SARANTEL

Antenna Choice Impacts Utility of Vehicle Navigation Systems

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Introduction

Vehicle navigation systems are in a period of tremendous growth globally, accounting for approximately €2 billion in 2004. The old impossible-to-fold paper maps are rapidly becoming relegated to the dustiest corners of the local library, as a plethora of solutions ranging from factory-installed built-in systems to portable "pay-as-you-go" mobile handset-based systems have hit the market. A number of factors are driving the navigation market. The cost of systems has dropped significantly. The utility of systems and accuracy of navigation software and maps has improved. The choices available to consumers in selecting a navigation system appropriate to their needs has increased. Regulatory initiatives like the EU eCall proposal have spurred interest in the safety benefits of such systems. And finally, the technology behind the systems has advanced to a level that consumers need not be "techno-savvy" to use them. A key component of that technology is the antenna choice available to the manufacturer, maximising the utility of the system while minimising the impact on aesthetics.

Navigation Systems Background

Vehicle navigation systems can roughly be divided into four categories: 1) Factory built-in systems; 2) After-market, dash-mounted systems; 3) Portable personal navigation devices (PNDs) and PDAs with GPS attachments; and 4) GPS-enabled mobile phones. Each has its own business model with implications on technology choices, particularly with respect to the antenna, that are worthy of consideration.

Factory built-in systems account for the majority of vehicle navigation systems deployed. From a business perspective, built-ins are an attractive, high margin feature. Such systems command €1,000 to €2,000. While they offer large screens, virtually unlimited power for fast processors and excellent graphical displays, they suffer from one reality of the automobile industry: time to market. The typical design cycle for an automobile is up to 36 months with perhaps 12 to 24 months for electronics approval, whereas the typical design cycle in the electronics industry is 6 to 12 months. Therefore, by the time a built-in system reaches the market, the electronics in the system are already 12 months old and in many cases surpassed by less expensive solutions available in after-market or portable devices. Built-ins primarily choose large antenna solutions, which provides an arguably unsightly bubble appendage on the roof or boot of the car and that requires metres of cable and additional electronics to mate the antenna with the receiver.

After-market solutions attack the built-in market with lower cost. These systems are attached to the dash or centre console of the car, with cabling to an external antenna that must be mounted as inconspicuously as possible. Usually too small to accommodate the large storage media of built-in systems, after-market products use solid-state memory, e.g., SD or CF cards, to store maps and will thus have smaller storage capacity. However, these systems typically sell for one third less than built-in systems. Further, they do not suffer the time lag that built-in systems must endure between product introduction and consumer availability. After-market systems can prove inconvenient to customers with lease covenants restricting modifications to the vehicle, and cabling to the antenna invariably results in holes drilled somewhere in the car.

Personal navigators in the form of general purpose PDAs have provided another entry point for after-market navigation. These devices sell for around €500 and offer portability to the consumer, i.e., the device is not tied to a specific vehicle and can offer general purpose GPS applications for hiking, fishing, etc. A sub-class of GPS-Bluetooth receivers has also arisen in recent years, allowing Bluetooth-enabled PDAs or mobile phones to act as the display and map storage for the navigation device, adding as little as €200 to the cost. Like after-market dash-mounted products, these devices have storage limited by the memory capacity of the PDA or plug-in cards, but have navigation software capability driven by a rapid turn development cycle. Antennas are usually built into these products with provision for an external antenna that can be suctioned to a window, placed on the dash, or magnetically mounted to the roof of the car if the user wants to deal with draping cables.

A new entry to the navigation market is the A-GPS equipped mobile phone. Several North American mobile operators, including Verizon and Sprint-Nextel, offer navigation services on a pay-per-use basis, reducing the cost of navigation to one or two euro per navigation request. Such an approach will have appeal to a segment of the market that needs navigation or traffic information sporadically, but is not willing to spend a great deal for navigation-specific hardware and software. A-GPS is a variant of autonomous GPS in which the network "assists" the GPS receiver to get a position fix by doing a portion of the work at a central point in the mobile network and downloading the assistance data to the mobile phone via a data channel. Over 100 million A-GPS equipped mobile phones have been shipped in the past decade, primarily in phones with the CDMA standard used in North America and Asia, but rapidly growing to include GSM-based mobiles.

Antenna Choices

As might be expected, the technological challenge of providing a satisfactory consumer navigation experience becomes greater as the size and cost of the system decreases, and this challenge is reflected nowhere better than the choice of antenna technology. For years, the antenna of choice for mobile navigation solutions has been the patch-style antenna, a planar structure consisting of a roughly square ceramic slab with metal plating on both sides and a feed pin going through the ceramic substrate. The patch is a single-ended antenna structure, which means that the bottom of the antenna couples with a larger metallic plane connected to earth. By the physics of the structure, this ground plane should be of infinite size; in practical terms, it must be double the area of the antenna itself for the antenna to form the proper reception characteristics. The smaller the ground plane, the less effective the antenna is at receiving GPS signals, particularly those coming from satellites that are lower on the horizon.

From a performance perspective, this doesn't prove to be too difficult a problem for externally mounted automotive patch antennas. These antennas have a very large ground plane with which to couple in the form of the roof or boot of the car, which conveniently also has the least obstructed view of the sky. However, as mentioned previously, the antenna must be cabled to the receiver by as much as several metres of cable and can be considered unsightly by some consumers. This cabling can add several euro of cost in the form of materials, installation, and electronics to amplify the GPS signal to compensate for losses accumulated between the antenna and receiver. Further, advancements in receiver and antenna technology may make the external GPS antenna obsolete.

One such advancement in antenna technology is the dielectrically-loaded quadrifilar helix antenna. A quadrifilar helix is a structure composed of two loop antennas, 90° opposed in phase, that creates a much more ideal reception pattern for GPS signals without the need for a ground plane – in fact, it is one style of antenna used to create the GPS signal on the satellites themselves. This property is called circular polarisation, describing the spinning nature of the signal. Dielectric loading refers to using a microwave ceramic material similar to that used in patch antennas to shrink the size of the antenna from a cylinder several centimetres long by a few across to one about the size of a thimble. This style of antenna can be less efficient than a typical patch antenna when measured in free space, but is far better at receiving GPS signals in an obscured environment, such as inside the boot of a car. The reasons for this are twofold. First, the antenna has better circular polarisation, making it effectively omni-directional – all things equal, a good circularly polarised antenna will be twice as efficient as one that isn't, e.g., a patch antenna with a small ground plane. Second, ground planes are excellent conductors of electronic noise, which the antenna will channel into the receiver if the noise falls within the GPS band. Because the quadrifilar antenna does not use a ground plane, it rejects this sort of noise, providing a clearer, more reliable signal to the receiver.

Another significant property of the dielectrically-loaded quadrifilar helix antenna is that it doesn't yield efficiency when it's near other conductive bodies. Antennas store energy in the space surrounding them, called the "near field." When conductive objects, such as cable harnesses, seat materials, or people, come in contact with the near field, that stored energy is given up to the better conductor, lowering the antenna's efficiency. Therefore, patch antennas, which do yield efficiency to other bodies, make a poor antenna choice when the object is to conceal the antenna in a car or embed the antenna in a device like an A-GPS mobile phone. Dielectrically-loaded quadrifilar helix antennas can be installed in the glove box, under the dash, under seats, in the boot, etc. – effectively anywhere a GPS signal can be heard – without fear of the antenna detuning due to nearby objects.

Given these properties, the dielectrically-loaded quadrifilar antenna makes an excellent choice for portable navigation devices because it can be embedded without losing efficiency, and will deliver the maximum amount of signal to the receiver when the device is inside the vehicle. For built-in or after-market dash-mounted systems, the dielectrically-loaded quadrifilar may still be an excellent choice. With the antenna close to the receiver, often times a passive (unamplified) antenna may be used. Several euro in installation and cabling costs are saved. The aesthetics of the system are improved by concealing the antenna inside the vehicle, while still delivering an excellent navigation service to the user.

Conclusion

Vehicle navigation systems are here to stay, with more and better choices being given to consumers each year on how the navigation service is to be delivered. Convenience and aesthetics are important factors for the consumer, and the conventional roof- or boot-mounted antenna remains the least convenient solution. Improvements in GPS technology have eliminated the need for the antenna to be mounted externally, provided the antenna is sufficiently efficient to receive signals in the attenuated environment inside the car. The dielectrically-loaded quadrifilar helix antenna provides a technology solution that provides an excellent service when embedded with the receiver in the car, and also reduces the cost and increases the convenience of the navigation service to the driver.

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