Michael L. Sena Consulting AB
Mobility Research Special Report

ITS Trend Report

Where we are today, and where it looks like we will be tomorrow

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Introduction

This *Mobility Research Special Report* was prepared at the request of an automotive client. Information contained in this report has been assembled soley by the author, and statements made in this report represent the author's personal, professional views on the subjects.

Scope

The *Special Report* includes the following points in detail:

- Mid-term and long-term technological developments and leaps in technology, as well as state-of-the-art activities in the technology field "Intelligent Transportation Systems", and the implications of the most important of these developments for the automobile industry.

- The relative positioning of the international competition with respect to the above-named technology field.

- A list of centres of excellence in research and technology worldwide in the above-named technology field, as well as the best-in-class companies active in this field.

Specifically:

- Perspective on the introduction of future ITS systems (both autonomous and telematics-based) expressed in likely rollout schedules.

- Identification of major roadblocks and obstacles (lessons learned).

- Assessment of the current government initiatives, likelihood of regulatory changes as a consequence of them.

- Assessment of the competitive strengths and weaknesses of the individual OEMs in the ITS field.

- Assessment of the developments in the triad markets (in particular to the availability of infrastructure, seed funds, system deployment incentives).

- Assessment on the applicability of ITS solutions in China

ITS Trend Report

Where we are today, and where it looks like we will be tomorrow

I. ITS Technological Developments and their Implications for the Autombile Industry

1.1. Background

Intelligent Transportation Systems (ITS) apply information technology to the interaction between humans, all forms of transportation infrastructures and vehicles, and the environment in which these interactions take place, in order to improve the safety, convenience and efficiency of personal, collective and commercial mobility. The term ITS came into general use in 1994 with the first ITS World Congress in Paris, France, but it was iintroduced earlier in the US. The Intelligent Transportation Society of America was established as a not-for-profit organisation in 1991 to coordinate the development and deployment of ITS in the United States. ITS America quickly developed alliances with ITS organizations in other countries, most notably in Europe and Asia. Japan founded VERTIS in 1994 as an equivalent to ITS America. The name was changed from VERTIS to ITS Japan in 2001. The equivalent European industry organisation, ERTICO (European Road Transport Informatics Cooperation Organisation) also uses the term ITS Europe, and many countries in Europe and other parts of the world have their own ITS industry associations.

There are eight major areas in which developments and deployments of ITS are taking place[1]. These areas and some examples of applications are:

- Traffic Management
  - Optimisation of traffic flow
  - Provision of traffic restriction information
  - Electronic toll collection systems
- Road Management
  - Maintenance
  - Road access
  - Roadway hazard provision
- Public Transportation Operation and Management
  - Information provision

[1] Prepared with the assistance of the ITS Handbook 2003-2004; Highway Industry Development Organization; Japan Ministry of Land, Infrastructure and Transport.

    - Intermodal transfer
- Commercial Vehicle Operation
    - Automated platooning
    - Fleet and freight management
- Emergency Vehicle Operation
    - Automated emergency notification
    - Route guidance for emergency vehicles
    - Disaster relief
- Assistance for Safe Driving
    - Provision of driving and road conditions information
    - Danger warning
    - Advanced driver assistance systems
    - Automated highway systems
- Support for Increased Driving Convenience
    - Navigation systems
    - Provision of traffic information
    - Provision of destination-related information
- Support for Pedestrians
    - Pedestrian route guidance
    - Vehicle-pedestrian accident avoidance

Addressing each of these areas is beyond the scope of this *Special Report*. What will be covered are the vehicle- and driver-centric functions within ITS, specifically advances in the interaction between the vehicle and the infrastructure services, the vehicle and other vehicles, and the vehicle and the driver. The table below provides a sample of these functions.

Car to Car *Collision Avoidance*	Car to Driver *Wake-up Call* *Intelligent Speed Adaptation* *Steering Assistance* *Breaking Assistance*	Car to Services *Theft Notification* *Automatic Emergence Assistance* *Toll Payments*
Driver to Car *Environmental Control* *Steering Breaking* *Acceleration* *Shifting* *AudioControls*	Driver to Driver *Signal Driver Intentions* *Traffic Warnings* *Location Identification*	Driver to Services *Manual Emergency Assistance* *Information Request*
Services to Car *Stolen Vehicle Tracking* *Remote Door Unlock* *Remote Diagostics* *Remote Repair* *Remote Database Update*	Services to Driver *Traffic Alerts* *Location Assistance* *Navigation* *Weather Alerts* *All Mobile Services* *InformationDelivery*	Services to Services *Ambulance* *Roadside Assistance* *Fire* *Police*

The term **Telematics** is used to describe many of the functions included in the above table. Telematics is two-way communications between a vehicle and a service center. Data communications are a pre-requisite for all services. Voice communication is necessary for some functions, desirable for others, and non-essential for most. Adding a positioning device in the vehicle and mapping capabilities at the service center enables a range of location-based services to be provided.

Telematics services can be vehicle-centric, driver-centric and/or passenger centric, but in all cases telematics refers to services which are delivered to a vehicle to enhance safety, security and comfort, and from a vehicle to provide information about the vehicle, its passengers or the vehicle's interaction with the transportation infrastructure. Updating software in the vehicle; reporting faults that can be fixed by such updates; delivering information from the car on the surrounding traffic situation; providing the latest information on the transportation infrastructure to the vehicle for ADAS[2] functions; sending out a mayday in case of an accident; unlocking the car when the keys have been left inadvertently inside: This is a sample of what telematics is all about.

Many of the vehicle- and driver-centric ITS functions listed in the table above will be available in most new vehicles by the end of this decade. Whether the drivers of the vehicles will be aware of this fact, or whether the functions will be integrated in an increasing number of systems that are invisible to the driver, remains to be seen. Many companies will make businesses out of delivering systems and services to the automotive OEMs and the car owners. However, for the automotive OEMs, these systems and services will be incorporated into their vehicles as part of the evolution of the vehicle, implemented to stay competitive and sell to more cars or trucks or buses, or to comply with increasingly stringent government regulations. Cars and trucks and buses will be safer, both for their occupants and pedestrians, they will be easier to drive by an increasingly elderly population, and they will be more convenient to own as a result of the addition of these new functions.

[2] ADAS – Advanced Driver Assistance Systems

Between today and when telematics devices are available in all vehicles there is much that needs to be done. One of the major tasks is to improve the *telecommunications infrastructure*. It needs to provide reliable service everywhere at affordable prices. It does not do so today. There are too many gaps in service, too many uncertainties when one operator hands off to another, too few well-adhered to standards at the operations level, and all at a cost that is still too high for the many applictions that will depend on the infrastructure[3]. It is likely that some government regulation will be needed to accomplish both functionality improvements and cost reductions.

Further, the IT platform in the vehicle needs to become more standardised, more stable, less brand-specific. When cars were isolated objects that could function with only the input of the driver, everything could be purpose-built if the buyer could afford it. Now that the car companies have decided to replace electrical systems with electronic, the car manufacturers are going to have to figure out how to get paid for fixing cars remotely rather than in their dealer's workshops. With 80% of today's profits derived from parts, accessories and service, the car companies cannot afford to give anything away that their customers had paid for previously.

1.2. Perspective on the introduction of future ITS systems—autonomous and telematics-based—expressed in likely rollout schedules

1.2.1. Market Drivers

There is a business context for making improvements to any product, and vehicles are no exception. Between 1996 and 2002, most automotive OEMs either had initiated operational telematics programs, or had evaluated the requirements and decided to wait for a more opportune time to implement these new systems. Companies with active telematics programs in Europe were: GM, DaimlerChrysler, BMW, Fiat, Audi and Volvo. In North America, they were: GM, BMW, DaimlerChrysler (Mercedes), Saab, Nissan Infinity, Toyota Lexus, Honda Acura, Subaru, Audi, Jaguar, Lincoln and Volvo. Those who had started and then halted their programs included Renault and Ford. Ford's highly publicised investments in Wingcast, its rival to GM's OnStar, and its peremptory closing before services even started, signalled a period when the automotive OEMs took a step back from the hype of the dot.com era. That was when telematics was going to "change the automotive paradigm" and propel car and truck manufacturers into distributors of very large information appliances (i.e. their vehicles).

The automotive industry has its own dynamics. Companies involved in it make (or lose) money as a result of selling (or not selling) a sufficient number of vehicles at prices that are suitably high to cover their costs. This sounds like any other industry that sells products, and to a certain extent it is, but it has very particular qualities that dramatically affect its ability to invest in new developments like ITS functions.

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[3] During the implementation of telematics services, it was found that base station systems from different manufacturers (e.g. Nokia and Ericsson) handled calls differently and required special software fixes in order to provide smooth transitions of voice calls in a moving vehicle.

Car Manufacturer's Perspective

The automotive industry does not normally invest in high risk projects because the payback for success is minimal and the result of a failure can be catastrophic. Payback for breakthrough investments is minimal because the number of people buying cars in the three major markets is relatively stable, and the probability is very low that one company will be able to take double-digit percentages of sales from rivals. The automotive industry is characterised by low or negative growth that is cyclical. Car and light truck sales in Western Europe increased in 2000 and 2001 over the previous year by only 1%. They decreased by 1% in 2002 over 2001, and they are projected to decrease by a full 3-4% in 2003 over 2002. Sales are projected to rise again in 2004 as the world economy emerges from war and recession. Some automotive companies have been more affected than others by economic conditions, but for different reasons. Fiat's sales have plummeted because it simply stopped building cars that people wanted to buy, compared to its closest competitors, Renault and Peugeot/Citroen, as well as the Japanese small car companies. Jaguar produced more cars, but the company has neglected one of the most important drivers in the automotive industry today: cost control.

Product development cost control and operations cost reduction are the two most important considerations for car manufacturers today as they desperately try to increase shareholder value. As Fiat's current struggles show—and in the past, those of companies like Chrysler, Jaguar, Rover and many others bare witness to—profitable companies survive, while the non-profitable ones are acquired or forced out of existence by unhappy shareholders.[4] The global economic recession between 2001 and 2003 has put pressure on sales, and car companies have used financial incentives (rebates, low interest and no interest loans) to compete for the available buyers. Margins on cars sold during this economic downturn were razor thin. GM was making only an average of $350 on every car it sold. It actually lost money on most of its sedans sold in the US. Volvo made an average profit of $435 per vehicle, but made an additional $1800 per vehicle on parts, service and accessories. To use another razor analogy, the car has become the razor, and parts, services and accessories have become the razor blades.

Car manufacturers have pressed their Tier One suppliers extremely hard during the past ten years, and there is little more they can give in price reductions. The main areas left to cut costs are in the marketing and warranty areas. One area of possible savings is warranty breakdown assistance. It is a large marketing outlay for every car company, between €20 and €50 per year per vehicle for the life of the vehicle's warranty. The car manufacturers would like to halt the practice, which was started by Volvo in the US less more than twenty years ago and eventually was adopted by all car companies and spread to Europe. But consumers have come to expect it. One company could not drop it without putting itself at a huge competitive disadvantage.

As a driver for telematics investments, cost pressure is both positive and negative. It is positive because telematics can be directly related to future warranty cost reductions by enabling remote diagnostics and remote software upgrades. It is negative because short-term cost reduction decisions might be

[4] Vehicle manufacturers collectively have had a negative shareholder value creation of –20.8% during the period of 1998. This was during the period that the overall market was increasing.

made by cost-conscious platform managers, with the result that telematics applications are reduced or eliminated[5].

Next to cost issues, market share protection is the highest priority for car manufacturers. They have found that the best way to maintain market share is to promote brand loyalty, that is, to keep existing customers rather than investing in acquiring new ones. They have to match or better their closest competitors in customer satisfaction surveys, and they have to match or better their closest competitors in the consumer reports surveys—value for money and the most features for the least amount of money.

Standing out in a crowded car market is not easy, especially since the automotive industry is characterised by homogeneity. Cars have different styling, different feature packages, different prices, but at the core, they are all basically the same product[6]. Companies compete within narrow buyer brackets: income; age; life-style; location. They compete to keep market share and possibly to steal a few fractions of percentage points from their competitors. Companies rarely have a monopoly on features for more than a car season because their competitors adopt and adapt them as soon as they know about them, and they know about them usually because auto companies are keen to invest in competitive research. More importantly, their Tier One suppliers are selling the same products to all of their competitors. They all purchase from the same Tier One suppliers. Cars have achieved a level of sameness because there are few rewards for sticking out from the crowd. No one wants to be first with something new unless they are almost certain that their competitors will follow shortly after. If competitors do not follow, it means that the feature has been a failure and their investments worthless.

The implications for vehicle- and driver-centric ITS functions are clear. No automotive OEM wants to be first with a pan-European telematics service because the costs are extraordinarily high and it is not enough of a differentiator to drive sales. On the other hand, when one or two companies have achieved it, all of the companies must follow. As long as DaimlerChrysler, BMW and Volvo had working systems in their home markets only, there was no pressure on the lower-end manufacturers to develop systems. When all three manufacturers announce new market openings in 2004 (BMW announced Dubai on January 21, 2004), it is likely that many of the other manufacturers will begin to roll out their own products. These products are already under development, even though they are not discussed publicly.

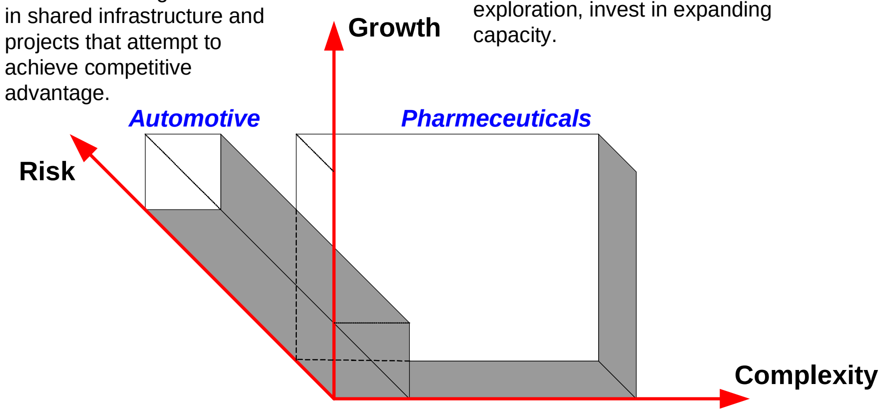
I have found the diagram below to be useful for describing the decision factors, "hot buttons", driving the auto industry. Auto companies invest in cost reduction and better information systems and processes to achieve cost reduction. They invest in what their competitors invest in, and they invest to learn about what their competitors are doing. They have not normally invested in shared infrastructure projects to achieve competitive advantage, and when they have (e.g. Wingcast) they have been major failures. The risk of failure is too great. Unlike other industries, like pharmaceuticals, there is no possibility of major

[5] In one example of this cost cutting mentality, the Volvo On Call system was eliminated from Volvo's flagship vehicle, the XC90. This means that Volvo's introductions of Volvo On Call in new markets cannot be sold on its most important product.
[6] "General Motors and Coca-Cola (have) enjoyed a relatively stable product paradigm—for more than a century, cars have had four wheels and a combustion engine and consumers have sipped caffeine-laced soft drinks." Gary Hamel and Liisa Välikangås: *The Quest for Resilience*; Harvard Business Review, September 2003.

growth in the existing markets. If anything, with the demographics of Europe showing population contraction, fewer cars will be sold. Emerging markets for vehicles, like China and India, are growing at a faster pace than Europe, North America and Japan, but they have started from a much lower base. New, local competitors in these markets are being established to meet demand. Unlike pharmaceuticals, where there are thousands of different illnesses that need treatment, the car industry builds one basic product that is very similar to all of its competitors' products.

What this means is that those trying to sell the idea of telematics into the automotive OEM boardrooms, whether from the inside or from the outside, must position telematics as a feature that first and foremost will reduce costs, keep customers loyal, and will be a feature that all other cars in its class will have in the near future. They should not be promoting telematics as a growth opportunity. The growth component is as a non-core business, which even at its best, does not add significantly to the core's source of revenue for car sales and sales of parts, services and accessories[7].

Investment Decision Factors



Automotive companies are highly risk averse, have low growth and low complexity. In contrast, pharmaceutical companies take large risks because the rewards are great, are in a high-growth field, and operate in specific medical niches that are largely independent of one another.

[7] As an example, General Motors' OnStar, which had approximately 3 million paying customers at the end of 2003 had 1200 employees and $300 million in turnover. This is less than one percent of GM's global earnings.

The principal reason that an automotive OEM will bear the cost of installing a telematics system in its vehicles is to get a communications device into the vehicle to achieve cost reductions, and to enable better communications with the customer to promote brand loyalty and improve customer satisfaction. Providing safety, security and convenience services, like those being offered today by some companies, and the advanced driver assistance systems being planned for the future, are necessary responses to competitive forces and government regulations, and to the extent possible, the automotive OEMs will try to get the customer to pay for them. Is the customer interested in paying for them?

End-user Perspective

According to a recent survey[8] conducted in Europe of 55,000 car drivers, the top reasons for buying a new car are:

- Price
- Reliability
- Comfort

Beyond the top three reasons, other reasons vary by nationality and stage in life. Quoting from the survey results:

- Germans worry least about safety or car style
- The French value security
- The British and young buyers in general, care most about style
- Speed ranks among the lowest considerations of all buyers, but it is important to the under 35-year-olds age group, especially men.
- Women are most influenced by safety and security.

An automotive product planner or marketing executive will be hard pressed to find a clear indication from available research that a consumer will choose to buy their brand because it has a telematics system, or will pay real money to have a telematics system and its services. There are no surveys of which I am aware that show either telematics or other in-vehicle systems or services as a reason for making a certain car purchase. There are consumer surveys that have been made by organisations like J.D. Power which have tried to determine which ITS features consumers might like to have, and their potential for purchasing vehicles with these systems.[9] The top four items on their wish list were roadside assistance, vehicle diagnostic information, real-time traffic information, and navigation information.

However, if we go beyond the model of telematics as a box with buttons, and look at how the fundamental components of telematics systems will be used in delivering a better, safer, more convenient and, perhaps, less expensive driving experience, there are clearly areas where consumers will accept these systems even though they may not ask for them specifically.

[8] Survey conducted by TGI Europa 2003. Data analysed by Nick Hiddleston, international research director at media buying and planning specialist Initiative Media. Report in Automotive News Europe, July 28, 2003.
[9] JD Power 2001 Automotive Emerging Technologies Study – Wave I & II

There is growing support among the public for speed safety systems. A market research report funded by the Federation Internationale de l'Automobile (FIA), indicates that "70% of those surveyed would support an audible in-car warning or a dashboard display that alerts them to the legal speed limit on residential roads and on trunk roads in built-up areas."[10] This result is consistent with results reported by the Swedish National Roads Administration following their tests of ISA (Intelligent Speed Adaptation) in Sweden.

Support for tolling schemes is mixed. Residents inside toll zones are in favour, while those immediately outside oppose them since they are the ones who will be most affected by them. Surveys of London residents following the institution on road user charging in Central London confirm these findings. Proposals by the Mayor of London to extend the zones have shown that there are split feelings. Those inside the new areas welcome them because they will pay lower fees (10% of the total £5 per day), and those in the new adjacent areas dislike them because they will have to pay to drive into areas that previously were free. The technology used in London does not require any in-vehicle systems. It is all based on cameras photographing vehicle registration plates and comparing the numbers to a database of those who have paid their fees for the day.

As traffic congestions worsen in large urban areas, more tolling schemes will be implemented, and the technology for tolling will increasingly be via telematics devices installed in vehicles, rather than with other methods. This has already started in the commercial truck arena. A new scheme in Germany for heavy truck tariff payments is based on telematics devices being installed in every truck that drives in and through the country. These devices are being installed for free by a consortium that is charged with managing the entire operation and collecting the tariffs.[11] When the German government announced the winner of the competition that was held to select tolling operator, there was an organised effort by competitors to each of the winning team companies to prevent them from having a monopoly on delivering telematics services. The objectors eventually prevailed, and the consortium has established a separate company that will manage all third party telematics services delivered to the in-vehicle devices.

1.2.2. Recent Trends

The automotive industry has already started to sell rudimentary advanced driver assistance systems (ADAS) that function with the aid of vision systems, usually radar. Automatic headlight steering to guide lights around corners is one of the first such systems, and it is being heavily advertised on billboards and in the media. The next generation of these systems, available near the end of this decade, will use geographic data to provide an "electronic horizon" to the ADAS applications. The road of travel with a positional accuracy that is ten times greater than what is available today and with much higher levels of attribute richness, will be used to guide these next generation systems.

Today, map data in vehicles is used for navigation systems. This data is delivered to the applications on CD/DVD media that can be up to eighteen months out of data when the customer receives it from the car manufacturer, the system supplier or the map data producer. Although inaccuracies in the data for

[10] Reported in The Intelligent Highways (September 15, 2003), page 10.
[11] The Toll Collect consortium consists of DaimlerChrysler, Deutsche Telekom and Cofiroute.

navigation purposes are inconvenient, they are rarely lift-threatening—unless, of course, the navigation system is being used in an emergency service. When this data is used for braking assistance or curve warning, it must be 100% up to date.

These higher demands on the data will necessitate constant updates of both the physical infrastructure and the attributes associated with the features in the infrastructure. This requirement is one of the principal reasons that car companies are working hard to install a communications device in their vehicles and to ensure that an communications infrastructure is in place to deliver data to and receive data from their vehicles.

There are several technical approaches aimed at reducing both hardware and operations costs that are currently being evaluated by the car industry and its suppliers. One approach is to have a customer SIM-card both for telematics services and private voice services. The objective is to remove the SIM-card from the entire hardware and operations equation and thereby significantly reduce costs.

The second approach is to have an embedded telematics SIM-card, but to limit telematics functions to data-only services. Any services that truly require live operator intervention, such as roadside assistance and emergency assistance, would be directed to the customer's private wireless device using Bluetooth, 802.11b, or a similar wireless LAN interface. All data services would be handled by an embedded SIM-card that is purchased by the OEM, the system manufacturer, or the service provider for a one-time cost. Ongoing costs for service usage would be billed to the customer and/or the OEM. Except for the limit on voice transactions, this is similar to Volvo's approach, in which there is an embedded SIM-card and Volvo has the billing relationship with the SIM-card provider (Vodafone Sweden)[12].

Embedded, data-only SIM-cards are being recommended by the network operators who claim that it is the only way they can offer the OEMs lower prices for data services. The network operators who provide the SIM-cards say that the regulators in each of their countries force them to offer equal pricing to all customers. They cannot, according to the regulators, offer one pricing structure to one set of customers, and a second to another set--as long as the services are equal. So, they argue, if the OEMs are willing to change the service so that only data is offered, they can lower the data prices below what they charge their other customers who want both data and voice.[13]

Another trend is the switch from GSM/SMS to GSM/GPRS (General Packet Radio Service). The main drivers for the switch to GPRS are a potential reduction in data transfer cost, and an increase in the amount of data that can be transferred in a shorter period of time. GSM/SMS is used by the majority of telematics systems in Europe. Even though the amount of data that can be

[12] Volvo has a full-function SIM-card purchased from Vodafone. It is a standard Vodafone Sweden SIM-card with an index of telephone numbers for each of the countries where Volvo On Call is offered. However, it functions like a so-called "re-homing" SIM-card that is manufactured to become a local SIM-card as soon as it enters a market from its manufacturing source. Volvo purchases identical SIM-cards from Vodafone and delivers them to Autoliv, who install them in each of the telematics systems that are delivered to the Volvo factory for installation in vehicles. There is no distinction at the installation stage between systems installed for one market versus systems installed for another market. When the car is delivered to the destination market and the first service is initiated, the SIM-card is registered as a local SIM-card by Vodafone in that market and local rates are charged for all voice and data calls.

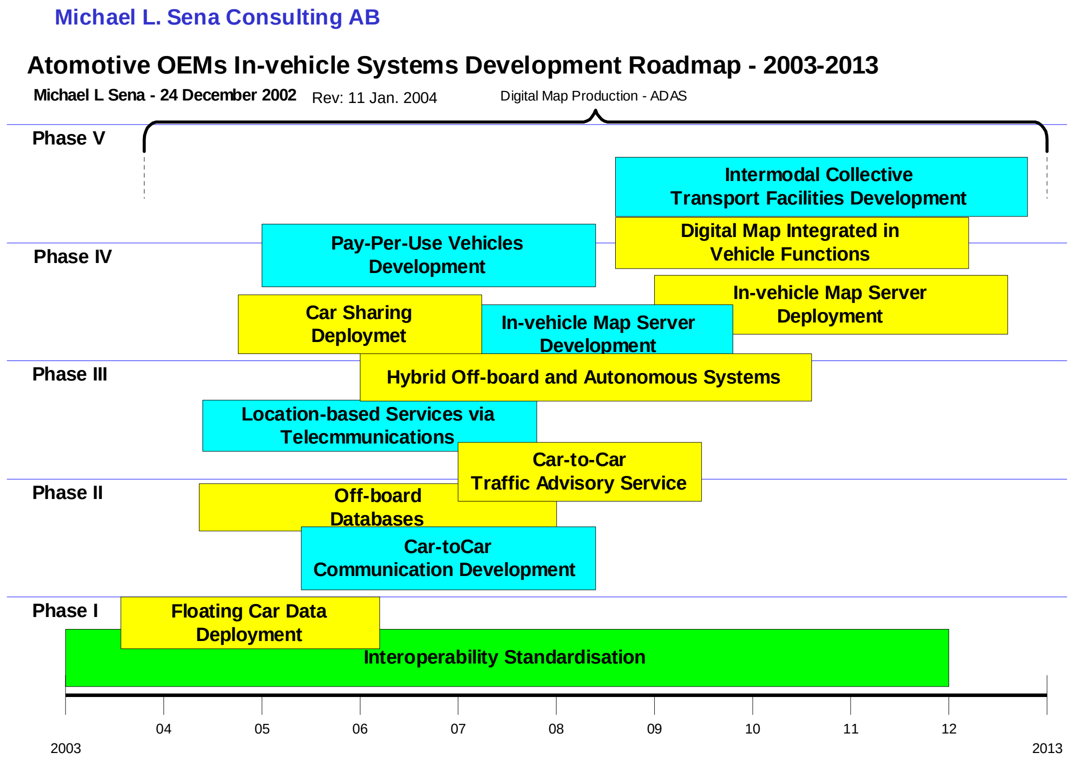
[13] This is first-hand information, not hearsay.

transferred is limited to 160 character messages, the method is reliable and fast, and SMS's can be sent from both the in-vehicle device and from the service centers. GPRS, with its always-on connectivity and faster data transfer rate, will enable more services, such as diagnostics, software maintenance and software uploads, and off-board navigation, that require larger data transfers that are both impractical and costly with GSM/SMS. However, GPRS is not yet a stable technology. It does not yet work as flawlessly as SMS. Another major problem is that the network operators have not yet signed GPRS roaming agreements to the extent that they have for SMS. And the connection must be established by the wireless device, which means that for some services there will have to be a continuation of SMS alongside GPRS or some time.

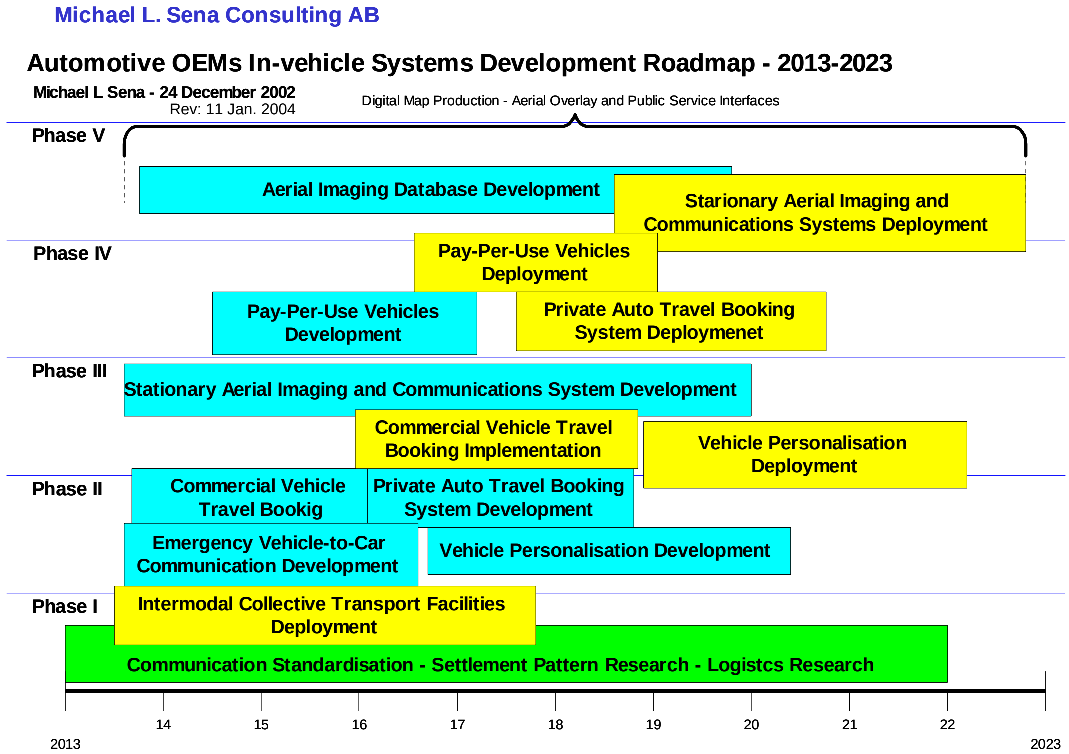
1.2.3. Vehicle-centric ITS Road Maps

What are the prospects for these factors changing positively or negatively during the coming five-to-ten years and beyond? Nils Bohr is attributed with saying, "Prediction is difficult, especially when it involves the future." But concerning telematics, there are certain inevitabilities, and a number of predictabilities. Many telematics developments have made significant progress because of one or a combination of the two market drivers listed above, and the government issues described in Section 1.4. (i.e. consumers want them, governments demand them, companies offer them), and these developments will be brought to market as products or services during the coming ten years.

In the diagrams below, the first for the coming decade, and the second for 2013-2023, the yellow boxes are developments that can be commercialised based on research and productification that has been occurring during the previous decade. In the first diagram, floating car data for traffic information collection is already deployed by, for example, Trafficmaster and Targa Infomobility's bConnect in Italy. Centralised map databases used in off-board navigation systems are in 2003 already being introduced to the market on a small scale. DaimlerChrysler is already offering a PTV-basd system in it's A-class and Smart vehicles. Systems from Wayfinder (Sweden), Telmap (Israel), T-Mobile Traffic (Germany) are in the pre-commercial phase. Blaupunkt's navigation radio will be the first large-scale introduction of this technology. These services require an in-vehicle device that combines telecommunications and positioning—a telematics device. As they are implemented by the vehicle OEMs and their suppliers, and as they grow in number, they will foster an increasing demand for connectivity, for end-to-end telematics solutions and all the services that support these solutions.



The automotive OEMs, their Tier One suppliers, and many of the small companies who support them, have decided on their research objectives for the coming decade—again based on their best guesses of what their commercial customers will have to purchase and install because of the push of government and the pull of consumers—and they include the items in the blue boxes. Car-to-Car communications, in-vehicle map server development (to simultaneously support navigation and Advance Driver Assistance Systems), and pay-per-use vehicle development are all being worked on for implementation in the following decade or sooner.



Within the 2013 to 2023 timeframe, the research projects of the previous decade should see implementation and commercialisation, as shown in the yellow boxes. The research program for the 2013-2023 timeframe is less certain. However, through a combination of interviews with car manufacturer research program directors and constant analysis of technical and business information sources, I have pieced together a picture of what I believe is a highly likely pattern of development of ITS products during the next decade, as shown in the blue boxes in the diagram above.

1.3. Identification of major roadblocks and obstacles—the lessons we have learned thus far

The Next Twenty Years

Inevitable	Invention	Predictable
Given the choice, individuals will choose to travel in their own vehicles, according to their own schedules	Personal Mobility	The tradeoff between societal costs and personal mobility will make the private automobile an increasingly less attractive option
Governments will legislate road usage pricing in order to reduce the societal costs of congestion	Collective Mobility	Traffic congestion will eventually eliminate the advantages of personal mobility
Globalisation will increase the need to transport goods for both manufacture and distribution, increasing the demand for road transport as the most cost effective option	Commercial Mobility	Traffic congestion will eliminate the advantages of trucks over fixed rail and air transport
Economic growth is now largely dependent on businesses and consumers using more data	Information Mobility	Information available to individuals will eventually exceed our ability to process and use it
Individuals desire more, not less, customisation	Ownership Mobility	Private cars will eventually become too expensive for most people to own
The Push for Inventions		The Pull for Inventions

The table above, *The Next Twenty Years*, shows where I believe inventions are needed to address the inevitable and predictable consequences of the dominant position that cars and trucks have achieved as transportation modes. The focus for inventions should be the following:

- Personal Mobility

Develop personal tranport that adapts to the needs of the individual driver, the driving environment and the driving task.

- Collective Mobility

Participate in developing a collective transport infrastructure that people want to use, that is truly integrated with and supportive of the personal transport system. Develop collective transport vehicles that can function in this infrastructure.

- Commercial Mobility

Participate in developing the infrastructure in which heavy trucks can operate safely and effectively, and develop commercial vehicles that can function in this infrastructure.

- Information Mobility

Participate in developing a seeing, feeling and hearing information infrastructure that will allow drivers and passengers to obtain the information they need when they need it, and to communicate their needs and desires to the appropriate recipients.

- Ownership Mobility

Develop vehicles that provide a personal sense of ownership to different drivers of these vehicles, and participate in developing the infrastructure that can manage the shifts of ownership

The obstacles and roadblocks that will inhibit invention are, in my view, the following:

1.3.1. New car and truck sales

Worldwide new vehicle sales are predicted by most market forecasters to grow by 5-6% through 2005, from 49 516 million units in 2003 to 53 867 million units in 2005. These increases will be sufficient for most car companies to continue to fund their vehicle- and driver-centric developments, but they are not sufficient to make them standard fit. Much of this 5-6% growth will come from developing countries where the service infrastructures that are necessary to support ITS functions will not be available for many years in the future. The navigable map data, traffic information, address and points of interest location information does not exist as yet in most of the high growth areas of China, India, Africa, South America.

1.3.2. Types of vehicles sold

The luxury car segment will expand as a total percentage of all car sales in the established markets. It is this segment that will provide the primary support for the implementation of vehicle- and driver-centric ITS systems. Heavy price pressure from consumers will mean that automotive OEMs will need to incorporate telematics in an option package, rather than making them standard, in order to recover some or all of the costs. The situation is different in North America, where it is more common for a dealer to order cars for display to attract buyers, rather than to build cars to customer specification. Buyers in the US are used to comparative shopping, and buying what they see, rather than ordering a car and waiting for several weeks (or months) for delivery. For the US market, it is more likely that telematics systems will have to be standard fit in a model range just to get past dealer resistance to order cars with features that they may have to give away to the customer when bargaining for a sale.

1.3.3. Technical capabilities

A major breakthrough for telematics will occur when the emergency services are able to communicate directly with vehicles, rather than having to route emergency calls through third party telematics service providers. This is not likely before the next decade because the emergency authorities have only recently started to address this issue. There are initiatives that have started in Europe led by the European Commission's mobility services sector directorate general for the information society (DG Info). They have published a report titled *Information and Communications Technologies for Safe and Intelligent Vehicles*. The report provides a set of guidelines for different areas of safety, including vehicle-to-vehicle and vehicle-to-infrastructure communications. A budget of €8 million has been provided by the EC to be spent over a three-year period in research into standardisation and technological developments. Only after the research phase can there be any progress toward a single, standard approach in all European countries. By then, countries like the UK, which already have a method of enforcing vehicle-to-emergency services communications, will have to be convinced to adapt their current approach in order to harmonise to a standard. When it comes to standardising at the public policy level, there are always significant delays. Perhaps a decade is an optimistic estimate.

Until the results of initiatives like those in eSafety are completed in all of the major European countries, systems will be dependent on connectivity and data routing services, like the one for Volvo On Call in the UK, or for first contact services like OnStar in the US, TeleAID, BMW Connect or Volvo On Call in Europe and the US.

1.3.4. Wireless communications

As stated earlier in this *Report*, the status of the wireless communications network is one of the biggest inhibitors to the general adoption of telematics solutions. As the usage of GPRS spreads and as network operators finalise their roaming agreements, GPRS will replace GSM/SMS as the message bearer. This will increase the range of services that can be provided. Gradually also, 3G and then 4G will be introduced. These improved telecommunications technologies will simply make it easier and faster to download large amounts of data to the vehicle and enable new services that cannot be contemplated with today's 2G and 2.5G technology. However, there are significant problems that must first be addressed.

Successful completion of an information request and information delivery requires the availability of a communications network (bearer service) that is compatible with the communications device, and the use of message transfer protocols that are compatible with the sending device, the intermediary (relay station) and the information source. Bearer service availability varies among the major markets (North America, Europe, Japan)[14]. Each market has a primary bearer service technology--in the case of North America, multiple technologies--which is not compatible with the other technologies. This is due to the establishment of different standards for radio frequency transmission. Within each market, service availability varies, depending on access to a cellular receiving station by the communications device. Remote areas are often not covered sufficiently by cellular receiving stations, and as a result, there are areas where cellular service is not available.

Protocols for message transfer are today primarily device- or application-specific. Examples are Motorola's ACP (Automotive Communications Protocol) which is used in the telematics systems developed by Motorola; GATS (Global Automotive Telematics Standard) used by the European telematics and consumer travel information industry in Europe.

What needs to happen for a connection to be made between an in-vehicle communications device and an application server, and for the session to be successfully initiated and completed?

- The user must be inside GSM coverage. If the user is in his or her home market, the coverage must match that of the network operator with whom the user has a subscription. If the user is out of his or her home market

[14] The major difference between Europe and the US is the existence of a single bearer standard in Europe: GSM. In the US digital services TDMA, CDMA and a version of GSM compete with AMPS, the ubiquitous analog service. Another difference is that TDMA and CDMA currently have poor data services compared to GSM.

(i.e. roaming), it should be sufficient that any network operator covers the user's current location—unless the system is restricted by agreement to a set of preferred networks and cannot roam into other networks (See 4.1.2. for exceptions).

- If the service uses packet switched data versus circuit switched data (e.g. GPRS or I-mode versus GSM data), there must be service available. If the user is roaming outside the home area, there must be an agreement in place between the user's network operator and the foreign network operator into whose coverage the user has roamed.

- There must be an active connection between the connection point and the application server.

If any one of these links is not functioning, there will be no service available to the user. At this stage in the evolution of wireless networks and location-based services, there are no guarantees that users will experience 100% success in connecting to a service in every section of every country.

Connection in the home market

For a SIM-card[15] in the user's home network, where it is not possible to roam into other networks, coverage can be a problem in some geographic areas. Usually, the incumbent network operator (former state monopoly telecommunications company) has the best coverage. If they are not forced to share their network with their competitors (as they are in some countries, like Iceland), a customer with the incumbent's SIM-card will have GSM access when a non-incumbent's customer will not. Since building wireless infrastructure is costly, network operators attempt to match coverage to where people live. In Sweden, two-thirds of the population live in the southern one-third of the country. Vodafone, the largest non-incumbent, has excellent coverage in the southern section of the country. In the middle one-third of the country, its coverage is concentrated along major roads and in the largest population centres. In the top one-third, it coverage is sparse to non-existent. TeliaSonera, the incumbent, has good wireless coverage over the entire country.

GSM availability is mostly problematic in the geographically large but sparsely populated countries (e.g. Sweden, Finland, Norway), and in the rural and underdeveloped regions of most countries. GSM availability cannot simply be taken for granted, particularly in the home country where it is not possible to roam into a competitor's network.

Connection when outside the home market

When wireless GSM subscribers are outside their home markets and in foreign GSM markets, they normally have the advantage of using any of the networks available in the foreign market. For example, a Swedish Vodafone subscriber who travels to the UK can roam into BT, O2, Orange, etc. However, it is possible for a network operator to restrict a subscriber from using other networks in foreign markets if there is an agreement between the subscription owner and the network. An example of permitted restrictions is Vodafone Sweden and

[15] SIM stands for Subscriber Identity Module. The SIM-card is what a user receives from a network operator when signing up for a subscription, and which is inserted in a wireless device to make it function.

Volvo Car Company agreeing that users of the Volvo telematics system, which employs a Vodafone Sweden SIM-card, will only have access to Vodafone or Vodafone Partner networks (e.g. SFR in France; Proximus in Belgium) outside of Sweden. Without such a restriction, access to the emergency services number in certain markets (e.g. the UK) could not be guaranteed. So Vodafone places a list of preferred networks in their system that apply to the SIM-card numbers covered by the agreement. When the SIM-card enters a country, it searches for the Vodafone or Vodafone Partner network, and uses only that network.

Packet Switched Data

There are two types of network bearer services:

- Circuit Switching - A bearer service where a dedicated connection is made over a network. The user pays for the duration of the call even though data is sent in bursts. The so-called 2G networks GSM and PCS (CDMA, TDMA, GSM1900) are circuit switched networks.

- Packet Switching - A bearer service where multiple users share a single connection. It is more efficient than circuit switching, but it does not guarantee performance. The user pays only for the time used to send a message. GPRS[16] and I-mode[17] are examples of packet switched networks.

The advantages to using packet switched data versus circuit switched data are:

- Cost savings – Receiving an SMS message costs the subscriber nothing. Sending an SMS costs between €0.025 and €0.25, depending on the network and country. They are inexpensive in Denmark, and expensive in Sweden.[18] An SMS can contain 140 bytes (8-bit/character) of user data, or 160 bytes of GSM 7-bit/character data. A minimum navigation instruction set for a short, in-city route would be around 10Kbytes, require around 60 SMS's, and would cost around €3.00 in SMS-equivalents in the home market, and €15.50 in foreign markets. A GPRS message of 10Kbytes, on the other hand, would cost approximately €0.016 in the home market, and €0.11 in foreign markets.[19]

- Faster transfer of more data – GPRS is rated at 100Kbps (kilobytes per second). This transfer rate is under ideal conditions. Delivering data to a moving vehicle is not considered an ideal condition. At best, the transfer rate is between 40-50Kbps. The transfer rate for GSM data is 14.6Kbps. Three-to-four times as much data can be transferred in the same amount of time with packet switched data than with circuit switched.

[16] GPRS - General Packet Radio Service for GSM, enables more efficient use of radio resources leading to increased capacity and higher speed data services.

[17] i-mode is a brand and a service owned by NTT DoCoMO, a subsidiary of Japan's Nippon Telephone and Telegraph.

[18] There does seem to be a relationship between cost/SMS and the number of SMS's sent per person. In Sweden, the number is 16 SMS per person per month, and the average cost for an SMS is €0.16. In Denmark, where the cost is €0.025, Danes send an average of 56 SMS's per person per month.

[19] These figures are derived from actual usage of a Vodafone Sweden subscription in Sweden and the following foreign countries: UK, Netherlands, USA, Spain, Switzerland, France, Israel, Belgium.

Of the three currently available GSM services—voice, data and GPRS—GPRS is the least dependable and SMS is the most reliable. In other words, when a signal is weak, an SMS sent by a wireless device will be picked up by the closest cell tower, while voice or GPRS will not. Put another way, a mobile device can be within GSM coverage and still not be able to connect to GPRS.

While there are GSM roaming agreements in place across Europe and most of the GSM world, including with GSM providers in the US, there are currently few GPRS roaming agreements in place. I have personal experience with the lack of roaming. My Swedish Vodafone subscription works well for phone coverage in Australia where there is a Vodafone company, but there was no GPRS coverage in October 2003. I confirmed this while in the country with Vodafone Australia and upon my return to Sweden with Vodafone Sweden. So even within the same company, agreements are not in place for GPRS roaming between countries. I have also not been able to obtain GPRS coverage in other locations where GSM coverage is excellent, like Singapore, Denmark and Iceland.

Further, when in a country where there are mutual GPRS agreements, such as in the UK between Vodafone Sweden and Vodafone UK, it is still possible to lose GPRS service because of the lack of roaming agreements with the other networks in that country. This is so because it is possible to roam into other networks when outside your home subscription country and when the subscription network has weak coverage.

Finally, in places where GSM coverage is very limited, like the US, it is possible to lose all service when outside of cities and off the major Interstate road network. I had full GSM and GPRS coverage for the 200 kilometre trip from Newark to Scranton, Pennsylvania, a city of 85,000 people in the north eastern corner of the state. However, as soon as I was outside of the city limits and off the major highway leading to Newark/New York, GSM coverage, and as a consequence, GPRS coverage, were lost.

The result of this present condition is that a service dependent on GPRS will simply not work outside of the home country in places where roaming agreements are not in place, and it will be spotty even where they are. What can be problematic for a application service provider (e.g. a company offering off-board navigation services) is attempting to guarantee service when customers are using multiple SIM-cards. This problem is similar to the difficulties experienced by automotive OEM's when trying to offer consistent telematics services to their customers on a pan-European basis.

1.3.5. Standardisation versus Performance

There are currently no standard formats for route directions or map data transfer from a central server to a wireless device. There are no standards for anything related specifically to navigation content, off-board or on-board[20], except the transfer of data from the content supplier to the system developer. This is ISO/GDF, which defines the data model and coding of digital map data for features, attributes and relationships. Nothing equivalent exists for the applications side. There are proposals for standards, such as GML from the

[20] Today, unlike in the CD audio or DVD video industry, it is not possible for navigation map data provided by one system supplier on CD or DVD to be used in other systems. All formats are proprietary. It is similar to the situation in the video game market, with each system (e.g. Nintendo, Microsoft or Sony) requiring its specially formatted software and data.

Open GIS Consortium, or another XML variant from the MAGIC Forum[21]. So far, no one has taken these suggestions seriously because tests have shown that the formats do not match up well with proprietary, binary formats developed specifically for sending data (voice, graphics, maps, text) to a wireless device. The situation with off-board systems today is similar to how it was with on-board navigation developments over a decade ago. Speed of processing is determining which developers get to move forward with the OEM's research and development groups. Currently, no one on the OEM side is demanding a standard navigation message format.

<u>The question is raised:</u> Does a data transfer standard matter with the off-board solution?

A standard data transfer format matters a great deal if the data will be stored on-board following transfer, and used by other applications such as ADAS[22]. It matters less if what is transferred over the wireless connection is used in an application that is built to operate only with the data it receives, and this application has the keys it requires to convert that data in real time to the application format. If the server can package the data in a highly compressed format, send it over the most available bearer service, and have it processed by software on the client; AND, if the client can be replaced if the server side is replaced, there truly is no need for a standard content format.

This is quite different from the safety and security telematics applications in which systems in use on GSM networks have used GSM/SMS to send content, and have programmed the on-board units with several different message protocols that require translation at the service end.[23] GATS was initiated as a standards effort in order to ensure that the work being performed on the telematics platforms would be interoperable with any service provider, and on-board systems could be upgraded and interchanged without having to perform extensive retooling at the server end. Because Motorola with its proprietary ACP was first into the market, and service providers had already developed translators for it, and because Motorola did not open up its format to non-Motorola system developers, there was no chance for a single, standardised format to be used during the first years of telematics. Any service provider wishing to work with the telematics on-board units of several OEM's must have a message translator tuned to the specific message format and version of the format of the each of the units. This has lead to OEM's tending to work with single telematics service providers who have invested the time and resources to create the two-way translators that work with their specific units[24].

Such a situation with off-board navigation would create a virtual lock by a service provider on an OEM and the eventual customer. This would be

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[21] XML is Extensible Mark-up Language. GML is Geographic Mark-up Language, an XML variation.

[22] ADAS stands for Advanced Driver Assistance Systems, which include functions like curve warning, braking assistance, steering of headlights around curves, lane departure warning and other active safety features. For supplying mission-critical information, such as that required for ADAS, large amounts of data will still need to be stored on-board, and the format for supplying this data is just as important for interoperability as the format for on-board media.

[23] GATS (Global Automotive Telematics Standard) developed in Europe by Vodafone and T-Mobile; ACP (Applications Communication Protocol) developed by Motorola for its devices; GTP (Global Telematics Protocol) Developed within the Telematics Forum in Ertico ITS Europe, the objective was to combine GATS and ACP to create a standardised solution that will create a mass market for telematics. The principal developers are Vodafone, one of the original developers of GATS, and Motorola.

[24] Volvo with WirelessCar; BMW with ATX Europe; Mercedes with T-Mobile Traffic; Fiat with Targa Infomobility; GM with OnStar.

unacceptable, just as it has been found to be unacceptable with telematics. It must be possible for the OEM to switch service providers, map data vendors, client-side software and hardware without incurring major costs.

The solution to the lack of application and presentation layer standards in the short term is to use the wireless standards for the underlying transport protocols that are truly international and not to get locked into any one bearer service or over-the-air protocol because it may provide a short-term solution.

Second, any solution should treat the mobile device—the client side application platform—as any other application platform, as little different from other platforms as possible. Wireless-specific elements are a necessary part of the mobile terminal protocol stack, but they should be confined to the lower levels of the protocol infrastructure and not visible at the application protocol layer.[25]

1.3.6. Government Actions

Another major influence on growth rates will be government actions. Government authorities will increasingly view telematics as an alternative to the public sector having to make investments in infrastructure or adding personnel for management and operation of the road and public transportation infrastructures. Automatic speed controls installed on vehicles is a substitute for police speed controls or the installation and maintenance of cameras. Putting speed control in vehicles shifts the cost from the public sector to the consumer or the automotive industry. Government authorities will therefore attempt to make telematics systems standard options, while the automotive industry will attempt to block such actions because making telematics systems standard will reduce their revenue opportunities and increase their costs.

1.4. Assessment of the current government initiatives, likelihood of regulatory changes as a consequence of them

1.4.1. What governments want from ITS solutions

Governments are concerned with the social and economic costs and benefits of transportation systems and infrastructures. They are most concerned about reducing traffic accidents and deaths, and optimising their investments in transportation infrastructures (roads, rail, public transport equipment, etc.). Governmental agencies in all major automobile markets have contributed human and financial resources in support of Intelligent Transportation Systems (ITS) initiatives, and they appear willing to continue to do so in the future.

As with most vehicle-related issues, the vehicle industry and governments will be at opposite poles with respect to their reasons for supporting telematics. Nevertheless, I expect governments to be one of the major driving forces behind telematics systems installations. Governments will have a major effect on the rate of growth for telematics systems through both enabling and restrictive legislation: enabling through tax incentives for installing certain types of equipment, such as traffic information systems and navigation; and, restrictive through requiring either car manufacturers or vehicle owners to install other

[25] Part of the recommendations from a Nokia Position Paper prepared for a W3C Workshop on Binary Interchange of XML Information Item Sets.

types of equipment, such as toll collection equipment and intelligent speed adaptors.

An example of the enabling side is in The Netherlands, where the minister of the environment has recently proposed that navigation and traffic information systems should be standard fit in cars and trucks because of their demonstrated ability to reduce traffic congestion[26]. He has proposed legislation that would encourage car and truck owners to pay the extra costs of these systems, and for the services needed to support them. It is noteworthy that the main opposition to this proposal comes from the car industry's own lobbying group, ACEA. They do not want to add systems as standard because they feel that they will not be able to recoup the costs through vehicle price increases. They would rather keep these systems as customer options, or as part of special option packages.

The Netherlands would also have been first with a mandatory GSM/GPS-based toll collection system for all motorists if it had not been for a change of government from labour to conservative. A consortium was to have been selected in 2001 to manage the development of the systems for recording the roads travelled and time of journey, and then sending this information to a central data management service for preparing regular invoices to motorists. The systems were to have the possibility of delivering value-added services to motorists, such as traffic information and route guidance, and even offering the safety and security services of current telematics systems.

The Toll Collect system in Germany that was re-scheduled to go live in late 2003, but which has been put off until late 2004, is a realisation of this same concept, although for commercial vehicles. All trucks operating in Germany will be fitted—for free—with a black box telematics system. Its principal purpose will be to report road of travel and time for tolling purposes, but it is planned that these systems will also deliver telematics services, and that the systems will be open for service providers outside of the telematics consortium operating Toll Collect[27].

The European e-Safety initiative, which had its official kick-off in Lyon, France in September 2002, has as its goal to help meet the EC's ambition of a 50% reduction in traffic deaths in the European Union by 2010. French officials, in order to reduce traffic-related deaths, have said that they will purchase new cars only if they are equipped with speed control devices. Some systems operate with GSM/GPS-based systems, and these systems are being evaluated at the European Commission level and by national governments. Peugeot and Renault already have such systems, and BMW, Saab and Volvo are reported to be readying systems for market introduction. A big worry for car manufacturers and their suppliers is that the European market will become fragmented and require different solutions, as is the case with toll collection systems.

1.4.2. Assessment of the developments in the triad markets

In Europe and the US, government financing has been ample for research and deployment of traffic control and road infrastructure systems, but, thus far, it has

[26] It is not clear in the article, seen in Automotive News Europe, on what the minister is basing his claim that navigation systems reduce traffic congestion. There are no research studies identified in the article. It is one of the main selling points used by the system manufacturers and the vehicle OEM's who install them, but I know of no research that prove the results.
[27] The Toll Collect consortium consists of DaimlerChrysler, Cofiroute and Deutsche Telekom.

been minimal to non-existent for in-vehicle systems. Exceptions are the intelligent speed adaptation (ISA) initiatives in Sweden and the UK, where government and insurance interests have been represented, but not the automobile industry, and government mandated tolling schemes, such as Toll Collect in Germany. Experience from Toll Collect shows how difficult it is for country governments to support home-based companies (i.e. DaimlerChrysler) to the exclusion of foreign competitors (Volvo Trucks and Scania Trucks) when pan-European in-vehicle systems are involved.

In my view, one of the major reasons that government funding has not been available on a large scale for in-vehicle systems research and deployment in the US and Europe is that the automotive industry has not given clear signals that it is prepared to introduce these systems on a large scale. Navigation systems are not developed or promoted as traffic reduction or safety devices, but as driver convenience aids. Telematics programs have been started and stopped with very little engagement with the public service agencies. The situation is very different in Japan, where government, research institutions and industry have worked side by side in the development and deployment VICS[28].

[28] Vehicle Information and Communication System. VICS suppliers real time traffic information to drivers who have VICS-enabled navigation systems. Traffic flow data on major arteries is sent to the vehicles and overlayed on the map displays.

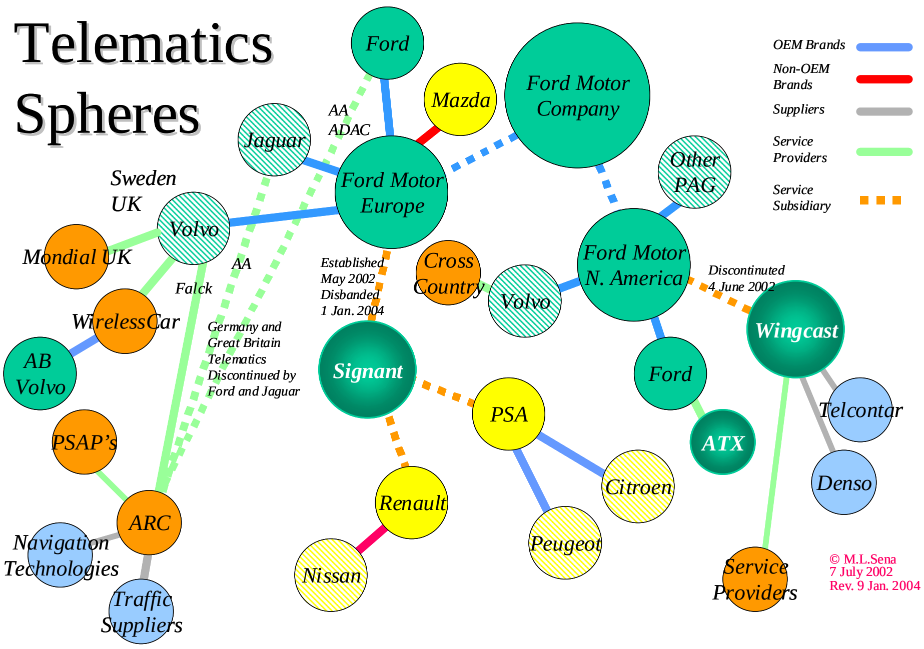
II. International Competition

2.1. Assessment of the competitive strengths and weaknesses of the individual OEMs in the ITS field

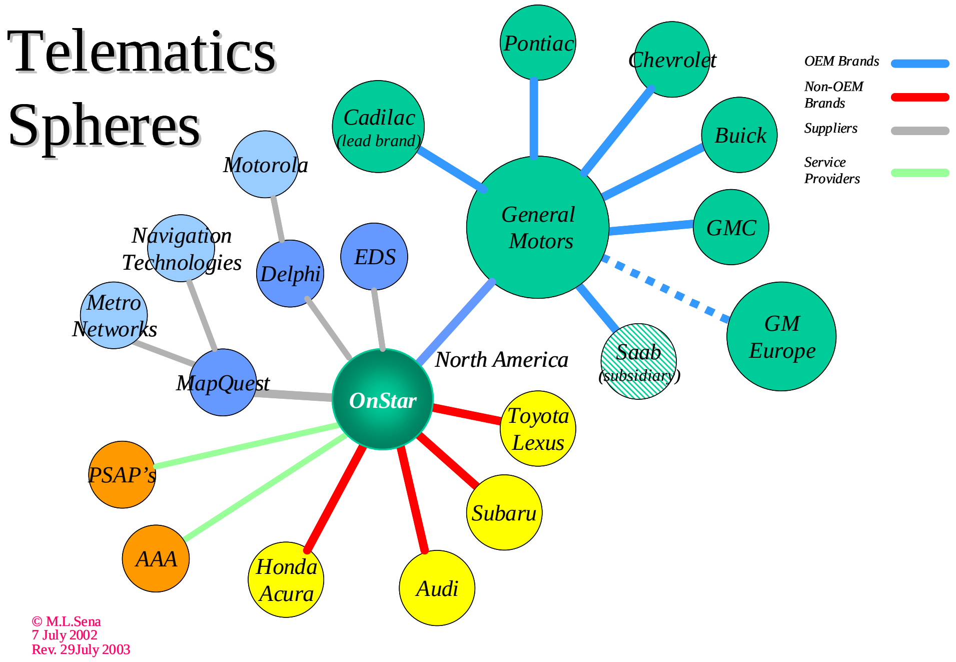
There are thirty-seven global vehicle manufacturers. Of that total, four of them are companies based in India that produce fewer than 125,000 cars per year. First Auto (Chinese) and AutoVaz (Russian) are reasonably large producers, and while they may be long-term prospects for telematics systems and automotive connectivity, they are unlikely candidates in the short term.

Of the remainder, ten are primarily truck manufacturers. That means that there are twenty-one car and light truck (pickups and SUVs) companies who control an additional thirty-eight wholly- or partly-owned subsidiaries. For example, GM includes Holden, Opel, Vauxhall and Saab. Ford includes Aston Martin, Jaguar, Land Rover and Volvo Car Corporation. In addition, there are brands within companies like DaimlerChrysler, GM, Ford and Toyota and others that have independent development programs. Examples are Maybach and Smart for DaimlerChrysler, Cadillac for GM, Lincoln for Ford, Infinity for Nissan, Mini for BMW, and Lexus for Toyota. So the total number of automotive groups who could potentially have their own, unique vehicle- and driver-centric ITS functions approaches seventy, most of which are selling cars in Western Europe. The number of groups is lower in North America where Fiat, Renault and PSA have no sales at present.

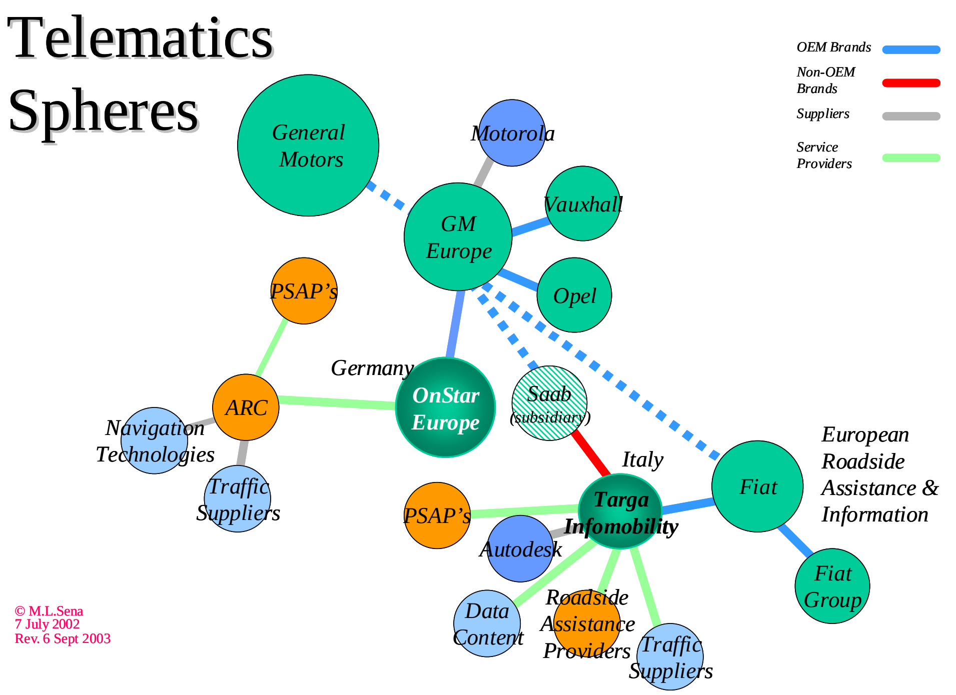
Many of the car producers are already part of a telematics sphere which share resources, platform technology or service providers. Most of the spheres are still loosely defined, with members joining or leaving and the hardware solutions left up to the individual companies. Volvo is, in theory, part of the Ford sphere, but has its own solution with WirelessCar that is not shared by any of the other Ford Group companies.



Two spheres, GM and Fiat, are intertwined through ownership (GM currently owns 10% of Fiat). GM has set up the OnStar sphere in North America. This is an end-to-end solution. As seen in the diagram below, a number of non-GM brands have taken OnStar on board in the US. Audi, Honda, Subaru and Toyota, which are not GM brands, are part of the GM OnStar telematics services sphere along with GM brands, including Saab.

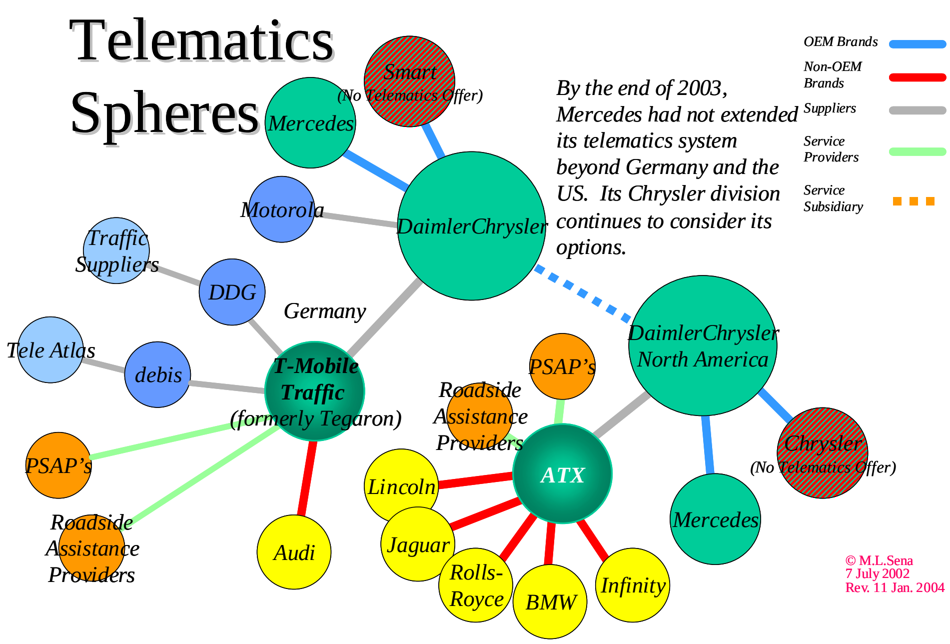


In Europe, the OnStar sphere is much more diffuse, with GM subsidiary Saab joining the Fiat sphere led by Targa Infomobility, and thus far OnStar being offered only in Germany.



OnStar Europe is attempting to do what OnStar North America has done, which is to offer an end-to-end telematics solution for GM brands and any other brands that care to join the sphere. The operations model will be the same as OnStar North America's, which is to build its own telematics service provider and integrate it with GM sales and marketing functions. GM has had difficulty in establishing its in-vehicle services business in Europe because they tried a different model to the one used in North America. They tried to push all of the development of infrastructure on country suppliers, like ADAC in Germany and the AA in the UK. The OnStar organisation thought that they did not have to own anything. What they found out was that they were duplicating all services in every country, and paying for these services each time they were developed. Also, they had no control over the customer information. They were giving their customers to the service providers, rather than keeping them for themselves. Volvo realised the same thing before they actually implemented their services, which is why they asked WirelessCar to build its centralised infrastructure. OnStar Europe just took a longer time to figure it out. Why didn't they choose to use WirelessCar's services or those of Tegaron or Passo, instead of building it themselves with Accenture? Because Accenture is building the systems to tie back into their own internal administrative, sales and marketing systems, and they did not see any of the other companies as a software developer of the calibre of Accenture.

DaimlerChrysler has two distinct and separate spheres, one in Europe and the other in North America. The company sold its interest in Tegaron to its joint venture partner, T-Mobile, but continues to work with the re-named company, T-Mobile Traffic. In North America, its telematics service provider is ATX, who are a competitor to T-Mobile Traffic in Europe since they bought rival TSP, Passo, from Vodafone in 2003.



It is only the Mercedes brand at present that has the TeleAID system. Smart has a PDA-based off-board navigation system supported by the German company PTV.

The table below lists the major companies selling vehicles in Europe, the number of vehicles they sold in 2002, and the telematics sphere to which each company is aligned.

Major Brand Prospects (excluding GM, Fiat and related companies)	Number of non-commercial vehicles sold in Western Europe 2002	Sphere[2]
1. PSA Group	2,190,092	None[1]
2. VW Group (exc. Audi)	2,134,744	None
3. Renault	1,560,953	None[1]
4. GM (exc. Saab)	1,401,583	OnStar
5. Ford (exc. Volvo, Land Rover and Jaguar)	1,297,301	Ford[1]
6. Fiat	1,173,835	Targa
7. DaimlerChrysler	967,329	Own with T-Mobile Traffic
8. Toyota Group	667,218	None
9. BMW	623,827	Own With ATX
10. Audi	548,190	T-Mobile Traffic
11. Nissan	371,506	None[1]
12. Hyundai Group	311,549	None
13. Volvo Cars	230,932	Own with WirelessCar
14. Honda	183,871	None
15. Mazda	156,868	None[1]
16. MG Rover	142,460	None
17. Mitsubishi	131,707	None
18. Land Rover	85,248	None[1]
19. Saab	72,654	Targa
20. Jaguar	51,755	None[1]
21. Porsche	25,351	None

1. All companies that were potentially part of the now defunct Signant sphere

2. "Own" means they have a current telematics offering and have developed a sphere with telematics service providers, content and applications servers. "None" means that they do not have a telematics solution currently on the market.

2.2. Companies Competing in the Telematics Space

2.2.1. An Evaluation Framework

Within each sector, there are four categories of competitors:

Market Leader – This is a company that has high market visibility, characterised by broad brand recognition and well developed external relationships. There can be more than one market leader, or there can be no clear market leader. In the automotive sector it would be difficult to name a company that is clearly in the lead. Although General Motors sells more vehicles than any other company, its total market share has been shrinking. Ford was close to overtaking GM a few years ago, but Ford is now struggling. In 2002, it relinquished second place for total sales to Toyota. DaimlerChrysler gained in size and market share following its acquisition of Chrysler, but Chrysler's losses have weighed heavily on DC's share price. Only Toyota seems to have solid momentum, earning industry record profits in 2002.

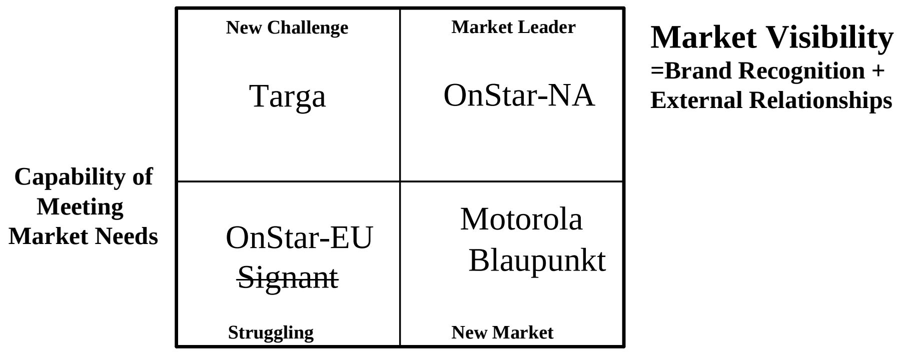
New Challenge – This is a company that has exhibited strong capabilities for meeting market needs, but has not yet achieved brand recognition or developed an extensive network of external relationships. New challengers eventually either achieve market leadership, or are relegated to the struggling companies.

Struggling – This is where the majority of companies are positioned. They compete for what is left over after the market leaders have taken the largest share. They attempt to develop new capabilities and move up into the new challenge sector, or they try to build external relationships and define new competitive ground by establishing a new market reference.

New Market – Within every business sector there are customer segments—they can be large or small—that are not served by available offerings. An example is navigation aids for small boats owners. When navigation aids for boats were introduced twenty years ago, positioning devices were prohibitively expensive for all but large shipping companies. When GPS devices were introduced, a large segment of the market opened, but small boat owners were still excluded. As GPS devices became less expensive, they became affordable by all boat owners. Each business sector has a new market player who is attempting to redefine the competitive landscape by introducing a new concept that is less expensive than the current offerings.

An example of the application of this categorisation is the comparison of companies delivering end-to-end telematics solutions.

End-to-End Telematics Solution



Market Leader

OnStar North America is the clear market leader in end-to-end telematics solutions. It was founded by General Motors in 1996, and began operations in 1997. Since then, it has collected over 3 million paying subscribers. In addition to all GM models, Toyota Lexus, Saab, Honda Acura, Subaru and Audi also offer OnStar on their models. Three million may not seem like a large number of subscribers in over six years of operation, especially since GM made it standard fit on one-half of its models a few years ago. That means that approximately 2.5 million cars per year are fitted with On Star. Of those who have OnStar installed in their vehicles, only 20% are actually paying for the continuation of services offered after the first year. Still, that is a better take-up rate than any other automotive OEM has achieved in terms of penetration, and three million subscribers is close to thee million more than their closest competitor.

OnStar is not an international organisation. Each market operates its telematics business as it sees fit, while still using the OnStar brand, or, if they choose, another brand. In South America, GM has introduced a system called ChevyStar. The hardware developer, EDT, is an Israeli Tier One automotive supplier. The services are delivered by a company set up by GM and EDT called RoadTrack.

New Challenge

Targa Infomobility's bConnect operation, recently renamed from TargaSys, claims to be profitable. They have Fiat's brands and Saab as customers for telematics services, and they have just added Citroen. They have also recently begun to deliver off-board navigation services to Blaupunkt systems installed in certain Fiat models. Targa Infomobility has recently reorganised, changed its name, broadened its service package. It is trying to re-enter as a new market player.

Struggling

OnStar Europe has had two failed starts in the UK and Germany, where they had major problems with their hardware supplier, Motorola. They have had three management changes during the past five years. They now appear to be stable, and have begun a new initiative using Accenture to build a complete infrastructure solution for them that will look similar to Volvo's WirelessCar system when completed.

Ford's Wingcast was due to start competing with OnStar in North America during the third quarter of 2002. It was shut down at the end of the second quarter. There is currently no rival to OnStar North America as and end-to-end telematics system and service provider. Signant was, until 1 January 2004, the closest thing to a new challenge to OnStar. But the venture of Ford, Renault and PSA seemed to get stuck very shortly after its formation. There was, from the outset, a great deal of uncertainty about its future, with constant questions about its practicality, whether it would continue, or whether one or all of the companies involved would pull out and pursue independent approaches. Ford's financial instability was the biggest concern. The questions are now answered. Ford backed out of the venture as of 1 January 2004. What will be done with the activities is still not officially announced.

New Market

Motorola and Blaupunkt are attempting to change the telematics paradigm with new types of systems that can be sold into the aftermarket or to OEMs. Blaupunkt is now introducing a 1-DIN radio that has a built-in GPS receiver and GSM module. In the back of the radio unit is a SIM-card slot for the customer's own SIM-card. A special roof-mounted antenna is part of the package. It includes radio, GPS and GSM antennae in a single unit. As an aftermarket product in Germany only, the customer can obtain route directions and route guidance. The service operator is a small German company called Tele Info. Blaupunkt has sold the system into Fiat. Targa Infomobility's bConnect is the service navigation provider.

Motorola's SmartNav system is a one-button telematics system that currently offers only navigation system operator and automatic services. It can easily become a vehicle-dependent telematics device, offering most of the telematics functions available on integrated systems.

Neither of these products consider the problems of GPRS roaming or the potential blocking of SMS messages in foreign networks. They work in one country only. By linking them through a connectivity provider, like WirelessCar, they could be competing with OEM devices in a very short period of time.

2.2.2 The Automotive OEMs

In order to make a competitive comparison of the automotive OEMs and their vehicle- and driver-centric ITS capabilities, I have developed a matrix in which I list the current status, to the best of my knowledge, of each of the OEM's activities.

Vehicle- and Driver-Centric ITS Functions

Automotive OEMs	Telematics Services	Dynamic Navigation	ADAS Applications	Data Expertise	Research Activities	Standards Activities
DaimlerChrysler	●	●	●	●	●	●
BMW	●	●	●	●	●	●
Volkswagen	○	○	◎	◎	◎	○
Audi	◎	○	●	◎	◎	○
GM Europe	◎	◎	○	◎	○	○
Ford	○	◎	○	◎	●	◎
Volvo	●	◎	○	○	○	○
Jaguar	○	○	○	○	○	○
Fiat	●	●	○	●	●	○
Renault	◎	◎	◎	●	●	◎
PSA	◎	○	○	○	◎	○
Toyota	○	◎	○	○	○	○
Honda	○	○	○	○	○	○
Nissan	○	○	○	●	●	○

● Very Active in Development and Deployment

◎ Somewhat Active in Development and Deployment

○ Marginally or Not At All Active in Development and Deployment

I have chosen six activities for inclusion in the evaluation matrix, and have used three levels of evaluation, from very active to marginally or not at all active.

Telematics Services

The company has a program in place for delivering safety and security or convenience telematics services to customers in one or more countries. DaimlerChrysler, BMW, Volvo and Fiat are the most advanced in this area. Volvo has programs in place in Sweden and the UK, and active projects for four additional countries during 2004. Fiat is the most advanced with regard to pan-European services. GM and Audi are developing extensive programs.

Dynamic Navigation

The company offers a navigation system that can be linked to a service provider who delivers traffic and points of address information, and who can deliver a destination position to the vehicle. DaimlerChrysler, BMW and Fiat have the most advanced programs that employ a service center that communicates via data with the on-board navigation system, and via voice with the driver. A number of companies, such as Volvo, Ford, GM and Toyota, have incorporated RDS-TMC traffic reception in their autonomouns navigation systems.

ADAS Applications

The company is currently supplying an advanced driver assistance system in its vehicles, or will deliver such a system imminently. DaimlerChrysler, BMW and Audi are the most active and advanced in this area. Renault and VW have development programs that are somewhat advanced. Other companies, such as Volvo and Ford, have research programs, but implementation is not imminent.

Data Expertise

The company employs staff who have experience in digital map data bases, traffic information and travel data, and uses this expertise to guide the company's research and development activities. DaimlerChrysler, BMW, Fiat, Renault and Nissan have excellent staff capabilities in this area. Nissan has recently added serveral individuals to its staff who have extensive data experience.

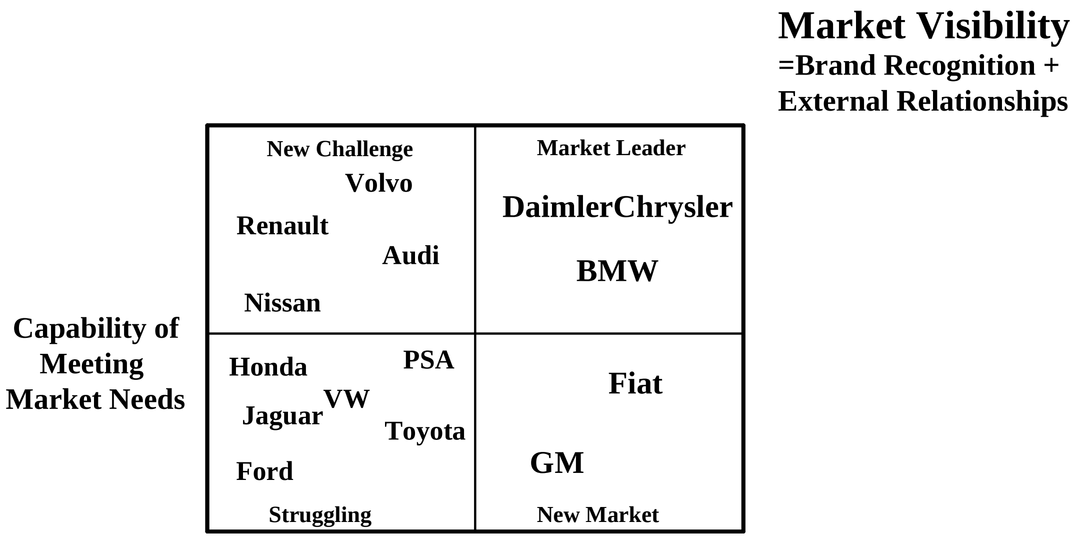
Research Activities

The company maintains a staff who conduct research in ITS functions, and there are organisational procedures for implementing the findings from this research. Many of the companies have well-funded and well-staffed research activities.

Standards Activities

The company takes part in country, regional and/or international standardisation activities. DaimlerChrysler and BMW contribute the most to standardisation among the car manufacturers, and both Ford and Renault parcicipate in specific areas.

Vehicle- and Driver-centric ITS Functions



Market Leader

The market leader position is shared between DaimlerChrysler and BMW. Both receive top marks in all six functional areas. DaimlerChrysler has and edge in telematics service delivery with its soon-to-be delivered pan-European service. In most other areas, they are quite even.

New Challenge

Volvo has one of the most active telematics program among the automotive OEMs, and it has had a strong position within the navigation arena. Since its acquisition by Ford, it has lost significant ground in all of the other areas because many of these functions were performed by Volvo Technological Development, which remained with AB Volvo. It is now dependent on input from Ford and confusing relationships with other companies within Ford's Premier Automotive Group (Jaguar, Land Rover and Aston Martin).

For the past two years, Audi has been in the process of updating its telematics offering, working with T-Mobile Traffic. It is not clear where they are in this process, but they do have an active telematics program and navigation system development group.

Renault has one of the best navigation system development groups in the industry. They have been one of the most active companies supporting an interoperable map data media standard. Renault started, then closed, its telematics service, later joining the now-defunct Signant venture with Ford and PSA. Renault is one of the industry leaders in active safety, and ADAS is an important part of its future car program.

Nissan has used its success in the market to build up its expertise in the areas of telematics and navigation. It is in the process of developing programs in these areas, and will begin to do the same with ADAS.

Struggling

Of all the automotive OEMs, Ford is struggling most with its position and direction. It has had a string of failures with telematics implementations, the most recent being its extraction from Signant, which caused the breakup of that group. Ford's European Advanced Engineering and Research Group, based in Aachen, is very active in all areas of telematics, ADAS and navigation. They take part in standards activities at the German and European level. Whether their work is applied by Ford, or any of the Ford companies, is decided by each of the brands.

VW initiated several new programs, including a telematics service through Gedas, that it has closed down. The company has also had difficulties recently with its navigation system program. Toyota has taken a very cautious approach to all forms of ITS functions in Europe, which is very different to its activities in its home market, Japan. The company has a navigation system that can accept traffic information broadcast via RDS-TMC in the UK (similar to DaimlerChrysler, Volvo, BMW, Renault in other markets), and has called this their telematics solution. Jaguar appears to be pulled in several directions at once. It had a solid navigation system program a few years ago, but then lost most of its staff (first to Saab and eventually to Nissan), and cannot seem to decide on a supplier. It has no telematics program after it decided to accept Ford's last solution (pre-Signant) and then Ford shut down its service.

New Market

Fiat and GM are New Market in this comparison because they are attempting to redefine the relationship between the automotive OEM and its customers. Each company is trying to build distinct operations that are tightly integrated into the management and operational infrastructures of the company's mainstream. These operations are intended to serve as a complement to the normal sales and service channels available to the OEM's customers. While they are intended to be self-funding, they serve mainly to reinforce the customer's long-term relationship to the brand.

Fiat, in spite of its enormous financial difficulties, has built a solid telematics service organisation in Targa Infomobility. By co-locating it with its Targa Connect roadside assistance group, integrating it with the Trafficmaster joint venture, and building bridges to one of its hardware suppliers, Magneti Marelli, Fiat has given Targa Infomobility the maximum chances to succeed. Safety is not one of Fiat's core values, so the company has not shown any activity in ADAS, and they are not active in standards work. However, they have programs with off-board navigation (Blaupunkt's off-board navigation radio is supported by Targa Infomobility), and will soon have more options to offer its customers.

GM will eventually get OnStar Europe operational. With the help of Accenture, they are building an infrastructure that will be similar to the one they have in North America. OnStar has become a key part of GM's marketing in North America, and it will be so in Europe as well. The question remains, when will it be ready. GM started its telematics program in the UK and Germany in 1997 without success. OnStar has had several organisational and management changes since its inception. It now seems to be stable and working on executing its plan.

2.3. China and ITS Solutions

I have not been to China, nor have I studied the Chinese business climate for ITS applications. My perspective on China is, therefore, based on a reading of the business press and information I have gathered from individuals who have worked or done business in China. The country is the world's fourth largest in land area, first in population[29]. It has approximately four-and-a-half times the number of people as the United States, but its citizens purchase less than one-fifth the number of cars as are sold in the US (2.9 million in 2002 in China versus 17.2 million in the US). Sales are projected to nearly double by 2007, to 4.9 million units, while they will increase only slightly in the US. Still, by the end of this century's first decade, China will still not be a market much larger than Japan. The country is adding motorway pavement at a faster rate than anywhere else in the world, but by 2010 it will still have only approximately double the length of expressways as Germany's 11,515 km (a country with 4% of the land area and 7% of the population of China), and less than one-half the number of cars as on the German roads.

ITS America recently conducted a Business and Trade Mission to China, and one of the delegates, Meifu Wang, shared her experiences with the ITS community in an open letter published on the Web. She reports: "Like all visitors, I experienced the hazardous conditions on the street first-hand. Drivers assume the right-of-way at all times; they make sudden and quick turns at intersections, and cut in front of cyclists, pedestrians and smaller vehicles." Ms Wang continues: "Chinese officials and planners recognize that ITS by itself cannot solve all the traffic problems in the cities. Lack of transportation infrastructure to support the fast-growing need for mobility is the main reason for congested and unsafe roads." The report concludes that ITS technology is being adopted in China at a fast pace, especially in the commercial center of Shanghai, but there is no Chinese framework for the investments. It is simply adopting the practices of the US, Europe and Japan.

The Economist[30] sums up the climate for technolgoy adoption in China. I extract the main points from their article below:

> "The country's success in putting a man into space this October, only the third nation to do so, was more than just a boost to national pride. It signalled the Chinese government's intention to turn the world's workshop into a technological powerhouse…So will China become the next technology superpower? Actually, probably not—at least not anytime soon. Overall, China's technology base remains limited and the capital infrastructure needed to produce advanced, high-tech goods largely absent. While politicians in Beijing shout about China's need to develop technology, the smartest Chinese firms are taking advantage of the labour supply and actually reducing their use of technology. A study by the Boston Consulting Group shows that Chinese manufacturers were more productive and made more profits if they reduced the technology used in production and returned to more people-heavy processes. China should seize this advantage with both hands. Its labour will remain cheap for decades. Only labour-intensive

[29] Russia, Canada, USA in that order are larger in land area; China had a population of 1.2 billion in 2002, India 983 million, USA 272 million, Indonesia 209 million and Brazil 160 million.

[30] Technology in China: The allure of low technology; *The Economist*; December 20th 2003 (p.100)

> industries can generate the millions of new jobs needed each year to maintain the social stability sought by the leadership in Beijing. Meanwhile, China can gradually build up the educational, legal and financial infrastructure needed for faster technological development in the longer term."

The Economist does not indicate how long "meanwhile" is, but when they state that their labour force will remain cheap for decades, this can provide a hint to how long they believe it will take for technological advancements to catch up with other, more advanced parts of the world.

Because of its shear size and growing importance, China cannot be ignored. However, it does not appear that it will be a source of innovation for ITS during the coming decade. Rather, it will be an observer and consumer of ideas that seem to work in other markets. Its greatest need is to build roads. Things should begin to change in this millennium's second decade, assuming that there are no catastrophic developments in the country's political and social framework.

nb

III. World Class Research

There are three research groups with whom I am familiar. Each group focuses on a different aspect of Intelligent Transportation Systems.

Japan

Keio University: Department of Administration Engineering, Faculty of Science and Technology

Postal Address: 3-14-1 Hiyoshi, Kohoku-ku, Yokahama-shi, Kanagawa 223-8522, Japan

Contact: Dr. Hironao Kawashima (kawashima@ae.keio.ac.jp)

Research at Keio University has been in human machine interfaces and cognition engineeering. Professor Kawashima's work on drivers' cognitive processes has important implications for navigation system design. He and his research group have compared the way that individuals from different cultures describe and diagram a route. In one study they compared Swedish and Japanese subjects living in their home countries with Japanese living in Sweden, and Swedes living in Japan. They found that the foreigners continued to use the wayfinding methods that they used in their home country, but to a lesser degree than in their home country.[31]

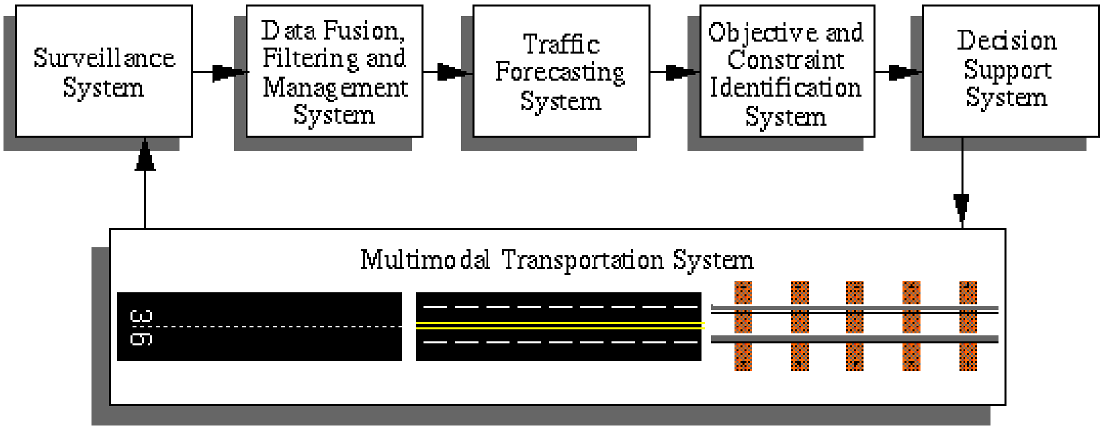
North America

Transportation Information and Decision Engineering Center – TIDE Center

Contact: Dr. Alain L. Kornhauser, Co-director (alaink@princeton.edu)

The TIDE Center is a jointly owned and funded organisation. Princeton University, Rutgers University and the New Jersey Institute of Technology are the research institutions, and funding is provided by the New Jersey Commission on Science and Technology.

The areas studied by the TIDE Center are shown in the following illustration:



[31] Kawashima, Hironao, et al; *Study of drivers' behavioral characteristics for designing interfaces of in-vehicle navigation systems based on national and regional factors*; JSAE Review 21 (2000) 379-384.

Europe

Viktoria Institute

Postal Address: P.O. Box 620, SE-405 30 Göteborg, Sweden

Visiting Address: Viktoriagatan 13, Göteborg

Contact: Dick Eriksson, CEO (dick.eriksson@viktoria.se)

The Viktoria Institute in Göteborg, Sweden was founded in 1997 as a local industry initiative. It is owned and funded by four organisations:

- The Swedish Research Institute for Information Technologies (40%)
- West Sweden IT Association (34%)
- Chalmers University of Technology (15%)
- Gothenburg University Holding (11%)

The objective of the Viktoria Institute is to do research, development and education in applied information technology in collaboration with industry, the public sector and with universities. Research projects are funded through competitive applications for grants from Swedish and EU institutions. There are five research areas, two specifically related to wireless technology and telematics. There are around thirty research staff and six PhD students currently working at the Institute.

Three active projects within the telematics arena are:

- SeamlessTalk – a Bluetooth-enabled car conversation system intended to increase the convenience and safety of mobile phone use in cars.
- Remote Diagnostics – To contribute to the field of remote vehicle diagnostics through the development of innovate applications.
- In-Car Route Decision Support – To identify and evaluate alternative route decision support services for everyday, routine journeys where the user has significant local knowledge.

Notes: