

Source model of Doc.29

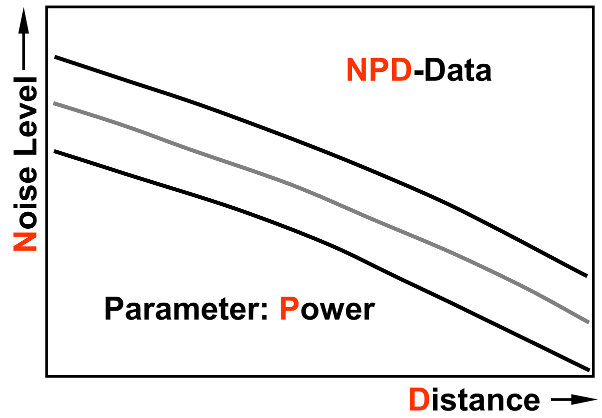


$$E_{seg} = F \cdot E_{\infty}$$

F „Energy fraction“

E_{seg} Segment contribution to exposure

E_{∞} Exposure from infinite segment



Approach: „4th-power-90°-dipole-model“ $p^2 \sim \sin^2\theta / d^2 \sim d^{-4}$

The principle of the „scaled distance"

Problem:

- The energy fraction is derived from the analytical dipole-model.
- The NPD-data are derived from measurements (i.e. from real directivities).

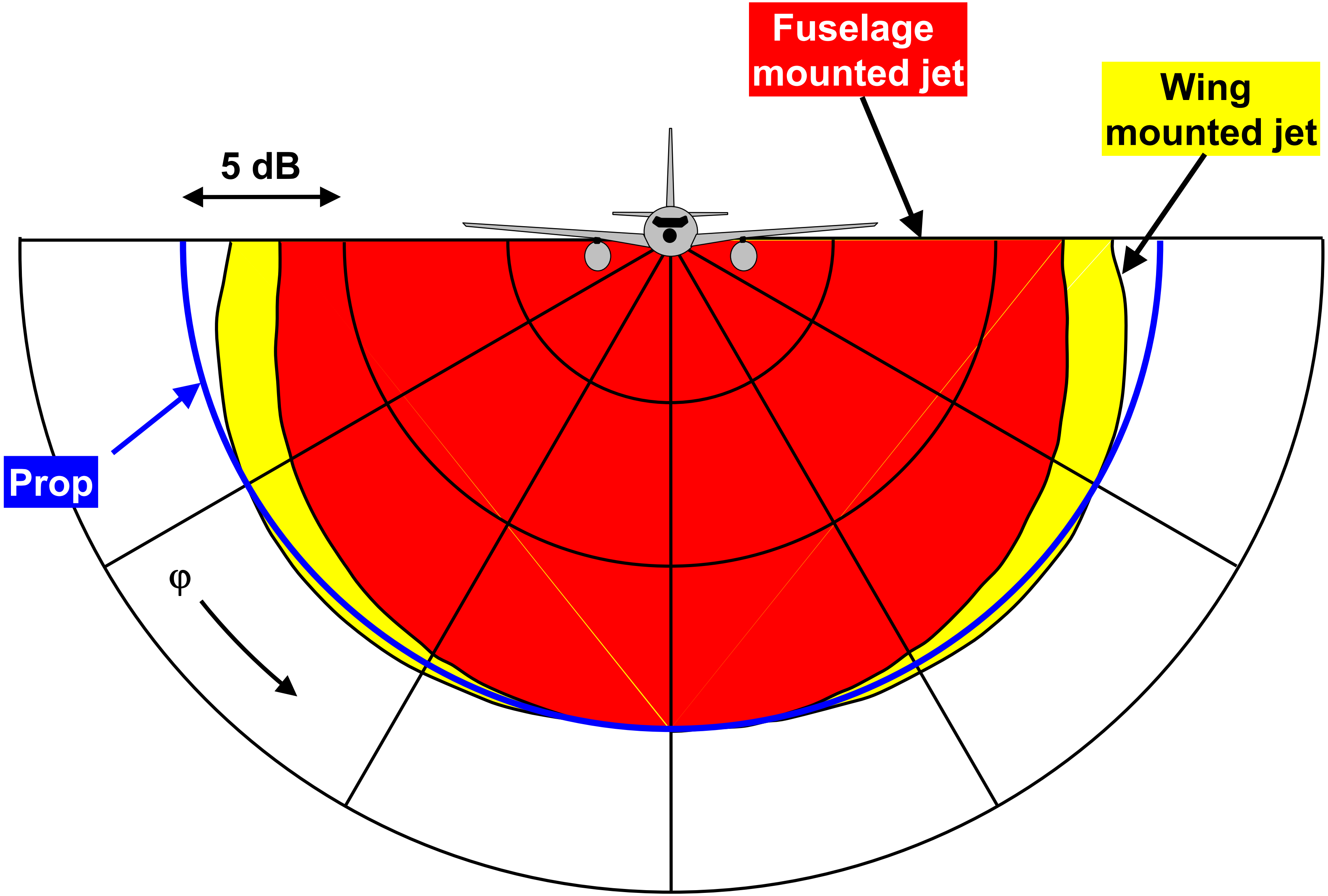
⇒ The differences $\Delta L = L_{E,\infty}(V) - L_{max}$ are not the same: $\Delta L_{Dipole} \neq \Delta L_{NPD}$

Solution:

- A „scaled distance d_λ" is introduced: $\Delta L_{Dipole}(d_\lambda) = \Delta L_{NPD}(d_\lambda)$
- The energy fraction is calculated for the scaled distance, not for the slant-distance.

The real directivity is modelled by a modified propagation distance.
⇒ The analytical model changes to a semi-empirical one !

Installation effect (lateral directivity, only Doc.29)



Propagation models

Both models account for

- geometrical spreading,
- atmospheric absorption and
- ground effect.

AzB: Explicit modelling of propagation effects

Doc.29: Geometrical spreading and atmospheric absorption implicit modelled by NPD

$\Rightarrow$ Changed atmospheric conditions require recalculation of NPD data

Excess attenuation

AzB:
- Ground effect correction
- Solid angle correction

⇒ Allowance for receiver height

Doc.29:
- Ground effect correction
- Engine installation correction

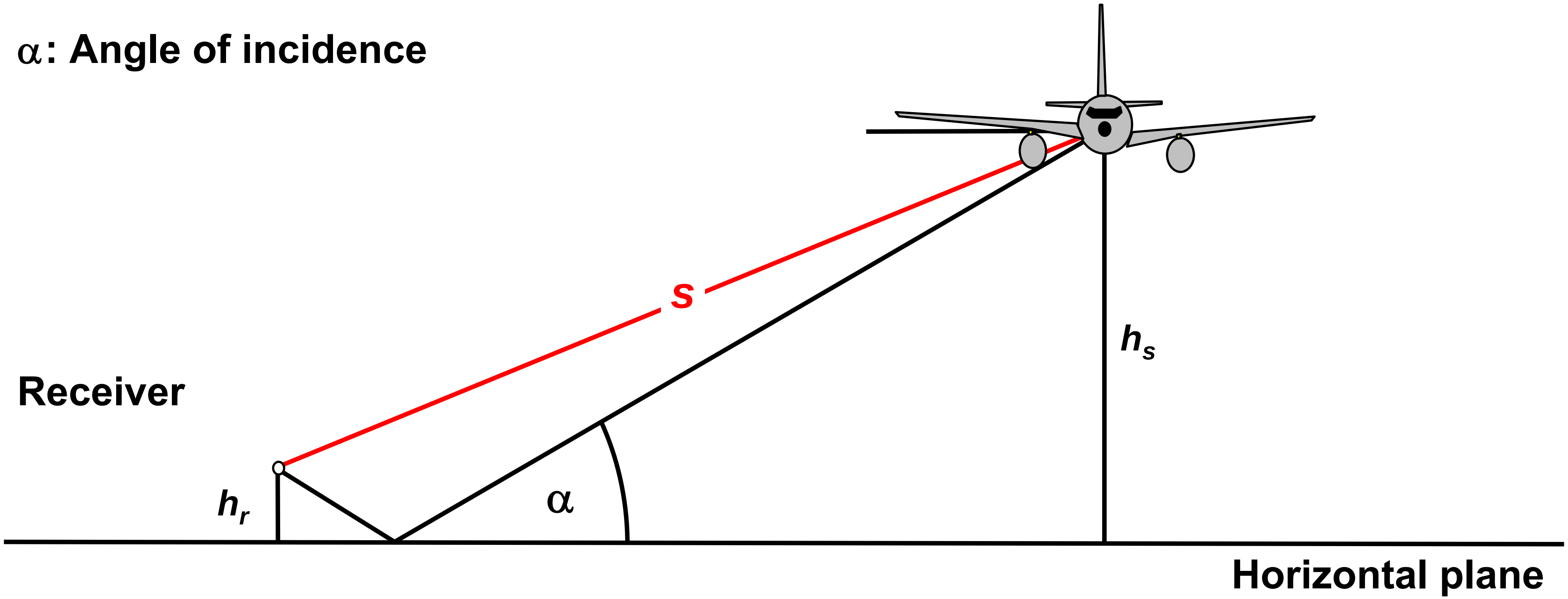
⇒ Receiver on the ground

Ground effect correction (AzB-2008)

Ground effect correction: $D_{Z,n} = f(\alpha) \cdot g(s)$ (spectral)

Solid angle correction: $D_{\Omega} = f(s,h_s,h_r)$

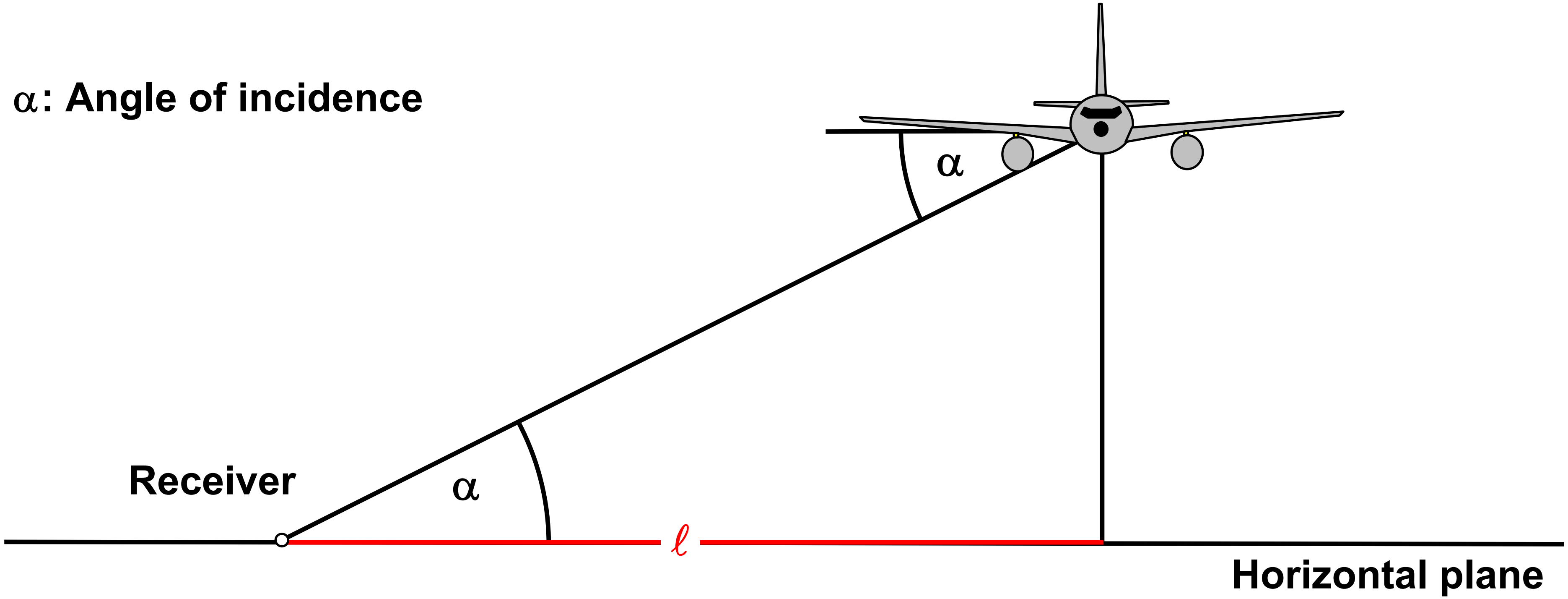
α: Angle of incidence



Ground effect correction (Doc.29)

Ground effect correction: $\Lambda = f(\alpha) \cdot g(\ell)$

α: Angle of incidence



Ground effect and installation correction (Doc.29)

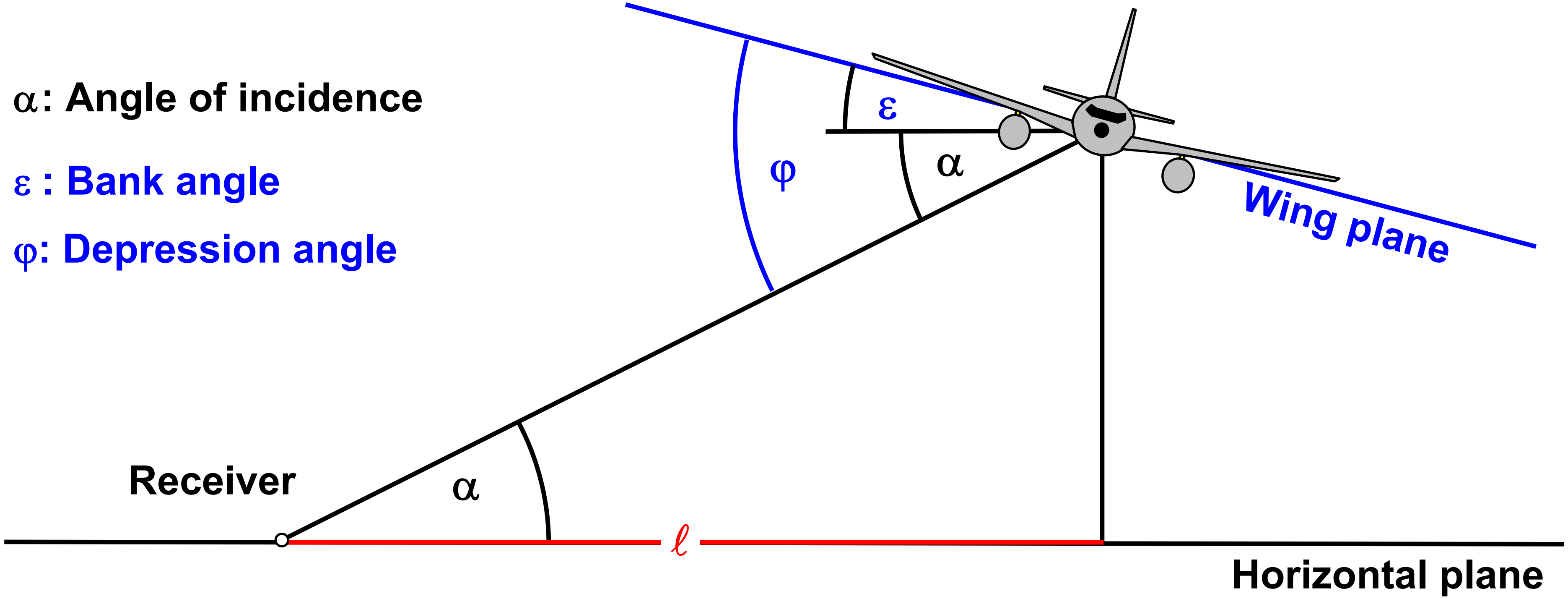
Ground effect correction: $\Lambda = f(\alpha) \cdot g(\ell)$ ⇒ **(propagation effect)**

Installation correction: $\Delta_{Inst} = \Delta_{Inst}(\varphi)$ ⇒ **(source property)**

α: **Angle of incidence**

ε : **Bank angle**

φ: **Depression angle**



Aircraft categories and flight profiles

AzB:
- Limited number of aircraft groups (23 civil, 8 military, 5 helicopter)
- Unambiguous rules for grouping
- Fixed flight profiles
- Grouping according to „acoustic equivalence"

Doc.29:
- Large number of airframe/engine combinations (123+ civil commercial, extensible)
- Procedural flight profiles
- Substitution rules for aircraft not in database

Flight path definition

Flight track segments

Flight profile segments

→ Flight path segments

Standard profiles (AzB):

- Fixed Profile segments
- Performance parameters as function of distance from brake release / landing threshold

➢ simple but not flexible

Procedural profiles (Doc.29):

- Variable profile segments
- Performance parameters as function of procedural step of flight procedure and aircraft mass

➢ flexible but complex

Example of AzB-2008 approach data set

n	(1) O_n [dB]	(2) R_n
1	68,0	{0,0,0}
2	76,0	{0,0,0}
3	74,0	{0,0,0}
4	75,0	{0,0,0}
5	72,5	{0,0,0}
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s_{On} = 300 m

(3) P_F: Landeschwelle

σ' [m]	(4) Z [dB]	(5) V [m/s]	(6) H [m]
-300 - S_V	-10	15	0
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-300	0	65	0
7400	0	75	-
X	-1	108	h_0
$X + S_z$	-1	108	h_0
σ' [m]	**dZ/dσ' [dB/m]**	**dV/dσ' [s^{-1}]**	**dH/dσ'**
> $X + S_z$	0	0	tan w

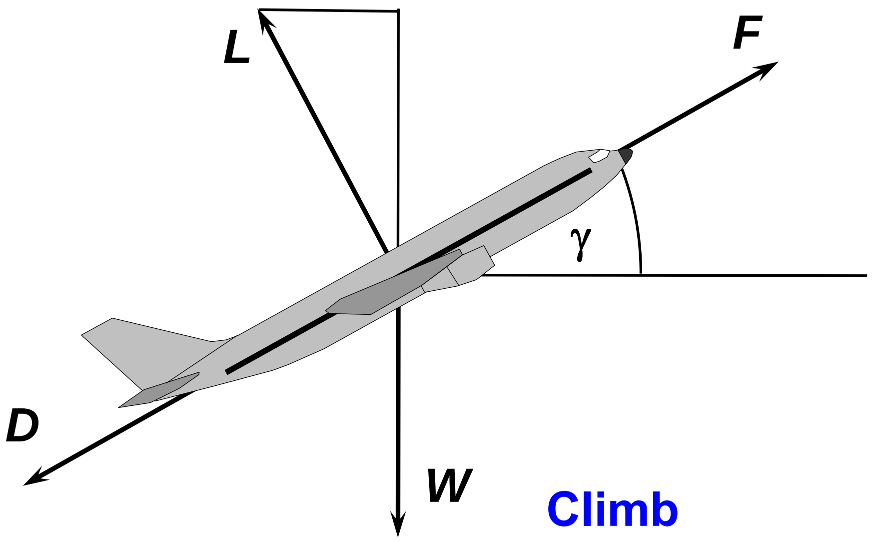
(7) h_Q = 1,4 m
(8) Q_σ = 3 dB
(9) S_V = 900 m

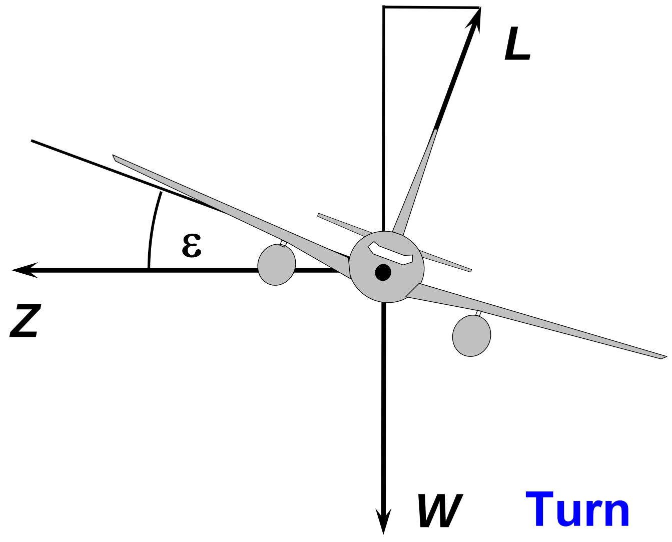
zugehörige APU-Klasse: APU 1 - L

$$X = \frac{h_0}{\tan w} - 300$$

Performance data (fixed point profile)

Procedural profiles: mass point model



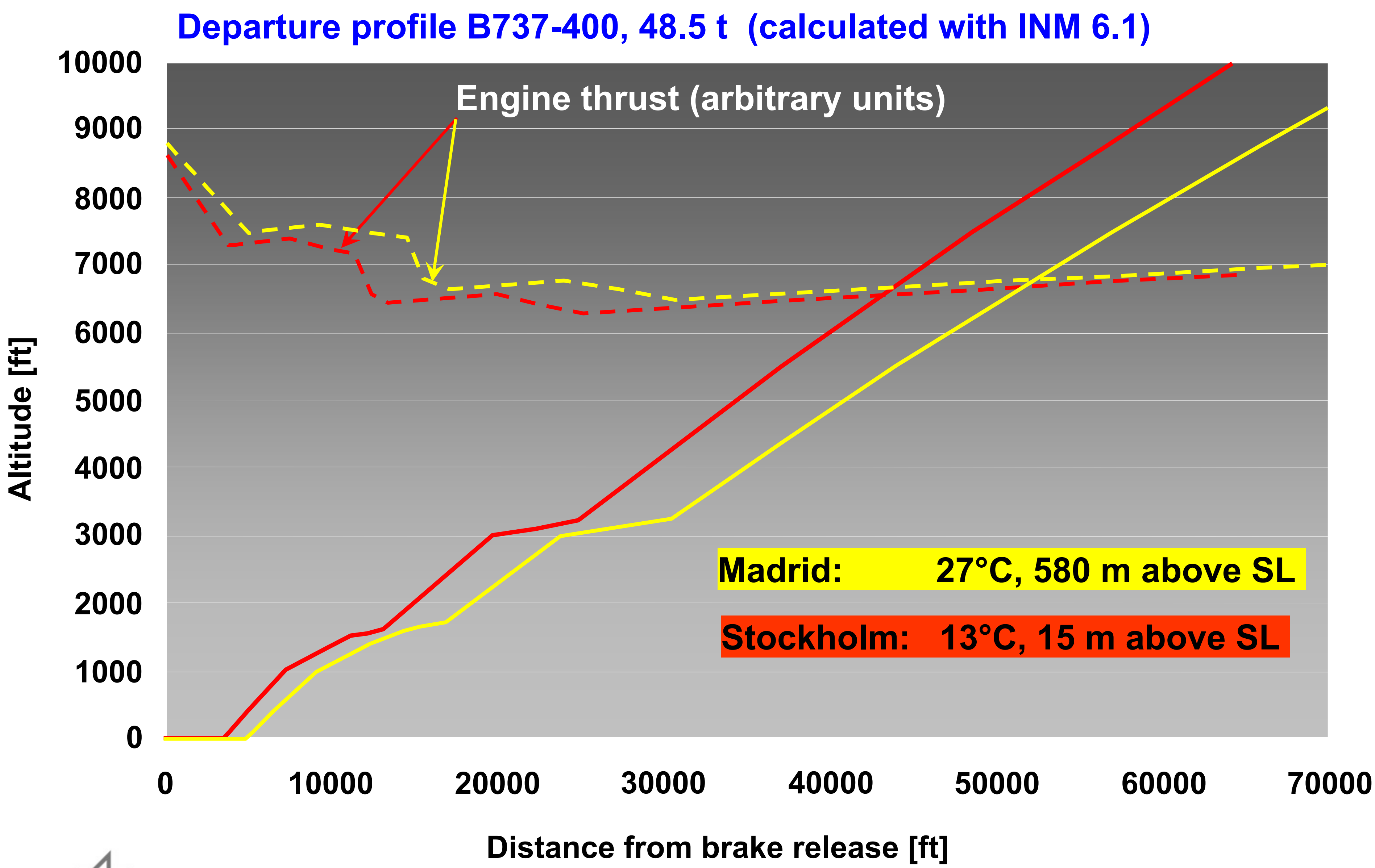


L : Lift
W : Weight
D : Drag
F : Thrust
γ : Climb angle

Z : Centrifugal force
ε : Bank angle

Lift and drag are estimated from the coefficients c_L and c_D .

Example for procedural flight profiles



Grouping criteria for AzB database

Acoustic equivalence:

„Two aircraft are acoustic equivalent in case that they produce similar noise footprints along the noise-relevant part of the flight path.“|

⇒ They can be assigned to the same aircraft group.

Noise significance:

„A noise significant aircraft co-determines considerably the noise situation in the vicinity of an airport (i.e. considerable changes in number of movements induce considerable noise changes).“

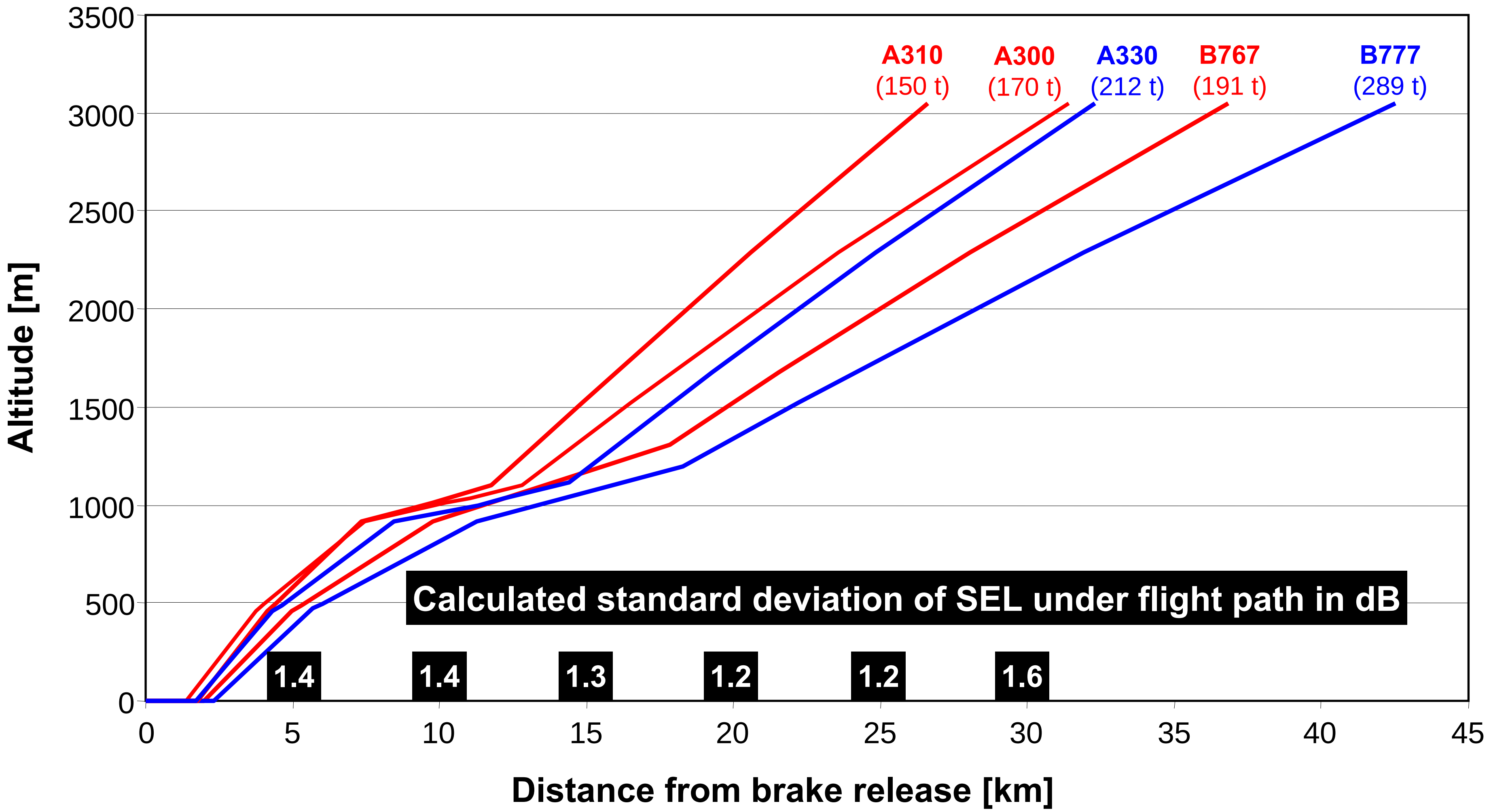
⇒ A noise significant aircraft must be modelled as precise as possible.

⇒ A separate group has to be created for it in case that there are no acoustic equivalent aircraft.

⇒ Noise insignificant aircraft can be grouped disregarding acoustic equivalence.

Example of acoustic equivalence: AzB-Group S6.1

Departure profiles for ICAO-A-procedure (calculation with INM 6.2)



Comparison of type mix for the main AzB-groups

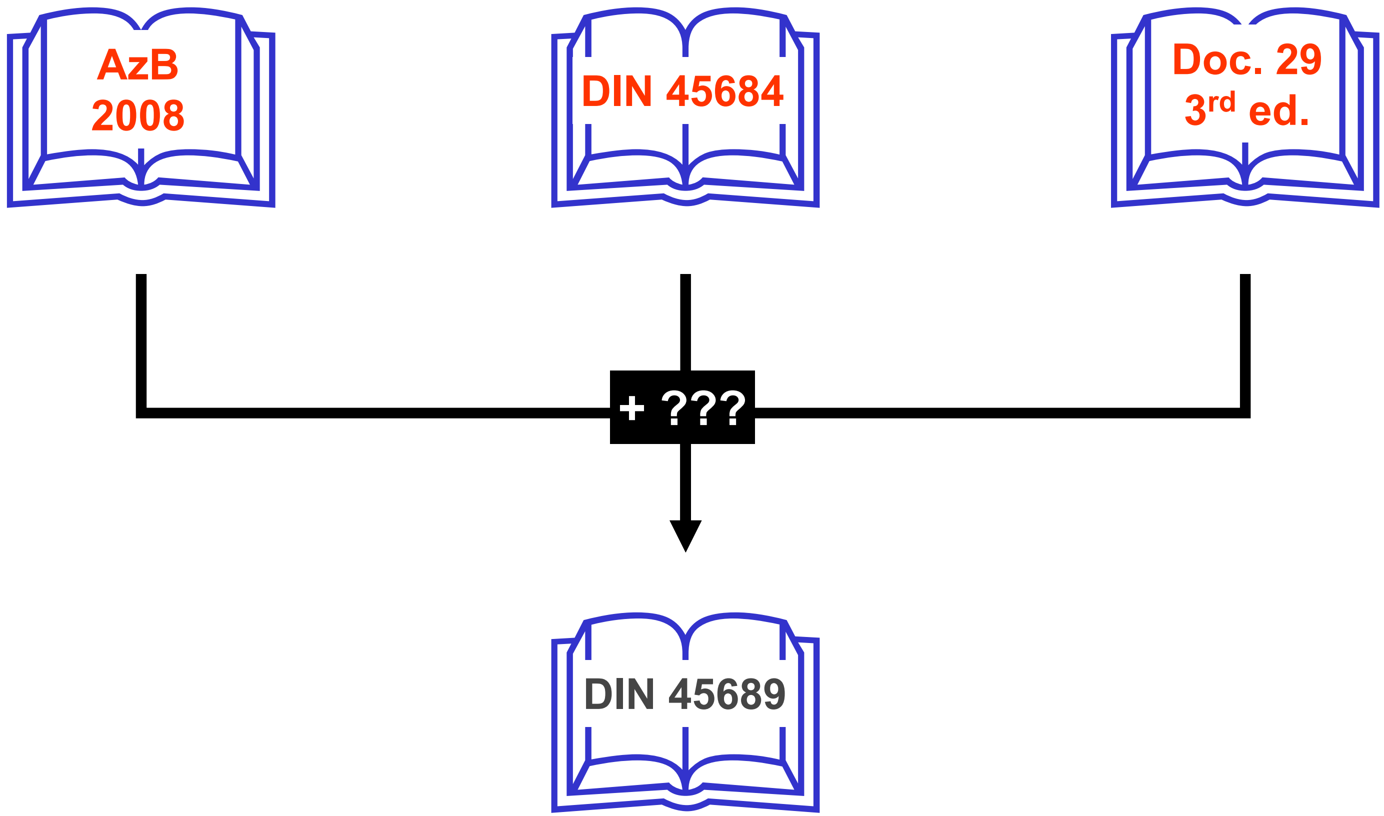
AzB-Group	Aircraft	Germany 2005 (5 airports)	Zurich 2007
S5.1	Avro RJ, Bae146	27%	51%
	Canadair RJ	48%	8%
	Fokker 70/100	13%	14%
	other	12%	27%
S5.2	A318..A321	48%	76%
	B737	48%	21%
	other	4%	3%
S6.1	A300	37%	> 1%
	A310	8%	1%
	A330	24%	59%
	B767	22%	33%
	B777	9%	7%

Summary

- Both models use a segmentation algorithm, whereas the AzB implements an additional step depending on observer location.
- From an acoustical view the AzB uses a more detailled algorithm (spectral calculation, non-generalised directivity) that is flexible with respect to a future expansion.
- Doc.29 provides much more flexibility in generating flight paths.
- The AzB is primarily designed for forecasts (grouping). Doc.29 provides more functionality, e.g. for what-if-studies (noise mitigation studies, effects of noise abatement flight procedures).
- The AzB covers additionally military and general aviation as well as helicopters and some ground operations.

However both models are in principle easily extensible (AzB with respect to operational aspects, Doc.29 with respect to other fields of application).

The next step: DIN 45689



- Work starts in 2010 (1st special meeting on radar data January 26).
- 3 – 5 years of development expected

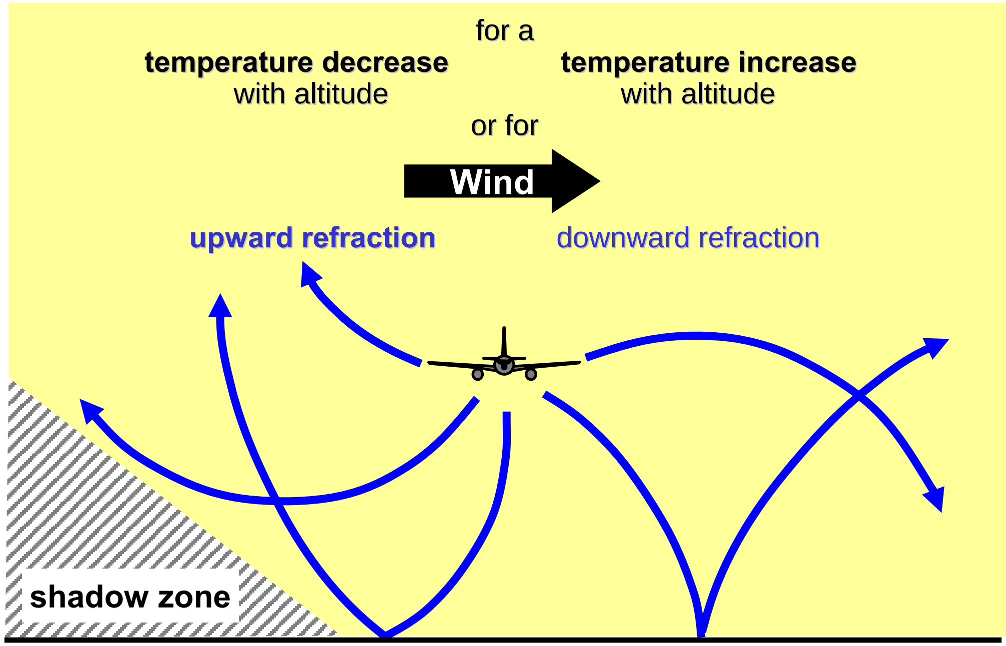
Problems to be discussed

… propagation modelling
for aircraft noise

Workpackage 4 of DLR project „Quiet Air Traffic II“

Problem: Conventional noise calculation procedures account only for standardised weather conditions (isotropic atmosphere, no wind)

Reality



Question: What is the error introduced by this simplifying assumption ?

Analysis of meteorological data (Hahn Airport, 2001)

Classification used by the DLR-IPA sound propagation model

stability class SC	stable			neutral						unstable		
	1	2	3	4	5	6	7	8	9	10	11	12
$v_{W,10m}$ [m/s]	0	1	2	0	1	2	5	10	20	0	1	2
$\gamma_{Prandtl}$ [K/m]	+0.1			-0.01						-0.02		
γ_{Ekman} [K/m]	+0.05			-0.01						-0.01		

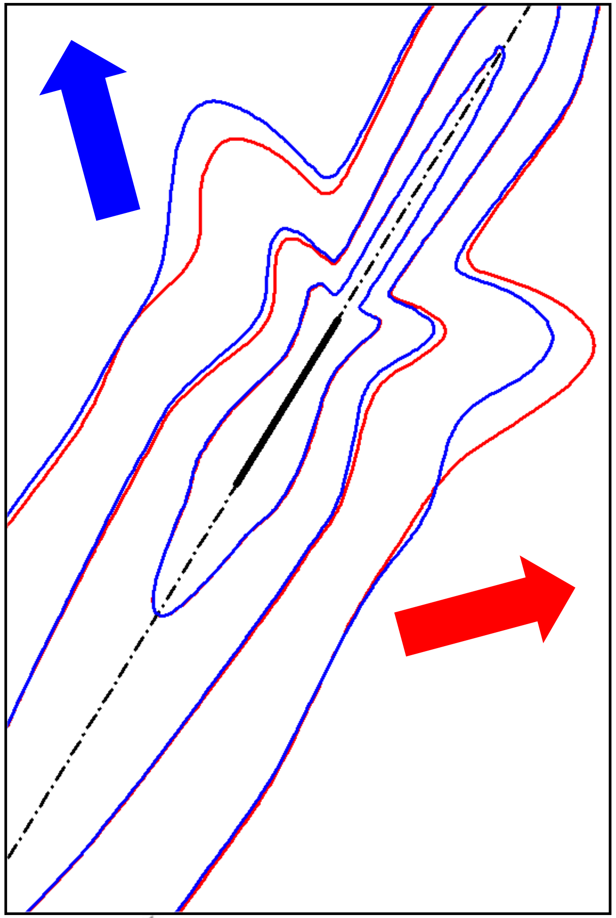
Distribution on wind direction and stability class

wind direction	percentage of occurrence during daytime in stability class											
	1	2	3	4	5	6	7	8	9	10	11	12
30° ⇒ 120°	-	0.8	2.1	-	-	1.3	7.6	0.0	-	-	0.3	2.3
120° ⇒ 210°	-	1.2	3.3	-	-	2.2	12.0	0.6	-	-	0.3	2.5
210° ⇒ 300°	-	0.6	2.5	-	-	2.6	34.1	4.0	-	-	0.4	2.4
300° ⇒ 30°	-	0.7	1.8	-	-	1.5	9.5	0.7	-	-	0.4	2.4

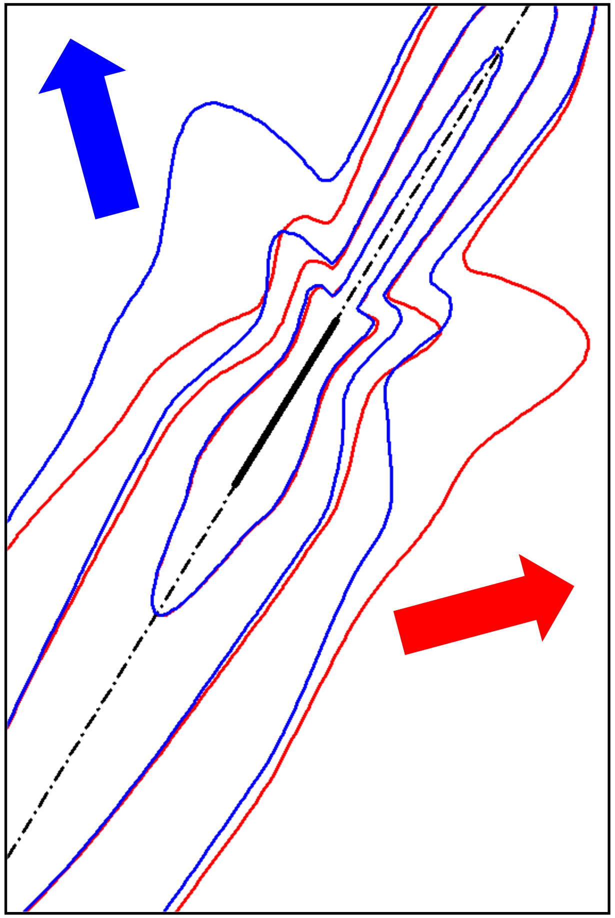
Calculation of noise contours using DLR model SIMUL

Influence of meteorology on SEL contours (runway direction 21)

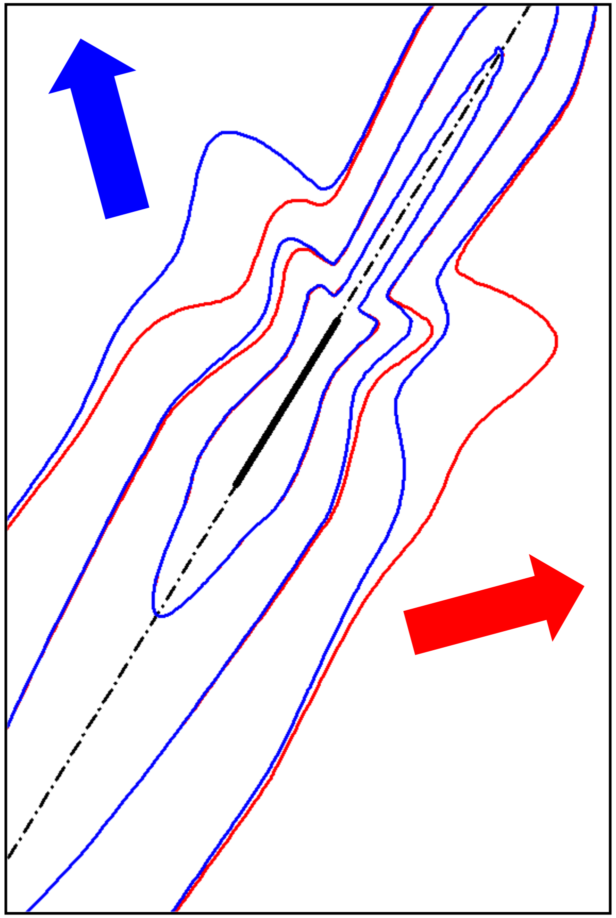
stable, v_w = 2 m/s (SC 3)



neutral, v_w = 5 m/s (SC 7)



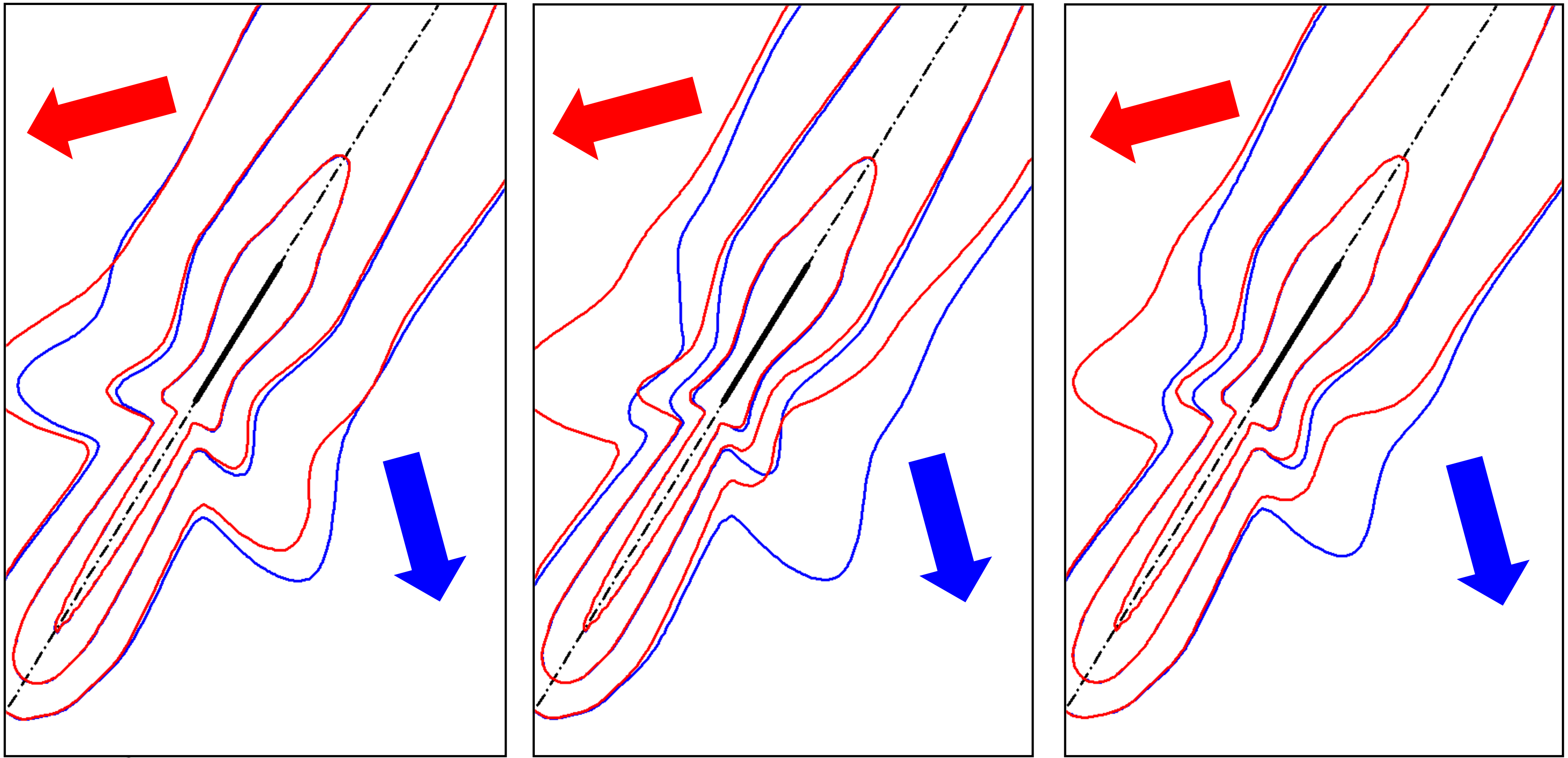
unstable, v_w = 2 m/s (SC 12)



Calculation of noise contours using DLR model SIMUL

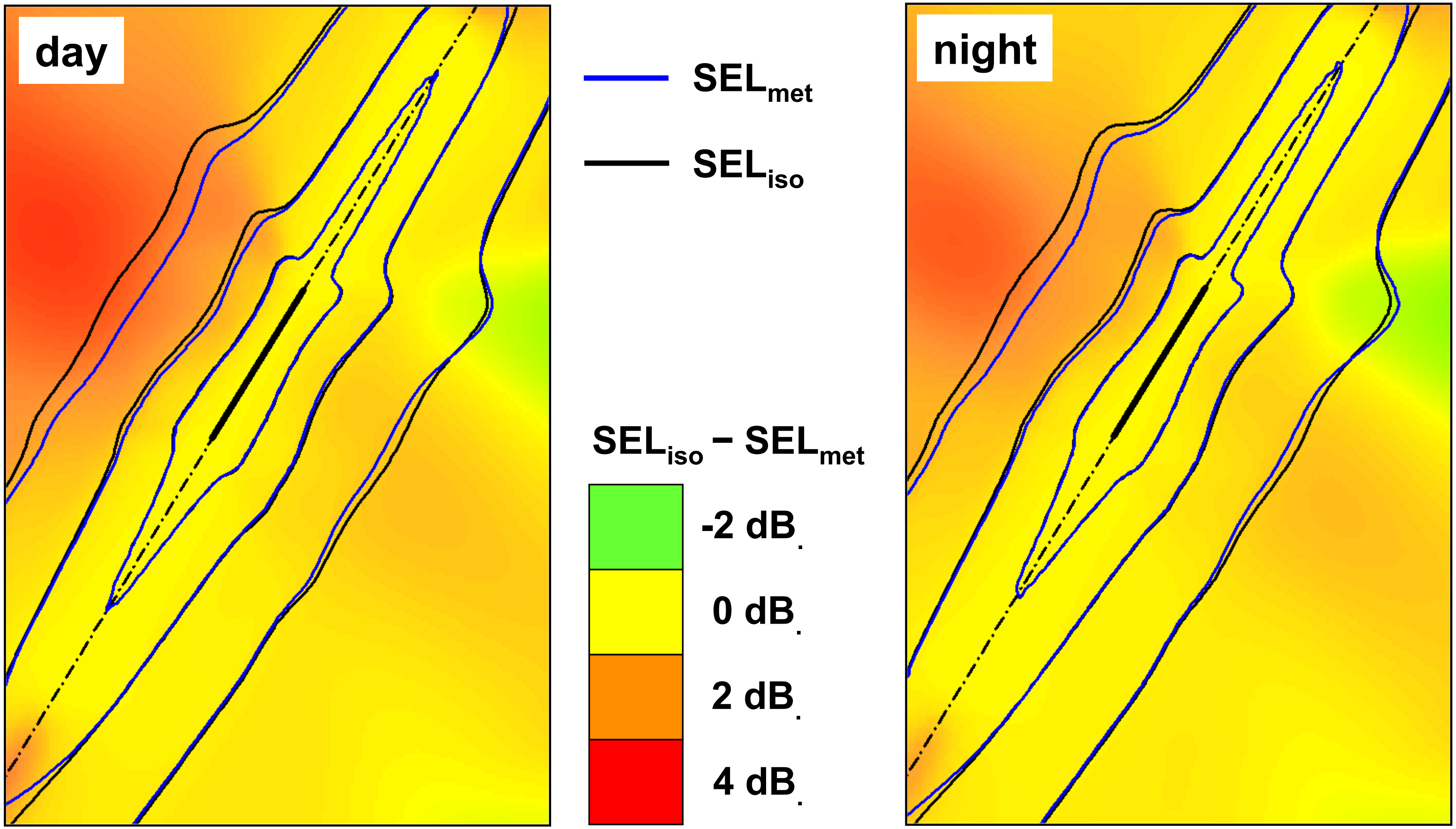
Influence of meteorology on SEL contours (runway direction 03)

stable, v_w = 2 m/s (SC 3) | neutral, v_w = 5 m/s (SC 7) | unstable, v_w = 2 m/s (SC 12)



Comparison with isotropic atmosphere

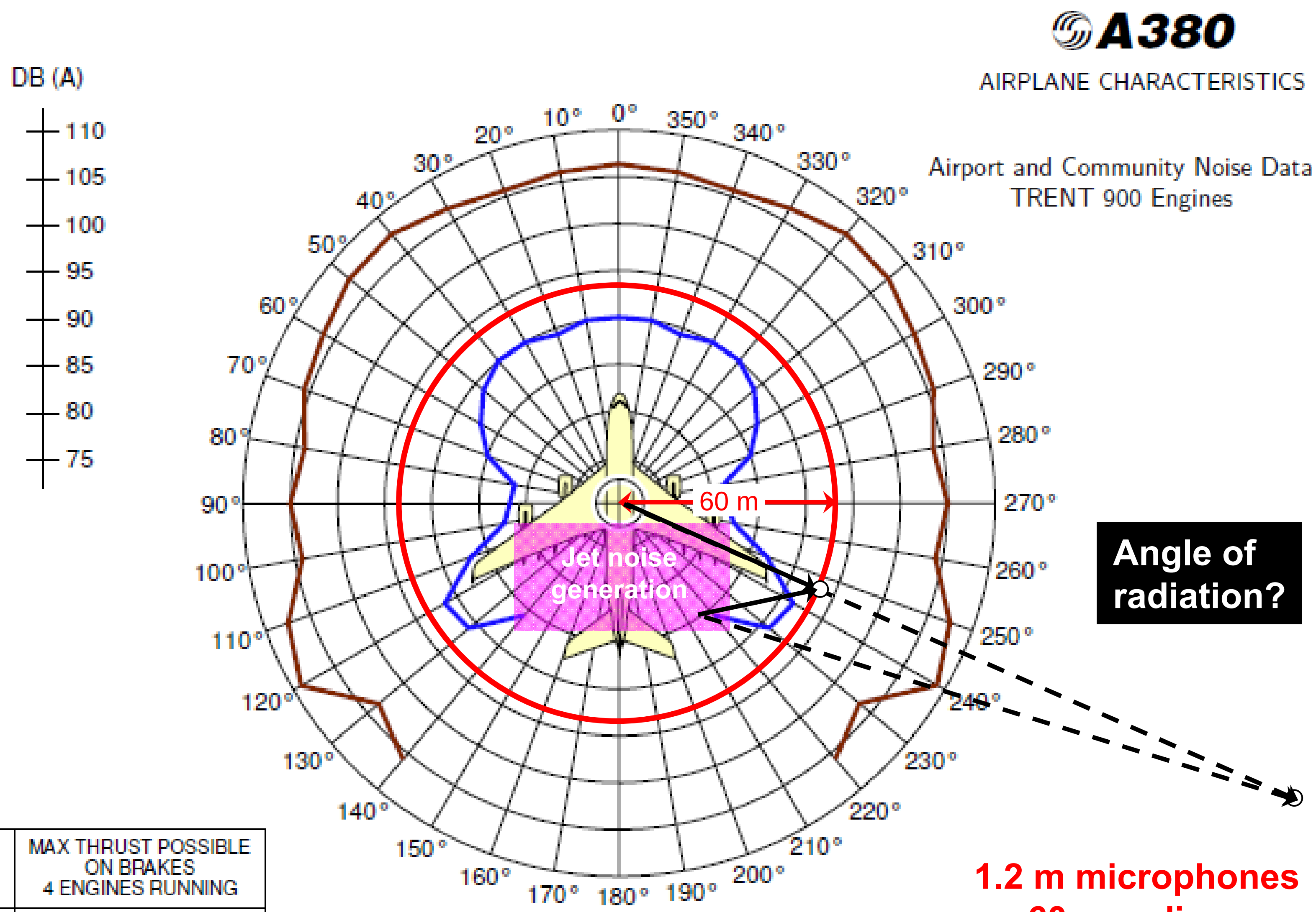
Contours SEL = 70, 80, 90 dB (weighted yearly average)



Problems to be discussed

… measuring directivities

Example: A380-800



Angle of radiation?

1.2 m microphones on 60 m radius

GROUND IDLE 4 ENGINES RUNNING	MAX THRUST POSSIBLE ON BRAKES 4 ENGINES RUNNING
(blue line)	(brown line)

Thank you !