

The use and value of hierarchical modeling in infrastructure network planning

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Abstract

This paper discusses the seemingly inescapable tension between two dominant approaches to governance that are implemented with regard to the planning, design and development of infrastructure networks, such as roads and railways. Roughly, these approaches can be framed in two styles of governance, the hierarchical and the consensual style (Smits, 1995).

In today's (western) societies, hierarchical approaches to governance seem to become more and more obsolete. This is especially the case with regard to 'problematic situations' that have a large spatial and environmental impact. For example, the planning, design and development of infrastructure networks have such a widespread, trans-sectoral impact, that a top down approach is considered to be no longer viable. The impact of large scale projects (such as the Betuwelijn, the development of the Tweede Maasvlakte or the High Speed Train Network) spreads into spatial, environmental, financial, legal, economic (with regard to exploitation and maintenance) and social aspects of everyday life. As a consequence, it is more and more to be considered as 'a normal procedure' to at least consult the stakeholders concerned. The almost inevitable involvement of large groups of stakeholders with different characteristics cannot be achieved with hierarchical approaches to governance. Top down is assumed to be inappropriate and thus, un-called for in these types of policy processes. Following this widely accepted assumption, consensual approaches are designed and implemented, under various appealing banners, such as co-production, open planning processes and participatory policy making. These appealing names lead to innovative forms of interaction and participation of stakeholders. Stakeholders are enticed to participate in design workshops, brainstorming, coffee table talks, internet based discussions and surveys and market consultations. Stakeholders are invited to information centres and travelling exhibitions.

All these efforts are undertaken based on the assumption that (this time) 'government will really listen and make effective use of all ideas, concerns and energy'. The question arises how effective and efficient these participatory efforts have been thus far. Is a consensual style of governance a solution for the ever increasing complexity of the impact of large scale infrastructural projects? Or has the hierarchical style still have some value for this type of policy processes? And if so, what kind value is this? And in addition, can hierarchical and consensual styles of governance simultaneously be helpful in planning, design and development of infrastructural networks, and if so, how and to what extend? Or must they be considered to be 'natural enemies' with regard to designing and implementing policy processes?

In this paper these questions will be addressed by discussing the two dominant styles of governance, the hierarchical and consensual style. Second, we will describe the role and value of hierarchical (top down) and consensual (bottom up) approaches in planning, designing and development of (road) infrastructural networks and projects. Third, we will make an attempt to combine both approaches, into a hybrid, cross over like, approach that incorporates both hierarchical and consensual approaches in governance.

Key words: road networks, hierarchical modelling, styles of governance.

Hierarchy as a natural phenomenon

It can easily be demonstrated that hierarchy is a common phenomenon in transport networks. Let us assume a perfectly square grid network where all origins and destinations are located at the crossings, all links being equal in length and travel time. The demand pattern is uniformly distributed, that is, at every origin the same number of trips start in all directions having the same trip length, leading to the same number of arrivals at all destinations coming from all directions. Since it is a grid network the traveler may choose between a number of routes having the same length and travel time. In this hypothetical situation no hierarchies in demand or supply are assumed and at first sight no hierarchy in network usage results.

However, if small deviations to these assumptions occur, a process is started that leads at least to a hierarchical use of the network. Examples of such small changes are:

- Travelers might prefer specific routes, even though all routes are equal in time and length from an objective point of view. Such a preference might be due to habit, to the

traveler's own perception of the routes or perception regarding the crossings, or to information provided by other travelers;

- Link characteristics might differ slightly leading to objective differences in route characteristics;
- Travelers might prefer to travel together, bringing in the stochastic element of travelers passing by and having an overlap with one of the possible routes;
- Some origins and destinations might be more attractive than others.

All of these deviations have the same effect regardless of the size of the change: namely some routes will become more attractive than others. This effect is mainly caused by the demand side of the transport system. The higher usage of some routes, however, also influences the supply side of the transport system. In the long run the most intensively used routes will receive better facilities and become more attractive, while the less used routes will be neglected. The supply side of the transport system thus strengthens the hierarchy started by the demand side. In fact, the process described here is an example from economics based on increasing returns (see e.g. Waldrop (1992), Arthur et al. (1987)), which is a fundamental characteristic in all kind of evolutionary processes, be they in economics or in biology. The final result in this case is a hierarchical network structure consisting of two link types, or put in other words, a higher-level network is superimposed on the original lower-level network.

Hierarchy in settlements stimulates hierarchical network structures. Furthermore, the introduction of faster modes speeds up the processes leading to hierarchical networks. Similarly, hierarchical transport networks lead to concentration of flows, and if these flows are large enough they allow for more efficient transport leading to lower travel costs per unit traveled (economies of scale), and reduce negative impact on the environment, which also stimulates the development of hierarchical network structures. Hierarchical networks are thus a natural phenomenon resulting from the interaction between demand and supply that, due to technological developments and modern decision processes focusing on environmental impact, are becoming more common in transport networks (see Figure 1).

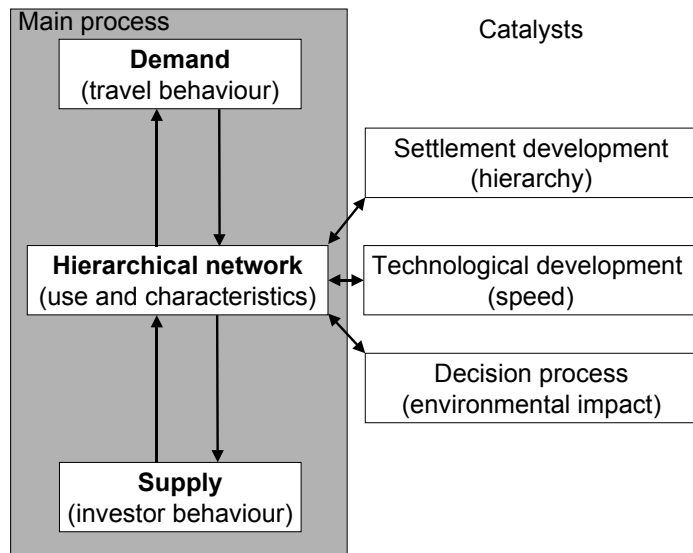


Figure 1: Main factors leading to hierarchical networks

Development of hierarchical network structures

The main process, that is the interaction between demand and supply, might have self-organizing characteristics. Many networks, however, have been developed over a long period of time and are, therefore influenced by many factors. Hierarchy in spatial structure has always been such a factor. The importance of technology has substantially increased in the last two centuries. Rail networks were developed early in the 19th century and were a true accelerator for hierarchical network development in transport networks and spatial structures. The introduction of high-speed trains today will have a similar effect. The introduction of the private car at the beginning of the 20th century led to more ambiguous developments. Private cars improved space accessibility and thus had a reverse effect with respect to spatial structure. At the same time, however, the private car allowed substantially higher speeds given the quality of the infrastructure, and can thus be seen as an accelerator for hierarchical road network development. In the second half of the 20th century a strong focus on planning processes, especially with regard to environmental impact, and the concept of bundling of transport and thus of infrastructure became dominant issues. Hierarchical networks can therefore be seen as a result of a continuous interaction process between demand and supply, which has a strong correlation with spatial development, and which is influenced over time by other developments such as technological advances and decision processes.

Hierarchical network levels

A hierarchical network structure is a multilevel network in which the higher-level network is characterized by a coarse network, limited accessibility, and high speeds, and is especially suited for long distance trips. The lower level networks are intricate, have high accessibility, and low speeds, making them suitable for short distance trips and for accessing higher-level networks. It can be shown that the hierarchy in transport network levels is linked with the hierarchy in settlements (Van Nes, 2002). Each network level then offers connections between cities of a specific rank and offers access to cities and networks of a higher rank. Figure 2 shows this concept as proposed for the German road network guidelines (FGSV, 1988). Table 1 presents a classification for road networks as proposed by Van Nes (2002). Please note that presently no higher speeds are possible for the two highest network levels. These network levels will therefore need more attention with respect to directness and traffic quality, i.e. reliability. For transit networks, however, high speeds trains really make it possible to provide higher network levels.

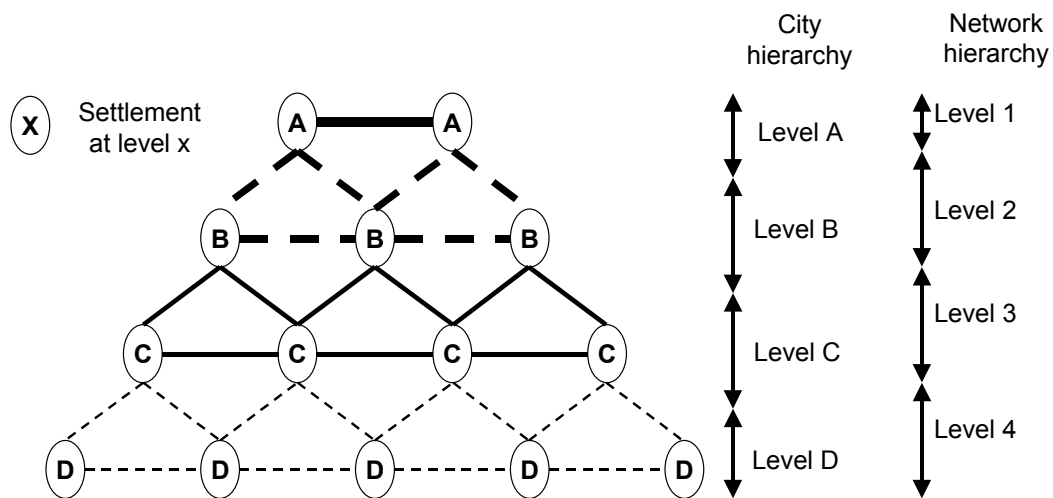


Figure 2: Road network structure according to Schönharting & Pischner (1983)

Table 1: Classification for road networks (Van Nes, 2002)

Network level	Spatial level	Distance [km]	Road spacing [km]	Speed [km/h]
International	Metropolis	> 300	300	*

National	/	Agglomerat	100	–	100	*
Interstate		ion	300			
Interregional	/	City	30	–	30	100 –
Freeway			100			120
Regional highway		Town	10 – 30		10	60 – 70
Local highway		Village	3 – 10		3	35 - 40

* Theoretically these network levels should have higher speeds, however, these are not yet technically feasible

The consequences of hierarchical modelling for governance in planning and design of network structures

The implementation of hierarchical modelling results in hierarchical governance. And this might be in sharp contrast with today's need for 'horizontalization' in current governance approaches. Horizontal coordination – i.e. working in business or policy networks – seems to be the current challenge in 'getting things done' in our societies (cf. Castells, 1996; Powell, 1990; Börzel, 1998). Participation and consensus building are becoming more and more common approaches to governance in all sorts of policy fields. These consensual approaches are also applied in the fields of infrastructural planning, design and construction (see e.g. the Infra-plan approach of the Dutch Ministry of Public Works, Transport and Water Management) and try to accommodate the network structure of today's society (Castells, 1996). And yet, the advance of hierarchical modelling in planning and designing network structures is clear. The question is how we can match hierarchical modelling – and its tendency to push for hierarchical governance – with today's more acceptable consensual governance approaches.

To answer this question we will first look into the difference between hierarchical and consensual governance approaches (cf. Smits, 1995).

Hierarchical governance structure can be characterised by top-down (unilateral) approach in policy making and implementation strictly in accordance with policy objectives and/or legal standards, procedures and conditions. Consensus governance structure can be characterised by bottom-up (mutual) approach; problems are solved by mutual agreement of all stakeholders.

According to Smits (1995), the appropriateness of the governance structure depends heavily on the relationship between government ((national) government as controlling actor) and society (other private/public partners as actors under control)

The basic assumptions of hierarchical approach are:

- Normative understanding of relationship between authority (controlling) and society (under control);
- Limited expertise within the executing organisations;
- Nature of (historic) relationship excludes all means of exercising power with the exception of laws, rules and regulations.

These assumptions add up to a ‘Command and control’-approach to policy making and implementation.

The basic assumptions of consensual approach are:

- Intensive mutual relationships between public and private partners
→ interdependence between policy making and implementation;
- No firm position of power (authority) in relation to target groups → formal interventions evoke disproportionate (negative) reaction of the other actors
- Limited expertise/experience of policy maker imposes negotiation and consultation.

These assumptions result in a participatory approach to policy making and implementation.

The hierarchical and consensual approaches to governance each have their own way of applying and implementing the same set of policy instruments. Two styles of governance in combination with three types of policy instruments result in six basic governance strategies (Smits, 1995). The hierarchical strategies are elaborated in the next section.

Applying legal instruments within the hierarchical approach (or style) result in the strategy of *commanding*. This means an unilateral imposition of standards by the authority/government, preserved by law.

Applying economic instruments within the hierarchical approach (or style) result in *incentive based manipulation*. This means an unilateral allocation to (subsidies) or withdrawal from (penalties, taxes) society of resources by the government.

Applying communicative instruments within the hierarchical approach (or style) result in the strategy of *informing*. This means a unilateral information supply by the government to target groups, based on policy objectives and not on information demand

Possible consensual strategies are: *contracting* (legal instruments), *facilitating* (economic instruments) and *consulting* (communicative instruments).

When does a hierarchical governance approach, conveyed in one or more strategies mentioned above, apply? Smits (1995) advocates that hierarchical governance approaches apply in three policy situations.

1. The authority has control of all relevant implementation tools. Policy making and implementation are in one hand. Implementation of the policy are carried out by ‘traditional policy instruments’, see e.g. NOTA-classification (Hood, 1976): N (information), O (organisation), T (finances) en A (legislation, rules and regulations).
2. Other stakeholders exhibit favourable autonomous behaviour. Stakeholders are forced, or are willing to exhibit, such behaviour as is favoured by the government (the authority in control).
3. The complexity of the stakeholder(s) is limited. The governing authority is dealing with a limited number of homogeneous and less dynamic stakeholders.

Mind you: the above applies to controlling authorities at the three government levels: national, regional and local for its domain in network planning and designing, principal road network (HoofdWegenNet), supporting road network (Onderliggend WegenNet) and local road network.

Overall conclusions

Hierarchy still plays a dominant role in policy making, because it helps us to deal with complexity. Moreover it relates to quality assurance, reduces uncertainty and facilitates prioritising (establishing a direct link between goals and measures). In addition, hierarchical approaches tend to create momentum in decision making – straightforward problem solving – in a time that public opinion sometimes seems to be fed up with exaggerated consensual processes (‘the polder model of decision making’ is no longer accepted).

However hierarchy is no panacea because it kills creativity and plurality, by introducing a deliberate limitation of spectrum of solutions, i.e. the experts view. Moreover, it can generate opposition – and therefore deadlocks – in the policy process, and neglects the advanced development in governance approaches that are more and more aimed at accommodating the network structure of our society.

Hierarchical modelling and governance still has its value but bears severe limitations.

To return to our question how we can match hierarchical modelling and hierarchical governance with more consensual governance approaches?

It is our proposition that top down and bottom up components of planning and designing network structures must be matched by a combination of both hierarchical and consensual governance strategies, i.e. by a hybrid governance strategy.

The ‘top down’ network components are: structure, capacity, quality and functionality and lastly, coherence, of the projected / desired network structure.

The ‘bottom up’ network components are: spatial design and accommodation, compliance with the existing road network (both principal, supporting as well as local road networks), mediating structures (such as geluidschermen, asphalt, maximum speed) and of course, public and private support.

In general, policy making and implementation – also in the field of planning and designing road network structures – tends to more and more exhibit a hybrid nature, in which hierarchy sets the tone and consensual efforts takes care of the fine-tuning.

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