Michael L. Sena Consulting AB
Mobility Research Report

Route Guidance Systems

Luxury, Convenience or Necessity?

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Preface

Mobility Research Reports are intended to generate discussion within the Intelligent Transport Systems (ITS) community. The community is defined in its broadest scope, and includes environmental and city planners and map and travel guide publishers, as well as the individuals associated with organizations that have thus far been the drivers behind ITS efforts. This widening of the forum for discussion is recognition of the important role that can be played by those who are responsible for designing the environments in which ITS solutions will operate, and by those who have traditionally provided the tools used for human orientation and wayfinding.

Each paper expresses the personal views of the author, with a focus on the interrelationships between the designs of the systems, services and infrastructure which are proposed to improve personal and collective mobility and the planning and design of our habitat. The fundamental premise of these papers is that land use and built form policies are inseparable from traffic and transportation policies.

Michael L. Sena Consulting AB is an independent company providing specialist consultancy in the design and development of mobility systems for in-vehicle and pedestrian usage, including navigation, traffic information and fleet management. The principal of the company, Michael L. Sena, is an internationally recognised expert in digital map databases, location-based services, navigation and telematics. He served as an expert delegate to both the European CEN and international ISO standards committees.

The company was founded in 1983, and since then, has worked closely with decision-makers and their staff to develop successful mobility system solutions that are on the market today.

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Executive Summary

The luxury car market alone cannot support the volumes of full-function, turn-by-turn route guidance systems required to make the high-precision, attribute-rich geographic data business profitable for database suppliers because. This segment represents only three million units in the European and North American markets. If every one of these cars came equipped with a navigation system--and a 100% penetration is unrealistic—it would still be too few map unit sales to make the business profitable for both of the database suppliers, Navteq and Tele Atlas. Government regulations, mandating route guidance systems in every vehicle, are highly unlikely in any market, although this would be the ideal way to ensure consumer acceptance.

Route guidance systems must be perceived by consumers as an irresistible addition to the driving cockpit, providing useful information that improves the safety and comfort of the driving experience. Current systems are not irresistible, and it is not their high cost which is the problem; it is their functionality.

Wayfinding is the problem which route guidance systems are supposedly addressing. System developers have looked at only one part of the wayfinding process: providing instructions on when and where to execute manoeuvres. Database suppliers have attempted to collect the data which supports this limited task, but the frequent changes made by traffic authorities makes it extremely difficult to keep the data up-to-date.

Wayfinding is difficult because our cities were not designed for vehicular traffic. City streets are the spaces left over after facilities are placed on the ground. The information signage systems in most cities are restrictive, not enabling, and inhibit rather than assist the driver in locating a destination.

Route guidance systems must be designed to help the driver become oriented in a mostly chaotic, disorienting driving environment. Systems designers and database developers must work with the public bodies that are responsible for designing and building the transportation network, and providing the driver information aids, in order to harmonize what the driver sees with the information provided by the in-vehicle systems. Unless this critical connection occurs between the two sides of the wayfinding equation—and happens soon—route guidance systems will become another good idea poorly implemented.

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Off-board Navigation

More irresis tible than on-board?

An Evaluation of the Options

In an evaluation of new technology, I find it useful to distinguish between a necessity on the one hand, and a convenience or luxury on the other. A necessity arises because of a threat, while a convenience or luxury is a response to an opportunity. Food, water and shelter are basic necessities. Any disruption in the production and distribution of food and water, or the catastrophic destruction of shelter, causes severe hardships and fatalities. Products and services related to their delivery become necessities themselves. Electricity and refrigeration have become modern necessities for urban dwellers. Telecommunications are now business necessities.

Governments can mandate that certain goods and services become necessities, and entire professions and industries develop around these mandates. Governments use the threats of fines or imprisonment to force conformity to regulations that are established to protect the individual and society. Regulations surrounding the private automobile are an example of the relationship between government threats and resulting product or service necessities. Mandatory state vehicle inspections are one example of how regulations foster business.

In certain countries (Sweden, for example), there is a political debate concerning the status of the private automobile. Is it a necessity with the associated right of every citizen to own and drive a car; or, is it a luxury the use of which, in its present form (i.e. energy-wasting and environment-damaging), should severely restricted? Politicians and those whom they govern appear to be on opposite sides of this debate. Politicians seem to favour high vehicle purchase and fuel taxes, they institute tolls on freeways, and they propose restrictions on driving and parking. Their constituencies, on the other hand, want more and better roads, lower prices at the fuel pump, lower car sticker prices, and no tolls. In a 1996 poll conducted by MIT University, 1,000 Americans were asked which of eight inventions they could not live without. The automobile was the hands down winner, with 63% of the respondents voting for it as the most indispensable of the inventions. Following the automobile on the list is the light bulb (54%), the telephone (42%) and TV (22%).

Whatever your own opinion is on this issue, components of the automobile, such as lights and turning signals, horns, mirrors, seat belts, exhaust systems, windscreen wipers, etc. must be present on every vehicle. Governments may question the necessity of the car

itself, but they have mandated that certain components must be built into every car that is sold. A company like Robert Bosch exists to satisfy the demand for the necessary components of an automobile, from windscreen wipers to headlamps.

Perceived necessities have almost the same status as real necessities. Information sources and delivery devices are perceived necessities. Few would consider not owning at least one television; a car without a radio is a rarity (although I owned one for twelve years); a telephone, fax and an Internet connection are indispensable business necessities. The threat is that one could miss seeing or hearing about an important event. (I can still remember listening to the first landing on the moon while driving my VW Beetle in the mountains of Vermont.) In today's information society, not having information can be life threatening.

Is Route Guidance a Necessity?

If route guidance systems are to become a necessity, then they must be viewed as a response to a threat, real or perceived. The argument would be something to the effect that the car's driver, its passengers, other drivers sharing the road, pedestrians, society in general, will be harmed unless every vehicle is equipped with a route guidance device. Can companies who make these devices convince government regulators that drivers who cannot find their way can cause irreparable harm to the environment, waste precious resources, reduce the effectiveness of industry, and increase the risks of accidents? If so, can they thereby force governments to mandate route guidance systems as a necessity? Perhaps they have tried, and although their arguments may be valid, they are weak. Likely responses from the government officials are: "Buy a map; Plan your trip before you make it; Take public transport instead of your car." Cost-saving, time-saving and environment-saving arguments are difficult to leverage into a personal or societal threat.

It is also unlikely that any government would admit that it has failed its citizens by building cities in which becoming lost is a potentially life-threatening experience—even if in some places it can be just that. Maps in cars have not been mandated. It is highly doubtful that route guidance systems would be declared a necessity for wayfinding purposes only.

Route Guidance Database Costs are Too High to Support It as a Luxury Item

If route guidance systems are not going to be mandated as a necessity, then it would appear that they can only become a perceived necessity via the luxury/convenience route. In other words, they must become irresistible. Currently, these devices are factory installed options in the high-end of the luxury class of vehicles, such as BMW, Lexus, Mercedes, Volvo and a few others. These systems cannot remain luxury items for long. The investments made thus far in the systems, the geographic data, and the infrastructure to maintain and

distribute the data, are too high to be supported by high-end luxury car sales alone.

A conservative estimate of the annual costs of geographic data construction and maintenance for the principal data suppliers in Europe and North America is approximately $150 million and growing. The total annual luxury car sales in these markets are less than 3 million units. With a predicted take-up rate of between 10-20% over the next five years, and with an estimated maximum revenue for the database supplier of between $50 and $100 per database carrier (predominantly CD-ROM through 2001 and then DVD), each system buyer would have to purchase the equivalent of up to ten CD's in order for the data suppliers to just break even on current operating costs.

The industry's investors, who have put in close to $5 billion (by my estimates) during the past fifteen plus years are not looking for break-even on operations. They are looking for the promised large profits. Businesses—not even large companies like Siemens, Bosch and Sony—cannot sustain such large investments indefinitely. The point of payback must be reached very soon. In order to generate sufficient revenues for this payback, and make the economics of dedicated route guidance work for all industry players, route guidance systems and databases must be part of every vehicle, regardless of price class. Route guidance systems must achieve the status of convenience appliances if they are to become standard equipment, or a must-have option in the next generation of new car models.

There is a window of opportunity for route guidance to become established as a convenience. When I wrote this report in 1997, I believed the window would close in three years. Seven years have passed, and both Navteq and Tele Atlas are still in business. Internet data sales and sales to companies producing portable map display and routing systems have helped to supplement the car industry income. Nevertheless, the business cases for the database suppliers were built on sales to the car industry, and I believe that the profits that can potentially be generated from in-vehicle navigation systems are of the magnitude necessary to sustain these companies. If these sales to not materialise, the industry will disappear because there will be no data to support it. In spite of all of the technologically advanced hardware and sophisticated software, route guidance cannot exist without the raw material of geographic data.

Can Route Guidance Achieve Convenience Status?

Route guidance systems have many advantages over traditional maps and street atlases that potentially could make them irresistible as convenience options. Some of these advantages are:

- One CD-ROM can store a car-load of street atlases—and a DVD a truck-load. As an example, all of Germany can fit on a CD, and the level of detail is equivalent to a street atlas at a scale of 1:10,000. One atlas of one city region in Germany, such as Rhein-Rhur, has 445 pages, including the index, weighs 1 kg, costs 30 DM, and it is at the

smaller scale of 1:20,000. It would take 61 such atlases to cover just Germany. That translates into about 61 kgs and 1,830 DM.

- The database is continuous, so it is possible to scroll anywhere without needing to flip between pages in an atlas, or unfolding a large map.

- Some systems have "windows" that can simultaneously display different parts of the database, like the start and end of a route, or different scales, like a very detailed view around the current position and an overview of the entire route.

- Most systems have both north-up and heading-up orientations, and unlike turning a map for heading-up orientation, the type is always readable.

- It is possible to switch between a daytime and night-time colour palette. A subdued colour palette is desirable in night driving to reduce distraction to the driver. Night-time reading of printed maps is extremely difficult.

- Type size does not need to be small to allow room for all the information that must be placed on the maps. Text and symbols can be turned on and off as needed, and the variable scales mean that only the type that is needed at the particular scale needs to be shown. Furthermore, street and place names can be shown in separate boxes in a large, readable size.

Increasing Utility by Adding Features

Even with all of their obvious advantages, route guidance systems will be a very hard sell to most consumers. An article in USA Today (September 24, 1997) reviewing the new Lexus GS models indicates just how difficult it might be:

"An optional navigation system ($2,159) relies on global positioning satellites and computerised maps to pinpoint your location and guide you to one you select. As navigators go, its good: eerily accurate on road trips; exact in its map displays. But, like most navigators, it's more video game than useful feature.

"It's too slow to recalculate a new route when you stray off the chosen path; hopelessly so in the city. It doesn't have a clue about high-crime neighbourhoods and traffic congestion. It can't tell that a formerly open road has been closed. You can't see it well wearing sunglasses. The touch-screen system requires you to put your greasy digits on the screen to make the system work. But doing that leaves fingerprints that make it harder to read and harder to work."

If this system is good, I wonder what a bad review would look like. Simply surpassing the paper map in functionality as a wayfinding device will not be enough to catapult these systems from luxuries to conveniences. Some system manufacturers, possibly anticipating that a single-dimension electronic navigator will not have broad enough appeal to consumers, are adding features such as real-time traffic information, Yellow Page listings, and car dealer directories.

In 1998, DaimlerChrysler began offering in their Mercedes cars a system developed by Bosch that can receive via a cellular subcarrier dynamic traffic information and re-routing instructions from a central

command facility. The facility was operated by then-Tegaron, which was a joint venture between Debis, a subsidiary of DaimlerChrysler and Deutsche Telekom's Mobilnet T-Mobil. The on-board route guidance device used the instructions to re-calculate a route to avoid traffic problems. The service will be offered initially only in Germany. The Volvo *RTI System* the Blaupunnkt *TravelPilot*, and several other navigation systems can present traffic information received via the RDS/TMC (Radio Data System/Traffic Message Channel) radio channel. Only a few European countries are presently broadcasting traffic messages via RDS/TMC, but wherever the service exists, systems with the functionality of the *RTI System* can process the information and present it to the driver.

Others have suggested that route guidance systems should be add-on items to systems that provide emergency response and breakdown assistance, like GM's *OnStar*, Volvo's *OnCall*, and the Mercedes *TeleAID* systems. These so-called 'Mayday' or 'Telamatics' systems can automatically relay the vehicle's position using GPS and cellular technology to an emergency call center. The call for assistance can be activated by crash detectors or when an airbag deploys, or by the driver pushing an emergency button. The center can see where the vehicle is located on a map display and dispatch the appropriate assistance. The same technology can be used for stolen vehicle detection and tracking, remote door locking and unlocking, even remote vehicle diagnostics. In addition, because of the two-way communication capabilities, it is also possible to provide the driver with route guidance and traffic.

Centrally Determined Route Guidance

In conjunction with telematics systems, or as a stand-alone service, there is serious thought being given to centralised route guidance (also called off-board navigation), without a geographic database and route calculation device in the vehicle. Centralised route guidance has a number of different forms, from sending turn-by-turn instructions to a driver on request, to transferring map display, voice instructions and manoeuvre images to a client device. The major advantages of a centralised database method are:

- Information on current traffic conditions can be assembled at a central location and used in the calculation of routes without having to send this traffic information to the vehicle and developing the on-board tools to incorporate the traffic data in the on-board database. The difficulties of sending dynamic traffic data to moving vehicles, and letting the on-board system process the data for re-routeing has been shown in several pilot project, including the ADVANCE project in the Chicago area, and the SOCRATES project in Germany and Sweden. The VICS system in Japan is proving that dynamic updating of in-vehicle systems is feasible, but there are many factors contributing to its success which are not present in the US or in Europe, primarily a single geographic database source with a single, unified coding structure.

- The data used for route guidance can more easily be kept up-to-date than millions of CD's or DVD's in on-board database. Autonomous route guidance systems (i.e. those with an on-board map database and routing software) have only the database in the vehicle to rely upon, and this database can be six-to-twelve months out of date by the time it is delivered to the customer. As the numbers of systems grow, so does the logistical problem of distributing new database releases with expanding coverages and the most recent additions, deletions and changes.

In spite of these two significant advantages, centrally-determined route guidance has two major flaws. The first is economic. By removing the database from the vehicle, the principal medium of commerce is taken away from the database manufacturers. As already noted, producing and maintaining highly accurate, geographically precise and attribute-rich geographic databases is a costly exercise.

Selling hundreds or even thousands of databases to centralised routing agents suggests a very different business case for the database developers than selling millions of databases to consumers. It is similar to a music recording company selling only to radio stations, or book publishers selling only to libraries, and having the music listener or book reader pay a fee for each use. When navigation systems were first introduced in the mid-1990s, consumer markets for intellectual property did not work this way. The companies make money on selling many units to consumers. The radio stations, in the case of music, is the advertising medium. A prospective music buyer hears a song on the radio and then purchases it.

A lot has changed since the above paragraph was written. Wider bandwidth, faster computers and better systems means that more content can be delivered to consumers. Pay-for-use has begun to take hold and appears to be a sustainable business model. Music recording companies, book publishers, even authors (e.g. Steven King) are putting their creations on the Web.

The sending agents for the routing instructions might have an economically viable business if a) they can keep the cost of licensing the geographic data low or pay only on a per-use basis; and, b) they can keep the number of calls high enough to generate a profit, but low enough to minimise their staffing costs. The communications agents, the cellular telephone network operators, will certainly make money since it is one more service that they can sell. However, if this is the primary market for database providers, it is highly doubtful that they can charge a high enough fee for each use--without creating a negative reaction from the consumer of the service--to make a profitable business. It is also doubtful that they can charge the relatively few sending agents enough to cover their costs.

The second flaw in centrally-determined route guidance is the delivery mechanism. How does the individual driver, with his or her particular abilities to orient and navigate, receive, interpret and use the instructions that are being offered. Without a database in the vehicle

and a device that the driver can control directly, the person (in the best case) or a computer processor (in the absolute worst case) must: a) know exactly where the vehicle is located; b) interpret for the driver all local conditions; and, c) provide the instructions in a way that the particular driver understands at exactly the moment which they are required.

It is technically possible to do a), feasible to do b), but extremely difficult to do c). In any case, is this a practical use of technology? Is it really worth the effort to have potentially millions of on-line connections for drivers who cannot navigate on their own, and potentially an equal numbers of call-handlers in remote locations trying to assist them? It is highly likely that in spite of their good intentions and access to the best technology, these call-handlers will never be able to do a really good job.

Centrally-determined route guidance can be a supplement to on-board route guidance, and as a supplement, it can be a way to interest the market in full-function route guidance. There will be instances in which centrally-determined route guidance will be useful, such as in conjunction with emergency services. However, for daily navigation and wayfinding, with or without traffic information, there must be a better solution, one that is at the disposal and control of the individual driver.

Technology will play an increasingly important role in changing the paradigm of centralized routing from one that is totally dependent on an operator to one that provides completely dynamic route guidance with no operator intervention. Improved text-to-speech and speech recognition techniques will be significant enabling technologies. The current off-board route guidance platforms will have to go through significant modifications to deliver performance equal to that achieved with autonomous systems. One of the major obstacles to overcome is the input of a destination, which, even with an on-board database that can be searched with each keystroke, is the most difficult and time-consuming task for the user. Standards for data transfer and the physical storage format of the data will have to be fixed. Business models being applied in other areas of e-commerce will be adaptable to the route guidance and other in-vehicle driver information systems.

Another Diversion: Down-scale Databases

There is a real danger that route guidance will move down-scale and become **trivialised** because of the high cost of data. There are signs that this is already happening. Several companies in the US are distributing PC-based software with an interface to a GPS receiver. The data used in some of these systems is from low-cost providers who are not building high precision, fully-attributed databases, but are taking publicly available data and adapting it to a form of route guidance.

A laptop computer is brought into the vehicle and the GPS antenna is placed on the roof or on top of the instrument panel. A route is calculated using the keyboard interface, presumably while the car is

stationary. The driver is given instructions to begin driving and then to make the manoeuvres suggested by the calculated route. The problem is that the route cannot consider turning restrictions and one-way's because they are not in the database. When a driver must ignore an instruction because it is incorrect, a new route is automatically re-calculated. Following this trial-and-error process, the driver probably reaches the destination, and the software appears to have guided the driver quickly and safely to the desired location.

I tested several routes familiar to me in Cambridge and Boston, Massachusetts with one of these packages. In every case, the routes traversed one-way streets in the wrong direction and suggested illegal turns.

Should such software be allowed? Are there any voices being raised to suggest that selling such software to unsuspecting consumers is irresponsible? Thus far, I have only seen glowing reviews in PC magazines, which suggests to me that the reviewers never actually used the software, or they never understood that they were being hoodwinked.

Route Guidance will become a Convenience—But Fundamental Changes are Needed

Summarising my position thus far, route guidance is not a necessity. The provision of route guidance systems as luxury items cannot support the high costs of geographic database production. Route guidance can become a convenience, but the methods of distributing routes must generate sufficient economic returns to the database and system developers.

All the signs point toward on-board emergency response systems and traffic information devices gaining a foothold in the US and Europe well before route guidance systems become common luxury items. Route guidance systems will not take hold as convenience items, not even as add-on's to the Mayday and traffic information systems, until there are fundamental changes in the methods used to deliver route guidance to drivers.

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, why travellers cannot reach their destinations on their own. Answering this "Why?" holds the key to route guidance systems becoming a consumer success.

A Proposal for Future Route Guidance Systems

My premise is that if ***cities*** were designed for today's mobility requirements, or if ***vehicles*** were designed for yesterday's cities

(which is what most cities are), there would be no need for route guidance systems—or perhaps even maps. But most large metropolises have evolved over centuries and reflect the past more than they enable the present. And, while today's safe, comfortable cars satisfy the desire—the necessity—for personal mobility, the modern-day vehicle is a problem to store, is a potential hazard to its occupants and pedestrians, requires large amounts of real estate for roads, which, at great expense, are made less attractive than they were before being paved over.

It is Our Cities That Make Route Guidance Essential

Route guidance systems 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 or the concentric rings and radials of Amsterdam, is the city's "deep structure." 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.

Some cities, such as Paris in the 1850's and 1860's, underwent restructuring to make movement easier. Nevertheless, the deep structures of most 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. It is paradoxical that cities exist to provide for the interchange of goods, services and interaction among people, but have been built to accommodate isolated activities (sleeping, eating, working, recreating) with very little thought given to how people should move between these 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. They have applied a "surface structure" in the form of city coding schemes, such as area names, street names and building addresses. They have developed sets of rules that regulate movement along streets and the placement of vehicles when they are not moving.

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. Even anomalies like Broadway 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 breaks the logic of consecutive numbers and hides the street within the city's grid. (I am not certain when Fourth became Park, or how Lexington and Madison inserted themselves, but I intend to do some research on this subject.)

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. Few signs 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 an 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" (ITS:intelligent highway systems; May/June 1997) 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. In his book, A Theory of Good City Form (MIT Press; 1981), 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 2.4 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. Travelers 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. Travelers 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.

The author of the 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.

Implementing Irresistible Route Guidance Systems

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

City officials have not exhibited 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. 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 population.

The report states 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 appear to be hostile toward route guidance systems, especially those systems which incorporate dynamic traffic information. An article in the Intelligent Highway (July 7, 1997) reports 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 and traffic planners in a 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 they have worked within the paradigm of collecting a string of streets together into a route. 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 an 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.

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.

Concluding Thoughts

The real potential value of route guidance systems will be reached when the following can be said of them (by consumers and journalists alike):

- 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!

A geographic database in the vehicle which contains an accurate and precise representation of the road network—and which is constantly updated with new and changing information--is essential for most of the functions that will make route guidance systems really useful, a necessity.

Notes: