ANNEXE

METHODOLOGY AND EXAMPLE OF ROADMAPS FOR THE GREEN SCENARIO

In terms of methodology, the roadmap was built by first, envisioning a future where all the goals have been accomplished and then, by going backwards and finding What needs to be previously accomplished to enable to reach the desired future.

Each situation or step along the way has a colour that indicates what type of changes is described.

- The green boxes represent the **main objectives** in order to realise a city's or region's future vision.
- The blue boxes represent **technical progress** and new product developments that are happening on the market.
- The red boxes represent **lifestyle and behavioural changes** of citizens towards the adoption of a new services and how they decide to change their travel patterns.
- The yellow boxes represent the actions and measures public transport authorities or transport agencies can implement.

The main goal is to create **liveable cities**. To achieve this, we need to accomplish three things:

1. Better environment
2. Vibrant public spaces
3. Better accessibility

1. To have a **better environment** we need to:
    a. **Minimise the use of non-renewable resources:** In a situation where we have accomplished minimal use of renewable resources, we believe that fewer cars are produced.
    b. **Have high energy savings:** In a situation with high energy savings, we also believe that fewer cars are produced and vehicles are used less, so strong decrease in vehicle miles kilometres travelled.
    c. **Reduce local pollution:** In order to reach this goal, a strong decrease in vehicle kilometres travelled in needed.
2. In a situation where we have accomplished **vibrant public spaces,** we've had to take land from vehicles infrastructure so that we can get more land for the users that make public spaces more vibrant: This is **large scale street reclaiming**.

a. In a situation where we have accomplished large scale street reclaiming, we've had to **decrease the vehicle miles travelled**.

3. In a situation where we have accomplished **better accessibility** for people, we have had to achieve:
    a. **Equitable mobility**: In a situation where we have accomplished equitable mobility we have:
        i. **Improved mobility for people who do not own a car or cannot drive**
        ii. Made sure that there are **affordable transport options within the system**
    b. **Safe mobility**: Autonomous technology will make vehicles safer, but if we still want to make transportation even safer, then we need to focus on **decreasing vehicle miles travelled**.
    c. **Efficient mobility:** In a situation where mobility is efficient, we must solve congestion. There is reason to believe that autonomous vehicles will drive more efficiently but space is such a scarce resource in cities, that we still have to focus on **strong decrease in vehicle miles travelled** to combat the congestion in the future.
4. **Strong decrease in vehicle miles travelled** is crucial to accomplish many of the goals above. To achieve this goal, we've had to focus on three things:
    a. **Fewer motorised journeys:** Cycling and walking more and using technology for remote meetings when possible. For this to happen, we must make sure that:
        i. **People in the future still prefer to cycle and walk** even in a future where time in a car is not wasted handling the wheel.
        ii. **The perceived costs of motorised travel** (per vehicle miles travelled) has to be high, because the high cost gives an incentive to travel together with others in order to share the cost. The keyword here is "perceived" costs because motorist travels are expensive today but the costs are mostly fixed costs and hardly related to use so we have to make sure that **fixed costs are included in cost per vehicle miles travelled.**
        iii. It can be accomplished **if mobility is bought as a service and car ownership is low.**
    b. When people travel using motorised vehicles, they travel with others in vehicles of high occupancy. The idea is that a train is better than a bus which is better than a car with many passengers, which is better than a single occupancy car. In a situation where we have accomplished the goal of **high average occupancy per motorised travel**, we've had to ensure that:
        i. **High average occupancy travels are effective**
        ii. Thanks to the creation of **infrastructure that gives priority to high occupancy vehicles:**
            1. **People are comfortable with travelling together with others in large but also in small vehicles**
            2. **Especially in smaller vehicles we need to make sure that shared travels does not challenge social norms.** For example, by **designing the vehicles** not as family spaces with large sofas but rather *as spaces* **where strangers can travel together**. This is easier if **none of the travellers own the vehicle**, as many that

have tried ridesharing report that it was uncomfortable to get into another person's private vehicle.

- This can be achieved if **mobility is bought as a service and car ownership is low** and **the perceived cost per vehicle miles travelled is high**. This means that people buy mobility every time they need it instead of buying a car to cover their needs.

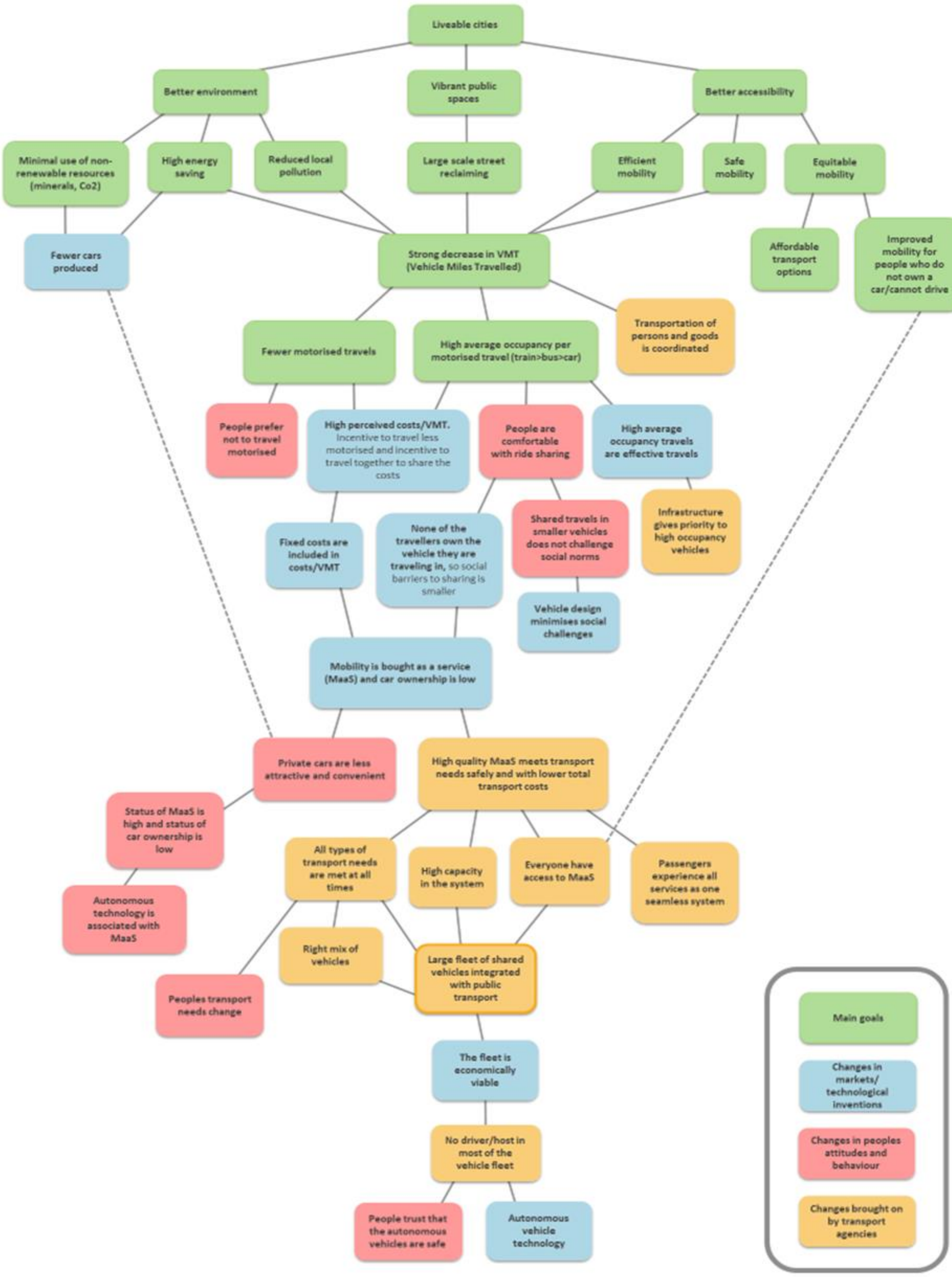
c. **Coordinating transport of persons and goods**.

5. Perhaps the biggest challenge so far is to ensure that **mobility is bought as a service and car ownership is low**. In a situation where we have accomplished this, we've had to do two things:
   a. **Make private cars less attractive and convenient**, even when autonomous, as this also **influences the cost of the new high quality transport system**
   - For this there's had to be a change in people's perception of status: **the status of the new system has to be high and the status of car ownership has to be low.**
   - **People had to think of public transport when they hear autonomous technology** instead of thinking about their future autonomous private Tesla.

   b. To **create a quality transport system that meets people's needs safely and with lower total transport costs.** For this, we've had to create a system where:
      i. **Passenger experience services all act as one similar system**
      ii. **Everyone must have access**
      iii. **There is high capacity**
      iv. **All types of transport needs are met at all times:**
      - **Thanks to on a right mix of vehicles**
      - **Thanks to a large fleet of shared vehicles that is integrated with public transport**
      - And **considering transport needs can change.**

6. So, **creating a large fleet of shared vehicles integrated with public transport** is key. It is possible to create this fleet today, but it will not function in the way that we want and be economically viable at the same time.
   - We need the **fleet to be economically viable**. For that to happen, there must be **no driver or host in most of the vehicle fleets**. To achieve this, we are dependent on **autonomous vehicle technology** and **people trust that autonomous vehicles are safe.**

Figure 1: Roadmap for the green scenario (Source: Ruter AS)



METHODOLOGY FOR STAKEHOLDERS' EVALUATION OF SPACE

The methodology that allows the explicit inclusion of different stakeholder perspectives in the evaluation is the Multi-Actor Multi-Criteria Analysis, or MAMCA[1]. It is a step-wise approach that quantifies stakeholder objectives and captures a criteria-based evaluation for each alternative solution.

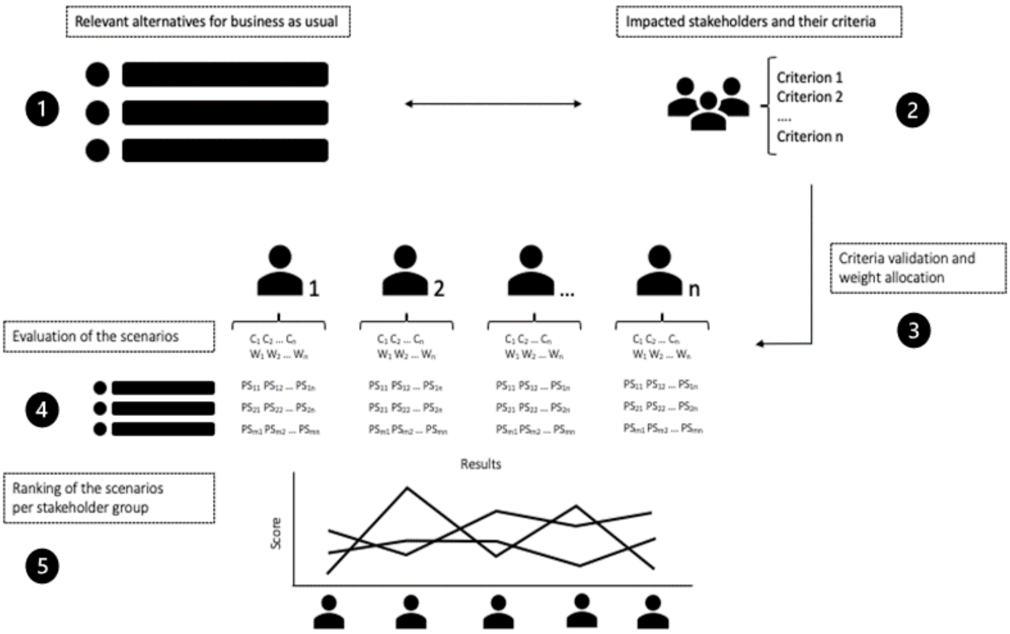


Figure 2: MAMCA flow chart. Note: C = criterion; W = weight; PS = performance score. Adapted from Macharis et al. 2010

Step 1: Definition of the problem and identification of the alternatives

The introduction of autonomous vehicles (AVs) has the potential to increase Vehicle-kilometres travelled (VKT) if vehicles replace single occupant trips in personal vehicles. To avoid a situation of increased traffic, the aim is to build a transport system in which shared AVs supplement mass public transport in order to attain a strong decrease in VKT.

Autonomous technology presents several opportunities for future mobility services, as illustrated by the non-exhaustive list of use cases. Depending on the environment (urban, suburban, rural) and the presence of a mass transport network, several automated transport services can be proposed as alternatives. To facilitate a clear understanding of the alternatives, it is important to include detailed aspects of the transport service in the

[1] Macharis, C., De Witte, A. & Turcksin, L. (2010), The Multi-Actor Multi- Criteria Analysis (MAMCA) application in the Flemish long-term decision making process on mobility and logistics, Transport Policy, 17(5), 303–311.

descriptions of the proposed alternatives. For instance, including the service area, operating hours, accessibility of the vehicle, passenger capacity, etc.

Step 2: Identification of the relevant stakeholder and their evaluation criteria

Stakeholders are parties that are affected by the proposed alternatives that will be implemented. They are interested in the consequences of any decisions taken. Within the context of automated and public transport the following (non-exhaustive) list of stakeholder groups is proposed:

- Users
- Public transport operators
- Public transport authorities
- Mobility service providers
- Vehicle manufacturers (or OEMs),
- Local authorities

Every stakeholder group has a different set of objectives or goals related to the project or problem. Therefore, it is important to consider the following two aspects for a successful evaluation of the alternatives. Firstly, enough stakeholder representatives should partake in each group to ensure that various objectives are presented and to encourage group discussions. Second, the objectives of each group must be translated into a set of clearly defined evaluation criteria. In a first phase, a preliminary list of criteria can be composed based on literature, industry reports and knowledge of the problem. Next, the criteria should be validated by the stakeholder group through interactive discussion and for pragmatic consideration the selected criteria should be limited (5 to 7).

Step 3: Setting criteria weights

To reflect the relative importance of the stakeholder group's objectives, each criterion must be assigned a weight. For the determination of the weights several methods can be used, such as allocation on a 100-points scale, trade-off between pairs or direct allocation. Through group discussion within each stakeholder group a consensus must be reached about the relative importance of every criterion.

Step 4: Evaluation of the alternatives based on the criteria

Further group discussion among the representatives of the stakeholder groups is needed as they evaluate the performance of each alternative in terms of the criteria. Different multi-criteria analysis (MCA) methods can be applied for the assessment of the alternatives. For example, representatives can be asked to select a performance score on a 10-points scale for each alternative in terms of every criterion. Subsequently, the Simple Multi-Attribute Rating Technique (SMART)[2] can be applied to calculate the multi-criteria score that represents the

[2] Von Winterfeldt, D., & Edwards, W, 1986. *Decision analysis and behavioral research*. Cambridge: Cambridge University Press.

stakeholder group's overall performance of an alternative. SMART is based on the additive value function and favoured for its transparent use.

Step 5: Presentation of and reflection on the results

The MCA method applied in the previous step will render a classification of the alternatives for each stakeholder group. Visualisation of these rankings allows for a comprehensive understanding of the essential stakeholder trade-offs and facilitates the discussion among all stakeholder groups as they reflect on the rankings. The results of the analysis can also be used to formulate policy recommendations toward the implementation of alternatives and design a deployment strategy that is generally supported by all stakeholder groups in the sector.

In the stakeholder assessment done within the SPACE project, the objectives and perspectives of public transport operators, public transport authorities and mobility service providers were captured during individual consultations with experts from the respective domains. In total, seven experts took part in the evaluation of the scenarios. The choice to conduct the assessment individually with each representative was driven by the restricted availability of each of the experts, limiting the possibility to organise a group assessment during a workshop.

The users in the assessment were represented by nine students and one employee of Brussels Health Campus. At the time of the research, the campus formed the testing ground for an autonomous shuttle pilot[3]. Two consultation sessions were set up in the form of a workshop, so that users could engage in an interactive discussion.

The stakeholders' evaluation was completed for a selection of relevant scenarios for an urban setting.

1) Business as usual (BAU): The current public transport system has an efficient high capacity network with high capillarity and frequency operated by metro, tram and bus. There are no autonomous services.

2) First/last mile feeder service to public transport stations operating on fixed routes, operational times in parallel to the core network, on-demand or fixed stops (rush hour), shared use, medium capacity, all-user access vehicles.

3) On-demand point-to-point service with dynamic routing, extended operational times, shared use, low capacity, all-user access vehicles.

4) Premium robo-taxis offering sequentially shared, on- demand, point-to-point private service with 24h operation.

5) Autonomous car-sharing offering sequentially shared, on-demand, private service reserved for period of time with dynamic routing and extended operational times.

[3] The results from the user experience and acceptance survey can be read in the following publication: Feys, M.; Rombaut, E.; Vanhaverbeke, L. Experience and Acceptance of Autonomous Shuttles in the Brussels Capital Region. *Sustainability* 2020, *12*, 8403. https://doi.org/10.3390/su12208403

6) Bus Rapid Transit (BRT): shared use, high-capacity buses operating on fixed routes with high frequency and fixed stops on a separate lane.

The sets of criteria used per stakeholder group for the assessment of each scenario are presented in the table below.

SPACE Stakeholder groups	SPACE Criteria
Public transport operators	• Accessibility for impaired users • Security • Safety • Cost • Income • Opportunities for new business models • Travel time efficiency
Public transport authorities	• Accessibility of services by public transport • Sustainability • Cost • Impact on space and land use • Socio-political acceptance
Mobility service providers	• Economic efficiency (profitability) • Opportunities for new business models • Social sustainability (inclusiveness)
Users	• Price • Travel time • Acceptance • Accessibility for impaired users • Travel comfort • Security • Safety

Beneficiating from a close collaboration with the Drive2theFuture project, the stakeholder' evaluation was captured during three workshops that focused on the assessment of future mobility scenarios with automated vehicles. During these workshops, the users, public transport operators, local authorities, mobility service providers and manufacturers were represented by a total of 53 participants. The detailed description of the scenarios, the set of criteria per stakeholder group and the results of the assessment per workshop are available in the Drive2theFuture deliverable D6.1[4].

[4] For more information: http://www.drive2thefuture.eu/dissemination/public-deliverables/