Transition through subsystem innovation? The case of traffic management

B. Pel*, F.A. Boons

Erasmus University of Rotterdam, Department of Public Administration, Postbox 1738, 3000 DR, Rotterdam, The Netherlands

Abstract

This article analyzes traffic management as an example of infrastructure operation and assesses to what extent the transition approach as developed by Rotmans, Geels, and others is helpful in providing insight and contributes to the transition of the mobility system. Based on a conceptual framework which draws on the work of Luhmann and Critical Systems Thinking (CST), two cases of traffic management innovation in the Netherlands are analyzed. From this it becomes clear that traffic management is more than the optimization of the current mobility system. Rather than being a technical exercise, traffic management has to deal with substantial uncertainty which results from political dynamics and interactions between traffic management and other parts of the larger mobility system. The cases show that, in dealing with these uncertainties, actors may start to explore broader system definitions. Thus, a transition of the car-dependent mobility system is shown to be strongly emergent, which questions overly linear projections formulated by transition researchers as well as practitioners.

Keywords: Transition, System boundaries, Critical systems thinking, Traffic management

1. Introduction

1.1. Persistent mobility problems and the need for transitions

Around the world, urban areas are suffering from mobility problems. And despite all efforts to combat congestion, pollution, and other societal side-effects, no definitive solution is in sight [1–3]. In the car-dependent mobility system, numerous solutions have been implemented, but somehow problems keep recurring. Improvements in fuel efficiency of cars have often been counteracted by growing volumes of motorized traffic and heavier cars. Also, solutions to congestion and pollution problems run the risk of increasing the negative social consequences of 'hypermobility' [1]. Thus, mobility problems are 'persistent' [4,5].

These problems are deeply rooted in the institutions of our society. They are indications of system failure [4,5], a whole institutional constellation failing to solve problems. 'System failure' is a diagnosis asking for observation of the operations and dynamics of the mobility system, rather than one of its components [6]. It suggests the specification of system components and the relations between those. Moreover, identifying a failure suggests that we should at least be looking for a way to amend this deficiency. Transition research and its prescriptive ally transition management have been used by several authors to develop ideas about ways to address this system failure.

This article focuses on the short-term operation of long-lasting infrastructure. Traffic management concerns the guidance of vehicles over an existing physical infrastructure, for instance by placing and programming traffic lights. The obdurancy of the physical infrastructure is a manifestation of the inertia of mobility patterns, whereas traffic management represents the possibility of changing these patterns. The aim of this paper is to analyze the scope for change that emerges from the interaction between these components of the car-dependent mobility system. Traffic management is not the simple technical optimization of traffic
flows over infrastructure. As will be shown, it entails dealing with substantial uncertainties that can eventually lead to establishing links to other components of the mobility system.

We begin with an illustration that highlights the complexity in the seemingly straightforward activity of traffic management, and the way in which politicians as well as engineers deal with such complexity and corresponding uncertainty (Section 2). This sets the stage for a critical reflection on the transition approach which enables us to analyze the way in which actors deal with such uncertainty. Insights from Luhmann and Critical Systems Theory (CST) provide the basis for placing the system definitions employed by actors at the heart of the analysis (Sections 3 and 4). In Sections 5 and 6 two cases of traffic management innovation are presented and analyzed from this perspective. In Section 7 we analyze both case studies. Section 8 contains our conclusions regarding transition research and the contribution of traffic management to a more sustainable car-dependent mobility system.

2. Traffic management: a complex endeavor

In the mobility system the land-use/transport cycle indicates the interdependency of spatial structure and transport patterns. Post-WW II urban planning has been shaped by the car and has provided for mass suburbanization. In its turn, this spatial structure has come to shape mobility choices: dispersed settlement patterns favor car mobility, whereas public transport and non-motorized transport thrive in densely built areas [7–9]. But mobility system lock-in is not only a spatial phenomenon. A car-dependent ‘automobility system’ has emerged in which spatial, social, economic, and infrastructural systems are intertwined [7–10]. As a result, transportation research has come to the point where holistic, integrated approaches are considered indispensable [11–15]. In this perspective, traffic management has to be connected to related mobility policy fields.

To what extent are these connections possible in practice? The example of traffic light engineers in Brisbane gives a first impression. Glyn Davis has described the uncertainties engineers and politicians are facing and how they handle them [16]. Traffic management is concerned with guiding vehicles over infrastructure. It seeks to make optimal use of the existing system [17]. Traffic lights, zebra crossings, traffic signs and ramp metering installations are the everyday manifestations of this activity dedicated to optimizing traffic flows and minimizing casualties.

Traffic management is simple in its aims, but it poses many challenges to professionals. The basic difficulty is that to keep traffic flowing in one direction, it has to be halted in the other. Tradeoffs are unavoidable. And the higher the traffic intensities, the more difficult it is to keep traffic flowing. Furthermore, all local solutions have their network effects. This makes it very hard to assess the collective results on higher scale levels. In addition, optimization can be done according to different criteria: average delay per vehicle, maximum individual delay, throughput of the system, and travel time are but a few examples. Also, this optimization takes place under constantly changing circumstances. Weather conditions matter, but there may also be incidents down the road: traffic-attracting events are organized, public transport may be on strike, spatial structure changes. Moreover, the definition of the system to be optimized is shaped in the context of transport policy, and of changing political preferences. In Brisbane, an alderman was responsive to community requests for controlled pedestrian crossings. This responsiveness may be laudable in certain respects, but tends to be ignorant of traffic engineering wisdom concerning network effects. To traffic engineers, installment of traffic lights depends on functional considerations such as the question whether a certain threshold traffic intensity is reached or not. To the politician, the traffic light constitutes a tangible record of achievement. In this particular case, the traffic engineers were confronted by a housing scheme that would generate serious traffic problems.

It is interesting to see the ‘coping behavior’ of the traffic engineers. “By inclination, or, more probably, experience, traffic engineers are stoic about such demands.” [18] The political imposition was turned into a challenge, making the best out of the situation. “Traffic engineers understand their concern is only one factor in the complex matrix of city planning. By focusing on individual problems rather than fighting about ‘the big picture’, they can fit into the bureaucracy while retaining control of their specialization. Accepting boundaries makes organizational sense.” [18]

This sketch of traffic engineering is telling in two respects: First, it shows the enormity of complexity behind the deceivingly simple function of traffic management. Second, the traffic engineers described deliberately limited themselves to problem-solving within given parameters. The uncertainties of traffic optimization are coped with by ‘satisficing’ behavior [19], in which delicate trade-offs are made based on experiential learning. So, rather than developing connections to other mobility policy fields, they draw a boundary around a system that they feel they can manage, and seek to shield themselves from turbulence in the environment of that system.

In other words: actors reduce complexity. For the traffic engineers it was a sheer impossibility to observe the whole ‘complex matrix’. They tended to take other developments, such as infrastructure provision and ‘politics’, as external contingencies, as given input for their problem-solving. Traffic management is difficult enough without an exhaustive analysis of all the changing circumstances that may disturb its planning. The alderman, as a politician, decides to have traffic lights installed in an act of distributive justice and political responsiveness. The traffic engineers install traffic lights with an eye on their effects in terms of quantitative traffic flow network effects. As an integral synoptic observation of both dimensions is bound to entail overwhelming complexity, actors can be expected to act self-referentially, relieving themselves from certain sources of complexity.

3. Transitions and the importance of system boundaries

Transition research, as a systemic approach to large scale socio-technical systems, offers a framework that supports the analysis of the interaction between components of the car-dependent mobility system, which is seen as co-evolution [20–22]. Societal systems are analyzed at three levels of structuration. Persistence is explained by ‘regimes’, a set of actors that operate according to
a set of relatively stable rules [23]. The regime exists within a landscape which provides pressures which are difficult to influence by regime actors. Change can occur as incumbent or outside actors develop alternative practices which occupy a niche within the system. The three levels of niches, regimes, and landscape are seen as interacting, resulting in dynamics that in certain cases produce system wide changes.

This framework is useful because it emphasizes the way in which long-term and short-term dynamics interact. Moreover, it allows an analysis of the specific causes of persistence in terms of a regime reinforcing system failure. However, several critical contributions stress that system definition issues are crucial to both transition research and management [24–30]. Labeling certain actors and practices as part of the regime constitutes a judgment that is not always made explicit in transition research. Such judgments constitute implicit statements about problem definitions, solutions and relevant actors [31]: whatever is part of the regime constitutes the problem, while those activities and actors labeled as niches are possible solutions. Given these implications, these critical contributions point out that transition researcher need to be explicit about such judgments, and be ready to reconsider assumptions made in the process of research. To be clear: such judgments are not only made by transition researchers. The example presented in Section 2 illustrates how actors in the mobility system also make such judgments when confronted with complexity.

4. Transition research as Critical Systems Thinking

According to Luhmann, actors necessarily deal with uncertainty by complexity reduction [32–36]. Selective observation is an unavoidable practical consequence of complexity, as Luhmann stresses with his ‘theory of self-referential systems’: In their actions, actors relate to their environment only in terms of the purposes of the system of which they are part [33].

Similarly, self-referential behavior can be expected from the many other actors somehow involved in the mobility system. What results is a vision of a fragmented society in which transitions are emergent, but almost impossible to plan [4,37–39]. The necessity of self-reference is the starting point of analysis: perceived needs for transition and diagnostics of ‘persistent problems’ lose their foundational status and are treated as dependent on system definitions [24,25]. This epistemological position also implies a reconsideration of the three level model of transitions; its overview cannot be accorded any privileged position over other observations. From an assumption, it becomes one of the possible conclusions.

The Luhmannian analysis assumes that the need for self-reference gives rise to the formation of autonomous subsystems [32,34]. This does entail the risk of reification, of making unwarranted assumptions about presumed ‘systems’ [40]. Actors in the field may entertain system definitions more diverse and dynamic than analysis on the level of interacting subsystems may suggest. The variety of system definitions needs to be studied to gain insights in the relation between transition management and other mobility system components.

In order to operationalize the theory of self-referential systems, critical systems thinking is a useful approach [41,42]. CST is a ‘critical’ form of systems thinking in the sense of Kantian critical rationalism. It emphasizes that ‘systemness’ is not an inherent property of objects, but is instead defined by an observer [43]. Behind any apparently self-evident identification of systems there is judgment, and to be critical means to account for these constitutive ‘boundary judgments’. In order to make systems research transparent to itself and to others, the system definitions of system-observing actors must be disclosed. CST inquiry takes place through boundary questioning: What is/ought to be the system to be optimized? Who are the actors to be included in this process?

CST questioning allows for in-depth transition research. In relentlessly asking for specification of implicit system definitions, it highlights and charts the fragmented conditions under which system innovations take place. It reveals how system evolution emerges from interactions between actors with diverse system definitions, a diversity working against concerted management of ‘system failures.’ In the following, we will describe two examples of traffic management innovation, taken from a multiple-case study after traffic management innovation attempts in the Netherlands. The boundary judgments of involved actors – both innovators and stakeholders – are reconstructed based on document analysis, semi-structured interviews and field observations as empirical material. These CST inquiries will be reflected upon in Section 7.

5. Traffic management innovation (1): networked road management

Traffic management optimization necessarily applies to a certain road segment. The solution of a local bottleneck tends to have its ramifications downstream. In the Netherlands these network effects are particularly difficult to manage as different segments of its road network are managed by national, provincial, and municipal governments, and water boards. First, the very segmentation into jurisdictions assists road authorities to cope with the already high complexity of their local traffic flow dynamics (see Section 2). Self-referential coping with complexity serves local optimization strategies, typically disregarding network effects. Secondly, self-reference is hard-wired in standards and protocols of technologies, such as sensor systems and data definitions; an open standard technological architecture would match the trend to a more open institutional architecture [44]. Thirdly, financial incentives conducive to supra-local coordination are limited: The economic gains from such coordination are difficult to establish and attribute [45].

Network effects are difficult to manage, running counter to various self-referential tendencies. But from the mid-1990s onwards there have been many initiatives to address network effects, and broaden the territorial scope of traffic management in the Netherlands. Two factors facilitated a softening of the aforementioned self-referential tendencies. First, the ICT revolution changed the technological landscape for traffic management by greatly enhancing the storage, processing and dissemination of actual traffic data [46–48]. Interoperability between traffic control systems became less problematic as the ‘technological niche’
market [49] for traffic management equipment matured. Interoperable protocols were developed, and suppliers gradually had to compete in terms of service levels. Interoperability became the norm on a formerly opaque, supplier-controlled market. Secondly, congestion levels continued to rise in the 1990s. Extra road capacity was difficult to provide for in the short term, however, and pricing continued to be too controversial a policy option. With these two options blocked, the National Mobility Policy [50] identified traffic management efficiency as key priority.

As the ICT revolution drastically enlarged the range of the technically possible, and capacity expansion nor road pricing could alleviate the mounting congestion problems, traffic management actors came to reconsider their jurisdiction-bound system definitions. In itself, the concept of network optimization was already an integral part of traffic management optimization, implemented for instance in the form of synchronized networks of traffic lights. ‘Area-oriented’ traffic management took this ‘networked’ approach a significant step further, however. Network optimization was pursued by bringing traffic management actors from different jurisdictions together to solve boundary-transgressing problems. The experiences with ‘area-oriented’ traffic management projects were gathered and elaborated into guidelines by Rijkswaterstaat [51], the executive agency of the ministry of transport. This boundary-spanning approach was actively propagated by reframing the central task for traffic management: traffic management was to assume the end-users’ system definition, focusing on network performance rather than formal responsibilities. This problem redefinition was expressed by the now widely used term of ‘network management’ [52]. This term expresses both the shift towards interjurisdictional management of network effects and to management influencing interactions between governing actors [53,54]. In other words, traffic management optimization is acknowledged as a governance challenge, instead of being a merely technical challenge.

So far, network management has been practiced mainly on a local, metropolitan or regional level. Coordination between governmental agencies from different jurisdictions tended to take the form of semi-permanent cooperation arrangements. These area-oriented approaches have yielded their successes, but congestion problems continue to exacerbate. And as the Dutch transport ministry continues to consider traffic management as virtually the only viable short-term instrument, it identifies network management as an innovation deserving wider application. A recent report of the ministry’s advisory council bears the title ‘From road management to network management’ [55]. It seeks to consolidate the network management initiatives into national policy. The multitude of cooperation initiatives is to be made into an integrated organization which has to ensure the establishment of more binding agreements than the current patchwork of ‘ad hoc’ arrangements [56]. A centralized ‘National Road Authority’ (NWA) is to be established that coordinates between Regional Road Authorities. This centralized authority is also to solve the currently fuzzy incentive structure [57] in which costs and benefits are insufficiently related. In the end, this authority is not only to coordinate the supply of infrastructure services; it will also administer road charging. The envisaged gradual consolidation of network management is considered by the council to be a transition [58].

The national road authority proposal amounts to a planned transition along a linear development path: the network arrangements are ‘rolled out’ nationally, with a meta-steering body above these networks. This super-network is to bring about changes not only in scale, but also in scope. Network-wide traffic management is proposed to become integrated with road pricing administration and infrastructure provision. The projected trajectory thus envisages strong ties between mobility system components that have up till now operated autonomously.

Agreeing with its advisory council’s problem definition of urgent congestion problems requiring measures at a network level, the ministry’s official policy document also endorses a more coordinated ‘networked’ approach. But notably, it seems not to embrace the national road authority’s proposal. It is stressed that regional network management arrangements need to conform to national traffic policy guidelines [59], but its ideas about the actors and institutional arrangements needed for network optimization express doubt about the idea of transition-by-centralization. The Ministry sketches an evolutionary path of overlapping waves of development (Fig. 1).

![Fig. 1. Waves of development in traffic management](image-url)
The first wave indicates the stage of isolated traffic management measures, taken primarily for traffic safety reasons. Their importance is considered to be almost on the decline already. Interestingly, the ‘networked approach’ is indicated as promising only on the middle term future. Its maximum relative importance it is expected to reach within 10 years. Interestingly, this evolutionary model stresses that networked traffic management is not only a matter of transcending the boundaries between governmental actors, but involves private sector actors as well. As indicated in the graph, the ministry observes itself to be in the middle of a transition-like development towards ‘cooperative systems’. Cooperative systems are to combine two distinct developments enabled by the 1990s ICT revolution. On the one hand, there was the earlier described boost to traffic information processing that enabled ‘networked’ traffic management. But on the other hand, there was the rise of in-car intelligence in the form of navigation systems that opened new markets for commercial traffic information provision. The in-car technologies developed into traffic information channels parallel to the governmental ‘roadside systems’. In 2003 a governmental commission was established to prepare for traffic information provision arrangements that would combine these two channels. Consumer-oriented traffic information provision does not necessarily serve the collective optima pursued by governmental traffic management, it was acknowledged. But on the other hand, the ministry of transport had already started to reinvent itself as a user-oriented organization. The relation between individual and collective optima was not considered problematic, until the congestion-avoiding strategies of drivers started to cause upheaval. Their shortcut routes posed disturbances of rural, residential or otherwise sensitive areas.

However complicating, the Ministry considers the growing impact of in-car navigation systems inevitable. It expects that by 2020–2025, the commercial in-car systems and the governmental roadside systems might cooperate. The ministry acknowledges that the co-evolution of traffic management regime innovation and commercial niche developments involves deep uncertainty. Beyond that stage, further system changes are considered to become even more unpredictable. As a fourth wave, ‘future transport modes’ are envisaged, i.e. automated vehicles and other intelligent applications that may blur the distinctions between individual and public transport. By that time, the optimization of traffic flow is done radically different from the times of isolated, low-tech, local and static measures. The overlapping waves of development of the ministerial evolutionary model each comprise a multitude of changes. These changes can be considered either radical or incremental, and may or may not be considered to result in a transition. But as for now, the trajectories sketched beyond current ‘network management’ arrangements are only projections into the future. The actual path that will be taken is highly uncertain, as the Ministry has come to acknowledge itself.

The uncertainties of this evolutionary path can be highlighted by taking a closer look at the system boundaries employed by the actors involved. Future developments are not only uncertain, but whatever emerges will also be observed differently by societal actors. By drawing also on observations from outside observers we are able to formulate the following system boundary issues.

### 5.1. Self-organisation and steering

The ‘cooperative systems’ arrangement is a projected evolutionary stage that would combine roadside traffic management systems and in-car traffic information systems. Both were enabled by the ICT revolution but developed independently. Together they could become the technological platform for the national road authority ‘super-system’, the constellation fully equipped for network-wide traffic management. But the in-car systems have been developed as commercial services; the system purpose of the service providers is to serve individual preferences. They allow customers to circumvent traffic jams, and warn them for speed controls, for instance. Both examples signal friction with the governmental definition of system purpose, focusing on collective optima and traffic control. The road authority proposals display a typical self-referential projection, anticipating future integration. Also, on the side of the in-car systems providers there is a similarly linear expectation that the governmental road-side systems will be outcompeted. This would create a strongly self-organizing traffic order. Thus the Ministry, the NWA, and commercial parties base their activities on radically different judgements not only about the purpose of traffic information, but also about the future prospects. Apart from competitive interaction there are also deliberations between private and public actors about the interferences between the two systems, however. This may lead to eventual integration into ‘cooperative systems’, but the essentially different system definitions of public and private actors give little room for idealism as expressed by. The diverging definitions only add to the uncertainty surrounding ICT applications in travel demand. In both cases, ICT applications could both support and undermine a transition towards sustainable mobility. The transition to ‘cooperative systems’ will emerge from the co-evolution between technological niche development on the one hand, and the planned transition to networked traffic management on the other. Future integration into fully ‘cooperative systems’ is only one possibility amongst many other possible mixes of self-organization and steering arrangements.

### 5.2. Technological future

Whatever mix between self-organization and steering emerges, the cooperative systems’ contribution to a mobility transition is ambiguous on another aspect as well: the social effects of the advances in traffic information are hardly articulated by both private and public actors, except for the protection of residential areas.

Already in 1995, Hajer identified the technological development of traffic information systems as an example of ‘subpolitics’. While the competitive and deliberative interactions between in-car and roadside systems are played out between government actors and entrepreneurs, these processes tend to escape from direct democratic control of citizens. A crucial system definition issue is whether the system to be optimized is taken to be a technological, or a societal system: Are the ‘cooperative
systems’ system innovations contributing to a transition to sustainable mobility, or are they merely technological innovations ‘colonizing’ the lifeworld of citizens through their subtle shaping of the ‘mobile sphere’, locking them up in their high-tech cars [3,7,12]? Interestingly, such concerns are voiced by academics but they are not addressed by actors involved in these developments.

5.3. Throughput complexity [73]

In the transition projected by the Ministry of Transport’s advisory council, cooperative systems would provide the technological infrastructure integrating traffic management with road pricing and intermodal traffic information. This advice seems to underestimate the involvement of other actors. The road to such an integrative platform will be slippery. Apart from technical complexity, there are legal restrictions on the acquisition, storage and dissemination of information on the whereabouts of citizens [74]. In contrast, the Ministry of Transport in its policy document acknowledges the uncertainties of implementation to a greater extent. The relevance of the issue of technological uncertainties is also indicated by academics [75].

5.4. Traffic flow optimization: transition pathway or pseudo-solution?

Finally, the question remains in what sense the projected advances in traffic information processing offer a pathway to a more sustainable mobility system. The advisory board of the Ministry of Transport explicitly labels the development of NWA as a transition. But as both traffic information entrepreneurs and the ministerial projections display a preoccupation with congestion problems, with travel time as a typical yardstick [55,59], this label is questionable. Several academics from the transport field argue that the relevant problem definition is not congestion but car-dependency [1,13,20], and thus this ‘transition pathway’ is a self-defeating ‘pseudo-solution’ [76]. Travel time gained arguably induces travel [77–80], and this is how today’s solutions risk becoming part of tomorrow’s problems. Topp has argued that most traffic management solutions will remain illusory unless they are backed by pricing measures that regulate the demand for traffic [81]. The cooperative systems arrangement is meant to offer such backing, to be sure. But the question remains which problem it is to solve, i.e. what weights are attached to the many ‘people, planet and profit’ aspects of sustainable mobility. Also among academics, advances in traffic information processing are seen as a potential transition pathway [67,68].

6. Traffic management innovation (II): the environment-responsive 80-kilometer zones

In May 2002 a segment of the A13 motorway between Rotterdam and The Hague was turned into an ‘80 km-zone’. The speed limit was lowered to 80 km/h with permanent camera surveillance as an ultimate measure to tackle air pollution and noise problems. In Overschie, a borough of Rotterdam, the distance between the A13 and residential areas is minimal. Local residents had been asking vehemently for measures based on concerns about the health effects of A13 traffic. The fate of the Overschie citizens had received extensive national media coverage.

The measure was set up as an experiment by Rijkswaterstaat, the executive agency of the ministry of transport affairs. The experiment was monitored intensively. The first results showed assuring reductions in noise, NO\(_x\), and PM\(_{10}\) emissions, without significant impairment of traffic flow and safety. The findings also brought forward the caveat that situational factors might have been decisive; more research would be conducted to assess the measure’s merits [82]. Meanwhile, the measure was embraced by environmentalists, scientists and local governments as a short-term solution to air pollution problems [83]. Traffic volumes were rising, environmental regulations were tightening, and source-oriented measures would not be available soon enough [84,85].

On the other hand, the strict enforcement of the 80 km didn’t fit the national mobility policy turn towards accommodation, rather than restriction, of motorized road traffic. And even when local governments were enthusiastic about the measure, the A13 was part of the main motorway network, under discretion of the ministry of transport.

When final evaluations came, an evaluative framework was established as a touchstone for further applications of the measure [86]. By the end of 2005, 4 other sites in Utrecht, Amsterdam, The Hague and in Rotterdam were selected for application, out of a long-list of air quality hotspots. Applications on entire ring-roads had been pleaded for, but this would have adverse network effects, Rijkswaterstaat traffic researchers had warned. The earlier caveat emphasizing situational factors was confirmed by the research results: Only the A10 (Amsterdam) could match the earlier Overschie success, whereas the A12 (The Hague) and A20 (Rotterdam) road segments displayed limited to no emission reductions [87]. Moreover, the latter sites displayed significant rises in congestion. These were explained by the specific location of exits and entries; together with the strict enforcement, which restricted the ‘natural’ flow of traffic. Meanwhile, congestion levels in the Netherlands were rising disproportionally compared to ongoing volume growth. The congestion figures of spring 2006 showed dramatic figures especially for the A12 (The Hague). These became subject to heavy debates in parliament, with a government majority leaning toward congestion, more than pollution, abatement.

The 80 km–zones couldn’t be withdrawn overnight, but the minister of transport made preparations to keep this option open. Furthermore, extra efforts were made to prepare the ground for dynamic speed limit arrangements: Through the ICT-revolution dynamic traffic management (DTM) arrangements had become available, responsive to actual conditions. This would allow for a more flexible version of the ‘Overschie measure’. In the beginning of 2009, the minister of transport opened the first ‘Dynamax’ (dynamic maximum speeds) test site. A national news bulletin commented as follows: “Driving faster when possible, driving slower when necessary, the slogan of the ministry of transport goes, but, when is it necessary? And when is it possible? If the weather is bad, you
have to slow down... and, also, when the air is filthy, you have to drive more slowly..... is it crowded on the road, one has to drive slower. And, sometimes, under ideal circumstances, one is allowed to go a bit faster.” After which the minister added, “Everybody knows this situation, you have to drive a long way home late in the evening, on a deserted highway, often a very broad highway, one faces this speed limit, and wonders, why do I still have, now, late in the evening, to drive only 80, or 100...” [88].

At the time of its introduction, air quality and noise were given as grounds for the 80 km-measure. Only seven years later, a more flexible dynamic arrangement is experimented with. As the minister of transport explains, speed reduction can be required by the circumstances of air quality, weather conditions, and congestion. But in the off-peak hours, with traffic able to flow smoothly, he did not consider such a restriction necessary. In other words, the environmental effects have become part of a broader trade-off also featuring congestion.

The minister’s comment is interesting for two reasons: First, the apparent broadening of speed limitation policy. Secondly, the reasons for speed limitation are observed from the driver’s perspective, whereas the earlier emphasis on environmental effects reflected the concerns of residents. Both indicate a change of perspective has occurred since the 2002 Overschie measure was taken. In the following a few system boundary issues will be exposed. These will highlight the uncertainty and ambiguity surrounding the assessments of the 80 km-zones, and the turbulent context in which the innovation attempt developed.

6.1. ‘Broadening’ traffic management

Traffic management is aimed primarily at securing traffic flow and safety. Environmental concerns do not belong to its ‘core business’. Geels indicates how in the 70s and 80s, environmental protests against road expansion did not bring about a transformation in the Dutch ‘highway regime’ [49]. The turn to more environment-responsive was neutralized by regime-insiders, for whom the new goals posed few inspiring elements and technical challenges. The participative decision-making arrangements of the 1990s he describes as ‘...a management tool, not as a fundamentally different style of system building.’ [89] In this light the 2002 80 km-zone displays remarkable responsiveness to environmental concerns; a broadening of traffic management system optimization. But did such fundamental change of system purpose take place? First, citizen protests had been exceptionally successful, being backed by considerable media attention and growing evidence on traffic-induced health effects [90,91]. Their health-centered system definition may have been difficult to ignore, but secondly, the difficulty for the Dutch government to meet NOx and PM10 emission ceilings has also been an important background to the 80 km-measure. Crucial for the decision to start the Overschie experiment seems to have been the temporary lack of adequate source-oriented measures. Non-traffic management measures such as filters and road bypasses were considered as alternative solutions to the Overschie bottleneck functional equivalents. Thirdly, the ‘Dynamax’ arrangement mainly displays continued traffic flow optimization within environmental norms, rather than minimization of health hazards. Whether traffic management optimization has really broadened, taking air quality and noise standards as intrinsic goals, is yet to be resolved [92]. The 80 km-zones were not the starting points of a ‘greening of traffic management’; its evolution clearly diverged from this linear expectation.

6.2. Network effects

The Overschie experiment received enthusiastic reactions from actors with a health oriented system boundary, such as citizens, local governments, environmental organizations and health care organizations. These actors valued the positive environmental effects, which even led to proposals to apply it on entire urban ring-roads. But Rijkswaterstaat researchers pointed out that this line of reasoning was too simple [86], indicating that local speed reduction will prompt traffic to flow towards other routes with less impediments. These routes will generally be the urban roads, with even more people exposed to pollution. They insisted that these network effects should be included in the system boundary in order to avoid counterproductive application of the measure.

6.3. Design speed

The 80 km-zone measure involved not only a change in speed reduction, but also a change in enforcement. Permanent camera surveillance was introduced to ensure compliance [93]. Compliance is problematic, traffic experts explained, as the A13 is designed for a higher speed: The motorway layout invites speeds well above the imposed 80 limit. Reasoning from the functions of the infrastructure, the 80 km-zone is a disturbing innovation [32,85], interfering with the expectations of drivers. In terms of traffic psychology, they raise the ‘task complexity’ for the drivers. Task complexity was an important explanation for the relatively disappointing results of the 4 follow-up 80 km-zones [94]. This relation between drivers and infrastructure layout is less problematic in the dynamic speed limit arrangement [95].

6.4. Science and politics

The 80 km-zones are restrictive measures; they are dissonant in an essentially accommodative mobility policy. This political dimension became prominent quite suddenly in 2006, when the rapidly rising congestion levels gained political attention. Heated parliamentary debates followed, revolving around the congestion-inducing effects of the zones. This debate urged the minister to release preliminary research findings immediately. This was earlier than would be scientifically feasible, Rijkswaterstaat researchers indicated, surprised by the sudden political dynamic. Their careful multi-criteria evaluations were essentially
overhauled by political developments that tended to narrow down the issue to an environment-versus-congestion abatement discussion. This is how political debate can filter the uncertainties indicated by scientific system analysis.

7. Analysis

Analyzing the two cases in terms of the system boundaries of actors displays a bewildering variety. Each actor reduces complexity in his own particular way. This leads to system definitions that sometimes overlap, such as a shared preoccupation with congestion abatement. In many other respects, these definitions diverge, as with the speed limit arrangement, where various actors emphasize different purposes. Developments in traffic management are the result of actions that flow from these partially overlapping and evolving system definitions.

This has two consequences. First, the necessary reduction of complexity at the level of individual actors leads to the reproduction of complexity at higher levels. As actors entertain partially incompatible system definitions, they generate dynamics that are difficult to understand, let alone predict. In the case of networked road management, the ICT revolution facilitated dynamic traffic management (DTM) and opened up the market for in-car systems. After initial enthusiasm, government actors were unpleasantly surprised by the interferences between the two innovations. Later on however, the projected ‘cooperative systems’ arrangement was seen to hold the promise to reconcile the interfering systems after all. But such reconciliation proves to be more difficult than initially expected. All in all, the governmental assessments of the effects of the ICT revolution on traffic management optimization kept being overhauled by new events and changing system definitions. Similarly, the enthusiasm about the 80 km-zone experiment waned soon after it was implemented on other sites with slightly different local conditions. Not only the disappointing environmental gains changed the assessments; rising congestion levels and a changing political balance brought actors to judge the measure primarily from a system definition emphasizing traffic flow as system purpose. Seven years after the first 80 km experiment, the dynamic speed arrangements followed. Both cases thus show the non-linear development of innovations, and the concomitant difficulty for societal actors to oversee development paths.

A second consequence of variety in system definitions is that confrontations between different system definitions spur actors to explore system definitions that are more inclusive in terms of issues and actors. ‘Networked’ traffic management emerged out of the acknowledgement that the various local optimization strategies would not add up to solve boundary-transgressing congestion problems. These collaborative initiatives reflected increasing responsiveness to the system definition of end-users; self-referential optimization was broadened beyond discretionary borders. Similarly, the planned transition towards ‘cooperative systems’ seeks to synchronize between the different system definitions underlying roadside and in-car systems, and combine the system purposes as viewed by both government, entrepreneurs, and citizens.

The 80 km-zone experiment resulted when traffic management optimization was confronted with system definitions focused on environmental and health standards. The latter were articulated by citizens, media and scientists, who urged for immediate action. They successfully challenged the solution strategy of road bypasses and particle filters, that would meet the environmental problems later than desired by these actors. Later on, the mounting congestion levels had politicians reassert the importance of traffic flow, and warn for the adverse effects of the 80 km-zones. Through the dynamic speed limit arrangements, the minister of transport reconciled the many performance criteria advocated by different parties.

8. Conclusion

8.1. Traffic management and the scope for transition

In this section we present the implications of our analysis for transition research in general, and more specifically on infrastructure operation. The growing transitions literature provides useful heuristics, conceptualizations and governance guidelines such as the multi-level framework. But in its very instructiveness, this theoretical armor bears the false promise of restoring comprehensiveness from the position of an outside observer. The innovations described above can be attributed to these three levels in different ways. When car dependency is identified as the persistent problem to be solved, each of these innovations can be considered to be part of the ‘regime’, contributing to a further lock-in. In the case studies, several actors perceived the ICT revolution as a promising landscape development enabling many technological niches to emerge, such as the in-car navigation devices and the many dynamic traffic management applications. For them, these developments hold the promise of a pathway to sustainable mobility by means of ‘cooperative systems’. In this issue discuss the ‘pathway’ concept, and apply it in their analyses of energy transition processes in the Netherlands and the UK, respectively. But skeptics from academia claim this ‘transition pathway’ risks to reinforce a car-dependent regime, in which the aforementioned technological niche developers have become regime-players. These competing identifications of the ‘regime’ to be changed are based on different notions of sustainable mobility; each of them reflects a different system definition.

Similarly, the 80 km-zones may be considered a successful challenge of the ‘mobility regime’ by its advocates, but adversaries see them as manifestations of an environmentalist regime that seeks to restrict drivers. To the latter, the citizen groups and environmental organizations campaigning for the zones were ‘regime players’, contrary to their self-image of incumbent niche actors, challenging an ‘unsustainable’ mobility regime. To both the development of environmentally efficient cars is a landscape development crucial for sustainable solutions. (See in this issue for detailed analysis of this development).

This does not imply that the three-level framework is without merits. From a CST perspective, attributing some initiative or development to one of these levels has the status of a judgment, for researchers as well as practitioners. One of the implications of...
CST is that researchers necessarily make such judgments by working from a specific system definition. In order to prevent self-referential research, a procedure of explicit continuous evaluation is called for. The conceptual tools of transition research can thus best be seen as heuristic devices. In this article, we have done this by defining the system in terms of traffic management as infrastructure operation and critically assessing the idea of car dependency as the persistent problem.

Identifying niche and regime developments in traffic management is possible, but they depend on one system definition. Consequently, it is dangerous to treat these developments as paths towards an eventual mobility transition [46,47,67,68]. However strategically instructive it may be, backcasting shares with forecasting techniques the risk of assuming a functionalistic view that underestimates the emergent properties of transitions. As the system definitions of the actors change, or new actors enter the scene, new dynamics ensue which lead to unexpected futures: innovations may spring from parts of the system that were not previously identified as niches. Assessments of the role of traffic management in mobility transition are always partial and open to debate. They are value-laden as they depend on the system definitions underlying the observations of both stakeholders and researchers.

Road networks are the long-lasting components of the mobility system. These physical expressions of car-dependency will not disappear overnight. The two cases of traffic management innovation show that this does not necessarily lead to inertia in terms of a transition towards sustainability. On the contrary, actors find ample scope to develop innovations in the short term operation of this infrastructure. First, efficient operation allows for accommodation of increasing traffic volumes, without giving in to the systemic pressure for more road provision. The ‘induced travel’ feedback mechanism does warn against high expectations, however. Secondly, the 80 km-zones and the subsequent ‘dynamax’ arrangements show how infrastructure operation can also serve goals beyond its core-business of traffic control, such as emissions and noise reduction. Thirdly, the projected transition to fully networked traffic management shows how infrastructure operation is conducive to a networked approach, attentive to systemic interdependencies. This may hold the key towards a more holistic systemic approach of persistent mobility problems, even when ‘throughput complexity’ and the quasi-autonomous development of in-car technology work against a planned transition.

The role of traffic management in a mobility transition not only depends on its traffic-controlling function. The scope for change is greater than initially transpired through the somewhat docile, reactive attitude assumed by the Brisbane traffic engineers in Section 2. Transition management could use this scope exactly by reversing their self-referential complexity reduction, and relate traffic management to the ‘complex matrix’ of which it forms a part. Recalling the overwhelming complexity of this bigger picture, it should acknowledge, rather than resist, self-reference. Without overly ambitious integration attempts, it should seek to establish connections between traffic management and other mobility policy fields [24,25]. Self-referential specialization can thus be made use of, instead of overburdening it with the additional complexities of ‘external demands’ [18].

As mentioned, the gains of traffic management are surrounded by the complexity arising from feedback loops and network effects. Transition management should think through the merits of these short-term gains from a long-term perspective, aware of the risk of ‘pseudo-solutions’ [76] in this particular area. It should observe traffic management innovation from its typical socio-technical angle. Such perspective, looking beyond immediate substantive results, might also be able to register the cultural and political effects of traffic management experimentation: The 80 km-zones may have yielded environmental gains, but these restrictive measures received little applause from congestion-plagued drivers. Such resentment could erode public support for other sustainability initiatives — another way to arrive at counterproductive measures. This only reasserts that transition management of infrastructure operation should have the strategic awareness that infrastructures have their ‘design speeds’.

Acknowledgment

This work was supported in part by the Knowledge Network for System Innovations and Transitions (http://www.ksinetwork.nl/).

References

Bonno Pel is a Ph.D candidate at the Governance Of Complex Systems research group at the Erasmus University of Rotterdam. He has a background in transportation planning and social philosophy. His research deals with innovation attempts in the traffic management field, as part of the Dutch Knowledge Network on System Innovations and Transitions research program.

Frank Boons is senior researcher at the department of Public Administration of Erasmus University Rotterdam, The Netherlands. An important part of his research revolves around the way in which actors in production and consumption systems are able to move towards sustainability. He coordinates a research group on the governance of material and energy flows and recently published Creating Ecological Value, which develops a strategy-based evolutionary approach to ecological innovation.