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END noise mapping for a sufficiently accurate people exposure estimation in epidemiological studies

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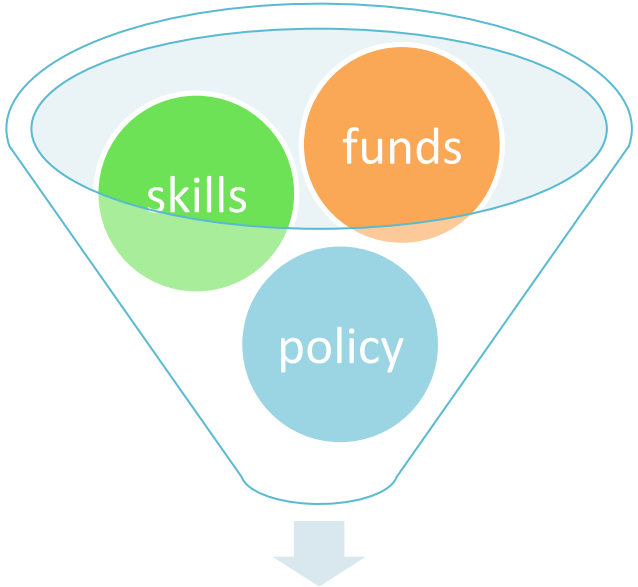
Introduction

END implementation



NEW

Thus, a common calculation method for all EU Countries has been developed in the years 2008-2011: CNOSSOS-EU.

Besides guidelines may help maps' accuracy and improve comparability, a limit is given by the different calculation methods.

- Different results in terms of no. of maps elaborated and calculation methods;
- Exposure results provided are not comparable, mainly due to different calculation methods used and to interpretation of END, which leaves some definitions unclear to be put into practice.

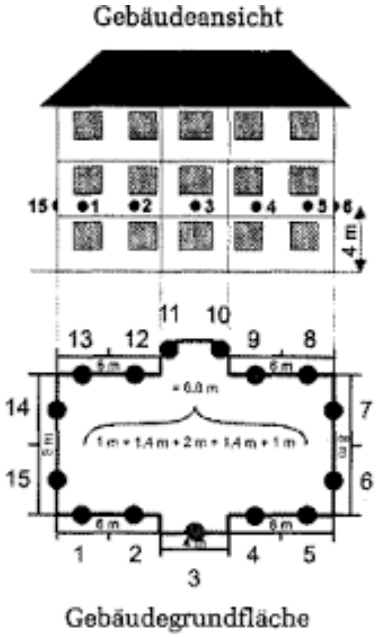
Introduction

- The recent revision of END Annex II not only includes CNOSSOS-EU, but also a specific method for assigning population along building façades.
- In the present study, examples of different assignment methods will be provided to stress the relevance of this issue not only for noise mapping and action planning but also for annoyance estimate and health risk assessment.
- Some indicators able to rate risk assessment and to drive prioritized actions will be presented, together with indicators that can estimate the Environmental Burden of Disease (EBD)
- Different approaches will be suggested according to the study extent (large, medium and small scale), which may follow a different approach maximising accuracy of estimation.

The new Annex II in the END

- The revision includes two major changes:

1. A common method to assign noise levels to the population, distributing people along façades according to the German method VBEB *.



2. The new common calculation method CNOSSOS-EU (customizable database and common propagation).

* Vorläufige Berechnungsmethode zur Ermittlung der Belastetenzahlen durch Umgebungslärm – VBEB, Federal German Gazette, 20/04/2007.

The new calculation method

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- CNOSSOS-EU will be mandatory after 31/12/18
  - Nowadays only a point to point calculation system is available for free.
  - The implementation in commercial software is partially published due to the difficulties in implementing the standard and the national adaptation coefficients.
  - The Commission has already provided tables to convert existing standard methods (as NMPB, Nord2000, CRTN, RLS90, SRMII).

- CNOSSOS is based on 1/3 octave-bands from 25 Hz to 10 kHz, then is valid in a wider frequency range respect to the actual interim methods.
  - This aims a better evaluation of annoyance effects which are mostly influenced by noise at low frequency bands.
  - A methodology considering the wide spectrum allows a correct evaluation of these effects and also a correct evaluation of possible solutions.

Needs analysis of epidemiological studies

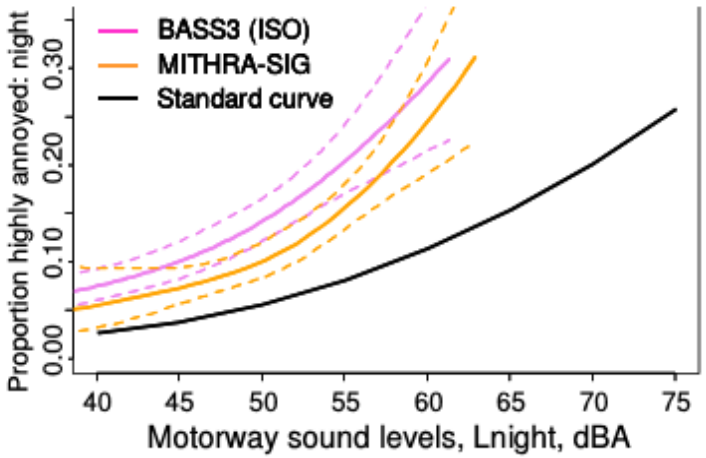
- The process of **risk assessment** of environmental noise requires:
  - the levels of exposure at which health effects begin to occur
  - how the extent of the effect changes with increasing noise levels
  - the number of people exposed to these levels of noise.
- **Assessment of exposure** to noise requires different possible methodological choices and considering many factors, including:
  - the noise indicator;
  - the measured exposure or calculated exposure (calculation accuracy);
  - population distribution/levels assignment (assignment accuracy);
  - time-activity patterns of the exposed population;
  - exposures to multiple sources of noise.
- Quantitative risk assessments based on Environmental Burden of Disease (EBD) methodology have been developed and are usually expressed using the metric disability-adjusted life year (**DALY**).

Calculation accuracy

- Different calculation methods leads to different estimates of noise levels exposure.
- A different exposure estimation also leads to different dose-effects relationships.

Lercher * compared implementation of ISO 9613 and NMPB-96, coupling their results with annoyance surveys.

The derived dose-effects relationships were compared to the standard ones demonstrating how they vary according the noise predicted level of exposure.



* Lercher P, et al. *The effect on annoyance estimation of noise modeling procedures*. Proc. 9th International Congress on Noise as a Public Health Problem (ICBEN) 2008, Foxwoods, CT.

Assignment accuracy

- In epidemiological studies the living environment is known with high uncertainty:
  - you can have people at dwellings but mostly at buildings;
  - sometimes you have address points and you should connect address points to buildings even when address points are placed at fences or property borders.

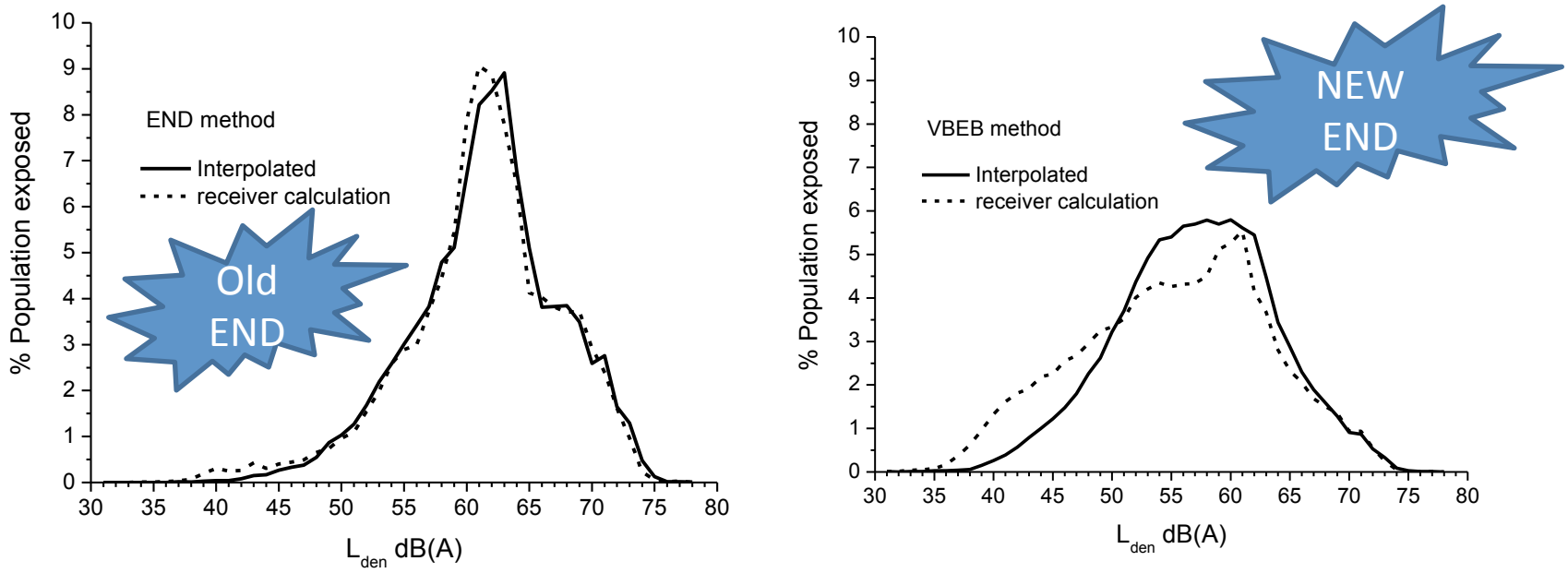
- The risk assessment and the dose-effects relationships can vary depending on the method chosen for assigning levels to dwellings, buildings or address points *.

- Also the way in which levels are assigned (maximum level, VBEB, nearest point) can influence the results.
  - In some cases levels are calculated at receivers (LUR models, façade calculations, receivers' calculation) in some others they are derived from noise maps interpolating the grid points.

* Eriksson C, et al. *Residential traffic noise exposure assessment: application and evaluation of European Environmental Noise Directive maps.* J Expo Sci Environ Epidemiol. 2013 Sep-Oct;23(5):531-8.

Assignment accuracy

- Moreover, according the assignment method, it was demonstrated that first reported exposure class (55-60 LDEN) is the most influenced by the method change. A test in Pisa municipality demonstrated the difference in people distribution according to the assignment method *.



Distributions of the population exposure to road traffic noise over the entire territory of Pisa's Municipality calculated by END (left) and VBEB (right) methods and noise levels at receivers or interpolated from grid levels.

* Licitra G, et al.. *Comparative Analysis of Methods to Estimate Urban Noise Exposure of Inhabitants*, Acta Acustica united with Acustica, Volume 98, Number 4, July/ August 2012 , pp. 659-666(8).

Indicators for epidemiological studies

- The noise level indicators and the way of aggregating exposure results may be different according to the aim of the study.

- Several indicators are available to assess risks.
  - The choice is driven by: data availability, source pattern, multi-source context, acute or chronic effects on health studied, daytime or night-time, policy interests in the results, extent of area involved.

- WHO defined the **DALY** for the estimation of the EBD.
  - DALY can be used to set priorities between different pollutants
  - It allows a comparative evaluation of the health risks.

DALY

$$DALY = YLL + YLD$$

YLL Years of life lost
YLD Years lost due to disability

$$YLL = \sum_i \left(N_i^m \cdot L_i^m + N_i^f \cdot L_i^f \right)$$

number of deaths of **m**ales (**f**emales) in age group *i*

the standard life expectancy of **m**ales (**f**emales)

$$YLD = I \cdot DW \cdot D$$

number of incident cases

disability weight [0-1]

average duration of disability in years

DALY pro & cons

- DALYs can be applied to economic evaluation of environmental policies in order to compare the health benefits of different options or at least to analyse whether the actions are worth the money invested.

- To estimate total EBD the exposure distribution in a population, a relative risk estimates from the literature, and the population-attributable fraction are required.

- Data collection for these methods is not easy. If data availability is poor also the DALYs calculation would not be accurate.

Other indicators to estimate risks

- Easier formula can be used if they are correlated with annoyance.
- GDEN and Gnight indicators have been estimated on the bases of LDEN and Lnight indicators*, being correlated to %HA.
- Other projects have defined different indicators able to rate priorities of different mitigation sites (e.g. the Qcity project indicator is based on annoyance dose-effects relationships).

All the methods take into account the annoyance response to each different noise source, resulting suitable to multi exposure contexts.

* Licitra G, et al. *G_{DEN}: An indicator for European noise maps comparison and to support action plans*, Science of The Total Environment, Volumes 482–483, 1 June 2014, Pages 411-419, ISSN 0048-9697

Large scale contexts (GDEN)

$$G_{DEN\,norm} = 10 \cdot \log_{10}\left(\frac{1}{N_{tot}} \sum_i n_i \cdot 10^{\frac{L_{DEN\,i}}{10}} \right)$$

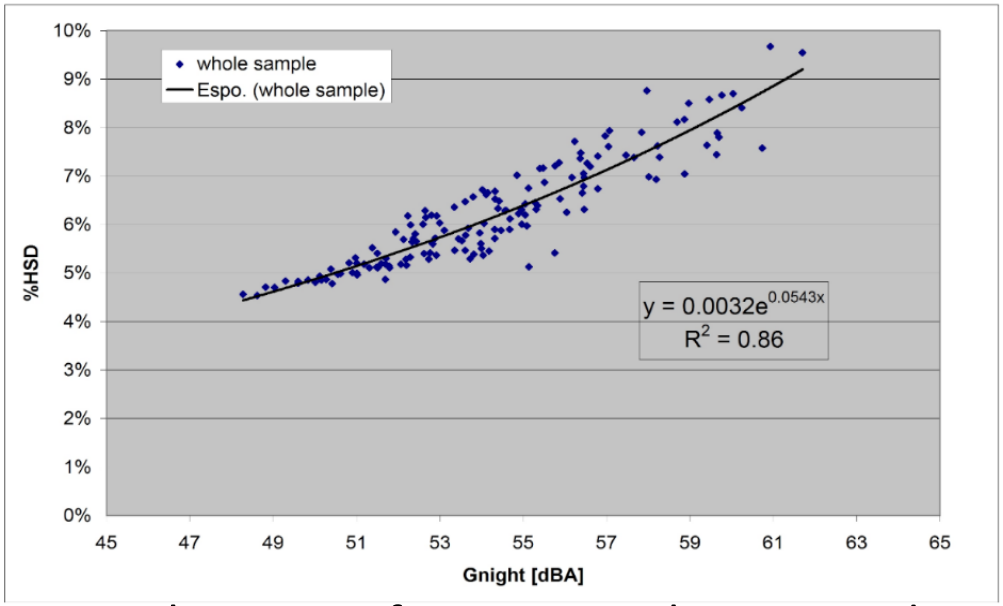
GDEN was calculated to obtain a global rate to compare cities at EU level.

- National clusters are evident: GDEN it is still not a reliable indicator to compare all cities in EU because of national methods, but this will change with the next implementation round where CNOSSOS –EU will be used by all countries.

- Meanwhile, GDEN could be useful for each MS to evaluate differences between its cities and to assign funds/fee policies based on relative rating.

Pro & cons of GDEN/Gnight

- The global indicators are related to %HA and %HSD

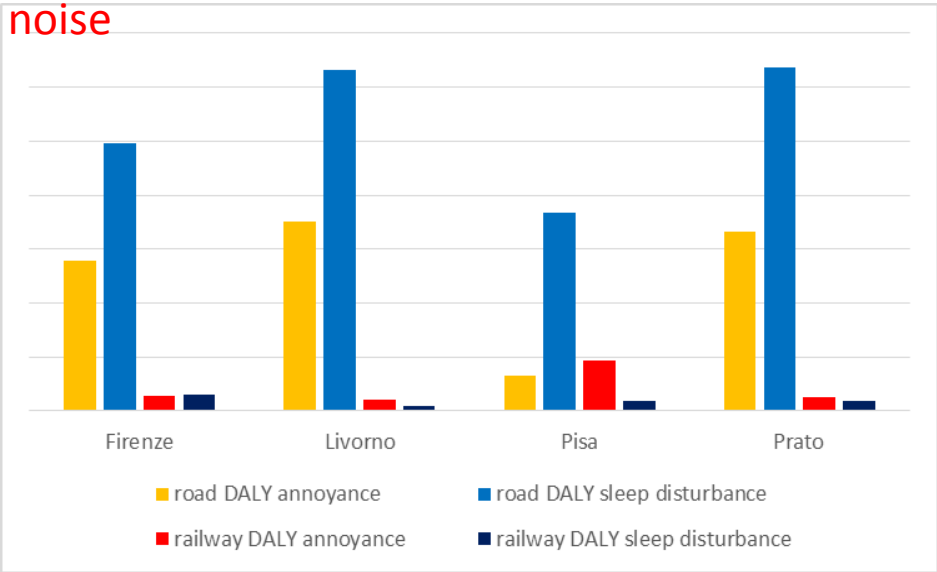


- GDEN could help in raising awareness because of its easy application and fast implementation
- After having identified most critical areas with GDEN method, it's possible to go into further detail and calculate exactly how many inhabitants really need mitigation.
- This step by step approach helps to offer cost effective solutions to policy makers and the possibility of involving citizens before carrying out complete calculation

Large scale contexts (DALY)

- DALY can also be used to compare cities relative risk, provided that DALYs values are normalized by population.
- In Tuscany, exposure data collected within the provisions of END were used to estimate DALY for road, railway and aircraft noise*.

Annoyance and Sleep disturbance DALYs, normalized to population, due to road and railway noise



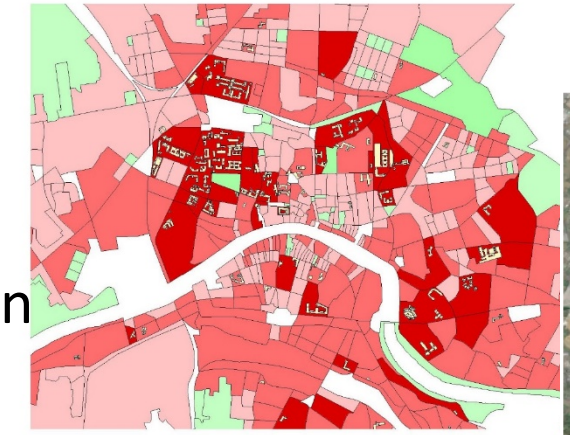
Livorno and Prato have a critical sleep disturbance due to road traffic noise, while railway annoyance is critical in Pisa.

⇒ DALY could be used to compare different agglomerations and this will became true also at EU level with CNOSSOS implementation.

* Palazzuoli D, et al. *Le esternalità dei trasporti: l'impiego dell'indicatore DALY per la valutazione degli effetti sanitari dell'esposizione al rumore nei principali agglomerati in Toscana*, Atti della conferenza SIET 2014.

Medium scale contexts

- To estimate relative risk of cities areas, indicators can be calculated on cities sub-unit and mapped on GIS to visualize results.
- Units might differ across MS, regions depending on policies but a solution can be census units or postal codes.
- Considering census units, different values of GDEN and DALYs have been calculated in Pisa and Florence respectively .



Gden in Pisa

DALY in Florence

- In this comparison graduated colour scales immediately highlight the most risky zones, pointing out mitigation urgency.

Small scale contexts

- Other methods like the Qcity one* are able to obtain finer estimations to drive mitigation actions but requires more calculation time.

- A test of the Qcity method is reported for one of the risky census units found in Pisa with GDEN indicator.

- <u>The method points out the single buildings having priority</u> (the U shaped buildings block is the one that needs mitigation within the focused area).

* Miedema HME, et al. 2007. *Rating environmental noise on the basis of noise maps*, Quiet City Transport Project D 1.5

Land Use Regression (LUR) method for epidemiological studies

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- LUR is frequently used to derive air pollution exposure data since propagation is simpler than noise one.
- When exposure estimation is needed for a large territory, a first fast raw approximation can be obtained with LUR also for noise.
- Ragettli* estimated exposure to road traffic noise in Montreal and calculated %HA and %A. LAeq24h levels of Montreal were computed basing the LUR model on 2-min noise measurements from 204 sites.
  - Input data of LUR models are measurements and few propagation rules.
  - Of course, LUR are more accurate next to the sources and generally are not suited to assess small scale variations.
- LUR models could be useful to estimate noise exposure at large/medium scale for a first attempt to demonstrate health effects without using noise mapping methods.
- Epidemiological studies and their indicators based on LUR would be more raw and similar within calculated units.

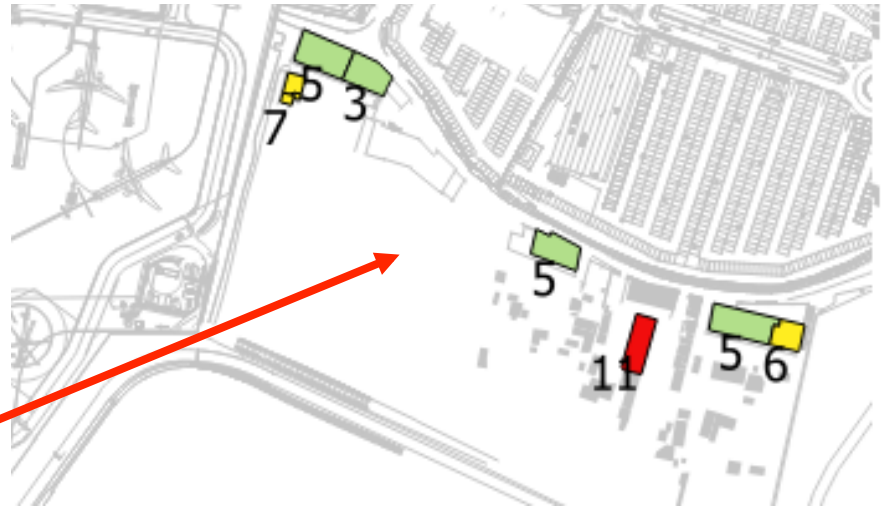
* Ragettli M.S.; et al. *Annoyance from Road Traffic, Trains, Airplanes and from Total Environmental Noise Levels*. Int. J. Environ. Res. Public Health 2016, 13, 90.

Measurements for epidemiological studies?

- Small scale studies could also develop indicators based on measurements if needed.
- In case of needing exposure of single citizens, noise indicators reporting the measured number of events above a given threshold could be correlated to health effects.

For example N70 for aircraft noise reports the number of events (aircraft overflights) having an LMax greater than 70 dBA.

Dwellings are reported based on average measured values of N70 in the relaxing period between 8 p.m. and 8 a.m.. Values ranges from 3 to 11 N70.



Conclusions

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- The need of common methodologies has been demonstrated by several studies and the work done within the revision of the END leads to new perspectives of exposure analysis.
- The next mapping round, should provide large scale reliable data, finally comparable.
- Their accuracy and their suitability for epidemiological studies should be questioned before trying to derive dose-effects relationships.
- As presented in the paper, several methods could be used at different scales to estimate noise levels.
- LUR methods and measurements could be a solution to avoid mapping:
  - LUR methods could be useful for epidemiological analysis considering not only noise but also other pollutants.
  - Measurements are obviously suited for high detailed studies especially on health effects needing higher detail than equivalent noise levels.

Conclusions

- The risk assessment of health outcomes should follow different approaches according the type of outcome considered in order to estimate the most suitable indicator.
- Indicators have been identified in literature and several assessing experience have been carried out.
- Beside the DALY is the indicator identified by WHO for EBD estimation, several other indicators may contribute to identify areas or citizen exposed to harmful effects of noise and there are ones that are more suitable for driving mitigation choices.
- The paper has shown some experiences in this sense and the efficacy of a new indicator (G_{DEN}) in highlighting risk areas at large scale.
- Moreover, DALY calculation examples have been given as method not only for comparing risk factors but also as method for identifying risk areas and to drive priorities across Countries.

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Thanks for your attention

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