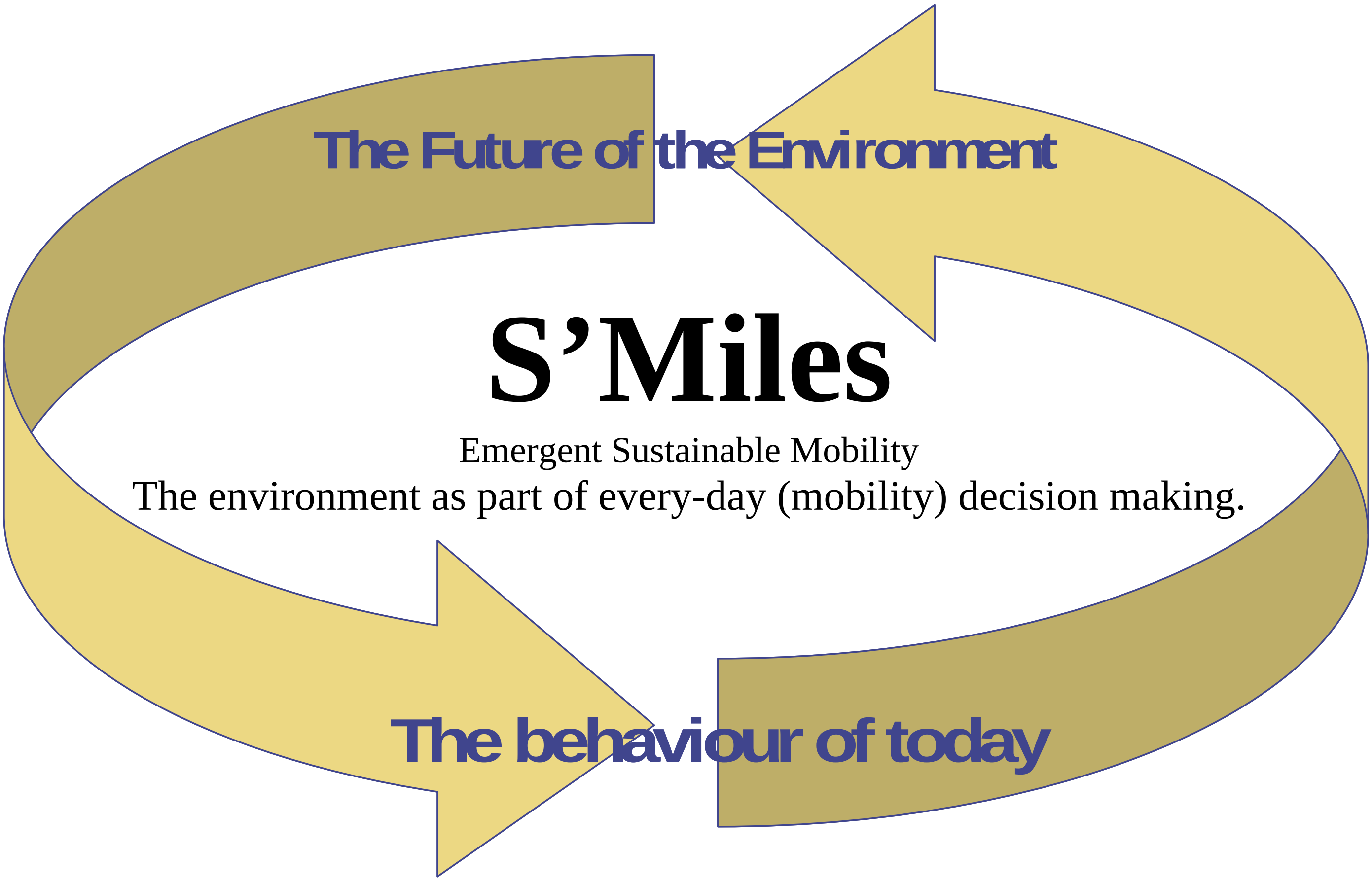

S'Miles

Emergent Sustainable Mobility

The environment as part of every-day (mobility) decision making.

System description and Simulation Tool

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Sustainability and mobility

Each of us takes a lot of decisions on mobility. Not just once a week, but for many of us, every day, or even several times a day. Yet for most of us the impact of our mobility choices on the environment is not very prominent in these decision processes. While we are generally aware of the macro-impact of mobility on the quality of our environment, this aspect plays little part in our routine decision making.

The isolated impact of each decision is low, the daily options to make an important contribution are limited, and the balance between personal convenience and environmental considerations readily tilts towards the convenience aspect. Sustainability is largely associated with new fuel and engine technology, improved public transportation, improving motorway-flow, etc. And all (or most) of these are considered to be outside our individual hands.

On the other hand governments are wrestling with the macro consequences of this behaviour. Kyoto compliance, health risks, etc increasingly cause the need for policies that systematically reduce the level of emissions gradually towards a sustainable level. Many of the available solutions and technology could contribute to this aim, but require critical mass to become viable. And enforced reduction of mobility threatens economic growth, employment and prosperity.

Seen from a systems point of view, none of the actors, although well-intentioned and aware of the macro-problem, seem to be capable of moving towards higher levels of sustainability at a pace that does justice to the recognized sense of urgency of this problem. It’s like a prisoner’s dilemma: although each and every one of us recognizes the need, our respective behaviour as actors in the system doesn’t do a great deal to achieve this aim.

Emergence as system concept

The above description of system behaviour is not just true for the mobility related issues in our society. It represents a general class of problems we are facing in the highly individualized modern societies. Whereas we might expect governments to take decisions for the good of us all, and implement and enforce these decisions by means of laws or regulations, this mechanism proves increasingly ineffective in producing the desired effects.

There are a number of reasons underlying this shortfall:

- Whereas in the past our needs and aspirations might have been sufficiently similar to be captured in a limited set of regulations, the increasing heterogeneity and individualization in today’s society severely complicates regulation and legislation. On top of that most regulation cannot any longer be isolated from an international context that limits the freedom of action of any particular country. The resulting complexity makes it difficult to agree, communicate and enforce such regulation.
- The growing competences and information available to each actor leads to increased evasion of such regulation, reducing the intended benefits, and sometimes leading to social injustice and inequality. This reduces the acceptance of the regulation and complicates enforcement.

- Due to the above, lead times to establish regulation get longer, and the regulatory process is unable to keep up with the pace of external change. In many cases the result is “too little, too late”.

All of this applies also to the environmental impact of out mobility behaviour. To put it bluntly: while we have “outsourced “ the environmental issues to our governments, they find it increasingly difficult to turn these issues into regulatory frameworks that recognize societal diversity, and secure a sufficient level of acceptance at the actor level to be effective in yielding new behaviour.

Metaphorically, the system works like a crossroad with traffic lights; the traffic becomes increasingly complex and the drivers become less and less likely to obey the light signals.

Using the same metaphor, there is an alternative in the form of a roundabout. While serving the same function, the working mechanism of a roundabout is markedly different from the traffic-light controlled crossroad. Not planning and top-down control, but a “clever” interaction rule (priority to the left – or to the right in the UK) hands the decision-making to the users of the roundabout. Pursuit of well-understood self-interest (clearing the roundabout) and a clever geometric design permitting continuous (albeit slowed down) movement, produce a much more acceptable solution to the problem with a performance (in terms of throughput and adaptation to changing traffic conditions) that is far superior to any traffic light solution in light and intermediate traffic conditions .

In the roundabout example one could say that the “macro-behaviour” of the system “emerges” from the micro decisions taken by the users. Such systems are called “emergent systems”. This is in contrast to the crossroad example where the macro-behaviour is a direct result of the traffic signals instructing the drivers.

This “roundabout principle” has a general applicability. The principle is very well known form biology. Flocking birds and ant-nest organisation are examples. Many societal processes use this very principle. Our market economy itself has many examples, but also recent initiatives as “individual budgeting” in the Dutch health service. It is increasingly applied in logistics processes, in self-organizing units within companies, etc.

Although the mechanisms to make it generally work are not yet fully understood, there is a growing belief that the application of principles of emergence to complex organisation problems might provide a solution for the problems described above.

The core design elements of such system are:

- The actor self-interest (roundabout: “keep moving”)
- Some “directional” mechanism, directing actor energy in meaningful behaviour at system level (roundabout: “left-priority rule”).
- Some form of governance, conditioning actor interactions within the “bandwidth” of the system (roundabout: liability when violating the priority rule).

In the following section we will apply these principles to the issue of mobility related emission.

S'Miles: transactioning sustainability

Emergent sustainable mobility requires the active involvement of the travellers themselves. Not choosing a car, but turning the ignition key starts pollution, so in the end it's the traveller behaviour that counts. Almost all relevant decisions are taken at the traveller level:

- **The travelling decision**
  Travelling is a way of establishing societal connectivity. Travellers themselves decide between physical displacement and other ways of connecting to others, e.g. through telecommunications. Sometimes (e.g. delivering goods) there is no substitute, sometimes (e.g. working from home using telecommunications) there is.
- **The modality decision**
  When travelling, the choice between the various modes (car, public transportation, cycle, walk, etc) is very much in the hand of the individual traveller. Not just in private travel, but also in business travel.
- **The timing decision**
  With current heavy traffic conditions the timing of travel affects the environmental impact of the chosen mode.
- **The car decision**
  Even with company cars, the traveller generally has a wide range of choices, not just in brands and types, but also with respect to fuel source and environmental impact.

Although in business related travel, company policies might provide some restrictions to above decisions, it is in general very much left to the individual to weigh the different aspects and make the decisions. Yet, especially in business travel, most of the consequences of these decisions, measured in time, money or otherwise, are absorbed by the employing company. Both in business and in private travel, the financial and the time impact seem to carry little weight in the traveller decision making process. Part of the problem is the limited marginal effects of every-day mobility choices, and the inertia of established habits.

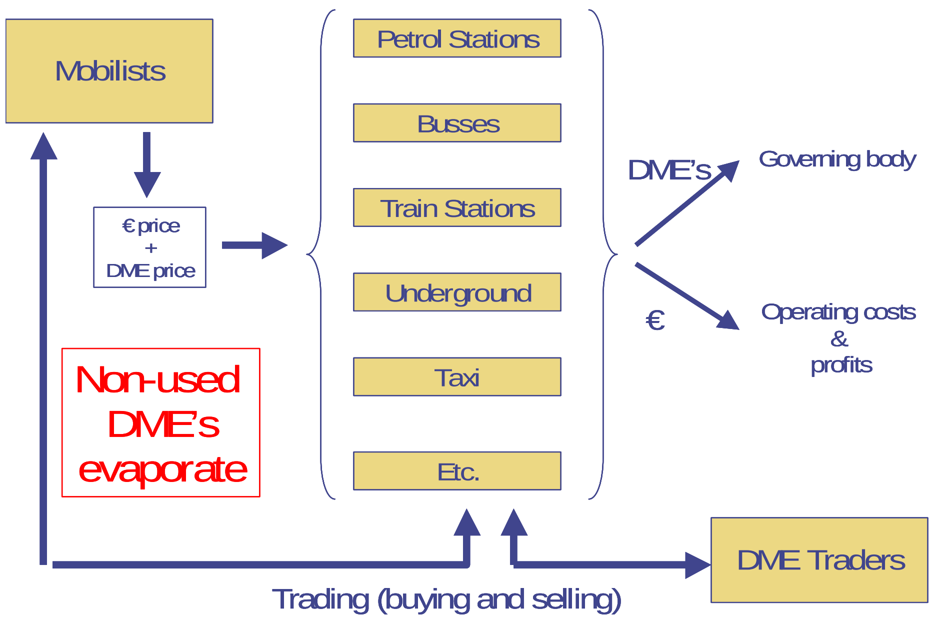
As a consequence, environmental impact is not a regular part of mobility decision making. It is delegated to government and employer regulation to take those aspects into account by means of fiscal policy and corporate lease arrangements.

Just like in our roundabout example, transferring the environmental dimension of mobility decisions to the level of the actors (travellers) is the key to establishing an emergent system. By requiring them to take the environmental impact of each of the four above-mentioned mobility decisions into account, these aspects become part of everyday-life. So we start by carving up the environmental space[1] available[2] over the traveller population. Each of them receives an equivalent part[3] of this space, expressed in "Sustainable Mobility Units" (or

[1] The definition could cover any aspect of environmental impact or combinations of such impact. For the purpose of this document we will use CO_2 emission as an example
[2] This could e.g. be the space available as per the Kyoto protocol, or the mobility related component of it.
[3] For a nationwide implementation this equivalent would be the total annual environmental space divided by, say, the number of adults in the country. For the pilot implementation the actual use of environmental space used by each individual could be used as a starting point.

Sustainable Miles: S'Mile".[4] To secure smooth working of the system, it is likely that this allocation will be made available in monthly slices with a 12 month expiration date attached to them.
Subsequently, all mobility will be dually priced: the economic price (as is currently the case) reflects the economic costs of the chosen mode, as well as a S'Mile price. This S'Mile price is equal to the environmental space used by the actual journey and the chosen mode.

This S'Mile price would be part of fuel prices, of public transportation tickets, taxi payments, etc. [5] This system is illustrated in the figure below.



S'Mile system concept

We are already very familiar with such dual pricing mechanisms, be they used for different purposes, in the form of "Air miles", "Shell stamps", and many other incentive schemes that are around. The difference is that the S'Mile system will be used for "paying the environmental price" rather than receiving benefits for client loyalty.

It is important to note that the existence of this S'Mile payment as a separate dimension is key to the working of the emergent system. If we were to embed the S'Mile price in the economic price, the awareness of the environment as a recognizable dimension in mobility-decisions would vanish. The recognition of this psychological effect in the aforementioned incentive schemes is (part of) the secret of their success. Furthermore, in business travel all the financial costs are born by the employer, so the personal meaning of the mobility decisions would be taken away[6]. Hence the S'Mile payment system creates a separate, individualized,

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[4] In Dutch the S'Miles are called DME's, and this is the term used in the illustrations

[5] Providers of these will be not be allowed to sell fuel or provide transportation without the S'MILE's being paid (this is an aspect of the governance required around the system). Under their licence to operate they will be obliged to return the S'MILE's collected to the governing body in accordance with the environmental space consumed to provide this transportation or fuel.

[6] This is markedly different from other "pricing" initiatives as road pricing.

space for decision making at the traveller level, detached from the financial consequences of the mobility decision.

In this way the environment becomes part of each and every mobility decision. Obviously, by making these choices, the individual traveller will experience shortage or abundance of S'Miles. Under conditions of overall shrinking space (steered by the governing body) there will be continuous shortage at the system level, but at the level of the individual travellers, conscientious travellers will end up with unused S'Miles while careless travellers might experience severe shortage. By making these imbalances in S'Miles tradable, clever users create advantages that can be exchanged for money. The price will be high when the overall shortage is severe, and low when the overall use of S'Miles declines with the availability at system level. The S'Mile trading price hence reflects the "system state" in terms of matching reality and goal, and will increase incentives when these are out of balance.

Yet, the choice remains an individual one, and each and every traveller can aim for his/her own balance in mobility choices between convenience and environment. By clever decision making in each and every mobility decision, considerable benefits can be achieved. In this sense, it is not a system of restriction and punishment, but a system of opportunity and reward.

As a consequence, the well understood self-interests of the travellers will pressurize the suppliers of mobility solutions to deliver better propositions in terms of utility versus S'Mile price: better lease-propositions, environmentally better cars and fuels, better public transport propositions, etc. These suppliers can be considered as a second process-layer, above the layer of travellers, and providing the "solution space" available to these travellers[7]. Responding becomes an existential need, not, as currently, forced by regulation, but by the mass of travellers looking for advantageous mobility solutions,. Every traveller, therefore, has the freedom to create new and innovative solutions to improve their competitive position.

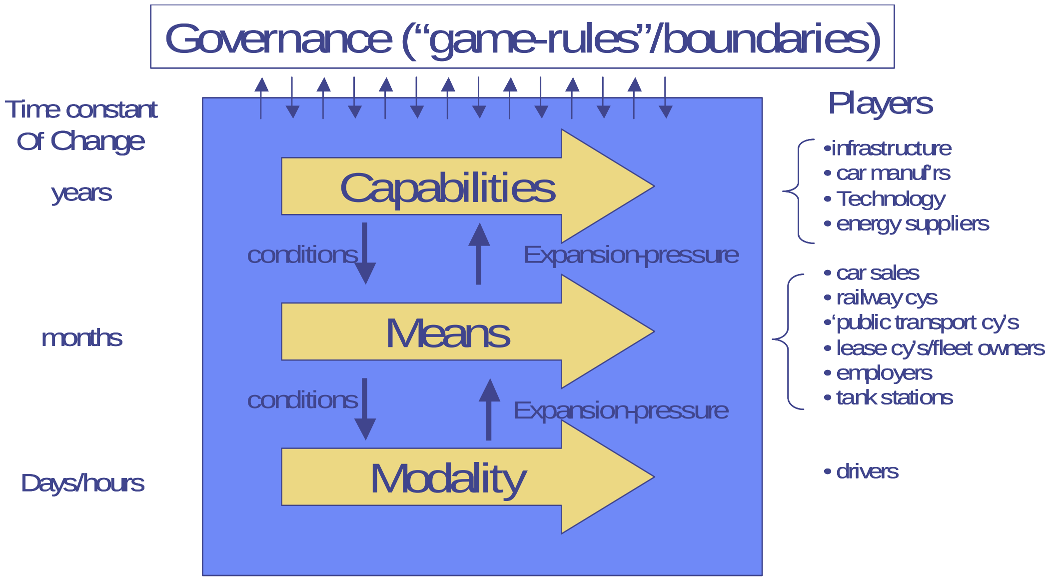
Indeed a third layer of system actors can be identified: the car manufactures, energy suppliers, transportation technology suppliers, infrastructure suppliers, etc. They provide the tools for the mobility solutions suppliers in the second process layer, and will in turn be pressured by their clients to come up with better propositions.

In this way the energy released at the traveller level will work itself upwards through the system to change the behaviour of all actors, and orient their energy towards better solutions and propositions in a "natural way". Complying becomes a matter of survival in the markets in which they operate. It reflects the fact that emergent systems are more about organising energy than about organizing specific solutions. These solutions "emerge" in the "solution space" of the system. This system of process layers is illustrated below.

Where does the government fit? In emergent systems the government is not a system-agent[8]. In the same way as an arbiter in a sports game is not a player, the governing body of an emergent system is not an actor. It doesn't prescribe the actor behaviour, but guards the "rules of the game" and sets some overall system parameters. It is. similar to the role of the national banks in the financial arena: it secures compliance of the players and sets the "base interest

[7] Unlike some popular beliefs, emergent systems require hierarchy. Yet it is not a "command and control" hierarchy but a hierarchy of process layers, stacked in a very precise way.
[8] in their governing role, governments may also be suppliers of e.g. infrastructure

rate" to steer the "health of the system" and to keep it within its operating bandwidth. If it were to compete with the players, the governing role would be terminal.



S'Mile system process layers

In vitro-testing: from idea to reality

Robert May, one of the pioneers in this area, wrote already in 1965:

> *"Even simple interactive dynamic systems do not necessarily have simple behavioural properties"*

The problem in understanding the system behaviour of emergent systems is that this behaviour is not simply the aggregate of isolated individual behaviour. The individual actors influence each other, both within a specific process layer, as well as between process layers. In our S'Mile system travellers will learn how to use the system to their advantage by looking at others; solution suppliers will adopt from and adapt to the initiatives of their competitors; travellers will be influenced by new propositions, etc. In system design terms: an emergent system is a complex dynamic interaction of positive and negative feed back loops, and its behaviour is highly non-linear. And the fact that it is non-linear makes it impossible to understand the whole by understanding the parts.

Simple design errors might cause the system not to work. The "right priority" rule most of Europe used for roundabouts up till the 1980's for example doesn't work. It was only when we changed this that roundabouts became the preferred solution in many situations. This is unlike the working example that existed in the UK. It took us a long time to draw this lesson and change the priority rule.

If we were not to know roundabouts, it is highly unlikely that the users would invent by themselves that a left-turn means driving 270 degrees around. And interweaving at motorways does work in Germany, but not in Holland, however much energy we put in promotion and communication. All of these are examples of failing emergence in an interactive system, without a clear relation between cause (at the actor level) and effect (at the system level).

Emerging order is hence not for free. The natural alternative to the order arising from "planning and control" is chaos and failure. Effective emergent systems require careful design of process hierarchy, interaction mechanisms and governance aspects.

One of the most powerful ways for designing emergent system is simulation. In such a simulation the real actors (in our case travellers and solution providers) interact with each other in a virtual space in which the S'Mile system is built. They are requested to take the decisions (at the traveller level the four decisions mentioned earlier, at the solution provider level the introduction of new propositions) at accelerated speeds ("plays a week/month in a minute"). This accelerated speed enables fast analysis of longer term system behaviour, but also forces the players into "rapid decision making" reflecting their "natural behaviour". By looking to "what they do", rather than "what they say they will do" it provides a much more reliable base for system design than other design methods.

By experimenting with the system design parameters and mechanisms, the system can be optimized prior to real life introduction, and solutions providers can make a first pass at new propositions that might differentiate them in their competitive position. It accelerates organisational learning and dramatically reduces the chance of failure of the system. Participating in the simulation also helps to understand the S'Mile system and how to use it cleverly to one's own advantage.

In summary a simulation for the S'Mile system will provide the tools for:

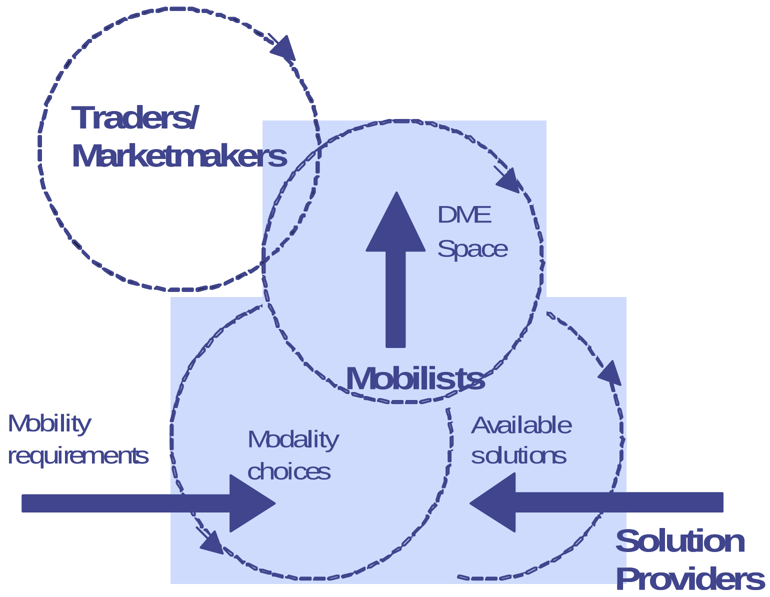
- Proof of concept for the S'Mile
- Testing and tuning design and mechanisms:
    - Accelerated "what-if" testing of system aspects
    - Complex dynamics and stability
    - Governance principles
- Communication to participants
- Behavioural research (travellers)
- Proposition testing (suppliers)

Simulator scope

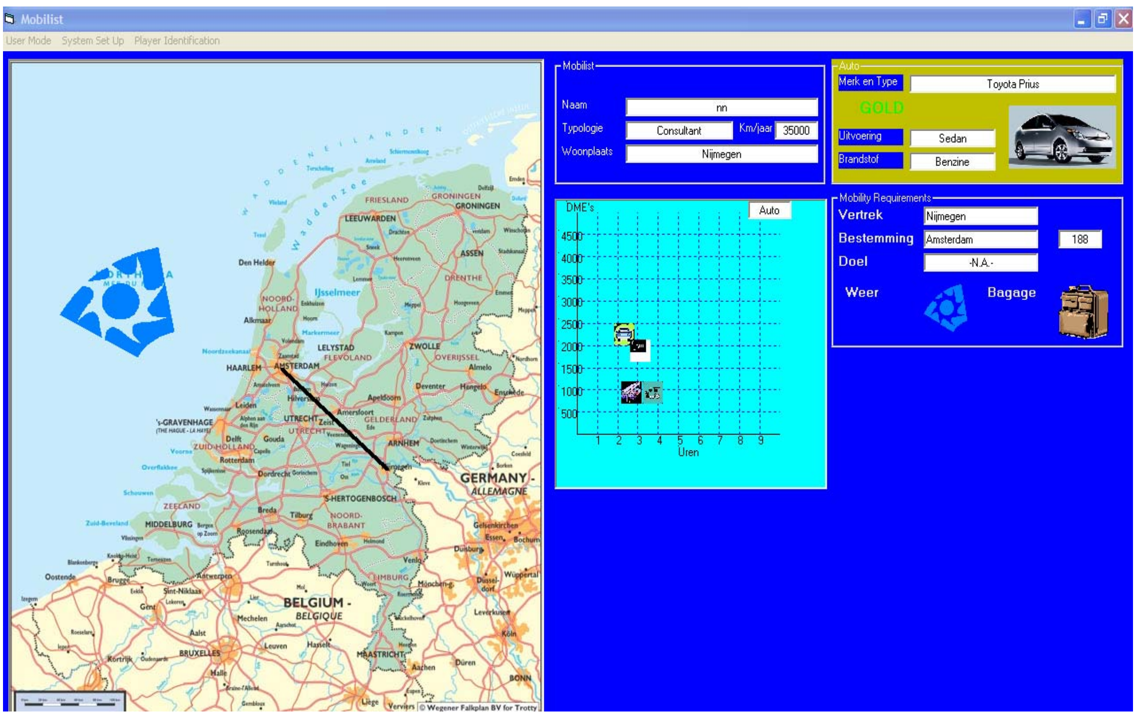
Based on above rationale a simulation tool was developed. With this tool the actors (travellers, solution providers and traders) essentially play a game in which 3 spaces interact:

- The modality choice space
- The solution space
- The S'Mile space

Repetitive mobility requests are put forward to travellers who then, according to personal need combined with S'Mile consequences, make a choice from the available solutions. One or more traders can participate as market makers(see figure below).



As indicated, each traveller receives continuous mobility requests, to which he needs to respond by making a choice from the available modes. These modes include the chosen car (and fuel type), and available public transportation (dependent on local availability). On request, relevant situational information will be given with respect to weather conditions, luggage and purpose of journey. This purpose will be linked to his/her professional activity.



traveller graphical interface (design concept)

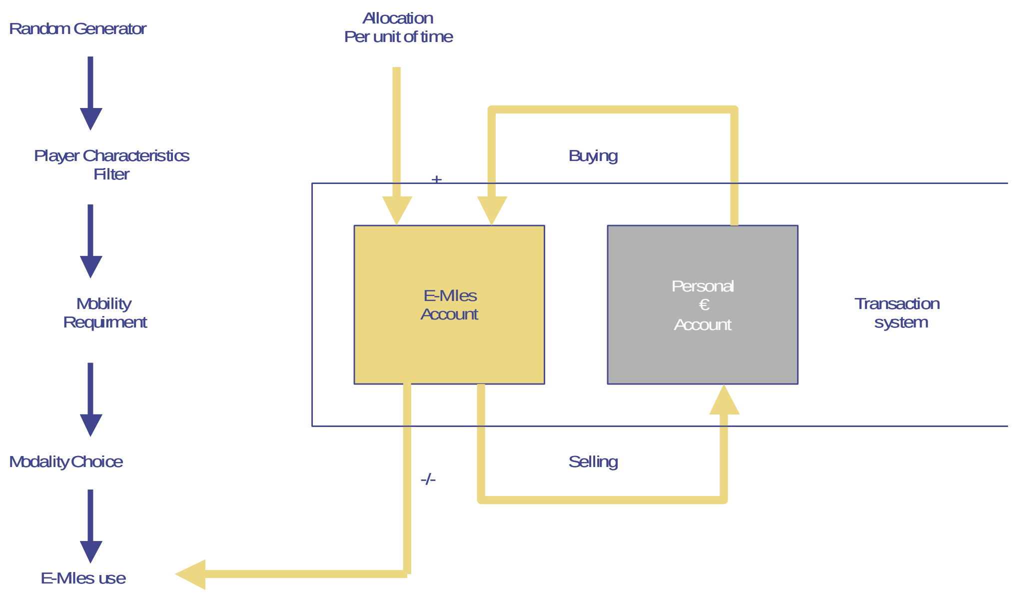
The interface is built to enable fast decision-making, by presenting all relevant information graphically and only requiring the click of a mouse button to choose from the available options. The system will the calculate S'Mile consumption and adjust the balance of his/her S'Mile account accordingly (see figure above).

The S'Mile account is fed regularly with the monthly allocation. The traveller can choose at any time to buy/sell S'Miles to other participants, and the result will be recorded in the € account.

Solution/means suppliers can introduce new propositions from which the travellers can make a choice. Such solutions could be new car types, new fuel sources, new public transport options, etc., each with their specific characteristic in S'Mile requirements.

At the end of the lease period (or other moments as specified by the lease proposition) the traveller can order a new car. The system will offer a wide range of cars, and give relevant user information for the choice. This information will include S'Mile performance in quantitative terms, but also in the form of the ECO-label which is currently under development as part of the Sustainable Mobility project.

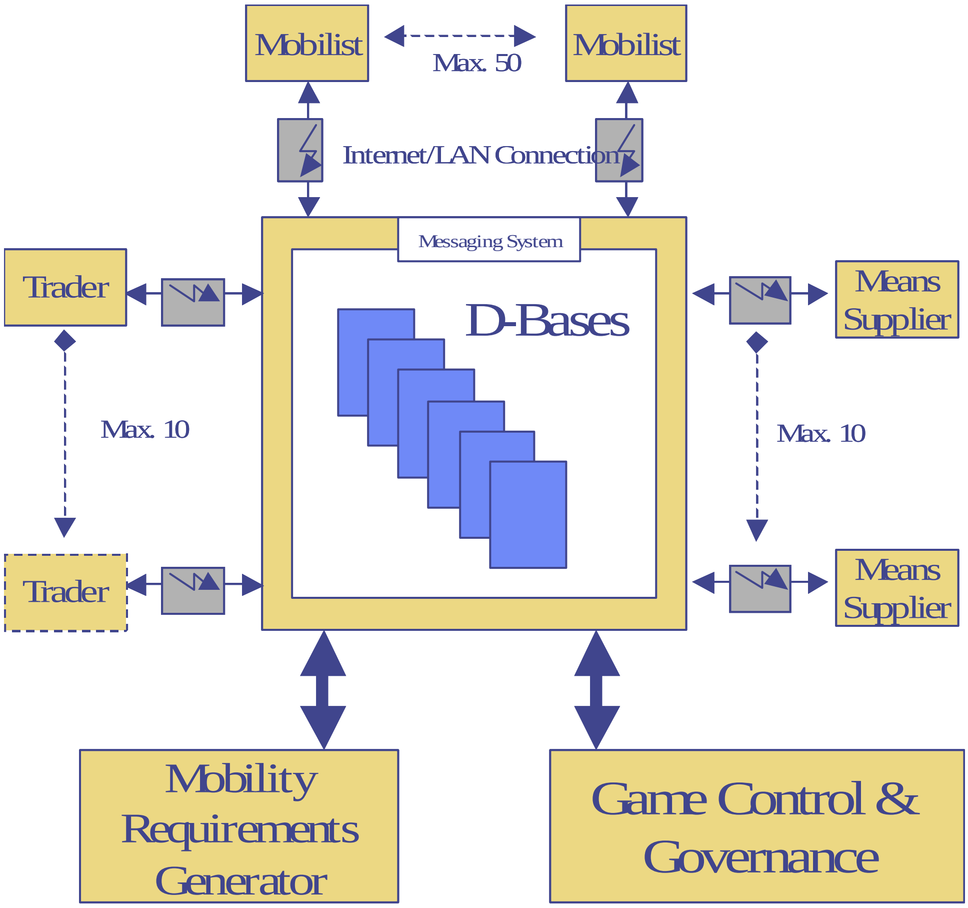
The simulator sequence is illustrated in the figure below.



simulator sequence

The tool is essentially an internet application running on a TVA server. It accommodates up to 20 concurrent players. Local PC requirements:

- Windows XP/Vista
- Explorer 8.0 or higher
- Broadband Internet connection.



Technical structure of the proposed simulator

The simulation tool can be used in two ways:

- It can be used as a stand-alone piece of software to track and log individual traveller decisions with respect to available modality choices. It will show the likely determinants of traveller choice under various circumstances, such as travel-time and uncertainty, S'Mile "price", weather conditions, type of travel, luggage type, etc. It will include car choice and eco-labels for these cars.

- It can be used as a S'Mile system-simulator, including group interaction, S'Mile trading, solutions-supplier propositions, etc and will enable internet/LAN linkage between the participants.