

# **THE CHALLENGE OF SUSTAINABLE UNIVERSITY MOBILITY: COMPARING THE ACCESSIBILITY AND QUALITY OF PUBLIC SPACE OF 14 CAMPUSES IN MADRID**

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## **ABSTRACT**

The 6 public universities of Madrid Region are developing a coordinated strategy to implement Sustainable University Mobility Plans (SUMPs) in their 14 campuses. To this end, a combination of mobility survey and data collection inventory were carried out to set a common methodological basis.

Based on data obtained in the inventory, indicators were designed to measure the accessibility and quality of urban space (for instance, pedestrian and cycling areas with respect to total area, percentage of the campus area occupied by parking facilities, etc), combining quantitative and qualitative aspects adapted to the reality of each campus.

Then, taking these indicators as reference, a comparative analysis of the 14 campuses was performed to identify mobility weaknesses and strengths to support the efficient implementation of the SUMPs.

The results showed that campuses with higher accessibility and compactness have a more integrated and higher quality public space, besides a stricter parking control policy. These characteristics are associated with a lower proportion of trips by car and a higher number of walking trips.

## **1. INTRODUCTION**

The university campuses of the 20th century provided an opportunity for the application of modern theories regarding the city and the building. Campuses occupied vast non-central areas, despite being easily accessible by public transport. They gathered all the necessary attributes of a functionally well-defined urban community.

However, the distorted evolution of this model has generated increasingly segregated and dispersed spaces, which are difficult to access. Currently, the unsustainable mobility pattern of university campuses, in which the large number of trips attracted by individual vehicles stands out, requires strategic actions to foster the use of public transport and active mobility.

On the other hand, universities are a good experimentation ground for innovative ideas in the field of sustainable mobility. Most students do not own their own vehicle, and are more open to alternative ways of transport, especially non-motorised modes (Whalen et al., 2013).

Aligned with the effort fostered by the Community of Madrid to decarbonise urban mobility, the 6 public universities of Madrid Region are developing a coordinated strategy to implement Sustainable University Mobility Plans (SUMPs) in their 14 campuses.

The aim of this study is to perform a comparative analysis of the accessibility and spatial characteristics of these 14 campuses. To this end, they were classified and separated in three groups, according to public transport accessibility and urban configuration. As a second step, quantitative and qualitative indicators were employed to analyse the strengths and weaknesses of the mobility infrastructure of each type of campus. Finally, this technical analysis was contrasted with the perceived quality of the campuses by their users, to establish guidelines to support the design and effective implementation of the SUMPs.

### **1.1 Background**

In recent decades, an increasing number of researchers have questioned the possibility of reducing travel demand, mainly by single-occupancy vehicle, through changes in the built environment (Arellana et al., 2020; Bozovic et al., 2020; Koszowski et al., 2019; P. J. Lamíquiz-Daudén & López-Domínguez, 2015; Lee & Moudon, 2006; Valenzuela-Montes & Talavera-García, 2015). As seminal papers, stand out the pioneer study of Newman & Kenworthy (1989) about the association between urban density and car dependence, and the study of Cervero y Kockelman (1997), concerning the influence of the built environment on travel demand and modal choice through three main dimensions, so-called '3 Ds': 'density', 'diversity' and 'design'.

Density combined with diversity approaches the origin to the destination, allows for better quality transport infrastructure, reduces the need for parking and foster a more diversified urban environment. (Cervero & Duncan, 2003; Lehmann, 2016). On the other hand, urban design characteristics such as street network density, block size, sidewalk width, urban furniture and tree-lined streets qualify the urban space and distinguish car-oriented environments from pedestrian ones (Ewing et al., 2006; Ewing & Handy, 2009).

Ewing & Cervero (2001) added two more dimensions to the '3 Ds': 'destination accessibility', which measures the ease of access to travel attractions, and 'distance to transit', related to proximity to rail stations or bus stops. 'Demand management', such as parking supply and cost, would be a sixth 'D' (Ewing & Cervero, 2010).

Despite the extensive literature on the subject, there are few studies on university campuses, major traffic generators that demands large parking areas. Balsas (2003) highlights that campuses layout varies according to their urban or peripheral location: suburban campuses generally have a more horizontal and dispersed configuration, apart from being more automobile dependent than urban ones. The distance to the city centre also affects the possibility of walking, cycling and use the public transport.

Accessibility plays a key role in the choice of more sustainable modes of commuting to the campus: 32% of the public transport users of the Autonomous University of Barcelona justify their modal choice by the existence of good public transport service options connecting their place of residence with the university, 30% by comfort, 12% by travel time and 10% by lack of private car or motorbike (Miralles-Guasch & Domene, 2010).

Built environment factors associated with campus active mobility includes proximity, mixed use development, street connectivity and accessibility (Ramakreshnan et al., 2020), as well as bicycle and pedestrian facilities, such as continuity and width of pedestrian paths, lighting, pedestrian signage, disabled-users accessibility, shading elements, safe and separate bike lines, bicycle parking lots, showering facilities, and traffic-calming schemes (Bonham & Koth, 2010; Menini et al., 2021). This schemes must be combined with transportation demand management (TDM) strategies, which include parking policies, subsidies for public modes of transit, rideshare programs, park and ride facilities, etc (Balsas, 2003; Delmelle & Delmelle, 2012).

The combination of the active modes with public transport, providing a well-defined walking and cycling network, has been shown to be effective in the case of longer travels: commuters to university campuses use public transport more often when such facilities are properly provided (Dehghanmongabadi & Hoşkara, 2018). Still, walking and cycling continue to play a marginal role as means of transport, and their infrastructure is continuously neglected in the planning of the campuses. Due to insufficient infrastructure, empirical findings show that there is an unsatisfied demand for non-motorised modes, especially for cycling (Miralles- Guasch & Domene, 2010).

## 2. CASE STUDY

The case study relies on the 14 campuses of the 6 public universities of Madrid Region: Universidad Autónoma de Madrid (UAM), Universidad Complutense de Madrid (UCM), Universidad Politécnica de Madrid (UPM), Universidad Carlos III de Madrid (UC3M), Universidad Rey Juan Carlos (URJC) and Universidad de Alcalá de Henares (UAH).

Table 1 presents the university population and area of each campus, as well as the modal split.

Name of the campus	University	University population	Area (ha)	Modal shift (%)			
				Car / motorbike	PT	Walking	Cycling
Cantoblanco	UAM	3220	125	36	61	3	0
Somosaguas	UCM	9840	36	32	65	2	1
Ciudad Universitaria	UPM / UCM	25774	480	28	63	7	2
Montegancedo	UPM	2720	23,5	51	47	1	1
Campus Sur	UPM	5062	25	34	61	3	2
Getafe	UC3M	16220	16,8	31	49	20	0
Leganés	UC3M	9101	7,7	44	44	11	1
Colmenarejo	UC3M	1554	7,5	61	36	3	0
Alcorcón	URJC	4914	29,3	38	56	5	1
Fuenlabrada	URJC	13503	50	41	54	5	0
Móstoles	URJC	9781	25,7	46	48	6	0
Madrid – Vicálvaro	URJC	16519	7,5	28	65	6	0
Científico – tecnológico	UAH	14255	76,3	69	28	2	1
Histórico	UAH	10194	82,9	23	58	18	0

**Table 1 – Public University Campuses in Madrid**

## 3. METHODOLOGY

In order to obtain information and data on the existing mobility infrastructures, a form was sent to the universities, requesting general data on the campuses. This data was checked and complemented through technical visits and orthophoto analysis to produce a complete inventory, including data such as number of public transport stops, parking places, pedestrian and motorized traffic area, length of cycle paths, etc.

From this inventory, a series of quantitative indicators were generated. Qualitative indicators were also defined to assess the spatial configuration and quality of public spaces on the campuses. The table 2 in the section 4 shows all the quantitative and qualitative indicators used in this study, as well as their results.

In the case of qualitative indicators, reference values from 1 to 6 were used: from “Poor” to “Excellent”. The spatial configuration (compact or dispersed) was defined based on the average of two qualitative indicators: “Density of users” and “Mixed use”. The quality of public spaces was determined by the average of 4 indicators: “Street furniture”, “Continuity and maintenance of the pedestrian network”, “Percentage of tree-lined streets” and “Landscape maintenance”.

Finally, to contrast this technical analysis with the perception of campus users, a survey among the university community was carried out to find out about mobility patterns and users' opinion regarding mobility infrastructure and services. For this study, two questions of the survey related to campus infrastructure were used:

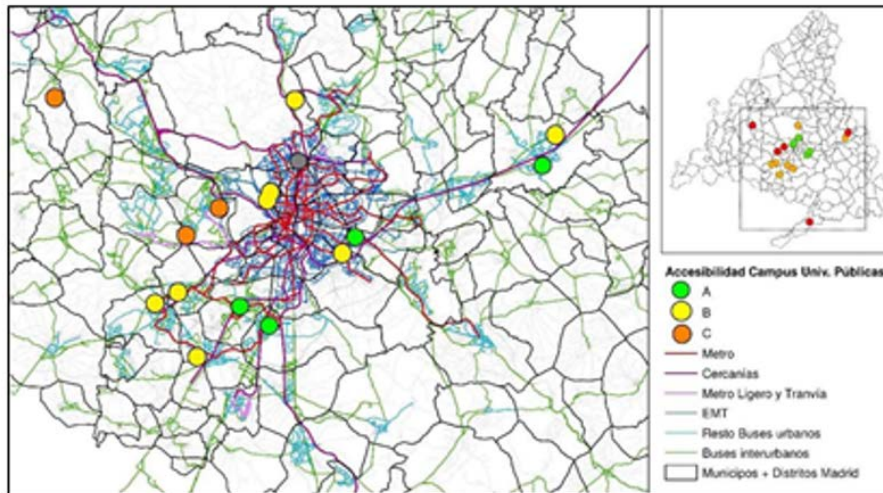
The question “F1: Value the quality of your campus' infrastructure and transportation services” provided a rating from 1 to 6 (from poor to excellent) for the following items:

- Good road access (A)
- Availability of car parking spaces (B)
- Availability of charging points for electric vehicles (C)
- Availability of motorbike parking spaces (D)
- Good access by public transport (E)
- Good access by bicycle (F)
- Availability of bicycle parking spaces (G)
- Good condition of sidewalks and pedestrian tracks (H)
- Proper lighting (I)
- Sufficient vegetation and shade (J)
- Security in accesses and parking (K)

The question “S7: Write down any improvements you deem necessary for your campus” requested a complementary point of view to the previous question (F1), while making it possible to particularize the answer for each campus.

### **3.1 Campus typology according to accessibility and spatial configuration**

For subsequent analysis, campuses have been classified into three types, according to their accessibility to public transport and spatial configuration.



**Fig. 1 – Campus typology according to accessibility and spatial configuration**

- Type A: Compact urban campuses with access to the Metro/Cercanías: Leganés (UC3M), Getafe (UC3M), Madrid-Vicálvaro (URJC) and Campus Histórico (UAH).
- Type B: Dispersed urban campuses with access to the Metro/Cercanías: Ciudad Universitaria (UPM + UCM), Campus Sur (UPM), Cantoblanco (UAM), Alcorcón (URJC), Fuenlabrada (URJC), Móstoles (URJC) and Científico-Tecnológico (UAH).
- Type C: Dispersed peri-urban campuses without access to Metro/Cercanías: Colmenarejo Campus (UC3M), Somosaguas Campus (UCM) and Montegancedo (UPM).

According to this classification, the analysis of the indicators identified the strengths and weaknesses of the mobility infrastructure and quality of public spaces of each type of campus.

#### 4. RESULTS

Type A campuses have high density of construction and users, as well as other uses other than educational one (housing, cultural, commerce and support services). They are located in areas of higher density and mixture of uses, as is the case of the historic centre of Leganés and Alcalá de Henares.

Furthermore, they have greater connection with the surrounding areas, maintaining a dialogue with the surrounding infrastructure and proposing activities open to the neighbouring population. Compared to the other groups, it presents a lower percentage of trips by car or motorbike, and a higher proportion of walking trips.

Type B campuses occupy larger terrains and have low density, as well as few uses other than educational ones. This classification includes both central campuses of Madrid (Ciudad Universitaria and Campus Sur) and located in subcentres of the Madrid Region (e.g. Alcorcón, Móstoles and Fuenlabrada).

Except for the Ciudad Universitaria, which is open and maintains a good connection with the dense and diversified district of Moncloa, the others have little relation to the surrounding area. This connection is hampered by perimeter closures and large metropolitan infrastructures, such as motorways and train lines.

Type C campuses occupy large areas in transition zones between urban and rural/natural environment, presenting low density, as well as an accentuated monofunctionality: apart from educational and administrative use there have few support services such as cafeteria and reprographics. The connection with the surrounding area is virtually non-existent.

However, this problem is more related to the distance separating these campuses from the nearest centralities than to the existence of barriers or lack of access. The absence of adequate support services to the university community makes it difficult to stay long periods of time on campus and acts as another factor, apart from distance, that encourages people to travel by car. Compared to the others, this group presents a higher proportion of trips by car or motorbike, and a lower proportion of walking trips.

These results are in line with the references consulted (Balsas, 2003; P. J. Lamíquiz-Daudén & López-Domínguez, 2015; Newman, P. and Kenworthy, 1989; Ramakreshnan et al., 2020).

Table 2 summarizes the result of each indicator by university campus, integrating quantitative and qualitative indicators. In green: type A campuses, in yellow: type B campuses and orange: type C campuses.

INDICATOR	UAM	UCM	UCM + UPM	UPM		UC3M			URJC				UAH	
	Cantoblanco	Somosaguas	Ciudad Universitaria	Montegancedo	Campus Sur	Getafe	Leganés	Colmenarejo	Alcorcón	Fuenlabrada	Móstoles	Madrid Vicalvaro	Científico-tecnológico	Campus Histórico
Nº of public transport stops - less than 1000m	25	44	196	45	82	100	124	6	54	39	74	81	65	201
Number of parking places/100 campus users	21	24	10	34	19	6	7	14	14	11	10	3	20	2
% of car parking places with access restriction	10%	25%	0%	11%	12%	87%	100%	47%	26%	6%	34%	43%	0%	76%
Car parking places/Total parking places	97%	98%	97%	97%	96%	87%	98%	100%	98%	98%	97%	97%	98%	98%
Disabled parking places/Total parking places	3%	1%	2%	1%	1%	0%	0%	0%	2%	2%	2%	3%	2%	2%
Electric car parking places /Total parking places	0%	0%	0%	1%	0%	1%	1%	0%	0%	0%	0%	0%	0%	0%
Motorbike parking places/Total parking places	0%	0%	1%	1%	3%	12%	1%	0%	0%	0%	1%	0%	0%	0%
Electric charging points/10000 users	0	0	0	26	2	6	4	0	0	0	3	0	0	0
Area dedicated to pedestrians	7%	7%	5%	4%	6%	21%	36%	20%	12%	16%	24%	21%	8%	No data
Length bike lanes/100 m street (m)	12	0	22	33	0	0	0	0	0	0	0	7	73	No data
Bycycle parking places/Total parking places	2,4%	0,9%	5,0%	2,6%	0,0%	32,8%	20,4%	5,3%	13,7%	3,1%	6,9%	6,2%	12,2%	19,3%
Users density	3	3	2	2	3	5	6	3	2	3	4	6	2	5
Mixed use	5	4	4	3	3	4	5	2	3	3	3	4	4	6
Quality and state of maintenance of the pedestrian network	3	3	3	2	2	5	6	5	4	4	4	3	2	5
Urban furniture	4	2	2	2	2	5	6	5	3	3	3	4	2	5
Tree-lined streets	5	2	6	4	5	4	4	4	2	2	2	6	4	2
Landscape maintenance	4	3	3	4	3	5	6	6	4	3	3	4	2	4

**Table 2 – Results of indicators by university campus.**

#### 4.1 Accessibility to public transport

Both type A and type B campuses have good accessibility due to the proximity of the Metro and Cercanías train station, as well as numerous urban and intercity bus lines. Type Cs do not have good accessibility. Usually, there are few bus lines departing from specific locations in Madrid city or other parts of the Madrid Region. The frequency of these buses is low, and users spend a lot of time on the journey.

#### 4.2 Parking facilities

The parking offer changes significantly according to the type of campus. Type A campuses stand out for the low number of parking spaces per user and a higher percentage of parking spaces with access restriction.

Despite good accessibility by public transport, especially in the case of the URJC and UPM campuses, which are accessible by Metro, Type B campuses have a wide range of parking and little or no restriction policy. Naturally, this is also the case for Type C campuses, justified by poor accessibility by public transport.

These results reinforce the results obtained by Balsas (2003) Delmelle & Delmelle (2012) and Ewing & Cervero (2010) regarding parking control policy and lower proportion of car trips



All campuses offer more than 87% of their parking spaces for cars, at the expense of spaces reserved for motorbikes and people with disabilities. None have a parking policy based on HOV criteria (High Occupancy Vehicles). They also do not have a significant number of parking spaces reserved for electric vehicles and/or equipped with electric charging points.

### **4.3 Pedestrian and cycling infrastructure**

Due to their compact configuration, type A campuses prioritize the pedestrian space. This situation varies for type Bs and Cs. The campuses of the Universidad Rey Juan Carlos y Colmenarejo (UC3M) concentrate most of the road system, as well as parking lots in the peripheral area. In contrast, the interior preserves large fully pedestrian areas. This configuration has the advantage of maintaining the continuity of the pedestrian zone and establishing a balance between the road system and the pedestrian space.

On the other hand, the UAM, UCM, UPM and Científico-Tecnológico (UAH) campuses prioritise the road system, which impairs the continuity and fluidity of the pedestrian space.

Regarding cycling infrastructure, although none of the campuses have a suitable cycling network, that is, continuous and extended, some stand out for a greater extension and balance between segregated cycle lanes and road system, as well as more bicycle storage facilities, as for example, Ciudad Universitaria (UCM + UPM).

Most campuses prioritise the shared use of road space with bicycles without adopting calm traffic strategies and proper signage. Type A campuses and those of the URJC that belong to group B are cyclable over most of their surface, without the need to compete for space with vehicles. However, in a scenario of greater use of bicycles to commute to campus, measures should be adopted to avoid conflicts with pedestrians, such as bicycle dismounting zones.

The Getafe and Leganés (UC3M) campuses have a higher supply of bicycle parking spaces than the others. This is possibly the result of a combination of factors: central location, more developed cycling infrastructure in the surrounding area and parking restriction policy, which mainly affects students.

Bicycle-friendly campuses also have more safety concern, locating the facilities in high-traffic locations and adopting surveillance and access control strategies.

#### **4.4 Quality of public space**

The quality of the public space is the result of the combined analysis of 4 indicators: 'urban furniture', 'continuity and conservation of the pedestrian network', 'percentage of tree-lined streets' and 'landscape maintenance'.

Being more compact, type A campuses have a more integrated space that favours the creation of convivial areas. On the other hand, these campuses spend fewer resources in the care of public space: they stand out for the quantity and quality of urban furniture, diversity of herbaceous plants with a high level of maintenance and good condition of the sidewalks.

In this sense, the Campus Histórico (UAH), for example, benefited from the pedestrianization plan developed by the City Council of Alcalá de Henares for the historic centre.

Unlike the previous case, the dispersed configuration of the campuses of groups B and C makes it difficult to create convivial spaces, as well as install and maintain urban furniture and the landscaping. The great distance between buildings and the excess of public space do not favour the appropriation of space by people. In the case of the UPM, UAM and Científico-Tecnológico (UAH) campuses, the car-oriented design prioritises the road system and fragments the space.

These results are in line with Cervero & Kockelman (1997); Ewing et al. (2006) and Ewing & Handy (2009).

In contrast, Colmenarejo (UC3M) stands out for its high quality of public space: the campus concentrates educational and administrative activities in a limited space, while the rest of the campus integrates a green area (Botanical Garden) with impeccable maintenance that also acts as a convivial space.

#### **4.5 Perceived quality of campuses according to users**

Table 3 shows the results of the assessment of campus infrastructure according to the perception of its users, according to a rating from 1 to 6 (from poor to excellent).

Name of the campus	University	A	B	C	D	E	F	G	H	I	J	K
Cantonlanco	UAM	5	5,1	2	3,9	4,7	3,9	3,8	4,5	4,5	4,8	4,6
Somosaguas	UCM	4,8	5,1	1,8	4	4,3	3,2	3,4	4,2	4	4	4,3
Ciudad Universitaria	UCM / UPM	4,8	3,8	2	3,6	4,8	4,2	3,8	4,3	4,3	4,3	4,2
Montegancedo	UPM	4,6	4,9	1,5	3,9	3,1	2,3	2,9	3,9	4	4,6	4,3
Campus Sur	UPM	4,8	5,2	1,7	4,1	4	3,3	3,3	4	3,7	4,5	3,7
Getafe	UC3M	4,9	4,5	2,5	3,4	4,5	3,8	3,9	4,7	4,6	4,3	4,5
Leganés	UC3M	4,6	2,6	1,8	3	4,5	3,7	4,2	4,5	4,7	4,3	4,4
Colmenarejo	UC3M	3,9	4,5	1,5	2,9	3,4	3,3	3,6	4,3	4	4,5	4,5
Alcorcón	URJC	5,2	4,7	1,9	3,5	4,5	4,1	3,7	4,7	4,5	3,6	4,3

**Table 3 – Perceived quality of campuses according to users**

According to the users' assessment, type A campuses stand out for their good accessibility by car and public transport, the quality of public space and the security. Weaknesses are related to the low availability of car, motorbike and bicycle parking facilities.

Most Type B campuses also stand out for their good accessibility by car and public transport. The evaluation of public space and security varies from campus to campus. According to the users, some have a lack of vegetation and shade, as is the case of Alcorcón and Móstoles. Others, lack of lighting and security, such as Campus Sur.

Regarding type C campuses, the most notable strengths were road access by car and parking lots, as well as quality of public space. Weaknesses are poor accessibility by public transport and by bicycle.

All campuses have a low supply of charging points for electric vehicles.

## 5. CONCLUSIONS

The comparative study of the 14 campuses showed that besides good accessibility, type A campuses have a higher degree of compactness than the others, which is related to a more integrated and higher quality public space, as well as a stricter parking policy. These characteristics are associated with a lower proportion of trips by car and a higher number of walking trips, which coincides with the references of the consulted studies on the relationship between modal choice and the 6 Ds: “density”, “diversity”, “design”, “destination accessibility”, “distance to transit” and “demand management”.

On the other hand, type B and C campuses stand out for their dispersed configuration, lower quality of public space, when compared to type

A campuses, and absence of control over parking, which is associated with a higher proportion of car trips, and a lower proportion of walking trips. This situation is aggravated in the case of type C campuses, which have low accessibility by public transport.

These conclusions are reinforced by the perception of users, which reinforces the need to improve accessibility in public transport, pedestrian and cycling infrastructure and the quality of public space on university campuses.

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