Indicators of environmental sustainability in transport
An interdisciplinary approach to methods

Final conference of COST 356 – EST

"INDICATOR ASSESSMENT FOR NOISE"

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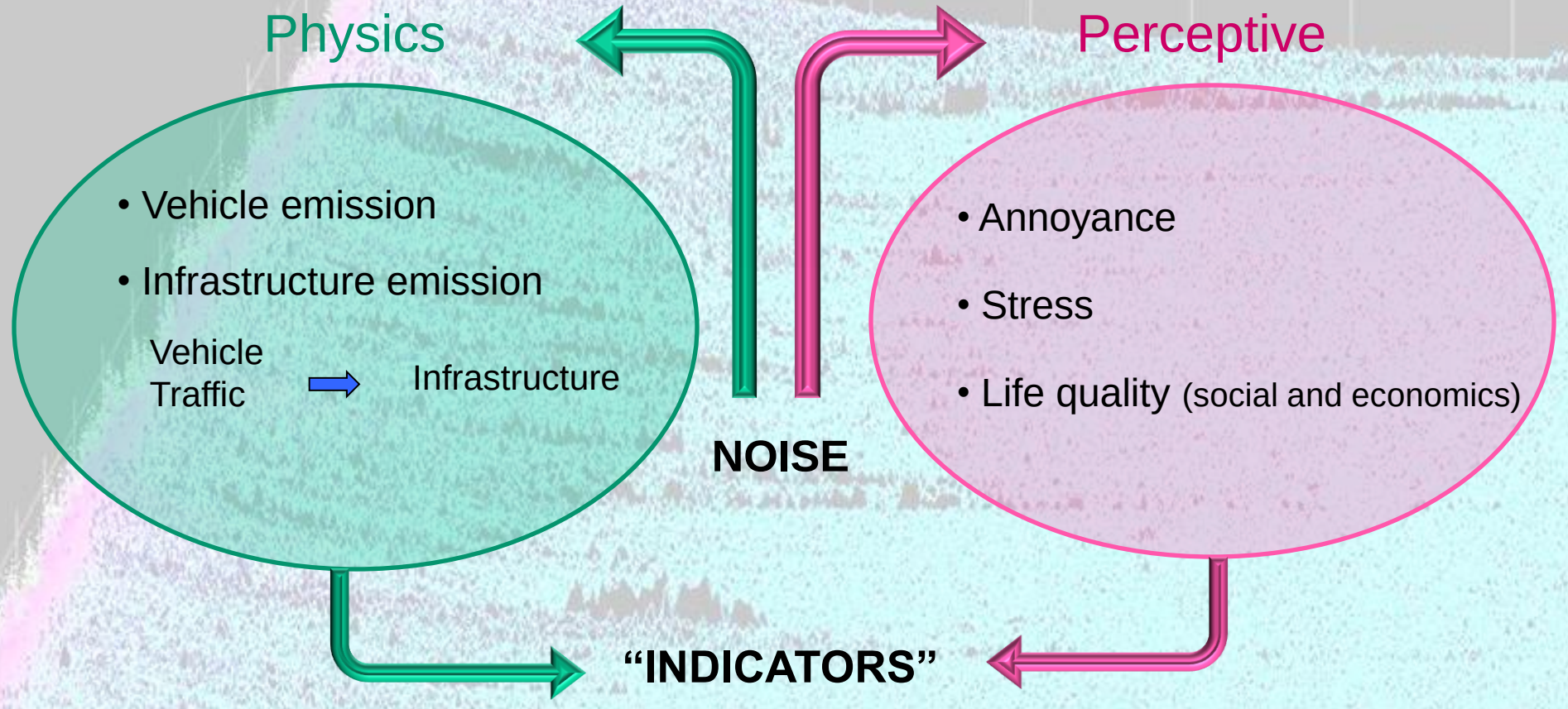

Physics
Perceptive
• Vehicle emission
• Infrastructure emission
Vehicle Traffic
Infrastructure
• Annoyance
• Stress
• Life quality (social and economics)
NOISE
“INDICATORS”

Energetic noise indicators

Equivalent Level "***Leq***"
(ISO 1996/1-1982)

Minimum Level "***Lmin***"

Maximum Level "***Lmax***"

Statistical Level "L_x"
(ISO 1996/1-1982)

Infrastructure noise indicators

Road

Traffic Noise Index "***TNI***"
(Griffiths & Langdon)

Noise Pollution Level "***NPL***"
(D. W. Robinson 1969)

CRTN Indicators "$L_{10,18h}$"

Railway

Sound Exposure Level "***SEL***" or "L_{AE}" or "L_{AX}"
(ISO 1996/1-1982)

Transit Exposure Level "***TEL***"
(EN ISO, 2005)

Aircraft

Perceived Noise Level "***PNL***"
(Kryter, ISO/R507)

Effective Perceived Noise Level "***EPNL***"

The Noise Number Index "***NNI***"

Noise Exposure Forecast "***NEF***"

Weighted Noise Exposure Forecast "***WECPNL***"
(International Civil Aviation Organisation ICAO)

Index for airport noise "L_{VA}"
(D.M. 11/12/1997 n°496)

General environmental noise indicators

Day Night Equivalent level "***Ldn***"

Day Evening Night Level "***Lden***"
Dir.2002/49/EC

Night Equivalent Level "***Lnight***"
Dir.2002/49/EC

Energetic noise indicators

"Leq"
"Lmin"
"Lmax"
"Lx"

Infrastructure noise indicators

Road

"TNI"
"NPL"
"$L_{10,18h}$"

Railway

"SEL"
"TEL"

Aircraft

"PNL"
"EPNL"
"NNI"
"NEF"
"WECPNL"
"L_{VA}"

General environmental noise indicators

"Ldn"
"Lden"
"Lnight"

Territorial extension

km^2 of the territory with *Lden>Lden,limit*
km of the infrastructure with *Lden>Lden,limit*
km^2 of the territory with *Ln>Ln,limit*
km of the infrastructure with *Ln>Ln,limit*

People exposure

% of people exposed to 55<*Lden*<65 dB(A)
% of people exposed to 65<*Lden*<75 dB(A)
% of people exposed to *Lden*>75 dB(A)

Energetic noise indicators	Infrastructure noise indicators			General environmental noise indicators
	Road	Railway	Aircraft	
"Leq"	*"TNI"*	*"SEL"*	*"PNL"*	*"Ldn"*
"Lmin"	*"NPL"*	*"TEL"*	*"EPNL"*	*"Lden"*
"Lmax"	*"$L_{10,18h}$"*		*"NNI"*	*"Lnight"*
"Lx"			*"NEF"*	
			"WECPNL"	
			"L_{VA}"	

Territorial extension	People exposure
km^2 of the territory with *Lden>Lden,limit*	% of people exposed to 55<*Lden*<65 dB(A)
km of the infrastructure with *Lden>Lden,limit*	% of people exposed to 65<*Lden*<75 dB(A)
km^2 of the territory with *Ln>Ln,limit*	% of people exposed to *Lden*>75 dB(A)
km of the infrastructure with *Ln>Ln,limit*	

Noise level indicators

Noise exposure indicators

Noise annoyance indicators

Indicator	Category: Representation			Operation			Application			
	Validity	Reliability	Sensitivity	Measurability	Data availability	Ethical concerns	Transparency	Interpretability	Target relevance	Actionability
Leq,h	xx	xxxx	xx	xx	xx	xxxx	xxx	xx	xx	xx
Lmax	xx	xxxx	xx	xx	xx	xxxx	xxx	xx	x	xx
Lmin	xx	xxxx	xx	xx	xx	xxxx	xxx	xx	x	xx
Lxx	xx	xxxx	xxx	xx	xx	xxxx	xx	xx	xx	xxx
SEL	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
TNI	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
NPL	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
CRTN	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
TEL	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
PNL	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
EPNL	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
NNI	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
NEF	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
WECPNEL	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
LVA	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
DNL	xx	xxxx	x	xx	xx	xxxx	xxx	xx	xx	xxx
DENL	xx	xxxx	x	xx	xx	xxxx	xxx	xx	xx	xxx
Lnight	xx	xxxx	xx	xx	xx	xxxx	xxx	xx	xx	xxx

Indicator	Category: Representation			Operation			Application			
	Validity	Reliability	Sensitivity	Measurability	Data availability	Ethical concerns	Transparency	Interpretability	Target relevance	Actionability
km² of the territory with *Lden>Lden,limit*	xxx	xxxx	xx	xx	x	xxxx	xxxx	xxxx	xxx	xxxx
km of the infrastructure with *Lden>Lden,limit*	xxx	xxxx	xx	xx	x	xxxx	xxxx	xxxx	xxx	xxxx
km² of the territory with *Ln>Ln,limit*	xxx	xxxx	xx	xx	x	xxxx	xxxx	xxxx	xxx	xxxx
km of the infrastructure with *Ln>Ln,limit*	xxx	xxxx	xx	xx	x	xxxx	xxxx	xxxx	xxx	xxxx
% of people exposed on the interval 55<*Lden*<65 dB(A)	xxx	xxxx	xx	xx	x	xxxx	xxxx	xxxx	xxx	xxxx
% of people exposed on the interval 65<*Lden*<75 dB(A)	xxx	xxxx	xx	xx	x	xxxx	xxxx	xxxx	xxx	xxxx
% of people exposed on the interval *Lden*>75 dB(A)	xxx	xxxx	xx	xx	x	xxxx	xxxx	xxxx	xxx	xxxx
Population having access to quiet areas (<500 m resid.)	xxx	xxxx	xx	xx	x	xxxx	xxxx	xxx	xx	xxxx

Validity

All the noise indicators are effective from the energetic point of view but they are not suited to fully evaluate the impact

Indicator	Category: Representation			Operation			Application			
	Validity	Reliability	Sensitivity	Measurability	Data availability	Ethical concerns	Transparency	Interpretability	Target relevance	Actionability
Leq,h	xx	xxxx	xx	xx	xx	xxxx	xxx	xx	xx	xx
Lmax	xx	xxxx	xx	xx	xx	xxxx	xxx	xx	x	xx
Lmin	xx	xxxx	xx	xx	xx	xxxx	xxx	xx	x	xx
Lxx	xx	xxxx	xxx	xx	xx	xxxx	xx	xx	xx	xxx
SEL	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
TNI	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
NPL	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
CRTN	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
TEL	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
PNL	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
EPNL	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
NNI	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
NEF	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
WECPNEL	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
LVA	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
DNL	xx	xxxx	x	xx	xx	xxxx	xxx	xx	xx	xxx
DENL	xx	xxxx	x	xx	xx	xxxx	xxx	xx	xx	xxx
Lnight	xx	xxxx	xx	xx	xx	xxxx	xxx	xx	xx	xxx

Indicator	Category: Representation			Operation			Application			
	Validity	Reliability	Sensitivity	Measurability	Data availability	Ethical concerns	Transparency	Interpretability	Target relevance	Actionability
km² of the territory with *Lden>Lden,limit*	xxx	xxxx	xx	xx	x	xxxx	xxxx	xxxx	xxx	xxxx
km of the infrastructure with *Lden>Lden,limit*	xxx	xxxx	xx	xx	x	xxxx	xxxx	xxxx	xxx	xxxx
km² of the territory with *Ln>Ln,limit*	xxx	xxxx	xx	xx	x	xxxx	xxxx	xxxx	xxx	xxxx
km of the infrastructure with *Ln>Ln,limit*	xxx	xxxx	xx	xx	x	xxxx	xxxx	xxxx	xxx	xxxx
% of people exposed on the interval 55<*Lden*<65 dB(A)	xxx	xxxx	xx	xx	x	xxxx	xxxx	xxxx	xxx	xxxx
% of people exposed on the interval 65<*Lden*<75 dB(A)	xxx	xxxx	xx	xx	x	xxxx	xxxx	xxxx	xxx	xxxx
% of people exposed on the interval *Lden*>75 dB(A)	xxx	xxxx	xx	xx	x	xxxx	xxxx	xxxx	xxx	xxxx
Population having access to quiet areas (<500 m resid.)	xxx	xxxx	xx	xx	x	xxxx	xxxx	xxx	xx	xxxx

Sensitivity

All the noise indicators are little depending on noise source fluctuations. Large variations in traffic and cinematic conditions thus in general give rise to only small variations of the noise indicator.

Indicator	Category: Representation			Operation			Application			
	Validity	Reliability	Sensitivity	Measurability	Data availability	Ethical concerns	Transparency	Interpretability	Target relevance	Actionability
Leq,h	xx	xxxx	xx	xx	xx	xxxx	xxx	xx	xx	xx
Lmax	xx	xxxx	xx	xx	xx	xxxx	xxx	xx	x	xx
Lmin	xx	xxxx	xx	xx	xx	xxxx	xxx	xx	x	xx
Lxx	xx	xxxx	xxx	xx	xx	xxxx	xx	xx	xx	xxx
SEL	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
TNI	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
NPL	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
CRTN	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
TEL	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
PNL	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
EPNL	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
NNI	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
NEF	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
WECPNEL	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
LVA	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
DNL	xx	xxxx	x	xx	xx	xxxx	xxx	xx	xx	xxx
DENL	xx	xxxx	x	xx	xx	xxxx	xxx	xx	xx	xxx
Lnight	xx	xxxx	xx	xx	xx	xxxx	xxx	xx	xx	xxx

Indicator	Category: Representation			Operation			Application			
	Validity	Reliability	Sensitivity	Measurability	Data availability	Ethical concerns	Transparency	Interpretability	Target relevance	Actionability
km² of the territory with *Lden>Lden,limit*	xxx	xxxx	xx	xx	x	xxxx	xxxx	xxxx	xxx	xxxx
km of the infrastructure with *Lden>Lden,limit*	xxx	xxxx	xx	xx	x	xxxx	xxxx	xxxx	xxx	xxxx
km² of the territory with *Ln>Ln,limit*	xxx	xxxx	xx	xx	x	xxxx	xxxx	xxxx	xxx	xxxx
km of the infrastructure with *Ln>Ln,limit*	xxx	xxxx	xx	xx	x	xxxx	xxxx	xxxx	xxx	xxxx
% of people exposed on the interval 55<*Lden*<65 dB(A)	xxx	xxxx	xx	xx	x	xxxx	xxxx	xxxx	xxx	xxxx
% of people exposed on the interval 65<*Lden*<75 dB(A)	xxx	xxxx	xx	xx	x	xxxx	xxxx	xxxx	xxx	xxxx
% of people exposed on the interval *Lden*>75 dB(A)	xxx	xxxx	xx	xx	x	xxxx	xxxx	xxxx	xxx	xxxx
Population having access to quiet areas (<500 m resid.)	xxx	xxxx	xx	xx	x	xxxx	xxxx	xxx	xx	xxxx

Measurability

The indicators are generally not easy to measure. Several indicators represent energetic means continuously measured on a 7-day period with stable weather conditions; this implies that they are demanding in terms of time and money.

Indicator	Category: Representation			Operation			Application			
	Validity	Reliability	Sensitivity	Measurability	Data availability	Ethical concerns	Transparency	Interpretability	Target relevance	Actionability
Leq,h	xx	xxxx	xx	xx	xx	xxxx	xxx	xx	xx	xx
Lmax	xx	xxxx	xx	xx	xx	xxxx	xxx	xx	x	xx
Lmin	xx	xxxx	xx	xx	xx	xxxx	xxx	xx	x	xx
Lxx	xx	xxxx	xxx	xx	xx	xxxx	xx	xx	xx	xxx
SEL	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
TNI	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
NPL	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
CRTN	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
TEL	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
PNL	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
EPNL	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
NNI	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
NEF	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
WECPNEL	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
LVA	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
DNL	xx	xxxx	x	xx	xx	xxxx	xxx	xx	xx	xxx
DENL	xx	xxxx	x	xx	xx	xxxx	xxx	xx	xx	xxx
Lnight	xx	xxxx	xx	xx	xx	xxxx	xxx	xx	xx	xxx

Indicator	Category: Representation			Operation			Application			
	Validity	Reliability	Sensitivity	Measurability	Data availability	Ethical concerns	Transparency	Interpretability	Target relevance	Actionability
km² of the territory with *Lden>Lden,limit*	xxx	xxxx	xx	xx	x	xxxx	xxxx	xxxx	xxx	xxxx
km of the infrastructure with *Lden>Lden,limit*	xxx	xxxx	xx	xx	x	xxxx	xxxx	xxxx	xxx	xxxx
km² of the territory with *Ln>Ln,limit*	xxx	xxxx	xx	xx	x	xxxx	xxxx	xxxx	xxx	xxxx
km of the infrastructure with *Ln>Ln,limit*	xxx	xxxx	xx	xx	x	xxxx	xxxx	xxxx	xxx	xxxx
% of people exposed on the interval 55<*Lden*<65 dB(A)	xxx	xxxx	xx	xx	x	xxxx	xxxx	xxxx	xxx	xxxx
% of people exposed on the interval 65<*Lden*<75 dB(A)	xxx	xxxx	xx	xx	x	xxxx	xxxx	xxxx	xxx	xxxx
% of people exposed on the interval *Lden*>75 dB(A)	xxx	xxxx	xx	xx	x	xxxx	xxxx	xxxx	xxx	xxxx
Population having access to quiet areas (<500 m resid.)	xxx	xxxx	xx	xx	x	xxxx	xxxx	xxx	xx	xxxx

Data availability

Data are scarce as the measurements are quite demanding. A limited number of public data bases are available. Some indicators (e.g. LDEN and the percentage of people exposed) are quite young; they have just recently been introduced in the European Directive and the countries have just started to measure and use them.

Indicator	Category: Representation			Operation			Application			
	Validity	Reliability	Sensitivity	Measurability	Data availability	Ethical concerns	Transparency	Interpretability	Target relevance	Actionability
Leq,h	xx	xxxx	xx	xx	xx	xxxx	xxx	xx	xx	xx
Lmax	xx	xxxx	xx	xx	xx	xxxx	xxx	xx	x	xx
Lmin	xx	xxxx	xx	xx	xx	xxxx	xxx	xx	x	xx
Lxx	xx	xxxx	xxx	xx	xx	xxxx	xx	xx	xx	xxx
SEL	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
TNI	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
NPL	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
CRTN	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
TEL	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
PNL	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
EPNL	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
NNI	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
NEF	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
WECPNEL	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
LVA	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
DNL	xx	xxxx	x	xx	xx	xxxx	xxx	xx	xx	xxx
DENL	xx	xxxx	x	xx	xx	xxxx	xxx	xx	xx	xxx
Lnight	xx	xxxx	xx	xx	xx	xxxx	xxx	xx	xx	xxx

Indicator	Category: Representation			Operation			Application			
	Validity	Reliability	Sensitivity	Measurability	Data availability	Ethical concerns	Transparency	Interpretability	Target relevance	Actionability
km² of the territory with *Lden>Lden,limit*	xxx	xxxx	xx	xx	x	xxxx	xxxx	xxxx	xxx	xxxx
km of the infrastructure with *Lden>Lden,limit*	xxx	xxxx	xx	xx	x	xxxx	xxxx	xxxx	xxx	xxxx
km² of the territory with *Ln>Ln,limit*	xxx	xxxx	xx	xx	x	xxxx	xxxx	xxxx	xxx	xxxx
km of the infrastructure with *Ln>Ln,limit*	xxx	xxxx	xx	xx	x	xxxx	xxxx	xxxx	xxx	xxxx
% of people exposed on the interval 55<*Lden*<65 dB(A)	xxx	xxxx	xx	xx	x	xxxx	xxxx	xxxx	xxx	xxxx
% of people exposed on the interval 65<*Lden*<75 dB(A)	xxx	xxxx	xx	xx	x	xxxx	xxxx	xxxx	xxx	xxxx
% of people exposed on the interval *Lden*>75 dB(A)	xxx	xxxx	xx	xx	x	xxxx	xxxx	xxxx	xxx	xxxx
Population having access to quiet areas (<500 m resid.)	xxx	xxxx	xx	xx	x	xxxx	xxxx	xxx	xx	xxxx

Transparency

The indicators are transparent as their calculation is clearly described. Energetic indicators do not give a useful interpretation in terms of disturbance or annoyance, however.

Indicator	Category: Representation			Operation			Application			
	Validity	Reliability	Sensitivity	Measurability	Data availability	Ethical concerns	Transparency	Interpretability	Target relevance	Actionability
Leq,h	xx	xxxx	xx	xx	xx	xxxx	xxx	xx	xx	xx
Lmax	xx	xxxx	xx	xx	xx	xxxx	xxx	xx	x	xx
Lmin	xx	xxxx	xx	xx	xx	xxxx	xxx	xx	x	xx
Lxx	xx	xxxx	xxx	xx	xx	xxxx	xx	xx	xx	xxx
SEL	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
TNI	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
NPL	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
CRTN	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
TEL	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
PNL	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
EPNL	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
NNI	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
NEF	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
WECPNEL	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
LVA	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
DNL	xx	xxxx	x	xx	xx	xxxx	xxx	xx	xx	xxx
DENL	xx	xxxx	x	xx	xx	xxxx	xxx	xx	xx	xxx
Lnight	xx	xxxx	xx	xx	xx	xxxx	xxx	xx	xx	xxx

Indicator	Category: Representation			Operation			Application			
	Validity	Reliability	Sensitivity	Measurability	Data availability	Ethical concerns	Transparency	Interpretability	Target relevance	Actionability
km² of the territory with *Lden>Lden,limit*	xxx	xxxx	xx	xx	x	xxxx	xxxx	xxxx	xxx	xxxx
km of the infrastructure with *Lden>Lden,limit*	xxx	xxxx	xx	xx	x	xxxx	xxxx	xxxx	xxx	xxxx
km² of the territory with *Ln>Ln,limit*	xxx	xxxx	xx	xx	x	xxxx	xxxx	xxxx	xxx	xxxx
km of the infrastructure with *Ln>Ln,limit*	xxx	xxxx	xx	xx	x	xxxx	xxxx	xxxx	xxx	xxxx
% of people exposed on the interval 55<*Lden*<65 dB(A)	xxx	xxxx	xx	xx	x	xxxx	xxxx	xxxx	xxx	xxxx
% of people exposed on the interval 65<*Lden*<75 dB(A)	xxx	xxxx	xx	xx	x	xxxx	xxxx	xxxx	xxx	xxxx
% of people exposed on the interval *Lden*>75 dB(A)	xxx	xxxx	xx	xx	x	xxxx	xxxx	xxxx	xxx	xxxx
Population having access to quiet areas (<500 m resid.)	xxx	xxxx	xx	xx	x	xxxx	xxxx	xxx	xx	xxxx

Interpretability

The indicators are well related to the emissions but some of the indicators are not strongly related to the annoyance since noise perception is highly subjective.

Indicator	Category: Representation			Operation			Application			
	Validity	Reliability	Sensitivity	Measurability	Data availability	Ethical concerns	Transparency	Interpretability	Target relevance	Actionability
Leq,h	xx	xxxx	xx	xx	xx	xxxx	xxx	xx	xx	xx
Lmax	xx	xxxx	xx	xx	xx	xxxx	xxx	xx	x	xx
Lmin	xx	xxxx	xx	xx	xx	xxxx	xxx	xx	x	xx
Lxx	xx	xxxx	xxx	xx	xx	xxxx	xx	xx	xx	xxx
SEL	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
TNI	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
NPL	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
CRTN	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
TEL	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
PNL	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
EPNL	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
NNI	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
NEF	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
WECPNEL	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
LVA	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
DNL	xx	xxxx	x	xx	xx	xxxx	xxx	xx	xx	xxx
DENL	xx	xxxx	x	xx	xx	xxxx	xxx	xx	xx	xxx
Lnight	xx	xxxx	xx	xx	xx	xxxx	xxx	xx	xx	xxx

Indicator	Category: Representation			Operation			Application			
	Validity	Reliability	Sensitivity	Measurability	Data availability	Ethical concerns	Transparency	Interpretability	Target relevance	Actionability
km² of the territory with *Lden>Lden,limit*	xxx	xxxx	xx	xx	x	xxxx	xxxx	xxxx	xxx	xxxx
km of the infrastructure with *Lden>Lden,limit*	xxx	xxxx	xx	xx	x	xxxx	xxxx	xxxx	xxx	xxxx
km² of the territory with *Ln>Ln,limit*	xxx	xxxx	xx	xx	x	xxxx	xxxx	xxxx	xxx	xxxx
km of the infrastructure with *Ln>Ln,limit*	xxx	xxxx	xx	xx	x	xxxx	xxxx	xxxx	xxx	xxxx
% of people exposed on the interval 55<*Lden*<65 dB(A)	xxx	xxxx	xx	xx	x	xxxx	xxxx	xxxx	xxx	xxxx
% of people exposed on the interval 65<*Lden*<75 dB(A)	xxx	xxxx	xx	xx	x	xxxx	xxxx	xxxx	xxx	xxxx
% of people exposed on the interval *Lden*>75 dB(A)	xxx	xxxx	xx	xx	x	xxxx	xxxx	xxxx	xxx	xxxx
Population having access to quiet areas (<500 m resid.)	xxx	xxxx	xx	xx	x	xxxx	xxxx	xxx	xx	xxxx

Target relevance

Some indicators simply represent the noise emissions, being not so relevant to political targets. The indicator describing the territorial impact is instead more useful.

Indicator	Category: Representation			Operation			Application			
	Validity	Reliability	Sensitivity	Measurability	Data availability	Ethical concerns	Transparency	Interpretability	Target relevance	Actionability
Leq,h	xx	xxxx	xx	xx	xx	xxxx	xxx	xx	xx	xx
Lmax	xx	xxxx	xx	xx	xx	xxxx	xxx	xx	x	xx
Lmin	xx	xxxx	xx	xx	xx	xxxx	xxx	xx	x	xx
Lxx	xx	xxxx	xxx	xx	xx	xxxx	xx	xx	xx	xxx
SEL	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
TNI	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
NPL	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
CRTN	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
TEL	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
PNL	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
EPNL	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
NNI	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
NEF	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
WECPNEL	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
LVA	xx	xxxx	xx	xx	xx	xxxx	xx	xx	xx	xx
DNL	xx	xxxx	x	xx	xx	xxxx	xxx	xx	xx	xxx
DENL	xx	xxxx	x	xx	xx	xxxx	xxx	xx	xx	xxx
Lnight	xx	xxxx	xx	xx	xx	xxxx	xxx	xx	xx	xxx

Indicator	Category: Representation			Operation			Application			
	Validity	Reliability	Sensitivity	Measurability	Data availability	Ethical concerns	Transparency	Interpretability	Target relevance	Actionability
km² of the territory with *Lden>Lden,limit*	xxx	xxxx	xx	xx	x	xxxx	xxxx	xxxx	xxx	xxxx
km of the infrastructure with *Lden>Lden,limit*	xxx	xxxx	xx	xx	x	xxxx	xxxx	xxxx	xxx	xxxx
km² of the territory with *Ln>Ln,limit*	xxx	xxxx	xx	xx	x	xxxx	xxxx	xxxx	xxx	xxxx
km of the infrastructure with *Ln>Ln,limit*	xxx	xxxx	xx	xx	x	xxxx	xxxx	xxxx	xxx	xxxx
% of people exposed on the interval 55<*Lden*<65 dB(A)	xxx	xxxx	xx	xx	x	xxxx	xxxx	xxxx	xxx	xxxx
% of people exposed on the interval 65<*Lden*<75 dB(A)	xxx	xxxx	xx	xx	x	xxxx	xxxx	xxxx	xxx	xxxx
% of people exposed on the interval *Lden*>75 dB(A)	xxx	xxxx	xx	xx	x	xxxx	xxxx	xxxx	xxx	xxxx
Population having access to quiet areas (<500 m resid.)	xxx	xxxx	xx	xx	x	xxxx	xxxx	xxx	xx	xxxx

Actionability

To the decision maker, indicators representing the territorial impact or the number of exposed people are more useful than indicators describing only the emission.

Which is the better indicator?

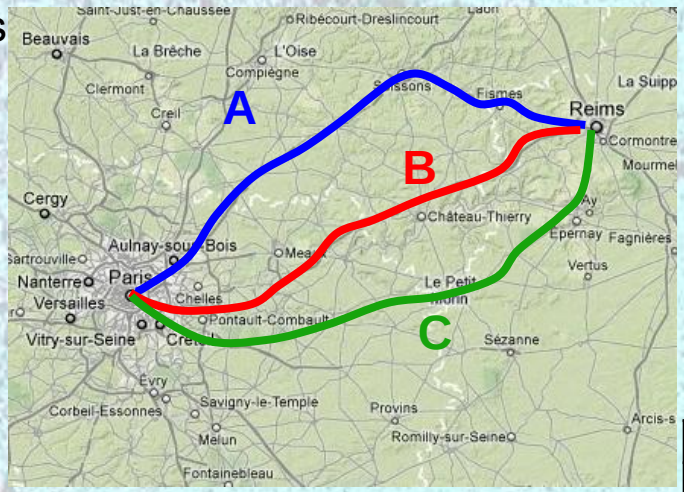
Dir.2002/49/EC → Unique noise indicators L_{den} *and* L_{night}

They depend on the users

"Designer" of new vehicles typologies or infrastructures' elements

Source noise level, L_{max}, or $L_{Aeq,T}$ *(pass-by measurement)*

Planner



Owner-Manager of existing infrastructures

Overcoming of $L_{den,limit}$ given by the regulation
Overcoming of $L_{night,limit}$ given by the regulation
km^2 of the territory with $L_{den}>L_{den,limit}$
km of the infrastructure with $L_{den}>L_{den,limit}$
km^2 of the territory with $L_n>L_{n,limit}$
km of the infrastructure with $L_n>L_{n,limit}$
Overcoming of $L_{AV,limit}$ given by the regulation

% of people exposed on the interval $55<L_{den}<65$ dB(A)
% of people exposed on the interval $65<L_{den}<75$ dB(A)
% of people exposed on the interval $L_{den}>75$ dB(A)

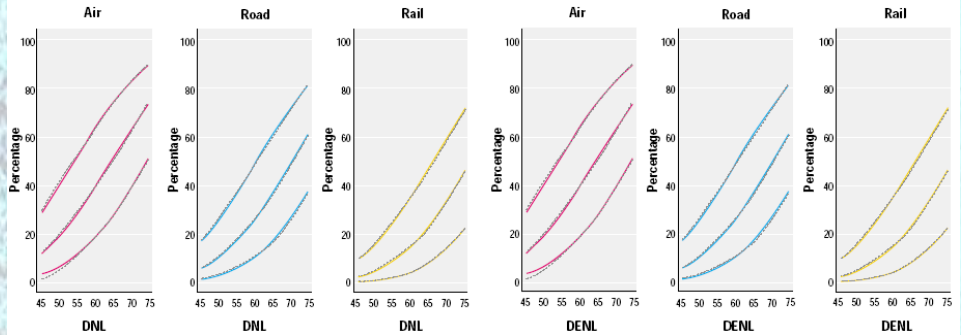
•Definition of indicators easy to measure (*Measurability*)

•Definition of DOSE-RESPONSE relationship (*Interpretability, Target relevance*)

Noise (Physics)

Annoyance (Perceptive)

Measure/source	DNL	DENL
%LA		
Aircraft	$-5.741\times10^{-4}(DNL-32)^3+2.863\times10^{-2}(DNL-32)^2+1.912(DNL-32)$	$-6.158\times10^{-4}(DENL-32)^3+3.410\times10^{-2}(DENL-32)^2+1.738(DENL-32)$
Road traffic	$-6.188\times10^{-4}(DNL-32)^3+5.379\times10^{-2}(DNL-32)^2+0.723(DNL-32)$	$-6.235\times10^{-4}(DENL-32)^3+5.509\times10^{-2}(DENL-32)^2+0.6693(DENL-32)$
Railways	$-3.343\times10^{-4}(DNL-32)^3+4.918\times10^{-2}(DNL-32)^2+0.175(DNL-32)$	$-3.229\times10^{-4}(DENL-32)^3+4.871\times10^{-2}(DENL-32)^2+0.1673(DENL-32)$
%A		
Aircraft	$1.460\times10^{-5}(DNL-37)^3+1.511\times10^{-2}(DNL-37)^2+1.346(DNL-37)$	$8.588\times10^{-6}(DENL-37)^3+1.777\times10^{-2}(DENL-37)^2+1.221(DENL-37)$
Road traffic	$1.732\times10^{-4}(DNL-37)^3+2.079\times10^{-2}(DNL-37)^2+0.566(DNL-37)$	$1.795\times10^{-4}(DENL-37)^3+2.110\times10^{-2}(DENL-37)^2+0.5353(DENL-37)$
Railways	$4.552\times10^{-4}(DNL-37)^3+9.400\times10^{-3}(DNL-37)^2+0.212(DNL-37)$	$4.538\times10^{-4}(DENL-37)^3+9.482\times10^{-3}(DENL-37)^2+0.2129(DENL-37)$
%HA		
Aircraft	$-1.395\times10^{-4}(DNL-42)^3+4.081\times10^{-2}(DNL-42)^2+0.342(DNL-42)$	$-9.199\times10^{-5}(DENL-42)^3+3.932\times10^{-2}(DENL-42)^2+0.2939(DENL-42)$
Road traffic	$9.994\times10^{-4}(DNL-42)^3-1.523\times10^{-2}(DNL-42)^2+0.538(DNL-42)$	$9.868\times10^{-4}(DENL-42)^3-1.436\times10^{-2}(DENL-42)^2+0.5118(DENL-42)$
Railways	$7.158\times10^{-4}(DNL-42)^3-7.774\times10^{-3}(DNL-42)^2+0.163(DNL-42)$	$7.239\times10^{-4}(DENL-42)^3-7.851\times10^{-3}(DENL-42)^2+0.1695(DENL-42)$



Source Henk M.E. Miedema and Catharina G.M. Oudshoorn, 2001

•Taking into account the different perception of noise, road, railway… (*Validity*)

•New infrastructure: evaluation of “differential level” (*Validity*)

Thanks for the attention!