A Proposal For Future Route Guidance Systems

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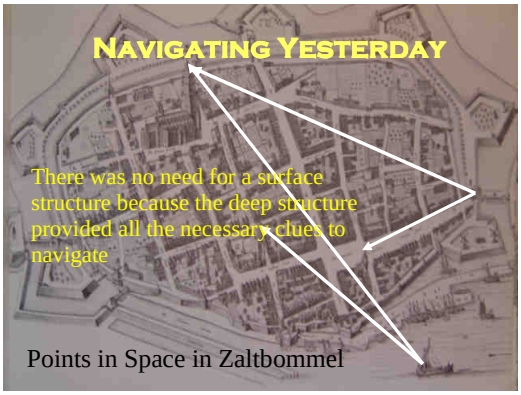
Abstract

Route guidance system developers and geographic database providers have been concentrating on only a small part of the wayfinding problem, that is, delivering instructions to a driver on when and where to turn to reach a destination. They have yet to address the underlying problem of why these instructions are needed, and why travellers have difficulty reaching unfamiliar destinations on their own. Answering this "Why?" holds the key to route guidance systems becoming a consumer success. My premise is that route guidance systems should be designed to help the driver become oriented in a mostly chaotic, disorienting driving environment. This environment is the responsibility of public authorities and their architects and engineers who have designed their cities' buildings and infrastructures. Route guidance systems designers and navigable map database developers need to work with these public bodies in order to harmonize what the driver sees on the streets with the information provided by the in-vehicle systems. Unless this critical connection occurs between the two sides of the wayfinding equation—in-vehicle and environment—route guidance systems will never reach the status of true convenience items.

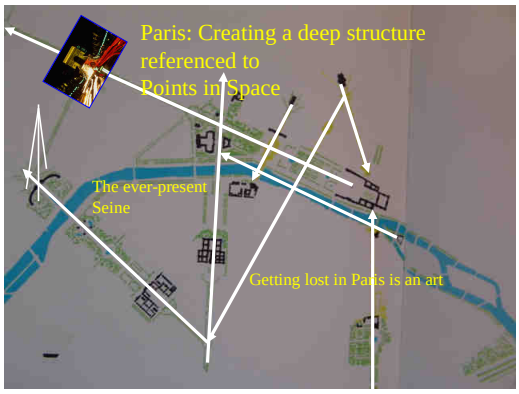
It is Our Cities That Make Route Guidance Essential

Route guidance systems[1] are needed because of the mismatch between what cities were designed for and how they are presently being used. Few cities were consciously designed to facilitate wayfinding, not even for people moving slowly on foot, and particularly not for cars and trucks moving much faster than a walking pace. The underlying design of a city, such as the grid of New York's Manhattan, the concentric rings and radials of Amsterdam, or the wards and blocks of Tokyo, is the city's "deep structure".[2]



The medieval city of Zaltbommel in The Netherlands is an example of how the placement of major structures, such as the churches and surrounding fortifications, affects the pattern of the city's streets.

The deep structure of most cities results from the accommodation of natural features, such as hills and water, the original and subsequent land parcelisation schemes, and the placement of fortifications, market squares, churches and public buildings.



The interconnecting axes designed by Baron Georges Haussmann during the reign of Napoleon III provide an organising, secondary deep structure to the expanding city, reinforcing the city's major natural feature, the River Seine.

Some cities, such as Haussmann's Paris in the early 1700s and Nash's London in the early 1800s, underwent major restructurings to make movement easier, and wide swathes of land were cleared to create monumental boulevards. Other cities, such as Washington, DC[3] in the USA, Canberra, Australia and Milton Keynes in

Great Britain, were designed as completely new towns, and Milton Keynes was actually created with the goal of accommodating vehicular transport.[4] Nevertheless, the deep structures of many cities are not conducive to either wayfinding or movement. Streets, especially those with their roots in the Middle Ages, began their lives as voids between structures, as in the example of Zaltbommel. It is paradoxical that early cities came into existence to provide for the interchange of goods, services and interaction among people, but many of them were built to accommodate isolated activities (praying, working, sleeping, eating and, in rare instances, recreating) with very little thought given to how people should move between these activities. The Roman gridded cities were the exception; the paths came first, and the spaces in between were filled with activities.

City managers and planners have tried to mediate the conflict between the inflexibility of their cities' deep structures and the need for efficient movement by developing sets of rules that regulate movement along streets and the placement of vehicles when they are not moving. They have applied a "surface structure" made up of signs consisting of text (e.g. No Entry, No Left Turn, No Parking), and/or symbols representing a piece of information or a desired or prohibited action.[5]

The surface structure tells us how to use a city's deep structure. The vast majority of the world's cities' signs and signals, their surface structure, are related to motorised vehicles, but most of them are used to restrict the movement and storage of these vehicles, and to the relationship between vehicles and pedestrians. People on foot can ignore most of these signs. However both pedestrians and vehicle drivers alike must use one part of the surface structure for wayfinding: address coding schemes.

In western cultures, address coding is usually hierarchical, beginning with country (continent is implied), region (such as European Union, Middle East), country, country region (e.g. Midwest, Midlands), county (optional in some places, required in other, such as the UK), municipality, neighbourhood, street name and building address. For added measure, postal codes are thrown in.

Address coding is quite different in Japan. There, a house has a number within a numbered sub-block; a sub-block is within a named block; a block is within a named ward; and a ward is within a municipality. Whether using maps or a navigation system, wayfinding in Japan involves a nested search: First the city, then the ward and so on down to the house. It also means that navigation can occur in more manageable segments than in the street-oriented western cities.

Logical Surface Structure Aids Wayfinding More Than Restrictive Signs

In the best of cases, a city's *surface structure* complements a city's *deep structure*. Manhattan is an example of a street naming convention that works with the orthogonal street grid. Streets run west to east, avenues south to north. Second follows First, Third follows Second, and so on. Even anomalies like Broadway, diagonally slicing through the grid, can be understood by reference to the names of intersecting streets. However, even the best laid schemes can go astray if successive generations do not preserve them. The well-intentioned re-naming of Sixth Avenue to Avenue of the Americas, or the trendy renaming of Fourth Avenue to Park Avenue, breaks the logic of consecutive numbers and hides the re-named streets within the city's grid.

Few signs in cities are devoted to aiding drivers of vehicles, or even pedestrians, in wayfinding. A different situation can be found on motorways and expressways that have been specially built for fast-moving vehicular traffic, or at facilities like the newer airports, which were consciously designed for vehicular access.

Once on a motorway, the driver is presented with signs announcing destinations and their distances, places that can be reached from exits, distances to rest areas and services. At airports, colour coding and terminal numbering schemes guide the driver to the four principal destinations: departures, arrivals, parking and car rental locations.

Motorway signage is better in some countries than others; some airports are easier to navigate in than others. The degree of success seems to be directly related to how well the designers

have matched the content and placement of the signs with the topography in the case of motorways, and the overall placement and organisation of structures in the case of airports.

Cities, even the gridded variety common in North America, could benefit from a revised view of their surface structure design along the lines of motorways and airports. Every location in a city cannot be a signed destination, but every eventual destination can be related to a signed location. If logical routes between the locations were clearly marked, it would be infinitely easier for a city's users to navigate on their own. This would be especially true for visitors and new arrivals who are not familiar with the city's deep and surface structures. It would make it easier for them to get close to where they want to be without requiring turn-by-turn instructions from everywhere to everywhere.

A completed project in the Pittsburgh region of Western Pennsylvania in the US provides an example of how this could be accomplished.

A Sense of Place Provides Orientation

An article titled "A Sense of Place"[6] describes an approach to designing a surface structure of destinations. The term "sense of place" was described by Kevin Lynch, a professor of environmental design at MIT. He wrote:

"A sense of place is the extent to which a person can recognise or recall a place as being distinct from other places—as having a vivid, or unique, or at least a particular, character of its own."

He also defined another element of sense, formal structure:

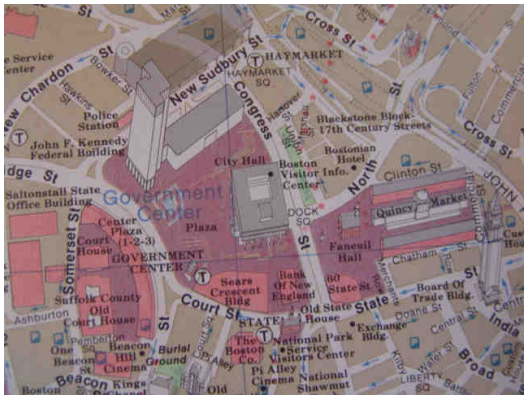
"…which at the scale of a small place is the sense of how its parts fit together, and in a large settlement is the sense of orientation: knowing where one is, which implies knowing how other places are connected to this place…The practical significance of orientation is clear enough: poor orientation means lost time and wasted effort, especially for strangers. Good orientation enhances access and so enlarges opportunity."

Professor Lynch argued for better design of cities to eliminate, in his words the "fear and confusion" accompanying poor orientation.

The ITS magazine article describes a project in Pittsburgh which is based on the principles set forth by Professor Lynch. The Pittsburgh metropolitan area has a population of over two million inhabitants. It has a very irregular street pattern due to its many hills and rivers. A local design firm, Informing Design, worked with the city's engineers to create a new road signage system which, they claim, provides travellers with an understanding of where they are and a feeling for where they are heading.

Pittsburgh's city form, its deep structure, is accepted, but on top of it has been laid by the designers a surface structure which attempts to provide a sense of place. The designers have identified destinations (places, in Lynch's terms) at varying levels of detail, from settlements and areas at the Greater Pittsburgh scale, to districts and buildings at the large scale within the city. A series of axes are defined for each level, with the axes growing closer together as destinations become nearer. Travellers are presented with direction information at any point where the axes cross. The information given is clearly differentiated into immediate, neighbouring and distant places. The signs are colour-coded, and the colours are reinforced with specially-designed graphics which symbolise the character of the place. Travellers can choose which directions they want to follow according to how far or near they are to their destination.

The result of this approach is that people always have a sense of where they are within the context of the city and the surrounding region. The concept seems to have gained many supporters. Residents of Pittsburgh have praised the new signage and the maps developed by the same design firm. Other US cities, like Boston, which has an even more disorienting street pattern, have shown strong interest in having their own cities demystified by the design firm.[7]



A 1980 map drawn by the author shows the Government Center section of Boston (in blue text), and the major places (in 3D) associated with this section. Wayfinding on a completely chaotic road pattern is facilitated by referencing the major landmarks.

The author of the ITS article asks, but does not answer the question of whether such an approach, applied in all cities, would spell the future or the end of in-vehicle navigation systems. I believe that by reducing the

complexity of cities' surface structures, the difficulty and cost of collecting, translating and maintaining the geographic data will be reduced. Also, the reliability of the route guidance systems to provide useful directions will be significantly increased. Lower costs and increased reliability will result in greater acceptance of the systems, and, eventually, make them irresistible to the driving public.

Implementing Irresistible Route Guidance Systems

Route guidance systems would be far more effective if the directions given to the driver were clearly reinforced by what the driver actually sees, rather than what the system reads in the database.

"Proceed straight ahead through the tower's portal. Once through the portal, follow the signs to Market Square."

Gimmicks, like placing the driver up in a helicopter above his or her car, make for interesting graphics displays, but they are not reinforcing the driver's actions. It would be far more useful to use such a view to show traffic incidents[8], as a supplement to the main navigation display, which I assume eventually will be the entire windscreen as in my mock-up above. Instead of showing the car on a map, the map is overlaid on the scene ahead, the vehicle's electronic horizon.

The real potential value of route guidance systems will be reached when the following can be said of them by their users:

- They have a truly convenient user interface. *Talk to me. Tell me where you would like to go*.
- They are not needed to move between or through cities, but are needed only to guide the traveller along the final few hundred metres to the destination. A logical surface structure takes care of the rest.
- They can function like a travel guide and identify all of a city's or a region's facilities, not just a few selected points of interest.
- They can provide traffic, travel, event and parking information when and where it is needed.
- They can provide really useful information about road conditions in various weather conditions, warnings before dangerous curves or animal crossings, speed limits, vehicle height, weight and width restrictions.
- They can be used to improve the performance of the vehicle and the driver in all driving conditions.
- They can print out trip logs with distance travelled, tolls paid, fuel consumed along various stretches of the journey.
- They are really useful inventions. *I wonder how I got along without them!*

Implementing this concept will not be easy. It will require co-operation among route guidance system developers, database providers and city planners and engineers. Such co-operation is not unthinkable, but we have not seen it as yet. The following is what should be done to make route guidance systems irresistible to consumers, welcomed by city officials, and profitable for system developers and database providers.

City Planners and Traffic Engineers

In the early days of route guidance, city officials did not exhibit a particular openness toward route guidance systems. A survey on the development of transport telematics in European cities was conducted by the European Digital Cities project in 1997. The survey was reported in the ERTICO newsletter (ERTICO News; 7/97). A total of ninety responses came from European urban authorities and municipal organisations in urban areas of greater than 100,000 inhabitants.

The report stated that "…almost 40% of respondents are not considering installing in-vehicle route guidance and navigation because these systems are not expected to solve urban mobility problems." Public officials actually appeared to be hostile toward route guidance systems, especially those systems which incorporated dynamic traffic information. An article in the Intelligent Highway (July 7, 1997) reported on Mercedes-Benz plans to offer dynamic route guidance in Germany. An official at Daimler-Benz said that public officials presenting administrative

complications were the major problem to implementation. "At an urban level, authorities are afraid of dynamic route guidance as it is thought to make traffic policy obsolete," he said.

In most cities, traffic engineers have confounded drivers with one-way streets, turn restrictions, restricted entry zones, pedestrian-only streets, and a confusing mixture of signs. Much can be learned from the Pittsburgh experience, where wayfinding is the principal objective of the new signage system. City officials must accept that route guidance systems are intended to compensate for defects in their cities' designs. If everyone could see where they were going, knew, or could see, how to get to their destinations, there would be no need for signs, maps or route guidance systems. But they cannot and do not.

City planners, builders and managers must begin to take their share of responsibility for helping visitors and inhabitants to feel oriented so that they can navigate easily, if not effortlessly.

Database Providers

Database providers have been busy collecting and field-checking whatever data is available; they have functioned as fact gatherers. They have attempted to collect as much data as possible about the road network in order for all of their potential customers' routing algorithms to synthesise the facts into logical routes. Gathering facts is a time-consuming and costly endeavour because it must be 100% correct. One error along a route and the synthesis unravels.

The critical piece that is missing in this process is the interpretation of the facts. This is what cartographic editors do when preparing a map. After they assemble the facts in a region to be mapped, they create an impression of how the data shall be presented to the map reader. The database producers are leaving the job of cartographic editing to the system developers, who are furthest from the data sources, and who, thus far, have taken a mechanistic approach to map display.

Ideally, the database providers would be supplied by a city's authorities with the surface structure of a city and region in a pre-synthesised form, with major routes and places pre-defined by the local authorities. In those instances when city authorities cannot be convinced to take on this responsibility, the database providers should engage local cartographic experts, traffic planners and urban designers in an effort to create a logical surface structure, which, to the maximum possible extent, is consistent with the existing signage.

Route Guidance System Developers

System developers have been experimenting with different ways of providing instructions to drivers, but, at least in Europe and North America, they have worked within the paradigm of collecting a string of streets together into a route. Instructions are provided as icons, actual roadway geometry and by voice. This is useful, but it is not as good as it can be.

What is this picture trying to tell us? What road is the driver on; which roads is he passing; where is the destination in relation to where she is now positioned?

An example of what can result from such stringing together is shown in a test conducted by the German automobile association, ADAC. The club equipped a van with six systems being sold in Germany from different manufacturers. They tested two sets of origins and destinations, one set in the middle of Munich, and the other in the countryside.

Each one of the six systems generated a different route for both the in-city and rural test sites. The main criterion was shortest distance, but the variation was almost 2.5 kilometres on the city route, and 11 kilometres on the rural route. The straight-line distance between the in-city route's origin and destination was approximately 5 kilometres, and the rural route's was around 45 kilometres. The two best results in both instances used competing databases. Little wonder that public authorities are sceptical about the systems' utility.

Presenting a factual picture of a chaotic environment does not necessarily make that environment any easier to understand and navigate. Following the instructions provided in an audible or graphic form, and matching the instructions to the actual scene, requires such a high degree of concentration from the driver that there is no chance for the driver to try to understand the logic of the manoeuvres. On the one hand, each time a manoeuvre is executed, the driver instinctively searches for

confirmation that it is correct. At the same time, the driver is waiting for the next set of instructions. The experience can be very stressful, especially if the confirming information, such as a street sign, is not immediately visible or readable. This is also not conducive to safe driving.

Future Route Guidance Systems

Route guidance system developers need to start thinking outside the (navigation) box, literally and figuratively. Once they do, they will be able to see what data they are missing, including what information they need to have placed in the environment by their city planner and traffic engineer partners, and what additional data they need to have collected by their database provider partners.

The first step is to redefine the route guidance paradigm. Those who have been deeply involved in the current systems are too close to the problem. In my opinion, the best places to look for new ideas are in the universities with programs in urban design, environmental cognition and cartographic representation. Both basic and applied research is needed, and support for this research by the route guidance industry will be well-rewarded.

We also need to raise the awareness of this issue with public authorities. Congestion charging and road closings are not the only ways to improve mobility in our cities; improving their navigability will do more in the long run to reduce congestion and improve the liveability of cities. Sponsoring design competitions and publicizing the results in local and national newspapers and on television is one very good way to get the attention of public officials, and an excellent way to introduce new ideas to a city's residents.

We need some form of route guidance today to find our way in increasingly chaotic driving environments. In my view, we can either try to continue to make electronic sense of this chaos, or we can begin the process of simplifying and clarifying the environment.

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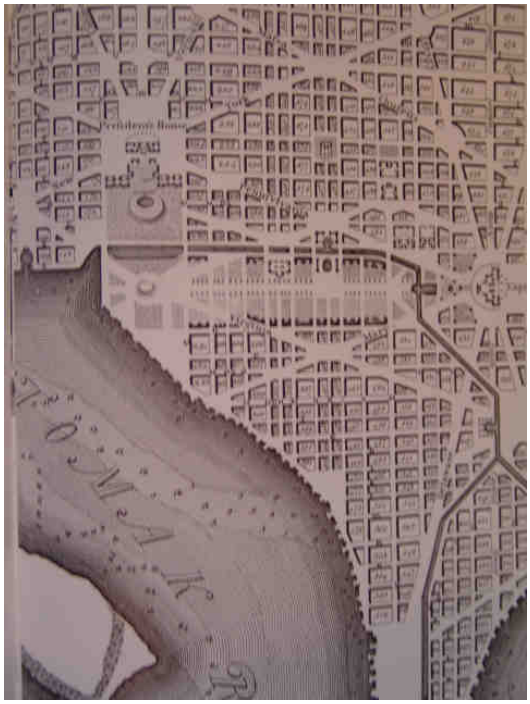
[1] Route Guidance is currently defined as the provision of turn-by-turn driving recommendations at decision points along a route in a visual and/or vocal manner. Route guidance is often used interchangeably with the word 'navigation' in combination with the word 'systems', as in route guidance systems, or navigation systems.

[2] I may have heard or read this term somewhere, but when I wrote this paper I believe I invented the term to illustrate my point.

[3] Major Pierre L'Enfant's original 1792 plan for the new capital of the new nation combined the cellular organisation of residences and shops along a gridiron pattern of streets with the monumental axial boulevards connecting the major public buildings.



[4] Llewelyn-Davies, Weeks, Forestier-Walker and Bor, *The Plan for Milton Keynes*, Wavendon, Bucks, Milton Keynes Development Corporation, 1970.

[5] The same applies to Surface Structure as to Deep Structure; I may have read or heard the term, but I cannot think of where.

[6] (ITS: Intelligent Highway Systems; May/June 1997)

[7] Esselte Map Service, USA, which I managed from 1978 through 1982, and which was responsible for developing the first commercial maps using digital map techniques, produced a series of maps of Boston, Salem and other cities that applied the principles of place identification using three-dimensional rendering of the city's various landmarks.

[8] I have also imagined a Personal Flying Camera (PFC), Personal Periscope (PP) that hovers or rises up directly above the vehicle and captures real-time traffic flow information. As the car gets closer to its destination, the PFC or PP gets closer to the car, taking in a smaller area.