Telematics Industry Dynamics and Strategies for Converging Technologies

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Abstract

The Telematics Industry faces tremendous challenges for growth. Regardless of the efforts and investment from vehicle manufacturers and suppliers, telematics has not been that profitable industry that many analyst forecasted five years ago; a 40 billion industry by 2003. This paper presents an analysis of the dynamics of the telematics industry and emphasizes on factors affecting the diffusion of telematics innovation. These factors are related to openness of telematics systems and establishment of standards, network externalities effects and attractiveness of complementors, customer's willingness to pay, telematics services pricing, and consumer knowledge of newer technology.

Based on an in-depth analysis of the telematics architecture and the technologies converging in the telematics system I suggest a mixed strategy with respect to standards. This strategy favors the growth of this industry. Based on this strategy there are developed some scenarios of how the telematics value network will look like and how the interaction among the players would take place.

Finally, a conceptual system dynamic model is presented to illustrate the dynamics of the industry and how the factors influencing the adoption of the telematics all play together to favor or affect the diffusion of the growing telematics industry.

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Contents

List of Figures

List of Tables

Chapter 1
Introduction

In 1997, the telematics category barely existed.[1] By the end of 2003, it was estimated that of the 222 million US vehicles in use, 7.0 million were Telematics-enabled vehicles in use; 3.2% of the total.[2]

However, enticed with the pledge of a large and lucrative market, Vehicle Manufacturers (VMs[3]) and electronics equipment manufacturers and their suppliers have invested heavily in telematics, only to find that instead of predicted revenues from as high as $30 billion, revenues from telematics were floating in the $1-5 billion range.

The evolution of newer, wireless technologies, commitment by major software companies, governments regulations, commitment and involvement of dealers, joint ventures and partnerships, customer education of benefits, cost reductions in hardware and software and, even more important, flexible pricing models are some of the most important factors that telematics vendors and vehicle manufacturers are considering to be the roadblocks for the diffusion and adoption of telematics.

Growth of Telematics will require all participants in the value chain to step up and invest. Key success factors will be:

- Sustaining innovation in products, services, and technology to ensure that telematics delivers what customers want in the way they want it. Only then can telematics represent a real source of competitive advantage.
- Experimenting continually; as with any other emerging technology, it is only though experimentation that the industry will figure out the application and products that appeal the most to consumers.
- Providing cost-effective services and technology to enable pricing at customer-acceptable levels.
- Overcoming consumers concerns that Telematics Systems distract drivers. Hands-free operation, involving voice recognition, will be the key factor for success, as will effective consumer education.
- Reconciling disparate telematics strategies and approaches to permit economies of scale. One major issue is the question of who will control the value chain. Although OEMs continue being the drivers of this industry, consumer electronics and telecommunications companies have equally legitimate claims to ownership.
- Determining how to arrange the mixture of business, business capabilities, and technologies required to design, build, deliver and operate Telematics Systems. A rich Telematics Systems combines customer service and support, billing, technology, infrastructure, application integration, and data mining, and

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[1] Barabba, Chuber. Cooke, Pudar, Smoth. Paich, A Multimethod Approach for Creating New Business Models: The General Motors OnStar Project, Interfaces, _ 2002 INFORMS, Vol. 32, No. 1, January–February 2002, pp. 20–34

[2] Telematics Research Group, November 2002. e-marketer.com

[3] For simplicity the abbreviation VMs will be used in this thesis to indistinctly describe Vehicle Manufacturers or Car Makers.

management. Many vehicle manufacturers will need alliances partners to assemble the full suite and will then need to manage those partnerships for success.

But, what is the Telematics?

Telematics is an emerging market of automotive communications technology that combines wireless voice and data to provide location-specific security, information, productivity, and in-vehicle entertainment services to drivers and their passengers. The different set of solutions that telematics aims to provide is depicted in figure 1.1.

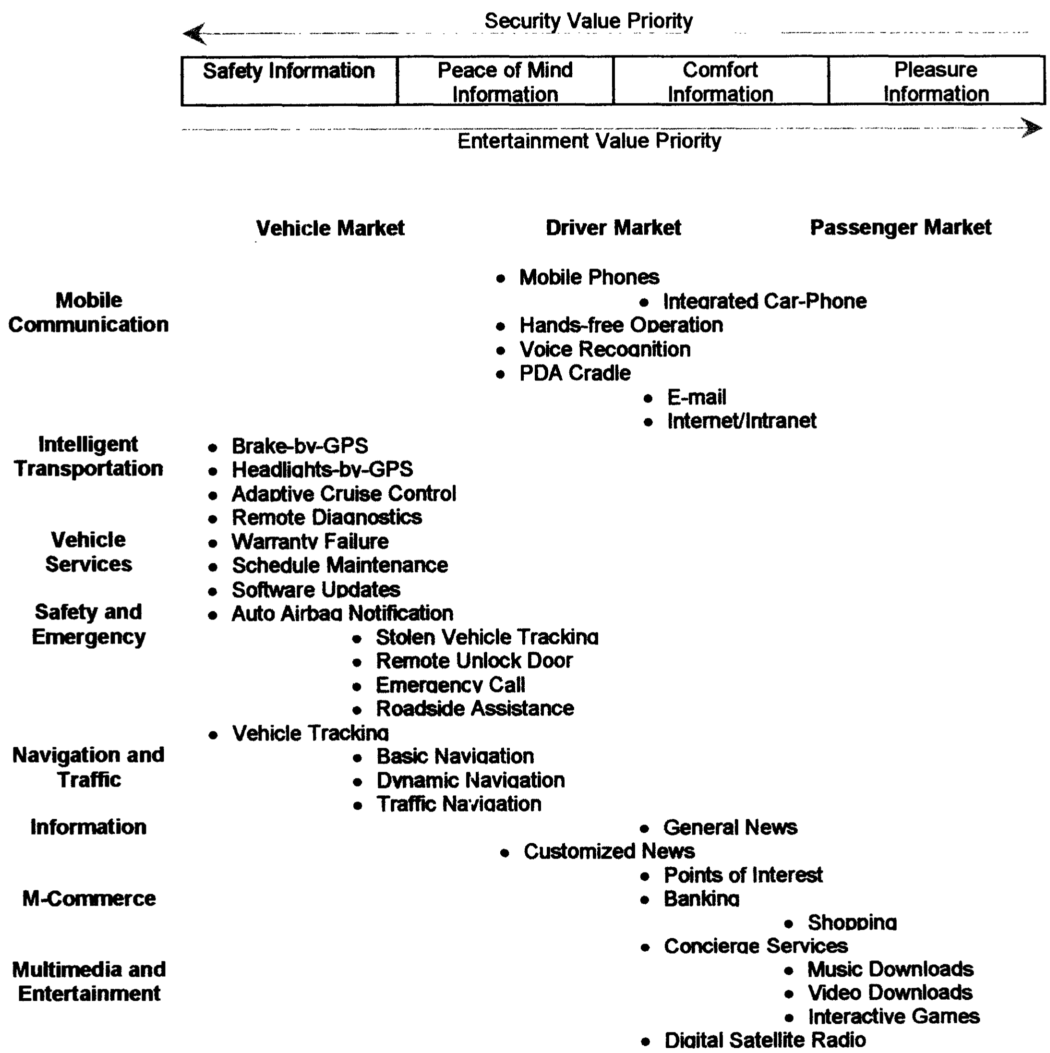

Figure 1.1 Telematics Services Features and Priority Level for Users

Telematics aims to enhance the driving experience. To create the new telematics innovation, vehicle manufactures are required to **converge different technologies and competences** from organizations of different industries consequently crafting the new Automotive Telematics Value Chain.

The telematics industry is still novel. The rapid evolution of the technologies converging into the telematics system motivates rapid changes in the environment of this industry. To elaborate in this regard, **chapter two** summarizes the most current trends in technologies and business models related to telematics. A research in the topic results in interesting statistics that show the current state of the art of the telematics industry.

Chapter three discusses the several factors affecting the rate of adoption of telematics. These factors are classified in five different groups which are considered as the most relevant to influence the future growth of this industry: customer benefits perceived from the technology, network externalities, cost of adoption of new technology, information about the technology, and industry and market environment. The discussion of these factors, which will be examined in further chapters, will set the basis for constructing a conceptual system dynamics model that illustrates how the dynamics of these factors play together to influence the adoption of telematics and growth of this industry.

Chapter fourth digs into the intimacy of the telematics architecture in order to analyze the major elements and underlying technologies that comprise the telematics systems. The analysis of those converging technologies is based on the different standards that define each technology as well as the technological evolution and the major characteristics that distinguish one standard from another. Special focus is placed on wireless communication technology and electronics devices, which are considered as key technologies for the future evolution of telematics. An in-depth analysis of the Telematics Systems would set the basis to define how the systems can de-bundled (if the time to do so arrives), and what strategies to pursue in order for car-makers to continue capturing value for their innovation. These strategies are discussed in the next chapter.

The lacking of standard interfaces in telematics systems has represented a challenge for product-development times. It takes as long as four years to launch a new vehicle; in the rapidly evolving consumer electronics sector, a new product is obsolete within a year. So today's vehicle programs launch with outdated electronic devices because the sourcing decisions were made years earlier, and the electrical architecture is locked in, prohibiting component upgrades. This situation demises the attractiveness of the telematics innovation.

The telematics industry calls for vehicle manufacturers to open up their integral telematics system and allow for a faster rate of adoption of telematics. **Chapter five** draws on information analyzed in chapter four to discuss some strategies suggested to vehicle manufacturers and telematics service providers when deciding between proprietary or open architectures for their telematics systems. In this chapter, I suggest that a mixed architecture where proprietary and non-proprietary open standards are combined should be the option for vehicles manufacturers to consider when the decision to open up their telematics systems arrives. The benefits and drawbacks of these strategies are discussed.

As it will be discussed in chapter three, pricing of telematics services (subscription fees) is a critical factor in attracting consumer's interest in telematics. The diversity of telematics features and heterogeneity of consumer's tastes complicates the process of deciding how to price telematics services. **Chapter six** proposes *bundling* as a strategy for pricing telematics services. The chapter reviews the underlying concept of pricing bundles of products and services, and discusses some specific bundling strategies suggested to telematics providers.

Chapter seven analyzes the dynamics of the telematics industry based on concepts of industry, and technology evolution, and value chain analysis. This process starts by framing the current forces shaping the telematics industry at the ferment phase of its evolution. Following, from the point of view of vehicle manufacturers and telematics service providers; I perform a value chain analysis by drawing a map of the telematics value proposition.

This step in the process is particularly important to identify what players' capabilities and technologies bring value to the telematics innovation. This value chain analysis will help to realize how the evolution of adjacent technologies, those converging in the telematics system, will impact the current telematics business model in the future and how the existing value chain players' capabilities may play against the incumbent innovator. Analysis of this nature plays an important role when the time comes to define a position between the integral/modular system architecture and appropriateness/openness standard in the decision making process.

There is not question that this industry will evolve. How the industry will evolve is the paradigm. Based on the information analyzed in this thesis, I suggest, draw, and describe three scenarios of how I think the Telematics value chain will look in the future.

Finally, **chapter eight** introduces a conceptual system dynamics model to describe some of the dynamics of the industry affecting the adoption and diffusion of telematics. I focus on two main variables; the telematics **value to users** and **awareness** of the technology innovation, as the drivers that motivate the rate of adoption or rate of users subscribing to the telematics offers.

In the case of value to users (or attractiveness of telematics), six factors are identified as the drivers influencing users' perceived value of telematics (as it is developed in chapter three). These factors are related to the availability of telematics features, as well as of complementary products and services. The effect of the openness of telematics standards is considered as well.

Subsequently, to analyze the important dynamics of the model, an assessment on the influence of some factors contributing to the telematics value to users is presented in order to illustrate how the influence of those factors may shift and how users may value telematics overtime.

Telematics is changing the automotive world. Who is driving this change? Who will emerge as the winner? Where will attractive profits be earned in the value chain of the future? What changes in circumstances will shift competitive advantage to specialized, nonintegrated companies? How can a dominant, integrated player determine what to outsource and what to hold on to as its industry begins to break into pieces? How can new entrants figure out where to target their efforts in order to maximize profitability?

This thesis aims to establish the basis to guide the search for the answers of those paradigms imposed by the emerging telematics industry.

Chapter 2
Telematics Industry Trends

2.1. Introduction

Because cars ship globally, telematics was built on the promise of providing a global solution that allows ubiquitous communication. This means data communication anywhere, anytime. With the demise of practical, global satellite data networks, the telematics initiative has been forced to rely on the cellular data infrastructure. While the majority of wire line traffic is now data, cellular providers are still locked in to business models that favor voice communications. Data communication is still fairly expensive in cellular networks. The cellular industry historically has not placed a high priority on air link interoperability (with the sole exception of AMPS) or migration path for their customers, and instead is depending on churn to force consumers to update their terminal equipment, which may not be compatible with other carriers. This is not encouraging for telematics applications that may require stability for five to ten years. OnStar, for example, is now facing the challenge of the "analogue sunset" as US wireless carriers convert analogue base stations to digital.

2.2. Business Trends

Telematics-service providers currently base these services on subscription or fee-for-use models because of the significant infrastructure required to make these dynamic services work (figure 2.1). A telematics-enabled navigation system not only can direct you to your destination, but also, by tracking your location and communicating with the central server, can dynamically reroute you around traffic delays. Some telematics-enabled systems can convey your exact location and assist in contacting emergency services if you experience a breakdown or an accident. **A challenge for telematics services is how the infrastructure can provide 100% connectivity**. Cellular service is not global within the United States, but it is the most popular and ubiquitous connection mechanism.

In comparison to the number of vehicles on the road, estimated by the Telematics Research Group (TRG) to reach 742 million worldwide in 2003, those currently equipped with in-vehicle information systems represent a small fraction -- roughly 1%. However, telematics services represent a high value-added component on new cars sold today in terms of the hardware as well as the service aspect. From a branding and customer relationship management standpoint, the question that arises for original equipment manufacturers (OEMs) stocking their vehicles with in-vehicle information systems and the Telematics Service Providers (TSPs) with which they contract is: to whom do the customers belong?

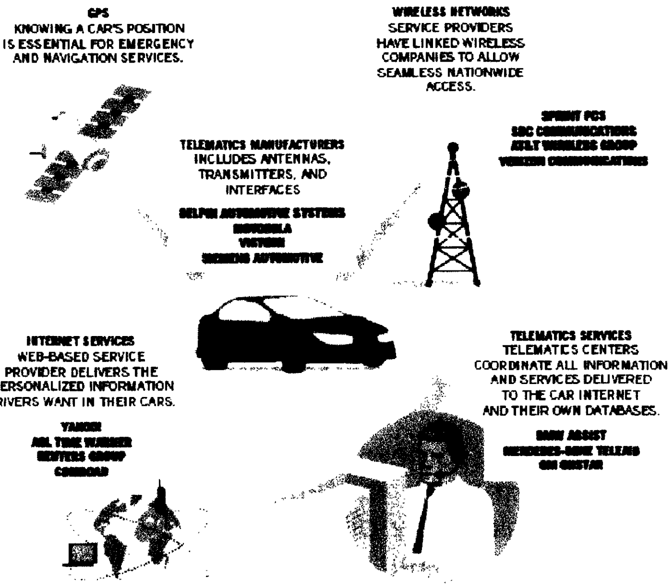

Figure 2.1 Infrastructure providers for telematics services[4]

An issue is the way that the two leading US TSPs -- OnStar, owned by General Motors (GM) and the independently owned ATX Technologies -- market and brand their services to OEMs. With the exception of a solution developed for Lexus, OnStar does not offer private-label services, while that is ATX Technologies' main business, with clients such as Mercedes, which markets its telematics service under the Tele Aid brand. The situation is complicated further by the Ford Motor Company's June 2002 decision to dissolve (as part of a campaign to stanch loss-making operations) its partnership with QUALCOMM in Wingcast, an attempt at building a service to compete with GM's OnStar. Although Ford continues to offer telematics services from ATX Technologies on its Lincoln brand (Lincoln RESCU) and on Jaguar models (Jaguar Assist), it recently contracted with Cross Country Automotive Services to provide a Telematics System for its Volvo brand, like Jaguar, a member of Ford Premier Automotive Group. The Volvo system, also a private-label solution, is known as Volvo On-Call Plus (see Table 2.1)

In the case of OnStar and the other car manufacturers to which it licenses its services, non-GM brands such as Acura, Audi and Subaru benefit from offering their customers cutting-edge technology, but a natural conflict also exists in that these OEMs are sending a revenue stream as well as access to their customers to a competitor. For those OEMs that contract with ATX Technologies and Cross Country Automotive Services, the conflict of interest does not exist, as the TSPs are there to collect and pass along customer usage data to the OEMs.

[4] Source: Adopted from Robert Cravotta, EDN, 2003

TSP	Ownership	OEM Partners (Telematics System Brand)
ATX Technologies	Independent	BMW (BMW Assist) Ford-Lincoln (Lincoln RESCU) Ford (VEMS), Infiniti (Infinite Communicator) Jaguar (Jaguar Net Assist), Mercedes-Benz (TeleAid, Command)
Cross-Country Automotive Services	Cross Country Group	Volvo (Volvo On-Call Plus) VW (VW Cross-Carline)
OnStar	General Motors (GM)	Acura, Audi, Buick, Cadillac, Chevrolet, GMC, Hummer, Isuzu, Oldsmobile, Pontiac, Saab, Saturn, Subaru (OnStar for all brands)

Table 2.1 Leading US Telematics Services Providers (TSPs) and OEM Partners, 2002[5]

The situation in Europe is somewhat analogous to the US, in that third-parties provide in-vehicle information systems to automotive OEMs. However, the European market is considerably different than the US market, not only because of its compact geography and multiplicity of languages but also for its consumers' emphasis on traffic data, navigation aids and travel information. To date, TSPs have tended to have single-country operations, but the Telematics Research Group indicates that pan-European service is in the works for Tegaron, among others. In Japan, meanwhile, all of the leading OEMs have sponsored their own TSPs, creating a model distinct from the US or Europe.

While consumers may be happy to use in-vehicle information systems as long as they are free, as many are for an initial period for those models that come equipped with telematics devices, renewal rates following the end of the grace period have been dismal. For instance, OnStar monthly subscription may vary from $17 to $70. The clear message from customers is that they are unwilling to pay high monthly service fees -- a lesson OEMs and their TSP partners should acknowledge.

Looking at the landscape of telematics services, as it was depicted in figure 1.1, the current trend today is that consumer's preferences are for services related to **Safety and Security**. A recent article from USA Today[6] presented some statistics of the most solicited services from the leading telematics provider, OnStar (see figure 2.3). More interesting about the article was to observe that up to 2003, 2.5 millions of vehicles were identified as using OnStar. However, the real statistic on this segment as well as the churn rate of subscribers, up to date, is iron-clanked by TPSs who have been reluctant to release more precisely information.

[5] Source: 045983 @2002 eMarketer, Inc www.eMarketer.com, company websites, 2002

[6] From Frank Pompa, USA Today, "OnStar enters 6Th Generation", March 23, 2004, paper edition

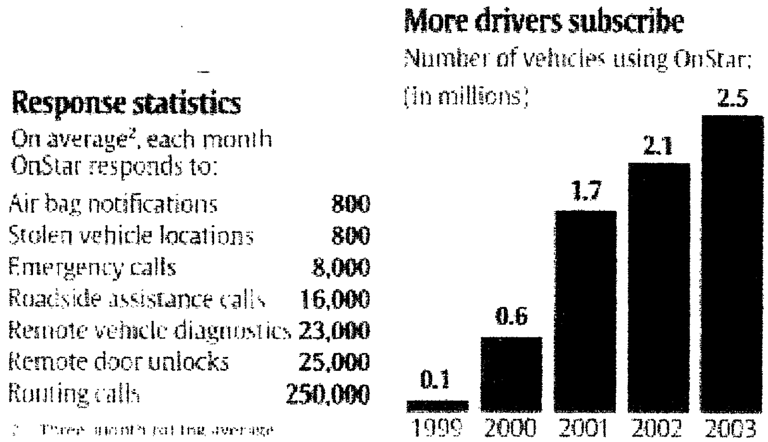

Figure 2.3 OnStar's most solicited services and number of vehicles using its telematics systems [7]

So far, lack of profitability and uncertainty of this industry has been pushing specially Telematics vendors to rethinking their business strategies in order to continue their presence in the scenario (see figure 2.2).

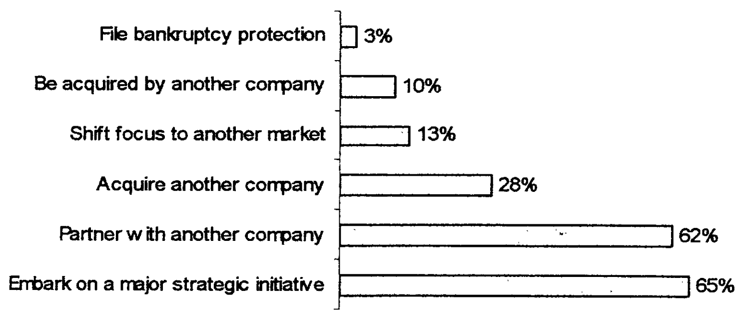

Figure 2.2 Business Strategies to Be Deployed in the Next 12 Months among Telematics Vendors Worldwide, Q2 2003 (as a % of respondents) [8]

Telematics device integration units will not be as popular in North America, with 164,000 shipped by the end of 2004. In the Asia-Pacific region, however, 250,000 device integration units will be shipped by the end of next year -- 30,000 more than the total embedded telematics units that will be distributed next year in the region, notes the Telematics Research Group.

[7] Source: USA Today, March 23, 2004

[8] Source: GartnerG2, September 2003, @2003 eMarketer, Inc

	2001	2003	2005	2007
US				
Vehicles in use (in millions)	216	222	230	239
Telematics-enabled vehicles in use (in millions)	2.7	7.0	13.9	25.6
Telematics-enabled vehicles in use (as % of total US vehicles in use)	1.3%	3.2%	6.0%	10.7%
Worldwide				
Vehicles in use (in millions)	721	742	770	799
Telematics-enabled vehicles in use (in millions)	3.0	8.5	18.9	39.9
Telematics-enabled vehicles in use (as % of total worldwide vehicles in use)	0.4%	1.1%	2.5%	5.0%

Figure 2.4 Telematics-Enabled Vehicles in Use in the US and Worldwide (in millions and as % of total vehicles in use, 2003 [9]

The Telematics Group explains that device integration units are mainly used now for mobile telephony while driving, but should evolve to include solutions like navigation and roadside services. The North American telematics market is primarily made up of embedded solutions, like OnStar.

2.3. Technology Trends

2.3.1. Trends In Wireless Technologies

The technology trend comes as the **802.11, 802.16** and **802.20** offerings begin to take hold, vary, and diverge. A huge number of technologies use the unlicensed 2.4 GHz band, everything from broadband to the noise emissions of home appliances such as microwave ovens. That's the band in which the traditional 802.11b exists. The applications so far are all limited-distance and count on the sender moving at about the speed of the coffee bar or lounge seat where most present-day access points are concentrated. **WiMAX**, the technical name for **802.16**, may offer transmission ranges of up to 30 miles and the capability of connecting with an antenna moving up to 150 miles per hour. But WiMAX is on the far horizon for telematics technology, as is the awe-inspiring **802.20** technology, which is meant to put a high-speed umbrella over an entire metropolitan area. [10]

Side-of-the-road spots. Wi-Fi itself works like a cell phone tower. Users have an array of various subscriptions and services that let them log in to the local area network (LAN) that each hotspot represents. This probably represents the near future telematics market use of Wi-Fi: the ability to tap a side-of-the-road spot for enhanced data services. Examples might include receiving an email download while filling the tank at a gas station, or a proximity-based maintenance download from the car computer to a dealership service bay when the car owner drives in.

[9] Source: Telematics Research Group, November 2002. @2002 eMarketer, Inc

[10] Adopted from Tim Moran, "Waiting for Wi-Fi on the go?", Telematics Update, December 2003-January 2004, Issue 25.

It's also possible to have a roadside data point, like a traffic control point or a commercial billboard that is capable of interacting with Wi-Fi equipped systems as they pass by. The technical challenges are data transmission speed, the relatively poor range of existing Wi-Fi LAN technology, and the power draw needed to pass the signal.

Vehicle-to-Vehicle (V2V). The near-term Wi-Fi world may also include a model in which each car becomes its own LAN and, at a stretch, a form of antenna-multiplier world in which a flock of cars might form a proxy sharing network, perhaps the ultimate peer-to-peer application. That concept is likely to rely on protocols like Dedicated Short Range Communications (DSRC). While it is appealing to think of a traffic-jam becoming a giant data packet-handling network, it is hard to envision because of the security concerns that Wi-Fi has already experienced.

Privacy and Security. Wi-Fi has become economically significant; privacy and security issues have taken relevance because of network hacking and geek sports such as rallying to find unprotected networks. This situation particularly diminishes still customers' attractiveness for the technology. On one hand, we want the systems to be open; on the other, if it is two-way, people do not particularly want other people to know what's wrong with their car. All of this tends to scare vehicle makers – but nothing worries them more than the rapid rise and fall of communications protocols that live and die at the frantic generational pace of a shrew. Before vehicle makers decide, vaguely, that they need to brand and dominate some form of Wi-Fi, it is imperative that Wi-Fi itself goes out and prevents the industry from waiting on another batch-loading ride.

2.3.2. Trends in Consumer Electronics Devices

What is it next for telematics in this sector? Looking at some new concept devices and at individual silicon vendors' roadmaps will give a pretty good indication of where things are going: a new prototype cell-phone from Mitsubishi that includes a high-resolution digital camera, a large color screen, a slot for a Memory Stick Duo card, built-in Wi-Fi and the ability to make voice-over-IP calls via Wi-Fi. This last feature is huge, and one that will potentially change the cellular carriers' business model forever as it could conceivably allow people to start making calls from Wi-Fi hotspots rather than having to connect to a cell network. This scenario also reduces the need for a classic, tethered landline service. [11]

The GSM-based wireless carriers in the US are pondering interworking functions that will connect devices on a wireless LAN to the core GSM network through a multimedia gateway, which will help them to maintain their business case for wireless voice services.

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[11] Adopted from Dr. Axel Fuchs, "Next Generation portable devices", Telematics Update, December 2003-January 2004, Issue 25.

A look at Texas Instrument's roadmap instantiated in the WANDA (Wireless Any-Network Digital Assistant) concept design shows a highly integrated solution that can connect via GSM/GPRS, WLAN 802.11b and Bluetooth. Powered by Windows CE, the device allows a variety of applications to run on its ARM 925 processor. The number crunching for communications is done on the TMS320C55x DSP. Both processors are part of the low-power OMAP chipset. Interestingly, all connectivity and charging is provided through a highspeed USB port. The device features a trans-reflective display, programmable buttons and navigation pads, stereo audio, a camera, an SD/MMC expansion slot, and USB synchronization support.

Qualcomm's high-end wireless chipsets sport similar feature sets, integrating CDMA2000 and WCDMA/ SM wide-area networking with Bluetooth baseband functions. The silicon supports a variety of multimedia functions, such as MP3 decoding, MPEG-4 encoding and decoding, videophone, megapixel camera support, GPS, and 3D graphics for gaming. Qualcomm also provides voice recognition and GPS positioning support, high-speed USB and SD Card connectivity for peripheral devices, and hardware support for its BREW programming platform, as well as for Java.

2.4 Conclusion

After seven year since its recognition, telematics has not met the expectations that players of the automotive and communications industries prognosticated from telematics. During this period of time, established firms and entrepreneurs have entered and exited the industry at a higher rate. Only those firms that own the capabilities, financial resources and a solid base of potential customers have survived the uncertainties faced by the emerging innovation.

Only few telematics players, like OnStar, have succeeded in their business strategies and have signed-up a significant amount of telematics users enough to justify a continuous investment in what still seems an unprofitable business. After seven years, consumer's behavior seems to show strong preferences for telematics services related to safety, emergency, and vehicle diagnostic.

Future trends of technologies converging in the telematics systems promise to offer alternatives to improve the performance of existing telematics systems. However, these technologies also present a threat to current telematics business models. Customer's experiences with those technologies (like wireless and mobile devices) are favorable for adding value to the telematics innovation. However, the decision to integrate those technologies into the telematics systems still remains in vehicle manufacturers and telematics providers hands.

The following chapter presents a structured description and analysis of the factor and determinant affecting the growth of this still emerging telematics industry. The further analysis attempts to provide a better understanding of why this industry has not yet overcome the uncertainties that characterize new innovations.

Chapter 3
Rate of Adoption of Telematics

3.1 Introduction

The concept of telematics is one that currently lacks a clear and consistent definition across the industries that support telematics-application development. This inconsistency results from the fact that the definition and expectations are constantly changing about what a Telematics System, as an emerging application, can do.

A recent study on the factors affecting the adoption of telematics performed by the Gartner Group among Telematics vendors and VMs revealed that the three major contributors are related to pricing, cost of the telematics hardware and software, and more importantly, education of consumer on telematics benefits (see figure 3.1).

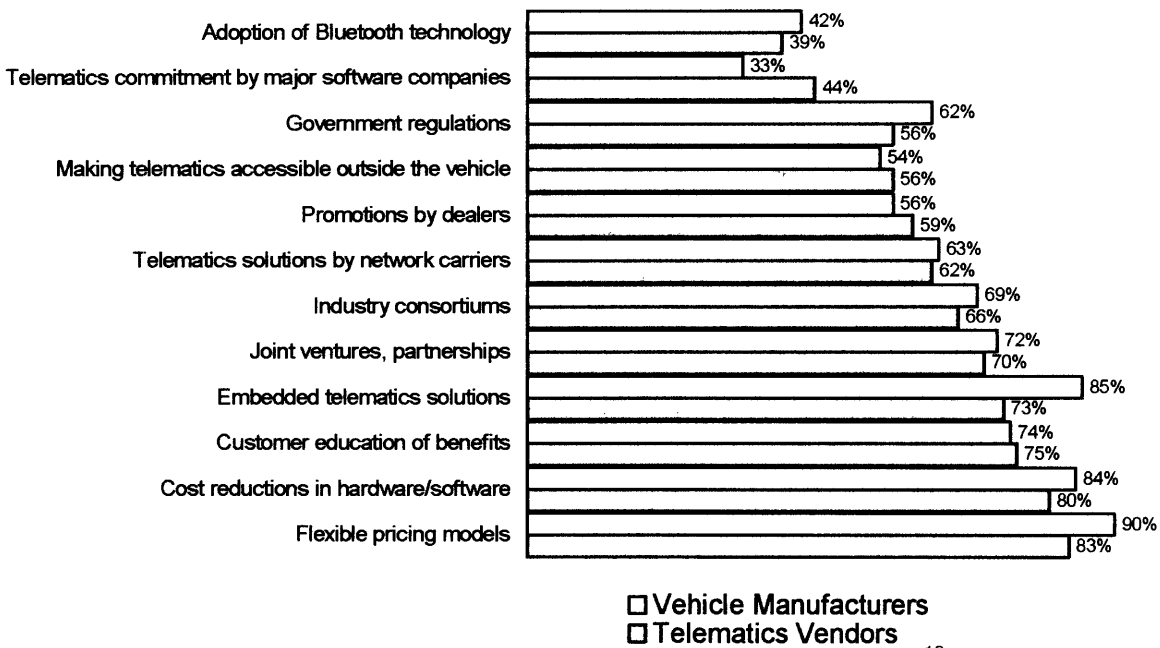

Figure 3.1 Factors Affecting Adoption of Telematics [12]

This section reviews the different factors that affect the rate of adoption of telematics by classifying these factors in five different groups. The analysis of these factors grouped this way will provide the basis for modeling the dynamics influencing telematics rate of adoption as it will be developed in Chapter 8.

[12] Source: Gartner G2, September 2003, @2003 eMarketer, Inc. According to 241 Telematics Vendors and Vehicle Manufacturers

3.2 Determinant for Diffusion of Telematics

In summary, the factors affecting the diffusion and adoption of Telematics can be classified if five different determinant groups: (1) Benefit received from the new technology, (2) Network Externalities Effects, (3) Cost of Adoption, (4) Consumer Information and Uncertainty, and (5) Industry and Market Environment.

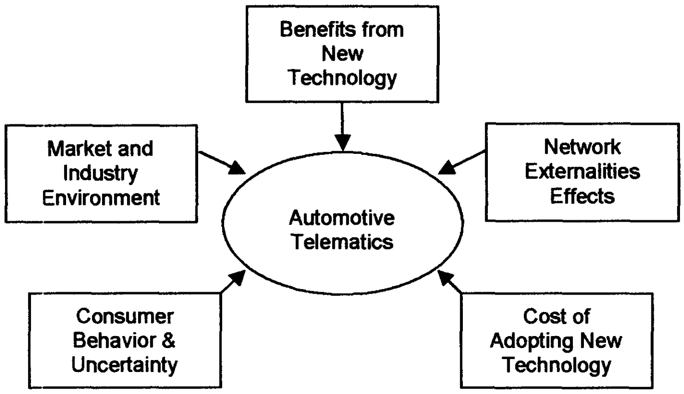

Figure 3.2 Determinants for Adoption of Telematics

3.2.1 Benefits received from the New Technology Innovation

Clearly, the most important determinant of the benefit derived from adopting a new technology is the level of improvement which the new technology offers over any previous technology. This, to a great degree, is determined by the extent to which older technologies exist that are fairly close. As many authors have emphasized, as diffusion proceeds learning about the technology takes place, the innovation is improved and adapted to different environments[13].

The implication is that the benefits of adoption generally increase overtime; if they increase faster than cost, diffusion will appear to be delayed (because the number of potential adopters will increase over time, expanding the size of the adopting population).

As it was summarized in Figure 2.1, the author believes that telematics should satisfy three different markets; the vehicle, the driver and the passenger. Telematics did not necessarily represent a technological innovation that is replacing a previous one, since no telematics industry existed prior to 1997. However, some of the features that telematics aims to provide are services that consumers have experienced for many years already but at home, at the office, or on-the-go for personal use. These services include mainly those related to driver and passenger markets: Mobile Communication, Information, M-Commerce, and Multimedia and Entertainment.

[13] Hall, Bronwyn H., "Innovation and Diffusion", October 2003, Forthcoming in Fagerberg, J.,D. Mowery, and R. R. Nelson (eds.), Handbook of Innovation, Oxford University Press.

So, should we say that telematics technology innovation is improving the way consumers have experienced those services? No. Telematics is just making those services available for the consumers while they are in their vehicles. So the aim of telematics is to enhance consumer's driving experience.

Analysts in the field have estimated that on average consumers spend 10%-15% of day time on the road (driving to and from the office, on-road business trips, taking kids to school, etc). Telematics intends to seamlessly close the communication gap between home and the office while consumers are in their vehicles.

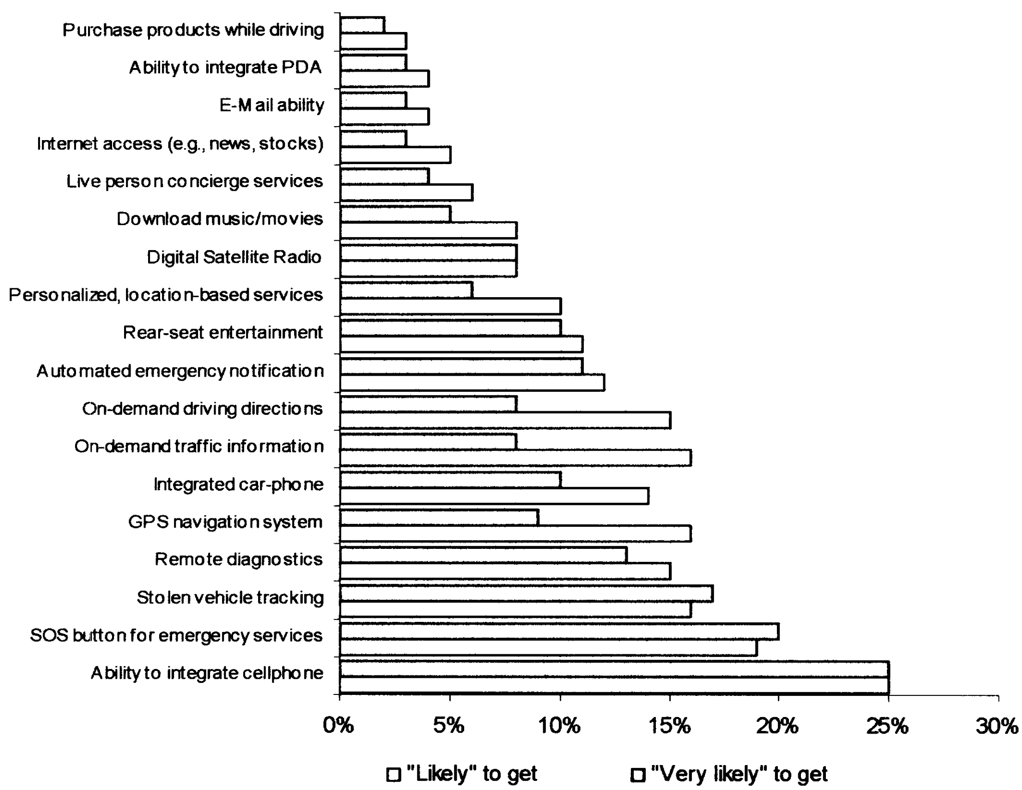

Figure 3.3 US Consumer Interest in Telematics Applications Q3 & Q4 2002[14]

The study performed by the Gartner Group (figure 3.3) shows that the features that consumers value the most are those related to Mobile Communication, Safety and Emergency, and Navigation and Traffic (reference to figure 1.1). This finding emphasizes the fact that consumers would be mostly willing to deploy new services that telematics innovation offers, unlike those that they already enjoy at home or at the office.

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[14] Source: Gartner G2, September 2003 @2003 eMarketer, Inc. As a % of US adults who are "likely" or "very likely" to adopt

Unlike the rest of telematics features, Mobile Communication is a service for which consumers have a great experience with and have placed a great value on. The critical decision TSPs and VMs must make is how to allow consumers to use their existing mobile devices plugged in their cars and still be able to safely (hands-free) place phone calls while driving. Also, they have to decide how to collaborate with cellular network providers to allow consumers to have only one source (mobile carriers) of connection to the cellular network instead of having one for their mobile device and one for their vehicles.

3.2.2 Network Externalities Effects

When the value of a product to one user depends on how many other users there are, economist say that this product exhibits *network externalities*, or *network effects* [Shapiro & Varian 1999] [15]. Technological innovations subject to strong network effects (as the case of telematics) tend to exhibit long lead times followed by explosive growth. The patterns result from *positive feedback*: as the installed base of users grows, more and more users find adoption worthwhile. Eventually the product achieves critical mass and takes over the market. Network effects lead to demand side economies of scale and positive feedback. The key challenge is to obtain critical mass –after that, the going gets easier. Once you have a large enough customer base, the market will build itself. However, having a superior technology is not enough to win. You may need to employ marketing tools such as penetration pricing to ignite the positive feedback.

The close connection between technological standards and network externalities comes from the fact that standards create a number of effects all of which go in the direction of making it more likely that Telematics product and services will exhibit network externalities. First, a technological standard increases the probability that communication between two products will be successful (when eventually telematics allows peer-to-peer communication). Second, standards ease consumer learning and encourage adoption when the same or similar standards are used in a range of products. The ease of learning allows consumers to interact and learn from other consumers also using the same Telematics standard. Third, a successful standard increases the size of the potential market for a product or service, which can be important in lowering the cost of its production and in increasing the variety and availability of complementary products and services.

So the shift from automotive telematics proprietary standard architecture to a more open one will allow the attraction of more complementary products and services, will contribute to reducing consumer uncertainty toward the new telematics innovation, and ultimately will contribute to speeding up the rate of adoption of the telematics products and services. On a broader perspective, an increase in the rate of adoption will increase the size of the network of consumers but it will also increase the network of complementary vendors willing to produce

[15] Shapiro, Carl and Hal R. Varian, 1999 "Information Rules", Harvard Business School Press. Page 14.

additional products and services that are compatible to the established Telematics System architecture. The dynamics of these contributing factors will be better illustrated in Chapter 8.

Telematics Service Providers, like OnStar for GM and Wingcast for Ford, took their chances to be first-to-market and made huge preemption investments in order to take advantage of the positive feedback that network externalities provide. Only OnStar has succeeded with this strategy since Wingcast was demised in 2002. OnStar has taken advantage of network effects. The critical decision OnStar must make is whether, how and when, to open up its proprietary Telematics System for adoption by complementary vendors. In the following chapter, I discuss the role of standard for the benefit of telematics networks.

3.2.3 Cost of Adopting the New Technology

No service comes for free. Telematics business models will work as long as there is a Telematics System installed in the vehicle. On the other hand, the continuous use of the telematics services is suitable for a subscription-based pricing model. However, the cost of adopting a new technology not only includes the cost of the hardware and the price of the services, but more importantly it includes the cost of complementary investment and learning required to make use of the new technology innovation.

For consumers willing to adopt telematics services, the cost of complementary investment is identified in their need to adapt their existing products and services that they currently enjoy into the new innovation. Lack of compatibility or interoperability between those products and services will result in an additional investment that the consumer must make. Thus the simpler example can be seen on the use of their mobile communication device and accessibility to the cellular network.

Telematics Systems require the deployment of cellular-based standards to access the network and allow the agents in the location-based center to communicate with the driver. Although consumers (driver and passenger) are allowed to place hands-free phone calls from the vehicle using that embedded cellular network, this service may be different from the one they use in their existing mobile devices, thus requiring them to pay twice for the same type of service. As shown in figure 3.3, the ability to integrate their cellular phone into the vehicle is the number one interest for consumer to adopt telematics. The viability of allowing interoperability and compatibility between the mobile device and the car phone system is an issue that will be discussed in the next chapter.

Again, standards play an important role for this determinant of diffusion. The presence of vehicle manufacturer telematics system proprietary standards makes difficult the opportunity to reduce the cost of Telematics Systems as well as to reduce the cost of subscriptions. If the standards were available, the industry would open up and more telematics vendors would be designing and manufacturing telematics system, increasing the availability of options, increasing competition, and thus reducing the cost of the system. Of course, this contention assumes that VMs would be willing to either factory-install compatible Telematics Systems in new vehicles or, more ambitiously, design the telematics architecture in the vehicle in a way that allowed the installation of telematics system after the sale of the vehicle.

TSPs have an opportunity to share the cost of producing telematics services by partnering with suppliers, providers of complementary products or services and, even further, with competitors. The aim of this kind of strategy is to subsidize the cost of telematics features and provide the consumer a lower subscription fee. Defining the best pricing strategy for a new service innovation is not an easy task. An interesting study performed by Gartner group even shows that there is a lack of unanimity among consumers to decide what the pricing strategy should be (figure 3.4).

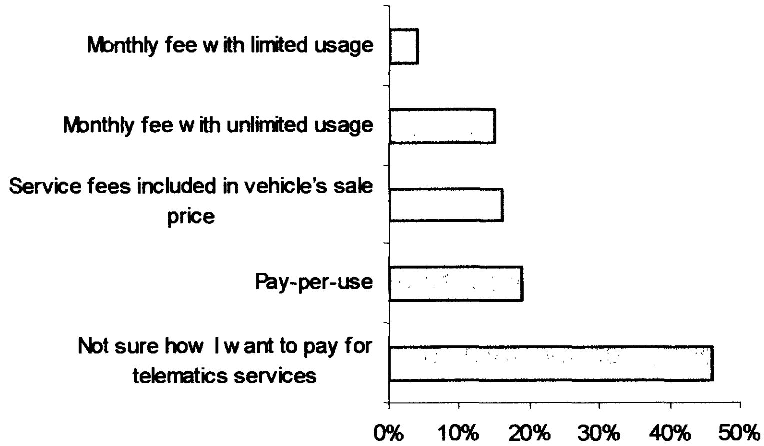

Figure 3.4 How US Consumer Want to Pay for Telematics Services[16]

Existing Telematics business strategies (like that of GM-OnStar) were based on factory-installing a telematics system in each brand new vehicle. After a year free-of-charge, telematics services would continue being provided as long as the customer would renew their subscription. For monthly subscriptions, consumers would be paying from $17-$70, depending on the type and number of telematics features. The cost of telematics system is included in the price of the vehicle. Telematics Systems cost varies from $400 to $600 usd. If consumer decided not to subscribe (renew) again, the cost of the telematics system will be sunk and will remain embedded in the vehicle for the rest of its life or until another consumer buys the car and subscribes to the services.

In the long run the strategy of embedding the telematics unit in the vehicle has another drawback. As it is the case of mobile network carriers, in order to sell the

[16] Source: GartnerG2, September 2003, @2003 eMarketer, Inc. Results from Q3 & Q4 2002 (as a % of respondents)

access to the network, they are giving away the cost of the mobile device. This strategy has irreversible consumer loyalty issues if they decided to de-bundle the offer and charge separately for it. For embedded telematics, vehicle manufacturers will probably suffer the same effects in the future.

Finally, since the product development cycle of the electronics and wireless communication technologies are shorter than that of automobiles, consumers will be hesitating to invest today in technologies embedded in the car that will be obsolete tomorrow. This situation adds up to the factors that encompass the cost of adopting a new technology.

3.2.4 Consumer Behavior, Information and Uncertainty

The choice to adopt a new technology innovation requires knowledge that it exist and some information about its suitability to the potential adopter's situation. Therefore an important determinant of diffusion is information about the new innovation, which may be influenced by the actions of the new suppliers of the new technology.[17] Obviously, in many cases this takes the form of advertising, which influences the cost of the telematics service directly. The choice to adopt may also depend on the information available about the experience with the telematics innovation in the decisions maker's immediate environment, either from those in geographic proximity or from those with whom he or she interacts (increase in the size of the network due to word-of-mouth effects).

Once aware of the existence of the innovation, consumers' behavior to adopt the new technology innovation depends on psychographic factors. To explain this phenomenon, Moore (2002) [18] developed a model that describes the market penetration of any new technology innovation (product or services) in terms of the progression in the types of consumers it attracts throughout its useful life. He distinguishes between five different groups of consumers (figure 3.5).

The psychographic factors previously mentioned are a combination of psychology and demographics that makes its marketing responses different from those of the other groups. The following is a quote from Moore that gives a brief description of each consumer group[19]:

> **Innovators** pursue new technology innovations aggressively. Technology is a central interest in their life. Often make a technology innovation purchase just for the pleasure of exploring the new product's properties. **Early adopters,** like innovators, buy into new products concepts very early in their life cycle, unlike innovators, they are not technologist. They just want to imagine, understand and

[17] Hall, Bronwyn H., "Innovation and Diffusion", October 2003, Forthcoming in Fagerberg, J.,D. Mowery, and R. R. Nelson (eds.), Handbook of Innovation, Oxford University Press.

[18] Moore, Geoffrey A. 2002 "Crossing the Chasm: Marketing and Selecting High-Tech Products to Mainstream Customers", published by Harper Business Essentials, an imprint of Haper Collins Press.

[19] For a more detailed description of each group consult the Geoffrey A. Moore 2002 "Crossing the Chasm: Marketing and Selecting High-Tech Products to Mainstream Customers", published by Harper Business Essentials, an imprint of Haper Collins Press, chapters 1 and 2.

appreciate the benefits of a new technology, and realize benefits of it for themselves. The **early majority** shares some of the ability to relate to technology, but ultimately they are driven by a strong sense of practicality. They are content to wait and see how other people are making out before they buy in themselves. They have a sense of productiveness rather than innovativeness. The **late majority** shares all the concerns of the early majority plus one additional one: whereas people in the early majority are comfortable with their ability to handle a technology product, should they finally decide to purchase it, members of the late majority are not. They wait until something has become an establish standard. Finally there are the **laggards.** These people simply do not want anything to do with the new technology, for any of variety of reasons, some personal and some economical. Laggards are generally regarded as not worth pursuing on any other basis.

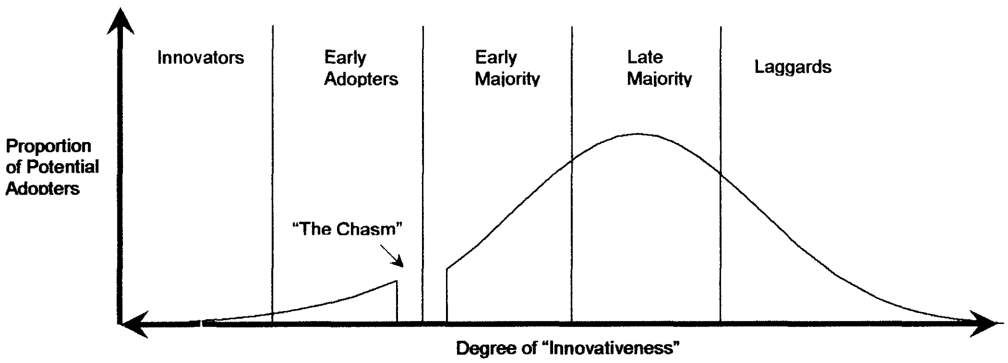

Figure 3.5 Technology Adoption Life Cycle
(Source: Moore, 2002)

The challenge that TSPs (and VMs) will face, when marketing the new telematics technology innovation, is to bypass the gap between the group of early adopters and the early majority. This is, where as innovators and early adopters like to try new technology innovations, early majority like to try a product innovation that is already probed and tested and to get references prior to acquiring the new technology. Because of these incompatibilities, early adopters do not make good references for the early majority. Early majority, lacking of good references, delay or deny the buying decision. This gap is typically known as The Chasm. TSPs should be aware of this phenomenon during the telematics' adoption life cycle. However, considering that telematics is still an emerging industry, not only should TSPs care about this issue, but those suppliers and collaborators that encompass the telematics value chain and that decided to invest in assets to build the Telematics Systems and infrastructure, should also take interest.

3.2.5 Market Size, Industry Environment and Market Structure

In section 2.2 we reviewed and discussed the market size and market structure for the telematics industry.

Along with market size and structure, the general regulatory environment will have an influence, tending to slow the rate of adoption in some areas due to the relative sluggishness of regulatory change and increasing it in others due to the role of the regulator in mandating a particular technological standard.

According to the NHTSA (**National Highway Traffic Safety Administration**, www.nhtsa.dot.gov), driver distraction and inattention to the road are significant contributors to automobile accidents. Drivers' handheld-cell-phone use while driving is one of the most visible and controversial sources of driver inattention. As a result, recent legislation efforts are aiming to limit handheld-cell-phone and other similar-device use while users are driving. The **Network of Employers for Traffic Safety** (www.trafficsafety.org) cites drivers' spilling hot coffee on themselves or dropping something on the floor while driving as the most frequent distractions preceding automobile accidents. The organization cites fiddling with a radio or a climate-control system as the second biggest distraction.[20]

New telematics-system vendors are focusing on providing hands-free interfaces and speech-recognition technology in an attempt to address the driver-distraction and safety issues. However, according to the **American Automobile Association Foundation for Traffic Safety** (www.aaafoundation.org), hands-free phones are also a source of driver distraction and inattention. The new in-car navigation systems are an additional source of distraction. A computer voice can tell you when to turn or change lanes, but the display screen can still be a source of distraction that takes your attention from the road. Some systems address this source of distraction by denying the driver access to the map display while the vehicle is in motion.

With vendors considering new, non-driving-related functions, such as e-mail and Web browsing, for future Telematics Systems, telematics system designers must provide these functions to the passengers without creating a source of distraction for the driver. An NHTSA test involving a car-following task shows a 30%, or 310-msec, increase in reaction time to a periodically braking lead vehicle when a speech-based e-mail system was present. Subjective workload ratings also indicate that speech-based interaction introduces a significant cognitive load on the driver. Product liabilities aside, a large risk to telematics vendors is devoting significant resources to designing and offering a product that lacks demand because it requires restricted use or is perceived as unsafe.

3.3 Conclusion

In this chapter we reviewed five different groups of factors affecting the rate of adoption of telematics. These factors included the *consumer's benefits from the new innovation*. Since telematics did not replace previous car communication services any effort to make telematics offer attractive will be beneficial for the consumer's adoption. *Network externality* is the second major factor. The role of aperture of vehicle manufacturer's proprietary standards will be beneficial for vendors of complementary product and services to join the bandwagon thus increasing the possibilities to increase the network of users deploying telematics

[20] Cravolta, Robert, "A look at Telematics", TechTrends, EDN, www.edn.com , November 2003.

products and services. The opening of standards will also contribute to overcoming the third factor of adoption of telematics, *cost of adoption of the new technology innovation*. The aperture of proprietary standards would allow an increase in availability of Telematics Systems vendors thus reducing the cost of it. On the other hand, TSPs will be able to build partnerships with suppliers and complementors to share the cost of telematics services.

The fourth factor of adoption relates to *consumer behavior, information and uncertainty*. Basically, advertising and word-of-mouth are identified as the main strategies to inform consumers of the benefits of telematics. However, I suggested that TSPs should consider the gap ("The Chasm") that occurs in the adoption life cycle of high technologies related to the behavior of consumers to adopt new innovations. Finally, *industry environment* in the form of regulatory policies that normalize the use of communications systems in the vehicle is also an important factor to consider in the adoption of telematics.

In this chapter I introduced the importance of standards for the proliferation of the telematics industry. In the following two chapters I will review in deep the elements that integrate typical telematics system architecture, and will propose some strategies for VMs to approach the decision over standardization.

Chapter 4
Telematics System Architecture: The Convergence of Technology Standards

4.1 Introduction

Existing Telematics Systems are highly integrated architectures and they are proprietary to vehicle manufacturers. At this stage of its evolution, the telematics industry calls for VMs to open their proprietary systems and cooperate to establish common industry standards.

This section reviews the basic elements of a telematics system. Several technologies converge in the telematics system. The deployment of specific technologies standard varies from one telematics system to another. Some technology standards are already mature and they are not proprietary to VMs, like those of wireless communication technologies. Deployment of these wireless non-proprietary open technology standards is key for telematics system and business models. A revision of the evolution of the wireless technologies is included to help understate how they will evolve in the future and how they may impact the telematics business model.

A more intimate analysis of the underlying technologies (existing and future) and standards (proprietary and non-proprietary) that assemble the telematics system is required for VMs to define the right strategy that benefit both the industry and themselves. This analytical procedure is the first step in the process of realizing how the dynamics of the industry will evolve in the future.

The information to be discussed in this chapter is useful in designing and suggesting a strategic framework for telematics players to consider when deciding how to play in this standard driven market. This strategic framework is developed in the next chapter.

4.2 Telematics System Architecture

Technically, a telematics system does not perform a user function but is an integral application that combines and integrates five interconnected elements: the telematics center unit, the location or positioning module, the wireless-network-access device, the user interface, and the chassis-level network (see figure 4.1).

The heart of a telematics system within the car is a **Telematics Center Unit (TCU)** that is connected (wirelessly) to a location-based service center. The TCU serves as the central platform of a telematics system, where all telematics-related technologies are deeply integrated. It communicates location-specific information to a location-based service center and in turn the center helps deliver telematics services to a driver via the cellular phone.

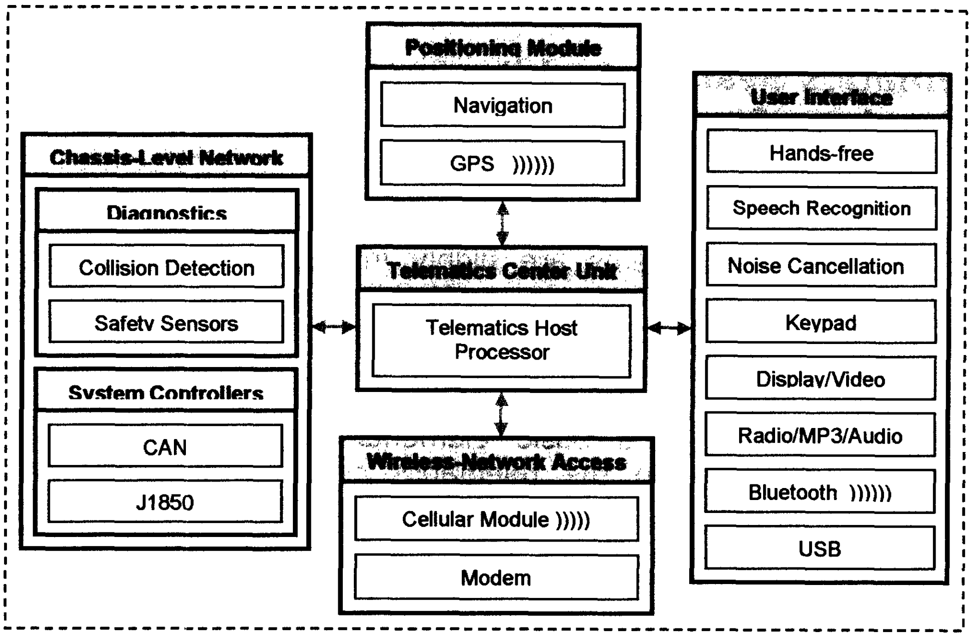

Figure 4.1 Typical Vehicle Telematics System Architecture[21]

The **location or positioning module** is usually GPS-based, but it could employ cellular-based methods if a customer needs only local, limited coverage. The **wireless-network-access device** is often cellular-based and it may include a modem for data transfer. Depending on the application, basic data transfer may instead occur over existing standards such as GPRS (General Packet Radio Service). But data transfer could also rely on local wireless hot spots, such as through 802.11- or Bluetooth-access points. The design of the **user interface**, especially for vehicle systems in the United States, is stressing hands-free-interface and speech-recognition technologies. The user-interface design is beginning to incorporate Bluetooth and USB interfaces to operate with users' mobile devices. The **chassis-level network** for automobiles, such as through CAN (controller-area-network) and J1850 interfaces, provides a gateway into the vehicle-command, vehicle-controls and vehicle-diagnostics and infotainment systems.

4.3 Location and Positioning Module

Typical Telematics Systems are based on GPS technology. A GPS chip (*GPS receiver*) is embedded in the vehicle Telematics Systems. This chip maintains contact with the GPS satellites for location and positioning when required.

Although much less precise, cellular-based devices are also usually used as location and positioning devices, when antennas triangulate to locate the position of the signal source.

[21] Source: Adopted from Cravolta, Robert, "A look at Telematics", TechTrends, EDN, www.edn.com , November 2003.

4.3.1. Global Positioning System (GPS)

GPS is a network of 24 Navstar satellites orbiting Earth from 11,000 miles. Originally established by the U.S. Department of Defense (DOD) at a cost of about US$13 billion, access to GPS is free to all users, including those in other countries[22]. With military accuracy restrictions partially lifted in March 1996 and fully lifted in May 2000, GPS can now pinpoint the location of objects as small as a penny anywhere on the earth's surface[23]

GPS provides specially coded satellite signals that can be processed in a **GPS receiver**, enabling the receiver to compute position, velocity, and time. Basically GPS works by using four GPS satellite signals to compute positions in three dimensions (and the time offset) in the receiver clock. So by very accurately measuring the distance from these satellites, a user can triangulate their position anywhere on earth. GPS receivers have been miniaturized to just a few integrated circuits and so are becoming very economical. These days GPS is finding its way into cars, boats, planes, construction equipment, movie-making gear, farm machinery, even laptop computers and mobile communications devices.

GPS technology has matured into a resource that goes far beyond its original design goals. There are five main uses of GPS today (only the first three have been used by existing TSPs):

1. Location- determining a basic position.
2. Navigation - getting from one location to another.
3. Tracking - monitoring the movement of people and things.
4. Mapping- creating maps.
5. Timing - providing precise timing, time intervals, and frequency.

4.3.2 Issues to integrate GPS receivers into a mobile phone.

There are several issues for integrating GPS functionality into a phone handset, instead of the vehicle itself[24]. First, the ability of a GPS phone to operate inside of the vehicle without an external GPS or cellular antenna. GPS antennas must have an unrestricted view of the sky to track satellites. So the decision must be made whether it's more cost-effective to have the GPS in the phone or in the car.

Second, integrating telematics into a portable phone may be very attractive from a cost and convenience perspectives, but it does not support the stolen vehicle alarm, door lock/unlock, and other features that require the device to remain in the car when the occupants have left. Finally, GPS is only one part of the locating solution. In addition, cellular infrastructure positioning, such as cell tower

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[22] GPS's competitors are the "Glonass" Russian Satellite System and "Galileo" Satellite System recently released by the European Community.

[23] Palo Alto Wireless, GPS Resource Center, www.paloalto.com, last time consulted March 16, 2004

[24] Source: Motorola Automotive Website. www.motorola.com

triangulation, can help. Given current technology, GPS does not operate as effectively inside multiple story, concrete or metal buildings, where many emergency calls originate.

4.4 Wireless Network-Access Module

To maintain communication with the outside world, the Telematics Systems architecture **must deploy** a communication wireless technology to transfer voice and data. Access to the network can be achieved by deploying any of the three generation of cellular-based standards (1G, 2G or 3G) or, in the future, it could also be from one of the more recently developed wireless technologies like WiFi or WiMAX.

Looking at the future trends and business applications of wireless technologies, the question remains of on how the evolution of these wireless technologies will affect the evolution of telematics industry in the future? And what wireless technology will be more suitable for telematics business models? (see figure 4.2)

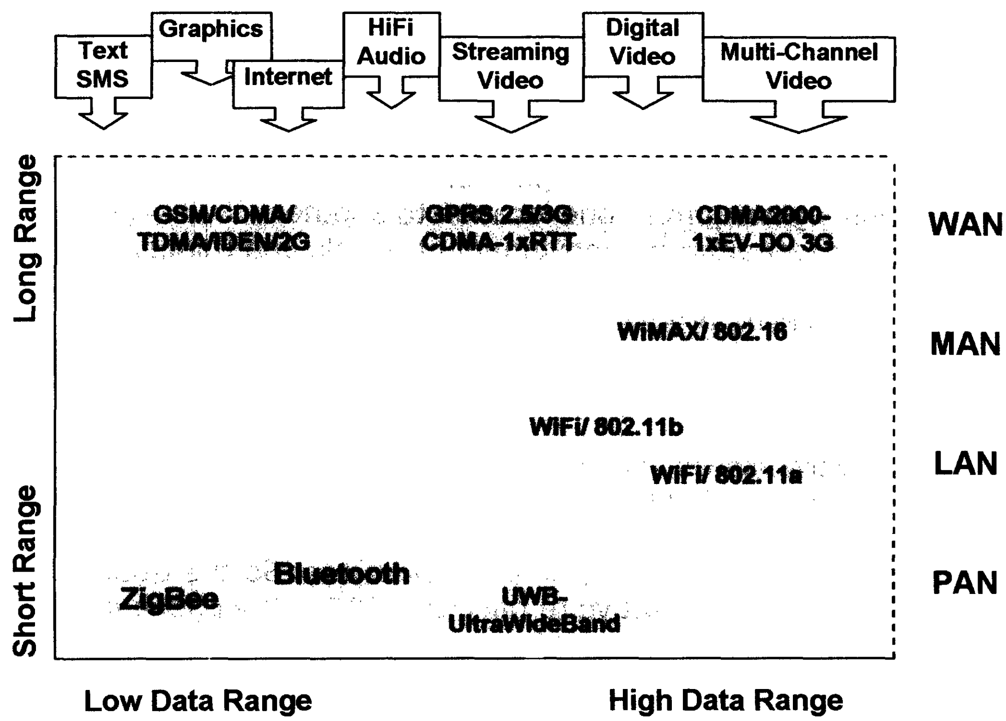

Figure 4.2 What wireless technology will be more suitable for telematics business models? [25]

[25] Source: Adopted from www.zigbee.org

4.4.1 Cellular Network Standards

The first generation (**1G**) network, AMPS (Advanced Mobile Phone Service), is the analog cellular telephone service provided in the US. Only AMPS offers the broad geographic coverage essential for reliable emergency response services. That is why it is the system primarily utilized by US TSPs. For data transmission on analog AMPS, modems have been added to the telematics system (hardware) and central service center.

In the future, the growth of telematics depends on digital cellular standards providing service over a larger geographic area, especially in cities. However the US market has multiple standards including TDMA, CDMA, GSM and iDEN. These standards belong to the second generation (2G) network. Although 2G standards improve the quality of voice, they are still unable to transfer data over the network.

Telematics industry endeavors to deliver comprehensive data services such as Internet access and customized entertainment services. To achieve this result, cellular network carriers must adopt 2.5G or even better 3G network standards. The migration to 2.5 and 3G digital communications technologies will be even more essential for telematics but their adoption depends on several factors, perhaps the most important of which is, that existing cellular providers must make a high investment to upgrade their cellular networks.

The transition path to upgrade to 2G, 2.5G and 3G Networks Background.

Mobile carriers upgraded networks to second generation (**2G**) digital cellular technologies to add capacity without adding spectrum. TDMA, GSM and CDMA are 2G air interfaces used to transmit signals between handsets and antennas at base stations. As cellular services became even more popular, carriers wanted to increase capacity for voice traffic and offer higher speed cellular service for data and multimedia capability. The throughput of 2G digital cellular is 14.4 Kbps (kilobits per second) on TDMA and CDMA networks and 9.6 Kbps on GSM networks.[26]

The International Telecommunications Union (ITU) subcommittees endorsed several third generation (**3G**) techniques. Ericsson backs one, W-CDMA (Wideband-CDMA), which is more suitable for upgrades from TDMA and GSM standards. Qualcomm supports the other, CDMA2000, which is more suitable for upgrades from CDMA. Qualcomm receives royalties on all W-CDMA and CDMA2000 services. It supplies chips for CDMA2000 handsets as well.

a) Upgrades from TDMA and GSM (2G) to W-CDMA (3G)

- Because of the lower cost, most TDMA and GSM carriers will upgrade their systems to **2.5G** General Packet Radio Services (GPRS) prior to upgrading to

[26] Dodd, Anabel Z., 2001, "The Essential Guide to Telecommunications", Prentice Hall PTR, 3rd Edition, pages 399-405

3G, W-CDMA. GPRS is a packet data service. **GPRS is a data-only service** with a peak speed of 115 Kbps. Interference, noise and possible network congestion cause the typical speed to be closer to between 10 Kbps and 60 Kbps rather than the peak GPRS speed of 115 Kbps. However, GPRS service has the advantage of being "always on." It is not necessary for users to dial into the network (unlike other wireless technologies like WiFi). *The major disadvantage of GPRS is that it uses voice capacity for data, which is a problem in congested areas.*

- **EDGE (Enhanced Data Rates)** standard was released for GSM Evolution. EDGE is considered a 2.5G technology or a 3G technology, depending on the type of EDGE service deployed. The 2.5G EDGE "compact" technology uses 60 KHz channels and the 3G EDGE "classic" uses 200 KHz channels. Most carriers considering EDGE plan to use it as an intermediate overlay for higher speed data. Enhanced rates for GSM evolution (EDGE) offers higher speed data rates than GPRS, up to a peak 384 Kbps but 60 to 180 Kbps achievable depending on network conditions. Upgrading to EDGE requires new hardware and software. EDGE compact is more suitable than GPRS for TDMA networks because it requires smaller chunks of spectrum than GPRS.

Upgrades to W-CDMA from GSM are costly. Because W-CDMA is based on code division rather than time division access, upgrades from GSM networks (based on time division) to full 3G service will require almost new infrastructure (new controllers must be added as well as hardware and software to the base transceiver station). The use of new, higher frequency spectrum will need more antennas and more base-transceiver systems than those used in 2G and 2.5G networks. In addition, hardware and software upgrades for mobile switching offices will be needed. Finally, new billing and back office systems will be required. W-CDMA service is not expected to be available on a large scale in the near future.

b) Upgrades from CDMA (2G) to CDMA2000 (3G)

Upgrades to 3G service on CDMA networks are less costly and less complex than those for GSM networks. This is because 2G and 3G CDMA networks are already based on code division multiple access. The major incentive for upgrading to 3G CDMA2000 is the increased voice capacity. CDMA2000 operates on the same spectrum as 2G CDMA and North American TDMA networks.

- **CDMA2000-1X** is the first phase (1X) of 3G CDMA2000 that provides "always on" data rates up to a peak data of 144 Kbps and additional voice capacity. As in GPRS, achieved data speed will be lower than peak data rates, anywhere from 18 Kbps to 71 Kbps. Handsets for earlier CDMA technology will work on **1XRTT** (First Generation candidate Radio Transmission Technologies) systems but the increased capacity for voice calls will not be totally achieved. Voice capacity can be doubled if all users have 1xRTT phones. The new handsets also will be required to achieve higher speed packet data rates.

- **CDMA2000-1xEV-DO (High Data Rate)** is for network providers who already have the first CDMA2000. They can upgrade to a higher data speed by adding software and channel cars to their base for High Data Rate (HDR). HDR service is a data-only enhancement with a stated peak data capacity of 2.4Mbps. No capacity is gained for voice traffic. In areas with high data traffic, the speeds are expected to be about 130 Kbps. HDR service can be mixed with first generation 1xRTT equipment so that only areas with high demand for data need be upgraded.

Upgrading to CDMA2000 from TDMA networks would require for TDMA cellular operators an entirely new base stations and base station controllers, new handsets for users and billing systems as well as routers and connections to IP data networks. If they use their existing spectrum, they will not need to add additional cell sites and antennas.

If we compare W-CDMA and CDMA2000, the latter has a major advantage because of the low startup cost for carriers such as Sprint PCS that have preexisting CDMA networks. Moreover, GSM and TDMA upgrades to 2.5G service do not provide any additional voice capacity. Voice traffic represents the major portion of carriers' revenue. The major advantage of W-CDMA is the large installed base of GSM networks. The majority of the world's cellular networks are based on GSM. If all of these networks as well as TDMA-based networks upgrade to GPRS and W-CDMA, roaming will be expedited.

Qualcomm stated that by the end of 2003 it would produce chips for mobile handsets that will support W-CDMA, CDMA2000, CDMA, GPRS, and GSM standards, all in one chip.

An overview of the current cellular network standards deployed by the major mobile carriers in the United States is depicted in table 4.1

There is a last concern that should be addressed by cellular carriers in order to improve their ability to connect to the internet network, **WAP (Wireless Application Protocol)**. WAP is a proposed standard designed for wireless Internet access. People with WAP-enabled cellular phones access Internet sites, which are written in a special programming language. The object is to make information downloaded from the site to fit into cellular devices' small screens. WAP is a menu-driven method for downloading information such as flight schedules and bank balances to cellular phones from the internet. However, its slow speed, incompatibilities with some phone and technical glitches have resulted in user dissatisfaction. In addition, there are not many sites available where operators had taken the trouble to re-writte them fro WAP access.

Mobile Carrier	Cellular-based Standard Deployed	Subscribers (3Q03)
Verizon Wireless	CDMA, AMPS (analog), CDMA2000 1x (since 2002). In October 2003, it commercially launched its CDMA2000 1xEV-DO network in the US (San Diego, CA and Washington, D.C., is being marketed to business users under the brand name "BroadbandAccess."	36.0 million.
Cingular Wireless	TDMA, Expected to have 90% of POPs covered with GSM/GPRS by year-end 2003. It is deploying EDGE (2.5G) in Indianapolis on 3Q2003.	23.4 million.
AT&T Wireless	850MHz analog/TDMA digital, 1,900MHz digital PCS, CDPD available in 89 million POPs. Moving to GSM with GPRS, which now reaches 75 percent of the U.S. population. Committed to launching WCDMA in San Francisco, Seattle, Dallas and San Diego but service will not be available until 3Q2004.	21.9 million.
Sprint PCS	CDMA, 100 percent digital, 100 percent PCS. CDMA2000 1x (since 2002)	19.3 million.
Nextel Communications	iDEN (800MHz, a TDMA-based system from Motorola)	12.3 million
T-Mobile USA	GSM with GPRS, Wi-Fi (802.11b). Trialing EDGE in select cities.	12.1 million
Alltel	CDMA and CDMA2000-1X launched in January 2003.	7.9 million

Table 4.1 Overview of US Cellular-based Mobile Carriers as of 2003

Something to add to it, WAP is a "dialup" service, and connection and download speeds are slow. It is possible that as networks are updated for packet data service and WAP technology is improved that WAP services may become efficient.

Companies such as Motorola, Nokia, Ericsson and Unwired Planet are addressing these issues for a wide variety of wireless devices. Through the Wireless Applications Protocol (WAP) consortium, these firms are working together to ensure a reliable and standard method of transferring data over wireless networks worldwide

The likelihood of deploying 2G, 2.5G or 3G network standards into the telematics system architecture and how it may impact existing business models is analyzed and summarized in next chapter.

4.4.2 Wireless Technology Standards

Wireless Fidelity, WiFi, promises to be a breakthrough wireless technology for TSPs' business models. If it will not completely replace cellular-based technologies in the telematics system, this technology may change the way service providers and VMs look at telematics as they may search better ways to deliver telematics services to consumers. For instance, with the deployment of VoIP technologies, WiFi may be a more economical second source for telematics mobile voice communications services.

But as the wireless technology evolves and VMs decide whether to incorporate it in their Telematics Systems and take advantage of it, newer and more sophisticated technologies are released thus changing preliminary TSPs' technology strategy plans.

The newer wireless technology, WiMAx (802.16 standard) sends data at a remarkable 70Mbps over distances up to 30 miles (50 Km) compared to 11Mbps to 54 Mbps data rate transfer and up to 1000 feet of coverage that WiFi is capable to provide. WiMAX does represent a more serious alternative for Telematics Systems to access the Internet network and establish cheaper voice communication contrasting cellular-based technology standards.

Early WiMAX versions are designed for fixed broadband, rivaling cable and DSL. Later versions will let users roam around. WiMAx will be used frost to connect (backhaul) WiFi hotspots to the Internet, later for broadband service to rural households. It could narrow the digital divide in developing countries but will create competition for cellular-based standards like 3G.[27]

WiFi

Wi-Fi is the industry-accepted term for "Wireless Fidelity." It provides high-speed wireless data access in limited geographic areas. [28]

Wi-Fi networks use radio technologies called IEEE 802.11b or 802.11a to provide secure, reliable, fast wireless connectivity. A Wi-Fi network can be used to connect computers to each other, to the Internet, and to wired networks (which use IEEE 802.3 or Ethernet). Wi-Fi networks operate in the unlicensed 2.4 and 5 GHz radio bands, with an 11 Mbps (802.11b), 22 Mbps (802.11g) or 54 Mbps (802.11a) data rate or with products that contain both bands (dual band), so they can provide real-world performance similar to the basic 10BaseT wired Ethernet networks used in many offices.

In addition to homes and enterprises, Wireless LANs are popping up in public spaces everywhere. These are the so called hot-spots or Wi-Fi ZONES™ (see figure 4.3). This is because Wireless LANS offer high-speed wireless access inside a limited geographical area with a range of 300 to 1000 feet. Once a Wireless LAN is installed, Wi-Fi users can take advantage of cost-effective, reliable, and fast wireless connections. A Wi-Fi network allows guest and travelers to connect to a public access point and obtain high speed Internet access for e-mail, to send and retrieve files and to connect to their corporate network or VPN. This provides a source of revenue and many other advantages to businesses and property owners. Also, many people are taking advantage of the freedom and flexibility afforded by having a wireless LAN at home.

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27 Source: Business Week, January, 2004

28 Actually, all three names – Wi-Fi, Wireless LAN (Local Area Network), and 802.11 – can be used interchangeably

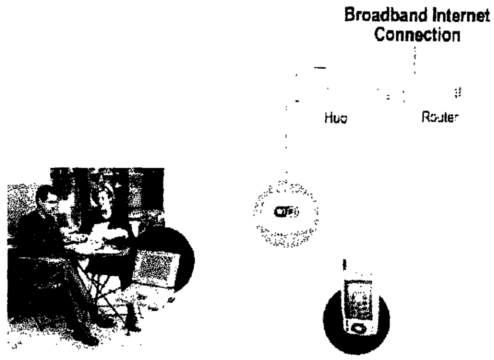

Figure 4.3 Wi-Fi Hot Spots Architecture

WiFi has escaped the confines of geekdom (innovator and early adopters), but it is only starting to approach the tipping point that will transform it into a mass–market phenomenon[29]. To achieve the mainstream market, Wi-Fi must overcome some roadblocks related to the following issues:

- **Security.** Perhaps this has been one of the most important issues for accelerating the rate of adoption on WiFi. Some trends to secure WiFi network are described as follow:

  WPA (Wi-Fi Protected Access) and other wireless encryption methods operate strictly between your Wi-Fi enabled computer and your Wi-Fi access point. When data reaches the access point or gateway, it is unencrypted and unprotected while it is being transmitted out on the public Internet to its destination — unless it is also encrypted at the source with SSL (Secure Socket Layer)when purchasing on the Internet or when using a VPN (Virtual Private Network). So while using WPA will protect you from external intruders, you may want to implement additional techniques to protect your transmissions when you use public networks and the Internet. There are several technologies available, but currently VPN works best. Although still wary, better security is built into a new WiFi standard called 802.11x, which offers enhanced encryption and authentication.

- **Accessibility.** WiFi hotspots may have different authentication mechanism to access the network. This is a hassle for consumer since they need to recreate their user names, install additional software, tweak their network-configurations settings, or adjust their firewall software as they move from one hotspot to another.

[29] Source: Business Week Online, "Before Wi-Fi Can Go Mainstream", February 18, 2004.

VoIP, the alternative for Telematics Mobile Communication Services in WiFi like networks.

Internet Voice, also known as Voice over Internet Protocol (VoIP), is a technology that allows making telephone calls using a broadband Internet connection instead of a regular (or analog) phone line. Some services using VoIP may only allow calling other people using the same service, but others may allow calling anyone who has a telephone number - including local, long distance, mobile, and international numbers. Also, while some services only work over your computer or a special VoIP phone, other services allow you to use a traditional phone through an adaptor.

VoIP works by converting the voice signal from your telephone into a digital signal that travels over the Internet. If calling a regular phone number, the signal is then converted back at the other end. Internet Voice can allow making a call directly from a computer or laptop. If you make a call using a phone with an adaptor, you'll be able to dial just as you always have, and the service provider may also provide a dial tone. If your service assigns you a regular phone number, then a person can call you from his or her regular phone without using special equipment.

One of the requirements to ensure quality of voice on VoIP calls is that it requires high-speed Internet access. WiFi is assumed to be deployed when a broadband high-speed is the connection to the Internet network on Wireless LAN "hotspots".

WiMAX

WiMAX, the technical name for **802.16**, may offer transmission ranges of up to 30 miles. The 802.16 standard specifies a metropolitan area networking protocol that will enable a wireless alternative for cable, DSL and T1 level services for last mile broadband access, as well as providing backhaul for 801.11 hotspots (see figure 4.4). The technological capability of connecting with an antenna while the vehicle is moving is not realized yet, but advances on a newer technology called **Mobile-Fi**, which is similar to WiMAX, would allow mobility and connectivity.

IEEE 802.16 represents a global standard for a wireless broadband access. Its typical cell size is 4-6 miles. 802.16 standard was designed from the ground up for outdoor, long range, carrier class applications. It allows high throughput and non line of sight propagation. It is scalable to up to 1000's of users at QoS of 1.5 MHz to 20 MHz. Supports both licensed and license-exempt spectrum (unlicensed). 802.16 can use all available frequencies, multiple channels support cellular deployment. WiMAX is applicable in many markets – from dense urban environments to rural areas. Where there is no existing or poor wired infrastructure. IEEE 802.16e extension enables nomadic capabilities for laptops. It allows for broadband connectivity beyond hot spots. Its bit rate is 5 bps/Hz peakUp to 100 Mbps in a 20 MHz channel. 802.16 is a dynamic TDMA-based MAC with on-demand bandwidth allocation.

The 802.16a standard specifies a protocol that among other things supports low latency applications such as voice and video, provides broadband connectivity without requiring a direct line of sight between subscriber terminals and the base station (BTS) and will support hundreds if not thousands of subscribers from a single BTS. The standard will help accelerate the introduction of wireless broadband equipment into the marketplace, speeding up last-mile broadband deployment worldwide by enabling service providers to increase system performance and reliability while reducing their equipment costs and investment risks.

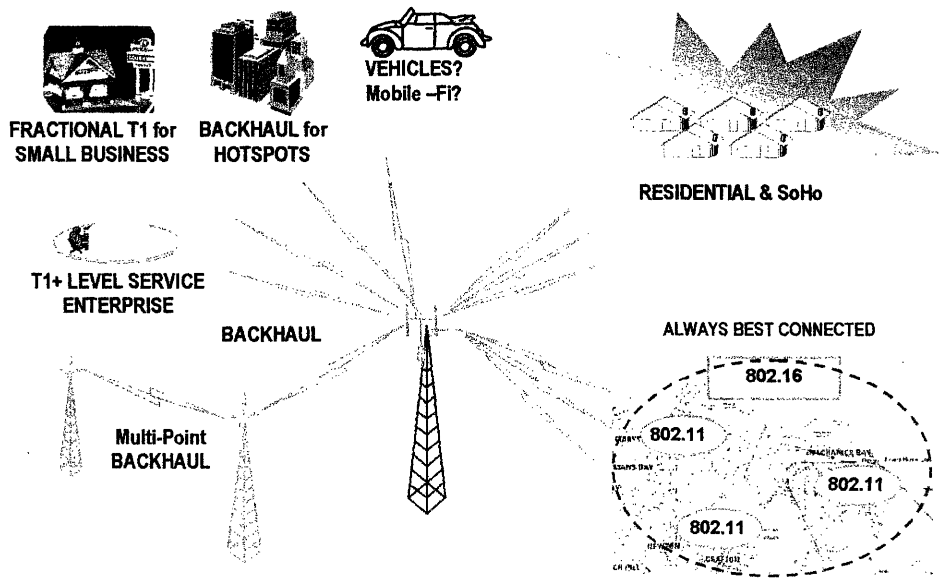

Figure 4.4 WiMAX Environment Applications[30]

However it has been shown repeatedly that adoption of a standard does not always lead to adoption by the intended market. For a market to be truly enabled, products must be certified that they do adhere to the standard first, and once certified it must also be shown that they interoperate. Interoperability means the end user can buy the brand they like, with the features they want, and know it will work with all other like certified products. The IEEE does not fulfill this role, leaving it to private industry to take a given technological standard and drive it that last crucial mile for mass adoption. In the case of WLANs this role was and is fulfilled by the WiFi Alliance. For the Broadband Wireless Access (BWA) market and its 802.16 standard, this role is played by the Worldwide Microwave Interoperability Forum or WiMAX. WiMAX is a non-profit industry trade organization that has been chartered to remove an important barrier to adoption

[30] Source: Adopted from www.wimaxforum.org

of the standard by assuring demonstrable interoperability between system components developed by OEMs.

A comprehensive technical comparison between the advantages of WiMAX over WiFi is presented in Appendix E1

4.5 User Interface

We define *user interface* as the bridge that allows the user to maintain communication with the vehicle and the outside while keeping his/her attention in the road. User interface systems may include hands-free communication technology like speech-recognition or text-to-speech. More sophisticated systems include human machine interfaces (HMI) which is a display embedded in the vehicle that allows visual interaction while using, for instance, GPS navigation systems. For passengers seating in the back, user interfaces include DVD displays located either in the back of the driver seat or at the ceiling on the car.

The trend in telematics is the ability to **connect mobile devices** with the car systems. For this reasons the deployment of wire technology like USB or short range wireless technologies like Bluetooth and more recently UWB or ZigBee represent an option to synchronize the user/vehicle information between the mobile device and the car.

4.5.1 Consumer Electronics Devices as Interfaces

It is clear that automotive electronics can't follow the trend of ever increasing computing, interoperability and storage performance as consumer electronics devices. That also includes the agility in connectivity and ability to share information while remaining at the cost of a consumer device. So the over-arching question is: what can car makers do to integrate these devices in cars? Looking for answers leads us to the few constants that all portable devices share:

Power. Given the increased connectivity and computing power of converged devices, it makes a lot of sense to charge these devices while they are used or stowed away in a vehicle.

External Antenna. The ever-increasing connectivity with Wi-Fi, Cellular, Bluetooth and GPS etc. will work better in the car environment if there is an external antenna. In addition, many car makers are also worried about the impact of the multi-spectrum radiator on their mission-critical wired car networks.

Connectivity to the Car Systems. An important factor is the choice of the connectivity standard. Today, wired systems use mostly simple serial lines, with the wireless integration realized via Bluetooth. Based on the roadmap presented above, USB should also be considered. USB is a very stable and backward compatible standard in the PC industry. On the wireless connectivity side, the question is whether Bluetooth will be enough to support all kind of connectivity. Bluetooth is already unable to stream decoded stereo audio data, let alone video, or handle remote displays. Many industry analysts forecast that UWB ultra-wideband (IEEE 802.15.3a) or Zig Bee (IEEE 802.15.4) technologies will eliminate Bluetooth in portable devices starting in 2006 (see appendix E2 for a technical comparison between Bluetooth and ZigBee technologies).

Data Synchronization. This is one of the main reasons to require connectivity. The portable device is able to serve as a personal storage device. Today, people synchronize their address books with their laptops and PC PIM software. In addition, personal settings such as seat or mirror adjustments and the driving log could also be stored in the portable device.

Software Applications. Looking at the consumer electronics industry today, we find that multiple application environments are established. Qualcomm has been very successful in rolling out its BREW environment, while PalmSource and Microsoft are fighting over the PDA market. Many devices and wireless carriers support SUN Microsystem's Java programming environment. The problem is that the automotive industry cannot live with just supporting one mechanism.

Therefore a standard "wire-level" messaging protocol (like the AMIC VSI specification) and the ability to update the firmware of the communication interface to accommodate newer consumer devices must be defined. However, existing software developers have released vehicle software applications to be deployed in vehicle electronics devices or HMIs. These applications allow drivers to hands-free communicate via speech-recognition software. Some players and theirs applications are Sun with its Java Car vision, Microsoft with its Windows CE Automotive, and IBM with its Frameworks.

4.6 Chassis-Level Network

The chassis level network module is assembled by the diagnostics systems module and the system-controllers module. The diagnostic systems module encompasses a network of sensors, valves and mechatronics devices which are installed in critical vehicle subsystems. These devices monitor the performance of the vehicle. The data generated by these devices is communicated to the system-controllers module. SAE J1850 and/or CAN are the protocol communications standards commonly used in the vehicle data communication networks. The fundamental difference between these protocols in the type of transmission channel, single for SAE J1850 and dual for CAN, the amount of nodes or devices it can handle, and the speed rate of data transmission (CAN offers higher capacity than J1850).

Communication Network Controller Systems are customized for specific vehicle brands thus resulting in proprietary and non-standardized architectures across vehicles.

4.6.1 Diagnostics

The diagnostics module encompasses all safety sensor and devices including the critical collision detectors devices. These monitoring devices are installed in vehicle sub-systems. The criticality of these devices is that they have to be tested and validated once installed in the vehicle subsystems in order to ensure compliance to safety requirements. Table 4.2 depicts the most common diagnostics devices.

Most of the time, the design and production of these devices are customized to specific vehicle manufacturers, or even more, to specific vehicle models.

▪ Engine Control Unit.	▪ Inertial Sensor
▪ Stability Control Unit.	▪ Pressure Sensors:
▪ Auto-body Modules.	- Barometric Absolute Pressure Sensor
▪ Positioning Warning Sensors.	- Manifold Absolute Pressure Sensor
▪ Auto Bus.	- Fuel Tank Pressure Sensor
▪ Server-Based Navigation.	- Injection Pressure Sensor
▪ Electric Power Steering.	- High Pressure Sensor
▪ Exhaust Gas Recirculation Sensor.	- Temperature/Manifold Absolute Pressure Sensor
▪ Transmission Control Unit.	

Table 4.2 Most Common Diagnostics Devices Installed in Vehicles Subsystems

4.6.2 System-Controllers

SAE J1850 Specification (SAE Class B)

The SAE J1850 specifies requirements for a vehicle data communications network and is the Communications Standard utilized in On- and Off-Road Land-Based Vehicles. Attributes of the J1850 protocol include an open architecture, low cost, master-less, single-level bus topology.

The SAE J1850 Standard had been a recommended practice for seven years before being officially adopted by the Society of Automotive Engineers, (SAE), as the standard protocol for Class B in-vehicle networks on February 1, of 1994. Today, J1850 is implemented in a variety of production vehicles for diagnostics and data sharing purposes. This wide spread integration of low cost J1850 in-vehicle networks can be found in engine, transmission, ABS, and instrumentation applications.

The utilization of the Class B J1850 protocol can be drawn from two different alternatives. One is a high speed, 41.6 Kbps Pulse Width Modulation (PWM) two wire differential approach. The other J1850 alternative is the 10.4 Kbps Variable Pulse Width (VPW) single wire approach. The 10.4Kb/s VPW protocol supports both General Motors, (GM), and Chrysler versions of J1850. A proliferate of solutions are available on the street for the VPW approach. To keep a reasonable depth of subject matter within the confines of this section, the focus will be on the 10.4Kb/s VPW approach.[31]

J1850 is an intermodule data communication network for the sharing of parametric information passed in frames (messages) between all vehicle electronic modules connected to the Class B bus. Digital signals between electronic components can be communicated utilizing the concept of multiplexing. Two multiplexing types exist: **Frequency division multiplexing** and time division multiplexing. Frequency division multiplexing simultaneously transmits two or more messages on a single channel. **Time division multiplexing** interleaves two or more signals on the same channel for either a fixed or a variable length of time. The 10.4Kbps VPW approach utilizes variable time length and time division multiplexing.

In conclusion, the SAE J1850 10.4Kbps standard fulfills mid-range Class B classification protocol requirements. Variable Pulse Width modulation is utilized to facilitate a single wire transmitting medium for harsh automotive environments.

CAN Controller Access Network (SAE Class C)

All cars and lights trucks from 1996 to the present have been mandated by the U.S. Environmental Protection Agency (EPA) under the OBDII (onboard diagnostics) Act to monitor the performance of the engine's major components and emission controls. Most OBD systems use the CAN bus because it is best suited for OBDII.[32]

Controller Area Network (CAN) is a serial network that was originally designed for the automotive industry, but has also become a popular bus in industrial automation as well as other applications. CAN is a SAE Protocol Classification C (see section Appendix F). The CAN bus is primarily used in embedded systems, and as its name implies, is the network established among microcontrollers. It is a two-wire, half duplex, high-speed network system and is well suited for high speed applications using short messages. Its robustness, reliability and the large following from the semiconductor industry are some of the benefits with CAN.

CAN can theoretically link up to 2032 devices (assuming one node with one identifier) on a single network. However, due to the practical limitation of the hardware (transceivers), it can only link up to 110 nodes (with 82C250, Philips) on a single network. It offers high-speed communication rate up to **1Mbps** thus

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[31] D. John Oliver, "Implementing the J1850 Protocol" Intel Corporation Report, 2003

[32] Roger Allan, Technolgy Editor, "OnStar System Puts Telematics in the Map", Electronic Design 03.31.03 www.elecdesgin.com

allows real-time control. In addition, the error confinement and the error detection feature make it more reliable in noise critical environment.

CAN was first developed by Robert Bosch GmbH, Germany in 1986 when they were requested to develop a communication system between three ECUs (electronic control units) in vehicles by Mercedes. They found that an UART is no longer suitable in this situation because it is used in point-to-point communication. The need for a multi-master communication system became imperative. The first CAN silicon was then fabricated in 1987 by Intel

The original CAN standard specification is the Bosch specification. Version 2.0 of this specification is divided into two parts: Standard CAN -Version 2.0A (uses 11 bit identifiers) and Extended CAN -Version 2.0B (uses 29 bit identifiers). The two parts define different formats of the message frame, with the main difference being the identifier length.

There are two ISO standards for CAN. The difference is in the physical layer, where ISO 11898 handles high speed applications up to 1Mbit/second. ISO 11519 has an upper limit of 125Kbps.

CAN in motor vehicles (cars, trucks, buses) mainly plays to important roles:

- Enables communication between ECUs (Electronics Control Units) like engine management system, anti-skid braking, gear control, active suspension ... (power train)
- Used to control units like dashboard, lighting, air conditioning, windows, central locking, airbag, seat belts etc. (body control)

What new technologies will help deliver greater telematics services?

An important, ongoing initiative that will help drive telematics growth is the **ITS Data Bus**, or **IDB**. IDB is based on an open protocol for networking car audio, video, communication and computing devices. Lead by the Society of Automotive Engineers (SAE) and supported by several corporations (including Motorola), IDB will allow seamless integration of multiple technologies inside the car.[33]

IDB will allow simple plug-and-play use of any consumer electronics, regardless of the manufacturer. In addition, a firewall contained in the IDB will allow all electronics in the car to operate independently of each other, eliminating signal interference.

Many companies are expected to integrate IDB into their telematics components and other electronics systems. Motorola, for example, plans to integrate IDBs into its Telematics Center Units, enabling the system to act as the central hub for all electronics interacting within the car. This will allow consumers to simply plug-and-play various electronics via their TCU, and take advantage of additional telematics services, without requiring multiple wires and cables overlapping in

[33] Source: Motorola website www.motorola.com

different areas of their vehicle. Not only will IDB allow easier installations, but it enables drivers to add new services without being concerned about propriety systems and wiring. With IDB, consumers will have greater choice, resulting in greater market growth.

4.7. Conclusion

The typical telematics systems architecture is integrated by a telematics center unit, a wireless-network access module, a user interface, a positioning module, and a chassis-level network. As we reviewed in this chapter, telematics system converge some technologies that may not be necessarily proprietary to vehicle manufacturers; they do not have control over standards over the standards.

The telematics value proposition depends on accessing the communication network. Current telematics systems deploy 1G or 2G cellular-based communication standards in their wireless-network access module. These standards require the use of a modem for transmission of data between the vehicle and the location-based center. The potential of incorporating newer technologies like 3G (cellular-based), which allow for faster and more reliable transfer of data, depends on wireless communication provider building the infrastructure that ensure full national coverage; very unlikely in the short term. Wireless standard like WiFi or WiMAX are not dependant of service providers since these technologies use an unlicensed spectrum and available for deployment to whoever has a fast internet connection. The investment on gear and infrastructure is cheaper than that of 3G technologies.

The user interface part of the telematics systems currently includes embedded electronics devices that allow communication between the driver and his exterior. The underlying technologies are software-based like voice recognition and speech communication. These technologies have proven efficient to allow drivers hands-free communication. No software platform dominates in the market, since the applications are developed specifically for each vehicle manufacturer. The possibility to connect mobile devices like PDA or Smartphones to the vehicle via wire (e.g., USB) or wireless (e.g., Bluetooth or UWB) and synchronize both user and vehicle information is feasible already. However, the access to vehicle information is limited (or inexistent) due to vehicle's proprietary telematics systems. This issue has been one the factors delaying the adoption of telematics.

At the chassis-level network, the information generated by the red of diagnostic and safety devices installed in critical subsystems of the vehicle is coordinated by the system controllers which use either traditional CAN or J1850 bus technology platform. These technologies vary from each other mainly in the speed of data transfer and the number of nodes or devices it can handle. These technologies can only handle communication among vehicle electronics devices but are limited to handle other electronics like those of consumers. New bus technologies, like IDB, will allow for seamless communication between all electronics, automotive and consumer, needed to be installed in the vehicle; including plug-and-play type.

The critical factor for the chassis-level network devices is that, due to safety requirements, they must be tested and validated altogether with the rest of the vehicle subsystems, which require them to be installed during the assembly of the vehicle.

In next chapter I discuss a strategy that refers to decoupling elements of the telematics systems in order to accelerate the adoption of telematics. The decoupling criteria is based on the rate of evolution of the technologies embedded in the system and on consumer's needs.

Chapter 5
The Role of Standards and Strategies for Standard-Driven Markets

5.1 Introduction

There is a myth that a common, standard interface to the vehicle will soon solve the telematics industry's profitability problem. The reality is that standardization will not occur anytime soon. To achieve standardization, VMs need to change their minds of using a **proprietary integrated system** to using a more **open architecture** for the benefit of the industry.

The telematics industry is still in its ferment phase[34] and no general standards exist for an industry-unified architecture or interoperability requirements. Each component of an automotive-telematics system may use a different interface—even among vehicle models from the same manufacturer. This lack of a common interface requires developers to create custom designs that make it difficult to extend and update the systems across many platforms.

The benefits for establishing industry standards are numerous, but the question for VMs is whether, when, and how to decide to opening their proprietary systems.

This chapter offers a strategic framework for VMs to decide what would be the most suitable strategy to follow so they capture value from the telematics innovation they created. The strategic decision taken today will define the future growth of the telematics industry.

The development of this framework also considers that the evolution of the technologies converging in the Telematics Systems (as we reviewed in previous chapter) may provide an advantage or become a challenge for VMs and TSPs. The basic concept is that the evolution of newer technologies may disrupt the existing value chain thus changing the curse of the industry and defining new winners.

5.2 The Need for Standardization

Today, if a consumer would like to buy a car with 1998 electronics, he or she will have to wait for model year 2001. Due to the differences in the design cycles of automobiles (3-5 years) and electronics (9-15 months) a car bought today is, inevitably, equipped with old technology. New technology can be retrofitted, but at great cost, with **potential safety compromises**, and with **little systems integration**. Dealer-installed or aftermarket electronics cannot take advantage of

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[34] Based on Utterback, James, 1996, "The Technological Innovation life Cycle Model" in Mastering the Dynamics of Innovation, HBS Press, page xvii

systems or devices already built into the vehicle at the factory (such as in-dash displays), since there is no safe and secure way to tap into these resources.[35]

Due to stringent requirements, any electronic device designed into a vehicle must undergo rigorous **bench and on-the-vehicle testing** together with all the other systems. The test cycle is 1-2, or sometimes 3 years. Therefore, since the device must be designed, built, and tested by the electronics manufacturer before delivery to the vehicle manufacturer, it will be at least 2 years old before the customer finally takes delivery. In the meantime, the electronics manufacturer has probably stopped manufacturing that model and is building newer models. The customer then has to settle for the two year old model, or spend additional money to have a newer device installed in the aftermarket, if this is even possible.

Throughout this work, I have mentioned several times the need for establishing open standards as a way to promote and to accelerate the growth of the telematics industry. However, although the establishment of open standards interfaces offers clear benefits for the industry, it also finds VMs facing some important challenges. Following is a summary of both positions.

Benefits from Open Standards

- Creates value for the telematics industry because they create network effects
- Allows for complementors to provide product and services compatible with the technology thus increasing the value of the technology
- Standard interfaces allows for backward compatibility and integration between old, the current and future technologies upgrades or new technologies
- Standard interfaces allows for interoperability thus reducing switching and adoption cost for the consumer
- Reduces the probability of consumers to be locked-in with only one technology
- Allows customers to only invest once in learning how to use the technology, thus reducing switching cost

Drawbacks from Open Standards

- Lowers barriers for new telematics industry players to enter the market
- Reduces possibilities for differentiation in the vehicle
- Reduces the ability to generate higher revenues and maximization of built-assets
- Increases the risk of failures in system integrated to the vehicle system (like those related to safety and security) that were not previously tested
- Creates confusion of delimiting responsibilities when defects in software or hardware is experienced in the field (vehicle in the road)
- Requires VMs assume responsibilities for defect in the Telematics Systems which may be detrimental to the quality performance of the vehicle as measured by industry agencies like J.D. Powers

5.3 Telematics System Architecture and the Role of Standards

[35] Extracted from SAE www.sae.com

As we review in previous section, besides the considerable drawbacks in revenue and profitability issues related to opening their architectures, VMs must be careful to ensure that the integration of modular devices does not interfere with the performance of the vehicle subsystems; mainly those related to safety, and security, and vehicle diagnostics.

A literature review on standard-driven markets suggest that there are four positions that vehicle manufactures can adopt when it is time to decide whether to open their proprietary standards. These positions are depicted in figure 5.1

Standards

Technology	**Open**	**Close**
Non-Proprietary	Details of standards are available to all. No single firm has control over how they evolve. There is no charge for their use Benefits: ▪ Interfaces of the standard are widely available and increases the probability of adoption ▪ No one benefits disproportionately from the standard ▪ Barriers to adoption are lowered Drawbacks: ▪ It takes a long time for multiple players to agree on standards ▪ Lower the barriers to imitation allowing new entrants into the market	Standards are owned and controlled by the public sector but are not freely available ▪ This case will be rare for telematics industry.
Proprietary	Details of standard are made available to all. But owner has control over how the standard evolves and may charge for use Benefits: ▪ Represent a revenue opportunity for the standard setter ▪ It can charge a fee for access to the standard (licensing) Drawbacks: ▪ It creates tension between driving adoption and capturing revenues from standard ▪ Users of the standard might be unlikely to adopt a standard that is promoted by a competitor	Technology may be standard, but details are not made available beyond the firm Benefits ▪ Tight linkage between vehicle and telematics ▪ Strong claim to revenues from the standard setter Drawbacks: ▪ Suppliers must develop components to multiple standards which dilutes efforts and reduces advantages of scale ▪ Unbundling of telematics features is unlikely

Figure 5.1 Strategies for Standard Appropriateness and Availability of Technology

Vehicles Manufacturers (TSPs) require to decide a strategy that allow them continue having control over the vehicle. The results of this research indicate two major reasons for that: first, they do not give away the revenues generated for the use of the technology and second, they do not want to loose the control of testing and validating vehicle electronic subsystems that may jeopardize the safety and security of consumers if unreliably aftermarket installed. In the former case, VMs are trading off the growth of the industry (limiting the rate of adoption) *by appropriating telematics systems and furthermore revenues. In the case of keeping control of subsystems, if VMs just worry about controlling those parts of the telematics systems that may have a direct impact in the functionality and reliability of the vehicle systems, then they can open up those parts of the telematics architecture for which consumers are more sensible to changes in technology and for which VMs and TSPs do not have any control or influence on technology and standards evolution.*

At the technology level, the author suggests that vehicles manufacturers should pursue the following strategies with respect to telematics system architecture and standards:

- Decouple the Telematics Systems
- Maintain proprietary/open architecture at the Chassis-Level Module level and at the Telematics Center Unit Module. A proprietary/open standard for the latter should be established in alliance with the other VMs.
- Adopt a non-proprietary/open architecture at the Position Module, User-Interface and Wireless-Network Access levels and adopt standardized industry interfaces.

This strategy requires VMs to shift the Telematics Systems from an integrated architecture to a modular architecture with mixed appropriateness of open standards. The implications of this strategy are depicted in figure 5.2).

Everett (2003) suggested that once the modularity is in place along the clockspeed boundary (the interface between products of faster product development assembled to products with slower product development cycles), standards should be established in order to allow the fast clockspeed systems and subsystems to be integrated, at the faster clockspeed pace, within the slow clockspeed vehicle platform. In this architecture, the standards should be designed so that if the faster changing-technology system or subsystem meets the standard, it by definition should satisfy the verification and validation requirements of the vehicle itself. Everett (2003) called this as "The design modularity along the clockspeed boundary."[36]

[36] Everett, Nathan, 2003, "Automotive Telematics: Colliding Clockspeeds and Product Architecture Strategy", MIT Thesis, Boston, MA.

Module	Strategy	Notes
▪ Telematics Center Unit ▪ Chassis-Level Network	▪ Proprietary/ Open	▪ Alliances to establish industry standards ▪ Manage of network market key assets to gain establishment of proprietary standard as dominant design ▪ Ensures testing and validation of vehicle security and safety subsystems ▪ Component supplier will continue to provide customized product to OEM at the chassis level ▪ To access TCU (which is tightly connected to chassis-level network systems) and further more vehicle systems, it will require to license the technology.
▪ Positioning Module	▪ Proprietary/ Open	▪ GPS technology is open and "free" standard
▪ Wireless-Network Access ▪ User Interface	▪ Non-Proprietary/ Open	▪ Allows for Adaptability and Compatibility ▪ Allows for Upgradeability and Interoperability ▪ Allows for integration of faster changing technologies ▪ Increases value to costumer since they would be able to adapt their mobile devices to their vehicles (synchronizing personal and vehicle information between devive and vehicle systems) ▪ Allows costumer for mobile communication using their latest-tech device ▪ Allows for complementary products/services Allow upgradeability of Cellular-based Standards like GSM, CDMA, TDMA, iDEN, and possibility to massively install 3G-based product into telematics systems. ▪ Allow for incorporation of wireless standard like WiFi and WiMAX, which increase attractiveness to consumers and enhance the value of telematics Allows for integration of faster changing technologies ▪ Design for standards that allow *adapter* interfaces (backward compatibility) ▪

Figure 5.2 Suggested Strategies for Telematics Systems and Appropriateness of Open Standards Architecture

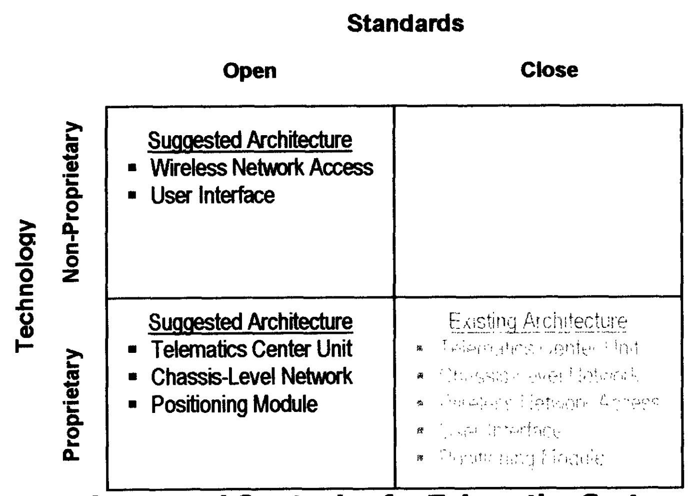

Figure 5.3 Suggested Strategies for Telematics Systems and Appropriateness of Open Standards Architecture

So, the suggestion for VMs is to pursue a dual strategy for standards that offer dual benefits to them, but also trade-off should be expected.

i. Proprietary technology-open standards strategy.

Keeping control of the chassis-level network, VMs will ensure testing and validating subsystems that are critical for a safer and more reliable vehicle performance. These systems will be integrally linked to telematics center unit. Of course, the drawback is that TCUs, if not becoming obsolete, will become slower because of memory capacity, processor speed, or application software (as it was the case of PC with the transition of Pentium II, III and 4 or Windows 2000 and XP).

Existing or new entrants, (like automotive suppliers), electronic device manufacturers, or mobile network carriers, would be required to license the access to TCUs technology if they are willing to enter into to the telematics market and/or have access to the vehicle systems information. This strategy is like the one that Nintendo followed when new entrants and complementors willing to enter the Nintendo market, needed to license "the chip" that gave them access to Nintendo system access.

As depicted in figure 5.4, by licensing their telematics technology, VMs will profit from the technology via licensing royalty revenues (reinforcing loop R1). But at the same time, VMs will allow for the creation of a network of products and services built by new entrants or complementors around the technology (reinforcing loops R2 and R4). This network of products and services around the Telematics technology will be more valuable for users triggering the effects of network externalities (reinforcing loop R3). This effect will also increase the intensity of competitors using the technology, beneficial for users (drop in prices), but with negative effects in market share and revenues for players (balancing loop B1).

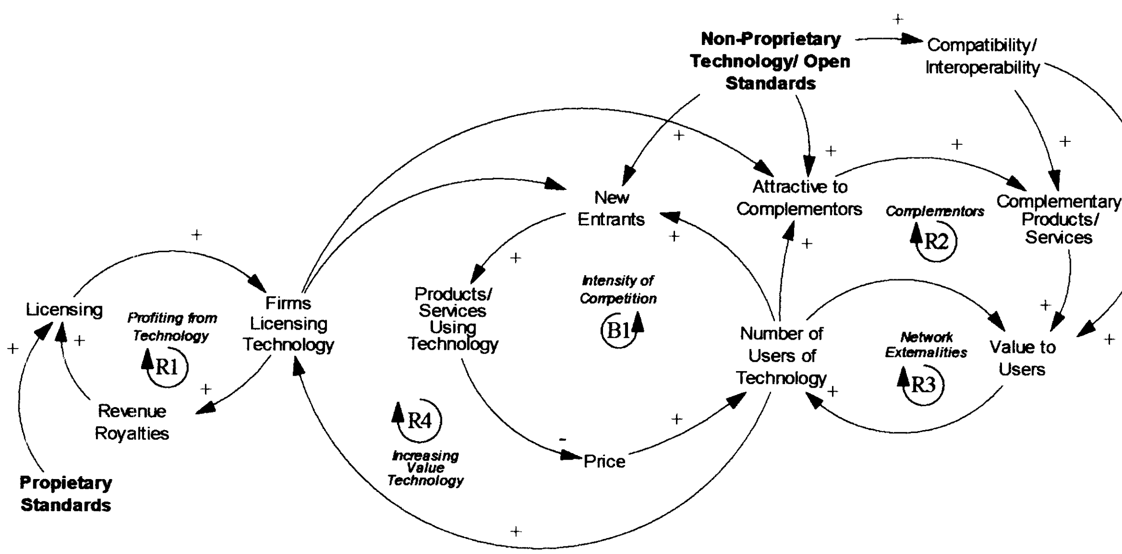

Figure 5.4 Dynamics of Standard-Driven Markets

In the case of the positioning module, neither VMs, TPSs, nor other market players are significantly benefited or affected if GPS chips are embedded and factory installed in the vehicle since this is a non-proprietary and open technology. The high-investment of this complementary asset (GPS satellite systems) is owned by the government and free for everyone.

ii. Non-Proprietary technology-open standards strategy.

Allowing for the integration of non-proprietary and open standards at the wireless-network access and users interface levels, VMs will be allowing primarily consumer, and secondly, other market players to benefit from the use of complementary products and services that can be incorporated at any point of the vehicle life cycle.

What it means for VMs is that they need to work closely with electronic device manufacturers, automotive supplier, and perhaps wireless network carriers in defining the standard interface that allows for electronics mobile gadgets (PDAs, laptops, smartphones, DVD consoles, HMIs, etc), those that contain the latest technology in electronics and wireless, to be adapted into and operated from vehicle dashboard or interiors. Today, this standards interface may be any of the above mentioned Bluetooth, Zigbee, UWB, or USB technologies. Consumer will be connecting or "hotsynchronizing" their mobile devices into the vehicle TCUs, and pulling and pushing information between mobile and vehicle systems.

The benefits for other players willing to enter the telematics market are obvious: access to a large base of customers, selling of mobiles devices that are compatible to consumer's vehicles, and so on. The more obvious benefits and drawbacks are depicted in figure 5.3, in reinforcing loops R2 and R3 and balancing loop B1.

From the perspective of VMs and TSPs, the underlying question is: How will the existing telematics business model, which is strictly dependant on the wireless-network access module, work if consumers will have the last decision in whether or not to integrate their wireless mobile devices into their vehicles?

My contention on this regard is that in order to enjoy the benefits that Telematics Services Providers and the Telematics umbrella of services provide, mainly those related to the vehicle market (see figure 1.2), consumers will be required to acquire an additional *adapter that is supplied by TSPs when consumers subscribe to the telematics service.* This *adapter* should be designed to be compatible with the latest electronics devices and wireless technology that consumer are willing to adapt to their vehicles. What it means for VMs, TSPs, electronic device manufacturers (EDMs) and wireless network providers (WNPs) is that they will be required to closely collaborate in a win-win business relationship to share information and access to technologies at any point in time. By licensing the vehicle telematics technology to specific EDMs and WNPs, VMs would allow players' products be able to access vehicle systems; creating value for customers. But on the other hand, VMs would be allowed to deploy the latest wireless technology available for their telematics systems.

At this point, suggested strategies have been discussed at the technology level. Organizational issues related to these strategies are to be reviewed in chapter 7.

The fundamental reasons behind the strategies discussed in this section are based on the strong influence that the evolution of converging technologies in which telematics systems depend on as well as the huge experience and changing needs that customers have for those technologies. These factors are prohibited for VMs and TSPs to ignore.

5.4 The Evolution of Technologies and the Evolution of Customer Needs

A portion of the mixed architectural model (non-proprietary/open industry standard interfaces), would encourage complementary hardware and software vendors to invest their own time and money to develop value added products for vehicles, taking advantage of the vehicle as a computing platform or as a peripheral. Moreover, it would create a competitive advantage for those auto companies who offer such a platform.

When deciding the appropriateness and openness of standards, VMs should not ignore either the **evolution of technology** in technology driven markets, mainly those **adjacent and complementary** to the telematics market, and the **pattern of customer needs**.

If we remember, the markets that Telematics is aiming to serve (as it was depicted in figure 1.1) include: vehicle, driver, and passenger. Consumers in the "driver" and "passenger" markets are experienced and are customized to keep up to date with the latest products that offer better performance and provide enhanced productivity. These products play an important role in the daily activities of the consumer in a manner that if they have the ability to access telematics systems through their devices, telematics would become more attractive to the consumer.

A good example of this scenario is the evolution of the Personal Assistance Devices (PDAs). Initially PDAs technology did not seem to be a threat for personal computers or even laptops, since PDAs were sold to a different market niche or, in other words, to different customers with different needs (see figure 5.5). But as PDAs continue improving (speed, power, memory, and connectivity) they also continue becoming a serious threat to PCs as customer preferences change. PDAs may improve sufficiently and take the whole market.

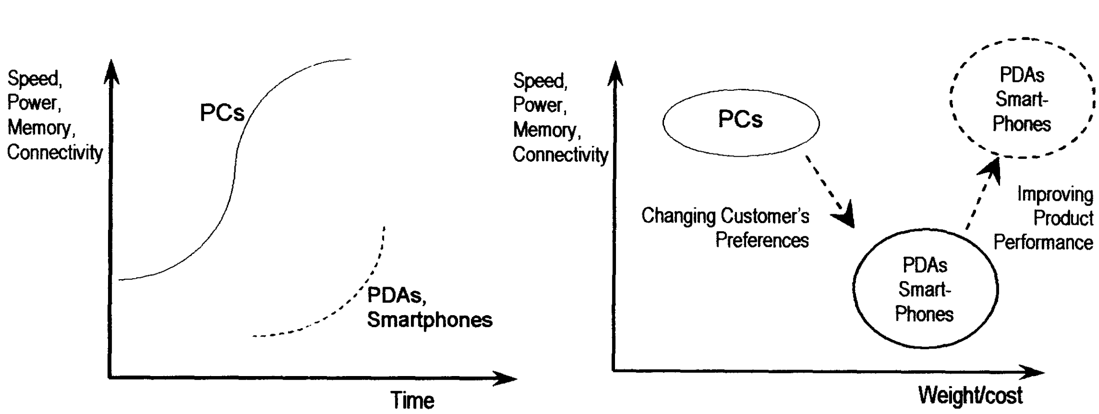

Figure 5.5 The threat of PDAs - Changing customer preferences or improving product performance[37]

Furthermore, because of the evolution of fast changing technology or changing customer needs, on products that are attractive to consumers, a non-proprietary/close architecture is recommendable for Telematics Systems at the User Interface level.

In the previous chapter, I extensively discussed the evolution of the cellular-based technologies as well as the introduction of newer wireless technologies like WiFi and WiMAX. The case of these wireless technologies is similar to that of PDAs, as we can see on figure 5.6

Again, when deciding the appropriateness/openness standard strategy, VMs should also look at the evolution of wireless technologies, technologies adjacent and complementary to telematics systems. The author has suggested that a non-proprietary/open standard strategy should be the option for the Wireless-Network Access level in the Telematics System. However, some factors should be taken into consideration when defining the best strategy to follow.

Because of the nature of the technological innovation, Telematics depend on accessing the network to maintain the communication in the telematics system. This situation makes VMs and TSPs highly dependant on firms that owns those complementary co-specialized assets[38], the mobile service providers. The ability to upgrade telematics features to better performance cellular-based technologies, especially to those that allow the transfer of data and video (like 3G), strictly depends on mobile service providers decision to upgrade their cellular networks. Analysts of the telecommunication industry list several issues in regards of the likelihood of this event:

[37] Source: Rebecca Henderson, class presentation from 15.912 Technology Strategy lecture, MIT

[38] Teece, David J. (ed), "Profiting from Technological Innovation: Implications for Integration, Collaboration, Licensing and Public Policy", in The Competitive Challenge, Cambridge, MA, Ballinger Publishing, pp. 185-219

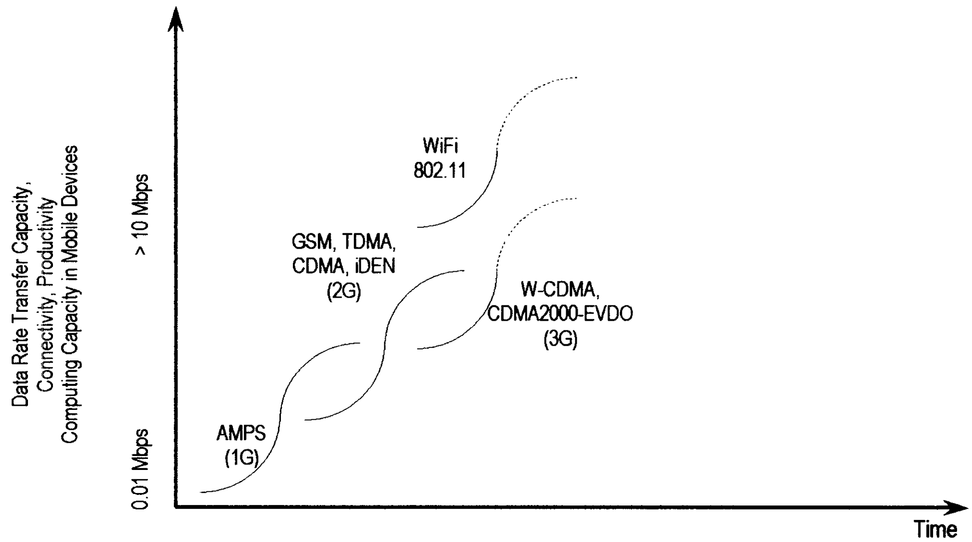

Figure 5.6 Technological Evolution of Wireless Network Standards

1. Upgrading from 2G to 3G technologies implies an irreversible high investment in infrastructure.
2. Qualcomm stated that it would produce chips for mobile devices that will support W-CDMA, CDMA2000 (1x and EV-DO), CDMA, GPRS, and GSM standards, all in one chip. Technology changes strategic intents.
3. The increasing growth of WiFi technology represents a threat for 3G capabilities.
4. Deployment of WiFi and establishment of hotspots increase the ability for consumer to set up calls over the internet of VoIP.
5. The release of the newer WiMAX (802.16) wireless technology and its scalability and connectivity capacity is a more serious threat for 3G.
6. VoIP and high rate data transfer deploying WiMAX may reach coverage of up to 30 miles radius.
7. Capital investments to deploy WiFi and WiMAX is much less than that required for upgrading to 3G
8. The only advantage of 3G over WiMAX and WiFi is its unlimited coverage (over 1000+ miles)

So, in conclusion, when deciding standard strategies for their Telematics Systems, VMs should take a look at the evolution of adjacent and complementary technologies, like wireless. The role of the evolution of consumer needs in wireless markets is similar to the PDA example; consumers might find more attractive to deploy WiFi (or in the future WiMAX) and excel the use of hotspots, rather than waiting for the establishment of what it could be a more ubiquitous 3G technologies network.

5.5 AMI-C (Automotive Multimedia Interface Collaboration).

Telematics organizations from around the globe are taking steps to minimize fragmentation in the mobile Telematics industry by strengthening their collaborative ties. On Nov. 18, 2003 the Automotive Multimedia Interface Collaboration (**AMI-C**) hosted a coordination meeting of international Telematics organizations connected to AMI-C to begin developing a framework for working together in the future (see table 5.1).

Vehicle Manufacturers	Associations	Contributors (Suppliers and Vendors)
Fiat Auto SpA	1394 Trade Association	Denso Corporation
Ford Motor Corporation	Bluetooth Car Working Group	General Dynamics
General Motors	ERTICO	Harmonia, Inc.
Nissan Motor Co. Ltd.	IDB (Intelligent Transport Systems and Services Data Bus) Forum	Infineon
PSA Peugeot Citroen	ISO TC 204 / WG 3	Kshema Technologies
Renault SA	Magic Services Forum	Mecel
Toyota Motors Corp	MOST Cooperation	Mindready
	OSGi™ (Open Service Gateway Initiative) Alliance	Molex
	OpenLS Forum	Motorola
	Open GIS Consortium, Inc. (OGC),	Navigation Technologies Corp.(NavTech)
	SAE	Parrot
	Consumer Electronics Association (CEA)	Sensoria Corp.
	Intelligent Transportation Society of America (ITSA)	Sumitomo Electric Industries
		Sun Microsystems
		TaTa Elxsi
		TeleAtlas
		Toshiba KN Systems
		Tyco Electronics
		Visteon Corp
		Wipro Technologies
		Xanavi
		XM Satellite Radio
		Yazaki

Table 5.1 Who is AMI-C?[39]

AMI-C has created a new architecture that can be applied to all vehicles, from company to company, reducing complexity, cutting product development time and saving big money. The organization was formed in 1998. Early 2003, AMI-C published its specifications, and the infrastructure is currently undergoing a battery of tests.

Car manufacturers are very concerned about safety and security and have so far been reluctant to open their systems. With the AMI-C automotive specification, first efforts are being made to ensure standard interfaces, reusability of components, broader choice of connectivity and lower cost. With the AMI-C spec opening up connectivity to the car, the wireless data portion of telematics is now the weak link

[39] Source: Consortium website, www.ami-c.org

for building a value proposition for the consumer and the car manufacturer that will drive the success of telematics.

However, AMI-C's work has been slow to find its way into the engineering trenches for two key reasons:

1. AMI-C is a non-profit corporation made up of dozens of companies – most of them competing head-on with each other, so the organization lack an aggressive marketing arm.
2. AMI-C is governed by strict antitrust provisions, which prohibit the participating companies from discussing specific product planning, timing and pricing with each other. The companies must jointly develop an architecture that benefits everyone in the industry – not just those writing the specification.

The question of how soon we will see AMI-C-equipped vehicles on the road, it is a question that OEMs cannot answer without violating antitrust rules and opening their "proprietary-standard" mindset.

5.6 Conclusion

The uncertainties that have characterized the telematics industry, at this stage of its evolution, challenge the ability of vehicle manufacturers and telematics providers of deciding when and how to proceed with respect to the establishment of industry standards. In this chapter, I reviewed the benefits and drawbacks implicit in the decision of pursuing an open telematics systems architecture strategy.

This chapter presented a strategy that combines both positions with respect to standards, open and proprietary telematics architecture. Opening the systems and decoupling the wireless-network access and user interface modules will provide incentives for other players of the industry to establish a standard interfaces that motivate them to develop product around the telematics system. In turn, establishing interfaces will allow costumer to interoperate their existing and future complementary goods. The evolution of adjacent technologies converging in the telematics system and the evolution of consumer needs represent another reason for vehicle manufacturers and telematics providers to pursue the discussed strategy.

Regardless of VMs and TSPs' course of action with respect to standards, strategies with regard to price and customer willingness to pay for telematics services should be addressed as they also represent a factor influencing the adoption of telematics. The next chapter suggests some strategies on this matter.

Chapter 6
Pricing Products and Services

6.1 Introduction

The Telematics industry faces tremendous complexity in product design because of the large number of different features and services that can be offered and the potential number of products and services that can be created in the future in this industry. **Bundling** appears in this industry as a natural mechanism to reduce complexity for TSPs and consumers and to reduce variability on the user's valuation of individual features. Bundling makes sense when customers have heterogeneous demands, and when the company cannot discriminate on price.

The present chapter analyzes the role of external environment, the customer interface, and the internal environment in the delivery process of telematics service operation. The analysis places special emphasis on the design of service platforms for customized services. Specifically, it presents an overview of current bundling policies to be considered in order to determine the profit-maximizing prices and configurations of services bundles.

6.2 Bundle Pricing Literature Review

The design of **customized services** is a dynamics process. The service interface should be a personalized interactive communication/selling channel where the communication stream and the service/product comes in the same package. During each interaction, the customer provides information that is used to dynamically design and deliver the most suitable service offering.[40]

One of the objectives of delivering personalized services is to induce **customer loyalty**. Customer receiving high quality customized services face barriers when they consider switching to competitors (*consider that customer loyalty benefit during the new car purchase decision process).* The size of these barriers depends on the amount of available information, the quality of the information, and the way in which that information is used works as deterrents to changes.

Highly customized services can be made possible through a service platform that provides the **basic offering** common to most regular and demanding customers. This platform must be complemented by **specific offerings** for a given customer that will shape the final service that is going to be delivered. The actual specifications of these offerings vary depending upon characteristics such as customer needs.

The final purchase of services and product packages will be a **bundle** consisting of many offerings that will meet the customer's needs and give them the most

[40] Ferrer, Juan-Carlos O. "Pricing Bundles of Products and Services in the High-Tech Industry", MIT Thesis, June 2002

value. Consequently, the issue of bundling becomes extremely important in deciding how to combine and price the offerings. In our case, TSPs want to maximize their revenue and help their customers choose bundles that best fulfill their needs. These objectives can be reached by understanding the concepts of bundling and bundling strategies.

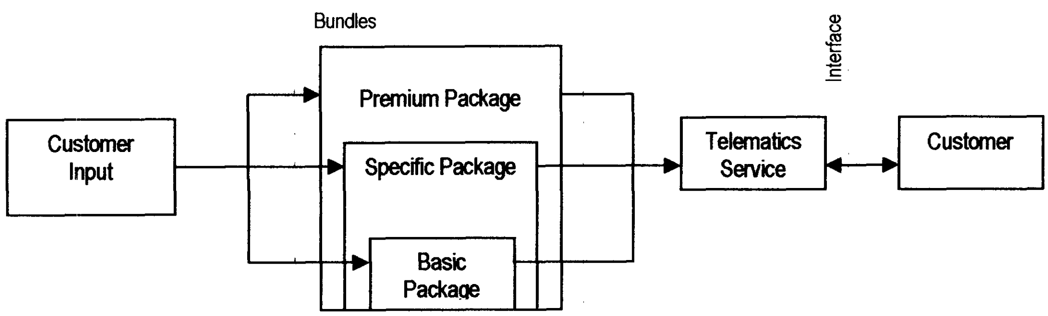

Figure 6.1 Customized Telematics Service Offerings

Bundling is a widely used price and design strategy. For example, when buying a new car, customers can purchase such options as power windows, power seats, a sunroof, or they can purchase a "luxury package" in which these options are sold as a bundle. Bundling makes sense when customers have heterogeneous demands, and when the company cannot discriminate on price. In other words, bundling involves offering special prices to buyers purchasing the main items plus one or more auxiliary items. This is widely used in marketing of high-tech products when complementary products and services exist. In order to be effective, bundling requires that a true relationship exist.

How can a firm decide whether to bundle its products and determine the profit maximizing prices? Most firms do not know their customers' reservation prices (the maximum amount of money that customers are willing to pay). However, by conducting market surveys, they may be able to estimate the distribution of reservation prices, and then use this information to design a price strategy. The following example illustrates this concept and the mechanism behind it.

A firm needs to decide whether to bundle two services or not. Table 5.1 shows the willingness-to-pay price of each customer for each service:

If the firm does not bundle, it can earn only \$26 since Price A=\$10 and Price B=\$3 are the optimal prices that maximize the revenues (both customers will purchase both services).

	Service A	Service B
Customer 1	\$ 12	\$3
Customer 2	\$10	\$4

Table 6.1 Customer's willingness-to-pay prices

On the other hand, if the two services are bundled, they can earn $28 since Price AB=$14 makes the bundle attractive for both customers. In economic terms, the consumer surplus from highly valued service A is transferred to the lesser valued service B ($1 is transferred from service A to service B in customer 1). In that case, with heterogeneous demand, the company is better off bundling.

6.3 Concept of Price Bundling

Bundling refers to selling two or more products or services at a price that is equal to or lower than the combined prices of the individual products. A prominent example in the software industry is Microsoft Office, a product that bundles together a word processor (MS Word), a spreadsheet (MS Excel), a database (MS Access), and a presentation tool (MS PowerPoint). Each of these products is also offered separately. This is what distinguishes bundling from tying, in which individual products are offered *only* in the package.

Even without the benefits flowing from integrating the different pieces in the bundle, bundling can be attractive and profitable. Since the price of the bundle is usually less than the sum of the component prices, a bundle of two products is effectively a way of offering one to customers who would buy the other product at a smaller *incremental price* than the stand-alone price (as we saw in the example in previous sections).

Other reasons for bundle are like *option value.* A consumer may find Microsoft Office an attractive purchase even if he doesn't currently use a spreadsheet, since he *might* use the spreadsheet in the future. If the consumer *does* decide to use a spreadsheet in the future, he will naturally choose the one that is "free" in the Microsoft Office bundle. Of course, the spreadsheet really is not free –the consumer paid for it when he purchased the bundle- but it does have a zero incremental cost once the bundle has been purchased.[41]

It is very important to emphasize that bundling makes sense if it reduces variation in willingness-to-pay. Combining complementary products and services increase revenue if it decreases the variation across customers in their willingness-to-pay.

Finally, bundling is an implicit way to price discriminate since it transfers consumer's surplus to the producer. The most well known types of price discrimination that may apply to the Telematics Industry are the following:

- 1st degree price discrimination: It is the practice of charging each customer his/her reservation price; i.e., the maximum price that a customer is willing to pay for each unit bought.
- 2nd degree price discrimination: It works by charging customers different prices for different quantities of the same product or service.

[41] Shapiro, Carl and Hal R. Varian, 1999, "Information Rules – A Strategic Guide to the Network Economy", HBS Press, chapter 3

- 3rd degree price discrimination: It involves the division of consumers into two groups, with separate demand curves for each group. The optimal prices and quantities are such that the marginal revenue from each group is the same and equal to marginal cost.

But, **why bundling?** In his thesis work, Ferrer(2002)[42] presented an exhaustive list of reasons for the use of *bundling* (only those pertinent to Telematics Industry are further described), including:

- *Extension of monopoly power or preserving a monopoly position*
- *Price Discrimination*. Bundling works as an implicit price discrimination tool because it allows sellers to extract more consumer surplus from buyers
- *Reduction in Complexity Cost*. Bundling reduces the wide variety of options, which leads to a reduction in complexity costs (e.g., the automobile industry)
- *Reduction in Transaction Cost*. Buyers avoid the transaction costs of contracting with several firms. Hence, they save time and information costs (e.g., the telecommunications industry)
- *Barriers to Entry*. Bundling can help to lock customers, and hence deny then to competitors. Switching costs may be increased, acting as a barrier to new entrants
- *Economies of Scope and Scale*. The incentive for quantity discounts arises from scale economies, whereas bundling yields scope economies.

6.4 Bundling Strategies

Making decisions about products/service bundling includes the assessment of each possible form in order to implement it. The most traditional strategies distinguished throughout the literature that are applicable to Telematics Industry are presented as follow:

a) No Bundling.
Product or services are offered and priced individually.

b) Pure Bundling.
Products or services are *only* offered in bundles and cannot be bought individually. This strategy is the one that yields the lowest profits, as opposed to mixed bundling, which yields the highest profits.

c) Mixed Bundling.

This type of bundling is a mix of the previous two. Technically, most companies deploy mixed bundling: consumers are given the choice of either buying products in a package or buying individually. In two-product bundles, buyers place a lower price on one item that will lead to additional sales of both products, while some buyers would otherwise pay for only one. When *complementary* relationships are

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[42] Ferrer, Juan-Carlos O. "Pricing Bundles of Products and Services in the High-Tech Industry", MIT Thesis, June 2002

very strong, the effects of the special price are even greater. There are two approaches to accomplish mixed bundling:

- Mixed leader: the price of a lead product is discounted on the condition that a second product is purchased.
- Mixed joint: two or more products or services are offered for a single package price.

Guiltinan showed some characteristics of successful mixed price bundling options, mixed leader, and mixed joint options:[43]

Mixed Leader Option:
1. Demand for the lead products should be price-elastic
2. Complementarity is based of the leader being enhanced by the other product(s) or convenience
3. If the objective is to cross-sell complements to regular customers, the leader is the lower margin products (so that the lost of profit from the price reduction is minimized); volume for the leader exceeds that of other products

Mixed Joint Option:
1. Demand for the total package is price-elastic
2. Complementarity is bi-directional (each product in the bundle enhances the value of the other) or is based on convenience.
3. If the objective is to cross-sell complements to regular customers, the various products in the bundle are approximately equal in volume and in profit margin so that sales gain from regular purchases of any product are about equal

d) Premium Bundling.

As in mixed bundling, sellers discriminate on price by offering products both separately and as bundles. However, bundles are sold as a premium (rather than at discount) relative to the prices charged for the individual components.

According to Cready[44], this is possible when individual products alone offer little benefit. Implementing a premium bundling strategy requires that the seller prevents component purchasers from purchasing more than one or two bundle components at component prices.

In general, sellers operating in service markets should find it relatively easy to implement premium bundling strategies because of their requisite knowledge of customers, while those selling products to larger numbers of unknown customers may find it difficult to implement such strategies.

e) Other types of Bundling.

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[43] Guiltinan, Peter M. and John D.C. Little, 1988, "Marketing Management: Strategies and Programs", McGraw-Hill, Princeton, NJ

[44] Cready, William M, 1991, " Premium Bundling" Economic Inquiry, Huntington Beach, no. 1, 173-181

- **Tie-in Sales** The buyer of the main product or service (tying good) agrees to buy one or several complementary goods (tied goods), which are necessary to use the tying good, exclusively from the same supplier. The best example is HP printer (leader product) and its cartridges.
- **Add-on Bundling** It is similar to tie-in sales, but here the "add-on" product will not be sold unless the lead product is purchased.
- **Cross Couponing** It is often used to introduce new products and/or to increase the sale of weak products by linking them with established products in the firm's products line.

6.5 Conclusion

In this chapter, I proposed bundling as the most suitable pricing strategy for telematics. Bundling makes sense because of the heterogeneity of customer likes for services and variability in customers' willingness-to-pay.

However, willingness-to-pay is the main issue when bundling. Several strategies were discussed in this chapter on this regard. The optimal strategy and the bundle itself depend on the distribution of the customers' willingness-to-pay prices. If reservation prices are high for one telematics product (or service) and low for the other product, separate pricing tends to be optimal. If willingness-to-pay prices are relatively high for both telematics products, pure bundling is recommended. If we have a combination of both customer groups, i.e., those with "extreme" preferences and those with "balanced" preferences, mixed bundling is probably the best pricing strategy.

Chapter 7
Industry Dynamics and Value Chain Strategies

7.1 Introduction

An industry roadmap should not describe how to depart from the present; it should show how to reach a desirable future.[45]

All industries evolve overtime. So does technology. Utterback and Afuah (1997) described these transitions as follows: Technology evolves as the firm's exploiting it interacts with their environment. As the technology evolves, so does industry structure, attractiveness and critical success factors. The evolution determines what kind of products or services (low cost, niche or differentiated) can be offered at each of the phase of evolution. To offer any of these products (and therefore survive), a firm needs certain kind of strategies and capabilities. The firms that do not have those capabilities, and therefore cannot offer specific products of the particular phase, are forced to quit the scene.[46]

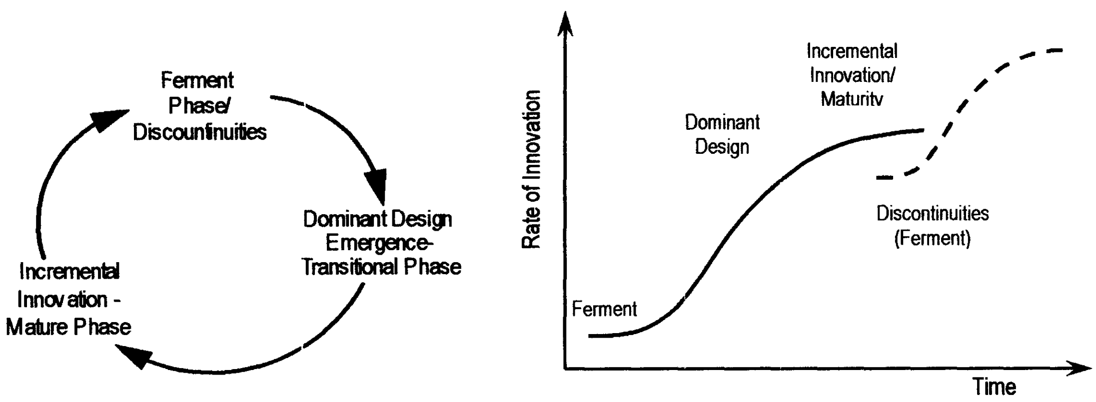

Figure 7.1 Two ways of looking at Technology and Industry Evolution

Thus, industry attractiveness and the kind of capabilities that a firm needs to succeed also vary from one phase of evolution to another, suggesting different strategies for each phase. A firm's heterogeneous capability in the latter part of evolution, and therefore its strategy, can be expected to depend on its strategies, capabilities and market positioning early in the life of technology (figure 7.1).

Based on Utterback and Afuah's hypothesis, we must presume that the power of the forces that shape the industry at each specific phase change as well. On the other hand, if the industry and technology change, so does the value chain of the

[45] Speech abstract of the "Communications Future Workshop, Inventing the Communications Future" held at the MIT Media Lab, October 28, 2003.
[46] Afuah, Allan N. and James M. Utterback, "Responding to Structural Industry Changes: A Technological Evolution Perspective", in Industrial and Corporate Change, Oxford University Press, 1997, Volume 6 Number 1

underlying technological innovation, its players, as well as their capabilities. Similar to technology evolution effects, the evolution of customer needs (as we analyzed on previous chapter) is also important to regard as a driver for value chain evolution.

In this chapter, I analyze the dynamics of the telematics industry based on concepts of industry and technology evolution and value chain mapping. This analysis starts by framing the current forces shaping the telematics industry at the ferment phase of its evolution. Following, from the point of view of the VMs and TSPs, I perform a value chain analysis by drawing a map of the telematics value proposition.

In this step in the process, it is particularly important to identify what player's capabilities and technologies bring value to the telematics innovation. This value chain analysis will help to realize how the evolution of adjacent technologies, those converging in the telematics system, will impact the current telematics business model in the future and how the existing value chain players' capabilities may play against the incumbent innovator. Analysis of this nature plays an important role when the time comes to define a position between the integral/modular system architecture and appropriateness/openness standard in the decision-making process.

There is no question that this industry will evolve. How the industry will evolve is the paradigm. Based on the information analyzed in this thesis, I suggest, draw and describe three scenarios of how I think the Telematics value chain will look in the future.

These illustrations attempt to identify who will be the winner of this industry and where the profits will be.

7.2 Telematics Industry Competitive Forces

According to Porter, the success of a firm is deeply rooted in the structure and its local environment[47]. The competitive environment varies from industry to industry, and so do the opportunities for sustained profitability. For each industry, five competitive forces combine to erode the long-term profitability of any industry of it: the threat of new entrants; the threat of substitutes' products or services; the bargaining power of suppliers; the bargaining power of buyers; and the rivalry among existing competitors.

For the purpose of this thesis, two more forces have been added to this framework; government regulation and complementors. The stronger these "seven" forces are, the lower the profitability on the industry. Figure 7.2 depicts the competitive forces of this industry under the lenses of the TSPs.

[47] Porter, Michael E., 1985, Competitive Advantage, New York; Free Press

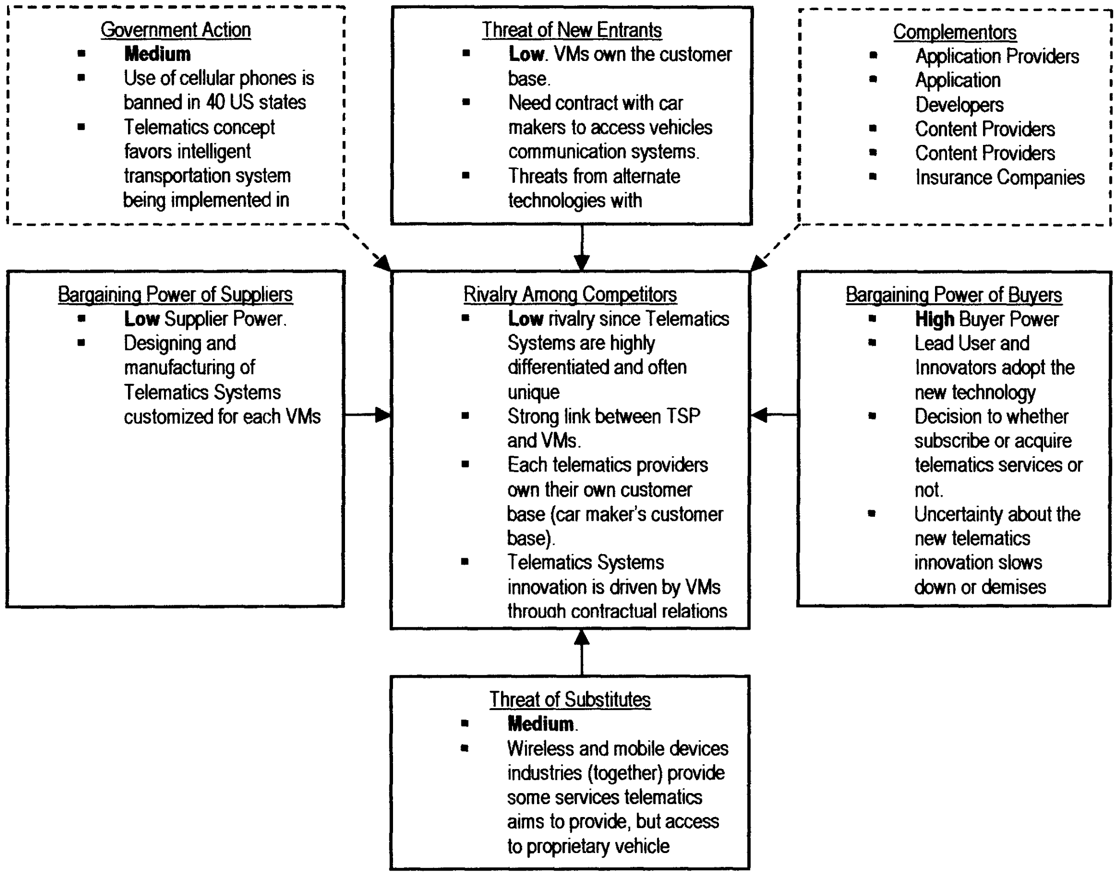

Figure 7.2. Telematics Industry Competitive Forces

As I previously acknowledged, today the telematics industry is at the ferment phase of its life cycle and no general standards exist for an industry-unified architecture or interoperability requirements. Telematics Systems are factory installed, hence embedded in the vehicle. There is a strong marriage between TSPs and VMs. This "marital" situation and the integral nature of the telematics systems make it difficult for new competitors to enter into the industry. TSPs exist because there is a contractual relationship with VMs.

TSPs, with the contractual support of VMs, make huge irreversible investments in fixed infrastructure, which includes the establishment of strategic location-based call centers as well as allocation and training of human resources or call center agents. Agents' tasks are to provide service and respond to consumers (driver and passengers) inquiries as well as to respond to vehicle wireless notifications. This investment also includes the set up of the back-end information technology and computer system management necessary to administer customer information, analyze vehicle performance data, and manage the transmission on content information to users.

Telematics Systems are highly differentiated. Driven by VMs and TSPs, there is continuous innovation to improve system performance (in 2003, OnStar just released its sixth telematics version). There is low bargaining power from software and hardware suppliers, since they depend on VMs decisions of whether to integrate their products in Telematics Systems or not. These suppliers design and manufacture customized telematics systems for VMs. Consequently, supplied systems are expensive due to the lack of standardization and economies of scale.

There is a set of telematics players whose roles are critical for the success of telematics. We identified these players as being more than suppliers who VMs and TSPs establish more than a contractual relationship with. They provide the complementary capabilities in which Telematics business models rely on. In this category segment, we identify firms that provide the back-end information technology infrastructure and providers of access to the network. Their experience, capabilities and complementary assets (as we will analyze in the next section) provide TSPs the competencies that otherwise they and VMs would have had to develop. For the purpose of this section, I decided to place these entities as complementary forces that also shape this industry (appendix H provides a comprehensive explanation of the concept of complementors). Providers of applications and content compatible and adaptable with existing telematics system architectures fall into this category.

The role of government in the body of driving regulations is also a significant force shaping evolution of this industry. TSPs and VMs might find the intervention of regulations a road-block for the diffusion of telematics. But on the other hand, if wisely managed, collaborating with entities like ITS (Intelligent Transportation System), U.S. Department of Transportation (www.its.dot.gov), and ITS America (www.itsa.org) in maximizing the utilization of wireless technologies for the safety programs in highways is critical to increase the Telematics value proposition.

Finally, uncertainties about the emerging telematics innovation and its value proposition reduce the probabilities of its adoption by consumers. This situation gives bargaining power to consumers since their decision of whether adopting telematics or not is determining the growth of this industry. Today, buying power is the strongest force in this industry.

In summary, the structure of the Telematics industry is a **vertical** integration (see figure 7.3). The fundamental reason of that is the **integral** nature of the telematics system **architecture**. VMs have control of the converging technologies that can be adapted in their proprietary systems.

This assessment matches up with the expected characteristics of vertically structured industries (as summarized in Appendix C2):

- VMs and TSPs have a competitive advantage. Owning an installed customer base provides them economies of scale.
- VMs and TSPs have control over delivery and quality of services
- VMs drive rates of technical change
- VMS are not vulnerable to holdup by suppliers;
- Quicker information flows between VMs and TSPs

- Limited direct competition and competitive threats do not exist.
- Trade-off exists; the vertical natures of the market reduces the competition for complementary products and drives slower adoption

As we are able to see in figure 7.3, the vertical upstream integration of OnStar's value chain is integrated by suppliers like Verizon (and recently Nextel), EDS, Motorola, Delco, and IBM. However, at the On Star value chain downstream level, GM is horizontally integrated since it decided to partner and license the technology to competitors like VW, Audi, Acura, or Isuzu in order to promote the diffusion of the Telematics offer.

Vehicle Manufacturers	GM	Acura	Audi	Isuzu	VW	Ford	BMW	Mercedes Benz	Volvo	Others
Telematics Services Providers	OnStar	ATX Technologies	Cross Country							
Cellular Network Operators	Verizon	Cingular	Sprint	ATT	Nextel	T-Mobile	Others			
Information and Data Management Providers	EDS	IBM	ATX Technologies	Microsoft						
Content Providers	Yahoo	AOL	CNN	MSN	Fidelity	Others				
Automotive Electronics Hardware Suppliers	Motorola	Delphi	Johnson Controls	Visteon	Others					
Software Applications Developers	QNX Software Systems	IBM	Microsoft	Sun Microsystems	Qualcomm	Others				
Electronics Device Manufacturers	Motorola	Samsung	LG	Nokia	Sony	Others				
Electronics Component Suppliers	Motorola	Delco	Johnson Controls	Visteon	Others					
Technology Suppliers	Motorola	Texas Instrument	Intel	Qualcomm	Ericsson	Others				

OnStar Value ChainPlayers — ATX Value Chain Players — Others TSPs Value Chain Players (including Cross Country)

Figure 7.3 Telematics Vertical Integration Industry Landscape

Previously, to anticipate what dynamics are to occur next in this industry, it is important to perform an in-depth analysis of the underlying capabilities that members of the industry bring to the telematics value proposition. Value chain analysis is the best approach.

7.3 Value Chain Mapping

Fine (1994) acknowledged that understanding and redesigning a company's capabilities chain begins with a map; one which identifies the organizations involved in that company's activities, the subsystems they provide, the capabilities they bring to the innovation, and the technological contribution each makes to the value proposition. [48]

[48] Fine, Charles H. 1998, "Clockspeed- Winning Industry Control in the Age of Temporary Advantage", Perseus Books, Page 105

Value chain mapping affords valuable tools for revealing risks and opportunities in the value chain. We are most commonly familiar with the organizational supply chain map, which arrays the entire set of organizations -upstream- that adds value in the chain to the final customers –downstream. To understand a capabilities chain thoroughly, as Fine suggested, we must draw the value chain map in multiple dimensions: **organization** or **supply chain**, **technology**, and **competences**.

The complexity when mapping competences value chains falls in identifying those competences in the value chain players. Prahalad and Hamel (1990) considered at least three tests that can be applied to identify core competencies in a firms. First, a core competence provides potential **access to a wide variety of markets**. Second, a core competence should make a **significant contribution to the perceived customer benefits** of the end value proposition. Finally, a core competence should **be difficult for competitors to imitate**. And it will be difficult if it is a harmonization of individual technologies and production skills. A rival might acquire some of the technologies that comprise the core competence, but will find it more difficult to duplicate the comprehensive pattern of internal coordination and learning.[49]

7.3.1 Automotive Telematics Value Chain

At the simplest level, the telematics value chain that VMs ended up creating consist of:

- Automakers, which must ensure that it all comes together in a way that meets their brand needs.
- TSPs for location-based call centers and the analysis of diagnostic information
- Information technology firms that build the call center backend office infrastructure
- Wireless carriers for the bandwidth or access to the network
- Hardware suppliers for the devices that send and receive wireless signals.
- Software suppliers for infrastructure and/or specialized applications
- Content providers that generate the information sent to vehicles

Over the last eight years (since the creation of the formal telematics industry in 1996), many of these firms have created partnerships with each other in order to provide telematics solutions for TSPs. Vertical partnerships among players of different levels of the value chain aim at using complementary capabilities. Table 7.1 illustrates the automotive telematics value chain in its technological, organizational, and capabilities dimensions.

Most of the firms involved in the Telematics business have a rather low level of competencies required to be successful and profitable. This is in part because telematics is still an emerging and uncertain industry, characterized by an unclear

[49] Prahalad, C.K. and Gary Hamel, "The Core Competences of the Corporation", Harvard Business Review, May-June 1990, pages 79-91

future technological trend and a lack of dominant or common industry standards. In essence, the Telematics innovation is not a pure, new technology but a combination –for all purposes- of already existing infrastructures, solutions, product and customer relationships, which allow the creation of new opportunities with new networks, products and customer portfolios. For most of the firms involved, these new business opportunities fall into a somewhat unfamiliar arena. Attempting to address the uncertainties of the emerging innovation, leveraging existing resource and know-how, and avoiding unnecessary (and sometimes irreversible) investments, players at any location of the value chain have preferred partnering with other firms from upstream or downstream of the chain. By doing so, telematics players share the risk and pain rather than developing and building new capabilities in-house.

What value chain dynamics are expected to occur next? What are the factors that will trigger the move to the next phase of industry evolution? How does the evolution of the converging technologies affect the value chain? What is the role of standards in the evolution?

The decoupling of telematics systems and the adoption of industry standards, I believe, will be the factors that will trigger the next shift of industry evolution. In fact, in chapter five, I suggested how VMs, if the decision to do so arrives, should open their proprietary standards. However, defining those factors is still too broad to realize how that evolution will occur.

As we concluded in section 7.2, the telematics value chain for VMs is predominantly vertically integrated. This conclusion is supported by the nature of the proprietary and integral architecture of their telematics systems. If VMs decided to open up their systems, due to industry and market pressures (some of these were listed in section 5.2), it will not only mean that the integral architecture of the telematics systems will be de-bundled to become a modular one, but also that the vertical integration of their value chains will either be affected or will be required to be adjusted toward a more horizontal-like structure. Why and how this phenomenon shall occur is explained in next section.

Supply & Organization Value Chain	Value Chain Players	Technology Value Chain	Competences Value Chain
Vehicle Manufacturer	▪ Acura, Audi, ▪ Buick, Cadillac, Chevrolet, GMC, Hummer, Isuzu, Oldsmobile, Pontiac, Saab, Saturn, ▪ Subaru, Volvo, BMW, ▪ Ford-Lincoln, Infiniti, Jaguar, Mercedes-Benz	▪ Vehicle Assembly Lines ▪ Electronics Module and Subsystems Assembly Equipment ▪ Subsystem Validation and Testing Facilities and Equipment	▪ Vehicle Assembly Management ▪ Vehicle Design and Engineering ▪ Vehicle Engineering Systems Design and Integration ▪ Electronics Subsystem Assembly, Debugging, Testing and Validation ▪ Vehicle Validation and Testing Data Management
Telematics Services Providers	▪ ATX Technologies, ▪ Cross-Country Automotive Services, ▪ OnStar	▪ Location-based Centers ▪ Virtual Advisor Data ▪ Data Management	▪ Customer Service and Assistance ▪ Billing ▪ Vehicle Relationship Management ▪ Call Center Agents Training
Information And Data Management Providers	▪ Sun Mycrosystems, IBM, EDS, HP, Microsoft	▪ Databases, Servers, Computer Systems Technology ▪ Information Technology ▪ Programming Software Technology ▪ Examples; Websphere-IBM, NET-Microsoft, Java-Sun)	▪ Operate Virtual Advisor Data Center. ▪ Design of Data Mining and Analysis Management Systems ▪ Information Technology and Infrastructure Services ▪ Computing System (Databases and Servers) Management Services ▪ Data Management Software Development
Network Operators	▪ Sprint, Verizon ▪ T-Mobile, ATT ▪ Cingular	▪ Voice& Data Service ▪ Services & Features ▪ Billing	▪ Distribution, Direct Sales, Network Connection, Billing
Electronics Device Manufacturers	▪ Nokia, Motorola, Ericsson, Siemens, Samsung, Palm	▪ Cell Phones, Smartphones ▪ Personal Digital Assistances ▪ SIM, Pads, Controls, LANs ▪ Audio Units ▪ Video Units ▪ Sound Systems	▪ Technology Components Integration
Content Providers (Portals)	▪ Yahoo, AOL, ▪ Comcast, MSN ▪ CNN, Navtech ▪ Sirius, XM Radio ▪ Sony, Sega	▪ Web Sites, Web Pages ▪ Channels, Portal, Interfaces ▪ E-Games, ▪ E-mail,	▪ Multimedia Communication development
Content Developers	▪ Disney, ESPN, Business Week, ▪ Weather Channel	▪ Traffic Information, weather, ▪ Digital Maps, Financial Information ▪ Points of Interest, General e-Information ▪ News, Entertainment	▪ Develop suitable content in specific customer formats ▪ Provision of suitable content
Car Dealer	▪ Many ▪ [Distributed Across US]	▪ Showroom, Databases, Shop Service Technology	▪ Showroom and Distribution ▪ Direct Customer Relationship Management ▪ Sales Management
Electronics Module and Subsystems Suppliers	▪ Motorota, ▪ Delphi ▪ Johnson Controls ▪ Visteon	▪ Telematics Center Units, ▪ GPS Units ▪ Electronic Center Units (engine and transmission) ▪ Collision Detector Systems ▪ Diagnostics Systems ▪ Antennas ▪ Display Screens	▪ Electronics Design and Components Integration ▪ Switches
Software Application Developers	▪ QNX Software Systems ▪ Microsoft ▪ IBM ▪ Sun Microsystems	▪ Operating Systems for On-board and Off-board devices ▪ Application Software ▪ Ex:Windows CE Automotive, Java, Frameworks.	▪ Development of Software Interfaces ▪ Development of Software Applications ▪ Development of Operating System adequate to operate with high technology components for performance and optimization
Electronic Component Manufacturers	▪ Motorola ▪ Delphi ▪ Delco	▪ Handsets ▪ Switch and Sensors ▪ Pressure Sensors ▪ Wiring and Harnesses	
Technology Manufacturers	▪ Motorola, Intel, Texas Instrument ▪ Qualcomm	▪ Microprocessors, ▪ Memory Chips and Cards ▪ GPS Chips	▪ Design and Development of High Technology Components

Table 7.1 Automotive Telematics Industry Organization, Technology, and Competence Mapping

7.4 Value Chain Dynamics

A summary of the literature research in industry and value chain dynamics concludes that firms that follow integrated (vertical) organizational strategies will match their internal organization better to the characteristics of **integral** technology. When innovative activities are integrated, firms can better manage the interactions between technical elements and share information freely inside the firm (Chesbrough and Kusunoki, 2001).

However, technology development may shift into a **modular** phase. At this phase, ***standards*** develop that articulate and codify the interactions between components of a system (often termed ***dominant design***). These standards permit even complicated components to be substituted for one another in a system. The presence of standards and associated know-how creates enough codified information (specifications) to enable players of the industry to coordinate the integration of technology across the members of the value chain. When rival suppliers with interchangeable products discipline one another to promote strong competition within this standard, the result is more rapid technological advancement and lower prices to systems customers.

The character of technology is not static and it may evolve from one type, *integral,* to an opposite type, *modular*, and then cycles back. In the early stage of a technology's history before the emergence of a dominant design, organizations competing to design successful products experiment with many different technologies. Since success in the market turns on the synthesis of unfamiliar technologies in creative new designs, organizations must actively develop both knowledge about alternate components and knowledge of how these components can be integrated[50]. The process of developing knowledge and learning about configurations of the established set of components ceases with the emergence of a dominant design.

Analyzing the technology evolution of different industries (including the automotive, electronics, and computer industries) Fine and Whitney (1996) attempted to illustrate the dynamics of the forces driving these shifts (figure 4.3). This hypothesis would be later formally denominated "double helix" by Fine in 1998[51].

As Fine and Whitney described these dynamics, in an industry exhibiting a vertical structure with an integrated product or system, a number of forces (niche competitors, the complexity of the task of staying ahead technically with a very complex product, and the organizational rigidities that can set in once a firm has an established market position) push toward a loss of the established position and possible dis-integration of the product architecture and industry structure. On the

[50] Henderson, Rebecca M. and Kim B. Clark, 1990 "Architectural Innovation: The Reconfiguration of Existing Product Technologies and Failure of Established Firms", Administrative Science Quarterly, Vo. 35, No.1, Special Issue: Technology, Organizations, and Innovations (Mar. 1990), page 14

[51] Fine, Charles H. 1998, "Clockspeed- Winning Industry Control in the Age of Temporary Advantage", Perseus Books, Chapter 4

other hand, with a modular product and horizontal industry structure, numerous forces (technical advances, market power in one or more module suppliers, and potential profitability from integrating into a proprietary system offering push toward the integration of product architecture and industry structure.[52]

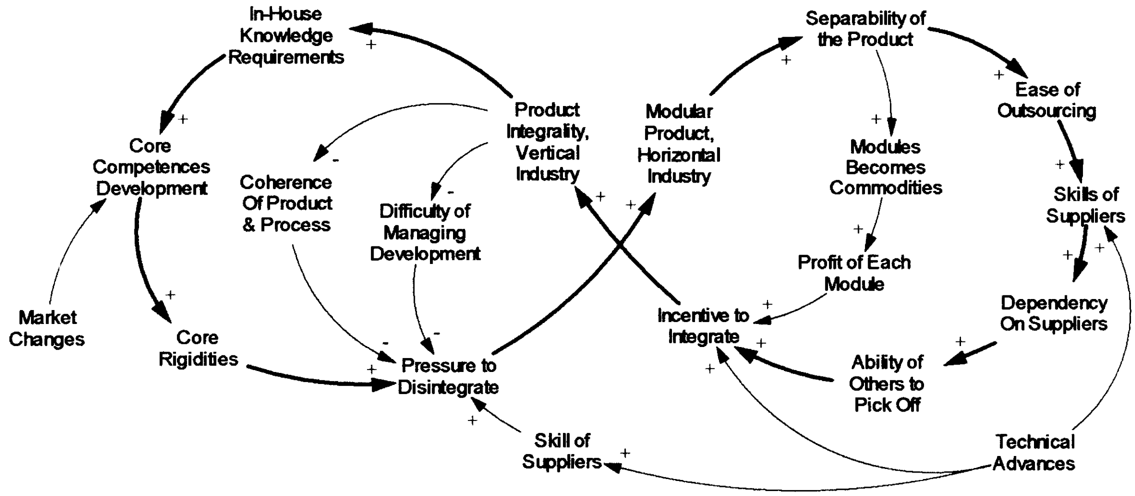

Figure 7.4 Influence Diagram of Integral-Modular Dynamics (Fine and Whitney, 1996, and Double Helix by Fine, 1998)

As the technology shifts from one stage (integral) to another (modular), the organizational architecture of the firm must also shift if it is to continue to capture value from its innovation. To profit from innovation, firms must evaluate the condition of the technology on which their business is based and then adopt appropriate organizational policies and structures based on that evaluation. During the cyclical transition of the technology, from integral to modular and back, firms that align their structures well will profit from their innovation activities, while firms that do not will fall into organizational traps. These traps will frustrate their ability to capture value from innovation investments[53].

On the basis of the hypotheses discussed above, decoupling Telematics systems and allowing for more modular open-standards architecture (as suggested in chapter 5), would also require VMs and TSPs to redefine their organizations and consequently a change in the structure of the value chain would be expected to occur.

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[52] Fine, Charles H. and Daniel E. Whitney, "Is the Make-Buy Decision Process a Core Competence?", MIT Center for Technology, Policy, and Industrial Development, February 1996

[53] Chesbrough, Henry W. and Ken Kusunoki, The Modularity Trap: Innovation, Technology Phase Shifts and the Resulting Limits of Virtual Organizations, chapter published in the book edited by Ikujiro Nonaka and David Teece, 2001 "Managing Industrial Knowledge", Sage Publications, Chapter 10

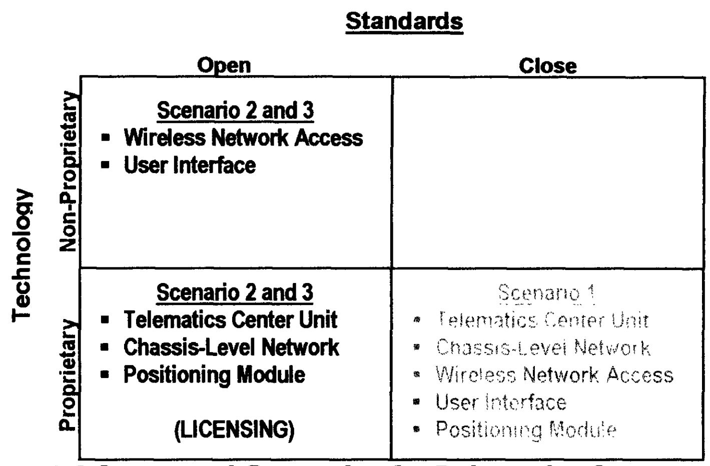

Figure 7.4 Suggested Strategies for Telematics Systems and Appropriateness of Open Standards Architecture

Decoupling telematics systems at the wireless network access and user interfaces module levels implies business opportunities for upstream players (and potentially new entrants) of the vehicle telematics value chain.

Especially in modular architectures systems (requiring horizontal structures) where different technologies converge, the linear relationship among players is diffused and a chain structure is not sufficient to illustrate the relationship among players. In this case, the new automotive telematics value chain must be seen as **value network** where the cross interaction among players is critical to maximize benefits, profits, and the creation of new business opportunities resulting from the new value proposition.

The interaction among players may take the form of horizontal technological partnership between players, cash and information exchange upstream and downstream the value chain, as well as multiple interactions between the end customer and several players of the virtual network.

In the following section, I present and discuss three scenarios of what I consider the telematics value network will look like, based on having decoupled the wireless-network access and user interface modules from the telematics system.

7.5 Value Network Scenarios

If VMs decided to open their integral telematics systems and provide opportunities to players of the industry to design and manufacture products and services around the technological innovation, the establishment of common standards would be required to ensure coordination among the elements of the system.

This work does not discuss strategies for how VMs and TSPs should push their telematics systems to become the dominant standard in the industry. However, as Shapiro and Varian (1999) suggested, the ability to successfully wage a standard war depends on firm ownership of seven key assets: control over an installed base of users, intellectual property rights, brand name and reputation, first-mover advantages, **manufacturing capabilities, strength in complementors**, and **the ability to innovate** [54]. If that hypothesis is right, VMs and TSPs would need to develop or leverage from other firms the accessibility of the last three assets to aspire to becoming the dominant standard.

When innovation depends on a series of interdependent innovations –that is, when innovation is systemic –independent companies will not usually be able to coordinate themselves to knit those innovations together. **Scale, integration,** and **market leadership** may be required to establish and then to advance standards in the industry.[55] So if VMs decided to open their telematics systems and modularize the telematics architecture, common standards to connect those modules must be established between VMs and the players involved in providing the products and services related to those modules.

The three scenarios suggested in this paper are based on the assumption that standards to integrate the different modules were established and that upgrades of technology can be achieved at any time in the telematics system; a kind of plug-and-play architecture. These scenarios are depicted in table 7.2.

Scenario	**Driver**	**Wireless-Network Access**	**User Interface**	**Telematics System Architecture**
(1) Base Case	Telematics Service Providers	1G or 2G	Embedded in the vehicle	Proprietary
(2) 3G Centric	Wireless Network Carriers	3G Wireless	Ability to plug-and-play any other electronic device.	Open Proprietary and Non-Proprietary
(3) WiFi or WiMAX Centric	Mobile Device Manufacturers	1G or 2G and WiFi or WiMAX (Mobile-Fi)	Ability to plug-and-play any other electronic device.	Open Proprietary and Non-Proprietary

Table 7.2 Telematics Scenarios

Scenario (1) -Telematics Service Provider Centric (Base Case)

This is the value network of existing telematics providers, like OnStar. This value network is centered on Telematics Service Providers since most of the telematics services are provided by a location-based service center. The telematics systems architecture is integral of vehicle manufacturers.

[54] Shapiro, Carl and Hal R. Varian, "The Art of Standards War", California Management Review, Vol. 41, No. 2 Winter 1999
[55] Chesbrough, Henry W. and David J. Teece, "Organizing for Innovation: When Is Virtual Virtuous?", Harvard Business Review, August 2002.

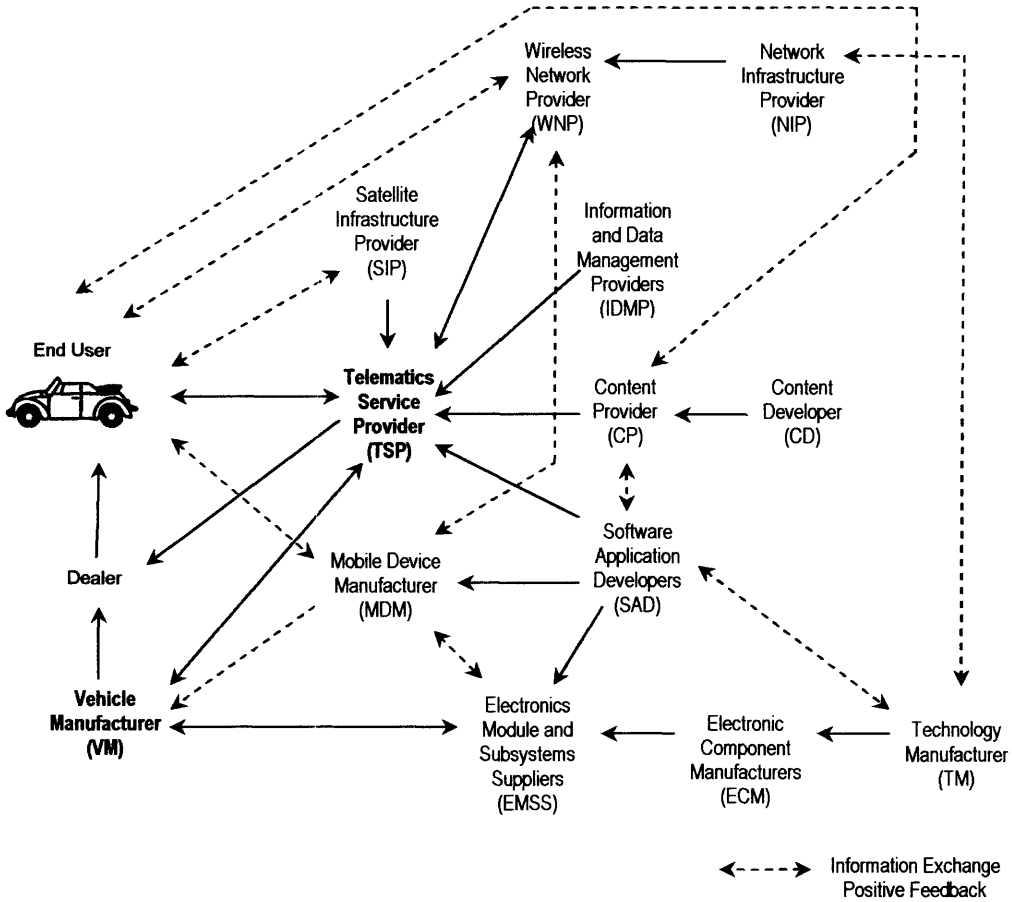

Figure 7.5 Telematics Value Network
Scenario (1) Telematics Service Provider Centric

VMs and TSPs work together to become the integrators of the value network (see figure 7.5). They decide what technologies to integrate into the telematics systems. They contract airtime network access with Wireless Network Providers (WNP). Electronics Module and Subsystem Suppliers (EMSS) design and develop telematics center units (TCU) specific to their needs. The development of the software embedded in the TCU unit is performed by EMSS themselves or they contract the service with Software Application Developers (SAD). Technology Manufacturers (TM) provides the microprocessor (and wireless access chip and GPS receiver chip) embedded in the telematics systems. Interaction (information exchange) between SAD and TM take place only when SAD is contracted to develop the TCU software, otherwise the coordination occurs directly between EMSS and TM.

Information and Data Management Providers (IDMP) build up the backend telematics service center infrastructure as required by the TSPs. Interaction between EMSS, SAD and IDMP occur to create an infrastructure that maximizes utilization of software as enabling technology is under the coordination of VMs and

TSPs. There are not incentives for them (EMSS, SAD, and IDMP) to do it otherwise, since the access to the telematics systems is limited.

IDMP in coordination with TSPs build the web page interface that allows end users to choose the information and customize the kind of content they want to receive in their vehicles either via the TSP agent or the virtual advisor (software developed to deliver web information to the end users). TSPs coordinate with Content Providers (CP), who in turn coordinates with Content Developers (CD), to deliver information, content and data as chosen by the end users; in the format the end users desire. For instance, BMW is partnering with search giant Google to provide voice-activated access to Google so that search terms can be spoken into the car's speakerphone, and search results quickly presented on a built-in LCD screen or on a user's mobile phone.[56] CPs and CDs do not have incentives to develop by themselves more content (web content) in the TSPs (and VMs) specifications format. Specific format as developed by contracted SADs (or EMSSs) does not allow for economies of scales, since the software platform varies across TSPs' Telematics Systems.

Mobile Device Manufacturers (MDM) have little participation in the value network, since integration and compatibility of their existing products with the telematics systems is very limited. The context of telematics (communication network for the user in the vehicle) the value MDMs bring to the user can be achieved only if the mobile device can be connected to the vehicle via wireless technologies (Bluetooth) that can be "adapted" to the vehicle electronics (radio speakers). However, this represents an additional investment for the consumers because of incompatibilities; reducing the attractiveness for using such products (in the vehicle).

Interaction between EMSS and MDM exists only with the intention of developing a common standard at the electronics devices and modules level but the final decision to incorporate such standards into the systems is made by VMs.

Scenario (2) – 3G Centric

The Telematics System architecture has been decoupled in its Wireless-Network Access and User Interface modules. Common standards to adapt these modules to the systems would be developed between players involved in developing product and services for these modules. Participants have included VM, TSP, EMSS, SAD, WNP, MDM and TMs.

Under this scenario, cellular-based wireless technologies of the third generation (3G) are deployed across the entire cellular network (full coverage in the US nation). This is the extreme case where WNP in joint with Network Infrastructure Providers (NIP) made the investment in 3G infrastructure.

[56] Source: Frank Spillers, Telematics Update, February –March 2004, Issue 26, page 16

Ideally, deploying 3G wireless would allow WNP to offer consumers a richer array of services (as they are listed in table 7.3): position location, personal and mass media, application downloading, messaging, video conferencing, internet connectivity, enterprise connectivity, pricing, and metrics.

Applications	Innovative Services
Position Location	Also known as LBS (location-based service), provides a mobile device location "fix," often tied into mapping or direction information. Many commercial 3G services use A-GPS (assisted-global positioning service) to provide highly accurate positioning information to mobile phones and other mobile devices.
Personal & Mass Media	Includes streaming or downloading of audio and video content such as sports replays, news headlines, music videos, movie trailers and more.
Application Downloading	Facilitates wireless downloads of programs and applications to mobile devices, typically mobile phones. These downloaded applications can be games, productivity apps, media players, ring tone applications, etc.
Messaging	Peer-to-peer messaging applications such as email, IM (Instant Messaging) and MMS (Multimedia Messaging Services), which can include photo messaging and video messaging.
Video Conferencing	Allows two or more mobile users to conduct a virtual meeting. Users can see and hear each other in real or near real time. The mobile device will typically display a picture-in-picture view with the other conference member(s) in the large window and the user in the smaller PiP window.
Internet Connectivity	Providing general wireless data access to laptops, PDA's and mobile phones for consumers and enterprises alike. These services usually include Internet and email access and can include secure access to enterprise data.
Enterprise Connectivity	Connectivity and applications specifically enabling the 3G mobile workforce. Many enterprise-specific services increase productivity and focus on securely connectiving mobile devices to key applications behind the company firewall.
Pricing and Metrics	Price Plans: Rate plans for 3G voice and data services. 3G services enable lower cost-per-minute pricing and larger bundles of voice minutes, as well as flat-rate pricing for unlimited data usage. Metrics: Financial and other performance metrics for operators providing successful 3G services. These metrics often demonstrate strengthened financial performance and increased competitive advantages for these 3G operators.

Table 7.3 3G Applications and Innovative Services[57]

What does this scenario mean for VMs and TSPs? First of all, under this scenario, VMs and TSPs would be required to focus their efforts into maximizing the benefits that consumers can obtain from telematics features like Intelligent Transportation, Vehicle Services, Safety and Emergency, Navigation, and Traffic (see figure 1.1.). This means that they will focus only in the Vehicle market and the portion of the Passenger market related to these features. VMs (and TSPs) will benefit the most from information generated by the vehicle performance and the driving behavior of the end users (driver). VMs will be able to use that information and data for incremental vehicle design improvements or during the designing of the next generation. VMs and TSPs jointly in coordination with Dealers, will be able to provide better, proactive, and prompt services as reported by vehicle subsystems or drivers. This would allow VMs and Dealers to enhance post-sale relationship with the costumer or better said, to excel the Vehicle Relationship Management (vRM).

The critical and most important relationship that must be established under this value network scenario is a strong collaboration between vehicle manufacturers,

[57] Source: 3G Today website, http://www.3gtoday.com/

telematics services providers, and wireless network providers. The incentives for these entities would be to **joint their capabilities to provide additional value to their existing base of customers** by providing them a richer array of services. This is, to allow customers to benefit from sharing information among their vehicles and personal electronics gadgets.

What are the incentives for Wireless Network Providers? The wireless communication industry is a saturated market. Strategies for service differentiation are becoming limited under the existing market rules. WNPs' wireless service will be more attractive if they allow consumers to interoperate their mobile devices with their vehicles.

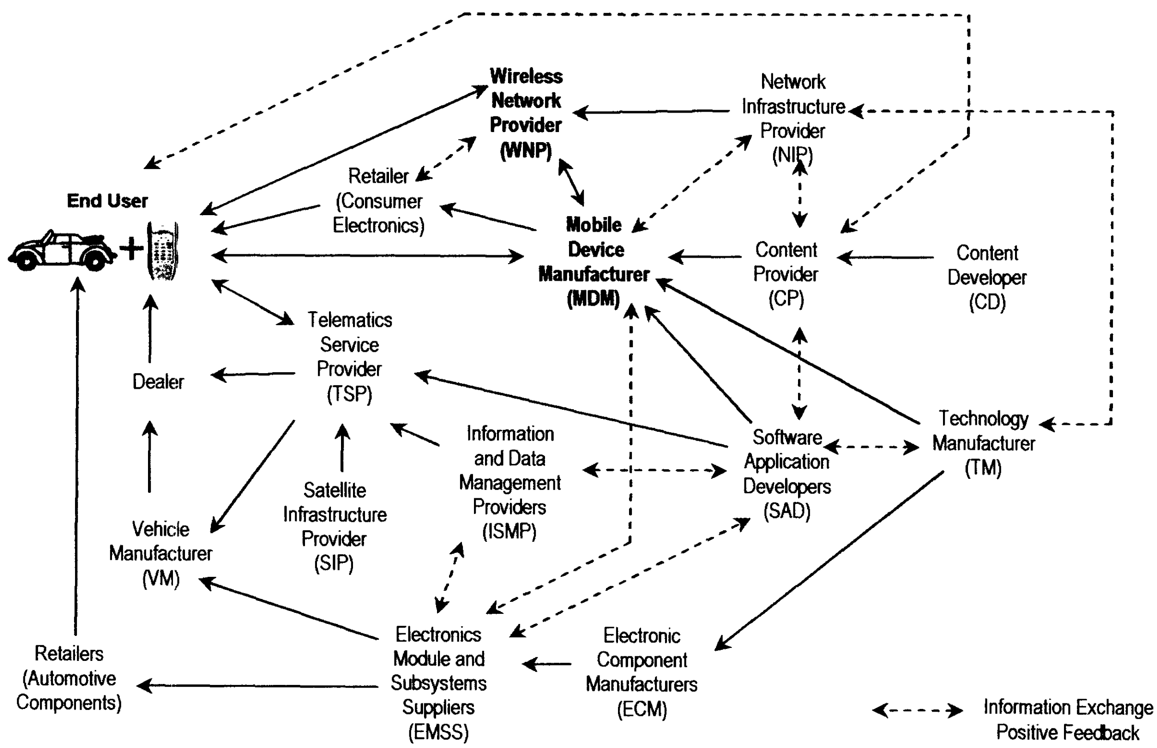

Figure 7.6 Telematics Value Network Scenarios (2) : 3G Centric

A second layer of players upstream the value chain must support this scenario. Value network interrelationship paybacks result when MDM, EMSS, SAD, ISMP and TM interact to build a common software application platform that allow for interoperation between the telematics service center back end infrastructure, the mobile device, and the embedded telematics center unit. The platform will also provide CPs (and perhaps CDs) incentives to develop content interface that fit the telematics software platform.

As it occurs in the wireless communication industry (or value network), there is an information exchange between MDM, NIP, WNP, and TM to agree on air interface compatibility (3G wireless standard).

Who would be most benefited from this scenario?

Undoubtedly, Wireless Network Providers (WNP) would be in a better position to profit from this scenario, since the telematics will signify to them a way to differentiate their existing services.

Scenario (3) – WiFi or WiMAX (Mobile-Fi) Centric

Also, in this scenario, the Telematics System architecture has been decoupled in its Wireless-Network Access and User Interface modules. Common standards to adapt these modules to the system have been developed between players involved in developing products and services for these modules. Participants for establishment of standards have included VM, TSP, EMSS, SAD, NEM, and TMs. Figure 7.7 depicts how the value network would look like.

VMs and TSPs continue to depend on 1G or 2G cellular-based networks to maintain communication with the driver for safety and emergency situations. However, the exchange of data and information, as generated by the vehicle, is achieved by deploying WiFi or WiMAX services. Access to the internet network will be through local access networks (LAN) or hot spots established along the road (or highway), in the case of WiFi technologies; or by reaching urban or rural areas that are providing WiMAX connectivity (MAN- Metropolitan Access Network). It is important to emphasize that WiMAX connectivity while the vehicle is in movement will be reached as long as Mobile-Fi technology (an extension version of WiMAX that allows connection to the network while in the move- at vehicle speeds) is deployed and available in the same areas.

This scenario opens the opportunity for entrepreneurs and new entrants wanting to benefit from telematics industry. Wi-Fi hotspots and even WiMAX "hot-cities" are not necessarily managed only by WNPs. However, because of the threat that these technologies are representing to cellular-based networks, it is logical that WNPs will want to take the leadership on this matter and take advantage of their existing customer base.

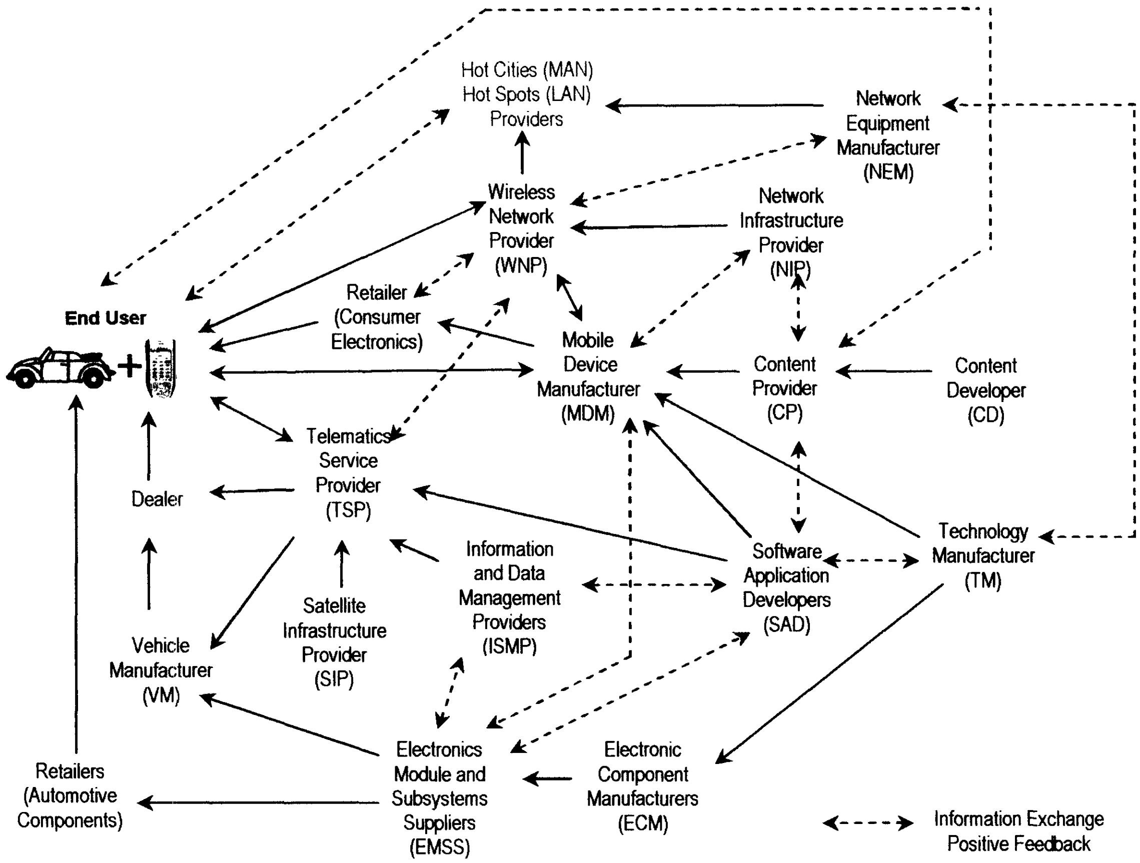

Figure 7.7 Telematics Value Network
Scenarios (3) : WiFi or WiMAX (Mobile-Fi) Centric

The basis of this scenario brings opportunities for MDMs (Mobile Device Manufacturers) to benefit from the telematics industry on a higher scale. Empowered by the support of SADs and TMs, MDM will be able to develop mobile devices (PDAs, Smartphones, Laptops, Notebooks, etc) that allow the access to wireless network via WiFi or WiMAX technologies but at the same time allow the interoperability with vehicle telematics systems; access to the telematics center unit –TCU, where the vehicle data and information is stored. As suggested in Chapter 5, VMs will be in the position of allowing the access to the TCU by licensing the enabling technology (the unlocking chip) to MDM.

SADs (Software Application Developers) will be in a unique position of developing the operating system platform that is compatible for mobile devices and telematics systems. To do so, the information exchange should take place between SADs and EMSS, ISMP, MDM, CD, and TM. SADs become a critical node in the network.

Another critical relationship (information exchange) of this value network should take place between TMs (Technologies Manufacturers) and the providers of the WiFi and WiMAX gear and infrastructure; the Network Equipment Manufacturers (NEMs). The development of chip technology embedded in mobile devices and telematics center units must be compatible with the wireless equipment as developed by NEMs. For instance, Intel Corporation succeeded with its Intel Centrino chip embedded in laptops and has been one the leading firms in promoting the deployment of WiFi technology. Intel wants to repeat that success with WiMAX and it has invested a lot of financial resources into motivating other firms to build the complementary assets needed to accelerate the launching to market of the newer technology.

Who will be most benefited from this scenario? If SADs (Software Application Developers) and TMs (Technology Manufacturers) take a leadership position and become a **platform** (as it occurred with Microsoft Windows OS and Intel Pentium chips in the Computer Industry), these players would be in the best position to profit from these scenarios.

It could be thought that MBMs (Mobile Device Manufacturers) would benefit as well. However, because of the highly competitive consumer electronic industry, rapidly changing technologies, and inabilities that players of this industry have shown to establish and adjust themselves to industry standards (e.g., many remote controls to operate home electronics), it is very unlikely that these players will be among the winners.

If Safety and Emergency, Vehicle Diagnostics, and Traffic and Navigation features continue to be the services that consumer value most, VMs and TSPs will continue benefiting and profiting from this industry. This conclusion is based on the assumption that VMs continue to have control over the telematics center unit, GPS, and Chassis-Level Network modules of the telematics system enable those features.

7.6 Conclusion

Telematics, as any other industry or technological innovation, is expected to evolve overtime. Vehicle manufacturers and incumbent telematics service providers will be in a good position to continue benefiting (and perhaps profiting) from telematics if they achieve to leverage collaborators and partner's capabilities. The competitive advantage that VMs and TSPs enjoy today is temporal, as temporal is the industry structure depicted in this chapter.

Events triggering the next stage of evolution will come from VMs' and TSPs' decision to open their vehicle telematics systems, from the establishment of industry standards, or from another alternative (disruptive) telematics innovation, among other sources. However, it is also true that this industry will not evolve at all if telematics does not cross the bridge from being a fad to being a real business opportunity; which marketers call it to "cross the chasm".

The scenarios presented in this chapter assume that VMs modularized their telematics systems. As the literature research indicates, modularization of the underlying innovation brings business opportunities for upstream value chain players, those players who own the capabilities that VMs need to create telematics. If the incentives to do so are attractive, upstream players would be in a good position to innovate their respective telematics module in collaboration with VMs and TSPs, or without them. Vehicle manufacturers have extensive experience in managing suppliers, as long as they control the changes made to the standard specifications. Telematics open architecture is not the best strategy for vehicle manufacturers, but it is for ensuring the existence of this industry.

Vehicle manufacturers' strategies should not be how to manage standards and specifications, but how to manage collaborative relationships and leverage the capabilities of others firms, in order to continue being the drivers and integrators of the telematics value network, whichever it will be.

Chapter 8
Virtuous Adoption of Telematics

8.1 Introduction

The growth of the telematics industry depends on several factors as I have discussed in previous chapters. Understanding how those factors contribute collectively would escape the capabilities of our mind. System dynamics modeling offers a tool that helps understand the dynamics of those factors and how they affect the desired outcome.

In this chapter, I present a conceptual model to describe some of the dynamics of the Telematics industry affecting the adoption and diffusion of telematics. I focus on two main variables; the **value to users** and **awareness** of the technology innovation, as the drivers that motivate the rate of adoption or rate of users subscribing to the telematics offers. Two factors are identified that affect the level of awareness of telematics; the amount of advertisement (marketing strategies) and word of mouth (WOM) effects resulting from the installed base of subscribers.

In the case of value to users, or attractiveness of telematics, six factors are identified as the drivers that influence the value that users perceive from telematics. The factors are related to the availability of telematics features as well as of complementary products and services. The effect of the openness of telematics standards is considered as well.

A brief summary of the current telematics business strategies provides the starting point for building this model. Subsequently, I present a graphical assessment to exemplify how the value that users perceive from telematics may shift over time when it is directly influenced by some variables as they were depicted in the model.

Finally, the dynamics illustrated in the conceptual model allows anticipating and describing several scenarios that may occur in the future evolution of the telematics industry.

8.2 Assessing Current TSPs Strategies

As discussed before, the aim of telematics is to enhance the driving experience. One of the challenges that TSPs have been facing is to find the killer application that triggers users' adoption of telematics. Features related to Safety and Emergency or Navigation and Traffic Information have been more appealing or valuable to users as reviewed in earlier chapters. Developing new telematics features and applications, or acquiring them from complementors, are the key strategies that TSPs have been focusing on to enhance telematics attractiveness and value to users.

More customers subscribing to TSPs' telematics increases the size of the installed base of subscribers and furthermore revenues stream. Research and development investment allows TSPs to find new features or applications that enhance product's attractiveness and increase probabilities of users' adoption. These dynamics have given GM and OnStar a favorable position against their competitors.

In order to increase the size of the market, this is, the number of vehicles with a telematics systems installed in them, VMs and TSPs should seek an opportunity in licensing their technology (OEM alliances) to other OEMs. This strategy would allow TSPs to achieve a larger network of vehicles using their telematics technology and contribute to the diffusion and growth of this still emerging telematics industry.

The challenge that existing telematics providers have been facing is the pressure to open their integral telematics systems and establish standards. OEMs that have decided not to join other TSPs' networks have been developing their own telematics solutions by partnering and collaborating with players from other industries (several vehicle manufacturers have partnered with ATX Technologies to create their own telematics service brand). Some of those telematics systems were designed to be open architectures. But all of them are using different telematics standards, which makes it difficult for complementors to develop products around a specific telematics system. So, as long as TSPs standard are compatible with those of some existing complementary products, then TSPs will maintain a leadership position in this aspect. Otherwise, the establishment of common standards (or dominant design) will eventually change the rules of the game for those TSPs whose standards were not favored. Issues like customers lock-out, due to lack of upgradeability or transferability of complementary features, may play against TSPs future.

The following system dynamics model illustrates some of the dynamics that drive the growth in demand, market share, and attractiveness of the telematics industry.

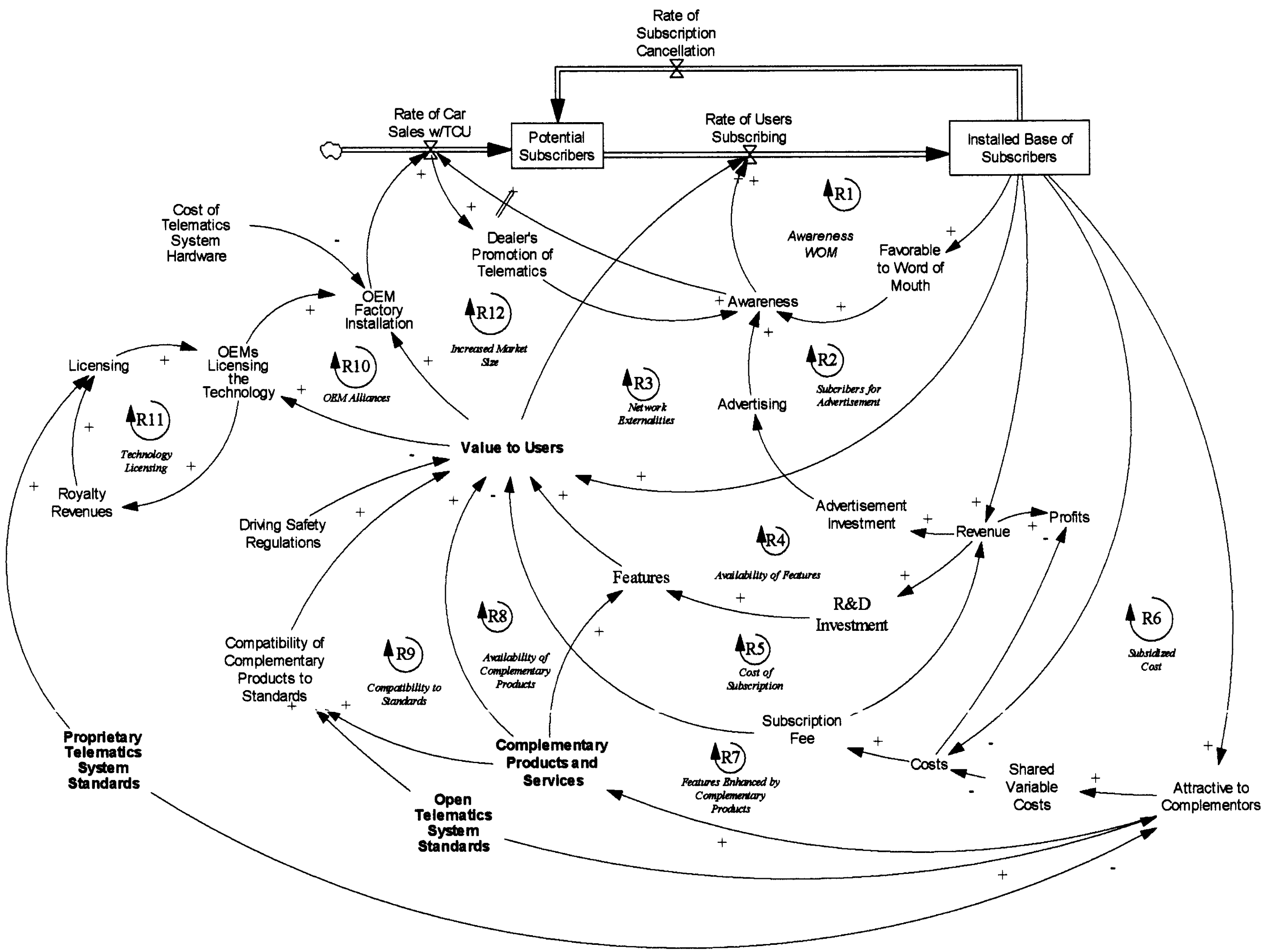

Figure 8.1 Telematics Industry Dynamics

8.3 Modeling the Telematics Industry Dynamics

In addition to building closer relationship with customers after the sale of the vehicle, the ultimate goal of VMs and TSPs is to increase the size of the *Installed Base of Subscribers (stock)* and to benefit from the monthly subscription revenues. The *Potential Subscribers* stock includes owners of all those vehicles with a telematics systems (or TCU-Telematics Center Unit) installed. The challenge is to motivate those potential customers to subscribe to telematics thus increasing the *Rate of Users Subscribing.*

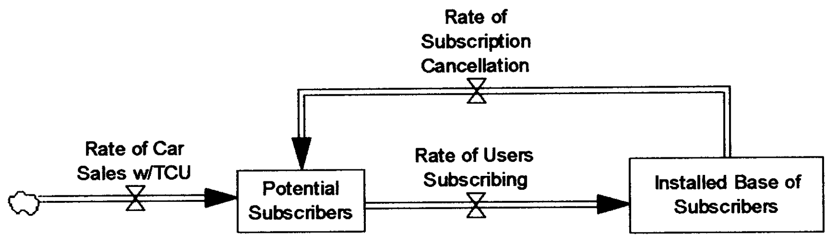

Figure 8.2 Installed Base of Customers Loop

However, we must consider that the installed base cannot grow forever. A balancing effect occurs when users decide to unsubscribe to the services thus influencing the *Rate of Subscription Cancellation.* Cancellation of the service may be due to several factors, including the termination of a vehicle lease contract, renewal of car, unsatisfactory experiences with the service, better competitor's offers, or outdated embedded telematics electronics offering lower performance.

Awareness WOM -Word of Mouth (Loop R1). Users' awareness of telematics initially comes when dealer promote telematics as an innovative feature in the new car. If the dealer succeeds and the user decides to purchase a telematics-enabled car, then the user becomes a Potential Subscriber. To let users try and test the telematics innovation, some telematics providers' strategies are to provide users an one-year subscription free of charge. After the year, users decide whether to subscribe (subscription renewal) or not thus affecting the size of the installed base of subscribers (see figure 8.3).

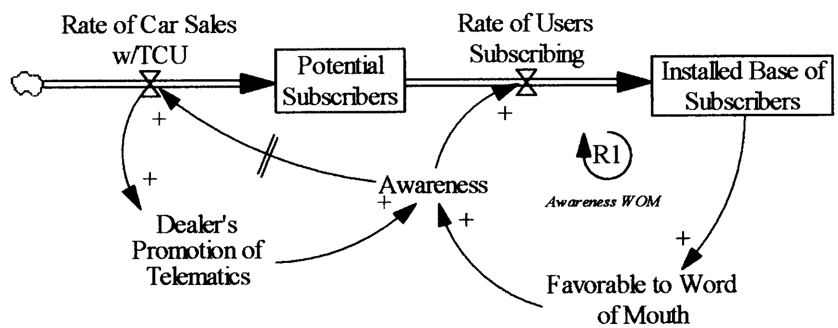

Figure 8.3 Word of Mouth Effects

Experiences with the service may be favorable to word of mouth, where users share information with other users that either do not own a telematics-enabled vehicle or do own one but have not yet decided to subscribe. The word of mouth effect is a reinforcing loop for increasing/decreasing that influences users' decisions to subscribe to telematics, thus affecting the size of the installed base of subscribers.

Subscribers from Advertisement (Loop R2). One of the primary means of notifying users of telematics and its benefits is by advertising. Specialized publications and TV advertising are the drivers of this reinforcing loop. As the revenue from subscriptions increase so do the possibilities to invest more in advertising, increasing awareness, thus creating a positive and reinforcing feedback loop for the adoption of telematics (figure 8.4).

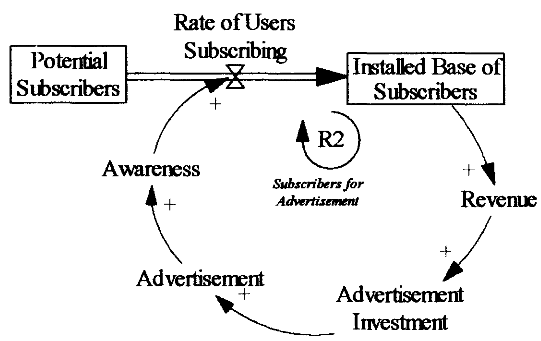

Figure 8.4 Information about the New Innovation

Even if it is not explicit in this loop, the role of Dealers in advertising telematics and the benefits that customers can gain from telematics is also critical considering that the Dealers are the last contact between the new telematics-enabled vehicle and customer's decision to purchase.

The revenue budget designated by VMs and TSPs to advertise telematics may include providing incentives to dealers (training and education), so they make customers aware of the telematics innovation. Ideally, Dealers should see in telematics a way to differentiate themselves during the vehicle selling process among dealers.

Network Externalities (Loop R3). When the value of a product to one user depends on how many other users there are, then the product is termed *network product;* such is the case with telematics. Telematics is strongly influenced by the dynamics of network externalities. As the size of the installed based of subscribers increases, so does the size of the network of users deploying the new innovation (figure 8.5). The size of the network is more valuable for users, since it reduces or eliminates uncertainties about the technology, thus motivating increases of the rate of adoption.

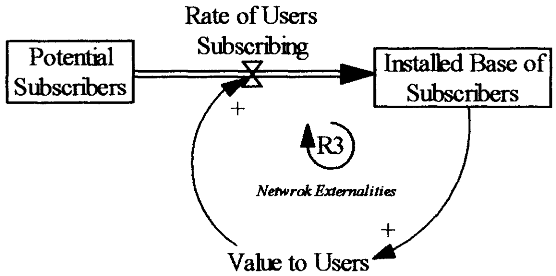

Figure 8.5 Network Externalities Effects

As I will further discuss, network externalities effects, or enhanced value to users because of the size of the network, also attract providers of complementary products and services.

Availability of Features (Loop R4). The number (and type) of features and applications that assemble the set of telematics solutions enhance the attractiveness of telematics to the potential subscriber. This dynamic is one of the most important drivers for the growth of this industry, since in the type and number features rests the value that telematics offers to the users. Two factors influence these dynamics (see figure 8.6). First, as the revenue from subscriptions grows, so does the amount of capital invested in the creation of new features or offers, creating more value to the consumer.

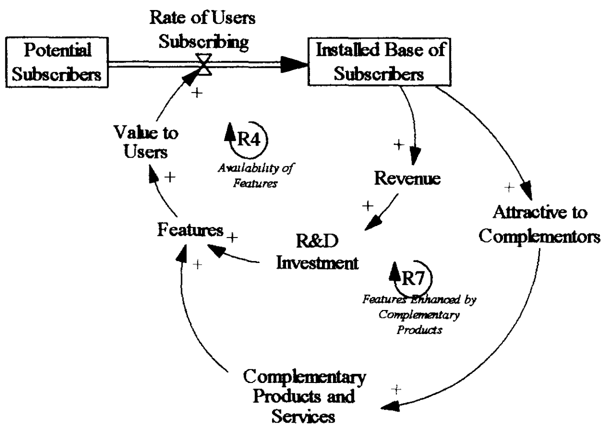

Figure 8.6 Developing New Features or Acquiring Features from Complementors

Second, telematics providers should attract suppliers of complementary products and services that can be provided **through** the telematics system. The dynamics of complementary products are depicted in the **Features Enhanced by Complementary Products loop (R7)**. These complementary goods mostly include customized services and information as those provided by content aggregators or web portals like Yahoo. Adding more complementary products to

TSPs services enrich the value of the set of solutions thus increasing the attractiveness of the offer.

Particularly, this strategy will be even more successful if existing customers' complementary products and services are compatible with the telematics system. This dynamic reinforces the attractiveness of the application and furthermore the probabilities for potential subscribers to adopt TSPs' offers.

An example that illustrates the dynamics of complementary services is the recent collaboration between GM OnStar and Progressive, a provider of car insurance. OnStar and Progressive are developing a system that takes advantage of the telematics GPS locating ability to monitor the movement of the car. By tracking the frequency and usage of the vehicle, Progressive would be able to charge customers an insurance fee based only on vehicle miles consumption (of course, other factors like driving behavior history would be considered).[58] The case of BMW and Google, as described in section 7.5, is another example.

Cost of Subscription (Loop R5). Subscription fee is one of the most critical factors influencing users' adoption of telematics. For example, OnStar's subscription fees vary from $17-$70 approximately. These fees depend on the **type and amount of features** users subscribes to. The lower the cost of the subscription fee, the more attractive the telematics offer is for the potential adopter (see figure 8.7).

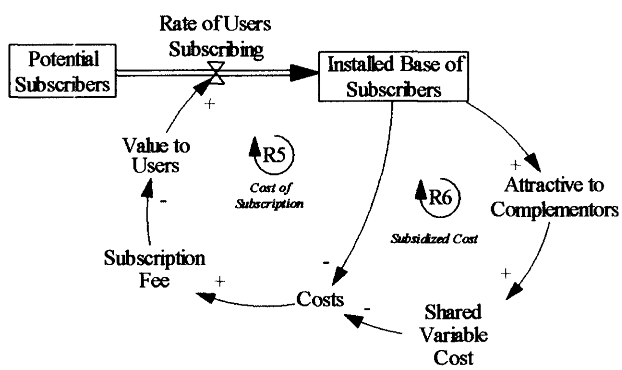

Figure 8.7 Effects of the Cost of Subscription

Evidently, an increase in size of the installed base of subscribers spreads out and reduces the fixed portion (assets utilization) of the cost of subscription.

So, how could TSPs reduce the variable portion of the subscription cost? As previously mentioned, adding complementary products makes TSPs' offers more attractive and furthermore increasing the rate of adoption, so it is also attractive for complementors to enter the TSPs network. There is a trade-off for

[58] Source: OnStar 's representative, Mark Paich, conference as part of 15.871 Systems Dynamics class, MIT. 03/09/04

complementors. The **Subsidized Cost Loop (R6)** intends to depict that variable portions of the cost could be shared with complementors. In order to enter the telematics provider's network, complementors would be required to absorb part of the cost of providing services to subscribers, thus sharing that cost with TSPs and opening an opportunity for, at least, providing more value for the same fee. The ideal situation would be to reduce the cost of the subscription.

There are two more loops that have been included to the conceptual model. They refer to the compatibility or incompatibility of complementary products and services with the telematics system architecture. However, unlike those complementary goods that enhance other telematics features, *these complementary goods that we refer to here are those products and services that users can adapt, install, or interoperate with the telematics system embedded in their vehicles. Those products include cell phones, PDAs, laptops, smart-phones, or any other mobile devices. In the case of services, they may include the existing wireless service contract that users already own.*

Because of the different architecture among telematics systems, complementary products (and services) may or may not be compatible with TSPs' telematics standards. If they are compatible, then the **Availability of Complementary Products (Loop R8)** loop depicts how the reinforcing dynamics increase the attractiveness of the telematics offers.

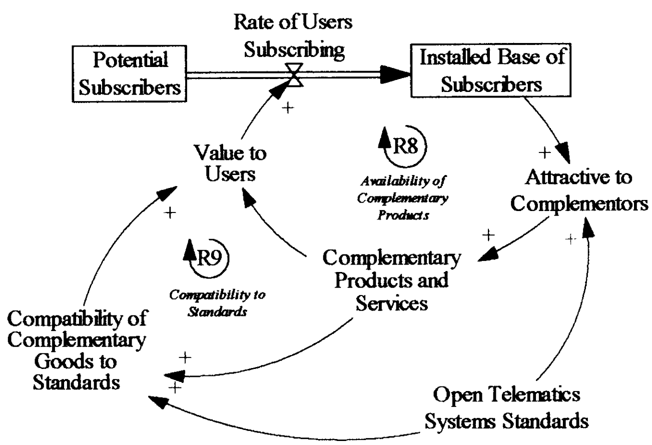

Figure 8.8 Effects of Complementary Goods' Compatibility with Telematics System Standards

If the complementary products are not compatible, then open-standards telematics architecture is attractive to complementors who in turn develop products and services around the telematics standards. This condition is attractive because complementors' fear to invest on complementary assets reduces the fear of being lock-in with one telematics system. The **Compatibility of Standards Loop (R9)** describes the dynamics of this condition.

I suggested that TSPs should be attracting and building relationship with complementors willing to build products and services based on their Telematics Systems standards. If this is possible, and occurs, TPSs' network will be not limited to the installed base of subscriber, but also will be extended to a pool of complementary products and services suitable to their standards. A larger network (and bigger market share) may give TSPs a temporary advantage when the time comes to establish industry standards.

What if the telematics architecture is close or proprietary to telematics providers or vehicle manufacturers? In this case, VMs and TSPs must make a business decision to open the telematics systems while keeping it proprietary to themselves. Licensing strategies are more suitable for these circumstances. These dynamics are depicted and described in loop (R11).

Increase Market Size (Loop R12). As the size of the installed base of subscribers increase, so does the value for users (network externalities). This favorable effect motivates VMs and TSPs to continue factory-installing TCUs in new vehicles, thus increasing the size of the market.

As mentioned above, another strategy to increase the size of the market or the number of potential subscribers would be if TSPs opt for forming alliances (**OEM Alliances Loop R10**) and licensing the technology (**Technology Licensing Loop R11**) to other OEMs.

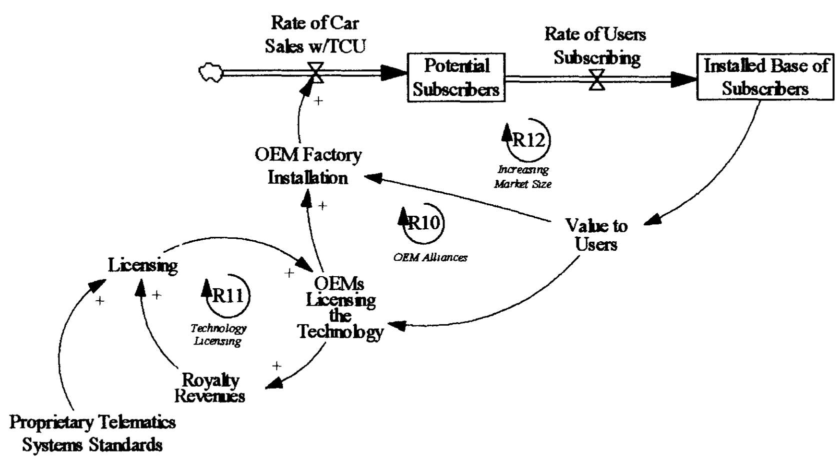

Figure 8.9 Effects of Licensing Proprietary Telematics System

These dynamics are a positive feedback loop, since it gives TSPs the possibility of increasing its network beyond VMs brand boundaries (OnStar and GM have followed this path). This strategy plays an important role in establishing industry standards, since the size of the diversified base of subscribers (from different car brands) provides TSPs' telematics offer an advantageous position in becoming the dominant industry standard.

This model does not consider factors related to changes in technologies that may occur in the future and that may influence the dynamics of the industry. Some of those factors are related to the evolution of wireless, mobile and electronics device technologies embedded in the architecture of the existing Telematics Systems (as we have discussed in previous chapters). However, the conceptual system dynamics model discussed in section 5.2 provides a framework of the dynamics influencing the adoption of newer technologies and the openness of standards.

8.4 Assessing the Determinants of Telematics Value to Users

In order to illustrate how the dynamics of some of the factors described in previous section affect the user's perceived value of telematics, a graphical reference model has been built for the following aspects: availability of complementary products, compatibility of complementary products to telematics standards, the number of features and the cost of subscription fees.

(A) Value to Users rises with availability of complementary products. The relationship is S-shaped. At the low end, there is a minimum level of availability that consumers require, so that low levels of value to users are still so inconvenient that the telematics service is unattractive. Above this threshold, value to users increases at an accelerating rate – with higher availability, uptake is high because the service is more visible and convenient. **Then, the curve levels off as availability increases because at high levels, incremental increases in availability have little impact on attractiveness**. For instance, current availability places OnStar on the higher end of competitors. Increased availability would have a larger impact on attractiveness.

(B) Value to Users rises with compatibility to standards. The relationship is S-shaped, but changes are more gradual compared to availability. At the low end, low levels of compatibility create hassle for the user and make the telematics service less valuable. Above some minimal level, value to users increase at an accelerating rate – with higher availability, uptake is high because more complementary products and services can be used together with the telemetry service. **Value to Users saturate at high levels of compatibility because there is a limit to the number of complementary uses a consumer has for the telematics service.** Current compatibility is low but better than competitors. Improvements would lead to a moderate increase in value to users.

(C) Value to Users rises with the number of features. The relationship is S-shaped and exhibits similar behavior to the compatibility curve. However, changes are more gradual because the adoption and use of features is dictated by compatibility issues. The current number of features is moderately low but is ahead of what competitors offer. An increase in features would lead to a moderate increase in value to users. **The ceiling will be achieved when there will be so many features that users will be unable to handle or be unaware of them.** The shallower gradient of the curve segment where OnStar is positioned suggests that investments in compatibility resolution will produce more significant improvements to attractiveness.

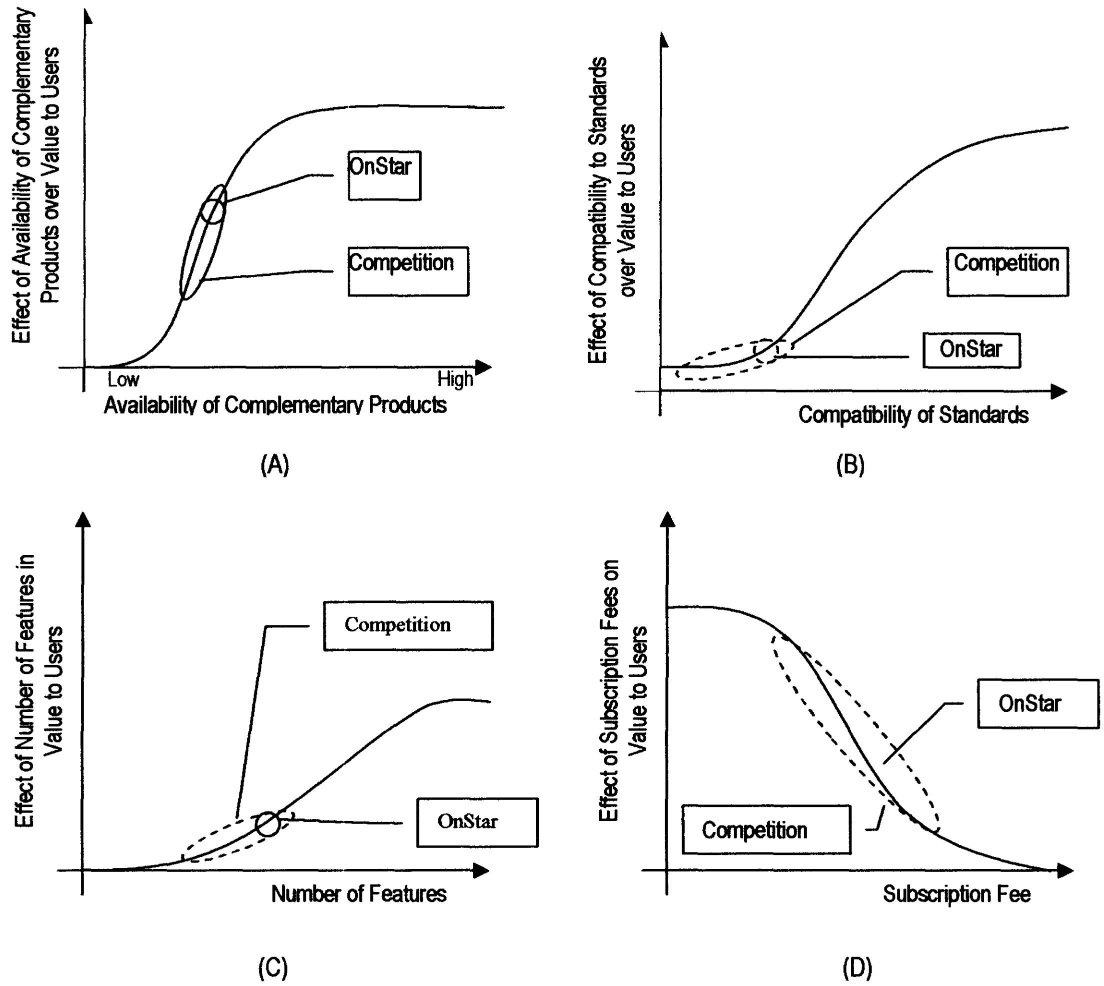

Figure 8.10 Telematics Value to Users Behavior

(D) Value to Users decreases with the subscription fee. The relationship is represented by an inverted S-shaped curve. When fees are lower, value to users is very high because it does not cost the consumer much to adopt the telematics services. As subscription fees increase, value to users decreases at an accelerating and then decelerating rate. **At a certain point when fees do not justify what the service offers, value to users falls to very low levels and finally, to zero.** For example, the current OnStar subscription fee varies from \$17-\$70, which depends on the number and type of features the customer subscribes to. This represents a difficulty to identify where OnStar may be located. Certainly, a decrease in fees would lead to a sizable increase in value to users.

8.5 Conclusive scenarios based on conceptual model

The conceptual model developed in this chapter identifies some adjacent scenarios around the dynamics already illustrated.

Scenario One - Slow vehicle replacement cycle (Installed Base of User's Loop)

Current VMs and TSPs' strategies with respect to telematics equipment is to install from factory the telematics systems (or TCU-Telematics Center Unit, to simplify). As I mentioned in Chapter 3, if the business model strategy is to embed the cost of the TCU in the price of the vehicle, then the user will be paying for a higher vehicle price even if they never use the telematics system. This cost is sunk for the consumer, and it is disadvantageous for VMs.

On the other hand, if the strategy is to recuperate the cost of the TCU in the subscription fee, then the risk is for VMs and TSPs, if the users (or future owners of the vehicle) decide not to subscribe to the service. The cost of the TCU will be sunk for VMs and TSPs. The average life-cycle of the vehicle is 10-13 years and perhaps, by the end of it, embedded telematics electronics will definitely be outdated to outperform existing ones.

As I mentioned in earlier chapters, factory-installing the telematics system as entry strategy may be a risky one in the long-run. This is the strategy that mobile service providers adopted to promote the rapid adoption of wireless communication services, giving away the mobile device. To date, it has been difficult for them to reverse this strategy.

Scenario Two –Customer Acquisition Cost and Timing based on WOM effects (Loop R1)

Word-of-Mouth (WOM) favorably effects attract potential telematics users. Under the circumstance that the new user decided to acquire a telematics-enabled vehicle, since VMs and TSPs' current strategy is to factory-install the telematics system, switching from one vehicle to another implies high cost for consumers. The decision of acquiring a new vehicle depends on consumer vehicle renewal behavior or consumer economics. This decision may be delayed up to 2 to 4 years (this delay effect is illustrated in figure 8.3).

Evidently, if the telematics system was an open architecture that could be installed at any time during the life cycle of the vehicle, a consumer's decision to subscribe to telematics would be based only in the cost of acquiring the telematics equipment and payment for installation cost.

Scenario Three –Customer's Unwillingness to Pay a High Fee (Loop R5) and narrowly defined user demand (Loop R4 and R7)

Even if a market research indicated customer willingness to deploy telematics in their vehicles, it does not mean that they will be willing to pay any price for it. The payment method and user's willingness to pay also influence these dynamics (as depicted in loop R5). **Payment methods** may include *up-front payment, monthly subscription with limited usage* and *monthly subscription with unlimited usage, pay-per-use*, or a combination of any. Consumer behavior and pricing theories suggest that the more frequent the payment is, the higher the probabilities that the consumer will use the service.[59]

Subscribing to telematics depends on a user's **willingness to pay** for specific telematics services. The research presented in this work suggested that customer have valued more telematics services that provides safety and peace of mind, more than those that provide comfort and pleasure or leisure (refer to figures 1.1., 2.3, and 3.3). So if customers valued the most safety related features but more features provides more value to customer, a strategic move would be to offer a combination of both types of features for the price of one. As I suggested in chapter 6, bundling is a viable strategy to pricing telematics services and reducing customer unwillingness to pay for services that are not attractive to them.

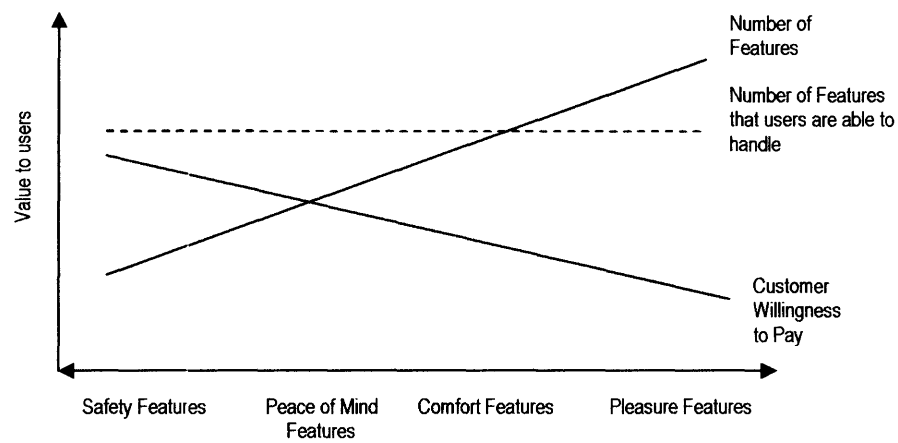

Figure 8.11 Effects of Number of Features and Willingness to Pay on Value to Users

There is a limit to the amount of features that consumers either can handle or realize they are paying for (but not using them). The relationship between the number of features, willingness to pay, and limit of features is depicted in figure 8.11. Telematics providers should find a balance (or sweet spot) between the number of features that can be provided and the number of features that customers will be really willing to pay for. In the long run, having defined user

[59] Gourville, John and Dilip Sonam, " Pricing and the Psychology of Consumption", Harvard Business Review, September 2002, pages 90-96

behavior data, new entrants will arrive to the scene with a "disruptive" innovation that will not saturate the costumer, but perhaps will under perform the existing innovation at a lower price. Christensen (2001) called this phenomenon "The Impact of Sustaining and Disruptive Technological Change."[60]

Scenario Four –Moving from Proprietary to Open Architecture, when?

Chapter five of this paper was devoted to describing a strategy related to standards that VMs and TSPs should consider when the *time comes to open proprietary telematics systems*. So, when will that "time" arrive?

If the relationship among variables chosen to illustrate the dynamics of this industry were correct, the outcome of this model would give some graphical indications of when it would be appropriate to decide opening telematics systems, or not.

Even with the limitations of this process, by analyzing the interaction among variables, several conclusions can lead to anticipate an answer. First of all, the size of the Installed Base of Subscribers (IBS) is the key variable (or stock) to look at in this model. If the size of IBS is not large enough, then costs, WOD effects, Revenue, Value to Users, and the attractiveness to Complementors will be negatively affected (see figure 8.12). This is obvious.

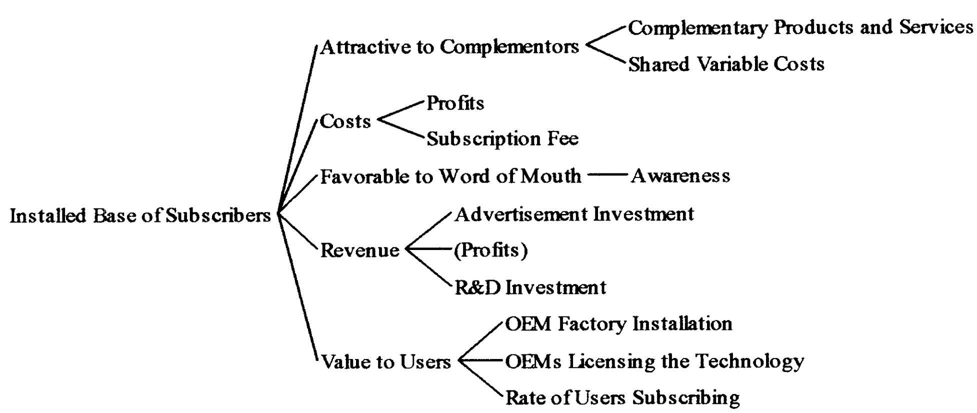

Figure 8.12 Reinforcing Variables Affected by the Size of Installed Base of Subscribers.

So, based on this model, what are the real determinants that ultimately motivate an increase in the Installed Base of Subscribers? Three exogenous[61] variables are identified in the model: Driving Safety Regulations, Proprietary Telematics Systems Standards, and Open Telematics Systems Standards. The

[60] Christensen, Clayton, 2002, "The Innovator's Dilemma", Harper Business Essentials, page XIX.

[61] There are exogenous variables because they are independent from other variables included in the model, but they significantly influence the behavior of the rest of the variables.

ability of VMs and TSPs to influence the former one is limited (this issues was in section 3.2.5). In case of the variables related to standards, VMs and TSPs must make a **business decision** about what position should be adopted, with respect to open or proprietary systems.

Consider the following analysis. As extracted from the model, figure 8.13 shows the three forces influencing the level of telematics attractiveness to complementors. A proprietary telematics system is less attractive for complementors to develop goods around the telematics systems (see figure 8.1). An open architecture has an opposite effect. As we have discussed in this paper, the value that complementors bring to the telematics innovation is critical for the growth of the industry.

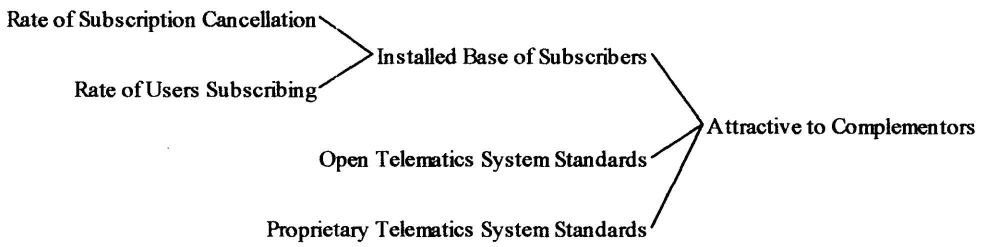

Figure 8.13 Forces influencing Telematics Attractiveness to Complementors

If VMs and TSPs choose to pursue a proprietary system strategy, they will need to continue investing (investment in R&D to create new features) in making telematics attractive for users to subscribe to it (even including licensing agreements). However, the capital will not necessarily come from the revenues generated from subscriptions (this is the case of GM subsidizing OnStar). If VMs and TSPs succeed in building an IBS large enough that its strength as a force to attract complementors is stronger than the force of proprietary standards, then complementors will be motivated to join the network.

A pure open telematics architecture strategy has one important downside; this gives opportunities for suppliers, collaborators, and even complementors to become competitors of telematics providers. If this is the case, then a mixed strategy, as suggested in chapter five of this paper, is more suitable for vehicle manufacturers and telematics services providers to consider.

Chapter 9
Concluding Remarks

During a recent conference in MIT, Motorola's CTO spoke about *seamless communication* as part of the technology strategy driving the future of this giant of the mobile communication and electronics industry. Seamless communication means that people are communicating at home, at work, and in the vehicle - all of the time. For Telematics, which is technology innovation that enables the communication while in the vehicle, the question is not if the innovation will happen. The question is when the technological innovation will reach the critical mass.

Early chapters of this thesis presented an analysis of the current facts and trends defining the state of the art of the telematics industry. Effectively, this industry has not exploded as industry analyst expected five years ago. The market research information permitted to identify the key determinants influencing the adoption and diffusion of this innovation. On the side of consumers, information about the technology, willingness-to-pay for services, and definition of the user interface seemed to be the most relevant. But in case of industry players, the proprietary systems mentality of vehicle manufacturers continues to be the major road block to open systems or establish industry standards.

Aiming to fully understand how the telematics system is integrated, I presented an in-depth analysis of the telematics architecture, underlying technologies and standards. This process was important to confirm that telematics is an innovation that is mostly dependent on technological capabilities that vehicle manufacturers do not own or do not have experience with, yet. To acquire those capabilities some car makers decided to develop their own telematics infrastructure, while others decided to ally with other firms and leverage those complementary assets from them.

Still, critical mass has not been reached. To achieve this goal, I suggested a strategic framework with respect to the decision of opening telematics system standards. I propose that vehicle manufacturers should decouple the telematics architecture and design standard interfaces that allow collaborators and complementors to develop products and services around the telematics innovation. This decoupling strategy would also allow vehicle manufacturers to upgrade the telematics systems with complementary products and services which underlying technologies evolve faster than that of the vehicle. But also, the upgrading ability will permit them to adjust to consumers' changing needs.

The shift from integral to modular (decoupled) system architecture will require vehicle manufacturers and telematics providers to adjust their organizations, since changes in the structure of the industry would be expected. Upstream value chain players will seek opportunities to profit from development, production, and innovation of the decoupled modules of the telematics system.

The interrelationships among upstream players will intensify and create a more complex value network. I presented two scenarios of what I believe the value network would look like in the future based on the evolution of wireless and cellular -based communication, which are key technologies in telematics innovation. Decoupling of the telematics systems, ubiquitous deployment of 3G wireless technologies, or the solidification of WiFi and, in the near future, WiMAX are events that anticipate a disruption on current telematics business models.

Finally, at the end of this dissertation, I presented a conceptual system dynamics model that integrates most of the concepts and ideas presented in this paper. The model built on two variables, awareness of the technology and telematics' value to users, are determinants in influencing consumers' rate of adoption of telematics. Based on the dynamic of the model, I presented some conclusive scenarios of, for instance, how the ability to attract complementors varies depending on how strongly it is influenced by the size of the installed base of subscribers, the proprietary or open state of the telematics systems, or any combination.

Topics for further research

The analysis of the dynamics of the telematics industry that are discussed in this paper left out for discussion many aspects equally important that influence the evolution of the telematics innovation. Following are some issues for further research on the topic:

- It will be interesting to run the conceptual model presented in this paper and to verify the influence of time in the outcome.
- What is the influence of leasing vs. selling in the rate of adoption of telematics?
- Convergence of telematics with wireless communications.

Appendix A
Vehicle Manufacturer's Sales and Top 20 Best Selling Vehicles in the U.S. Market

	2002	2003	% change
General Motors	4.78	4.67	-2
Ford	3.40	3.25	-5
Daimler-Chrysler	2.21	2.13	-4
Toyota	1.76	1.87	+6
Honda	1.25	1.35	+8
Nissan	0.74	0.79	+7
Hyundai	0.25	0.4	+7
Volkswagen	0.34	0.3	-10
BMW	0.26	0.28	+8
Mitsubishi	0.35	0.26	-26
Mazda	0.26	0.26	0
Kia	0.24	0.24	+1
Mercedes-Benz	0.21	0.22	+3
Subaru	0.18	0.18	+3
Volvo	0.11	0.13	+22
Audi	0.09	0.09	+1
Suzuki	0.07	0.06	-14
Saab	0.04	0.05	+27
Jaguar	0.06	0.05	-11
Land Rover	0.04	0.04	-5
Porsche	0.02	0.03	+33
Isuzu	0.05	0.03	-42
Daewoo	0.02	0.0*	-100

Figure A.1 US Vehicle Sales, by manufacturer, 2002 & 2003
In millions and a % change vs. prior year
(Source: Automotive Company Reports, @2004 eMarketer, Inc)

	2002	2003	2002 rank	% change
1. Ford F-Series pickup	813,701	845,586	1	3.9%
2. Chevrolet Silverado pickup	652,646	684,302	2	4.9%
3. Dodge Ram pickup	396,934	449,371	6	13.2%
4. Toyota Camry	434,145	413,296	3	-4.8%
5. Honda Accord	398,980	397,750	5	-0.3%
6. Ford Explorer	433,847	373,118	4	-14%
7. Toyota Corolla/Matrix	254,360	325,477	9	28%
8. Ford Taurus	332,690	300,496	7	-9.7%
9. Honda Civic	313,159	299,672	8	-4.3%
10. Chevrolet Impala	198,918	267,882	19	34.7%
11. Chevrolet TrailBlazer	249,568	261,334	13	4.7%
12. Chevrolet Cavalier	238,225	256,550	12	7.7%
13. Dodge Caravan	244,911	233,394	11	-4.7%
14. Ford Focus	243,199	229,353	10	-5.7%
15. Ford Ranger pickup	226,094	209,117	14	-7.5%
16. Jeep Grand Cherokee	224,233	207,479	15	-7.5%
17. Nissan Altima	201,822	201,240	16	-0.3%
18. Chevrolet Tahoe	209,767	199,065	17	-5.1%
19. GMC Sierra pickup	202,045	196,689	18	-2.7%
20. Ford Expedition	163,454	181,547	-	11.1%

Figure A.2 Top 20 Selling Vehicles in the US, 2002 & 2003
(Source: Automotive Company Reports, @2004 eMarketer, Inc)

Appendix B1
Technology Life Cycle and Dynamic Model of Innovation[62]

The Utterback and Abernathy dynamics model of innovation details the dynamic processes that take place within an industry and within member firms during the evolution of a technology. According to the model, at the onset of an innovation, in the ***fluid phase,*** there is a lot of product and market uncertainty. At this stage the new innovation is considered an emerging technology for which market still does not exist. Manufacturers are not quite sure of what should go into the product. Customers may not know what they want in the product neither. There is a competition between the new and old technologies as well as between different designs using the new technology. Manufacturers interact with their local environment of suppliers, customers, complementary innovators and competitors to resolve both technological and market uncertainties.

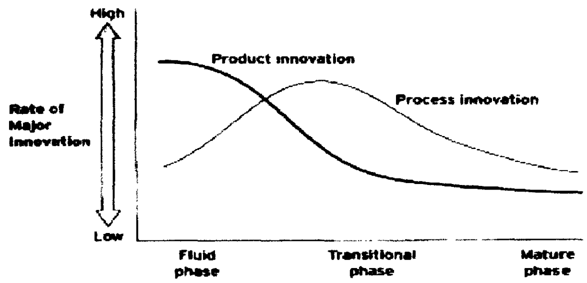

Figure B.1 Dynamics of Technological Innovation

The evolution enters the ***transitional phase*** when standardization of components, market needs and product design emerges, signaling a substantial reduction in uncertainty, experimentation and major design changes. A dominant design is one whose major components and underlying core concepts do not vary substantially from one product model to other, and the design commands a high percentage of the market share. The rate of major products innovations decreases and emphasis shifts to process innovation and incremental innovation. Competition is based largely in differentiated products.

In the ***mature phase*** products built around the dominant design proliferate, and there is more and more emphasis on process innovation with product innovations being largely incremental. Products are highly defined with differences between competitors' product often fewer than similarities.

The pattern described above repeats itself when a new technology with the potential to render the old one non-competitive is introduced, often by a competitor from outside the established industry. This results in a ***discontinuity***, plunging the innovation cycle back to the fluid phase with another wave of entering firms.

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[62] Utterback, James M. 1996, "Mastering the Dynamics Of Innovation", HBS Press, Chapter 4

Appendix B2
Technological Innovation and Industry Forces Dynamics[63]

Force	Fluid Phase	Transitional Phase	Mature or Specific Phase	Discontinuities Phase
Dynamics of the Phase	• Uncertainty in products and markets • High rate of product innovation and high degree of process flexibility • Fast-growing demand; low total volume • Greater importance of product functionality than brand names • Little direct competition	• Appearance of dominant design • Increase clarity about customer needs • Increase process innovation • Importance of complementary assets • Competition based on quality and availability	• Strong pressure on profit margin • More similarities than differences in final products • Convergence in product and process innovations	• Invasion of new technologies • Increasing obsolescence of incumbent's assets • Lowered barriers to entry; new competition • Convergence of some markets as new technologies emerge
Rivalry Among Existing Competitors	• Low since products are highly differentiated and often unique • Maybe increased by campaigns to win dominant design of the transitional phase	• Low but the emergence of a dominant design increases rivalry leading to an industry "shake out"	• High because of the commodity nature of the products • May be reduced by such things are tacit collusions	• Low or high depending on the reaction of incumbents
Threat of New Entrants	• High. Given high market and technological uncertainty, it is difficult to erect barriers to entry • Threats from alternate technologies with comparable price/performance	• Differentiated products assure some level of protection from new entrants but threat increases with the emergence of standard or dominant design • Low if "winners" of dominant design keep technology proprietary (close standards) • High if "winners" of dominant design license technology generously (open standards)	• Low because of measures such as: irreversible investments in capacity, brand name, patents, special licenses or contracts and distribution channels; reputation for retaliating • There may also be a threat for alternate technologies with better price/ performance potentials	• High since new entrants can use the new technology to enter
Bargaining Power of Suppliers	• Low since materials and equipment used are usually of general-purpose	• Higher than in the fluid phase since materials and equipment become more specialized	• High for major suppliers of specialized materials and equipment who are also sources of innovation	• Low since their specialized materials and equipment may be replaced soon by general purpose materials
Bargaining Power of Customers	• High since products are still unique and more users are lead users	• Higher that in the fluid phase since products are not longer unique	• Higher since product is more or less a commodity	• High since discontinuity leads to fluid phase with its unique products
Threat of Substitutes	• High, especially from old products that are still viable substitutes in many applications	• Higher than at the fluid phase a products become more standard	• High specially from invading technologies	• High

[63] Adopted from Allan N. Afuah and James M. Utterback, "Responding to Structural Industry Changes: A Technological Evolution Perspective", in Industrial and Corporate Change, Oxford University Press, 1997, Volume 6 Number 1

Appendix B3
Technological Innovation Dynamics and Resource-Based View Strategies[64]

Force	Fluid Phase	Transitional Phase	Mature or Specific Phase	Discontinuities Phase
Strategies	• Focus on niche products • Build Complementary assets • Invest to try and influence the dominant design of the transitional phase	• Focus on differentiated products • Make irreversible investment in capacity, brand advertising, process and product R&D in preparation for specific phase • Contract with suppliers for equipment or specialized materials that will be needed in the specific phase	• Focus on low cost • Emphasize quality • Signal commitments by advertising, investing in capacity and R&D	• Ensure compatibility with the old technology if technology exhibits network externalities • Take necessary steps to identify lead users
Sample Competences (Resource-Based View)	• Ability to: • Manage projects • Patent • Unlearn old competences and acquire new ones • Make sense out of chaos • Work with suppliers to modify general purpose equipment to unique needs • Decipher customer needs and translate to products • Make sense out of customer feedback • Communicate with complementary innovators to understand how they can provide complementary products	• Ability to: • Design products that meets customer needs • Know where to make irreversible investments • Negotiate contracts with specialized materials and equipment that are needed in the specific phase • Synthesize emerging customer needs • Develop installed base, distribution and service networks • Build network of complementary innovators	• Ability to: • Design for manufacturability • Reduce cycle times • Effect process in and incremental innovation expertise • Integrate innovations from suppliers to own processes • Sell • Create new distribution channels • Co-ordinate innovations with complementary innovators	
Strategies (Resource-Based View)	• Focus on key customers, especially lead users, and their needs • Build technical competences, project management skills and endowments such as patents	• Focus on skills for product differentiation • Focus more attention on marketing than in the fluid phase • In preparation for specific phase, advertise to establish brand recognition	• Focus on competencies that assure low cost and profitability from it • Boost process innovation and incremental product innovation skills • Scan and prepare for invading technologies	

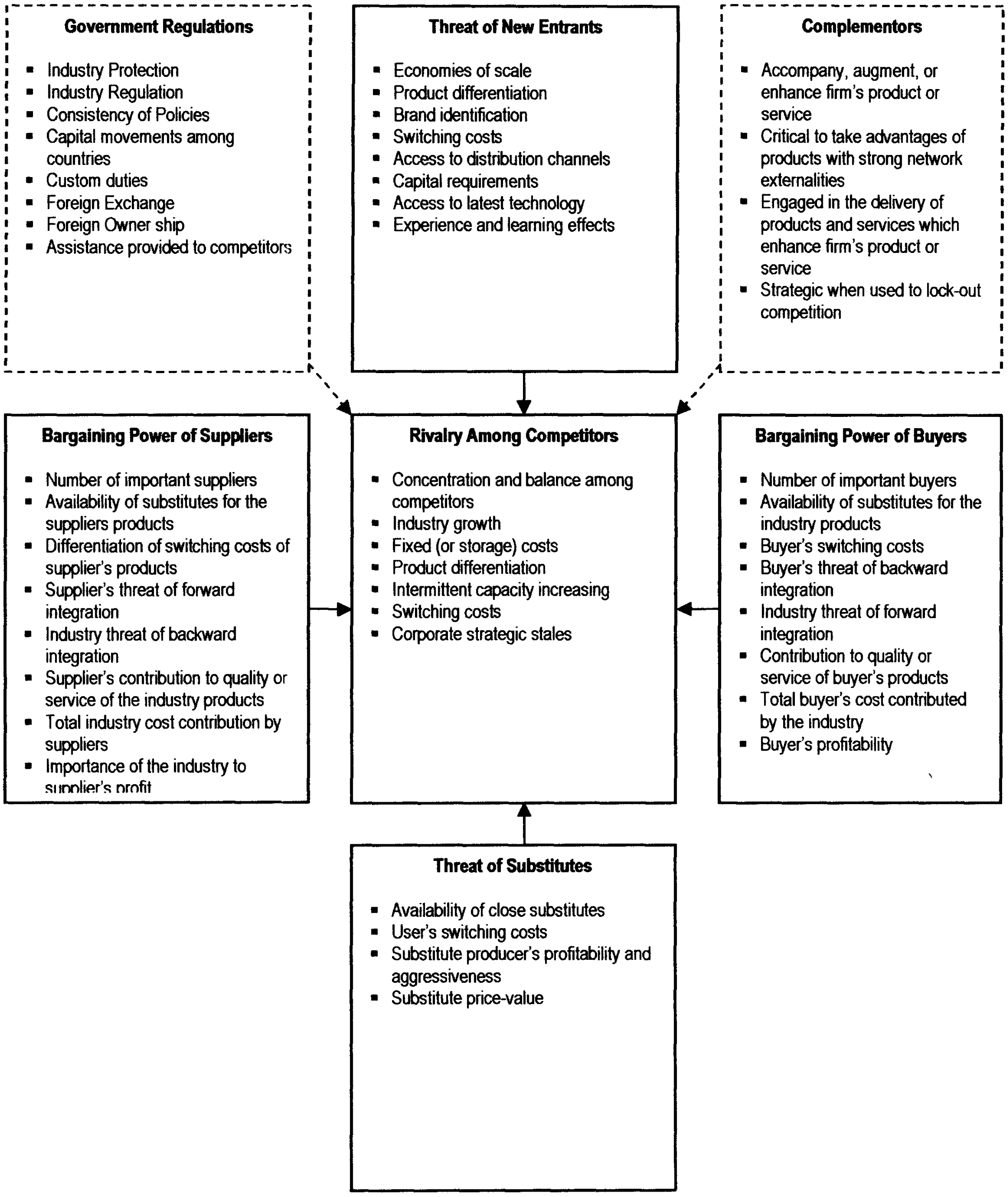
64 Adopted from Allan N. Afuah and James M. Utterback, "Responding to Structural Industry Changes: A Technological Evolution Perspective", in Industrial and Corporate Change, Oxford University Press, 1997, Volume 6 Number 1

Appendix B4
Technological Innovation Dynamics and Strategies for Collaboration at each Phase[65]

Force	Fluid Phase	Transitional Phase	Mature or Specific Phase	Discontinuities Phase
Priorities	• Development and preservation of technology (with focus on product development and aggressive patenting) • Promotion of proprietary technology as industry standard	• Realignment of technological capabilities with the dominant design • Continued exploration of technological opportunities • Pursuit of a growth strategy (through aggressive capacity building or by establishing a close relationship with suppliers and customers	• Cost control throughout the value chain • Strong customer focus • Lean and efficient organization	• A need for incumbents to identify new technologies and realign core competencies • An option for incumbents to exit the market • Attackers' need to gain market recognition • Attackers' need to focus on product development
Strategic Alliances	• Formation of alliances to promote technology as the industry standard • Adoption of licensing strategies (say, open source licensing or aggressive licensing to users) • Formation of marketing alliances (with key players of the supply chain or with one industry leader) • Formation of technology alliances with established companies, often coupled with equity investments	• Winners' aggressive licensing to customers and to companies that lost the dominant –battle • Formation of joint R&D ventures with companies in the market • Formation of marketing alliances; signing of supply agreements to guarantee consistent quality, price, availability	• Formation of joint R&D ventures to share risks and cost of technology development • Formation of marketing alliances to attack latent markets or lure customers away from competitors • Manufacturing alliances to ensure availability of essential products • Open alliances with suppliers and customers	• Attackers' formation of marketing alliances to gain market recognition • Attacker agreements to supply technology leaders • Incumbents' acquisitions of the disruptive technology through license agreements
Mergers and Acquisitions	• Acquisitions of start-ups by well-established technology companies from more mature high-tech industry • Corporate equity investment by well-established high-tech companies	• Acquisitions of competitors by the winners of the dominant-technology battle • Acquisitions by established technology companies entering the market	• Horizontal mergers between companies with complementary products and services • Divestiture of manufacturing capabilities that are not essential • Acquisitions of technology start-ups making products that would be difficult to develop in-house	• Possible equity financing for attackers form established technology companies • Established companies' move into new markets through acquisitions of niche technology companies • Established companies' acquisition of enterprises that have related product capabilities • Divestiture of companies as priorities shift with market convergence

65 Adopted from Edward B. Roberts and wenyun Kathy Liu, "Ally or Acquire? How Technology Leaders Decide", MIT Sloan Management Review, Fall 2001

Appendix C1
Forces Competitive the State of the Industry[66]



[66] Source: Adapted from Michael E. Porter, Competitive Advantage, New York; Free Press, 1985

Appendix C2
The Cycles in Industry Structure

Industry Structure

Industry Structure	Vertical	Horizontal
Vertical	<u>Totally Vertical</u> ▪ Competitive advantage comes from economies of scale in manufacturing components. ▪ Control over delivery, quality, and rates of technical change ▪ Reduced vulnerability to holdup by suppliers; quicker information flow ▪ Limited direct competition and competitive threats does not exist ▪ Trade-off exist; the vertical natures of the market reduces the competition for complementary products and drives slower adoption	<u>Transition from Vertical to Horizontal</u> ▪ Increases competitiveness of the market ▪ Niche competitors provide incentives for firms to give up pieces of production, which increases entry and supplier power. ▪ Higher dimensional complexity limits the economy of scale, increases potential vulnerability to holdup ▪ Organizational rigidities decreases the transparency of information ▪ All this increases the pressure to dis-integrate and increases both competition and adoption
Horizontal	<u>Transition from Vertical to Horizontal</u> ▪ As adoptions slows, firms identify technical advantages is one subsystem and gain competitive advantage over their many competitors ▪ This market power encourages bundling with other subsystems (modules) to increase control and add more value. ▪ Further increases in market power in one subsystem encourage engineering integration with other subsystems to develop proprietary integration solutions. ▪ Competition begins to decrease as suppliers are squeezed out of the market and larger firms regain vertical control	<u>Totally Horizontal</u> ▪ Industry is highly competitive ▪ Competitors enter the market freely driving down profits and competing cost. ▪ Firms seek to use their small-differentiated advantage to push other competitors out of the market ▪ As prices drop though price wars adoption accelerates and the market continues to expand from new entrants

Appendix D1
3G Cellular Services

W-CDMA, CDMA2000 and EDGE are collectively known as IMT-2000 International Mobile Telecommunications for the year 2000. IMT-2000 is an ITU initiative.

Service	Others Designations for the Service	Comments
W-CDMA Wideband Code Division Multiple Access	Also know as Universal Mobile Telecommunications Systems (UMTS).	Ericsson and Nokia supports this 3G technology for higher speed data. Most GSM networks have stated they will evolve their networks to W-CDMA
CDMA2000	An updgrade from CDMA IS-95A and IS-95B service	Qualcomm supports this 3G technology.

The following are three different CDMA2000 3G platforms

CDMA2000 1X	First Generation candidate Radio Transmission Technologies (1x RTT) or First Generation Multicarrier (1xMC)	First '"generation" of CDMA2000 service that doubles voice capacity and increases data speeds.
CDMA2000 1xEV-DO	1xED-DO (first generation evolution data only). HDR high data rate.	Higher data speeds but no increase in capacity for voice traffic.

Appendix D2
Transitional 2.5G and 3G Cellular Services

Carriers with GSM and TDMA networks implement these technologies before installing more costly W-CDMA networks

Service	Other Designation for the Service	Comments
GPRS General Packet Radio Services.	None	This a 2.5G platform for sending packet data in spare voice channels of cellular networks.
EDGE Enhanced Data Rates for GSM evolution.	UWC-136 Universal Wireless Communications	More suitable for American TDMA networks because it uses spectrum for data in smaller chunks that GPRS. Depending on implementation, either 2.5G or 3G.

Appendix E1
A Technical Comparison Between WiFi and WiMAX

WiFi (IEEE 802.11)

- Wi-Fi networks use radio technologies called IEEE 802.11b or 802.11a to provide secure, reliable, fast wireless connectivity
- A Wi-Fi network can be used to connect computers to each other, to the Internet, and to wired networks (which use IEEE 802.3 or Ethernet)
- Range - Less than 300 ft. (add access points for greater coverage)
- Coverage is optimized for indoor performance, short range
- Scalability is intended for LAN (Local Access Network) application, users scale form one to tens with one subscriber for each CPE device. Fixed channel sizes (20 MHz)
- Bit Rate – 2.7 bps/Hz peakUp to 54 Mbps in 20 MHz channel
- No QoS (Quality of Service) support
- Wi-Fi networks operate in the unlicensed 2.4 and 5 GHz radio bands, with an 11 Mbps (802.11b) or 54 Mbps (802.11a) data rate or with products that contain both bands (dual band), so they can provide real-world performance similar to the basic 10BaseT wired Ethernet networks used in many offices.

WiMax (IEEE 802.16)

- IEEE 802.16 represents a global standard for a wireless broadband access. Similar to Cable, DSL and Ex-level services
- Range is up to 30 miles. Typical cell size of 4-6 miles
- Designed from the ground up for outdoor, long range, carrier class applications.
- High throughput, non line of sight propagation, scalability for up to 1000's of users, QoS
- Flexible channels sizes from 1.5 MHz to 20 MHz. Supports both licensed and license-exempt spectrum. 802.16 can use all available frequencies, multiple channels support cellular deployment.
- Applicable in many markets – from dense urban environments to rural areas. Where there is no existing or poor wired infrastructure
- IEEE 802.16e extension enables nomadic capabilities for laptops. Broadband connectivity beyond hot spots
- Bit Rate- 5 bps/Hz peakUp to 100 Mbps in a 20 MHz channel.
- 802.16 is a dynamics TDMA-based MAC with on-demand bandwidth allocation.

WiFi vs WiMAX

Scalability

At the PHY layer the standard supports flexible RF channel bandwidths and reuse of these channels (frequency reuse) as a way to increase cell capacity as the network grows. The standard also specifies support for automatic transmit power control and channel quality measurements as additional PHY layer tools to support cell planning/deployment and efficient spectrum use. Operators can re-allocate spectrum through sectorization and cell splitting as the number of subscribers grows. Also, support for multiple channel bandwidths enables equipment makers to provide a means to address the unique government spectrum use and allocation regulations faced by operators in diverse international markets. The IEEE 802.16a standard specifies channel sizes ranging form 1.75MHz up to 20MHz with many options in between.

WiFi based products on the other hand require at least 20MHz for each channel (22MHz in the 2.4GHz band for 802.11b), and have specified only the license exempt bands 2.4GHz ISM, 5GHz ISM and 5GHz UNII for operation. In the MAC layer, the CSMA/CA foundation of 802.11, basically a wireless Ethernet protocol, scales about as well as does Ethernet. That is to say - poorly. Just as in an Ethernet LAN, more users results in a geometric reduction of throughput, so does the CSMA/CA MAC for WLANs. In contrast the MAC layer in the 802.16 standard has been designed to scale from one up to 100's of users within one RF channel, a feat the 802.11 MAC was never designed for and is incapable of supporting.

Coverage

The BWA standard is designed for optimal performance in all types of propagation environments, including LOS, near LOS and NLOS environments, and delivers reliable robust performance even in cases where extreme link pathologies have been introduced. The robust OFDM waveform supports high spectral efficiency (bits per second per Hertz) over ranges from 2 to 40 kilometers with up to 70 Mbps in a single RF channel. Advanced topologies (mesh networks) and antenna techniques (beam-forming, STC, antenna diversity) can be employed to improve coverage even further. These advanced techniques can also be used to increase spectral efficiency, capacity, reuse, and average and peak throughput per RF channel. In addition, not all OFDM is the same. The OFDM designed for BWA has in it the ability to support longer range transmissions and the multi-path or reflections encountered.

In contrast, WLANs and 802.11 systems have at their core either a basic CDMA approach or use OFDM with a much different design, and have as a requirement low power consumption limiting the range. OFDM in the WLAN was created with the vision of the systems covering tens and maybe a few hundreds of meters versus 802.16 which is designed for higher power and an OFDM approach that supports deployments in the tens of kilometers.

Quality of Service (QoS)

The 802.16a MAC relies on a Grant/Request protocol for access to the medium and it supports differentiated service levels (e.g., dedicated T1/E1 for business and best effort for residential). The protocol employs TDM data streams on the DL (downlink) and TDMA on the UL (uplink), with the hooks for a centralized scheduler to support delay-sensitive services like voice and video. By assuring collision-free data access to the channel, the 16a MAC improves total system throughput and bandwidth efficiency, in comparison with contention-based access techniques like the CSMA-CA protocol used in WLANs. The 16a MAC also assures bounded delay on the data (CSMA-CA by contrast, offers no guarantees on delay).The TDM/TDMA access technique also ensures easier support for multicast and broadcast services.

With a CSMA/CA approach at its core, WLANs in their current implementation will never be able to deliver the QoS of a BWA, 802.16 system.

Appendix E2
A technical comparison between USB, Bluetooth, and ZigBee

USB (Universal Serial Bus)
It is a high-speed bidirectional serial connection between a PC and a peripheral that transmits data at the rate of 12 Mbps. The new USB 2.0 specification provides a data rate of up to 480 Mbps. 1394, FireWire and iLink all provide a bandwidth of up to 400 Mbps.

Bluetooth™ Bluetooth™ (IEEE 802.15.1)

- The Bluetooth Specification defines a short range (around 10 meters) or optionally a medium range (around 100 meters) radio link capable of voice or data transmission to a maximum capacity of 723.2Kbps per channel.
- The asynchronous data channel can support maximal 723.2 Kbps asymmetric (and still up to 57.6 Kbps in the return direction), or 433.9 kbps symmetric.
- Radio frequency operation is in the unlicensed industrial, scientific and medical (ISM) band at 2.40 to 2.48 GHz, using a spread spectrum, frequency hopping, full-duplex signal at a nominal rate of 1600 hops/sec.
- The signal hops among 79 frequencies at 1 MHz intervals to give a high degree of interference immunity. RF output is specified as 0 dBm (1 mW) in the 10m-range version and -30 to +20 dBm (100 mW) in the longer range version.
- When producing the radio specification, high emphasis was put on specifying a design that enables low cost, minimum power consumption and a small chip size required for implementation in mobile devices.
- Up to three simultaneous synchronous voice channels are used, or a channel which simultaneously supports asynchronous data and synchronous voice. Each voice channel supports a 64 kbps synchronous (voice) channel in each direction.

ZigBee™ (802.15.4)

- Data rates of 250 kbps and 20 kbps. Star topology, peer to peer possible.
- It support up to 255 devices per network. CSMA-CA channel access.
- It is fully handshaked protocol for transfer reliability.
- It ensures low power (battery life multi-month to nearly infinite).
- It manages a dual PHY (2.4GHz and 868/915 MHz) at a extremely low duty-cycle (<0.1%).
- Range is 10 meters nominal (1-100m based on settings).

Appendix F
SAE Protocol Classifications

SAE has defined three distinct protocol Classifications: Class A, Class B, and Class C. **Class A** is the first SAE classification and maintains the lowest data rate, a rate that peaks as high as 10Kbps. Class A devices typically support convenience operations like actuators and "smart" sensors. The implementation of Class A has significantly reduced the bulk of automotive wiring harnesses. At the time of this printing, the concerned implementor could assume an approximate cost of $4.00 per node.

The second SAE classification is the **Class B** protocol. Class B supports data rates as high as 100Kbps and typically supports intermodule, non-real time control and communications. The utilization of Class B can eliminate redundant sensors and other system elements by providing a means to transfer data (e.g. parametric data values) between nodes. At the time of this printing, one could expect Class B nodes to cost about $5.00 per node. The **SAE J1850 Standard is a Class B protocol**. Current industry developers are realistically working to drive J1850 implementation costs to as low as $2.00 per node by the end of this decade.

Class C is the last of these three classifications. Performance, as high as 1Mbps, is readily supported under the guise of Class C. Because of this level of performance Class C is typically used for critical, real-time control. Class C facilitates distributed control via high data rate signals typically associated with real-time control systems. Typical expectations of Class C utilization at the time of this printing should run in the $10.00 per node range. However, the upper end to Class C utilization invites expensive media, like fiber optics, that can push node costs much higher than estimated. The most predominant in-vehicle networking standard for Class C is **CAN (Controller Area Network)**. Higher performance communication classifications from 1Mbps to 10Mbps are expected in the future. Classifications like **Class D** can be expected as bandwidth and performance needs push forward.

Appendix G
How On-Star works?[67]

OnStar employs a three-button system (white, blue and red) mounted either on the rear-view mirror or on the dashboard. Interactive hands-free communications takes place via a built-in cellular phone and the radio's speakers. The **white-dot** button is used for voice-activated cellular phone communications or connecting with the Virtual Advisor. The **blue button** connects the driver with a Call Center Advisor for help with a variety of services (figure 1 shows the OnStar screen, a PC and a Car). The **red button** is used for emergencies. A driver's personal identification number (PIN) or a code number is used to initiate some security services such as door unlocks and stolen-vehicle location request.

Within the vehicle a communications processor is located and tied to a bus, the car's radio, a remote GPS antenna, and a microphone located above the rear-view mirror, along with a cellular antenna that's mounted on the rear window (figure G.1). It is believed that OnStar uses a CAN (Controller-Area-Network) bus to monitor engine's performance and emission controls as required by EPA OBD II.

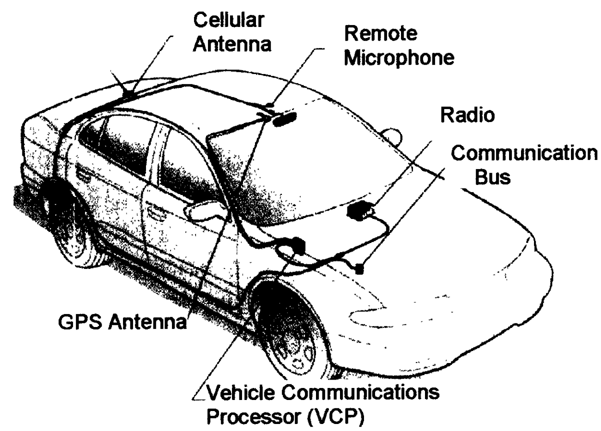


Figure G.1 OnStar Telematics System

During early OnStar generations, analog cellular-telephone communications were implemented instead of digital for maximum geographic coverage at an affordable end-user price. Most recently OnStar has partnered with Nextel to provide digital coverage in some US regions. Nextel deploys iDEN digital technology standards. It is estimated a call rate of $0.10 per minute.

The system transmits at a mobile frequency of 824 to 855 MHz. The base transmitter operates from 824 to 900 MHz. This produces 3W of output power using an antenna (which is much more than the typical 0.6W output used in

[67] Source: Allan, Roger, "OnStar System Puts Telematics in the Map", www.elecdesign.com 03.31.03 Electronics Design

handheld cellular phones). That ensures that coverage is available in just about any geographic location a vehicle could conceivable be in.

Once contacted, the Call Center has the vehicle's location, vehicle-identification number, make, model year, and color and is ready to assist. Airbags on the vehicle come with sensors. Once the bags are activated, the sensors trigger a call to automatically notify the Call Center of a collision, which prompts the center to contact the vehicle, before contacting or emergency personnel, if necessary.

Crash Notification System. OnStar has introduced an advanced automatic crash notification (AACN) system on approximately 400,000 of its most popular 2004 vehicles, making it the first automaker to do so (figure G.2). The new system goes beyond the CAN system already in place on the airbags. By using a collection of strategically located sensors, AACN, through the OnStar system, automatically calls for help if the vehicle is involved in a moderate to severe front-, rear-, or side-impact, regardless of airbag deployment. It provides crash-severity information to the Call Center operator, who relays it to 911 dispatchers, helping dispatchers determine the type of emergency service required and hoe fast it's necessary.

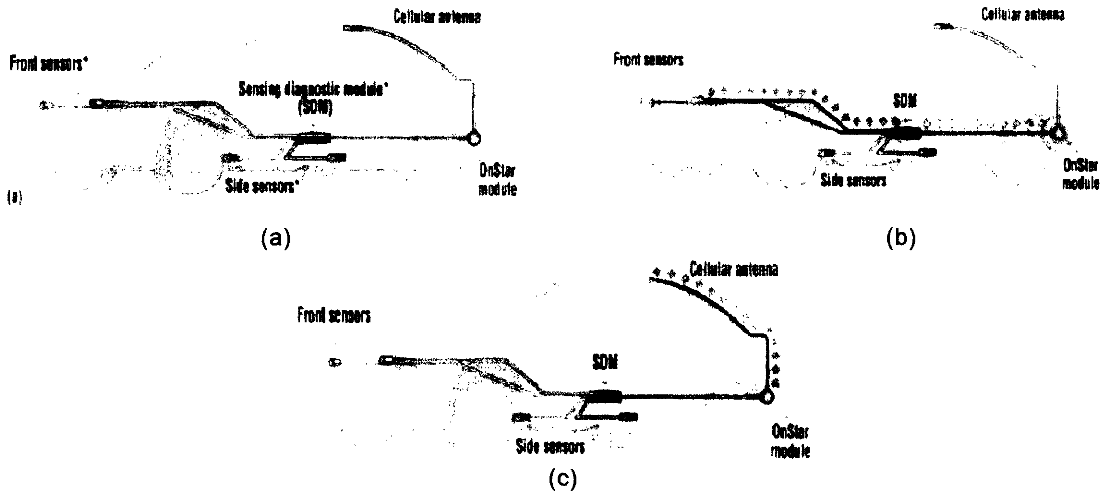


Figure G.2 How OnStar Advanced Automatic Crash Notification system works.

In OnStar's advanced automatic crash-notification (AACN) systems, front and side sensors along with the sensing capabilities of a sensing diagnostic module (SDM) plus accelerometer measure crash severity (a). For moderate to severe crashes, determined by the SDM, crash data is transmitted from the sensors to the SDM regardless of airbag deployment (b). Within seconds, the SDM transmits crash information to the OnStar Call Center, which is then forwarded to 911 dispatchers for emergency help (c).

Appendix H
About Complementors

A complementor is a firm engaged in the delivery of our products and services which enhance our product and service portfolio. The key strategy is to identify, attract, and nurture the complementors. They are typically external, but may also be internal to the corporation, particularly in large and diversified organizations. These complementors are rarely detected and exploited effectively.[68]

Complementary product and services in the telematics industry can be found in application providers, application developers, content providers, and content developers. These entities are considered complementors because their current set of products and services fit and *complement* the existing telematics offer making it richer and attractive for the consumer. If they do not *fit,* they develop product and services to be compatible to the Telematics Systems architecture.

Telematics players should attract, satisfy, and retain customers by attracting, satisfying, and retaining complementors.

The value of complementor in the Extended Enterprise

Thought the technology and industry evolution life cycle, the extended enterprise eventually may also recognize our competitors as our complementors. For instance, at early stages of technology evolution the firm owning the technology innovation may establish alliances or licensing agreements with its competitors to promote the diffusion of the new technology and growth of the industry. In this case, competitors become *your* channel to diffuse *your* technology innovation and thus reaching the end-user.

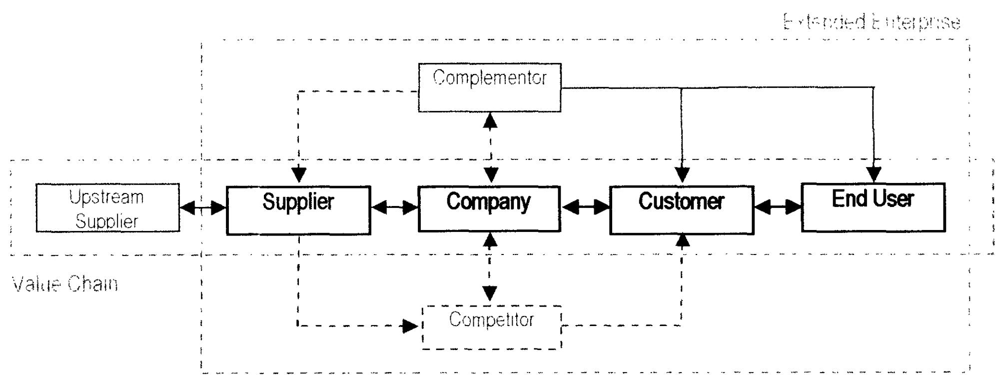


Figure H1 The Extended Enterprise

[68] Hax, Arnoldo C. and Dean L. Wilde II, 2001, "The Delta Project", Palgrave Press,

So how could we differentiate when your competitor is a complementor or not? In the book their "Co-opetition" Adam M. Brandenburger and Barry J. Nalebuff presented a useful framework to differentiate competitors form complementors [69]

A player is a... if...	Demand Side	Supply Side
Complementor	...customers **value your product more** when they have the other player's product than when they have your product alone.	... it's **more attractive** for a supplier to provide resources to you when it's also supplying the other player than when it's supplying you alone
Competitor	...customers **value your product less** when they have the other player's product than when they have your product alone	... it's **less attractive** for a supplier to provide resources to you when it's also supplying the other player than when it's supplying you alone

Figure H2 How to Differentiate a Complementors?

Content Providers as Complementors

Many of the companies that are vying for attention in the internet are trying to wheedle their way into car as well. Some of these firms like Yahoo, AOL, MSN, newspaper and financial services, weather and traffic information, etc., are companies that have mastered the real-time, customizable information feed to the home PC are looking to do the same for the car. And in addition to the stock quotes and headlines, real-time traffic reports can be fed directly into the navigation systems that automatically re-route around bottlenecks.

Taking the technology a little bit further, modeling software is being developed to predict traffic jams based on information from roadside sensors and change routes to avoid delays before they materialize. Of course, that requires a new layer of infrastructure, something cash-strapped cities and states may not ant to pay for.

[69] The concept of complementors has been introduced by Adam M. Brandenburger and Barry J. Nalebuff, 1996, "Co-opetition", New York, Doubleday Press