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AUTOMOTIVE HDD WHITE PAPER TOSHIBA STORAGE DEVICE DIVISION

Please attribute to:

Boris Hafner, Senior Account Manager

OEM and Project Business Unit, Toshiba Europe Storage Device Division

Introduction

The market for automotive grade electronic systems is experiencing substantial end-user interest. Since the explosion of digital media applications within consumer markets, demand for a more advanced and multi-media rich in-car experience has grown dramatically. It is expected to be worth about US\$36 billion by the end of 2012.

Driven by this market demand, stand-alone after-sales devices such as GPS mapping units - which are sold separately and independently to the vehicle itself - have experienced a substantial increase in sales. Yet as this sector saturates and consumers shift their attention to additional in-car applications such as integrated digital audio libraries and rear seat entertainment, automotive electronic OEMs have realised the opportunity for integrating in-car 'infotainment' applications directly into the dashboard.

As this market transitions, system designers are faced with increased pressure to integrate newer technologies and components that had previously never been considered for in-car systems. Furthermore, with emerging applications such as 3D GPS mapping, extensive digital audio libraries, video streaming and even gaming appearing in a broad range of mid to high-end cars, the need for on-board storage has grown dramatically.

Whilst the consumer market for high capacity media storage devices has grown significantly, the automotive industry has to date continued with a myriad of storage technologies including CD, DVD and flash memory. Although Flash memory is already used extensively in the embedded computing chips in most high end vehicle electronic systems, it is fast approaching its limits to deliver cost effective and high capacity storage.

Demand for automotive-grade HDDs

Portable drives have initially offered a cheap and readily available stop-gap solution that can be removed from the vehicle in order to be synced with a home PC. In fact, many manufacturers have already introduced support for USB powered consumer devices. Once attached to the vehicle dashboard they can add additional capacity to the existing on-board memory. But with system designers and car manufactures looking to increase profitability by adding additional features and functionality, and with competitors seeking to differentiate their product offering by adding more complex in-car applications, the requirement for a higher capacity storage solution is undeniable.

This trend is very much in line with the development of consumer technologies outside of the automotive industry where product developers must strive to develop in-car applications that will ensure consumers continue to purchase and return to a product or brand. This is vital in order for manufacturers to sustain revenues from products in saturated markets. Ultimately, it also drives designers to develop additional features and functionalities within their products that will maintain consumer interest or drive repurchase. This has been exemplified by the fast growing market for GPS navigation systems for which has driven initial demand for automotive grade hard disk drives. Whilst the earlier generations of GPS mapping units relied on removable flash memory cards or optical media such as CDs for storage of local maps and point of interest, as this technology and service has developed, so has the need for higher, on board capacity far beyond the limitations of solid-state memory.

In Asian markets, complex street layouts and a lack of street names has driven demand for 3D mapping functionality. This has served several purposes and is reflective of the impact hard drive technology can have on in-car applications. Firstly, 3D mapping offered a solution where streets are recognisable by buildings and points of interest and could only be delivered using the high performance and high capacity of hard disk technology which offer much higher data access speeds of approximately 10 to 15 times faster compared to optical drives. Hard drives ultimately impact the end-user experience in such devices by offering the consumer a quicker route calculation or re-calculation. Secondly, by offering additional features and functionality beyond mapping capabilities and utilising storage capacity not required by map data, GPS manufacturers can differentiate their product offering amongst an extremely busy market

For global electronic system manufacturers, it also offers the opportunity to remove the challenges posed by regional specifications for formats such as CD and DVD. Even in advanced markets, regional differences drive specific applications. For example, in-car DVD players and broadcast video devices are most prevalent as an option for backseat passengers in North America, while terrestrial TV access is more prevalent in Japan where drivers and front-seat passengers regularly tune in during rush-hour traffic.

With hard disk technology, a single design unit can be applied to cars for sale in multiple regions without the need for the costly regionalisation and tailoring of systems. Instead, passengers and drivers can enjoy music and video content from their CDs, DVDs and digital music players by storing them on the car's hard disk drive for playback on the go.

Greater Capacity, Greater Functionality

When the first in-car entertainment systems were introduced, the storage requirements were minimum with the primary sources of data consisting of cassette tape, then CD and, most recently, DVD. To date, GPS navigation and digital music will be the primary functions in most new vehicles. Each of these applications require additional capacity between 4GB and 20GB depending on the size of the individual's digital jukebox library and the level of mapping data required by the user at any given time. With the introduction of video-based applications the requirements for data storage will far exceed 40GB. At this size, flash memory becomes prohibitively too expensive.

Table 1: Storage requirements for in-car 'infotainment' applications

- GPS/Navigation = 4-15 GB
- Digital Music 1-5k songs = 4-20 GB
- Digital Video* (std def) = 1 GB
- Digital Video* (hi def) = 10 GB
- Gaming = 1-20 GB
- Audio Books = 1 GB

Capacity Requirements – HDD = 20-65+

*1 hour



New approach to HDD design

While similar in appearance to existing notebook PC hard drives, which primarily utilise the 2.5-inch (6.35cm) discs form factor and parallel ATA interface, automotive grade drives have a much broader operating range which, in turn, dictates design changes for both mechanical and electronic components.

At extreme temperature ranges, traditional PC hard drives would experience operational problems that could potentially cause application failure, data loss and disk corruption. Existing hard drives, which operate at speeds between 4,200rpm and 7,200rpm, would require substantial power to ensure that the hard drive spindle motor, which rotates the disk platter, starts up in sub-freezing temperatures. In comparison, at high temperatures, the lubrication system for the motor would experience substantial difficulties in delivering consistent performance. To overcome this issue, the operating temperature range of

Toshiba's automotive drives range between -22° to 185° F (-30° to +85° C) whilst the spindle motor runs at only 4,200rpm.

Table 2: Comparative operating temperatures

	Minimum operating temp.	Maximum operating temp.
Traditional CE Hard drives	40° F (5° C)	130° F (50 ° C)
After sales products	- 4° F (-20° C)	158° F (70 ° C)
Automotive hard drives	- 22° F (-30° C)	185° F (85 ° C)

SOURCE: Toshiba Europe Storage Device Division

Conclusion

For product designers, automotive grade hard disk technology offers a completely flexible solution that can drive both future innovation and cost efficiencies. Advanced 'infotainment' applications are already well embedded within the market for high-end luxury cars and will eventually reach mid to low end cars as extensive on-board digital media libraries become standard.

Due to the high performance and high capacity offered by automotive grade hard disk drives, electronics system designers can quickly realise the benefits of additional storage capacity and design multi-function systems that can share the capacity across several applications. GPS mapping and digital audio archives are already swallowing the capacity of existing drives and with the introduction of advanced video playback, such as the ability to stream multiple content to different locations within the vehicle, further demands on in-car storage will increase dramatically to at least 100GB and beyond. As additional capacity is realised and new applications come to market that can take advantage of hard drives' unique capabilities the only limitations for in-car entertainment will be those of the designers' imaginations.