



**Mobile and PDA Technologies:
Looking around the corner**

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1. Introduction

We've come a long way since Apple's John Sculley first coined the term 'personal digital assistant' and launched a new computer product category with the Newton in 1992. In the succeeding decade or so there has been a phenomenal growth in mobile or handheld computing and communication devices: personal digital assistants (PDAs), mobile phones, smartphones and personal media players. Mobile phones, in particular, have become extremely widespread and as they become more sophisticated they have begun to offer the information processing facilities of other, more traditional, handheld devices. The availability of such handheld, portable ICT devices has led many in education to explore the implications for teaching, learning and research and, as a contribution to this process, in November 2004, JISC Technology and Standards Watch published a report entitled 'Mobile and PDA Technologies and their future use in education' (Anderson and Blackwood, 2004). The report laid out the current state of the art in handheld devices and provided some trends and predictions of future developments. This short report is provided as an update to that previous report with a view to reviewing progress and discussing, in brief, the future trends in the light of recent developments.

2. Summary of key points from previous report

The previous JISC report on mobile technologies outlined the following key points with regard to the development of these devices in the coming years.

Smartphones will form the dominant platform

Smartphones are a hybrid of the functionality of PDAs and mobile, or 'cellular', phones. Increasingly, mobile phones include such office-type applications as note takers, calendars, e-mail clients, address books, to-do lists, PDF document readers and other functions traditionally found in PDAs. These devices are also beginning to include cameras and the ability to take video. The report predicted that these smartphone devices would increasingly incorporate the capabilities present in the relatively new category of device – the Personal Media Player (PMP), which provides the ability to store, view photos and play-back music and video (e.g. Apple iPod and Archos). The report also described how smartphones and PDAs would become Internet-enabled and able to connect through a range of wireless communications protocols, becoming Mobile Internet Access Devices (MIAD) as defined by Livingston (2004).

Battery Life

The November report noted the general view that the development in the performance of batteries continues to lag that of the other elements of the hardware of these devices such as processor speed and storage sizes. Most devices use rechargeable Lithium Polymer cells which have limitations in overall lifecycle and levels of power provided. At the time, the restrictions in battery power were becoming the limiting factor on further major development in the devices. In order to provide improved processing and communications facilities in smaller devices, new types of power supply would need to be developed and the report predicted the possible introduction of fuel cells.

Hard Discs

The prediction of convergence between smartphones and personal media players was partly based on the increasing role of very small hard disc drivers incorporated into the latter category of device. These devices, a well-known example being Apple's iPod, can hold several gigabytes of data in a disc that is only an inch or two across and weighing a few ounces. They provide the large storage required for media (photos, music and video) files. The report concluded that it seemed likely that such hard drives would rapidly be incorporated into PDAs and smartphones and facilitate a convergence between PMPs and the other types of device.

Software

The report discussed the market battle between the three major operating systems present on these devices; Symbian, Windows (Pocket PC) and PalmOS. As the smartphone begins to dominate the role of Symbian (the development of which is being driven by smartphone manufacturers) seemed likely to increase. Many

commentators were predicting the demise of PalmOS and possibly the increasing role of Linux on portable devices.

Location-based services and GPS

The November 2004 report outlined how Global Positioning Satellite (GPS) systems were available and mainly aimed at 'outdoor types'—sailors and others. These devices were provided as separate, self-contained, hardware devices which could be plugged into a higher-end PDA via a serial interface. The report did not predict the rapid take-up of these devices nor the direct incorporation into handheld devices.

Wireless technology will become cheaper and faster

The report predicted that wireless technologies and networks would continue their rapid evolution and uptake. Devices would connect to the Internet and provide voice and data calls through a range of data communication protocols and standards including WiFi, GPRS and 3G. These different technologies provide differing capabilities, ranges of coverage and bandwidth. Such technologies would become "cheaper, faster and increasingly common" particularly with the development of the WiFi standard. The report also discussed the development of seamless networking where devices could access the Internet through a range of communication technologies. Such networking would allow a device to remain connected when one particular type of communication technology becomes unavailable, for example, when a mobile user moves into a place where only GPRS is available rather than 3G. New communications standards and protocols would help with the process of increasing the bandwidth made available to mobile devices, for example, WiMax and 4G. These developments would assist in the development towards an 'always-on' Internet access.

3. Current Situation

"The era of the smartphone is upon us"

Gartner, Gartner Predicts 2005: Mobile and Wireless Technologies, 29th October 2004.

In section two we reviewed some of the trends and developments presented in the original JISC report. In this section we will discuss the current state of the market and the state of the technological art.

3.1 The state of the market – the growing dominance of converged Smartphones

Within the market place the rising dominance of converged smartphone devices continues as, in parallel, the share of the 'pure' PDA device declines. According to figures from market researchers Canalys, shipments of converged smart mobile devices, namely smartphones and wireless handhelds, rose by 170% year-on-year in first part of 2005 in Europe and Middle East as, in contrast, standard mobile phone shipments rose by only 11% (Canalys, 2005). In the meantime PDAs and other devices, known in marketing terms as 'unconnected handhelds', declined worldwide, although there was some growth in the EU, driven by the demand for PDAs with integrated GPS navigation. In the second quarter of 2005 almost half the number of PDAs sold had GPS included.

The leading manufacturers in smartphone and handheld markets are Nokia, Palm, RIM (providers of Blackberry), Motorola and Fujitsu. Nokia dwarfs the other manufacturers with nearly 55% share of the market (as measured in the early part of 2005) and its series 60 and series 80 ranges dominate the segment in Europe (it is estimated that 80% of smartphones sold in the EU, Middle East, and Africa were Nokia Series 60). What growth there is in the non-smartphone handheld device market is being driven by the uptake of wirelessly connected email devices based on the concept pioneered by Blackberry, which allows connection to corporate/enterprise email accounts whilst on the move. The continuing dominance of the smartphone is changing the dynamics of the operating system market, with Symbian's presence on a majority of smartphones leading it to attain a 60% share of the market, with Microsoft on 15.9 and PalmSource on 9.5% (Canalys, 2005).

3.2 The state-of-the-art in technology

Table 1 presents a summary of the current state of the art with regard to the technology offered by available devices in the market place as of October 2005. In a very rapidly developing market the table is necessarily a snap-shot and it is intended to give a flavour rather than be exhaustive, and we have provided details of some of the more notable newer models offering the latest developments in hardware and software. The table also shows some forthcoming models.

The state-of-the-art can be summarised as a device which incorporates the functionality of a PDA, provides mobile cellular telephony via 3G, incorporates Bluetooth and WiFi networking, has an LCD TFT screen of perhaps 640x320 (VGA), a 1.3 mega pixel camera, and offers integrated GPS. Such a device might cost between £400 and £500.

Storage

PDAs and mobile devices can lose data if the battery power is allowed to run low for long periods. This lack of what is known as 'persistent storage' is a major drawback for these devices. As discussed in the original report, the introduction of persistent storage through hard discs (i.e. convergence with personal media players) is imminent. The Palm LifeOne™ has recently been introduced, the first PDA-style device with such a hard drive (see table 1 for specification details), and other manufacturers intend to follow suit e.g. the forthcoming Nokia N91 and the Pace. However, it is interesting to note that, to date, sales of the Palm LifeOne have apparently been lower than expected (Singer, 2005b). In the meantime, Apple have been exploring the market potential of replacing the moving parts of hard-disc storage with up to 4GB of solid-state flash memory.

Processor/CPUs

The speed and capabilities of the core processors and CPUs embedded in devices ultimately determines the applications and peripheral hardware/communications that a device can support. The developments in CPU architecture are therefore a useful guide to the type of devices that can be supported in the near future. The ability to deliver fast processing speeds with low levels of power usage (measured in Watts) and heat dissipation are the key in CPUs for handheld devices. The levels of power used must be kept low in order to reduce the drain on the battery if a reasonable period between recharges is to be allowed.

Intel continue to dominate the provision of CPUs to the more traditional PDA/handheld market with a great many devices running on Intel®'s Xscale PXA27x architecture at speeds of up to 6234Mhz (referred to in the previous report by its marketing name—the Bulverde range). This range will be built upon in 2006 in an update codenamed Monahans and predicted to have speeds of 1GHz.

However, as discussed in the previous section, the growth in the marketplace is primarily coming from smartphones and wireless connected Blackberry-style email devices. These devices tend to run on Texas Instruments processors. The Texas Instruments OMAP High Performance family of scalable processors is built around a core provided by UK company, ARM, and Texas Instrument's in-house Digital Signal Processing (DSP) technology. The family includes the OMAP 1710 (used in Nokia's 6680) and OMPAP 1510 (Texas Instruments, 2005). As part of efforts to gain momentum in the smartphone market, in late 2006, Intel will launch a dual-core processor for the mobile market called the Merom (Goodwins, 2005) with a power consumption of 45watts and 600+Mhz speeds.

Operating Systems

The three main operating systems in the market remain PalmOS, Windows Mobile and Symbian, and developments continue on all three platforms. One of the drivers for these new generations of OS is to make it easier for the development and production of cheaper smartphones with the kind of functionality that, to date, has only been available on the more expensive smartphones. Why? In order to sell more smartphones because network operators accrue increased revenue from value-added and data services.

Symbian dominates the converged mobile device operating system market with a 55% share in 2004, and this is expected to grow to 60% by 2009 (IDC, 2005). Since the last TechWatch report the company has

released another upgrade (Symbian OS 9.0). Microsoft recently released its new operating system for mobile devices—Windows Mobile 5.0 (Microsoft, 2005). This includes increased support for 3G telecommunications, media manipulation, corporate email, Office software and US-government inspired security enhancements and, most importantly, persistent storage.

Most commentators agree that PalmOS is fading and in 2004, for the first time, more handheld devices featuring Microsoft Windows Mobile (Pocket PC and Windows CE) shipped globally than those featuring the Palm OS (IDC, 2005). The consensus is that the battle is now between Symbian (which dominates the smartphone device market) and Windows Mobile. However, interestingly, PalmOS is now provided by PalmSource, a company separated from Palm and who recently acquired China MobileSoft who specialize in Linux technology for mobile devices (PalmSource, 2005a). PalmSource itself was then recently acquired by the Japanese company, Access. PalmSource has announced that it will be extending Palm OS® to run on top of the Linux kernel developing a Linux-Palm hybrid operating system, but no timescales are available for its release (Singer, 2005c). This follows developments that have resulted in more Linux-based phones shipping, and Linux is particularly popular in Asian markets (in the second quarter of 2005 demand for Linux smartphone devices grew by 418% (PalmSource, 2005b).

Wireless communications

Wireless Fidelity (WiFi) offers a wireless connection between a handheld device and a fixed base-station connected to the Internet (an access point) and is based on the IEEE 802.11 family of communications standards, of which there is a range of variants offering differing speeds. As discussed in the November 2004 report, WiFi wireless Internet access has become increasingly widespread, with analysts estimating that by the end of 2005 there will be at least 100,000 WiFi access 'hot-spots' (Best, 2005). However, some commentators are expressing concern at the lack of usage, particularly from the initial target market of travelling executives (Gartner, 2005).

An increasing number of handheld devices now include WiFi support as standard (see table 1). The current state-of-the-art is based on 802.11b and most handheld devices offering WiFi will support this variant. This offers a theoretical speed of 11 Mb/s, although in practical, real-world usage the bandwidth is probably a lot lower. Products will shortly (early 2006) come on-stream which offer the faster, 802.11g, at speeds of up to 54Mb/s. An even faster variant 802.11n is still under discussion, but will offer speeds of up to 250Mb/s and is likely to be first available in 2007. So-called 'pre-n' products which implement some of the 802.11n standard have been announced, but this is unlikely to affect the handheld products market at this stage.

The previous report also discussed WiMax, an alternative standard based on IEEE 802.16. This offers handheld devices a wireless, *direct* connection to the Internet, rather than a short-range connection to a base-station. The technology is expected to offer speeds of up to 75Mb/s and over distances of several kilometres. There has been considerable interest in this technology as it promises Internet access 'on the move' over wide geographical areas, but developments have been relatively slow (Dornan, 2004). However BT recently announced that UK trials would start early in 2006.

Third generation (3G) mobile telecommunications cellular access is also starting to become widespread in the UK and most of the cellular phone companies now offer this service. A small number of smartphones are now supporting 3G calls which allow data transfer rates of up to 2.4 Mb/s (e.g. Nokia 6680 and the forthcoming Treo). Fourth generation, 4G, telecommunication remains under discussion and is considered to be a decade or so away.

All these developments contribute to the development of mobile access to data and the Internet, so called 'wireless roaming'. Such access to data through a variety of wireless access points, 'hot spots' or 'nets' throws up the question of handling the authentication of visitors. This is particularly an issue for education, where visitors to a campus or school may like easy data access through the local wireless network. JISC is currently undertaking work in this area under the UKERNA National Location Independent Networking (LIN) trials (Howlett and Sankar, 2005).

4. Where next? Looking around the corner

Intel and processors

As discussed in the previous section the direction in the development of the processors that support handheld devices gives an indication of forthcoming developments. In the medium term, Intel plans to bring processing chips based on its desktop PCs to handhelds through the Lower Power Intel Architecture Project (LPIA), which is trying to make energy efficient versions of the standard x86 processors (Pentiums etc.). Power and energy/heat dissipation is a major issue with handhelds and the goal is a device using 0.5 Watts of power. Intel believes that these handheld devices will become powerful computing devices, comparable to desktop systems.

Fuel cells

For some time, commentators have been predicting that the introduction of fuel cell technologies would alleviate problems with the life of lithium batteries. The Japanese tend to be the leading developers of this technology and in 2005 there were a number of announcements concerning the development of prototype Direct Methanol Fuel Cell (DMFC) devices for use in mobile phones (see for example, Singer, 2005a) and these are now expected in 2007. Such devices will initially offer a hybrid with existing battery technology or even simply provide a convenient portable recharge mechanism. In anticipation of this a recent report by Nanomarkets argued that 2006 could be "break out year" for fuel cells (Nanomarkets, 2005).

In the meantime, others argue for the use of 'wireless' power systems which can distribute power directly to a mobile device. This has been demonstrated for very low power devices (it is essentially how RFID works) and for large-scale solar power generation, but further work is required over the long term (Rossetti, 2005) to develop a portable device.

Display Screens

Mobile devices currently contain a range of small screens based on active-matrix Thin Film Transistor (TFT) or Organic Light Emitting Diode (OLED) technologies and offer diagonal sizes ranging from 2" to around 4". The LCD display surfaces need backlighting to be visible in daylight conditions and are generally found in PDA-type devices. The smaller OLED displays offer self-luminescence and are thinner, and have started to appear in mobile devices and personal media players in 2005 (Electronic News, 2005).

Building on the introduction of OLEDs, a number of technology developments are pointing to a trend towards reflective, flexible display surfaces that can be rolled, like paper. It is likely that these roll-up displays will be incorporated into handheld devices in the near future and many different types of applications are envisaged that provide larger information screens to be carried on the move. Prototypes have been demonstrated by manufacturers in 2005 (see the picture below).

In the longer term, 'near-to-eye' systems, which scan the display directly into the eye's retina may well replace the traditional screen. The JISC Technology Watch's latest report "Advanced Display Technologies" provides more details of this and other display developments (Anderson, 2005).

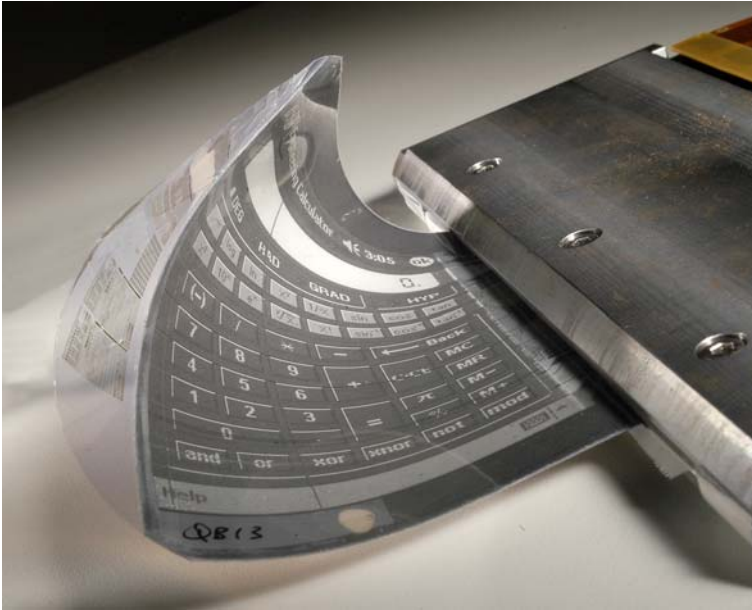


Figure 1: World's thinnest flexible active-matrix display using Philips's ultra-thin back plane with organics-based thin film transistors, combined with E Ink's electronic ink front plane. Photo: Philips

Digital TV on handhelds

Digital broadcast live TV is predicted to be delivered to mobile and handheld devices in the coming decade. The main standards for providing live television services on a handheld device currently available are DMB, ISDB-T, MediaFLO and DVB-H. In the UK there are currently two options for the delivery of mobile TV: Orange's LiveTV (an on-demand service in which individual users request programmes, and pull content down via a 3G data call) and one-to-many broadcasting in which signals are broadcast/pushed to many devices. For the one-to-many broadcast model the leading standard is DVB-H (Digital Video Broadcast – handhelds), formally adopted in November 2004 by the European Telecommunications Standards Institute (ETSI, 2005). This operates in a similar manner to the digital Freeview TV service. In the UK trials of DVB-H are underway in Oxford, overseen by O2 and Vodafone, but widespread use of such a service will partly depend on Ofcom's on-going review of the use of the radio spectrum. Digital Multimedia Broadcast (DMB) uses a similar radio spectrum to the DAB digital radio service.

Handheld use in education: media appliances

Whilst there is tremendous interest in handheld devices as new computing devices (because they provide the ability to carry computational applications on the go and to access Internet-based materials), one can also argue that these are also *media* appliances. Increasingly, converged devices are offering media-rich features such as MP3 audio record and playback, 2 mega-pixel cameras, video recording/playback and wireless Internet access – all highly attractive to users in the key age group involved in school and higher education. The video functionality of these converged devices will rapidly improve, for example, JVC recently announced a video camera with built in hard-disc (the Everio HDD).

Recently, we have seen the rapid development of blog-based news publication/gathering and filming of news events by participants using handheld mobile phone cameras. It is highly unlikely that this changing perception of what media is and who is responsible for publishing it will not soak through to young people. Educationally, might not the true impact of these devices be the ease with which young people can record and manipulate media materials? It may not be too long before lecturers are routinely video filmed and audio recorded during their talks and such lectures are instantly uploaded onto blogs or passed around a class via peer-to-peer networks? What are the education opportunities and threats afforded by this?

In the first commercial trial of mobile TV in Finland, the average participant watched around 20 minutes of mobile TV a day (Finnish Mobile, 2005) and the most popular location was on public transport. As an

example of a potential opportunity for these media appliances, the chance to target this timeslot with educational materials is obvious.

5. Conclusion

This report has provided a short update on the previous JISC Technology Watch report on the future of PDA and mobile devices which was published in November 2004. In the space of a year we have seen a number of developments including the introduction of hard-disc based storage on handhelds, the spreading of WiFi Internet access and the continued rise of the smartphone, many with third generation (3G) telecomms access. Larger increases in the storage, processing and communications capabilities of these devices is predicted over the coming years, as is the continued miniaturisation. Much of this is dependent on the development of hardware that can operate efficiently since the major barrier to continued development is the power usage of CPUs and the portable battery lifecycle. The introduction of fuel cells could be the catalyst to further development.

In the meantime, the educational opportunities offered by these new devices continue to be explored. As was concluded in the original report, "these developments present education with a number of opportunities to enhance learning, administration and research, but also present new challenges". The 'always-on' nature of the devices was seen as a particular challenge. That much, at least, has not changed in the intervening year.

Table 1: State of the art in mobile devices, October 2005

Manufacturer	Model	CPU	OS	Memory	Exp Memory	Display	Multimedia	Wireless	Extras	Comments
PalmOne	LifeDrive	XScale 416MHz	Palm OS Garnet 5.4	16MB ROM 4GB Hard Drive	SD/SDIO/ MultiMedia Card	480x320 pixels TFT	No camera	WiFi 802.11b Bluetooth 1.1		New market category: Mobile managers
PalmOne	Treo650 Smartphone	Intel™ PXA270 312 MHz	Palm OS 5.4	21 MB	MultiMediaCard/SD/SDIO	TFT 320x320 pixels	Camera:VGA (0.3 megapixels)	Bluetooth	GSM/GPRS Phone	
PalmOne	Treo 700w	Intel	Windows Mobile 5.0	64MB RAM			1.3 megapixel camera		GSM/GPRS phone	<i>Due 2006</i> First Palm with Windows Mobile
HP	iPAQ HW6510/15 Mobile Messenger	Intel® PXA270 312MHz	Windows 2003 2nd	128 MB total memory (64 MB ROM and 64 MB SDRAM	SD and Mini SD Slots	3" QVGA TFT 240x240 pixels	SXGA, HP Photosmart 1.3 megapixels	Bluetooth	GSM/GPRS /EDGE phone GPS	
HP	HP iPAQ h6340	TI OMAP 1510	Windows 2003 Pocket PC	64-MB SDRAM, 64-MB Flash ROM Memory	SD slot	3.5" 240x320 pixels	Optional 1.3 megapixel Digital Camera	WiFi 802.11b Bluetooth	Quad band GSM/GPRS /EDGE	
Dell	Dell Axim X50v Pocket PC	Intel® PXA270 624MHz	WM for PPC 2003 SE	64MB 120MB ROM	Secure Digital/SDIO/ MMC Memory Card Slots	3.7" VGA display - 640x480		WiFi 802.11b Bluetooth		
Sony Ericsson	P910i	ARM9, 156MHz	Symbian OS v7.0	32MB RAM 64MB Flash ROM	Sony Memory Stick Duo™	208x320 18-bit	0.3 megapixel VGA camera	Bluetooth	GSM phone	MP3 playback
Nokia	6680	TI OMAP 1710 220 MHz	Symbian OS	10MB flash 20MB RAM	DV RS-MMC 64 MB ¹	176x208 pixels	1.3 megapixels	Bluetooth	GSM + 3G Phone	video calls MP3 stereo player
Nokia	7710	ARM9 based processor 150 MHz	Symbian OS v7.0 series 90	90MB	1x MMC slot with 128MB MMC	widescreen 640x320 pixel display	Near megapixel resolution 1152x864	Bluetooth	GSM/ GPRS phone	Landscape size Video MP3/FM radio Touchscreen
Nokia	770 Internet		Linux-based Internet	64MB RAM 128MB Flash	64MB RS-MMC	4.13" (800x480)		Wifi 802.11b/g Bluetooth 1.2		<i>Due late 2005</i> Use external phone as

¹ Reduced Size Dual Voltage MultiMediaCard (MMC)

Manufacturer	Model	CPU	OS	Memory	Exp Memory	Display	Multimedia	Wireless	Extras	Comments
	Tablet		Tablet 2005			touch screen				modem 230g.
Nokia	9500 Communicator	TI OMAP 150MHz	Symbian OS v7.0 series 80	80MB RAM 32MB ROM	1 x MMC	640x200 & external phone display of 128x128		Wifi 802.11b Bluetooth	Tri-band: GSM/EDGE	MP3 Video play
Orange	SPV C550	TI 200MHz	Windows Media 2003 SE	64MB	Mini SD	2.2" 240x320 pixels	1280x1024 pixel camera	Bluetooth	tri-band GSM GPRS	MP3 Music Player
Orange	SPV M500 Pocket PC	Intel PXA 272 416Mhz	Windows Media 2003 2 nd Edition Phone	37MB RAM 8MB Flash	1 x SD	2.8" 240x320 pixels	960x1280 pixel camera + 240x320 video	Bluetooth	GPRS	Small form size Windows Media Player
QTEK	Qtek 8100	TI OMAP 730	Windows Mobile Smartphone 2003 E	32MB RAM	1 x MiniSD	176x220 pixels	VGA camera (640x480 pixels)			
Orange	SPV M5000	Intel PXA272 520MHz					1 megapixel camera	Bluetooth	Tri-band, GPRS + 3G phone	<i>Due Oct 05</i>
Nokia	N90			32 MB	RS-MMC card slot 64 MB card	2.1" 352x416 pixels	2 megapixel camera	Bluetooth 1.2	tri-band GSM/ 3G	video phone
Nokia	N91			4 GB HD hard drive			2 megapixel camera	Bluetooth WiFi 802.11b 802.11g	3G phone MP3 music player	<i>Due Dec 05</i>
O2 XDA	Exec Communicator	Intel 520 MHz PXA270	Windows Mobile 5.0		SDIO capable SD/MMC card expansion		swivel screen with VGA resolution	WiFi 802.11b Bluetooth	tri-band GSM, GPRS, 3G,	
T-Mobile	MDA Pro	520 MHz Intel processor	Windows Mobile 5.0	48 MB	SD Card slot SDIO capable SD/MMC card slot	3.6-inch VGA	1.3 megapixel camera	Wi-Fi 802.11b	tri-band GSM GPRS 3G	PalmTop style
Samsung	SGH-i300 ²		Windows 5.0	3G Hard disc			1.3 megapixel	Bluetooth		<i>Due Nov 2005</i>

² http://www.techdigest.tv/2005/09/samsungs_hard_d.html

Manufacturer	Model	CPU	OS	Memory	Exp Memory	Display	Multimedia	Wireless	Extras	Comments
							camera			
Pace	PDH400 Portable media player			40GB HD	SD Card	4.3" 480x272 pixels	Video playback, MPEG2, 4 etc		TV reception DVB-H standard	<i>Due 2006</i>

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