# REDESIGN OF URBAN ROADSPACE IN EUROPE CONSIDERING ALL ROAD USES

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## ABSTRACT

Urban roads in Europe are under pressure, as the available roadspace cannot meet the demands from an increased variety of road uses. This paper presents a new process for the allocation of roadspace in busy roads, considering the impacts on all road uses (both movement and 'place' uses) and a range of social, economic, and environmental objectives. The method comprises four stages: 1) generation of options for road redesign using two new online tools; 2) generation of further options in collaboration with the community; 3) micro-simulation of the options considering the interactions between movement and 'place' uses; and 4) assessment of the options using a new appraisal tool. The new tools bring objectivity to a process that is usually contentious and political.

## 1. BACKGROUND AND OBJECTIVE

Urban roads have a wide variety of uses, related to two functions of the road, one which is generally acknowledged (movement) and another which tends to be forgotten (“place”) (Von Schönfeld and Bertolini 2017). The place function includes vehicle-based activities (e.g. parking, loading) and people-based activities (e.g. waiting for public transport, strolling, relaxing). Road uses have benefits and costs for the respective users and wider social, economic, and environmental consequences, affecting not only the area next to the road but also the whole city and beyond (Bertolini 2020). There are policy objectives attached to these impacts, although they are not always explicitly recognized in transport and urban plans.

Many roads in European cities are under pressure to accommodate a variety of potential uses in limited space, at a time when travellers are using new forms of mobility (Marsden *et al.* 2020), producers and consumers are relying on timely deliveries and servicing (Schocke et al. 2020), and governments are prioritizing the quality of public places (Anciaes and Jones 2020). The COVID-19 pandemic brought added design requirements to urban roads, to meet the increased demand for home deliveries, ensure physical distancing for pedestrians, and provide opportunities for physical activity close to home (Honey-Rosés *et al.* 2021).

The reallocation of roadspace among different uses is a contentious issue. However, decisions for redesigning roads tend to be made on an ad-hoc political basis and there are no methods to assess the desirability of the available options.

Currently, the process of roadspace allocation has several gaps, as shown in Figure 1. The usual steps of this process are shown in brown. The process starts with a set of road design options. These options are modelled and presented for public consultation. However, there are no structured methods to identify the options. In addition, the modelling tends to focus only on the movement of the various modes of transport, producing performance indicators such as speeds, travel time, or delays (and sometimes a few local environmental impacts such as air pollution). There are also no methods compare options using the outputs of the modelling and consultation stages.

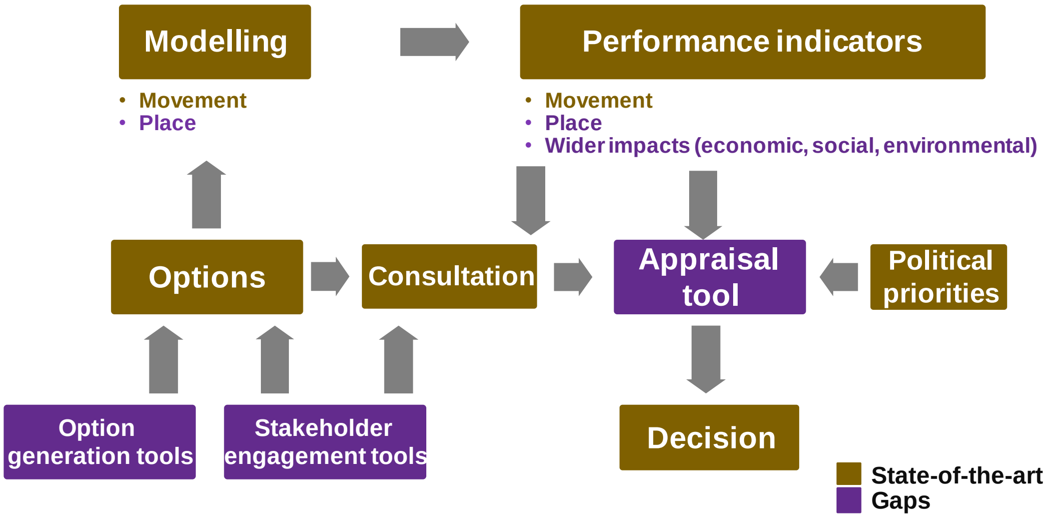



**Figure 1:** Roadspace allocation process: state-of the-art and gaps covered by this research

This paper presents a new method for the allocation of roadspace, considering the impacts on all road uses (both movement and 'place' uses) and social, economic, and environmental objectives. The method has four stages: 1) generation of options for road redesign using two new online tools, 2) generation of further options in collaboration with the community; 3) micro-simulation of the generated options considering the interactions between movement and 'place' uses; and 4) assessment of the options using a new appraisal tool. The method was trialled during 2021 in five cities: Budapest, Constanta, Lisbon, London, and Malmö.

## 2. OPTION GENERATION

Option generation is a neglected stage in transport policy. The new method fills this gap, starting the roadspace allocation process by using two option generation tools. The Policy Interventions tool presents road design options that fulfil specified priorities regarding road uses to improve, uses not to deteriorate, and objectives to achieve. The tool includes 28 road uses (e.g. pedestrians walking, pedestrians crossing, cyclists parking) and 28 objectives (e.g. reduce travel time; improve access to local buildings). The tool selects solutions from a database of 210 interventions, in terms of the likely effect (positive, uncertain/neutral, or negative) on all road uses and objectives, based on empirical evidence or the theory.

The following information is shown for each of the generated policies: a description of the intervention (Figure 2), examples, empirical evidence on the outcomes of the policy, and the possible effect on all road uses (Figure 3), and on policy objectives.

− Green area location: kerbside

Description | Examples and evidence | Effect on road uses | Effect on policy objectives

Source of image: MORE

**Type of policy:** Space allocation

Location of green areas (trees, grass strips, planters) on the kerbside area, replacing spaces for parking and loading. Green areas can be continuous or alternated with parking/loading spaces, bicycle parking, or other kerbside uses.

Planters can be used to delimit cycling infrastructure, footway extensions, or cycle parking, separating these elements from moving vehicles on the carriageway. They can also be used simply to narrow the carriageway, to reduce traffic volumes/speeds.

Strips with grass or other vegetation at the kerbside (known as swales) can channel surface water run-off and facilitate its absorption, reducing flood risk and pollution. They may also replace kerbs.

Trees or planters can be a solution to restrict space for car parking in the kerbside strip. However, green areas with low walls do not physically impede vehicles from parking on them - this solution requires enforcement measures.

**Figure 2:** Policy Interventions tool output: Description page (example)

Description | Examples and evidence | Effect on road uses | Effect on policy objectives

**Likely impact of intervention on road uses**

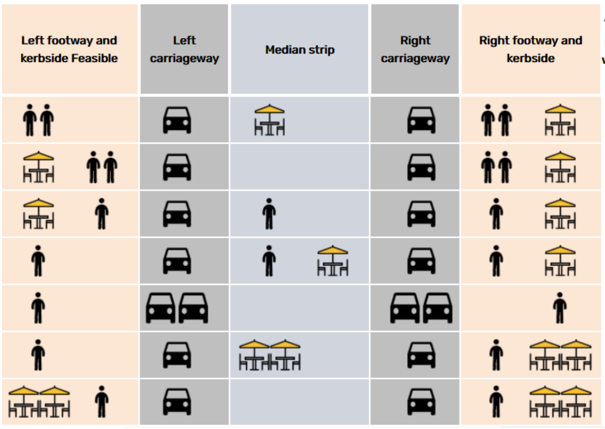
Compared to: Green area on footway

| Road user | Road use | Impact | Reason |
|---|---|---|---|
| **Pedestrians** | Walk | + | Provide shade, attractive views, less pollution and noise |
| | Cross the road | - | May reduce visibility |
| | Stroll | + | Provide shade, attractive views, less pollution and noise |
| | Sit (street furniture) | + | Provide shade, attractive views, less pollution and noise |
| | Sit (outdoor cafe) | + | Provide shade, attractive views, less pollution and noise |
| **Pedestrians with restricted mobility** | Walk | + | Provide shade, attractive views, less pollution and noise |
| | Cross the road | - | May reduce visibility |
| **Cyclists** | Move | o | May take space from cycle lanes/tracks |
| | Park | o | May take space from cycle lanes/tracks |
| | Rent (dock) | o | May take space from cycle lanes/tracks |
| | Rent (dockless) | o | May take space from cycle lanes/tracks |

**(…)**

**Figure 3:** Policy Interventions tool output: *Effect on road uses* page (example)

The Road Designs tool presents all permutations of design elements (e.g. bus lanes, footways) that meet the specified priorities regarding the width allocated to each road design element, while fitting in the total road width available. The tool considers nine design elements (e.g. cycle lane/track; space for parking/loading). It contains 30,300 possible options, i.e. permutations of all design elements (and their widths) that fit into the road width and are technically feasible. Figure 4 shows the output of a trial application of the tool. The output page is a list of options, characterised by the design elements used in each position and the total road capacity (per m2 of road space) assigned for movement, place activities and parking/loading.



| Left footway and kerbside Feasible | Left carriageway | Median strip | Right carriageway | Right footway and kerbside | Total road width (m) | Width of Design Elements (m) | | | | | | | | Capacity per 75m² of roadspace | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Walking | Place activities | Green area | General purpose | Bus lane | Cycling | Parking/loading | Tram line | Movement (people) | Place activities (people) | Parking/loading (vehicles) |
| | | | | | 18 | 6 | 4 | 0 | 6 | 0 | 0 | 0 | 0 | 110 | 45 | 0 |
| | | | | | 18 | 6 | 4 | 0 | 6 | 0 | 0 | 0 | 0 | 110 | 45 | 0 |
| | | | | | 18 | 6 | 4 | 0 | 6 | 0 | 0 | 0 | 0 | 110 | 45 | 0 |
| | | | | | 18 | 6 | 4 | 0 | 6 | 0 | 0 | 0 | 0 | 110 | 45 | 0 |
| | | | | | 18 | 4 | 0 | 0 | 12 | 0 | 0 | 0 | 0 | 90 | 0 | 0 |
| | | | | | 18 | 4 | 6 | 0 | 6 | 0 | 0 | 0 | 0 | 80 | 65 | 0 |
| | | | | | 18 | 4 | 6 | 0 | 6 | 0 | 0 | 0 | 0 | 80 | 65 | 0 |

**(…)**

**Figure 4:** Road designs tool output (example)

## 3. STAKEHOLDER ENGAGEMENT

The second stage of the process is the generation of further design options in collaboration with the community. The innovation brought with this process is the provision of tools that facilitate discussion and co-creation of new road designs during workshops and then streamline the transfer of the designs into formats that can be modelled, appraised, and presented for public consultation.

Participants in workshops are provided with a toolkit of blocks and acetates representing design elements (e.g. bus stop, parking/loading bay, trees, bus lane, cycle lane, etc.), all at the same scale (Figure 5). Participants then experiment (negotiating with each other) with different arrangements that fit into the available road width (Figure 6). The toolkit facilitates the co-creation exercise, by illustrating the types of elements that can be included in the design and ensuring that the designs are feasible, as each element is drawn to scale.


**Figure 5**: Road design toolkit. Photo: Marga Marin

**Figure 6**: Road design toolkit in use in Malmö. Photo: Per Wisenborn

The created designs are then digitised into LineMap, a design software developed by Buchanan Computing, a project partner. The designs can be represented either as road markings or as blocks replicating the design toolkit (Figure 7Figure 8). The designs can then be refined by professionals and then be exported to other software (e.g. GIS, microsimulation)

The designs can also be published in TraffWeb, an online consultation platform (also developed by Buchanan Computing) to gather feedback from the public. The same platform can also be used before the co-creation stage, (to assess problems felt by road users) or after (to consult the public about the design options).

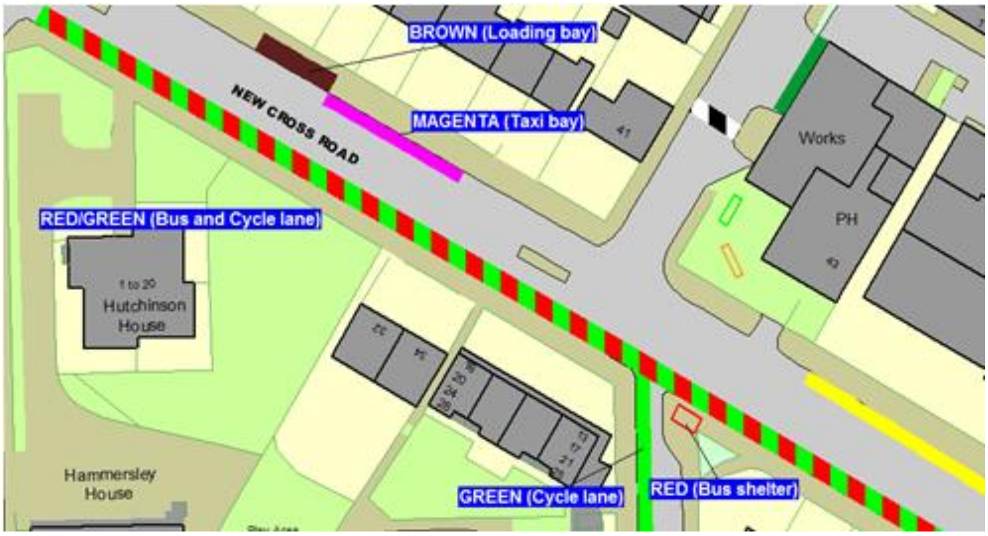



**Figure 7**: Road designs represented as blocks in LineMap.

## 4. MICROSIMULATION

The third stage of the process is the micro-simulation of the generated options using microsimulation software (PTV Vissim). The options are exported as shapefiles from the LineMap software described in the previous section and then imported as backgrounds into PTV Vissim. PTV Vissim then simulates the interaction between road users, based on models of the movement of each user.

Additional functionalities and approaches to PTV Vissim were developed, to improve the representation of: 1) interactions between motorised vehicles and pedestrians at crossing points (both formal and informal); 2) people-based place activities (e.g. pedestrians sitting in benches or looking at a smartphone, queues and activity in waiting areas and when boarding buses) (Figure 8); and 3) parking and loading (distinguishing between vehicles that are parked, waiting for a free parking space, driving to a parking space, blocked while leaving parking space, and back to their route).

The simulation produces indicators of the effects of road design options on all road uses. Previously, most of the indicators produced by microsimulation software were relative to the movement of motorised vehicles (e.g. vehicle density, travel time, average speeds, delays, stops). The new functionalities allow for the calculation of new indicators, including the average number of stops per pedestrians, average number of pedestrians waiting for public transport, share of time a parking space is occupied by stopped vehicles, total number of stopped vehicles, total value of parking fees, and number of vehicles that could not be parked.

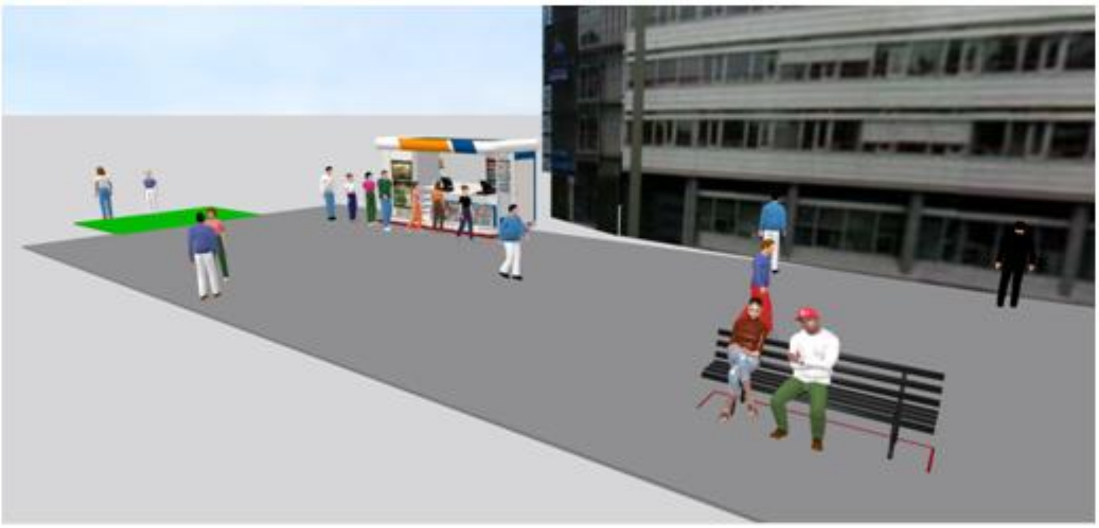


**Figure 8**: Microsimulation of place activities (Extract from PTV Vissim model).
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## 5. APPRAISAL

The final stage is the assessment of the options using a new appraisal tool. Appraisal is a usual practice for projects for building new roads but rare for projects to change existing roads, including reallocating space. The new tool accounts the impacts of each option on all road users and policy objectives.

For each option, the tool requires the following inputs: 1) cost; 2) current space allocation; 3) performance indicators for movement (e.g. speed/travel time per mode) (see example in Figure 9); 4) performance indicators for place activities (number, duration, quality of people-based activities, parking, and loading); and 5) wider impacts (e.g. forecasted change in property prices, safety, air quality). Other inputs include the political priorities assigned to each road use and policy objective.

| | Option 0 (Do nothing) *6 traffic lanes* | | | | |
|---|---|---|---|---|---|
| | **Volume** | **Speed or travel time** (in road section) | **Delays** (comparing with free-flow) | **Reliability** ⓘ | **Trip quality** ⓘ |
| **Indicator** *Choose from dropdown menu* | Average flows per day | Average speed (km/h) | Average delay (minutes/km) | | % of satisfied users |
| **Transport mode** *Insert value of the indicator chosen above* | | | | | |
| **Private cars** | 62,547 | 31 | 0.4 | | 0.54 |
| **Taxis** | | 31 | 0.4 | | 0.43 |
| **Motorcycles** | 783 | 31 | 0.4 | | |
| **Vans/Light Goods Vehicles** | 33,660 | 31 | 0.4 | | 0.34 |
| **Heavy Goods Vehicles** | 10,176 | 31 | 0.4 | | 0.51 |
| **Buses** | 6,262 | 31 | | | |
| **Bicycles** | 4,697 | 12 | | | 0.03 |
| **Scooters, skates, etc** | | | | | |
| **Pedestrians** | 3,812 | 4 | | | 0.09 |

**Figure 9:** Appraisal tool: extract of an input page (movement indicators for an option)

The tool then provides a comparative assessment of all design options for all indicators. Some indicators are copied from the inputs page; others are calculated from those inputs. The tool highlights in green, for each indicator, the best option or options (see example in Figure 10). It also highlights the options that go against political priorities (in yellow) and against technical or design standards (in red).

The tool can then perform two types of additional assessment: cost-benefit and multi-criteria analysis. Cost-benefit analysis requires the specification of unit monetary values (or the choice of built-in values, which come from the literature). The output is, for each option, the present monetary value of each indicator and the overall benefit-cost ratio. Multi-criteria analysis requires the specification of the worst and best possible value for each indicator and the priorities of each stakeholder. The output is the ranking of the options for each stakeholder.

| Performance indicator | Unit | Now (Do nothing) *6 traffic lanes* | Option 1 *Widen pavements* | Option 2 *Add green median* | Option 3 *Add cycle lane* | Option 4 *Radical change* |
|---|---|---|---|---|---|---|
| Implementation cost | 1,000 € | 0.0 | 135.7 | 90.5 | 81.3 | 375.4 |
| Maintenance cost per year | 1,000 € | 0.0 | 24.4 | 16.3 | 14.6 | 67.6 |
| **Link function** | | | | | | |
| **Private cars** | | | | | | |
| Level of service | Space per vehicle (m2/vehicles/day) | 0.08 | 0.07 | 0.09 | 0.07 | 0.03 |
| Speed (km/h) | Average speed (km/h) | 31 | 18 | 18 | 18 | 9 |
| Delays | Average delay (minutes/km) | 0.4 | 0.6 | 0.6 | 0.6 | 0.6 |
| Reliability | | | | | | |
| Trip quality | % of satisfied users | 0.54 | 0.14 | 0.6 | 0.12 | 0.02 |
| **Taxis** | | | | | | |
| Level of service | Space per vehicle (m2/vehicles/day) | 0.08 | 0.07 | 0.09 | 0.07 | 0.03 |
| Speed | Average speed (km/h) | 31 | 18 | 18 | 18 | 9 |
| Delays | Average delay (minutes/km) | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 |

**(…)**

| Performance indicator | Unit | Now (Do nothing) | Option 1 | Option 2 | Option 3 | Option 4 |
|---|---|---|---|---|---|---|
| **Wider impacts** | | | | | | |
| **Economic** | | | | | | |
| Property values | | | | | | |
| Visits to local businesses | Number of visits to local shops per day | 1,018 | 2,463 | 2,463 | 2,463 | 3,015 |
| Expenditure in local businesses | Per-visit expenditure on local shops (€) | 8.2 | € 11.1 | € 11.1 | € 11.1 | € 35.0 |
| Total expenditure | Total expenditure per year (1000 €) | € 3,046.87 | € 9,979 | € 9,979 | € 9,979 | € 38,517 |
| **Social** | | | | | | |
| Safety | Number of fatalities per year | 0.98 | 0.88 | 0.95 | 1.31 | 0.6 |
| Health (physical activity only) | | | | | | |
| Community severance | UCL index | 0.08 | 0.08 | 0.08 | 0.08 | 0.02 |
| Personal security | % users feeling safe (from crime) | 0.6 | 0.81 | 0.51 | 0.61 | 0.95 |
| Equity (inclusive design) | | | | | | |
| Visual impacts | | | | | | |
| **Environmental** | | | | | | |
| Energy consumption | | | | | | |
| Air pollution | | | | | | |
| Co2 emissions | | | | | | |
| Noise | LAeq16h (dB(A)) | 81 | 68 | 65 | 66 | 43 |
| Local climate | | | | | | |
| Land use | | | | | | |
| Nature | | | | | | |

**Figure 10:** Appraisal tool: extract of an output page

## 6. CONCLUSION: A PRACTICE-READY PROCESS

The new tools bring objectivity to the roadspace reallocation process in urban roads, as this process tends to be based on political decisions and be subject to controversy, due to the variety of users using the road and their conflicting needs.

The two new online option generation tools allow planners to produce a large set of options for roadspace allocation, each balancing the needs of the various users in a different way. The two tools are openly available, bringing more transparency to the process, as any member of the public can easily generate their own options as possible alternatives to the ones presented by authorities.

The stakeholder engagement tools then facilitate the achievement of consensus among road users regarding the options previously generated using the online tools. They can also be used to generate further options during co-creation workshops, and to gather feedback from the public on the options created.

The improved procedures for the microsimulation of the interaction between users reduce the previous bias of the process by improving the simulation of pedestrian movement and people-based and vehicle-based stationary activities. This brings more realism to microsimulation, which until now relied on the estimation of performance indicators for movement (especially of motorised vehicles). The procedures are integrated into existing software that is already used by many planners.

Finally, the appraisal tool is a systematic method to account for the variety of effects of reallocating roadspace, considering all road uses and policy objectives. The tool is also available to members of the public and runs even when data is not available to fill some of the inputs.

## Acknowledgements

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement 769276. The authors benefited from suggestions from the other members of the project.

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