UNIVERSITY OF BELGRADE
FACULTY OF TRANSPORT AND TRAFFIC ENGINEERING

anotec engineering

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Dynamic Noise Maps for Ljubljana Airport

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Agenda

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- Traditional vs Dynamic noise maps
- Methodology
- Ljubljana airport case study
- Results
- Conclusions

About ANIMA project

Aviation Noise Impact Management through novel Approaches

22 partners from 11 countries

€7.45m of EU Contribution

48 months duration

ANIMA
Aviation Noise Impact Management through Novel Approaches

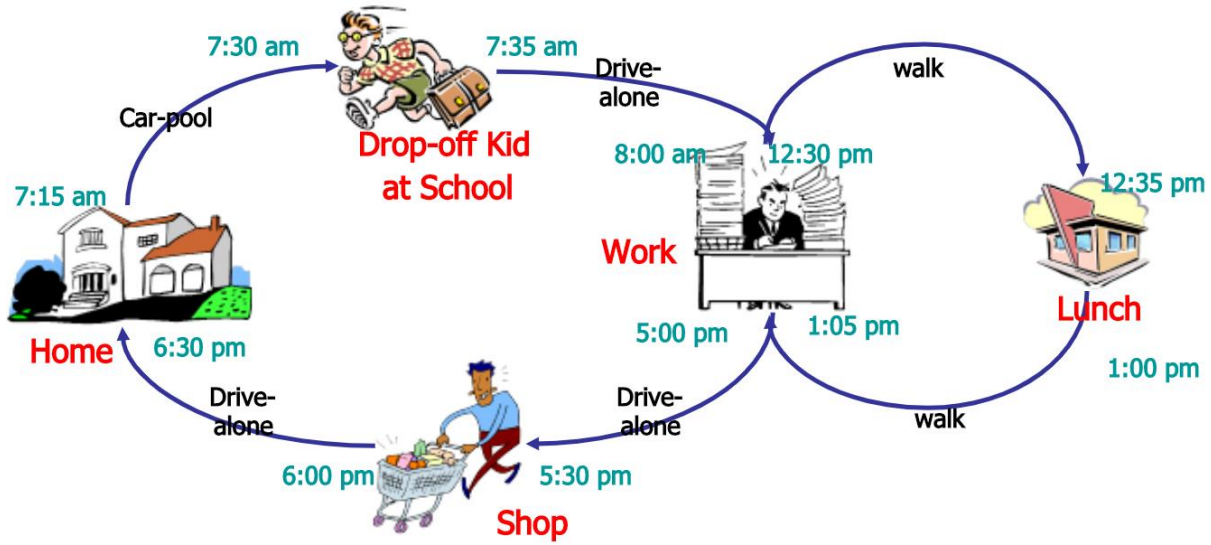
https://anima-project.eu

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 769627

Traditional vs Dynamic noise maps

Traditional noise maps

- Noise exposure only at residential locations
- Assume that people stay at their homes for the whole day (24 hours)
- Census population



Dynamic noise maps

- Noise exposure at all locations where people spend time
- Daily mobility patterns of population
- Synthetic population

Illustration source: Model Task Force Meeting November 29, 2007 Activity-based Modeling from an Academic Perspective Transportation Research Center (TRC) Dept. of Civil & Coastal Engg. University of Florida Siva Srinivasan

Methodology

Daily mobility patterns of population

- Census data
- Household Travel Survey
- Digital services (mobile phones, smart phone apps, social networks, etc.)

Aircraft noise contour modelling

- Input data
- Noise model - SONDEO
- ECAC Doc 29

Calculation of dynamic noise maps

- Spatial and temporal distribution of people
- Calculated noise levels at each location
- Estimated number of people annoyed by noise

Methodology

Equations to estimate the number of people annoyed (NPA) and highly annoyed (NPHA) by aircraft noise based on the L_{den} noise indicator

$$L_{den_j} = 10 \cdot \log_{10}\left(\frac{1}{T}\left(\sum_{l\in L}\sum_{t\in T_d} t_{jlt} \cdot 10^{\frac{LA_{eq,1h_{lt}}}{10}} + \sum_{l\in L}\sum_{t\in T_e} t_{jlt} \cdot 10^{\frac{LA_{eq,1h_{lt}}+5}{10}} + \sum_{l\in L}\sum_{t\in T_n} t_{jlt} \cdot 10^{\frac{LA_{eq,1h_{lt}}+10}{10}}\right)\right), \forall j$$

$$NPA = \sum_{j\in J}\left(\left(8.588 \cdot 10^{-6} \cdot \left(L_{den_j} - 37\right)^3 + 1.777 \cdot 10^{-2} \cdot \left(L_{den_j} - 37\right)^2 + 1.221 \cdot \left(L_{den_j} - 37\right)\right)/100\right)$$

$$NPHA = \sum_{j\in J}\left(\left(-9.199 \cdot 10^{-5} \cdot \left(L_{den_j} - 42\right)^3 + 3.932 \cdot\ 10^{-2} \cdot \left(L_{den_j} - 42\right)^2 + 0.2939 \cdot \left(L_{den_j} - 42\right)\right)/100\right)$$

Methodology

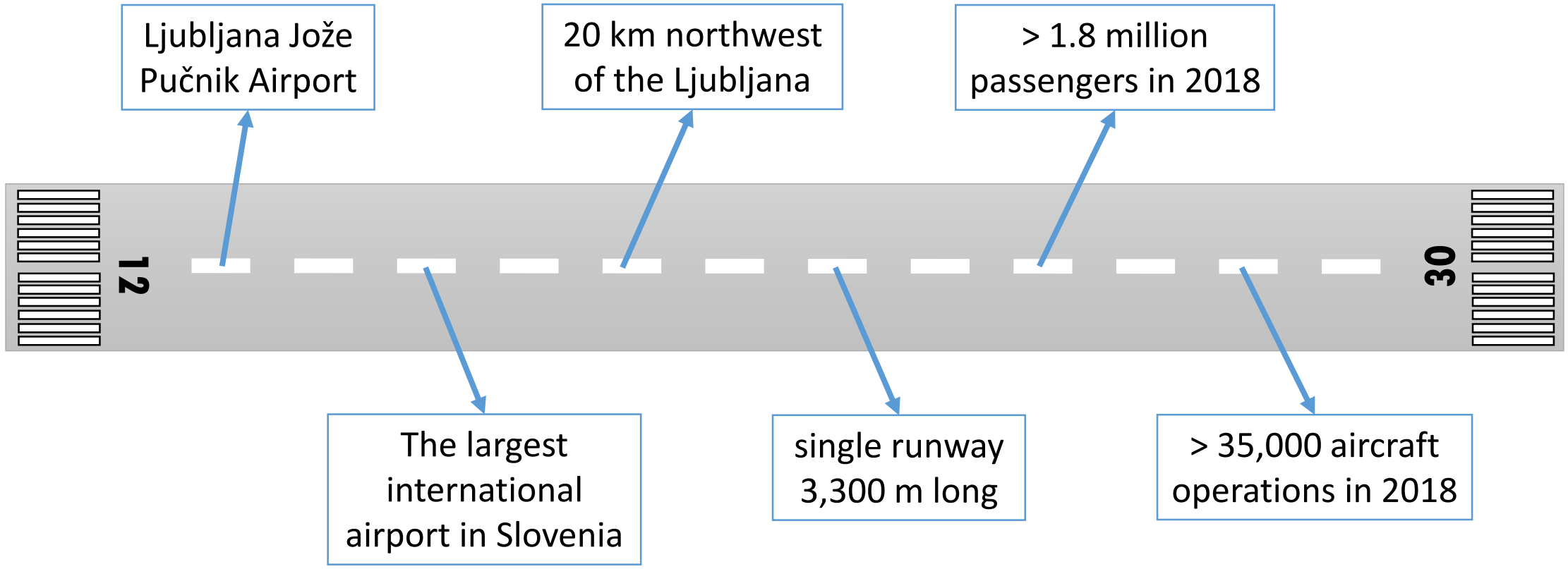
Equations to estimate the number of people who are sleep-disturbed (NPSD) and highly sleep-disturbed (NPHSD) based on the L_{night} noise indicator

$$L_{night_j} = 10 \cdot \log_{10}\left(\frac{1}{T_n}\left(\sum_{l \in L}\sum_{t \in T_n} t_{jlt} \cdot 10^{\frac{LA_{eq,1h_{lt}}}{10}}\right)\right), \forall j$$

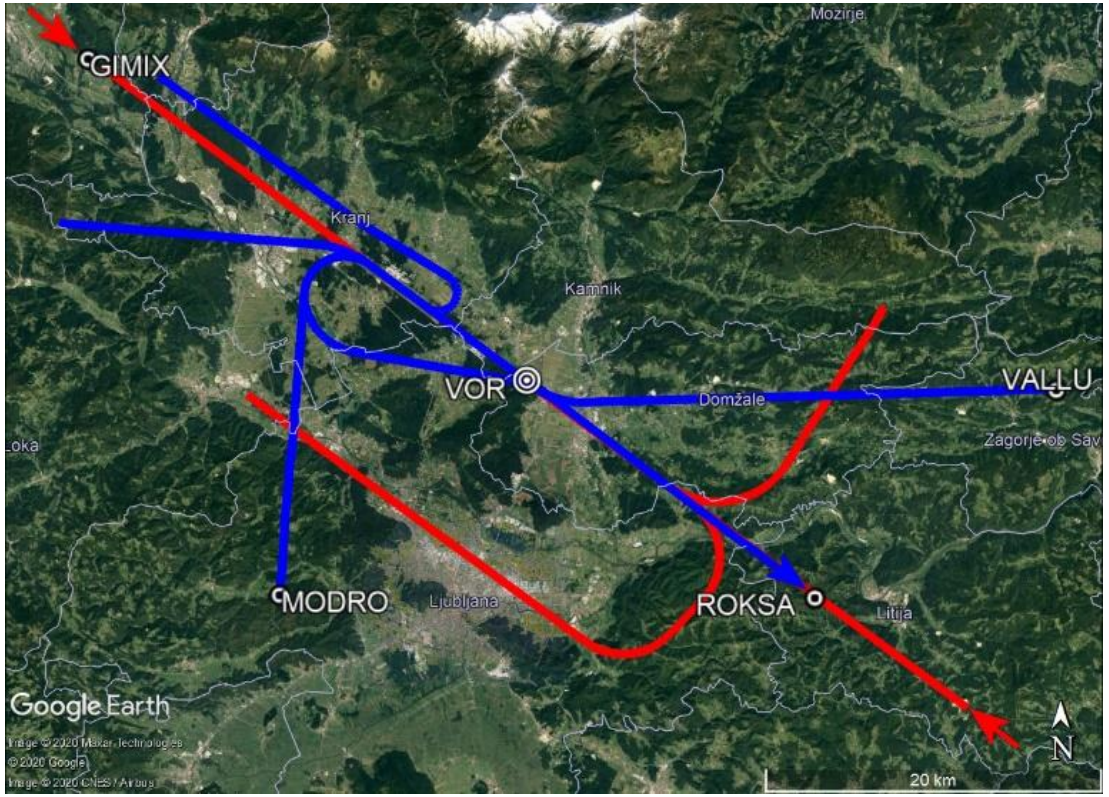
$$NPSD = \sum_{j \in J}\left(\left(13.714 - 0.807 \cdot L_{night_j} + 0.01555 \cdot \left(L_{night_j}\right)^2\right)/100\right)$$

$$NPHSD = \sum_{j \in J}\left(\left(18.147 - 0.956 \cdot L_{night_j} + 0.01482 \cdot \left(L_{night_j}\right)^2\right)/100\right)$$

Ljubljana airport case study



Ljubljana airport case study



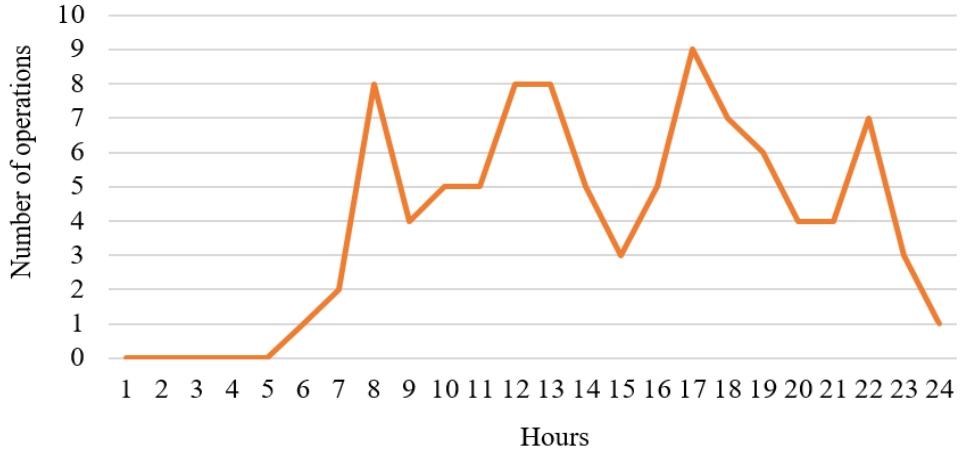
Departure (blue) and arrival (red) routes (source: OpenSky, Google Earth)

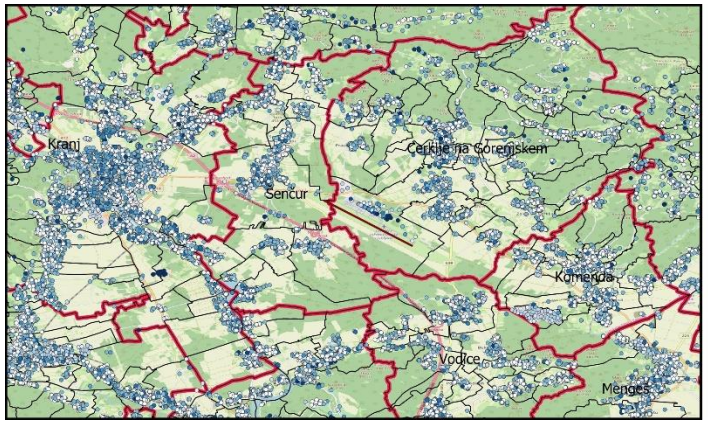
ICAO aircraft type code	Day		Evening		Night	
	A	D	A	D	A	D
CRJ9	3586	4674	1284	522	445	117
A319	1302	1542	587	434	305	219
CRJ7	875	1116	305	101	85	48
CRUZ	796	855	79	19	0	0
F100	505	633	137	88	100	21
A320	259	249	262	263	22	29
C172	367	416	84	40	5	0
B734	328	2	3	401	80	8
A320	119	118	72	60	148	162
AT72	369	214	158	350	110	74
L410	66	311	253	6	1	1
DH8D	289	278	2	12	0	1
P28A	239	263	30	6	0	0
SW4	54	260	211	5	0	0
AT75	110	110	132	130	0	2
All others	2709	2868	763	613	119	111
Total	11973	13909	4362	3050	1420	793

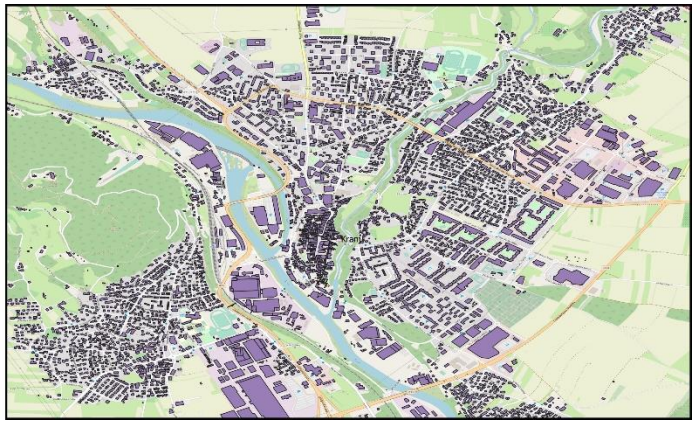
Flight statistics per aircraft type and time of day

Ljubljana airport case study

Average hourly distribution of aircraft operations for year 2018







Real Estate Register and Building Cadastre data (source: GURS https://egp.gu.gov.si/egp/, validity date 22.08.2020)

Daily Passenger Mobility Survey

Statistical Office of the Republic of Slovenia

Data collected during the last two weeks in September and in October 2017

Equal distribution of working and non-working days

Residents aged 15–84

The number of respondents was 8,842

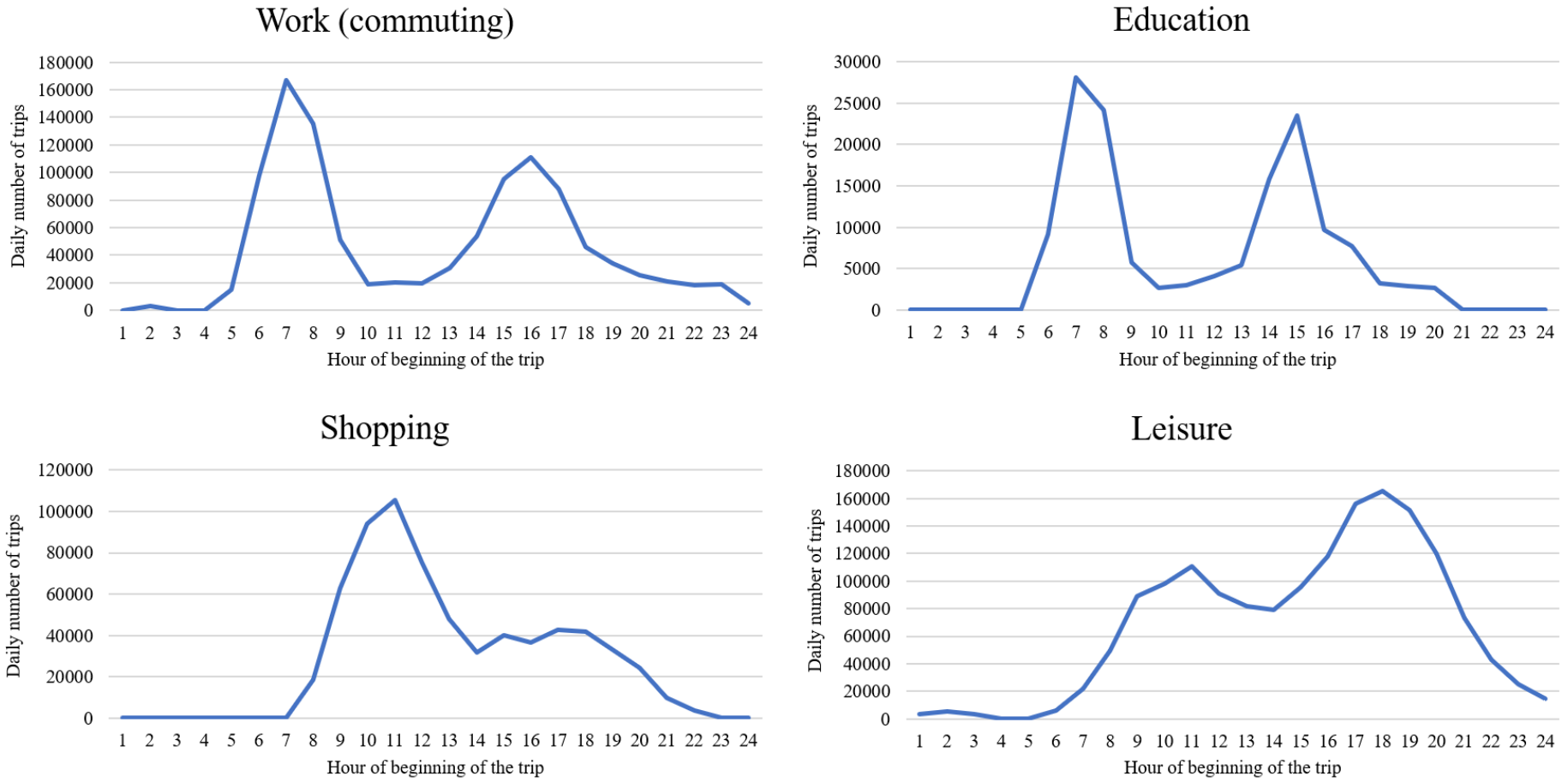
1,355 (15.3%) survey participants stayed at home on a selected day

7,487 persons made 24,195 trips (3.2 trips per day)

Trip Purpose	Description	No. of trips
Work (commuting)	Going to work	5871
Professional, business	Business or official errands, business trip up to 300 km	640
Education	Going to school, faculty (education facility)	989
Escorting (of parents)	Driving / picking up/ accompanying a child or other person	2339
Shopping	Visiting stores	3544
Leisure	Visiting friends/relatives, going out to eat or drink, recreational activities (indoor or outdoor), hobbies, walking a pet, working in the garden, sightseeing, visiting cultural or sport events.	8620
Personal business	Health treatment, personal care (e.g. hairdresser), services (e.g. car maintenance), going to the bank, post, religious activities (also funerals).	2192

Description and frequency of trip purposes

Daily Passenger Mobility Survey



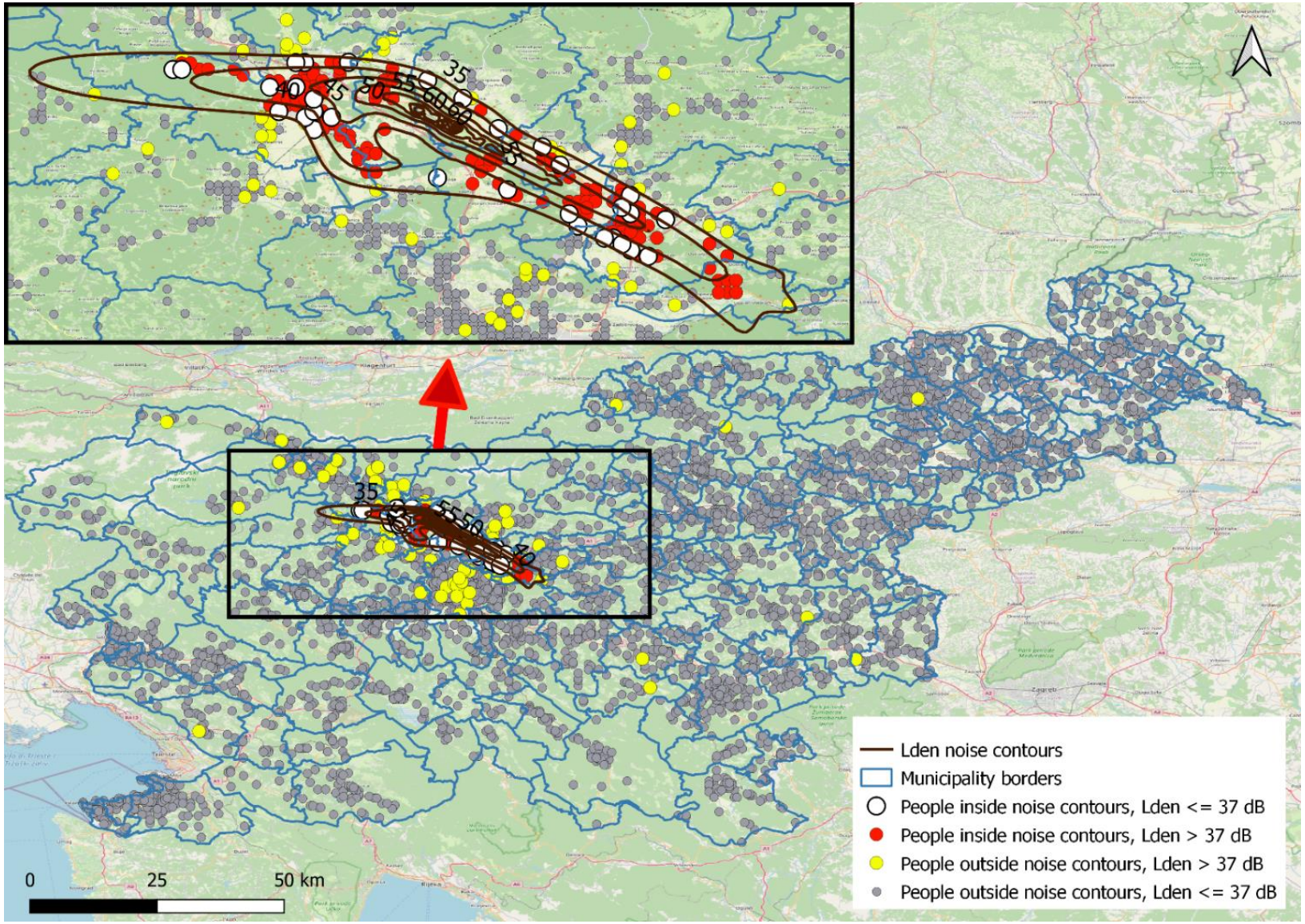
Daily number of trips by trip commencement hour and purpose (source: SURS https://www.stat.si/statweb)

Results

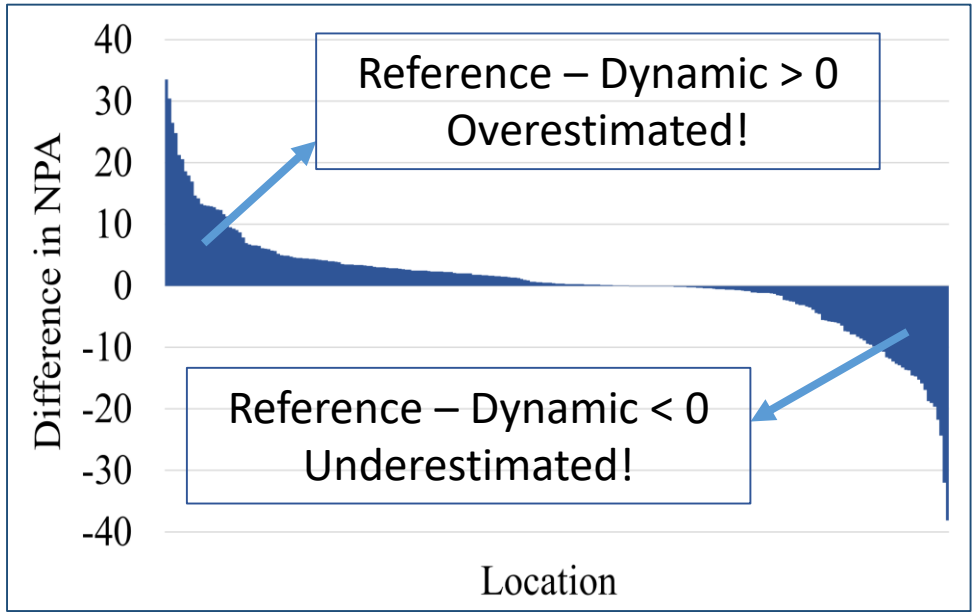
L_{den} noise contours and people affected by aircraft noise

10.1% of people living within the L_{den} 37 dB noise contours are not annoyed by aircraft noise

14.4% of people living outside the L_{den} 37 dB noise contours are annoyed by aircraft noise



Results



Difference in number of people annoyed by noise per location

2.9%

10%

Statistics	Reference scenario				Dynamic scenario			
	NPA	NPHA	NPSD	NPHSD	NPA	NPHA	NPSD	NPHSD
Mean	5430	588	158	92	5588	529	158	91
Median	5435	589	156	90	5588	530	155	90
Min	4756	408	33	19	5058	386	37	22
Max	6227	810	301	174	6226	700	288	167
Range	1471	401	268	155	1168	313	251	145
Standard deviation	202	53	43	25	193	50	43	25

Results based on 1000 iterations

Conclusions and future research

- The number of people annoyed by noise increases by 2.9% compared to Reference scenario
- The number of highly annoyed people decreases by 10% compared to Reference scenario
- The number of people annoyed is either overestimated or underestimated
- Sleep disturbance indicators do not differ significantly between the two scenarios
- 10.1% of people living within the L_{den} 37 dB noise contours are not annoyed by aircraft noise
- 14.4% of people living outside the L_{den} 37 dB noise contours are annoyed by aircraft noise
- The results must be validated in urban areas that are more diverse in terms of land use
- The sample of the population considered must be widened to prevent uncertainty in the metrics

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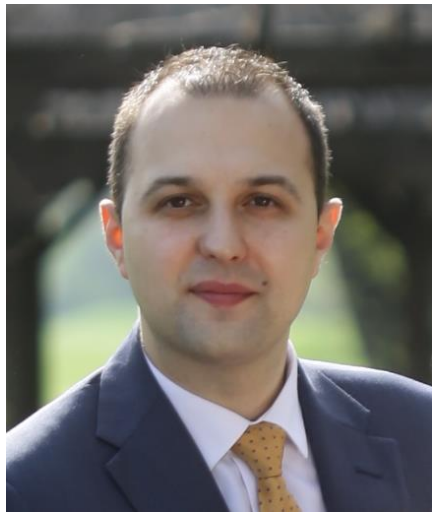
Thank you for your attention!



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