Adaptation of Urban High-density Neighbourhoods in Nodes of Sustainable Intelligent Mobility Condensers

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Abstract
In Europe and since the early twentieth century, municipal mobility policies have provided underground parking and public transport to many of the rapidly built social neighbourhoods between 1960 and 1980, which were planned lacking them. However, the climatic emergency requires new approaches that reduce CO2 emissions. This paper sets out the steps for the implementation of an Intelligent Mobility Condenser (IMC) in an existing neighbourhood. IMCs combine connectivity to public transport, together with the creation of a transport cooperative that meets the mobility needs of its neighbours without the need to own a private car. Similar to car-sharing, the IMC offers hybrid, electric, solar cars, along with motorcycles and electric bicycles. This together with a digital platform that facilitates the management of their needs. On the other hand, IMCs are automatic surface parkings, with solar collection and urban gardens, which, being high-access nodes in the neighbourhood, allow the incorporation of community, social and commercial spaces. The paper discusses the results based on the economic and environmental benefits of the model, and the threats of its implementation due to the difficulties of giving up the private car.

Keywords
Neighbourhood Mobility, Car Sharing, Smart Mobility, Transport Cooperative

1 Introduction

In recent decades, urban planning has been largely conditioned by the role of the car: the streets have been dimensioned according to the number of lanes to drive, the parking spaces occupy the space that would be destined for public sidewalks, and large traffic nodes that create fractures in the urban fabric with dehumanized spaces. This situation promotes a more individualistic and less cohesive society as there are fewer spaces for relationships. Current mobility is made up of public and private transport systems that share traffic lanes, with bus stops, metro / tram, taxi for the former and parking for the latter. Intermodal transport normally focuses on large metropolitan facilities in cities, especially on large transport infrastructures (airports, ports, bus and train stations) in an approach of superposition of transport networks and generation of interconnection points between public networks or from private to public transport, which is generally accompanied by parking areas.

Faced with this approach, the urban mobility model is evolving (a) through the development of new hybrid and electrical technologies that reduce CO2 emissions to zero and minimum levels, (b) the development of new transport models based on platforms collaborative technological technologies (Uber, ...), as well as the offer of car-sharing as an alternative to not needing to acquire a car in property, (c) the implementation of policies that promote Slow Metropolis and pedestrianization to make a city more human (Mezoued et al., 2021). These policies in Europe have been implemented especially in historic centres. However, an approach from the needs of the citizen becomes more necessary. Along these lines, progress has been made in the definition of superblocks (islands of neighbourhoods with reduced or non-existent mobility surrounded), but there is a lack of reflection on the mobility models that combine the above challenges from the perspectives of neighbourhoods, and especially in neighbourhoods of high urban density in the second urban peripheries, created during the migratory periods of the 50-80s and which was resolved with standardized social housing, and in the case of Spain, with the absence of parking, in addition to low urban standards.

The access to the private vehicle of the residents of these neighbourhoods has forced them to transform free spaces into parking islands, double-row parking, generating a very poor urban landscape and reducing the space of relationship. Faced with this problem, policies have been developed for the construction of underground car parks, which have partly solved the problem. However, the high costs and difficulties of construction in the existing city and the limitations of this model in the renaturation of spaces (normally the surface of parking lots are hard places and also do not allow evapotranspiration and the recharge of aquifers does not make it a generalized solution for the neighbourhoods in question.

For this reason, Intelligent Mobility Condensers (IMC) are defined for the neighbourhoods. They constitute an alternative to the use of the private vehicle in property since they offer a range of means of displacement according to the needs of the users. The IMC is defined as an intelligent mobility hub for neighbourhoods, it allows the creation of an infrastructure and a service that solves the mobility movements of the inhabitants of the neighbourhood. On the one hand, they are public transport micro-exchangers (taxi, urban bus) and car & ride-sharing companies that provide services to the inhabitants of a neighbourhood and, in the case of the existing city, they are elements of urban denaturalization, acting especially in areas with a large concentration of surface vehicles. This paer intends, through a case study, to see the advantages and disadvantages that the construction of this model would entail from the urban, neighborhood and architectural-constructive scale, through a case study of a southern European city.

2 Background

The idea of multi-functional hubs as architectural-engineering elements that combine multimodal mobility, parks and a functional mix of public services has been developed by Carlorosi et al. (2015) seeking an innovative use of public transport in relieving areas saturated by private transport. However, its application to solve the problem in the neighbourhoods and its link to new forms of cooperative mobility is an aspect little analysed. The use of ride-sharing and car-sharing offers neighbourhood residents mobility without the necessity of vehicle ownership (Kane & Whitehead, 2017). Among the benefits of car-sharing we highlight: the reduction in traffic congestion and pollution (Kane & Whitehead, 2017), lower vehicle ownership (Martin et al., 2010), reduced urban travel costs (Belk, 2014), and a reduction in public and private car parking space (Shaheen et al., 2009). This increases opportunities for better urban design and increased walkability (Kane & Whitehead, 2017).

Regarding the design and effective deployment of car-sharing stations. Efthymiou et al. (2020) have identified as external factors to consider in its location, among others: population density, proximity to public transportation stations, land use, distance to services, number of enterprises near the stations and vehicle. With an integrated transport, cities can reduce traffic congestion and environmental pollution (Dacko & Spalteholz, 2014). In this regard Terrien et al. (2016) have analysed the integration between public transport and one-way carsharing (shared use of a fleet of vehicles that are typically free-floating throughout an urban area). The integration of the IMC with the transportation system turns the IMC into a HUB that favours transit-oriented development (TOD), with an improvement in the community development model in relation to healthier communities reducing their carbon footprint housing.

3 The IMC model

The IMC is focused on creating a parking and rental system for electric and solar vehicles for the use of superblock residents. For this, the model has two dimensions: An urban dimension and a neighbourhood dimension. According to Rueda (2011) the creation of superblocks in the neighbourhoods allows generating an area of 400 x 400 m, of calm traffic, to be used for mobility on foot, by bicycle, while motorized transport is concentrated in the perimeter roads. For each superblock, the IMC resolves sustainable mobility by being connected to the city's public transport means: Bus and metro or tram, if available. Thus, in a general city-scale model, each citizen could move from superblock to superblock by accessing the different IMCs. This would generate a large network of interchanges, which would facilitate a more sustainable mobility in the city, with greater benefits for the TOD model. The IMCs are mobility nodes associated with each superblock where all available public transport systems are concentrated, and they facilitate the movement of the users of said superblock through intelligent and sustainable travel. Therefore, they need:

a) Closeness (50 to 100 m) to any of the means of public transport: bus, tram, metro and secondarily taxi

b) Connection to the bicycle lane network

c) Existence of vacant or opportunity spaces (> 600 m2), if possible in a central position of the superblock.

d) Qualified density (> 100 inhab / ha). High-density areas are the ones with the greatest parking problems and the best to encourage BMIs.

In this model, the user travels from his home to the IMC, either on foot, with a bicycle, or an electric scooter. From there, he uses the means of transport, most appropriate to his needs, depending on the place, the management that he is going to carry out and the availability of transport available. The IMC concentrate the available means of public transport: Urban bus stop, metro stop (if applicable), taxi stop, public bicycle stops. And it manages the car sharing system for the inhabitants of the superblock through an offer of hybrid, electric and solar vehicles, as well as electric bicycles and motorcycles.

4 Málaga as a study case

To carry out this study we have taken as a study case a Malaga's neighbourhood. The distribution of mobility in Malaga is characterized by a predominance of mobility on foot (48%) compared to the car (31%) and where other means of collective transport or more ecological transport have a very reduced use (bus 11% and bicycle 2%). This distribution is mainly due to a good climate and a good heterogeneity of uses in the city that promote transport on foot in short trips, however the efficiency of means of transport in the city can be measured by the time used to travel an average distance of 5 km. In this comparison, the vehicle and the bicycle are the fastest methods to move around the city, but one of the main problems is the low rates of passenger occupancy per vehicle of the private car, due to some extent to the high rate of motorization. So that, the ration surface occupation and number of people is lower. The car has an occupancy ratio of 6.7 m2 / pers. as it remains parked an average of 20 to 22 hours a day on the streets, causing a situation that is not very encouraging and unsustainable. In the case study, large urban spaces occupied for private vehicle parking are observed as it is the most economical form of parking at first. However, this decision entails serious economic problems (related to consumption to move these vehicles and the time to park in saturated spaces), environmental (related to noise and harmful emissions from so many vehicles) and spatial (related to mortgaging public space and Social relations).

Fig. 1. View of the parking area in the study case. Source: by authors

5 Results

In a radius of 200 m there are three large surface parking pockets with a total of 236 parking spaces on and 919 parking spaces in the basements of the residential buildings that surround it (Fig. 1). Therefore, there is a provision of 1,155 places. However, in accordance with the Spanish standards of urban regulations, 1,486 parking spaces are required: 995 parking spaces (1 / home) + 491 parking spaces for office and commercial uses (1 / 100 m2). Therefore, if we want to eliminate those parking areas and get urban standard, an underground car park with 567 parking spaces would be the traditional solution.
As an alternative to traditional parking, ICM offers this solution. The 919 underground parking spaces are divided into 491 revolving spaces for rotating commercial and office uses and 428 fixed spaces for residents. This allows users to have income from the rental of said parking spaces. Residents have, therefore, 428 fixed places (43% of their needs) and 567 places (57% of their needs) that the ICM must solve. For this, it is estimated that a fleet of 332 vehicles made up of: E-bike, electric motorcycles (80 units) and Electric vehicle (252 units).

The ICM incorporates an automatic parking for electric vehicles and an e-bike rental point. At the same time, it concentrates public bus transport stops, and has space reserved for a taxi rank. In this way, and for urban displacements, residents of the neighbourhood, in addition to the car-sharing and ride-sharing offer, can opt for: Taxi and urban bus stop. In this way, the implementation of the ICM frees the space occupied by the parking bags that become green areas and becomes a car-sharing interchange with public transport, facilitating the offer to users (Fig. 2).

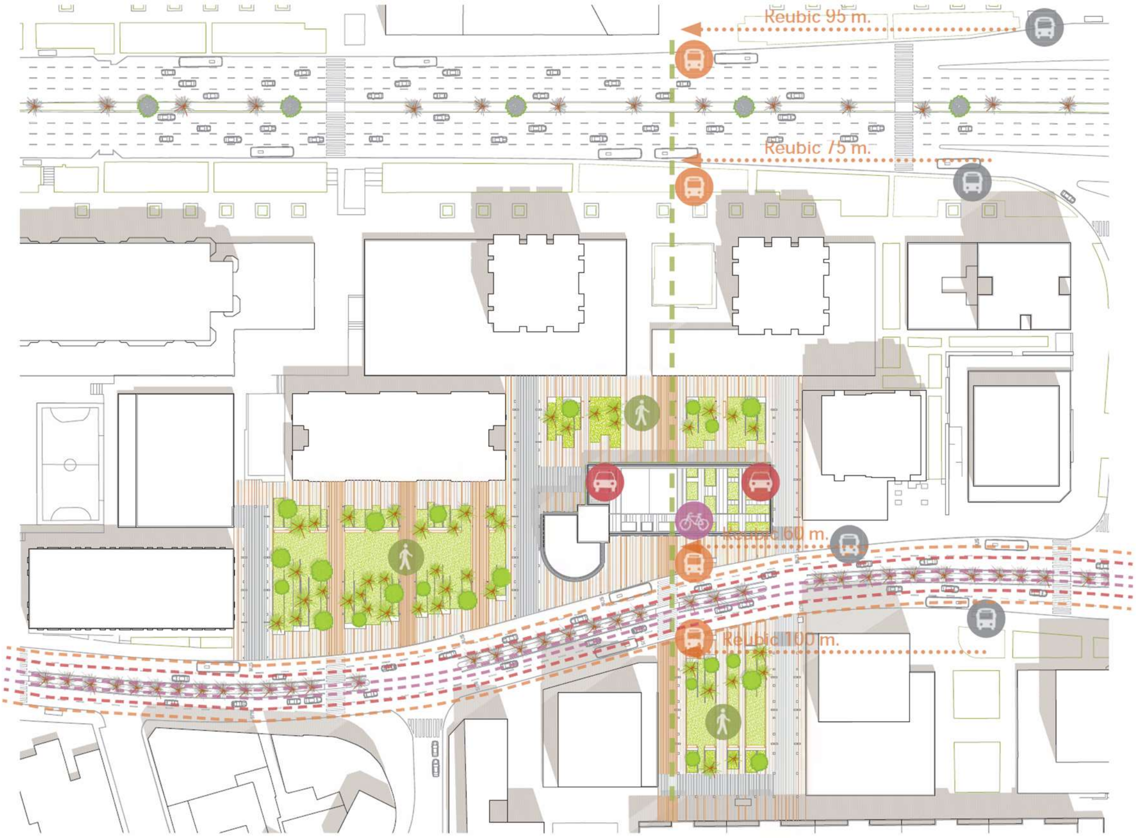

Fig. 2. Implementation of ICM, creation of tree green areas a new location of public transport stops. Source: By authors.

The IMC building occupies an area of 915 m2 and is organized on five levels, 4 stories high, with a total constructed area of about 4,000 m2. This allows the development of a building with three differentiated functions:

a) The central body is made up of the four levels of the automatic car park and whose envelope is active since it allows the capture of energy and the environmental improvement of its surroundings.

b) Community use cover and water catchment. The roof is a space that is also considered public (that is how it would be if the parking were underground) but which, by staying on a higher level, allows the development of uses with some control. In this case, the development of an urban community garden has been proposed.

c) At surface level, the access of e-car vehicles, management offices and small commercial premises is carried out.

Automatic parking allows the user to deposit the vehicle in a room and, mechanically, store the vehicle through a system of rotating, lifting and sliding platforms. Storage trays require a much lower height and surface than a traditional car park, which is an added advantage to conventional storage. The storage and loading of electric bicycles take place on the ground floor of the IMC, the use of double-height rack parking allows doubling the storage capacity. In addition, the e-bike or electric motorcycle has a charging point in the storage itself.

The IMC is also designed as an active envelope building. In other words, enclosures that capture photovoltaic and water energy, as well as capture CO_2 through green panels. This function, in addition to reducing energy demand and water consumption, also allows incorporating a green design. The roof allows the collection of rainwater for storage in tanks under the ground floor slab and from which to redirect the filtered water for irrigation use of the covered plant social gardens and the hydroponic panels mainly, and secondarily for the cleaning of vehicles.

The ICM implies an improvement in air quality for three reasons: (1) Due to a reduction in the number of combustion vehicles; and the replacement of part of the fleet by electric vehicles without emissions; (2) due to the increase in green areas that are replacing the parking area; (3) and by the use of vegetal panels on the north façade (with a lower solar incidence), as well as by the use of GRC facades with ecological concrete in the volumes of the facilities absorbs CO2 emissions.

On the other hand, the active façade acquires a function of capturing energy on facades exposed to sunlight (East, South and West), through a modular system of photovoltaic panels and slats (Fig. 3). This increases the solar control protection of the interior spaces and, in turn, the obtaining of electrical energy for the consumption of the building itself and of the electric mobile park.

Fig 3. South facade of IMC with solar panels. Source: By authors.

6 Discussion

Therefore, the BMI produces a series of improvements and positive aspects that we will now analyse. Firstly, there is an increase in green spaces for social activities and CO2 sinks that significantly reduces the existing waterproofed surface, and increases the levels of evotranspiration by facilitating the flow of water to the subsoil. To this we must incorporate the urban gardens that can be developed on the roof of the building. In other words, the IMC allows an area of 7000 m2 to be increased for the re-naturalization of the neighbourhood, with the simple occupation of 1/7 of the old parking lot.

This intervention helps both to reduce CO2 emissions and to reduce the heat island in the urban environment, thanks to the new green spaces with trees that absorb said CO2, and that together with the vegetal panels of the second skin of the building generate a beneficial microclimate for the environment (Fig. 4).

Fig. 4. West facade of ICM in front of new green area. Source: By authors.

The car, despite its high initial cost (an average of € 2000 / year and € 0.23 / km), is the preferred means of transport for the citizens of Malaga due to its comfort, independence and time spent by distance. However, for short or medium trips (not exceeding 15,000 km / year per user), carsharing and public transport are cheaper and more efficient alternatives, as shown in the following table (Fig. 5):

	Transporte Privado	Carsharing	Transporte Público
5.000 km/año	4.824'00 €/año	2.220'00 €/año	650'00 €/año
10.000 km/año	5.121'00 €/año	3.183'20 €/año	1.300'00 €/año
15.000 km/año	5.339'00 €/año	4.694'60 €/año	1.950'00 €/año
20.000 km/año	5.653'00 €/año	6.366'40 €/año	2.600'00 €/año

Fig. 5. Average costs of private transport, public transport and carsharing.

Although the active façade initially has a higher cost, the self-generation of solar electrical energy to recharge the vehicle fleet reduces the fixed cost in the medium and long term. The capture of water reduces the use of drinking water for activities that do not require a high level of purification: planting crops and cleaning vehicles. In this regard, automatic parking has a series of spatial and economic advantages compared to traditional parking: by not having to pass people, the height between slabs can be reduced by 75% (to make it similar to the height of the vehicle 1.60 m) Furthermore, as there is no need for ramps or traffic lanes, the area per square is reduced by 60% to 15 m2.

Despite the fact that the economic cost of automatic parking is more expensive per square meter, however, the reduction in surface area and height makes it possible to lower the impact of construction costs per space, until it is more competitive than traditional parking. By one hand, the increase in the cost of construction involved in the construction of new basement levels is reason for it to have as large an area per floor as possible, so the resulting public spaces are usually hard squares with difficulties to plant trees, generating public spaces with many occupation difficulties in the hot seasons in southern climates. By the other hand, given that the average occupancy rate for private vehicles ranges between 1 and 1.5 people per vehicle, it is not necessary to acquire a fleet of vehicles with 4 or 5 seats in its entirety. The ICM makes it possible to offer a diversified offer of vehicles that also makes it possible to take better advantage of the size of the car park itself.

The development of this model to the rest of the study city is feasible, insofar as it is possible to organize the city in superblocks of 400x200 m surrounded by main road, and within the same areas of opportunity in which to implement the IMC. What would generate a network of IMCs at the city level, which would be superimposed on the network of interchanges of the large transport systems that currently exist (Fig. 6).

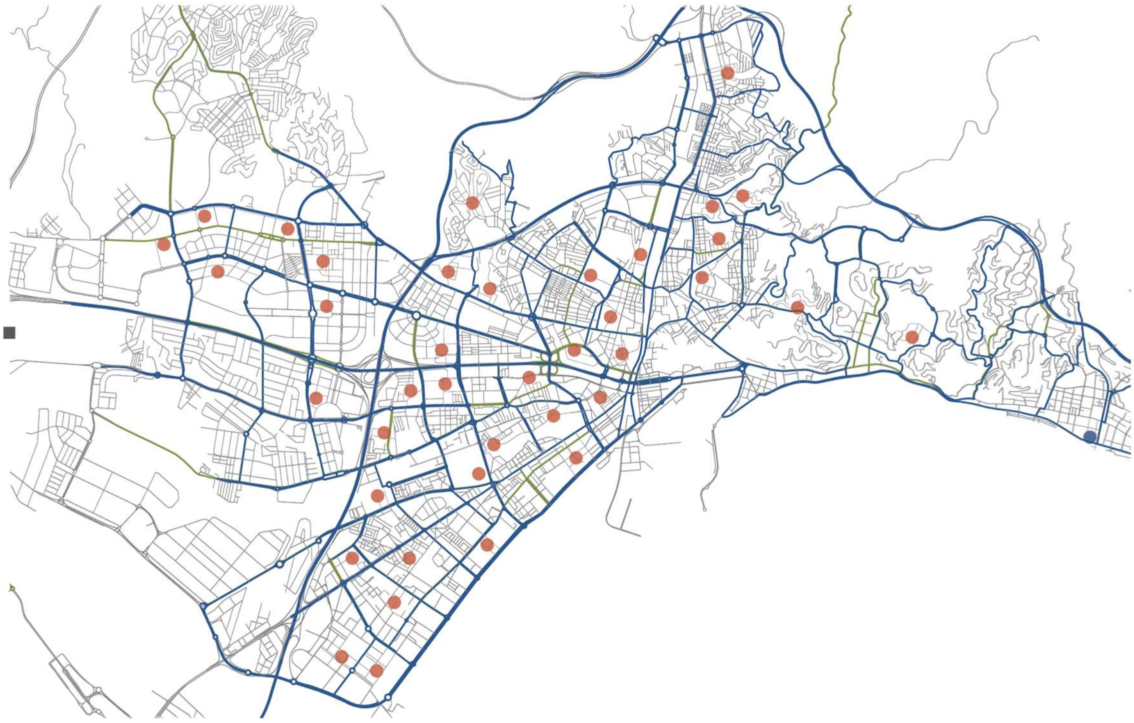

Fig. 6. Possible new locations of ICM for all Malaga's neighbourhoods. Source: by authors.

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