Evaluation of Urban Spaces Through the Integration of Universal Design and Microsimulation: The Case Study of the Marina District in Cagliari (Italy)

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Abstract. Ensuring safe, functional, and integrated urban environments requires the identification and organisation of qualitative and quantitative analyses to assess the quality of urban spaces, the perceived well-being and by safety the city users, and the interactions between traffic components (e.g., pedestrians and vehicles). Many techniques based on quantitative and qualitative indicators of urban space and transport mobility are offered in literature and this paper provides a methodological approach to perform a comprehensive evaluation of urban spaces and mobility interactions by calculating an Index of Integrated Road Spaces (I_{IRS}) composed of two indicators: the Universal Design Indicator (I_{UD}) and the Service Level Indicator (I_{SL}).This provides the evaluation of Perceived Road Quality (e.g. crossing; visibility; speed limit; road pavement; services), as well as the measurement of network efficiency (e.g. level of service; queue length; number of stops; delay) and environmental impact (e.g. pollutant emissions). The authors applied the merging of the two theoretical approaches of Universal Design and Transport Microsimulation by considering a real case study coinciding with the Marina district in Cagliari (Italy). Future developments of the research will be characterised by a more in-depth analysis, both in terms of spatial extension and number of indicators, useful for performing scenario analysis.

Keywords: VISSIM/VISWALK · Universal Design · Microsimulation · Active mobility · Redesign urban spaces · Level of service · Emissions · Pedestrian evaluation · Smart City

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1 Introduction

Urban public spaces are essential for the development of cultural, social, economic, and political activities within cities. The quality of public spaces is the first element to characterise a well-organised and safe city, with efficient services able to guarantee fairness and social inclusion [1–7]. These aspects involve a good design and management of transport infrastructures and, in some cases, a redesign of urban environment [8, 9]. To ensure an urban space perceived as safe and functional, it is advisable to pursue an integrated transport-land planning, designing user-centred environments that guarantee a good interaction between transport components within the urban environment [10–13]. There are several models which analyse the transport-territory interactions, both from a conceptual and a methodological point of view. One of the proposed methodologies based to the concept of accessibility focuses on the relationship between transport and land use, by using a synthetic indicator of the organization level of the territory [14]. Another study proposed multi-criteria analysis methods, combining the quantifiable results of traffic microsimulation and AHP multi-criteria optimization method, developing five groups of criteria (functional, safety, economic, environmental, and urban-spatial ones). [15]. Within this context, it can be advisable to combine this research with investigations about the propensity of users to modal shift and other forms of mobility [16–18]. Other work provided operational definitions to assess the road environment through a walkability index useful for later testing significant associations with pedestrian behaviour [19]. More specifically, by using an expert panel assessments five qualities of Universal Design are measured associated with the physical characteristics of the road infrastructures. And their edges: imaginability, enclosure, human scale, transparency, and complexity [20]. As regards the traffic microsimulation modelling, there are many applications that analyse the traffic influence within urban environments. For example, a study focused on a pedestrian crossing and the related indicators have been evaluated. This method allowed the assessment of different scenario and comparative analysis through the calculation of performance indicators related to both private transport and pedestrian users [21]. However, still today, the literature lacks a specific analysis on the integration of dynamic approaches that better define urban mobility management and static approaches that analyse accessibility from the point of view of the user to roads, transit stations or more generally to other public places. Thus, it is necessary to identify a methodology to define measurement, evaluation and monitoring indicators characterizing the relationship between road infrastructures and urban built. In this direction, the authors focus on the integration of two theoretical approaches, a dynamic one and static one. Universal Design is a static design approach that aims to create "products" for all users, e.g., regardless of gender, age, ability to move, prior knowledge, by following the principles of equity, flexibility, and intuitiveness [22]. In the case of urban planning this is linked to the concept of usability which "encompasses an activity component and refers to the extent to which a space, product or service can be meaningfully utilised by users with different individual abilities" [23, p.2]. Therefore, it is a design approach that recognises the diversity of human needs and seeks to satisfy them, avoiding segregating or excluding some users' categories (e.g., vulnerable users). In recent years, the principles of Universal Design have been applied to the built environment, including streets and public spaces, to create more accessible and user-centred environments [24–27].

User-centred design focuses on the needs, capabilities, and preferences of the end user, rather than just technical or engineering considerations. For example, a user-centred approach applied to the road design might include the involvement of users with disabilities or the elderly to understand their needs and designing road infrastructures with appropriate characteristics to meet those needs [28]. This can lead to changes in the physical layout of streets, e.g., wider sidewalks, intersections with interventions to increase pedestrian safety and visibility, as well as to the use of more specific materials, e.g., brightly coloured pavements to improve visibility or tactile markings to guide movements of visually impaired. Furthermore, Universal Design and user-centred design principles have a key role in improving the accessibility of the road environment, promoting social inclusion, increasing physical activity and personal independence, and reducing mobility inequalities.

Starting from these assumptions, the authors intend to develop a methodology that integrates qualitative and quantitative assessments of urban environments. This goal is pursued by identifying an index (composite indicator) of Integrated Road Spaces (I_{IRS}), perceived as the capacity of an urban environment to be comfortable for all user types of and in all its spaces (i.e., infrastructures, streets, pedestrian paths, and services). The paper is structured in five sections: after a brief introduction which states the goal of the paper (Sect. 1), Sect. 2 describes the study area, i.e., Stampace and Marina districts of the city of Cagliari, within which some indicators are analysed. Section 3 presents the methodology used for identifying an index of Integrated Road Spaces (I_{IRS}), being composed of a Universal Design Indicator (I_{UD}) and Service Level Indicator (I_{SL}). Section 4 will report some of the obtained results for the case study and the calculation of the composite indicator through the combination of normalised results of Universal Design and Transport Microsimulation. Finally, Sect. 5 provides conclusions and future work perspectives.

2 Case Study

The selected area is in the historical center of the city of Cagliari in (Sardinia), on the border between the Stampace and Marina districts. This area is characterised by numerous monuments, religious and civil architectures, and archaeological sites. Moreover, there are many for commercial activities and leisure services.

The work focuses on the intersection between Via Roma and Largo Carlo Felice (Fig. 1), one of the most popular meeting places in the city of Cagliari, from which some of the main arteries of the city branch off [29]. The analysis of the area shows that it is one of the busiest in the city, with high rate of pedestrians and vehicular traffic. In addition, it is characterised by the presence of many car parking spaces (Fig. 2), as well as the transit of numerous urban public transport lines. These factors greatly contribute to the increase in the level of congestion within this area. The study area has been analysed within the Sustainable Urban Mobility Plans (SUMPs) of the city of Cagliari [30–33], a tool containing actions and strategies for the promotion of sustainable mobility and the deployment of Information and Communication Technologies (ICT) and Intelligent Transport Systems (ITS) to foster smart cities [34–37]. It represents a critical interchange node both at local and regional level [38–40], from which reference

is made for the vehicular flows for the microsimulation methodology. These traffic flows have been obtained from the SUMP General Report of Cagliari, drafted in December 2018.

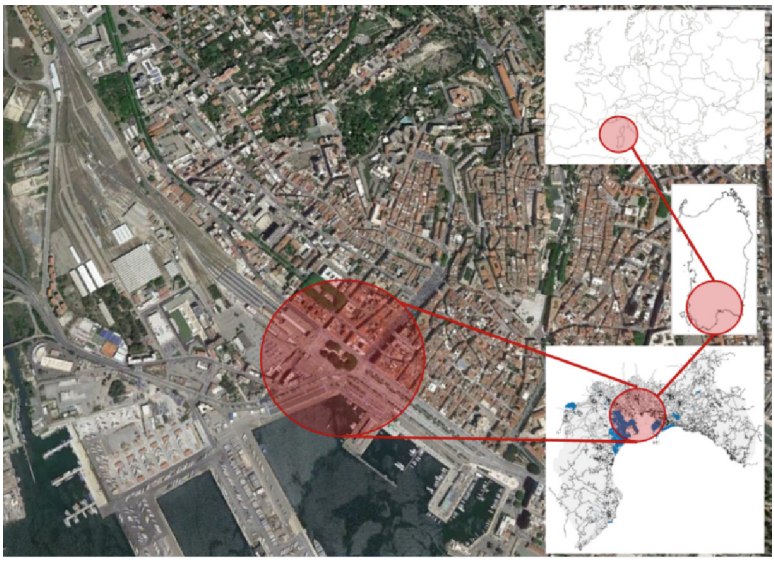

Fig. 1. Study area. Source: Author elaboration from Google Earth

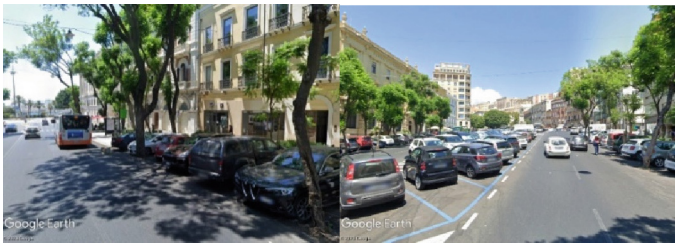

Fig. 2. Study area. Source: Author elaboration from Google Earth

Data recorded refers to the turning manoeuvres at the traffic light intersection, between the main road of Via Roma and Largo Carlo Felice. The traffic data have been counted for one working day for each section, from 7.30 a.m. to 9.30 a.m. and classified by type of vehicle (i.e., car, bike, motorcycle, bus, commercial vehicles, etc.). Simulating a time interval of 3600 s for microsimulation, only data for the time slot 8:30–9:30 a.m. have been considered, with a total of 2,407 vehicles, divided between bikes/motorcycles, cars, light commercial vehicles, heavy goods vehicles, and buses. The table below show the traffic flows for the diagram of the manoeuvres at the intersection (Table 1 and Fig. 3).

Table 1. Traffic Flow

Origin	Destination	Bike/Motorcycle	Car/LCV	HCV	Bus	Total
A	B	1	35	0	10	46
	C	18	165	3	0	186
	D	7	277	0	7	291
	E	0	0	0	12	12
B	A	37	270	0	0	307
	C	61	762	0	1	824
C	A	8	219	0	7	234
	B	14	346	0	0	360
	D	1	84	0	15	100
	E	0	0	0	47	47
Total		**147**	**2158**	**3**	**99**	**2407**

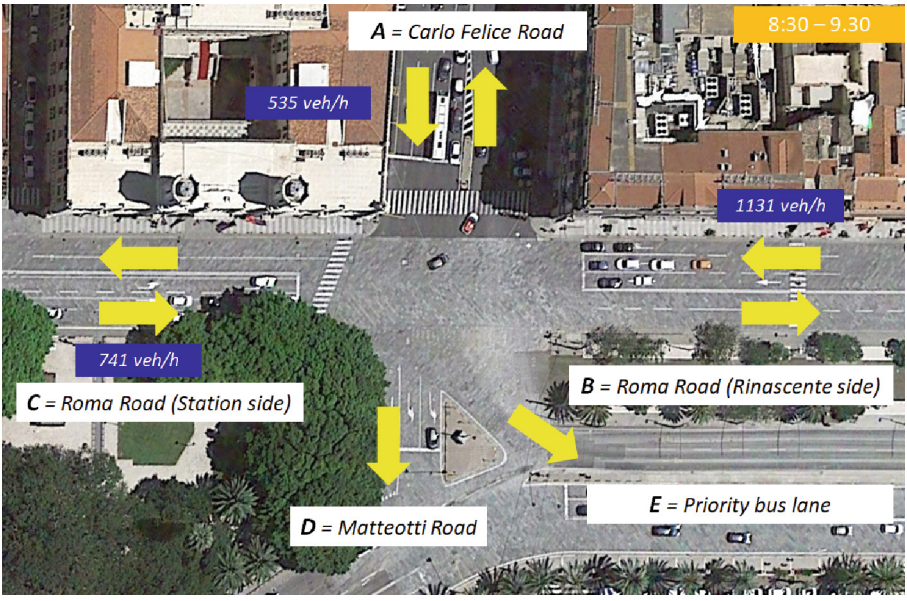

Fig. 3. Intersection with vehicular flows. Source: Author elaboration from SUMP of Cagliari

3 The Methodological Approach.

This methodology is based on the combination of Universal Design indicators and traffic micro-simulation indicators. To compare, the authors adopted a systematic approach [41–43], which results in a specific Index of Integrated Road Spaces (I_{IRS}). Figure 4 schematises the methodological framework characterized by an integrated approach

between urban analysis through Universal design which studies spaces that are safe, comfortable, and usable for everyone, regardless of one's physical or cognitive limits, and the Microsimulation approach which simulate the transport network in details and the interactions between transport components and surrounding urban environment.

The Index of Integrated Road Spaces (I_{IRS}) has been defined by use of a geometric mean [44]. Formula 1 shows how the two factors shown in Fig. 4 (Universal Design and microsimulation model) have been combined, once the parameters identified for each key factor were normalised.

$$I_{IRS} = (I_{UD} + I_{SL}) \tag{1}$$

Universal design is an urban planning strategy that focuses on creating accessible and inclusive public spaces for all people, regardless of their physical abilities, age, gender, ethnic or socioeconomic origin. The main objective of the indicators described in Fig. 4 is to analyse the physical conditions of the spaces around the streets (analysed with the microsimulation approach) to allow people to take full advantage of public spaces and participate in community life.

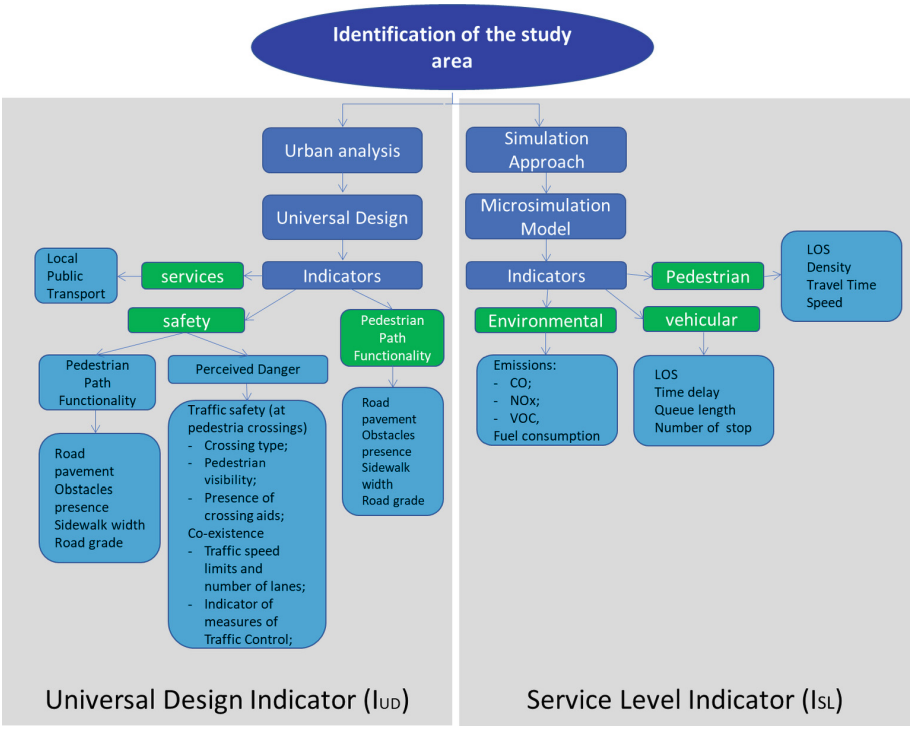

Fig. 4. Methodological framework. Source: authors elaboration.

Micro-simulation shows the movement of individual road users (vehicles, bicycle, and pedestrian traffic) through the traffic network and their interaction with each other.

Microsimulation helps you make the right decisions when it comes to designing and controlling transport infrastructure [45]. Therefore, cities, operating companies and consulting firms rely on software support for planning, evaluating and visualizing traffic measurements.

The analysed indicators for the identification of factors of Universal design (UD) are obtained through (i) google maps (or direct display), (ii) Geographic Information System (GIS) and (iii) regional or municipal laws, in this case Zone30 km/h of the City of Cagliari. In particular, the indicators used define:

1) Safety is a composite indicator that intersects the perception of danger perceived by the user and the functionality of the pedestrian path. In particular, the first is analysed by calculating traffic safety, which describes the type of crossing, pedestrian visibility, presence of crossing aids, and the coexistence between pedestrian and road, i.e., traffic speed limits, number of lanes and control measures traffic). In this way, from a UD perspective, the user's safety describes his perception of the shared space.
2) pleasantness is calculated through the quality of services for the community by making a proportion between the number of activities (Commercial Activities, Food Service, General Services, Recreational Functions) existing in each portion of land and the number of activities accessible to all the types of users. In fact, from a UD perspective, activities accessible to all types of users are important because (i) they guarantee the inclusion of people with disabilities, reducing the risk of discrimination and social isolation, (ii) they improve everyone's quality of life citizens, promoting the use of free time in a healthy and constructive way and (iii) promote social interaction and integration between people, improving the quality of life of all citizens, promoting the use of free time in a healthy and constructive way.
3) Local Public Transport (LPT) services are calculated with a proportion between existing and optimal nodes (understood as LPT stops) (from one node to the other 600 m). The importance of this indicator lies in the fact that the number of stops determines the accessibility of the areas served by the public transport service. The more stops there are along a given line, the greater the spatial coverage of the service and therefore the greater the accessibility to the destinations. This is particularly important for people with disabilities, the elderly, children, and other categories of users who may need an accessible public transport service close to their homes or workplaces.

Table 2 shows for each indicator its normalisation scale from 0 to 1 where 0 represents a poor level of UD and 1 represents an excellent level. The final index of Universal Design is calculated by averaging the resulting values.

The microsimulation indicators of traffic are analysed by modelling the study area using the PTV VISSIM software. VISSIM is a microscopic simulation tool based on simulation behaviour and steps, for modelling urban and suburban traffic as well as pedestrian flows [46, 47].

Indicators can be evaluated for both traffic flows and pedestrian flows and they can be measured at point, link, or node level. For the study area we focus on node evaluations. Node evaluation is used to determine intersection-specific data without having to manually define all sections to derive data.

Table 2. Normalisation classes of UD Indicators

Indicators	Normalisation Values					
	0	0.2	0.4	0.6	0.8	1
a) Safety						
a.1) Perceived Danger						
a.1.1) Traffic safety						
Crossing type	No intersection			Crosswalk		Signalized intersection
Pedestrian visibility	no distancing			Distancing from parking lots	Curb extension	Curb extension (L = 7 m) and raised platform
Presence of crossing aids	No					Yes
a.1.2) Co-existence						
Traffic speed limits and number of lanes	70 km/h	50 km/h (>2 Lanes)	50 km/h (2 Lanes)	50 km/h (1 Lane)	20–30 km/h	Pedestrian space
Measures of Traffic Control	None	single speed bump	single raised crossroad		Roundabout; series of speed bumps; chicane	series of raised crossroads; road closure; curb extensions

(*continued*)

Table 2. (*continued*)

Indicators	Normalisation Values					
	0	0.2	0.4	0.6	0.8	1
a.2) Pedestrian Path Functionality						
a.2.1) Road pavement	path with numerous deformations, cracks, lesions, and grasses that grow on the surface or between the cracks			some deformation, cracks, lesions, and grasses that grow on the surface or between the cracks	good run-in maintenance conditions are such when crack deformations, lesions and grasses growing	excellent maintenance condition course is one with a smooth, stable, continuous, and non-slip surface
a.2.2) Obstacles presence	Yes					No
b) Pleasantness						
b.1) Commercial Activities	(N° TOT_SERV_acc)/(N° TOT_SERV)*					
b.2) Food Service						
b.3) General Services						
b.4) Recreational Functions						
c) Services (LPT)						
c.1) Local Public Transport	NODES/NODES_OCT**					

*N° TOT_SERV_acc = total number of services accessible according to Universal Design parameters; N° TOT_SERV = total number of services in the analysed area.

** NODES = nodes (bus stops) existing in the analysed area; NODES_OCT = optimal nodes (bus stops) calculated with formula (segment length/600)

The calculated indicators at the node level for traffic flows are LOS, time delay, queue length, number of stops:

i) LOS, Level of Service (transport quality): The levels of transport quality A to F for movements and edges, a density value (vehicle units/mile/lane). It is based on the result attribute Vehicle delay (average).
ii) Time delay [s]: Total time delay is determined from the "time lost" per time step. This is determined from the difference between actual speed and desired speed if the pedestrian is slower than desired.
iii) Queue length: Mean of all average queue lengths in a node. Vissim automatically generates queue counters in a node to detect queue lengths. Vissim calculates the average queue length detected by queue counters in a node and then calculates their mean.
iv) Number of stops in the queue: A queue stop occurs when a vehicle that is directly in or upstream of the queue length exceeds the speed defined for the queue conditions in the attribute Start.

In the results of microsimulation at the node level, indicators can be also displayed for exhaust gas emissions and fuel consumption. The data refers to a typical North American vehicle fleet; the node evaluation is used to compare the emissions of different scenarios. These indicators are: (i) Emissions CO: Quantity of carbon monoxide [grams]; (ii) Emissions NOx: Quantity of nitrogen oxides [grams]; (iii) Emissions VOC: Quantity of volatile organic compounds [grams]; (iv) Fuel consumption: Quantity of fuel consumed [US liquid gallon].

The implemented model, based on Helbing or Wiedemann formulations, allows to calculate indicators for the pedestrian simulation, which are: (i) Pedestrian LOS, level of service; Levels of pedestrian movement quality from A to F for displacements and segments, density value. (ii) Pedestrian density in sections [ped/m^2] or [ped/ft^2], depending on the unit selected for short distances. (iii) Travel time [s]: time the pedestrian spent in the section. (iv) Speed: average pedestrian speed in traffic conditions.

4 Application and Results

The indicator for Universal Design is calculated for each segment depicted in Fig. 5, which identifies the study node of the two methodologies: segment 1 and 3 via Roma and segment 2 and 4 Largo Carlo Felice). The right and left sides of each segment were considered, and the indicators were calculated and normalised from 0 to 1 using the formulas and parameters described in Table 2. Table 4 shows the results of the normalisation of each universal design indicator for each segment. In particular: (a) Safety is high as demonstrated by the sub-indicators that calculate Perceived Danger and Pedestrian Path Functionality (which vary in almost all segments from 0.6 to 1). However, the co-existence indicator, and consequently the relationship between different modes of transport and pedestrians, highlights some problems in all the segments analysed, underlining the need to reduce the risks to pedestrian safety and promote safety measures in the community. These safety measures will assist in altering the public's perception of pedestrian safety and enhance the quality of life for all users. Pedestrians

must have access to designated secure zones, such as dedicated cycle lanes, footpaths, and pedestrian areas, as well as adequate pedestrian crossings. The high traffic speed of this junction coupled with many lanes poses significant risks to pedestrians when crossing the road. To mitigate this risk, the speed limit should be reduced, and road lanes should be marked accordingly. Additionally, a reduction in speed limits will improve drivers' reaction times and give pedestrians more time to cross safely. (b) The pleasantness of the road is an important aspect in any urban context and is closely linked to the quality of life of citizens. In particular, its evaluation was made through a series of indicators that focus on various aspects, such as the presence of commercial activities, the level of services offered, the quality of the recreational facilities and the availability of food services. The analyses have shown that the commercial activities present along the road contribute significantly to its pleasantness. In fact, all the activities have activated actions against architectural barriers, satisfying the different needs of the local community, making the street a welcoming and inclusive place. In the analysed node there are no General Services and Recreational Functions. (c) The accessibility of local public transport has been implemented effectively and in a targeted manner to meet the needs of all people. This is demonstrated by the values of the Services Indicator (LPT). For those living with disabilities, the accessibility of local public transport is of paramount importance in order to be able to participate fully in community life.



Fig. 5. Study area and calculation segments of the Universal Design Indicator. Source: elaboration by Chiara Garau and Giulia Desogus

The Universal Design Index measures how a product, service, or environment promotes accessibility and inclusion. I On a scale from 0 to 1, the Universal Design Conclusive Index is reported to be 0.61 in Table 4. This means that the studied node scored quite well in terms of accessibility and inclusion. However, there is still room for improvement to ensure greater accessibility and ease of use for people with different abilities. To achieve the goal of designing universal environments, one should adopt a set of universal design principles. These principles include flexibility of use, clarity of information, elimination of physical and cognitive barriers and simplicity of use. Furthermore, as shown in Tables 3 and 4, there should be a constant awareness of the needs of people with disabilities and the challenges they may face, especially in critical design areas as an example in traffic speed limits and number of lanes and measures of Traffic Control.

Table 3. Universal Design analysis results

Indicators	Segment			
	Seg_1	Seg_2	Seg_3	Seg_4
a) Safety				
a.1) Perceived Danger				
a.1.1) Traffic safety				
Crossing type	0.6	0.6	0.6	1
Pedestrian visibility	0.6	0.6	0.6	0.8
Presence of crossing aids	0	1	0	1
a.1.2) Co-existence				
Traffic speed limits and number of lanes	0.2	0.2	0.2	0.2
Measures of Traffic Control	0	0.2	0.2	0.6
a.2) Pedestrian Path Functionality				
a.2.1) Road pavement	1	1	1	1
a.2.2) Obstacles presence	1	1	1	1
b) Pleasantness				
b.1) Commercial Activities	1	1	1	1
b.2) Food Service	1	1	1	1
b.3) General Services	0	0	0	0
b.4) Recreational Functions	0	0	0	0
c) Services (LPT)				
c.1) Local Public Transport	1	1	1	1

As regards the application of the methodology in the study area, this has been modelled within the Vissim software. First, the entire intersection between Via Roma and Largo Carlo Felice was built by modelling the arches with the various lanes and the

Table 4. Universal Design analysis results

Indicators	Average for each indicator	
a) Safety		
a.1) Perceived Danger		
a.1.1) Traffic safety		
	Crossing type	0.7
	Pedestrian visibility	0.65
	Presence of crossing aids	0.5
a.1.2) Co-existence		
	Traffic speed limits and number of lanes	0.2
	Measures of Traffic Control	0.25
a.2) Pedestrian Path Functionality		
	a.2.1) Road pavement	1
	a.2.2) Obstacles presence	1
b) Pleasantness		
	b.1) Commercial Activities	1
	b.2) Food Service	1
	b.3) General Services	0
	b.4) Recreational Functions	0
c) Services (LPT)		
c.1) Local Public Transport		1
UNIVERSAL DESIGN INDICATOR		0.61

relative connectors. Subsequently, the traffic light system that regulates the intersection was implemented (Fig. 6).

Finally, the vehicular flows have been simulated. These have been taken from the General Report of SUMP of Cagliari, as defined in the case study. Once the vehicular flows were entered for each route and for each vehicle category, the simulation for the calculation of the indicator parameters was started. The figure shows how vehicles queue up at traffic lights before crossing the intersection (Fig. 7).

Table 5 shows the results of the simulation in terms of vehicle parameters (Service Level, Time Loss, Queue Length, and number of stops) and environmental parameters (CO, Nox and VOC emissions). Environmental indicators, emission levels and fuel consumption per node were calculated for each crossing manoeuvre in the intersection. Table 5 shows how the average Service Level of the entire intersection is very bad as it appears to have a value of F. In particular, the service level assumes level F for most manoeuvres crossing the intersection, except for some manoeuvres where the level of service assumes values between E and D. As regards time wasters, it is noted that the

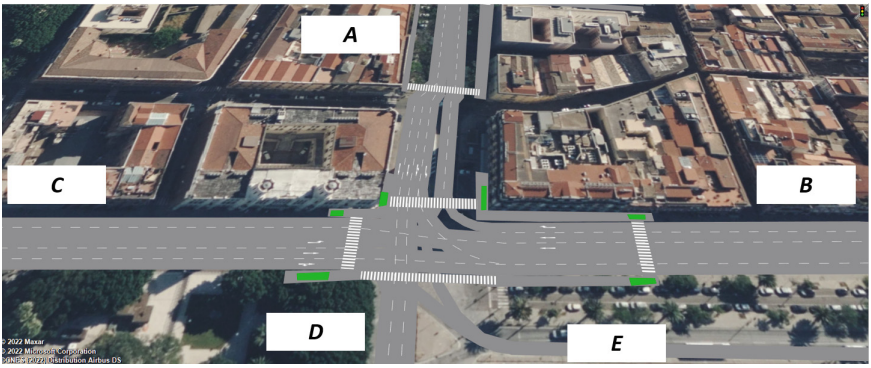

Fig. 6. View of the modelling study area. Source: authors elaboration.

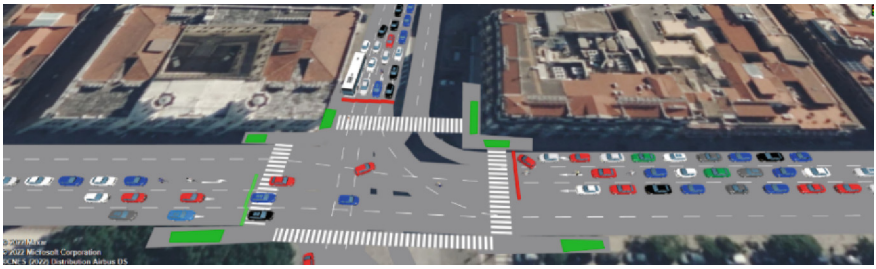

Fig. 7. 3D simulation showing the behaviour of vehicles near the intersection.

Table 5. Output microsimulation

Movement	LOS	VehDelay	Queue Length	Stops	CO [g]	NOx [g]	VOC [g]
A-B	LOS D	47,41	31,91	1,58	305,791	59,496	70,87
A-C	LOS E	76,31	31,91	2,38	87,047	16,936	20,174
A-D	LOS E	67,67	31,91	2,56	570,061	110,913	132,117
A-E	LOS D	45,13	31,91	1,14	9,284	1,806	2,152
B-A	LOS F	211	255,38	10,89	1450,853	282,283	336,249
B-C	LOS F	209,39	255,38	10,52	4304,589	837,517	997,63
C-A	LOS F	85,6	52,35	2,97	616,309	119,911	142,836
C-B	LOS D	54,54	52,35	1,46	697,22	135,654	161,587
C-D	LOS E	70,42	52,35	1,89	158,84	30,905	36,813
C-E	LOS E	76,41	52,35	1,62	78,296	15,234	18,146
Total	**LOS F**	**126,18**	**113,22**	**5,69**	**8312,36**	**1617,283**	**1926,47**

greatest time wasters are found in via Roma in correspondence with arch B, where the value of time wasters exceeds 200 s. This is caused by an excessive flow of vehicles coming from branch B of via Roma. With reference to the length of the queue that forms in the branches near the intersections, in branches A and C, queues are formed on average, respectively about 30 m and 50 m long, while for branch B the length of the queue exceeds, on average, 250 m. Similarly, the number of stops for each vehicle due to traffic lights is approximately 2 for each manoeuvre in branches A and C, while for manoeuvres relating to branch B the number of stops for each vehicle rises to 10. The emission levels relative to the reference node were also calculated. As can be seen from Table 5, the value of emissions increases as the level of service and the number of stops worsen for each crossing manoeuvre. In particular, in manoeuvres coming from branch B, where the number of stop and go is high, there are high values of emission levels. To make a comparison with the Universal Design composite indicator once these values have been determined, the obtained results for vehicle delay, Queue Length, and pauses are normalised on a scale of 0 to 1 (Table 6). After normalisation, the mean value of these three normalised indicators is calculated, resulting in a singular composite indicator. As is evident, the value of this normalised indicator is not particularly high.

Table 6. Microsimulation normalised indicators

Movement	VehDelay	Queue Length	Stops
A-B	0.99	1.00	0.95
A-C	0.81	1.00	0.87
A-D	0.86	1.00	0.85
A-E	1.00	1.00	1.00
B-A	0.00	0.00	0.00
B-C	0.01	0.00	0.04
C-A	0.76	0.91	0.81
C-B	0.94	0.91	0.97
C-D	0.85	0.91	0.92
C-E	0.81	0.91	0.95
Total	0.51	0.64	0.53
SERVICE LEVEL INDICATOR (I_{SL})			

Using Formula 1, the Index of Integrated Road Spaces (I_{IRS}) allows to accurately evaluate the level of integration between the road infrastructure (Service Level Indicator_I_{SL}) and the contour under a Universal Design perspective (Universal Design Indicator_I_{UD}) to improve accessibility and usability general for all people. I_{IRS} is therefore a complex measure of the connectivity and integration of road spaces within both a transport network and a pedestrian network. The I_{IRS} provides a quantitative assessment of the quality and accessibility of road spaces (Table 7), allowing for a better understanding of the fixed transport network and its impact on the community. The I_{IRS} considers

several factors, such as the presence of adequate pedestrian spaces, public transport opportunities and the interconnection capacity of the various spaces. A low I_{IRS} (equal to 0.58) indicates that the various street spaces are not well integrated and do not offer easy access to public services, residential and commercial areas, and other parts of the city. This can lead to increased traffic congestion, isolated communities, and increased reliance on private car use.

Table 7. Composite Indicator of Integrated Road Spaces

Indicators	values
UNIVERSAL DESIGN INDICATOR (I_{UD})	0.61
SERVICE LEVEL INDICATOR (I_{SL})	0.56
INDEX OF INTEGRATED ROAD SPACES (I_{IRS})	**0.58**

5 Conclusions and Future Research

This work proposed a methodology to present and evaluate some indicators of two different methodological approaches, namely, those of the Universal Design methodology and those of the traffic microsimulation methodology. Using these two static and dynamic approaches, it was possible to carry out an analysis of the urban environment in the spaces of the road network, within the Marina district of Cagliari.

As regards the Universal Design indicators, the indicators with normalised values of Safety, Services and pedestrian Path functionality obtained with various geolocated IT systems were identified, these were then calculated in the form of a single Universal Design indicator. On the other hand, the traffic microsimulation indicators (service level, number of stops, time wasters and queue length and emission levels) were calculated by modelling the study area within a software, entering data detailed inputs (i.e. number and width of lanes, vehicular flows and routes); in this case, however, in order to make a comparison with the Universal Design indicator, the Vehicle Delay, Queue Length and Stops indicators were normalised and averaged to form a single composite indicator. As the intersection in question is one of the busiest intersections in the city, the results show that the Universal Design indicator has a good value, while the single service level indicator has a modest value. The final goal of this paper was to merge the two indicators of Universal Design and level of service into the composite Indicator of Integrated Road Spaces (I_{IRS}) to obtain a complex measure of connectivity and integration of road spaces within both a transport network and a pedestrian network. The deepening of the research work moves in this direction, which foresees the expansion of the study area and the calculation of more indicators for both methodologies to represent an important decision support tool for administrations and planners in the evaluation of different strategies and actions for the redevelopment of pedestrian and vehicular urban spaces and their mutual interactions.

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