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Where do planes fly past overhead? Determining departure and arrival routes from radar traces

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ABSTRACT

This paper questions the main techniques of mapping in the context of aircraft noise in the vicinity of airports, and compares these techniques in terms of their purpose, benefits and limitations. Then the paper describes a method to summarise radar traces of a given air transport departure or arrival route into a median route and its envelope containing 80% of flights. This makes it possible to map global and easy-to-read maps of current air procedures around airports based on actual pathways flown by the aircraft. It also makes it possible to investigate the impact of change in aeronautical procedures on the actual geography of air routes around airports. Such maps complement noise contour maps and offer a good basis for debating aeronautical procedures at airports whose operations expose the population to noise.

1. Introduction

Increasing volumes of air traffic, expanding cities and spatial conflict between the location of many airports and the geography of residential areas have made aircraft noise a very topical issue (Bröer, 2007; Daley, 2010; Rodríguez-Díaz, Adenso-Díaz, & González-Torre, 2017). Aircraft noise is known to disturb people's lives and to affect health, including sleep (Basner, Griefahn, & van den Berg, 2010; Franssen, van Wiechen, Nagelkerke, & Lebret, 2004; Kaltenbach, Maschke, & Klinke, 2008). This has led to many protests and has forced governments and international organisations to pay more attention to the local adverse impacts of aviation.

This has involved a large production of maps to feed information reports and websites, expert reports, public debates, news and citizen participation. While these documents may appear technical and neutral, a deeper insight suggests there is no perfect solution, although various options are available. All have benefits and limitations and fit with different purposes.

In this context, the present paper compares the main techniques of mapping related to aircraft noise issues (Section 2) and proposes a transparent method to compute pathways followed by departing or arriving planes for those analysts who have the opportunity to access radar traces (Section 3). The method is then applied to the Brussels case (Section 4), where vibrant political debates and new citizen protests could be observed in the aftermath of new procedures.

2. A review of main mapping techniques

2.1. What and how to map? A classification

As far as aircraft noise is concerned, stakeholders (including public authorities, airports, activists, the media and scholars) can produce a range of maps that differ in terms of scope, aim and mode of representation. These maps are classified in Fig. 1. Basically, one can oppose indicators (1) focused either on noise or on pathways followed by planes, and (2) resulting mapping as lines or surfaces. These techniques depend on the purpose but can also be imposed by the availability of data and the skills required by the mapmaker. The noise vs.

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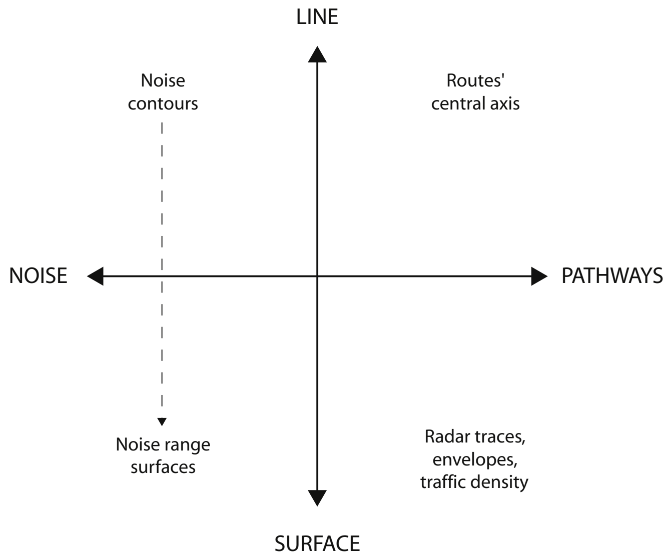

Fig. 1. Classifying maps used in the context of aircraft noise.

pathway representation also refers to effects vs. causes, respectively. They all have benefits and limitations that are summarised in Table 1 and discussed hereafter.

2.2. Noise contours and noise range surfaces

Noise contours and noise range surfaces have become a common means to objectify aircraft noise around airports. In Europe, for instance, they are at the core of common rules imposed by Directive 2002/49/EC to assess and manage noise emitted by industrial activities and transport, including air transportation, and to inform citizens. Such a technique is based on noise models fed by 3D radar traces of planes (thus their horizontal position and altitude), planes' characteristics (especially engine type and climb profile) and weather conditions (temperature and wind) (see ECAC, 2016). Noise models are calibrated thanks to ex post measures of noise usually extracted from noise-monitoring systems.[1] They are usually used to produce average noise maps and possibly the number of noise events above given thresholds (Cho, Kim, Kim, Hong, & Lee, 2014; Goldschagg, 2013). Fig. 2 shows an example of such contours. The main purpose of these maps is to assess the spatial extent of aircraft noise by level of noise, and to compute the number of buildings and inhabitants included within noise contours equal to or more than a given threshold. As such, it is used to assess how much both actual and potential departure and arrival procedures expose residents to noise. It thus makes it possible to estimate the cost of place-dependent measures (e.g., grants for building insulation and expropriations) and to compare the cost/benefit ratio of different operational schemes (time range of operations, aircraft types allowed to operate, definition of departure and arrival routes,[2] etc.), typically under the auspices of the so-called balanced approach (ICAO, 2008) that also promotes reduction of noise at the source through technological progress (Suryadi, Martens, & Herr, 2017). And in case of proactive policies, noise contours are used to help public authorities to set land-use planning in order to restrict the number of inhabitants exposed to noise.

Table 1
Comparing maps used in the context of aircraft noise.

Mapping	Main purposes	Benefits	Limitations
Noise contours and related noise range surfaces	- Assessment of actual and potential aeronautical procedures regarding number of people (or buildings) exposed - Feeding political measures aimed to deal with noise	Standardised definition of areas exposed to noise so political measures can be envisaged Based on planes' altitude and specifications, weather conditions and distance to the noise source	- Imposes a spatial border to noise level that is a continuous phenomenon - Political definition of noise that may diverge from residents' views
Raw radar traces	Showing all departing or arriving flights	- Spatially comprehensive and accurate - Investigation of deviations	- Misleading representation due to flight overlap - All flights are made equal and distance to the noise source is not considered
Traffic density	Showing the concentration of flights	Circumvent the flight overlap issue	- All flights are made equal except in the case of 3D radar traces and taking engine types into account - Distance to the noise source is not considered
Routes' central axis	- Help air-traffic controllers and pilots to visualize air procedures (AIPs) - Clear and efficient basis to discuss air procedures	- Easy-to-read outputs - May clarify nomenclature of routes and other objects	- All flights are made equal and distance to the noise source is not considered - Accuracy rarely questioned - AIP charts: basically not geographically accurate
Authors' suggestion: routes' central axis and 80% envelope, all computed from radar traces	- Clear and efficient basis to discuss air procedures - Ex post assessment of changes in procedures	- Accurate inputs - Transparent method - Easy-to-read outputs	- All flights are made equal and distance to the noise source is not considered - Requires access to radar traces and extended GIS skills

[1] The gap between calculations and measurements depends on various factors. In the case of Brussels Airport, for instance, and considering 25 relevant measurement stations, 2016 modelling of noise events $L_{Aeq,24h}$ suggests gaps ranging between −1.4 dB(A) (noise is overestimated) and +1.6 dB(A) (noise is underestimated), with a root-mean-square error of 0.8 dB(A) (Dekoninck, Van Renterghem, & Botteldooren, 2017).

[2] For instance, Continuous Descent Approach as a means to reduce (to some extent) the noise of landings compared to the traditional stepwise approach (see White et al., 2017).