Linking urban structure and activity dynamics using cell phone usage data

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The second half of the 20th century has witnessed mass residential development in city expansions and new towns in west European countries. In general, the resulting neighbourhoods and new towns have low activity densities and a high level of land-use segregation. Jane Jacobs (1961) already warned that urban vitality would decrease with such development. At the start of the 21st century, many of the socio-economic problems of western societies have culminated in these areas: social exclusion in British new towns (Royal Town Planning Institute, 2002); urban decline and unsafety in Dutch post war city expansions (Priemus, 2006; NICIS, 2008). To counter the part of these problems that may be related to the layout of post-war city expansions, recent urban redevelopment plans in the Netherlands have centred on creating areas with relatively high building densities and mixed land use. In Amsterdam, examples are the `Amsterdam Arena' and 'Shell terrain' areas (Gieling, 2003) and the `Eastern Docklands' (Hoppenbrouwer and Louw, 2005). However, evidence that land-use mixing and densification contribute to more intensive use of the urban fabric is scarce, often only available at the aggregate city level, and mostly of an anecdotic nature.

The past years have seen an upsurge of *crowd-sourced* data in geographical information science (see, for example, Goodchild, 2007). Of these data, cell phone usage has been emphasised as particularly suitable for urban analysis (Ratti et al., 2006). It provides information on how the city is used in a high spatial and temporal resolution. It has less of the "spatial error" (Gould, 2000; p. 190) inherent to census data and therefore provides a useful addition to such traditional data sources. We obtained total number of new mobile phone calls per hour from circa 600 cell phone antennae in Amsterdam and use these as a proxy of *how many people are where*. These cell phone antennae cover an area of 0.5 km^2 on average. We expect that areas where more people are present over longer periods of the day have a higher urban vitality. We aim to add to the understanding of urban vitality problems by statistically analysing on a fine spatial resolution how physical characteristics of the city, such as urban density and land use mix, affect how many people are where.

Using cell phone data as an approximation of human presence and relating it to physical characteristics is conceptually challenging. Mobile phone usage might be biased towards groups of people with specific income, lifestyle or age. By relating mobile phone use to census data we show that this bias is not necessarily present in the data at hand. Furthermore, care must been taken in attributing city characteristics to antennae because the link between caller locations and the connecting network antenna is of a stochastic rather than deterministic nature. The antenna to which a caller connects depends on his geographical position, weather conditions, shape of the urban environment and additional phone network mechanisms. The relation between caller location and physical characteristics is further obscured because people are likely to use their cell phones while travelling to their destination. So the characteristics of the location where a call is made do not necessarily link to the purpose of the caller. To overcome the unclear relation between city attributes and where callers are, the applied model relates cell phone usage to the averaged attributes of a much larger area of the city than is primarily serviced by cell phone antennae.

We proceed to analyse how factors such as land-use mix, urban density and accessibility influence where people are. We find that places with better accessibility, higher building density and a higher degree of land use mix are, in general, attract more people over a longer period of the day. However, we find that in Amsterdam's post-war city expansions, densification and land-use mixing is not as effective in increasing urban vitality as it is in the old town. We attribute the higher urban vitality of the old town to the much finer scale of land uses and land use mixing there. Our main conclusion is that densification and land use mixing, as it has occurred, can at best slightly increase the urban vitality of Amsterdam's post war city expansions.

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