Industry Focus

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Integration & consolidation

The roadmap for wireless semiconductors

- **Wireless matters in Europe** — Our chip company coverage universe has a material exposure to the >US$40 billion handset semiconductor market, ranging from 17% to 65% of revenues.
- **Moderating handset growth to impact the sector** — As emerging market volume growth moderates, we expect volume growth for the handset market to move from 23% in 2006 to 9% in 2009. We expect this to increase competition in the handset sector, which in turn will increase pressure on chip prices.
- **Integration the driving force** — The trend towards integration of baseband and radio functions onto one chip started a couple of years ago and is gathering pace. We see this as a vital skill for chip makers and see Infineon as best placed within our coverage.
- **Further consolidation likely** — With a large number of chip suppliers fighting over the Top 5 handset OEMs, we expect further consolidation. We see ST as a potential acquirer (of RF integration expertise) and CSR as a potential target (for its non-cellular RF expertise).
- **Longer-term trends to consider (1)** — The move from 3G to 4G cellular technologies will provide a new opportunity for chip makers. Three standards are currently in the running: LTE, UMB and WiMAX. We expect most chip makers to focus on developing LTE solutions, as this is a natural evolution from HSPA.
- **Longer-term trends to consider (2) –** The development of software defined radio (SDR) could result in a single communications chip that could handle all radio functions (cellular, PAN, LAN, mobile TV, GPS) in a handset. This offers a significant opportunity for SDR designers but could challenge those chip makers with purely RF capabilities.

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Contents

Summary

European semiconductor companies have material exposure to the handset market. In this report, we look at the trends impacting the wireless semiconductor market in the short, medium and long term. We assess the competitiveness of our coverage universe in respect of these trends and highlight areas where we expect to see M&A. We see Infineon as best positioned due to its RF integration expertise and improving customer base. We believe that ST has less integration expertise and consequently may need to make an acquisition, as although it is taking on highly experienced Nokia R&D engineers as part of the recent 3G deal, we believe the timescale for integrated products is too far out. CSR has integration expertise outside of cellular RF, and we believe this makes it an attractive acquisition target for those companies with limited RF expertise. Wolfson and AMS are increasingly competing in the same space – it remains to be seen to what extent their products will be integrated into baseband/application processors or RF chips, reducing their total available markets.

Assessing the roadmap for wireless semis

The handset market is an important market for seven of the stocks we cover. Revenues from this end market make up anywhere from 17% to 65% of total revenue, and we forecast similar contributions over the next three years (see Figure 1, page 10).

The handset market has shown phenomenal growth over recent years and remains a high profile market, due to the combination of a large unit market (forecast to exceed one billion in 2007) and high fashion products (eg iPhone launch earlier this year). With such widespread ownership, everyone has an opinion on handsets, and form factor and user interface are more heavily discussed than for any other end product.

Our Telecom Equipment team expects the handset market to show decelerating growth over the next three years as emerging market growth moderates (see Figure 2, page 11). In this environment, we would expect to see ever-increasing price pressure on chip manufacturers. We look at how chip makers can address this, considering consolidation in the wireless chip industry as one route, as we believe there are too many companies chasing too few customers.

Short- to medium-term trends

Integration expertise

One way to reduce overall system cost for handset manufacturers is to make ever smaller solutions. Integrating several functions on one chip results in a smaller footprint solution and overall lower cost than using separate chips for each function. We believe the ability to design integrated chips is a key requirement for a successful chip company in the wireless space.

Increasing RF functionality

As we progress from 2G to 2.5G to 3G and ultimately 4G, handsets need to be able to cope with the new air interface as well as the old ones. This increases the amount of cellular functionality needed in each handset. In addition, increasing demand for other types of connectivity (Bluetooth, WiFi) and entertainment (mobile TV, FM radio) increases the number of radios needed in each handset. Expertise in RF becomes more valuable.

Power of the Top 5 handset OEMs is undiminished

Although Motorola has lost market share over the last three quarters, this has almost all been to the benefit of the remaining Top 5 handset OEMs. Any successful chip manufacturer will need strong relationships with at least one of the Top 5, or will need a very strong position outside the Top 5 to lay claim to the remaining 20% of the market. As the large number of chip suppliers to the wireless industry fight for access to the smaller number of handset manufacturers, we expect to see further consolidation.

Chinese 3G growth

The Chinese government should be granting licenses for 3G imminently. The Chinese TD-SCDMA standard represents a new market where the existing 3G chip suppliers will not necessarily hold any sway. There is an opportunity here for local companies such as MediaTek and Spreatrum to take market share.

iPhone shakes up the industry

The launch of the iPhone in June 2007 served as a wake-up call to handset manufacturers. While the iPhone may not be perfect (some complain about the touch screen keyboard or lack of 3G), it presents a new form factor and user interface. Since the launch, we have seen a spate of new product launches from the incumbent handset manufacturers trying to compete with the iPhone. This is good news from a chip perspective, as it increases the demand for smartphones which contain significant silicon content.

Longer-term issues

Software defined radio

Software defined radio (SDR) is the Holy Grail of wireless chip design. The aim of SDR is to enable all communication functions to operate on one chip. A communications chip would be made up of 10-20 DSPs (digital signal processors) and microprocessors plus antennae, tuners, LNAs (low noise amplifiers) and ADCs (analog to digital converters) for the radio interfaces required. As a radio signal is received, the software is designed to manage the operation of the DSPs, allocating work to process the signal to each DSP on an ad-hoc basis. As new standards are introduced, the relevant new software can be downloaded onto the chip. This single chip would replace the multiple baseband and transceiver chips used currently. This would be attractive for handset manufacturers, as it would reduce silicon footprint while lowering cost. However, it may be counter-productive, as it could reduce the need for handset users to upgrade their handsets for the latest radio technologies. It would be a threat to many chip manufacturers, particularly those active in the RF space.

Challenges include the complexity of getting all the DSPs operating efficiently together and high power consumption.

In November 2007, NXP unveiled its programmable vector processor, the Embedded Vector Processor (EVP). The EVP enables mobile devices to support multi-mode and multi-standard platforms as well as providing flexibility for emerging telecom standards. The RF portion of the design is broken down into three sections, depending on data rates. The low-end would combine NFC, Bluetooth, Zigbee, ULP Bluetooth and UWB (Bluetooth 3.0). The mid-range would consist of a reconfigurable RF channel for cellular communications. The high-end would also be a reconfigurable RF channel for high-bandwidth applications such as WiFi, WiMax and LTE. NXP expects the EVP to be available for embedding into ICs this year and will be included in several NXP products due for release in 2008/2009.

Move to 4G

Three standards are in the running for 4G: LTE, UMB and WiMAX. While operators consider which standard they will adopt, it is difficult for chip makers to decide which standard to develop. There are signs that UMB may be less popular than Qualcomm would like, considering the recent news that Verizon Wireless is to start trialling LTE. We expect the majority of wireless chip companies to focus on the development of LTE, as it is a natural evolution from HSPA, and initial indications are that this is what the majority of operators will adopt.

Implications for our coverage universe

ARM

ARM's success has been driven by its near monopoly in the handset market. Over 90% of handsets contain at least one ARM core, as ARM is the de facto standard for MCU design in the baseband. Many handsets contain two or more cores, as ARM cores are used in several Bluetooth and WiFi baseband designs. As the handset market has grown, so royalties have increased as a percentage of total revenues. Although ARM is keen to increase its penetration of non-wireless end markets, a large proportion of upgrade and derivative license sales will continue to be generated by wireless chip designers as they move along the ARM roadmap. And at over a billion handsets shipped a year, royalty volumes will continue to be heavily skewed towards the wireless market.

AMS

AMS has supplied power management solutions for several years, supplying Tier 2 OEMs such as Sagem. More recently, AMS launched combined lighting and power solutions that have been selected by several Top 5 handset OEMs, and its exposure to Sagem has declined to zero.

CSR

The majority of CSR's revenues are generated from the handset market, either in handsets or headsets. We don't expect this to change materially, as CSR's new products (UniFi and GPS) are both targeted at the handset market. CSR's key challenges are to maintain market share in the face of strong competition from Broadcom and to develop products that continue to deliver increasing functionality to customers. With its experience in several connectivity technologies, we believe that CSR would make an ideal acquisition target for a company looking to acquire RF expertise.

Epcos

Epcos' main exposure to the wireless market is via its SAW division. Each air interface served by a handset will require a SAW filter to enable the receiver to select the correct frequency. Consequently, a 3G phone (with WCDMA capability and fall-back capability for EDGE, GPRS and GSM) will need many more filters than a low cost GSM-only phone. Epcos has the top position in this market, although is under pressure from the No. 2 manufacturer, Murata, particularly when the Yen is weak versus the Euro. For Epcos, the continued volume growth of the handset market combined with the transition to new air interfaces should help counteract the price pressure experienced across all SAW products.

Infineon

We view Infineon as having a strong position in the wireless market, due to its combination of baseband and RF expertise. This has allowed Infineon to develop integrated single chip solutions ahead of the market and should allow it to participate in the trend for ever increasing amounts of integration. Having hit a trough in wireless revenues in 1Q07 (after the BenQ Siemens bankruptcy was announced), the company has won contracts with each of the Top 5 handset manufacturers which should drive wireless revenues in FY08 and FY09. In addition, the acquisition of LSI's handset business gives Infineon a stronger position at Samsung (although this is not guaranteed permanently). No design win is forever – with the short lifecycles of handsets (1-2 years), wireless chip suppliers need to be able to win multiple designs to maintain share at each customer.

ST

ST's wireless revenues are predominantly generated through supplying ASICs to Nokia. Earlier this year, ST signed an agreement with Nokia that will result in ST supplying 3G baseband chips to Nokia. As part of this agreement, Nokia has transferred R&D engineers to ST and has licensed technology to ST. Also, as part of the agreement, ST is allowed to sell 3G chips to other customers, although we believe that ST's focus will continue to be on Nokia.

As part of the Nokia deal, ST has access to experienced Nokia R&D engineers, but despite this does not expect to develop an integrated 3G chip until the end of 2010. Consequently, we view ST as lacking RF integration capabilities and consider this an area where ST could benefit from buying in expertise.

ST generates a substantial proportion of its wireless revenues from outside the traditional baseband/RF space, supplying camera modules, Bluetooth and application processors.

Wolfson

We estimate Wolfson will generate c20% of revenues from the handset market in 2007. This is predominantly through the supply of audio chips to customers, including Apple, LG and Samsung. In 4Q07, Wolfson launched its combined audio and power management chip. Wolfson's strategy is to combine analog functions into a single chip to reduce footprint and overall cost. A question still remains whether handset manufacturers will use this approach or will look for these functions to be increasingly integrated into the baseband or application processor. In Wolfson's favour is the difficulty chip manufacturers are likely to have in combining leading edge digital CMOS design (used for baseband/application processors) with the trailing edge design used for analog processes such as audio and power management. Another option is for the audio and power functions to be integrated with the non-cellular RF functions – this would require Wolfson to acquire RF expertise or potentially to be acquired by a chip maker lacking audio/power expertise.

The launch of the iPhone has also increased Wolfson's exposure to the wireless market. As a long-term supplier of audio codecs in the iPod, Wolfson was selected by Apple for the iPhone. Roughly 10m units sold in 2008 would equate to revenue of US$7 for Wolfson, equating to c2.6% of sales.

Current Market for Wireless Semis

According to Gartner, wireless handset semiconductor revenues were US$41bn in 2006, making up 16% of total semiconductor revenues.

In the table below, we estimate wireless revenues generated by our coverage universe and also calculate the contribution of wireless revenue to total revenue for each company. It is clear that the wireless market has a greater impact on European companies than the market as a whole, with wireless applications driving anywhere from 17% to 65% of revenues in 2007.

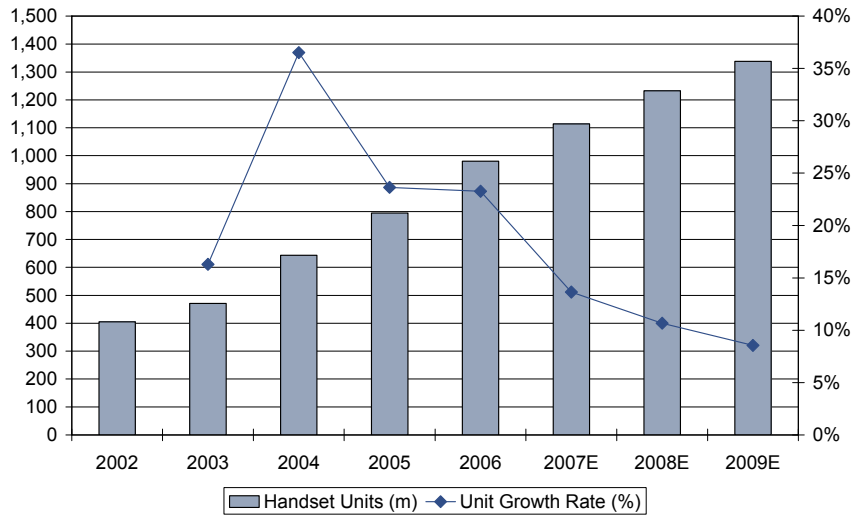
Figure 1. European Wireless Semiconductor Exposure, 2003-2009E (US Dollars in Millions)

	2003	2004	2005	2006	2007E	2008E	2009E
Revenues (US$m)							
AMS	43	54	69	74	83	95	103
ARM	136	182	275	315	344	387	435
CSR	37	151	368	493	548	575	633
EPC	426	481	393	387	459	538	570
IFX	1264	1682	1289	995	895	1625	1919
ST	1451	1689	1889	2267	2301	2528	2684
WLF	2	5	15	35	47	53	66
% of total revenue							
AMS	28%	27%	31%	30%	30%	30%	30%
ARM	65%	65%	65%	65%	65%	65%	65%
CSR	54%	60%	76%	70%	65%	59%	56%
EPC	31%	29%	25%	24%	24%	24%	24%
IFX	33%	32%	26%	20%	17%	24%	27%
ST	20%	19%	21%	23%	23%	27%	27%
WLF	2%	4%	9%	17%	20%	20%	20%
Revenue growth (%)							
AMS		27%	28%	8%	12%	15%	9%
ARM	-8%	34%	51%	15%	9%	13%	12%
CSR		312%	143%	34%	11%	5%	10%
EPC	11%	13%	-18%	-2%	19%	17%	6%
IFX	59%	33%	-23%	-23%	-10%	82%	18%
ST		16%	12%	20%	2%	10%	6%
WLF		215%	214%	132%	34%	14%	25%

Source: Company Reports and CIR Estimates

Handset units have grown more than 20% over each of the last three years. Our Telecom Equipment team expects this growth to moderate, forecasting unit growth of 14% in 2007 and 11% in 2008.

Figure 2. Global Handset Shipments and Growth, 2002-2009E (Units in Millions and Percemtage)



Source: Citi Investment Research

Increasing adoption in emerging markets has been the prime driver of growth. We compare the split of the handset market by geography in Figure 3 to highlight the recent growth in emerging markets. We estimate penetration rates of 18% in China and 12% in India in 2007.

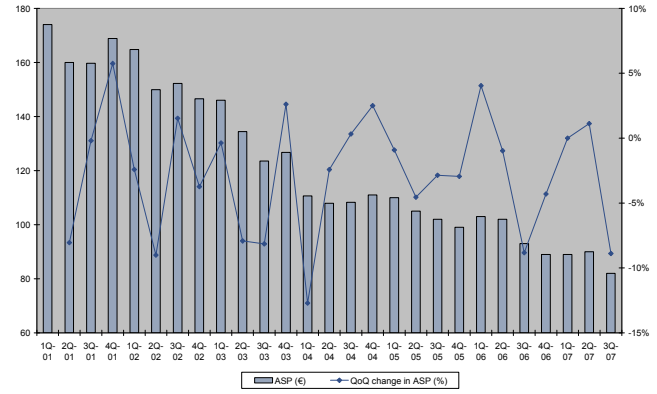
Figure 3. Handset Shipments by Geography, 2005 & 2008E (Units in Millions)

	Shipments (m)		Share of market	
	2005	2008E	2005	2008E
Europe	237	286	30%	23%
Middle East & Africa	71	134	9%	11%
China	**100**	**183**	**13%**	**15%**
India	**32**	**134**	**4%**	**11%**
Asia Pacific	109	183	14%	15%
North America	145	179	18%	15%
Latin America	101	133	13%	11%
Total	795	1233		

Source: Citi Investment Research

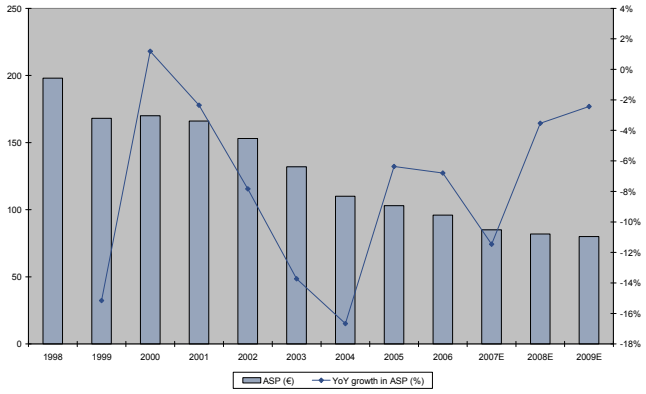
This partially explains the trend for falling handset ASPs. Figure 4 and Figure 5 show Nokia's average selling price per handset on a quarterly basis since 2001 and an annual basis since 1998. The decline in ASP pressures chip makers to find news ways to cut costs.

Figure 4. Nokia Quarterly Handset ASP & ASP Growth, 1Q01-3Q07



Source: Company Reports.

Figure 5. Nokia Annual Handset ASP & ASP Growth, 1998-2009E

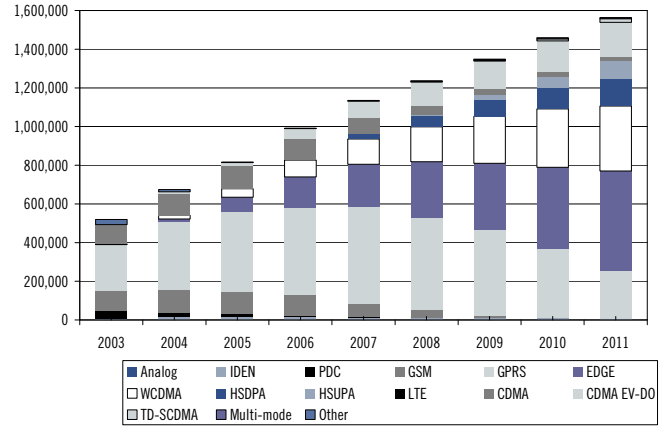


Source: Company Reports and CIR Estimates

Growth drivers for handset market

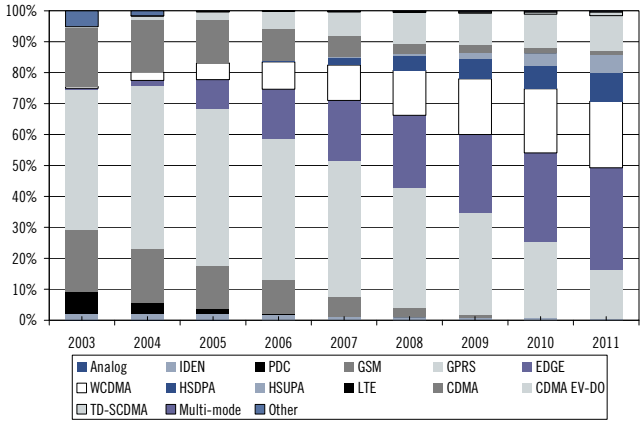
A key driver of replacement handsets is the transition to new air interfaces. The chart below shows the split of the handset by air interface in units and the percentage share of the market by interface. The EDGE market is forecast to gain share, rising from 16% in 2006 to 24% in 2008. The WCDMA is forecast to rise from 9% in 2006 to 20% in 2008.

Figure 6. Handset Shipments by Air Interface, 2003-11E (Units in Millions)



Source: Gartner, July 2007

Figure 7. Handset Shipments by Air Interface, 2003-11E (Percentage)

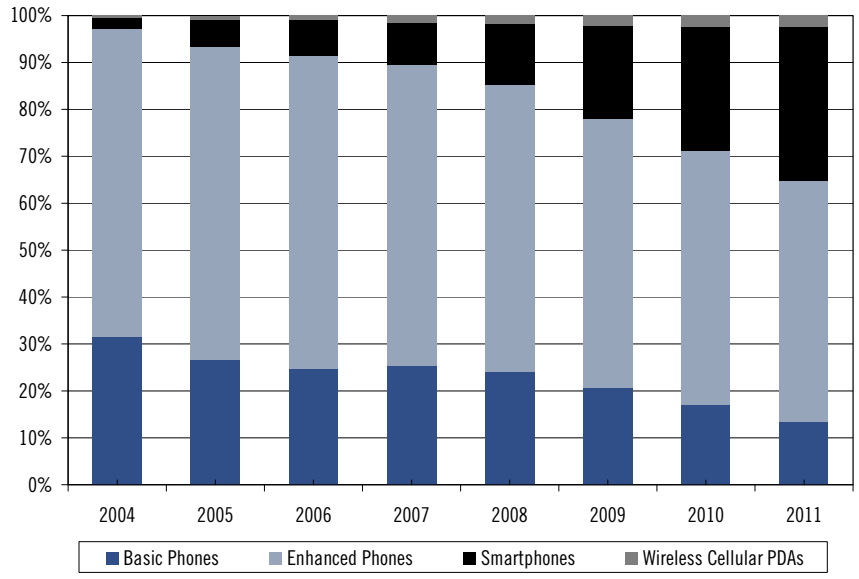


Source: Gartner, July 2007

The move to new air interfaces allows chip makers to introduce higher ASP chips, partially counteracting price pressure.

The strong demand for handsets in emerging markets has driven strong growth in ultra low cost handsets. Chip manufacturers have worked to lower the silicon cost through the introduction of single chip solutions. These combine a smaller footprint with a lower cost. Over time, we expect ultra low cost handset owners to want to upgrade to higher functionality handsets. The chart below shows the forecast for shipments by type of handset. While the low cost handset market will remain stable at c24-25% of units from 2006 to 2008, from 2009 it will start to decline as the number of new users in emerging markets is outweighed by existing users upgrading to enhanced phones and smartphones.

Figure 8. Handset Shipments by Type, 2004-2011E (Percentage)



Source: Gartner

Other ways to counteract price pressure include providing additional functionality such as GPS, mobile TV, music, video and internet services.

In the following chapters, we look at the different semiconductor functions in a handset, assessing the current landscape and considering how each market may change in the medium term. We look at baseband, cellular RF, application processors, Bluetooth, GPS, Mobile TV, NFC and WiFi.

Baseband Market

Current status

There is a relatively large number of baseband chip suppliers, compared to the number of major handset suppliers (the top five handset OEMs make up 80% of the market).The companies in the table below all sell baseband chips, to a greater or lesser degree.

Figure 9. Handset Baseband Suppliers

Analog Devices	NXP
Broadcom	Qualcomm
Freescale	Renesas
Infineon	Spreadtrum
Marvell	ST
MediaTek	Sunplus
NEC Electronics	Texas Instruments

Source: Citi Investment Research

We estimate that the three largest baseband chip companies (Texas Instruments, Qualcomm and Freescale) supply over 75% of the handset market, with the remaining companies supplying niche products or being legacy suppliers to certain handset manufacturers.

In the tables below we attempt to show the split of the handset market by technology, handset supplier and chip supplier, based on 2006 data.

Figure 10. Handset Chip Suppliers, 2006

2006	GSM/GPRS		EDGE		WCDMA		CDMA	
	Baseband	RF	Baseband	RF	Baseband	RF	Baseband	RF
Nokia	TI, TI*	IFX	TI	RFMD, ST	TI	ST	QCOM	QCOM
Motorola	FSL, TI*	RFMD	FSL	RFMD, Sky	FSL	FSL	QCOM	QCOM, RFMD
Samsung	NXP, Agere	SLAB	Agere	IFX, Sky	QCOM, BCOM	IFX	QCOM	QCOM
Sony Ericsson	BCOM, EMP, TI*	EMP	EMP	EMP	EMP, Renesas	EMP	QCOM	QCOM
LG	ADI	Sky	IFX, ADI	IFX	QCOM, EMP	QCOM, EMP	QCOM	QCOM, Sky
BenQ-Siemens	IFX, IFX*, MediaTek	IFX	IFX	IFX				
Sagem	TI*	SLAB	TI	TI, FSL	EMP	EMP		
Sharp	ADI, TI	EMP	ADI, TI	RFMD	Renesas, EMP	EMP	QCOM	QCOM
TCL-Alcatel	TI*, MediaTek	SLAB	NXP	NXP				
Sanyo					QCOM	QCOM	QCOM	QCOM
Kyocera							QCOM	QCOM
Ningbo Bird	BCOM, IFX, IFX*,MediaTek		NXP	NXP			QCOM	QCOM
NEC		SLAB			NECE	IFX		
Panasonic	Panasonic, IFX	IFX			Panasonic, IFX, BCOM	IFX		
ZTE	ADI				QCOM	QCOM	QCOM	QCOM
Pantech Group	MediaTek						QCOM	QCOM
UTStarcom	MediaTek						QCOM	QCOM
Toshiba					QCOM	QCOM	QCOM	QCOM
RIM	Marvell	FSL	Marvell	FSL			QCOM	QCOM
Amoi	Agere	SLAB	TI, Agere	TI, RFMD	QCOM, EMP	QCOM, EMP		
Haier	NXP, MediaTek							
Lenovo	TI*, BCOM, MediaTek	RFMD, SLAB						
Fujitsu					Renesas	Fujitsu		
Konka	MediaTek							
Mitsubishi					Renesas	ADI		

Notes: *=single chip solution; RF=transceiver

Abbreviations: TI=Texas Instruments, IFX=Infineon, FSL=Freescale, Sky=Skyworks, EMP=Ericsson Mobile Platforms, BCOM=Broadcom, QCOM=Qualcomm, SLAB=Silicon Labs, NECE=NEC Electronics

Source: Citi Investment Research

Figure 11. Baseband Chip Market Share, 2006 (Percentage of Units)

	2006A
Texas Instruments	43.1%
Qualcomm	18.6%
Freescale	16.8%
LSI	4.9%
MediaTek	4.7%
Infineon	3.3%
NXP	2.6%
Renesas	1.6%
Analog Devices	1.3%
Broadcom	0.7%
NEC Electronics	0.7%
Marvell	0.3%
ST	0.1%
Others	1.1%
	100.0%

Source: Citi Investment Research

The Incumbents

Texas Instruments

As the GSM-based baseband supplier to Nokia (using Nokia's custom designs), TI automatically supplies c32% of the market. In addition to Nokia, TI supplies EMP with GSM/GPRS and EDGE baseband chips, adding a further 6%. TI's single chip solution, LoCosto, has been adopted by many Tier 2 and 3 handset makers, taking its market share over the 40% level.

In light of Nokia's decision to widen its supplier base and start to use standard products, TI's baseband market share is likely to decline as Infineon, Broadcom and ST products start to ramp from 2008.

Qualcomm

Qualcomm supplies the vast majority of CDMA baseband chips, which gives it a c16% market share. In addition, its WCDMA solution is used by Samsung and LG, driving its baseband share closer to 20%.

Freescale

Due to its historic relationship with Motorola, Freescale supplies nearly all its baseband needs. This situation is unlikely to continue, as MOT has selected TI and QCOM for certain handsets.

The up-and-coming

MediaTek

MediaTek supplied c5% of the baseband market in 2006, predominantly via low cost Chinese handset manufacturers. MediaTek goes one step further than the other companies we discuss in this report, designing handsets as well as the chips that go inside them. In 2007, our MediaTek analyst, Andrew Lu, estimates that the company will supply c10% of the market, rising to c15% in 2008. Considering that the top 5 manufacturers have c80% market share, this implies MediaTek is selling to a large proportion of the Tier 2 & 3 players.

Broadcom

Broadcom entered the wireless market relatively late compared to its US and European peers. It has used its expertise in consumer electronics and wireline ICs to develop handset chips with multimedia processing capabilities and is taking an aggressive approach to integrating multiple radio functions into baseband chips. Broadcom supplies Samsung with a WCDMA baseband chip and has been selected by Nokia to supply its EDGE single chip solution. Broadcom announced the availability of a single chip HSDPA product, although we are not aware of any customer wins yet. Broadcom is targeting baseband market share of 10-15% by 2009.

Spreadtrum

Spreadtrum designs chips for the Chinese market, in particular producing dual-mode TD-SCDMA/GSM chips. The company has entered into a partnership with ZTE for TD-SCDMA and has announced that it supplies BYD, Hisense, Lenovo and Panda Group. The company recently announced plans to acquire an RF transceiver company, allowing it to offer a complete solution to handset manufacturers.

The recovery plays

Infineon

Infineon historically has had a decent position in the baseband market, as it supplied Siemens handsets. However, with Siemens' sale to BenQ and then BenQ's subsequent withdrawal from the handset market, its share was in danger of dropping to near zero. To counter this, the company has made efforts to win new significant customers and now supplies two of the top five with baseband chips. Its single chip solution has proved popular with low cost handset manufacturers in China and its WCDMA solution is used by Panasonic. We believe its EDGE platform was selected for use in the iPhone.

Infineon announced in August 2007 it would be buying LSI Logic's wireless business and the acquisition completed in October. LSI acquired its wireless business when it bought Agere in April 2007. LSI supplies baseband chips to Samsung.

ST

ST halted development of GSM/GPRS baseband products in 2005, preferring to focus on developing 3G digital baseband chips. In December 2006, ST announced that EMP had selected this chip. In August 2007, Nokia announced it would be using ST for its 3G baseband chips. This is not straightforward, as the deal involves a team of Nokia engineers moving to ST, and then ST licensing technology from Nokia. We view this as Nokia "outsourcing" its custom chip design to ST.

The laggards

Analog Devices

ADI has only a small share of the baseband business (<1%), but it has developed TD-SCDMA baseband and RF technology. We believe this is what attracted MediaTek to buy ADI's wireless business.

NXP

NXP's Nexperia platform is used by Samsung and several Chinese handset manufacturers. The acquisition of Silicon Labs in February 2007 has given NXP access to RF integration technology, and the company sells SLAB's AeroFONE single chip solution.

Future shape of baseband market

Based on chip design wins year to date and changes to handset manufacturers' market positions, we estimate baseband market shares in 2008.

Figure 12. Handset Chip Suppliers, 2008 (Estimated)

2008	GSM/GPRS		EDGE		WCDMA		CDMA	
	Baseband	RF	Baseband	RF	Baseband	RF	Baseband	RF
Nokia	TI*, IFX*	IFX	TI, BCOM*	IFX,RFMD, ST	TI, ST	ST	QCOM	QCOM
Motorola	FSL, TI*	RFMD	FSL, TI, TI*	RFMD, TI, Sky	FSL, TI, QCOM	FSL, IFX, QCOM	QCOM	QCOM, RFMD
Samsung	NXP, IFX	NXP	IFX	IFX, NXP, Sky	QCOM, BCOM	IFX	QCOM	QCOM
Sony Ericsson	EMP, TI*	EMP	EMP	EMP	EMP, Renesas	EMP	QCOM	QCOM
LG	IFX*, MediaTek	Sky	IFX, MediaTekl	IFX, Sky	QCOM, EMP	QCOM, EMP	QCOM	QCOM, Sky
BenQ-Siemens	MediaTek		MediaTek	Sky				
Sagem	TI*	NXP	TI	TI, FSL	EMP	EMP		
Sharp					Renesas, EMP	Renesas, EMP	QCOM	QCOM
TCL-Alcatel	MediaTek, TI*							
Sanyo							QCOM	QCOM
Kyocera							QCOM	QCOM
Ningbo Bird	IFX*, MediaTek						QCOM	QCOM
NEC					Adcore	Adcore		
Panasonic					IFX, Adcore	IFX, Adcore		
ZTE	IFX*						QCOM	QCOM
Pantech Group							QCOM	QCOM
UTStarcom							QCOM	QCOM
Toshiba							QCOM	QCOM
RIM	Marvell	FSL	Marvell	FSL			QCOM	QCOM
Amoi			IFX		QCOM, EMP	QCOM, EMP		
Haier	NXP	NXP						
Lenovo	BCOM, MediaTek	RFMD, NXP	NXP, MediaTek	NXP, Sky				
Fujitsu					Renesas	Renesas		
Konka	MediaTek		MediaTek	Sky				
Mitsubishi					Renesas	Renesas		

Notes: *=single chip solution; RF=transceiver

Abbreviations: TI=Texas Instruments, IFX=Infineon, FSL=Freescale, Sky=Skyworks, EMP=Ericsson Mobile Platforms, BCOM=Broadcom, QCOM=Qualcomm.

Source: Citi Investment Research

Figure 13. Baseband Market Share, 2008E (Percentage of Units)

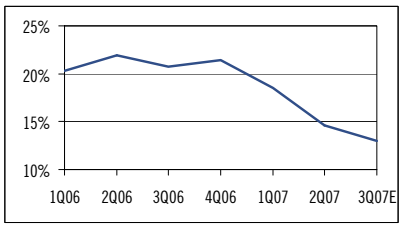
Texas Instruments	43.6%
Qualcomm	15.0%
MediaTek	13.0%
Freescale	9.5%
Infineon	9.2%
NXP	2.4%
ST	1.7%
NEC Electronics	1.7%
Renesas	1.6%
Broadcom	1.3%
Marvell	0.5%

Source: Citi Investment Research

We make the following assumptions regarding handset manufacturer market positions:

- Nokia: We assume the company's share of the US market falls, in line with the trend seen over the last two years. We slightly reduce its share of EDGE as we believe this was disproportionately high in 2006.
- Motorola: As the company lost market share from 4Q06, we assume the company manages to regain a small amount of share in 2008, but is still at a lower level than the 21.1% achieved in 2006.
- Samsung: Based on market share data year-to-date, we estimate that Samsung has gained share at Motorola's expense.
- Sony Ericsson: As Sony Ericsson gained share through the course of 2006, and has stabilised at that level in 2007, we use a higher share than for 2006.
- LG: We use the same share as in 2006.
- BenQ: We assume the share falls to very low single digits, as the company only sells handsets in Asia.
- We maintain the remaining vendors at similar shares to 2006.

Figure 14. Motorola Market Share, 1Q06-3Q07E



Source: Gartner and Company Reports.

Future trends

We see several trends operating over the next three to five years:

Further integration of baseband with RF

To date, this has been focused on the low-end of the market, where cost is critical. We expect chip manufacturers to expand their single chip products to include increasing complexity. For example, Infineon's EDGE single chip will ship from 2H07, and TI's EDGE single chip has already been selected by Motorola and should ship from 2008.

In October 2007, Broadcom announced the availability of its Zeus chip (BCM21551), a single chip 3G solution. The chip integrates a baseband capable of processing up to HSDPA, transceivers for HSDPA/WCDMA/EDGE/GPRS/GSM, power management, Bluetooth and FM radio. Broadcom is sampling the chip and expects design-ins in 2008.

Consolidation of baseband chip market

Over the last 12 months, we have seen several changes in the baseband chip landscape, as laggard or recovery chip makers have bought businesses to complement their existing technologies and customer relationships, or have sold off underperforming business lines. We think this trend still has further to play, as the number of chip suppliers remains high compared to the customer base.

Figure 15. Baseband Industry Consolidation

Asset sales	Acquirer	Seller	Details
Sep-07	MediaTek	ADI	Wireless business
	Infineon	LSI Logic	Baseband business (includes business acquired from Agere)
Feb-07	NXP	Silicon Labs	Cellular business
Nov-06	Marvell	Intel	Communications & application processor business
Other			
2006	Skyworks		Exited baseband business

Source: Citi Investment Research

Emergence of Chinese 3G

The Chinese government has been on the verge of licensing 3G technologies for several years now. Ultimately, the government plans to license three 3G technologies: WCDMA, cdma-2000 1x and TD-SCDMA, a home-grown technology. The introduction of TD-SCDMA opens up a brand new market for baseband chip manufacturers.

China Mobile is currently building out TD-SCDMA commercial trial networks in eight cities (including Beijing, Shanghai, Guangzhou, Shenzhen and Qin-huang-dao). TD-SCDMA handsets are required to be dual-mode ie TD-SCDMA/GSM, hence will need dual-mode baseband chips. Our China Mobile analyst, Michael Meng, expects the company to start ordering handsets on a limited scale in 4Q07.

Motorola expects to launch TD-SCDMA handsets in 2H08, in collaboration with local companies. Nokia plans to ship handsets in early 2008.

A limited number of chip companies have TD-SCDMA products, including Analog Devices, T3G (a joint venture of Datang, NXP, Motorola and Samsung), Commit (a joint venture of Potevio, CATR, TI and Nokia) and Spreadtrum. MediaTek recently announced the planned acquisition of ADI's cellular business, mainly, we believe, to access this technology.

Changes to IP ownership

Qualcomm/Nokia and Broadcom/Qualcomm are involved in various patent infringement cases, both for CDMA and GSM-based technology. During the course of the litigation, it is possible that injunctions could be imposed on any of the parties. This would force customers to seek out new suppliers and could change the market share landscape. If the Qualcomm litigation results in changes to its business model (forcing QCOM to charge lower royalty rates), this could help stimulate handset sales as lower priced handsets become possible, particularly for 3G.

Implications for our companies

Considering the above trends, we believe successful baseband companies will need the following:

- RF CMOS integration expertise. A stand-alone baseband supplier is going to find it difficult to compete against single chip suppliers on a cost and footprint basis.
- Good relationships with top 5 handset OEMS. As c80% of the market is supplied by the top 5 handset manufacturers, a baseband manufacturer needs to build relationships with some, if not, all top 5 OEMs in order to generate meaningful volumes.

We discuss below how our companies are positioned considering these factors.

Infineon

1. Infineon has strong RF integration expertise and was the first chip company to ship a single chip product. It is currently in volume production with its second generation GSM single chip product (ULC2). It is due to ship an EDGE single chip product by the end of 2007 to several (as yet unnamed) customers.
2. Having struggled to cope after BenQ acquired the Siemens handset business, the company now has strong relationships with the top 5 OEMS:
   - Nokia: supplies transceivers for GSM/GPRS and will ship single chip GPRS from early 2008; starting to ship EDGE transceivers.
   - Motorola: recently announced it would be developing a WCDMA transceiver for Motorola. This could open the way to Infineon supplying baseband chips to Motorola in the future.
   - Samsung: supplies EDGE transceivers. Although unannounced, we believe Infineon may supply WCDMA transceivers for Samsung.
   - Sony Ericsson: Infineon was recently selected to supply 3G transceivers for EMP, as a second source to NXP.
   - LG: Infineon supplies its ULC2 single chip for GSM/GPRS as well as its EDGE platform.

ST

1. It is not clear to us that the company has sufficient expertise in this area. The company's main focus in wireless is on digital 3G baseband, its Nomadik application processor and peripheral chips such as Bluetooth, WiFi and camera sensors. On the conference call to discuss the recent Nokia/ST agreement, ST stated that it would be working on RF CMOS for its 3G design, but that initial chipsets would not integrate RF. The company expects an integrated 3G product to be available by late 2010.

2. ST has strong relationships with some of the top 5, although not for baseband.

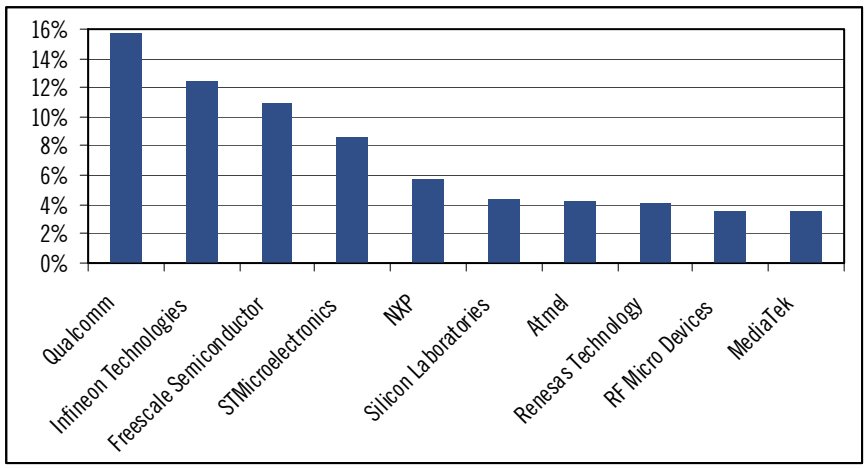
    - Nokia: ST will provide 3G baseband from 2010. ST currently supplies EDGE and 3G RF ASICs.
    - Motorola: no relationship.
    - Samsung: ST supplies its Nomadik application processor for certain models.
    - Sony Ericsson: ST was selected to supply its 3G digital baseband to EMP at the end of 2006, replacing TI in the majority of models.
    - LG: ST supplies its Nomadik application processor for certain models.

RF Market

Current status of RF market

There is a different supplier base for the transceiver market compared to the baseband market. In 2006, the largest RF transceiver supplier by value was Qualcomm, supplying 16% of the market, as it supplies the majority of the CDMA RF market. Infineon was the second largest supplier, partly due to its strong position in the DECT cordless phone market. Smaller specialist RF companies such as RF Micro Devices (RFMD), Skyworks and Silicon Labs (now part of NXP) all have a single digit percentage of the market.

Figure 16. RF Transceiver Market Share by Value, 2006 (Percentage)



Source: Gartner, July 2007 (Note: includes revenues from cordless phones and mobile phones)

Within the RF market, there are several types of transceiver design.

1. Single chip transceiver, where the transmit and receive functionality for each radio interface is integrated into one piece of silicon, eg WCDMA/EDGE/GPRS/GSM.

2. Multiple chip packaged transceiver, where there is a separate transmit/receive chip for each air interface eg WCDMA + EDGE + GPRS + GSM

3. Integration into the baseband to create a true single chip product. This requires the use of RF CMOS technology so that the RF functionality can be produced on silicon rather than silicon germanium.

Consolidation to date

Figure 10 and Figure 12 show our estimates of the RF transceiver suppliers for the Top 20 handset manufacturers in 2006 and 2008 respectively. The number of suppliers falls in 2008 to reflect several acquisitions affecting the RF space (see Figure 17).

Figure 17. RF Industry Consolidation

Asset sales	Acquirer	Seller	Details
Nov-07	RFMD	Sirenza	RF components
Nov-07	Spreadtrum	Quorum Systems	RF CMOS transceiver designer
Sep-07	MediaTek	ADI	Wireless business
Feb-07	NXP	Silicon Labs	Cellular business
Dec-06	MediaTek	Airoha	MediaTek took a 41% stake in the company
Jan-06	Qualcomm	Birkana Wireless	RF CMOS solutions

Source: Citi Investment Research

Future shape of RF market

We see three trends that are impacting and will continue to impact the RF market in the medium term:

- Demand for more RF functionality in handsets
- Integration of cellular RF with baseband
- Integration of non-cellular RF functionality

Increasing demand for radio applications

From 2G to 3G

Handsets used to contain only one type of RF functionality – transmitters and receivers for the cellular bands served eg GSM/GPRS at several frequencies (known as dual-band, tri-band or quad-band). As networks have moved to EDGE, WCDMA and HSDPA (or cdmaOne to cdma 1xRTT and cdma 1xEV-DO), handsets have added transceiver functionality for each air interface.

And at some point, 4G

The next generation of RF interface, 4G, is currently under development. As the next step on from HSPA, many GSM-based companies are investigating LTE (Long Term Evolution) and CDMA-based companies are working on UMB (Ultra Mobile Broadband). Companies involved predict that LTE products will be commercially available by 2009. The GSMA recently announced its backing for LTE. Alcatel, Cisco, Intel, Motorola, Nortel and Samsung support a third alternative, mobile WiMAX.

Other radio functions

With the introduction of Bluetooth (using the unlicensed 2.4MHz band), this added a second radio function. Other optional functions include WiFi (also using the unlicensed 2.4GHz band), GPS (1.575GHz – receiver only), DVB-H (depends on country – typically in the UHF band 400-750MHz or L-band 1.4GHz), T-DMB (used in South Korea (200MHz) and Germany (1.4GHz)), FM radio (88-108MHz), UWB (>6GHz), and NFC (using the unlicensed 13.56MHz band).

Handset manufacturers adding more than just basic cellular functionality to their products will need to consider the size and cost of the additional chips as well as the potential interference between the different radios.

Integration of cellular RF functionality

We have already seen this process begin, with RF integrated with baseband in GSM/GPRS chips from Texas Instruments and Infineon, and soon to be available EDGE single chip products from the same companies plus Broadcom.

In October, Broadcom announced that it had developed an HSUPA single chip that integrates baseband, transceiver, Bluetooth 2.1 with EDR, an FM radio receiver and an FM radio transmitter. Qualcomm has indicated that it will have a UMTS single chip product available in 2H08.[1] ST plans to develop a 3G single chip product although this is unlikely to be available until late 2010.

The impact of this integration is that stand-alone transceiver companies are going to see a long-term decline in sales. For those supplying baseband and RF, the ability to produce single chip products should (partially) compensate for the loss of transceiver sales.

Integration of non-cellular RF functionality

We have discussed the increasing demand for additional non-cellular radio functionality in handsets. Currently, each function tends to be provided by a separate chip, and this tends to consist of integrated baseband and RF functionality. In the Bluetooth market, CSR was the first company to successfully integrate the baseband and RF, and now it is unusual to find companies supplying separate chips. The exception is Qualcomm, as it integrates Bluetooth baseband functionality into the cellular baseband chip. Any handset using this chip will require a separate Bluetooth radio chip.

[1] "We remain on track, I believe, to deliver handsets in the marketplace based on single chip solutions in the second half of next year" Sanjay Jha, Qualcomm 4Q07 conference call, 8 Nov 2007.

We are seeing companies beginning to move from separate integrated chips to combining several different radios on one chip. For example, Broadcom's BCM2048 and CSR's BlueCore5 integrate Bluetooth and FM radio functionality on one chip. We think that over time, chip makers will go one of three ways:

- Integrate several radios onto one chip eg Bluetooth, WiFi, NFC, GPS.
- Integrate some of the RF functionality into the application processor.
- Integrate some of the RF functionality into the baseband chip.

Broadcom's Zeus chip appears to be following the third route. Conversely, CSR has spoken about its aim to follow the first route and ultimately to combine these functions with the audio and power management functions. The company argues that integrating analog/mixed signal functionality with low linewidth digital functionality can result in sub-optimal performance for several of the functions.

Implications for our stocks

CSR

CSR has already proven that it has RF integration capability for Bluetooth. The company has developed a single chip WiFi product (UniFi) targeted at the UMA handset market although this has seen limited success to date. BlueCore 5 integrates Bluetooth and FM radio onto single chip. If the market develops in the direction of a single radio chip containing various functions (eg Bluetooth, WiFi, UWB, DVB-H/T-DMB), we see CSR as having the necessary skills to be successful in this market. CSR has stated that it does not see the various non-cellular functions being integrated into the baseband, as this would result in performance geared to the lowest common denominator. We also view CSR as an attractive target for a company lacking such skills – its current market cap of US$1.6bn would be a digestable acquisition for one of the larger wireless players.

Infineon

Infineon has significant RF expertise and is a leader in RF integration. Its GSM/GPRS single chip has proved successful (selected by Nokia) and the company is soon to launch its EDGE single chip. The product roadmap includes single chip 3G. The plan is to maintain the platform alongside single chip products to serve all segments of the market.

Infineon's single chip expertise means that it can partially compensate for the reduction in demand for RF-only chips.

Infineon is not a strong player in non-cellular RF chips. It supplies Bluetooth chips as part of its platform solution when required, but rarely sells them on a stand-alone basis. Due to the acquisition of its technology partner, Global Locate, by Broadcom, its GPS solution will be phased out. Infineon is willing to consider further partnerships or licensing deals to access such technologies, but is not willing to devote significant R&D resources to developing products in-house. We see the potential for such expertise to be bought in if Infineon manages to sell its stake in Qimonda for cash (as opposed to spinning off Qimonda shares to shareholders).

ST

ST has supplied custom RF products to Nokia for many years. However, its integration ability is in doubt – no single chip products are available yet (a function of having terminated development of GSM/GPRS baseband). On the conference call to discuss Nokia's 3G plans, ST stated that it would ultimately develop a single chip 3G solution, but with no prior expertise we would not expect this to lead the market. We view ST as a potential acquirer of RF expertise.

ST has more expertise in the non-cellular RF space, with solutions for Bluetooth and WiFi. ST has tended to sell these mainly to Nokia and is likely to continue to do so, particularly when it starts to supply 3G solutions to Nokia.

Other Handset Chips

Application processors

Application processors deal with the computational needs of peripheral functions such as cameras, mp3, video, etc., leaving the baseband free to concentrate on optimising the cellular functionality of the phone. Increasing demand for smartphones drives the need for application processors. Initially, application processors were developed as stand-alone chips. Products include:

- Broadcom: BCM2820 (high performance low power application processor) and BCM2702/2722/2724/2727 (high performance mobile multimedia processors).
- Freescale: iMX family of multimedia application processors. We would only expect to see this used with Freescale's platform in Motorola handsets.
- Marvell: PXA 3xx and 2xx families of application processors.
- Renesas: the SH-Mobile family of application processors. Customers include LG and Sagem.
- ST: the Nomadik processor. After a slow start, this has been designed into several Nokia, LG and Samsung handsets.
- TI: the OMAP processor family (OMAP331/1510/16xx/1710/24xx/34xx). TI has also supplied Japanese FOMA handset manufacturers since FOMA was launched in 2001. FOMA subscribers totalled c35m at the end of June 2007. TI is the largest application processor supplier, counting Nokia, LG and Samsung as customers.

More recently, chip designers have started designing baseband processors with integrated application processor functionality. TI's OMAP7xx/850 processors consist of integrated baseband and application processing functionality, as do NEC Electronics' M1 and M2 chips and Renesas' SH-MobileG1 & SH-MobileG2 chips. This has the benefit of combining two digital chips which can be manufactured at leading edge linewidths to get maximum performance with minimal footprint.

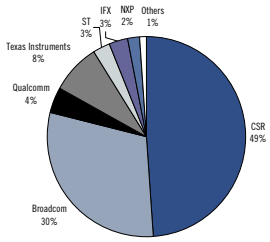
Bluetooth

The current version of Bluetooth is v2.1 + EDR (enhanced data rate). The next iteration will be v3.0, which will use ultra wideband (UWB) technology with Bluetooth software protocols. Also being developed is Ultra Low Power (ULP) Bluetooth (formerly known as WiBree). With power consumption equivalent to the shelf-life of a battery (up to 10 years for a Li ion battery), we see ULP Bluetooth as being extremely attractive for a number of low power portable products.

CSR maintains its No1 position in terms of unit shipments. We estimate below volume market share in 2006 and 2007. We believe that Qualcomm has gained share this year at the expense of Broadcom[2], due to the fall in Motorola's market share leading to share gains by Qualcomm customers' LG and Samsung.

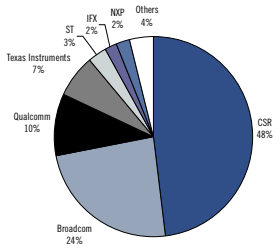
[2] Qualcomm integrates Bluetooth into the baseband chips in its Multimedia & Enhanced Multimedia chipsets. For a complete Bluetooth solution, a handset manufacturer needs to add a Bluetooth RF transceiver.

Figure 18. Bluetooth Unit Market Share, 2006 (%)



Source: Citi Investment Research

Figure 19. Bluetooth Unit Market Share, 2007 (%)



Source: Citi Investment Research

Bluetooth has proved to be an ideal starting point for further RF integration. Broadcom, CSR and ST have all started integrating FM radio functionality into their Bluetooth solutions. Broadcom and Texas Instruments have even started combining Bluetooth, WiFi and FM radio.

Figure 20. Bluetooth Solutions

Company	Product	Description
Broadcom	BCM2004	Radio for Qualcomm-based handsets
	BCM2037	V2.0 + EDR wireless audio processor
	BCM2040	Single chip BT for mouse & keyboard
	BCM2042	Advanced wireless keyboard/mouse BT chip
	BCM2044	Single chip BT mono headset chip
	BCM2044S	ROM-based noise & echo reduction mono headset chip
	BCM2045	Advanced single chip BT solution
	BCM2046	Single chip BT EDR HCI solution
	BCM2047	Single chip BT wireless audio solution with DSP
	BCM2048	BT EDR single chip solution with integrated FM & RDS radio receiver
	BCM4325	Low power 802.11a/b/g with BT v2.1+EDR & FM
CSR	BlueCore 3 (v1.2 platform).	BlueCore3-ROM (single chip solution with on-chip MCU & 4Mb ROM)
		BlueCore3-Multimedia/BlueCore3-Multimedia Flash (single chip solution with on-chip DSP and stereo codec for high-end headset/headphone applications)
		BlueCore3-Multimedia Plug-n-Go
	BlueCore4 (v2.0+EDR).	BlueCore4-Ext (single chip solution with on-chip MCU, an external flash memory interface. Ideal for high datarate/multi-link PC applcaitions).
		BlueCore4-ROM (single chip solution with on-chip MCU & 4Mb ROM)
		BLueCore4-ROM Plug-n-Go/BlueCore4-Flash Plug-n-Go
		BlueCore4-Audio ROM (single chip solution for headsets with an on-chip mono codec peripheral, 6Mb of embedded ROM, switch-mode power supply, battery charger circuitry)
		BlueCore4-Headset (single chip headset solution based on BlueCore4-Audio ROM with embedded application firmware).
	BlueCore5 (v2.1+EDR)	40% smaller than BlueCore4 as made on 0.13micron. BlueCore5-Multimedia (programmable, single chip solution with on-chip DSP, stereo codec and flash. Ideal for high-end headsets/headphones).
		BlueCore5-FM (single-chip solution with on-chip MCU, 6Mb ROM, embedded FM radio with RDS demodulator).
	BlueCore6	v2.1+EDR plus new baseband codec option called AuriStream that improves voice quality and power reduction). Available from 1H08.
Infineon	Single-chip solution	BlueMoon UniCellular (v2.0+EDR)
		BlueMoon single Cellular (v1.2)
	Module	UniStone module (v2.0+EDR)
		SingleStone module (v1.2)
NXP	BGB210S	v2.0+EDR single chip solution
	BGB204	v2.0 SiP (system in package) with embedded ROM
	BGB203	v2.0 SiP with embedded flash
Qualcomm	BTS4020	v2.0+EDR SoC solution
	BTR1722	Transceiver for CDMA & WCDMA phones
ST	STLC2592	v2.1+EDR & RDS FM radio combo solution. Combines STLC2500D Bluetooth chip and Si4701 FM radio chip
	STLC2590	v2.0+EDR & RDS FM radio tuner combo solution
	STLC2500C	v2.0+EDR single chip solution
TI	BlueLink 7.0	Single chip (integrated Bluetooth & FM (transmit & receive)) - sample by end 2007, handsets on the market in 2008.
	BlueLink 6.0	BRF6350 – integrated Bluetooth v2.1+EDR and FM receive single chip.
	BlueLink 5.0	BRF6300 – Bluetooth v2.0 + EDR single chip
	BRF6150	v1.2 single chip

Source: Company Reports

GPS

GPS has become the most talked about function in handsets this year. The launch of Nokia's N95 with GPS functionality has brought the topic into the mainstream, after several years of increasing adoption, particularly in the US market. The high profile planned acquisitions of map providers (TomTom/TeleAtlas, Nokia/Navteq) have also helped bring location-based services into the public eye.

InStat estimates that 180m handsets will have GPS functionality in 2007 (c16% penetration), rising to 720m (c46%) in 2011, a CAGR of 41%.

The basics of GPS

The Global Positioning System (GPS) consists of 24 satellites orbiting the Earth. The satellites travel at 7,000 mile/hour, meaning that they travel round the earth on a precise orbit once every 12 hours. Satellites transmit low power (50W) signals on several frequencies: the L1-band (at 1575.42MHz) has been designated as the civilian frequency. Each satellite transmits a constant stream of information, containing three types of data:

- Pseudo-randomcode: This is an ID code that identifies which satellite is transmitting information.
- Ephemeris data: This comprises orbital information for the satellite as well as for the other satellites in the system. Ground monitor stations keep track of satellite orbits, altitude, location and speed and send this data to a master control station. This sends corrected data up to the satellites – the corrected data is valid for 4-6 hours.
- Almanac data: This contains information about the status of the satellite, the current date and the time.

To calculate a 2D position (longitude and latitude), the GPS user needs to receive a signal from at least three satellites. To calculate a 3D position (longitude, latitude and altitude), the user needs to receive a signal from at least four satellites.

For the GPS receiver to calculate its position, it needs to know two things: where the satellites are (location) and how far away they are (distance).

The **location** of the satellites is contained in the almanac data which is constantly corrected and updated by the ephemeris data.

The **distance** of the user from each satellite is calculated using the equation:

velocity x travel time = distance

The velocity used is the speed of light reduced by the delay as the signal passes through the Earth's atmosphere. The system uses an average amount of delay in the calculation. The travel time is calculated by comparing the pseudo-random data generated by the satellite with the same data generated by the receiver. The receiver calculates how much it needs to shift its own code to match the satellite code – this delay is travel time used in the equation.

Once the GPS receiver has locked onto a sufficient number of satellites to calculate a position, the user can start using the device to navigate. A problem for GPS devices is the time it can take to lock onto sufficient satellite signals. The time taken to lock-on is called the "time to first fix" or TTFF.

GPS device manufacturers tend to quote four different TTFFs:

- Factory: This is the TTFF when the device has no almanac or ephemeris data stored. This could take around 15 minutes.
- Cold: This is the TTFF when the device has stored almanac data but has no up-to-date ephemeris data. Ephemeris data is broadcast for 30 seconds every 30 seconds. If there is an error in receiving the data, the device will have to wait for the next 30 second cycle and ensure this is completely received.

- Warm: This is the TTFF when the device has some ephemeris data.
- Hot: This is the TTFF when the device has nearly a full set of ephemeris data.

The receiver needs a line of sight to the satellites. The satellite's signal can pass through clouds, glass and plastic but is obstructed by more solid objects such as buildings, mountains and trees. This means that the receiver will not work inside or underground. The signal can also experience delays in travel time if it bounces off of surfaces before reaching the receiver. This is known as multi-path error.

The process is computationally complex, requiring substantial processing power in the device. This is not a problem for devices where size is not an issue, eg in-built automotive GPS systems or portable navigation devices. However, the cost of including the necessary hardware and software in a handset would be prohibitive.

To reduce the hardware requirements and to overcome the problem of receiving a signal when indoors, several techniques have been developed to provide location-based data for handset users. Demand for such techniques has been driven by the E911 requirement in the US. The Federal Communications Commission (FCC) in the US mandates that it must be possible to pinpoint the location of a cellphone user to the nearest 50-300 metres to enable emergency services to find the person in the event of an emergency.

Methods considered include:

- TDOA: time difference on arrival
- EOTD: enhanced observed time difference
- AFLT: advanced forward link trilateration
- A-GPS: assisted GPS

The most commonly used method in handsets is a-GPS.

Assisted GPS (a-GPS)

Assisted GPS (a-GPS) makes use of the cellular network to speed up the TTFF. By positioning GPS receivers at base stations, these receivers can continuously receive data from satellites and store it on assistance servers. When a user wants to pinpoint his position, his handset will identify the nearest base station, and the assistance server at that base station can provide up-to-date satellite location data (that the user would otherwise have had to download from the nearest three/four satellites) over the cellular network. This helps the receiver in the handset to find the closest satellite signals by narrowing down the number of satellites that could be in range.

A-GPS helps the user to receive a signal when indoors by narrowing down the range of possible frequencies that need to be searched for a signal. This allows the receiver to spend longer searching fewer frequencies, increasing the possibility of receiving the necessary data.

Information provided by the server will be either ephemeris data (which should be relatively accurate as the base station is sufficiently close to the device) or acquisition data (code phases and Doppler ranges over which the mobile has to search).

The assistance server can also reduce TTFF by performing some of the necessary calculations, reducing the burden on the handset's host processor.

GPS chip suppliers

We focus on those semiconductor companies supplying the handset market, as opposed to those supplying the PND market. Not included in the table is MediaTek: the company is currently working with Taiwanese GPS module manufacturers to provide a solution to handset manufacturers. However, MediaTek is working to develop its own GPS baseband IC which we expect will be launched in 1Q08.

As Qualcomm's solution is integrated into many of its chipsets, it has a large share of the handset GPS chip market. Nokia's N95 uses TI's NaviLink product and SiRF supplies Motorola handsets (having acquired Motorola's GPS chipset business in 2005).

Figure 21. Suppliers of GPS Chips for Handsets

Company	Products (sensitivity)	Detail
Broadcom	BCM 4750 (-162dBm tracking)	Expertise gained through acquisition of Global Locate in July 07. Single chip a-GPS solution made on 90nm RFCMOS. Interfaces with phone's host processor.
CellGuide	CGX5900 (-160dBm); CGA3100	GPS co-processor (uses host processor); GPS RF front-end
CSR	E5000; enhanced GPS	Software GPS receiver, runs on the host processor; enhanced GPS is the name of the software solution acquired from CPS in January 2007
eRide	OPUS III chipset (-161dBm acquisition & tracking); OPUS III ezRide-2x/nanoRide	Opus III baseband IC plus prelude III RF receiver (Navigation Software uses host processor); module containing Opus III chipset.
GloNav	GNS4540 (-157dBm acquisition, -159dBm tracking); GNR1040; DynaTrak technology	Single chip a-GPS solution, uses host processor for navigation software; low power RF IC. GloNav is the combination of CEVA's GPS business and RFDomus.
Infineon	Hammerhead PMB 2520 (-160dBm) & Hammerhead II PMB 2525 (-160dBm)	Single chip a-GPS solution designed in partnership with Global Locate. No further development of GPS chips since Global Locate acquired by Broadcom.
NemeriX	NJ2020 (-158dBm); NX3; NJ1006A; NJ1030A; NEX	Indoor a-GPS baseband (uses host processor); single package a-GPS (baseband & RF); RF front-end; baseband processor; extended ephemeris solution
Qualcomm	gpsOne (-155 to -160dBm)	Fully integrated into handset chipsets - no additional hardware or software required.
SiGe Semiconductor	SE4100L; SE4110L	GPS RF receivers
SiRF	SiRFstar III GSC3LT/GSC3LTf (-159dBm), GSC3e/LP/GSC3f/LP (-159dBm), GSC3LTi/GSC3LTif (-159dBm), GSD3t (-160dBm); SirF Instant GSCi-5000 (-157dBm); SiRFstar II GSC2x (-148dBm)	Single chip a-GPS solutions. GSD3t uses host processor.
SkyTraq	Venus 6 (-155dBm acquisition & -159dBm tracking); Venus 5 (-158dBm tracking); Venus 120	a-GPS baseband chipsets; GPS RF IC
Texas Instruments	NaviLink 5.0 (NL5350); NaviLink 4.0 (GPS5300)	Single chip solutions using TI's DRP technology. Interfaces with TI's 3G chipsets or OMAP processors.
u-Blox	UBX-G5010-ST (-160dBm); UBX-G5000-BT; UBX-G0010-QT	Single chip solution with SuperSense; GPS baseband with SuperSense; GPS RF front-end
u-Nav	uN3010 (-156dBm acquisition)	Single chip GPS solution, uses host processor

Source: Company Reports

FM Radio

For several years, handset manufacturers have been adding FM radio functionality via FM radio receivers. More recently companies have also started to add FM radio transmission capability that allows handsets to transmit data such as music to FM receivers, for example in cars. NXP is the largest supplier of FM radio ICs for all applications and hence has a strong position in the handset FM radio IC market with its TEA57x range of FM radio ICs.

Other companies offer FM radio functionality integrated with other radio functions. Broadcom's BCM2048 integrates Bluetooth and FM radio on a single chip. CSR has a similar product, the BlueCore5 and ST the STLC259x. Qualcomm recently introduced three new single chip solutions that include integrated FM radio and Bluetooth in addition to cellular functionality. While Frontier Silicon is mainly a DAB and mobile TV chip producer, some of its DAB chips also incorporate FM functionality (its Apollo FS1110 RF tuner includes FM mode). Skyworks' SKY74310 FM radio tuners are optimized for small form factor, low power applications. Airoha supplies the AR1000 FM radio tuner.

Mobile TV

Mobile TV has been slow to take off outside of South Korea (T-DMB/S-DMB) and Japan (ISDB-T also known as One-Seg). The table below shows current mobile TV chip offerings. Until spectrum is made available, the adoption of mobile TV is likely to be slow. Spectrum availability is often linked with the adoption of digital TV – when analog spectrum is vacated it is possible that governments may allocate or auction off spectrum to mobile TV operators.

Figure 22. Mobile TV Chip Products

Company	Products
Analog Devices	T-DMB/DAB receivers & tuners, S/T-DMB tuner, DMB-TH tuner, ISDB-T tuners and receivers
Broadcom	BCM2900 dual-band tuner for DVB-T and DVB-H. Covers UHF IV, V (470MHz-890Mhz), US L-band (1670-1675MHz) and L-band (1450-1490MHz).
DiBcom	DIB9080-H (integrated demodulator & RF tuner for DVB-T/DVB-H), DIB19088-H (integrated demodulator & multi-band RF tuner for DVB-T/DVB-H/T-DMB), DIB7000-H (demodulator for DVB-H)
Freescale	MC44CD02 (zero IF DC receiver tuner for DVB-H), MC44CD03 (1.67GHz zero IF DC receiver for DVB-H)
Frontier Silicon	Paradiso 1T FS1032 (single-chip T-DMB RF receiver and baseband demodulator), Paradiso 1 FS1030 (DVB-H/T-DMB/DAB baseband demodulator), Kino 2 FS1026 (T-DMB baseband demodulator), Apollo FS1110 (tri-band dual-mode T-DMB RF receiver).
Infineon	OmniVia TUS9090 (mobile TV silicon tuner & demodulator for DVB-H/T), OmniTune TUA 9000 (mobile TV silicon tuner for DVB-H/T).
NXP	TDA18291HN/C1 (low power DVB-H/T tuner in VHFIII & UHF bands)
Qualcomm	Pioneered MediaFLO technology for mobile TV. MBD1000 multicast chipset: includes RBR1000 radio receiver which operates in the 700MHz spectrum. MBP1600 solution, the first Universal Broadcast Modem, supports MediaFLO, DVB-H and 1-seg ISDB-T
Siano Mobile Silicon	SMS1000 (CMOS receiver chipset for DVB-H/DVB-T/T-DMB/DAB-IP consisting of SMS1001 RF tuner and SMS1002 demodulator), SMS1010 (CMOS single chip receiver for DVB-H/DVB-T/T-DMB/DAB-IP), SMS8021 (passive, ultra low cost chip-antenna for mobile TV, developed in conjunction with Vishay).
Texas Instruments	Hollywood single chip tuner & demodulator: DTV1000 (supports DVB-H operating at 470–750 MHz (UHF) and 1.670–1.675 GHz (L-band)), DTV1001 (supports ISDB-T one-segment operating at 470–770 MHz)

Source: Company Reports

NFC

Near Field Communications (NFC) is a standards-based short-range wireless technology that enables safe two-way interactions between electronic devices. NFC is a variant of RFID and operates at 13.56MHz, enabling data transfer at up to 424kb/s. Devices need to be 4cm or closer together to communicate. NFC can be used to perform contactless transactions such as payment via mobile phone, transfer of information from digital cameras, and payment for travel, as well as acting as an electronic key to access buildings or vehicles. The NFC Forum has credit card companies, handset manufacturers, chip manufacturers and software companies amongst its members.

In Japan, Sony has pioneered the use of NFC with its FeliCa service. This enables mobile phones to be charged up with cash and then used for payments wherever there is an NFC reader.

The MIFARE platform is NXP's NFC solution. NXP has trialled NFC chips in South Korea with SKT, in Germany with the regional public transport authority for Frankfurt Rhine-Main and in France for the city of Caen. After the trial in Germany, the transport authority has decided to roll-out the service commercially.

In November 2007, NXP and Sony announced their Moversa joint venture. Moversa will plan, develop, produce and market a secure chip, the Universal Secure Access Module (U-SAM) that incorporates both MIFARE and FeliCa operating systems and applications. The U-SAM will also support other contactless operating systems and applications based on customer requirements. First samples of the secure chip will be available by mid-2008 for solutions embedded in mobile phones with initial commercial deployments targeted for the end of 2008. NXP and Sony will continue to offer chips and applications based on their respective technology platforms MIFARE and FeliCa, while developing NFC technologies jointly.

Also in November 2007, Nokia, and O2 announced the start of a six-month trial of the O2 wallet in London. This is an NFC-enabled handset (Nokia 6131) that can offer Barclaycard and Oystercard functionality. The phone can be used to pay for travel within the London area, to get information from smart posters and to pay for small ticket items (sub £10) at participating retailers.

WiFi

Suppliers of WiFi chips for handsets tend to be the same companies that supply Bluetooth. This is still a relatively small market compared to Bluetooth.

Figure 23. Handset WiFi Chip Suppliers

Company	Product	Description
Broadcom	BCM1161	Mobile VoIP processor
	BCM4318E	AirForce One single-chip 802.11g transceiver with BroadRange technology. Combines high performance 2.4GHz radio, 802.11a/g baseband processor, MAC and other radio components onto a single chip
	BCM91161	WiFi phone reference design – comprises BCM1161 & BCM4318E
	BCM91161VP	WiFi Video Phone reference design – as for 91161 with addition of BCM2702 multimedia processor
CSR	UniFi-1	Single chip 2.4GHz 802.11b/g in small footprint packages for handheld devices
	UniFi-2	Single chip solution supporting both 2.4GHz/5GHz 802.11a/b/g in three variants: portable a/b/g (802.11a/b/g), portable (802.11b/g), enterprise (802.11a/b/g +PCIbus/CardBUs interfaces).
Freescale		Supplies PAs for 802.11a and 802.11g.
Marvell		No handset products listed on website, but Marvell is known to be the WiFi supplier for the iPhone
Qualcomm	WBF400	802.11n chipset solution: combines WFB4030 MAC/baseband with WFR4031 dual-band radio.
ST	STLC4550	Single chip 802.11b/g solution
TI	WiLink6.0	WL1271. Single chip with WLAN 802.11b/g, Bluetooth v2.1+EDR & FM radio functionality. Integrates MAC/baseband for WLAN & BT, radio for WLAN & BT, MAC/BB for FM & radio for FM (transmit & receive). Needs a separate WLAN/BT front-end. Made on 65nm CMOS process & DRP technology.
		WL1273. Single chip with WLAN 802.11a/b/g/n, Bluetooth v2.1+EDR & FM radio functionality. Integrates MAC/baseband for WLAN & BT, radio for WLAN & BT, MAC/BB for FM & radio for FM (transmit & receive). Needs a separate WLAN/BT front-end. Made on 65nm CMOS process & DRP technology.
	WiLink5.0	Module made up of WiLink 4.0 (WLAN MAC/BB/RF chip), power management chip, BlueLink 6.0 (Bluetooth v2.1+EDR & FM single chip). Made using a 90nm CMOS process and DRP technology.
	WiLink4.0	WL1251. Single chip solution for 802.11b/g.
		WL1253. Single chip solution for 802.11a/b/g.

Source: Company Reports

Appendix 1: Product Teardowns

Product Teardowns

Figure 24. Handset Teardowns

Chip	Supplier	Code
Blackberry Pearl 8100		
Application processor	Marvell	PXA900B3C312
Power management	Texas Instruments	TP565820RSH
RF transceiver	Freescale	MMM6000
PA	Freescale	MMM6027
Bluetooth	CSR	BC41B143A05
Audio codec	Maxim	MAX9853ETM+
NOR flash	Intel	2x256Mb, 1x128Mb
LG Chocolate KU800		
Baseband processor	Qualcomm	MSM6275
Power management	Qualcomm	PM6650
RF transceiver	Qualcomm	RTR6250, RFR6250
PA	Triquint/Anadigics	TQM7M 5003/AWT6277R
Bluetooth module	Kyocera	RB06A
Image sensor	Micron	MT9D011
Memory	Toshiba	256Mb NOR + 64Mb PSRAM in MCP
MEMS microphone	Knowles Acoustic	SP 0103BE3
Motorola SLVR L7		
Digital baseband	Freescale	SC29343VKP
Analog baseband	Freescale	MC13890
Multimedia co-processor	ATI	IMAGEON 2240
RF transceiver	Freescale	RF6025
PA module	RFMD	
Bluetooth	Broadcom	BCM2035KWB
Image sensor	Micron	MT9V112
Memory	Intel	256Mb NOR + 64Mb PSRAM in MCP
MEMS microphone	Knowles Acoustic	
Nokia N95		
Baseband processor	Texas Instruments	
Application processor	Texas Instruments	
Power management	STMicroelectronics	
RF transceiver	STMicroelectronics	
PA	RFMD	
Bluetooth	CSR	BC41B143A
WiFi	STMicroelectronics	STLC4550
GPS	Texas Instruments	GPS5300
FM Radio	NXP	TEA5761
Apple iPhone		
Baseband processor	Infineon	XMM 2010 platform
Application processor	Samsung	
RF transceiver	Infineon	XMM 2010 platform
PA	Skyworks, RFMD	
Bluetooth	CSR	BlueCore4 ROM
WiFi	Marvell	
Memory	Samsung/Intel	8GB NAND, 1Gb DRAM/ 32Mb NOR + 16Mb PSRAM in MCP
MEMS accelerometer	ST	
Audio codec	Wolfson	
Touch screen controller	Broadcom	

Source: Citi Investment Research

Appendix 2: Company Snapshots

Analog Devices (ADI)

Analog Devices wireless revenues made up 7% of FY07 revenues. The wireless business supplies baseband processors, RF transceivers, and power management chips as well as cellphone platforms.

In September 2007, MediaTek announced it would be acquiring ADI's wireless business. The acquisition is due for completion by the end of 2007.

Figure 25. Revenues, FY07 (y/e Oct)

	US$m
Revenues* (total)	2705
Wireless business**	194

*Including discontinued revenues

**Discontinued revenues

Source: Company Reports

M&A History

- **July 2006:** ADI acquired Integrant Technologies Inc (Integrant). Integrant supplies low-power radio tuners that allow mobile communications, computer and consumer devices to receive digital TV and digital radio broadcasts. Integrant already supplies tuners that are used in T-DMB handsets in Korea and ISDB-T handsets in Japan.
- **May 2006:** ADI acquired certain intellectual property assets from TTPCom Ltd. The acquisition included intellectual property, engineering resources and related assets associated with the support and customization of TTPCom's GSM/GPRS/EDGE modem software for use in ADI's existing and future generations of SoftFone baseband processor.

Product Portfolio

Figure 26. Analog Devices Wireless Product Portfolio

Product	Air Interface	Details
Baseband ICs		
AD6720 SoftFone	GSM/GPRS	Integrated analog & digital baseband processor
AD6721 SoftFone	GSM/GPRS	Integrated analog & digital baseband processor
AD6722 SoftFone	GSM/GPRS	Integrated analog & digital baseband processor for featurephone
AD6525	GSM	Digital baseband processor
AD6526	GSM/GPRS	Digital baseband processor
AD6527/6527B	GSM/GPRS	Digital baseband processor for featurephone
AD6528B	GSM/GPRS	Digital baseband processor for featurephone
AD6529B	GSM/GPRS	Digital baseband processor for featurephone
AD6758 SoftFone (Ares)	GSM/GPRS	Multimedia digital baseband processor
AD6900 SoftFone (LeMans)	EDGE/GPRS/ GSM	Multimedia digital baseband processor
AD6532	EDGE	Digital baseband processor
AD6901 SoftFone (Monaco)	TD-SCDMA	Digital baseband processor
AD6902 SoftFone (Monza)	W-CDMA	Digital baseband processor
AD6903 SoftFone (LeMans-LCR+)	TD-SCDMA/ GPRS	Digital baseband processor
AD6535	GSM/GPRS	Analog baseband processor w/ power management & stereo audio outputs
AD6537B	GSM/GPRS	Analog baseband processor
AD6855 SoftFone (Stratos-S)	EDGE/GPRS/ GSM	Analog baseband processor
AD6555	EDGE	Quad-band analog baseband processor
AD6854 SoftFone (Stratos-L)	TD-SCDMA	Analog baseband processor
AD6857 SoftFone (Stratos-T)	TD-SCDMA	Analog baseband processor
SoftFone chipsets		
SoftFone 430	GSM/GPRS	Digital baseband processor (AD6522/6525/6527/6528), analog/mixed signal interface chips (AD6521/6535/6537) & integrated devices. Compatible with all Othello RF ICs.
SoftFone 500	EDGE/GPRS/ GSM	Digital baseband processor (AD6531/6532/6900/6901/6903), analog/mixed signal interface chips (AD6555/685x) & integrated devices. Compatible with all Othello RF ICs.
SoftFone-LCR	TD-SCDMA	Baseband signal processor, control, RF and analog-interface ICs
SoftFone-LCR+	TD-SCDMA	Baseband processor (AD6903), analog baseband/power management/audio IC (AD6857), RF Transceiver (AD6552/6541/6547)
SoftFone-W	WCDMA/EDGE /GPRS/GSM	Baseband signal processor, control, RF and analog-interface ICs
RF ICs		
Othello-G AD6548	GSM/GPRS	Single chip quad-band transceiver
Othello-E AD6546	EDGE/GPRS/ GSM	Single chip quad-band transceiver
Othello-W AD6541	WCDMA	Monolithic transmitter
Othello-W AD6547	WCDMA	Monolithic receiver
Othello-3 AD6551	WCDMA	CMOS RF transceiver
Othello-3T AD6552	TD-SCDMA	CMOS RF transceiver
Handset Reference Design		
MERCURY	GSM/GPRS	Entry level phones. AD6720 baseband, AD6548 Othello-G transceiver
NOVA	GSM/GPRS	Feature phones.

Source: Company Reports

Broadcom

Broadcom's Mobile & Wireless division made up 30% of revenues in FY06. The division produces baseband processors, RF transceivers, single chip solutions, power management chips, multimedia processors, Bluetooth chips and WiFi chips.

Figure 27. Broadcom Revenues (US$m)

	FY06
Revenues (total)	3668
Mobile & Wireless	1101

Source: Company Reports

M&A History

- **July 2007:** Broadcom acquired Global Locate, a supplier of GPS and a-GPS chips and software.
- **October 2005:** Broadcom acquired Athena Semiconductors Inc (Athena). Athena specialises in mobile digital TV tuners and low-power WiFi technology.
- **March 2005:** Broadcom acquired Zeevo Inc, a supplier of Bluetooth wireless headset chips and software.
- **July 2004:** Broadcom acquired Zyray Wireless Inc (Zyray). Zyray provides baseband co-processors for WCDMA devices. Zyray's SPINNERchip technology enables data device manufacturers to update their products for 3G technology. Pairing the SPINNERchip with Broadcom's EDGE/GPRS/GSM and GPRS/GSM processors enables a two-chip WCDMA multi-mode phone.
- **May 2004:** Broadcom acquired WIDCOMM Inc, a provider of software solutions for Bluetooth products.

Product Portfolio

Figure 28. Broadcom Wireless Product Portfolio

Product	Air Interface	Details
Baseband ICs		
BCM2124	GSM/GPRS	Single-chip baseband processor
BCM2133	EDGE/GPRS/GSM	Single-chip multimedia baseband processor
BCM2141	WCDMA	Baseband co-processor
BCM2152	HSDPA/WCDMA/EDGE/ GPRS/GSM	Single-chip multimedia baseband processor
BCM2153	HEDGE	Single chip multimedia baseband processor
Single chip		
BCM21331	EDGE	Single chip baseband plus RF plus multimedia
BCM21551	HSUPA/WCDMA/EDGE	Single chip baseband plus RF, BT, FM & mixed signal analog
RF ICs		
BCM2085	EDGE/GPRS/GSM	Single chip quad band CMOS DigRF transceiver
Multimedia Processors		
BCM2702	n/a	High performance multimedia processor
BCM2722	n/a	High performance multimedia processor
BCM2724	n/a	High performance multimedia processor
BCM2727	n/a	High performance multimedia processor
Power Management		
BCM59001		Power management unit

Source: Company Reports

Freescale

Freescale's Wireless and Mobile Solutions business makes up 34% of total revenues. The division makes ZigBee, mobile TV, and WiFi chips, baseband processors, RF transceivers, handset platforms, audio processors and power management chips.

Figure 29. Freescale Revenues (US$m)

	FY06
Total	6359
Wireless & Mobile Solutions	2136

Source: Company Reports

M&A History

- **October 2005:** Freescale acquired CommASIC, a provider of modem processing multimode technologies, including orthogonal frequency division multiplexing (OFDM)-based solutions such as WiFi 802.11a/b/g.

Product Portfolio

Figure 30. Freescale Wireless Product Portfolio

Product	Air Interface	Detail
RF ICs		
RFX250-20	GSM/GPRS	MMM6000 (Quad-band transceiver with DigRF interface) plus MMM6015 (PA module)
RFX275-20	EDGE/GPRS/GSM	MMM6000 (Quad-band transceiver with DigRF interface) plus MMM6027 (PA module)
RFX275-30	EDGE/GPRS/GSM	MMM7010 (Quad-band transceiver with DigRF interface) plus MMM6028 (PA module)
RFX300-20	WCDMA/EDGE	MMM6000/6007 (Quad-band transceivers with DigRF interface) plus MMM6029/6032 (PA modules)
RFX300-30	WCDMA/EDGE	MMM7210 (Quad-band transceiver module with DigRF interface), MC13853 (tri-band LNA), MC13882 (DC/DC converter), MMM6038 (GSM/EDGE PA) & WCDMA PA module.
Platforms		
i200-22	GSM	DSP56634 (baseband processor), MC13977 (GSM front-end), MC13790 (integrated power management & audio circuit) & MMM6035 (dual-band GSM PA)
i250-22	GSM/GPRS	DSP56631 (baseband processor), MC13977 (GSM front-end), MC13790 (integrated power management & audio circuit) & MMM6035 (dual-band GSM PA)
MXC275-30	EDGE/GPRS/GSM	ARM11-based baseband processor, GSM/EDGE transceiver module, GSM/EDGE PA & power management and audio chip.
MXC300-30	WCDMA/EDGE/GPRS/GSM	ARM11-based MXC baseband processor, GSM/EDGE & WCDMA transceivers, GSM/EDGE & WCDMA PAs & power management and audio chip.
i300-30	HSDPA/WCDMA/EDGE/GPRS/GSM	ARM11-based baseband processor, GSM/EDGE & WCDMA transceiver modules, GSM/EDGE & WCDMA PAs & power management and audio chip.
PA Modules		
MMM5063	GSM/GPRS	Tri-band PA module
MMM6015	GSM/GPRS	Quad, tri- and dual-band PA module
MMM6025	GSM/GPRS	Quad- and tri-band PA module
MMM6035	GSM/GPRS	Quad, tri- and dual-band PA module
Power Management & User Interface ICs		
MC13790	GSM/GPRS	Integrated power management & audio chip
MC13883	WCDMA/EDGE/GPRS/GSM	Integrated power management, audio & user interface chip
MC13890		Feature-rich power management & audio chip
MC13783	WCDMA/EDGE/GPRS/GSM	Integrated power management, audio & user interface chip

Source: Company Reports

Infineon

Infineon produces baseband, RF and power management ICs. The company also produces single chip ICs that integrate the baseband and RF and in some cases also the power management. We estimate that Wireless revenues made up c17% of total non-memory revenues in FY07.

Figure 31. Infineon Revenues, FY07 (Y/E Sept)

	€m	US$m
Total (excluding Qimonda)	4074	5418
Communications	1051	1398
Wireless (our estimate)	675	898

Source: Company Reports and CIR Estimates

M&A History

- **August 2007**: Infineon announced plans to acquire LSI Corporation's mobility products business (this was acquired by LSI from Agere in April 2007). The deal closed in October 2007.

Product Portfolio

In Figure 32, we list Infineon's product portfolio. Since the acquisition of LSI's mobility business, Infineon also offers the LSI wireless product range. This is based on LSI's Vision architecture. Products consist of analog and digital baseband for GSM up to WCDMA. Infineon plans to offer the Vision baseband chips with Infineon's transceivers.

Figure 32. Infineon Wireless Product Portfolio

Product Type	Air interface	Details
Baseband ICs		
E-GOLDlite - PMB 7860	GPRS	Mixed signal baseband
E-GOLD+V3 - PMB 7850	GSM/GPRS	Mixed signal baseband
X-GOLD 208 - PMB 8877	GSM/GPRS/ EDGE	Baseband integrated with application processor
X-GOLD 201 - PMB 8876	GSM/GPRS/ EDGE	Baseband integrated with application processor
X-GOLD 608 - PMB 8878	HSDPA/ WCDMA/ EDGE/GPRS/ GSM	Baseband integrated with application processor
RF ICs		
SMARTi SD2 - PMB 6271	GSM/GPRS	Single chip transceiver with analog I/Q interface
SMARTi PM+ - PMB 6275	GPRS/EDGE	Quad-band single chip transceiver with analog I/Q interface
SMARTi PM - PMB 6272	GPRS/EDGE	Quad-band single chip transceiver with analog I/Q interface
SMARTi PM2 - PMB 6277	GSM/GPRS/ EDGE	Quad-band single chip transceiver with DigRF interface
SMARTi UE - PMB 5703	UMTS/EDGE	Single chip dual mode transceiver with DigRF interface
SMARTi 3GE - PMB 6952	WEDGE	SMARTi PM quad-band GSM/EDGE transceiver plus SMARTi3G six-band WCDMA transceiver in one package
SMARTi 3G - PMB 5701	WCDMA	Single chip transceiver
SMARTi LTE	LTE	Single chip transceiver
Power Management ICs		
X-PMU 611 - PMB 6821		Optimised for X-GOLD 208 & X-GOLD 608
X-PMU 201 - PMB 6814		Optimised for E-GOLDlite & E-GOLDradio
X-PMU 600 - PMB 6812		
Single chip		
X-GOLD 101 - PMB 7880	GSM/GPRS	Single chip integrating BB, RF transceiver, mixed signal & PMU
E-GOLDradio - PMB 7870	GSM/GPRS	Single chip integrating BB, RF transceiver & mixed signal
X-GOLD 206 - PMB 8888	GSM/GPRS/ EDGE	Single chip integrating BB, RF transceiver, mixed signal & PMU
Platforms		
ULC1	GSM/GPRS	E-GOLDradio plus E-Powerlite
XMM 1010	GSM/GPRS	X-GOLD 101
BP2	GSM/GPRS	E-GOLDlite plus SMARTi SD2 plus E-Powerlite
BP3	GSM/GPRS	E-GOLDradio plus E-Powerlite plus Bluemoon Cellular plus PASiG
BP3 Entertain	GSM/GPRS	E-GOLDradio plus E-Powerlite plus Bluemoon Cellular
P2002+	GSM/GPRS	E-GOLD+V3 plus SMARTi DC plus E-Power
XMM 2060	EDGE/GPRS/ GSM	X-GOLD 206
XMM 2080	EDGE/GPRS/ GSM	Baseband plus RF plus PMU
XMM 2010	EDGE/GPRS/ GSM	X-GOLD 201 plus SMARTi PM plus SM-Power
XMM 6080	HSDPA/ WDMA/ EDGE/GPRS/ GSM	X-GOLD 608 plus SMARTi 3GE plus SM-POWER3
XMM 5010	UMTS/EDGE/ GPRS/GSM	Baseband plus RF plus PMU

Source: Company Reports

Marvell

Marvell's wireless business makes up a small percentage of revenues; Communications revenues made up 44% of total revenues in FY07, although very little of this would have been generated by wireless handset products as until the acquisition of Intel's XScale business in November 2006, Marvell had no wireless handset products, although the company has a strong position in the WiFi chip market.

Figure 33. Marvell Revenues, FY07 (y/e Jan)

Revenues (US$m)	FY07
Total	2238
Communications	984

Source: Company Reports

M&A History

- **November 2006:** Marvell acquired Intel's communications and application processor business.

Product Portfolio

Figure 34. Marvell Wireless Product Portfolio

Product	Air Interface	Detail
Communications processors		
PXA90x	WCDMA/GPRS/ GSM	Baseband processor
Application processors		
PXA320	n/a	Application processor up to 800MHz for high-end multimedia cellphones and PDAs
PXA310	n/a	Application processor up to 624MHz
PXA300	n/a	Application processor up to 624MHz for cost-efficient smartphones, industrial embedded solutions & handheld devices.
PXA27x	n/a	Enables high-performance multimedia acceleration & flexible and powerful camera interface for capturing digital images & video.
PXA255	n/a	Features boosted processing speeds and advanced power management

Source: Company Reports

MediaTek

Unlike the other companies in this section, Mediatek produces both chips and handset designs. In FY06, handsets made up c40% of MediaTek's revenues, although this is forecast to rise to over 50% in 2007. MediaTek's chips integrate EDGE/GPRS/GSM, 3M pixel DSC, WiFi, Bluetooth and FM radio onto the baseband chip. We understand that MediaTek produces GSM/GPRS RF transceivers, but the company also partners with Skyworks for the supply of its Helios EDGE RF transceiver.

M&A History

- **September 2007:** MediaTek announced plans to acquire Analog Devices' wireless business. The deal should complete by the end of 2007.
- **December 2006:** MediaTek buys a 41% stake in Airoha. Airoha is a Taiwanese RF transceiver designer specialising in GSM/GPRS RF transceivers, WiFi transceivers (covering 802.11b, b/g, a/b/g & n), PHS RF transceivers and FM radio tuners.

Product Portfolio

Figure 35. MediaTek Product Portfolio

Product	Air Interface	Detail
MT6226	GSM/GPRS	VGA camera phone solution
MT6226M	GSM/GPRS	1.3 mega pixel camera phone solution
MT6227	GSM/GPRS	Video phone solution, with 2M pixel camera
MT6228	GSM/GPRS	High-end video phone solution, with 3M pixel camera
MT3318	GPS	32 channel receiver

Source: Company Reports

MediaTek started shipping an EDGE capable product at the end of 2006, however its website has not been updated to reflect its current product portfolio. The website does not provide any detail on the contents of each product.

NEC Electronics

NEC Electronics' Communications business made up 14% of total revenues in FY07. The Communications business includes networking ICs and handset-related ICs.

Figure 36. NEC Electronics Revenues, FY07 (y/e March)

Revenues	Y bn	US$m
Total	692	5867
Communications	100	844

Source: Company Reports

Product Portfolio

Figure 37. NEC Electronics Product Portfolio

Product	Air Interface	Detail
Baseband IC		
CB-130		Digital baseband
M1(S)	WCDMA/ EDGE/GPRS/GSM	Single chip integrated baseband and application processor
M2	HSDPA/WCDMA/ EDGE/GPRS/GSM	Single chip integrated baseband and application processor
Application Processor		
MP-201		For high-performance portable equipment
RF IC		
uPC8220T5A	PHS	SiGe transceiver for 1.9GHz PHS
Platform		
Medity 1	WCDMA/ EDGE/GPRS/GSM	M1(S) plus 3GRF/analog baseband IC plus power IC for RF plus power management IC plus peripheral interfaces plus PAs
Medity 2 (under development)	HSDPA/WCDMA/ EDGE/GPRS/GSM	M2 plus WCDMA and EDGE/GPRS/GSM transceivers plus HSDPA accelerator plus power management IC plus audio ICs

Source: Company Reports

NXP

NXP's Mobile & Personal division made up 32% of FY07 revenues. This division includes a wide variety of products: ICs for portable media players, Bluetooth, WiFi, cordless and IP phone ICs, handset baseband ICs, handset platforms, and RF transceivers.

Figure 38. NXP Revenues, FY06

	€m	US$m
Total	4960	6232
Mobile & Personal	1568	1970

Source: Company Reports

M&A History

- **February 2007:** NXP acquired the cellular business of Silicon Labs. Assets acquired included RF CMOS technology-based transceivers for cell phones as well as monolithic cellular systems chips. The business acquired had revenues of US$176m in 2006.

Product Portfolio

Figure 39. NXP Wireless Product Portfolio

Product	Air Interface	Detail
Baseband ICs		
PNX5230	EDGE/GPRS/GSM	Quad-band baseband processor
PNX5221	UMTS/EDGE/GPRS/GSM	Baseband processor supporting quad-band for EDGE/GPRS/GSM & dual-band for UMTS
PNX5220	UMTS/EDGE/GPRS/GSM	Baseband processor supporting quad-band for EDGE/GPRS/GSM & dual-band for UMTS
PCF0501	UMTS	Companion chip for PCF5213 baseband, to create dual-mode terminals
RF ICs		
AERO4205	GSM/GPRS	Aero I quad-band transceiver
AERO4206	GSM/GPRS	Aero I+ quad-band transceiver
AERO4208	GSM/GPRS	Aero II ULCH quad-band transceiver
AERO4209	GSM/GPRS	Aero II ULCH quad-band transceiver
AERO4210	GSM/GPRS	Aero II quad-band transceiver
AERO4213	EDGE/GPRS/GSM	Aero IIed quad-band transceiver with integrated analog baseband and DigRF interface
AERO4220	EDGE/GPRS/GSM	Aero IIe quad-band transceiver
AERO4221	EDGE/GPRS/GSM	Aero IIe quad-band transceiver
UAA3582	UMTS	Single chip transceiver
Single chip		
PNX4901 - for ULC phone	GSM/GPRS	Single chip integrating baseband, RF transceiver and power management - ultra low cost
PNX4903 - for ULC phone	GSM/GPRS	Single chip integrating baseband, RF transceiver and power management
PNX4905	GSM/GPRS	Single chip integrating baseband, RF transceiver and power management
Power Management		
PCF50603		Power supply, battery management
PCF50606		Programmable power switches, battery management system, 10-bit ADC, touchscreen interface
PCF50611		Programmable power supplies, fully integrated charger, USB charging, DC-DC converter for low power consumption, 256 steps backlight dimming
PCF50626		21 programmable power supplies, fully integrated main & back-up battery chargers, touchscreen support, DRM

Source: Company reports.

Figure 40. NXP Wireless Product Portfolio (cont.)

Power Amps		
AERO4300XC/1		For dual-band applications
AERO4300XC/2		For tri-band applications
Application processor		
PNX4150	n/a	Companion chip for picture enhancement
PNX0103	n/a	Media processor for portable flash storage devices & phones to improve audio features
PNX0105x	n/a	High-performance audio processor
PNX0161	n/a	Low-power USB audio device for mobile/portable devices
Platforms		
NSS 5130 - for ULC phone	GSM/GPRS	OM6357-7 (baseband processor), AERO4209 (transceiver), FEM, PCF50600 (PMU)
NSS 5209 - for entry level EDGE phones	GSM/GPRS/ EDGE	PNX5209 (baseband processor), AERO4220 (transceiver), PCF50611 (PMU). Option: Bluetooth
NSS 5210 - for basic EDGE multimedia phone	GSM/GPRS/ EDGE	PNX5230 (baseband processor), AERO4230 (transceiver), PCF50611 (PMU). Options: Bluetooth, FM radio
NSS 5211 - for mid-range feature rich phones	GSM/GPRS	PNX5231 (baseband processor), AERO4208 (transceiver), PCF50611 (PMU). Options: FM radio, Bluetooth
NSS 5212 - entry level EDGE multimedia phone	GSM/GPRS/ EDGE	PNX5212 (baseband processor), AERO4220 (transceiver), PCF50611 (PMU). Options: Bluetooth, FM radio
NSS 5213 -for mid-range EDGE phones	GSM/GPRS/ EDGE	PNX5213 (baseband processor), AERO4220 (transceiver), PCF50611 (PMU). Options: Bluetooth, FM radio
NSS 61x0 - for feature phone	GSM/GPRS/ EDGE	PCF5213 (baseband processor), UAA3587E (transceiver), PCF50603 (PMU). Options: FM radio, Bluetooth, NFC, WLAN, USB 2.0, MMC flash card
NSS 6100 - for UMA feature phone	GSM/GPRS/ EDGE	PCF5213 (baseband processor), UAA3587E (transceiver), PCF50603 (PMU). Options: FM radio, Bluetooth, NFC, WLAN, USB 2.0, MMC flash card
NSS 7210 - for feature phone	GSM/GPRS/ EDGE/UMTS	PNX5221 (baseband processor), UAA3582 & UAA3588E (transceivers), PAs, PCF50626 (PMU), FM radio, Bluetooth, WLAN, NFC
NSS 7210 Linux- for Linux-based feature phone	GSM/GPRS/ EDGE/UMTS	PNX5221 (baseband processor), UAA3582 & UAA3588E (transceivers), PAs, PCF50626 (PMU), FM radio, Bluetooth, WLAN, NFC
NSS 7210 a-GPS - for feature phone	GSM/GPRS/ EDGE/UMTS	PNX5221 (baseband processor), UAA3582 & UAA3588E (transceivers), PAs, PCF50626 (PMU), FM radio, Bluetooth, WLAN, NFC, a-GPS
T3G 7130 - for feature phone	GSM/GPRS/ EDGE/TD-SCDMA	PCF5213 (baseband processor), UAA3587 (transceivers), TD60186 (TD-SCDMA modem), MAX19700(TD-SCDMA analog BB), xx (TD-SCDMA RF module) GOFORCE4000 (video co-processor), PAs, PCF50611 (PMU). Option: Bluetooth

Source: Company Reports

Qualcomm

Qualcomm's chip business made up 59% of total revenues in FY07. The chip business includes baseband processors, RF chips, power management chips and handset chipsets.

Figure 41. Qualcomm Revenues, FY07 (Y/E Sep)

Revenues	US$m
Total	8870
QCT	5275

Source: Company Reports

M&A History

- **December 2006:** Qualcomm acquired Airgo Networks, a WLAN technology provider.
- **December 2006:** Qualcomm acquired the majority of RFMD's Bluetooth assets.
- **August 2006:** Qualcomm acquired Qualphone Inc., a provider of IP-based Multimedia Subsystems (IMS) embedded client software solutions for mobile devices and interoperability testing (IOT) services.
- **January 2006:** Qualcomm acquired Flarion Technologies, a leading developer of orthogonal frequency division multiplex access (OFDMA) technology and the inventor of FLASH-OFDM technology for mobile broadband IP services.
- **January 2006:** Qualcomm acquired Berkana Wireless, a developer of RF CMOS solutions.
- **August 2005:** Qualcomm acquired ELATA, a developer of mobile content delivery software.
- **October 2004:** Qualcomm acquired Trigenix, a mobile user interface company.
- **September 2004:** Qualcomm acquired Iridigm Display Corporation, a display technology company. Iridigm's patented iMoD technology is based on a MEMS structure combined with thin film optics.
- **September 2004:** Qualcomm acquired Spike Technologies, a semiconductor design services company. Key areas of expertise are in physical design for deep sub-micron process technologies, circuit development, and design and verification engineering for pre-silicon design debug and analysis.

Product Portfolio

Figure 42. Qualcomm Wireless Product Portfolio

Product	Air Interface	Detail
Value Platforms		
MSM6245	GSM/GPRS/ EDGE/WCDMA	MSM6245 (baseband), RTR6280 (transceiver), PM6652 (PMU)
MSM6225	GSM/GPRS/ WCDMA	MSM6225 (baseband), RTR6250 (transceiver) RFR6250 (WCDMA receiver), PM6650 (PMU)
MSM6050	CDMA2000 1x	MSM6050 (baseband), RFT6150 (transmitter), RFR6155 (receiver) PM6620 (PMU)
MSM6025	CDMA2000 1x	MSM6025 (baseband), RFT6150 (transmitter), RFR6155 (receiver) PM6620 (PMU)
MSM6000	CDMA2000 1x	MSM6000 (baseband), RFT6122 (transmitter), RFR6122 (receiver) PM6610 (PMU)
QSC6055	CDMA2000 1x	Integrated baseband, transceiver and PMU.
QSC6030	CDMA2000 1x	Integrated baseband, transceiver and PMU.
QSC6020	CDMA2000 1x	Integrated baseband, transceiver and PMU.
QSC6010	CDMA2000 1x	Integrated baseband, transceiver and PMU.
QSC1100	CDMA2000 1x	Integrated baseband, transceiver and PMU.
Multimedia Platforms		
MSM6500	1x (Rel.0 & Rev A), 1xEV-DO (Rel.0), GSM/GPRS	MSM6500 (baseband with BT), RFT6150 (transmitter), RFR6500 (receiver with GPS), PM6640 (PMU)
MSM6300	1x Rev A, GSM/GPRS	MSM6300 (baseband with BT), RTR6300 (transceiver), RFR6000 (receiver with GPS), PM6050 (PMU)
MSM6260	HSDPA/WCDMA/EDGE/GPRS/GSM	MSM6260 (baseband with BT), RTR6285 (transceiver with GPS), PM6658 (PMU)
MSM6255A	WCDMA/EDGE/GPRS/GSM	MSM6255A (baseband with BT), RTR6285 (transceiver with GPS), PM6658 (PMU)
MSM6250	WCDMA/GPRS/GSM	MSM6250 (baseband with BT), RTR6250 (transceiver), RFR6250 (receiver with GPS), PM6658 (PMU)
MSM6125	CDMA2000 1x (Rel.0 & Rev A)	MSM6125 (baseband with BT), RFR6500 (receiver with GPS), RFT6150 (transmitter), PM6650 (PMU)
MSM6100	CDMA2000 1x Rev A	MSM6100 (baseband), RFR6155 (receiver with GPS), RFT6150 (transmitter), PM6640 (PMU)
QSC6085	CDMA2000 1xEV-DO Rev A	Integrated baseband, transceiver and PMU.
QSC6075	CDMA2000 1xEV-DO Rev 0	Integrated baseband, transceiver and PMU.
QSC6065	CDMA2000 1x	Integrated baseband, transceiver and PMU.
Enhanced Multimedia Platforms		
MSM6800	1x (Rel.0 & Rev A), 1xEV-DO (Rel.0 & Rev. A), GSM/GPRS	MSM6800 (baseband with BT), RFR6500 (receiver incl GPS), RFT6150 (transmitter), PM6650 (PMU)
MSM6550	1x (Rel.0 & Rev A), 1xEV-DO (Rel.0), GSM/GPRS	MSM6550 (baseband with BT), RFR6500 (receiver incl GPS), RFT6150 (transmitter), PM6650 (PMU)
MSM6280	HSDPA/WCDMA/EDGE/GPRS/ GSM	MSM6280 (baseband with BT), RFR6275 (receiver incl GPS), RTR6275 (transceiver), PM6650 (PMU)
MSM6275	HSDPA/WCDMA/EDGE/GPRS/ GSM	MSM6275 (baseband with BT), RFR6250 (receiver with GPS), RFR6220 (receiver), RTR6250 (transceiver), PM6650 (PMU)

Source: Company reports.

Figure 43. Qualcomm Wireless Product Portfolio (cont.)

Convergence Platform		
MSM7600	1xEV-DO (Rel. 0 & Rev. A), WCDMA/ HSDPA, EGPRS	MSM7600 (baseband), RFR6500/RFR6525 (receivers with GPS), RTR6275 (transceiver), PM7500 (PMU)
MSM7500	1xEV-DO (Rel. 0 & Rev. A), GPRS/GSM	MSM7500 (baseband), RFR6500 (receiver), RTR6150(transmitter), PM7500 (PMU)
MSM7200	HSPA/WCDMA/EDGE/GPRS/ GSM	MSM7200 (baseband), RFR6500/RFR6525 (receivers with GPS), RTR6275 (transceiver), PM7500 (PMU)
QSC7830	1x EV-DO Rev.B	Integrated baseband, transceiver , PMU, Bluetooth, FM Radio & GPS
QSC7630	1x EV-DO Rev.B/HSPA+	Integrated baseband, transceiver , PMU, Bluetooth, FM Radio & GPS
QSC7230	HSPA+/WCDMA/EDGE/GPRS/GSM	Integrated baseband, transceiver , PMU, Bluetooth, FM Radio & GPS
RF ICs		
RFR6170	450MHz	RF receiver
RFT6170	450MHz	RF transmitter
RFR6122	JCDMA 800 or Cellular 850MHz	RF receiver
RFT6122	JCDMA 800 or Cellular 850MHz	RF transmitter
RFR6125	JCDMA 800 or Cellular 850MHz	RF receiver with GPS functionality
RFR6120	JCDMA 800 or Cellular 850MHz	RF receiver
RFT6120	JCDMA 800 or Cellular 850MHz	RF transmitter
RFR6175	450MHz	RF receiver with GPS functionality
RFR6135	KPCS 1800	RF receiver with GPS functionality
RFT6100	KPCS 1800	RF transmitter
RFR6000	JCDMA 800 or Cellular 850MHz	RF receiver
RFR6155	JCDMA 800 or Cellular 850MHz/KPCS 1800 or PCS 1900MHz	RF receiver
RFT6150	JCDMA 800 or Cellular 850MHz/KPCS 1800 or PCS 1900MHz	RF transmitter
RFR6500	JCDMA 800 or Cellular 850MHz/KPCS 1800 or PCS 1900MHz	RF receiver
RFR6525	JCDMA 800 or Cellular 850MHz/IMT 2100MHz	RF receiver with GPS functionality
RFR6185	JCDMA 800 or Cellular 850MHz/KPCS 1800 or PCS 1900MHz	RF receiver with GPS functionality
RTR6285	UMTS/EDGE/ GPRS/GSM	RF transceiver, also includes GPS receiver
RFR6250	UMTS/EDGE/ GPRS/GSM	Single band WCDMA, quad band EGPRS RF receiver with GPS functionality
RTR6250	UMTS/EDGE/ GPRS/GSM	Quad-band EGPRS RF transceiver, dual-band UMTS transmitter
RTR6275	UMTS/EDGE/ GPRS/GSM	Single band UMTS receiver, quad band EGPRS RF transceiver, triple-band UMTS transmitter
RFR6275	UMTS	Dual-band WCDMA RF receiver, GPS receiver
RFR6202	UMTS	Dual-band WCDMA RF transceiver

Source: Company Reports

Renesas

Renesas' main wireless product is its SH-Mobile family of application processors. The company also manufactures a wide selection of discretes suitable for use in handsets. In 2006, Renesas joined forces with NTT DoCoMo to develop an integrated baseband and application processor for use in 3G phones (SH-Mobile G1). The chip was selected by NTTDoCoMo for use in the FOMA 903i handsets to be manufactured by Fujitsu (F903i) and Mitsubishi Electric (D903i).

The partnership was expanded to include Fujitsu, Mitsubishi Electric and Sharp, and in 2007, a new integrated processor was developed as part of a handset platform (SH-Mobile G2). This is due to ship in 2H07. A sixth partner, Sony Ericsson, joined the group in 2007, and together the group is developing the third generation of the integrated processor (SH-Mobile G3) as part of a 3G handset platform that is targeted for completion in mid-2008. The Group intends to market the platform in both the Japanese and international 3G markets.

Product Portfolio

Figure 44. Renesas Wireless Product Portfolio

Application Processors	Air Interface	Details
SH-MobileL3V2	n/a	For use in terrestrial digital broadcasting & video applications, with MPEG4 &H.264 accelerator & support for 5M pixel camera with on-chip dedicated audio DSP.
SH-Mobile UL	n/a	High performance, low power multi-codec video processor. Suited to mobile phone terrestrial digital broadcast.
SH-Mobile R	n/a	For use in car navigation systems and PMPs supporting One-Seg terrestrial digital broadcasting.
SH-Mobile 3AS	n/a	Incorporates a 32-bit RISC CPU core, 2D/3D graphics engine, MPEG4 &H-264 accelerator for advanced multimedia applications. Supports 5M camera.
SH-MobileL3V	n/a	For use in terrestrial digital broadcasting & video applications, with MPEG4 &H.264 accelerator & support for 5M pixel camera.
SH-MobileL2	n/a	For multimedia applications in cell phones (MPEG4 accelerator, supports UXGA camera). "Super slim down"
SH-MobileJ3	n/a	Offers enhanced image processing functions for mid-range cell phones (MPEG4 accelerator, JPEG hardware engine, supports 4M pixel camera); incorporates 128Mb SDRAM.
SH-Mobile3A	n/a	For high-end cell phones. Supports terrestrial digital TV & 5M pixel camera module & features such as a JPEG hardware accelerator for still images.
SH-Mobile3	n/a	Incorporates a 32-bit RISC CPU core, 2D/3D graphics engine, MPEG4 hardware accelerator for advanced multimedia applications. Supports 3M camera.
SH-MobileL	n/a	For multimedia applications in cell phones, achieves optimal cost-performance. "Super slim down"
SH-MobileJ2	n/a	Successor to the SH-MobileJ, with enhanced multimedia functions (MPEG4 accelerator, USB function)
SH-MobileV2	n/a	Enhanced version of the SH-MobileV, with enhanced image processing functions (MPEG4 accelerator, 2D/3D graphics engine, 3M pixel camera support)
SH-MobileV	n/a	Supports SXGA camera mode, incorporating an MPEG4 accelerator
SH-MobileJ	n/a	Has enhanced camera support funtion: supports VGA camera & versatile screen displays; slimmed down
SH-Mobile1	n/a	For multimedia applications in cell phones
Baseband/app processor		
SH-MobileG1	GSM/GPRS/ WCDMA	Integrated baseband and application processor. Developed with NTT DoCoMo.
SH-MobileG2	GSM/GPRS/ WCDMA/ HSDPA	Integrated baseband and application processor. Developed with NTT DoCoMo, Fujitsu, Mitsubishi Electric & Sharp for use as part of a phone platform.
RF ICs		
PF08127B	GSM/GPRS/EDGE	Power amplifier for triple band phone
HD155155NP	GSM/GPRS/EDGE	RF front-end IC for GSM phone
	GSM/GPRS/EDGE	Quad-band RF transceiver

Source: Company Reports

RFMD

RFMD supplies RF products including power amplifiers, power amplifier modules, transceivers, and front-end modules. Cellular revenues made up 94% of FY07 revenues, with the remainder coming from wireless infrastructure and wireless connectivity (WLAN, GPS) products.

Figure 45. RFMD Revenues, FY07 (y/e Mar)

Revenues	US$m
Total	1024
Cellular	958

Source: Company Reports

M&A History

- **November 2007:** RFMD acquired Sirenza Microdevices, a supplier of RF components.
- **December 2006:** RFMD sold the majority of its Bluetooth assets to Qualcomm. The remaining products (v1.2 or earlier) will be produced and supported for up to four years post-disposal.
- **May 2004:** RFMD acquired Silicon Wave, a provider of integrated Bluetooth solutions.

Product Portfolio

Figure 46. RFMD Wireless Product Portfolio

Product	Air Interface	Details
RF transceivers		
Polaris 3 Total Radio	GSM/GPRS/EDGE	RF6030 (quad-band transceiver), RF3251 (transmit FEM), RF9003 (DC-DC SMPS)
Polaris 2 Total Radio	GSM/GPRS/EDGE	RF6026 (transceiver), RF3178 (transmit FEM)
Polaris Total Radio	GSM/GPRS	RF2722 (quad-band receiver), RF3146 (quad-band PA module), RF6001 (transceiver)
PA & transmit modules		
RF3159	GSM/GPRS/EDGE	Quad-band PA module
RF5198	WCDMA	PA module
RF5184	WCDMA	Dual-band PA module
RF3166	GSM/GPRS	PowerStar PA
RF3146x	GSM	PowerStar PA
RF3203	GSM/EDGE	PowerStar II transmit module
RF3161	EDGE	PA
RF3159	EDGE	Quad-band PowerStar PA module
RF3158	GSM/GPRS/EDGE	Quad-band PowerStar PA module
RF3166	GSM/GPRS	PowerStar PA module
RF4180	GSM/GPRS	Dual-band PowerStar transmit module
RF7115	GSM/GPRS	Quad-band PowerStar transmit module
RF3198	GSM/GPRS	Dual-band PowerStar PA module
RF3196	GSM/GPRS	Quad-band PowerStar PA module
RF3163	CDMA2000 1x	PA module (824-849Mhz)
RF3164	CDMA2000 1x	PA module (1850-1910Mhz)
RF6281	UMTS	PA module (1920-1980MHz)
RF6285	UMTS	PA module (824-915MHz & 1710-1980MHz)
RF1450	GSM/EDGE/WCDMA	GaAs SP4T (single-pole four-throw) switch
RF1200	GSM	GaAs SPDT (single-pole double-throw) switch

Source: Company Reports

Skyworks

Skyworks operates through two divisions: Mobile Platforms and Linear Products (the company does not disclose revenues by division). Within its Mobile Platforms division, Skyworks supplies RF transceivers, PAs, RF sub-systems and RF front-end modules. The company exited the baseband business in FY06 (note that baseband revenues totaled US$50m in FY06).

Figure 47. Skyworks Revenues, FY07 (y/e Sept)

Revenues	US$m
Total	742

Source: Company Reports

Product Portfolio

Figure 48. Skyworks Wireless Product Portfolio

Product	Air Interface	Details
RF Sub-systems		
SKY74100	CDMA/PCS	Tri-band, dual-mode receiver with GPS
SKY74068	CDMA/PCS	Dual-band, dual-mode transmitter
SKY74092 LNA	CDMA/PCS	Low noise, dual-band amplifier
SKY74675	CDMA (incl. 1xEV-DO rev. 0)	Single-band single mode receiver
SKY74075	CDMA (incl. 1xEV-DO rev. 0)	Single-band single mode transmitter
SKY74660	KPCS	Single-band, single-mode receiver
SKY74760	KPCS	Single-band, single-mode transmitter
SKY74400	GSM/GPRS	Quad-band DCR transceiver with PA & integrated PA control
RF Transceivers		
SKY74117	GSM/GPRS/EDGE	Quad-band DCR transceiver
SKY74963	GSM/GPRS/EDGE	Quad-band DCR transceiver
CX74063	GSM/GPRS/EDGE	Quad-band DCR transceiver
CX74017	GSM/GPRS/EDGE	Quad-band DCR transceiver
Power Amplifiers		
SKY77340	GSM/GPRS/EDGE	Quad-band PA module
SKY77328	GSM/GPRS	Quad-band iPAC module
SKY77318	GSM/GPRS	Quad-band iPAC module
SKY77316	GSM/GPRS	Quad-band PA module
SKY77420	WCDMA	PA module: 1920-1980MHz
SKY77410	WCDMA	PA module: 1850-1980MHz
SKY77173	WCDMA	AutoSmart PA module for WCDMA (1920-1980MHz)
SKY77171	WCDMA	AutoSmart PA module for WCDMA (1920-1980MHz)
SKY77170	WCDMA/HSDPA	PA module: 1920-1980MHz
SKY77418	CDMA/PCS	LIPA module: 1850-1910MHz
SKY77178	WCDMA/HSDPA	AutoSmart PA module for WCDMA/HSDPA (1850-1910MHz)
SKY77164	CDMA/PCS	AutoSmart PA module for CDMA/PCS (1850-1910MHz)
SKY77149	CDMA/PCS	System Smart PA module for CDMA/PCS (1850-1910MHz)
SKY77112	CDMA/PCS	PA module: 1850-1910MHz
SKY77107	CDMA/PCS	PA module: 1850-1910MHz
SKY77179	WCDMA/HSDPA	AutoSmart PA module for WCDMA/HSDPA (824-849MHz)
SKY77175	WCDMA/HSDPA	Dual band PA module for WCDMA/HSDPA (1850-1910 & 824-849MHz)
SKY77174	WCDMA/HSDPA	PA module for WCDMA/HSDPA (1920-1980MHz)
SKY77163	CDMA/AMPS	AutoSmart PA module for CDMA/AMPS (824-849MHz)
SKY77162	CDMA/AMPS	System Smart PA module for CDMA/AMPS (824-849MHz)
SKY77156	CDMA/AMPS	System Smart PA module for CDMA/AMPS (824-849MHz)
SKY77154	CDMA/AMPS	System Smart PA module for CDMA/AMPS (824-849MHz)
SKY77140	CDMA/AMPS	PA module (824-849MHz)
SKY77105	CDMA/AMPS	PA module (824-849MHz)
SKY77177	WCDMA	AutoSmart PA module for WCDMA (1710-1755MHz)
SKY77155	CDMA/PCS/ WCDMA	System Smart PA module for CDMA/PCS (1750-1780MHz) & WCDMA (1710-1785MHz)
SKY77148	CDMA2000	PA module: 450-460MHz
SKY77147	CDMA/PCS	System Smart PA module for CDMA/PCS (1750-1780MHz)
SKY77144	CDMA	PA module: 887-925MHz
SKY77106	CDMA KPCS & China SCDMA	PA module: 1720-1780MHz
SKY77161	TD-SCDMA	PA module

Source: Company Reports

Figure 49. Skyworks Wireless Product Portfolio (cont.)

RF Solutions		
Helios EDGE RF Sub-system	GSM/GPRS/EDGE	SKY74045 (quad-band DC transceiver), SKY74046 (PA controller), SKY77316 (PA)
Helios EDGE RF Sub-system	GSM/GPRS/EDGE	SKY74945 (DC transceiver), SKY74046, SKY77316, external coupler, switch
Helios Mini EDGE RF Sub-system	GSM/GPRS/EDGE	SKY74945 (DC transceiver), SKY77332 (PA w/ controller & coupler)
Helios II EDGE RF Sub-system	GSM/GPRS/EDGE	SKY74137 (DC transceiver), SKY77331 (PA w/ integrated coupler)
Helios II-Plus EDGE RF Sub-system	GSM/GPRS/EDGE	SKY74138 (DC transceiver), SKY77523 (T/R front-end module w/ integrated coupler)
Helios DigRF EDGE RF Sub-system	GSM/GPRS/EDGE	SKY74200 (DC transceiver), SKY77520 (T/R front-end module)
Helios 3 EDGE RF Sub-system	GSM/GPRS/EDGE	SKY74218 (DC transceiver w/ DigRF interface), SKY77524 (T/R front-end module)
Helios WEDGE transceivers	GSM/GPRS/EDGE/WCDMA/HSPA	SKY74210 (DC transceiver w/ 3G DigRF interface)
Front-end Modules (FEM)		
SKY77531	GSM/GPRS	Transmit-receive iPAC (integrate power amp control) FEM
SKY77526	GSM/GPRS/EDGE	Transmit FEM
SKY77520	GSM/EDGE	Transmit-receive FEM
SKY77519	GSM/GPRS/EDGE	Transmit-receive FEM
SKY77518	GSM/GPRS	Transmit-receive iPAC FEM
SKY77517	GSM/GPRS	Transmit-receive iPAC FEM
SKY77437	WCDMA/HSDPA/HSUPA	Integrated interstage filter, input/output matching, PA, directional coupling & duplexer
SKY77433	WCDMA/HSDPA/ HSUPA	Integrated interstage filter, input/output matching, PA, power detection & duplexer
SKY77427	WCDMA/HSDPA	Integrated interstage filter, input/output matching, PA, power detection & duplexer
SKY77434	WCDMA/HSDPA/ HSUPA	Integrated interstage filter, input/output matching, PA, power detection & duplexer
SKY77414	WCDMA	Integrated interstage filter, input/output matching, PA, power detection & duplexer
SKY77409	CDMA/PCS	AutoSmart FEM. Integrated interstage filter, PA, power detector & duplexer
SKY77435	WCDMA/HSDPA/ HSUPA	Integrated interstage filter, input/output matching, PA, power detection & duplexer
SKY77436	WCDMA/HSDPA/ HSUPA	Integrated interstage filter, input/output matching, PA, power detection & duplexer
SKY77413	WCDMA	Integrated interstage filter, input/output matching, PA, power detection & duplexer
SKY77408	CDMA/AMPS	AutoSmart FEM. Integrated interstage filter, PA, power detector & duplexer

Source: Company reports.

Spreadtrum

Spreadtrum supplies baseband chips for the Chinese handset market. Historically, the company supplied handset boards and turnkey services in addition to baseband chips – boards were phased out in 2006 and the module business is being phased out during 2007.

In 2006, baseband chips made up 51% of revenues, but this had risen to 89% by 3Q07 (US$82.2m for first nine months of 2007).

In addition to the products listed below, the company is developing baseband processors to support EDGE and WCDMA/UMTS.

Figure 50. Spreadtrum Revenues, FY06

Revenues	US$m
Total	107.1
Baseband	54.9

Source: Company Reports

M&A History

- **November 2007:** Spreadtrum announced plans to acquire Quorum Systems, a US-based RF CMOS transceiver designer. Products include the QS1000 GSM/GPRS/EDGE transceiver and the QS3000 GSM/GPRS/EDGE/HSDPA transceiver. The transaction should complete by the end of 2007.

Product Portfolio

Figure 51. Spreadtrum Product Portfolio

Product	Air interface	Details
Baseband ICs		
SC6600B/6600D/6600M/6600I/ 6600H/6600R	GSM/GPRS	Single chip analog/digital baseband processor with multimedia processor and power management
SC6800D	GSM/GPRS	Single chip analog/digital baseband processor with multimedia processor and power management
SC8800D	TD-SCDMA/ GSM/GPRS	Single chip analog/digital baseband processor with multimedia processor and power management
SC8800S	TD-SCDMA/ HSDPA/EDGE/ GSM/GPRS	Data card chip.
SC8800H	TD-SCDMA/ HSDPA/GSM/ GPRS	Single chip analog/digital baseband processor with multimedia processor and power management

Source: Company Reports

STMicroelectronics

Figure 52. STMicroelectronics Revenues, 2006

Revenues	US$m
Total	9855
Telecommunications	3695

Source: Company Reports

ST generated 37% of revenues from the Telecommunications market in FY06. This comprised wireless and wireline products, including NOR flash memory for handsets. ST's business is divided into three operating segments: Application Specific Groups (ASG), Industrial and Multisegment Group, and Flash Memory Group. Within ASG, 40% of revenues or US$2,168m were generated by the Mobile, Multimedia, and Communications segment.

The majority of ST's wireless products are ASICs. Wireless ASICs include 3G digital baseband, 3G RF transceivers, and power management ICs. ST also supplies its Nomadik application processor and camera sensors for use in handsets. ASSPs include Bluetooth and WiFi solutions.

Sunplus

Sunplus has four business divisions: LCD IC (in the Orise Technology subsidiary), Personal Entertainment and Communication Solutions (in the Sunplus mMobile subsidiary), Controller and Peripheral Solutions (in the Sunplus Innovation Technology subsidiary) and Home Entertainment Solutions. We estimate Sunplus mMobile generated 15% of group revenues in FY06. The division supplies baseband and multimedia processors for handsets as well as ICs for portable media players, digital still cameras and game platforms.

Figure 53. Sunplus Revenues, FY06

Revenues	NT$m	US$m
Total	27,445	844
Sunplus mMobile (our estimate)	4,071	125

Source: Company reports & CIR estimates.

Product Portfolio

Figure 54. Sunplus Wireless Product Portfolio

Product	Air Interface	Details
SPCA552E	n/a	Multimedia processor: integrates CMOS sensor interface, DSC processor, JPEG codec engine, LCM interface and other peripherals.
SPW6400	GSM/GPRS/ EDGE	Quad-band baseband processor (DigRF interface) with integrated multimedia functionality
SPWx	PHS	Baseband processor with integrated multimedia functionality

Source: Company Reports

Texas Instruments (TI)

TI's wireless semiconductor business made up over one-third of total semiconductor revenues in 2006. 3G-related semiconductor revenues made up c30% of wireless semiconductor revenues, showing year-on-year growth of 48%. TI has a strong wireless ASIC business, having been the main baseband provider for Nokia for many years.

Figure 55. TI Revenues, FY06

Revenues	US$m
Total	14,255
Semiconductors	13,730
Wireless semis	>5,000

Source: Company Reports

M&A History

- **January 2006**: TI acquired Chipcon, a Norwegian designer of short-range, low power wireless RF transceiver products, including ZigBee.

Product Portfolio

Figure 56. Texas Instruments Product Portfolio

Product	Air Interface	Details
Chipsets		
TCS1110	GSM	TBB1100 (digital baseband), TWL3012 (analog baseband), TRF6150 (RF transceiver)
TCS2010	GSM/GPRS	TBB2010 (digital baseband), TWL3014 (analog baseband), TRF6151 (RF transceiver)
TCS2110	GSM/GPRS	TBB2110 (digital baseband), TWL3014 (analog baseband), TRF6151 (RF transceiver)
TCS2200	GSM/GPRS	TBB2200 (digital baseband), TWL3016 (analog baseband & power management), TRF6151 (RF transceiver)
TCS2500	GSM/GPRS	OMAP710 (integrated digital baseband & dedicated applications processor), TWL3012 (analog baseband), TRF6150 (RF transceiver)
TCS2600	GSM/GPRS	OMAP730 (integrated digital baseband & dedicated applications processor), TWL3016 (analog baseband & power management), TRF6151 (RF transceiver)
TCS2630	GSM/GPRS	OMAP733 (integrated digital baseband & dedicated applications processor), TWL3016 (analog baseband & power management), TRF6151 (RF transceiver)
TCS2700	GSM/GPRS	OMAP750 (integrated digital baseband & dedicated applications processor), TWL3016 (analog baseband & power management), TRF6151 (RF transceiver)
TCS3500	GSM/GPRS/EDGE	OMAP850 (integrated digital baseband & dedicated applications processor), TWL3027 (analog baseband & power management), quad-band EDGE RF transceiver
OMAPV1030	GSM/GPRS/EDGE	OMAPV1030 (EDGE digital baseband), analog baseband/power management/audio, GSM/GPRS/EDGE RF transceiver. Options: BlueLink (BT IC), NaviLink (GPS IC), WiLink (mWLAN)
OMAPV1035 ("eCosto")	GSM/GPRS/EDGE	OMAPV1035 (integrated baseband & GSM/GPRS/EDGE transceiver), TWL3034 (power management/audio). Options: NaviLink, Hollywood, WiLink, BlueLink
OMAP730	GSM/GPRS	Integrates ARM926EJ-S for apps processing with digital baseband.
OMAP750	GSM/GPRS	Integrates ARM926EJ-S for apps processing with digital baseband.
OMAP850	EDGE/ GPRS/GSM	Integrates ARM926EJ-S for apps processing with digital baseband.
Single chip		
TCS2305 "LoCosto ULC"	GSM	Integrated baseband, RF transceiver and power management
TCS2315 "LoCosto ULC"	GSM/GPRS	Integrated baseband, RF transceiver and power management
TCS2300 "LoCosto"	GSM	Integrated baseband & RF transceiver.
TCS2310 "LoCosto"	GSM/GPRS	Integrated baseband & RF transceiver.

Source: Company Reports

Figure 57. Texas Instruments Product Portfolio (cont.)

Application processor	Air Interface	Product Details
OMAP331	Any	ARM925 processor, 2D graphic accelerator
OMAP1510	Any	Dual core: TMS320C55x DSP core & ARM925 processor
OMAP1610	Any	Dual core: TMS320C55x DSP core & ARM926TEJ processor
OMAP1611	Any	Dual core: TMS320C55x DSP core & ARM926TEJ processor
OMAP1612	Any	Dual core: TMS320C55x DSP core & ARM926TEJ processor
OMAP1621	Any	Dual core: TMS320C55x DSP core & ARM926TEJ processor
OMAP1710	Any	Dual core: TMS320C55x DSP core & ARM926TEJ processor
OMAP2420	Any	Based on OMAP 2 architecture. TMS320C55x DSP, ARM1136 processor, 2D/3D graphics accelerator, imaging & video accelerator
OMAP2430/ 2431	Any	Based on OMAP 2 architecture.ARM1136 processor, 2D/3D graphics accelerator, IVA 2 imaging, video & audio accelerator
OMAP3410	Any	Based on OMAP 3 architecture.ARM Cortex A8 processor, IVA 2 imaging, video & audio accelerator
OMAP3420	Any	Based on OMAP 3 architecture. ARM Cortex A8 processor, IVA 2 imaging, video & audio accelerator, PowerVR SGX, Image Signal Processor ISP
OMAP3430	Any	Based on OMAP 3 architecture. ARM Cortex A8 processor, IVA 2+ imaging, video & audio accelerator, PowerVR SGX, Image Signal Processor ISP

Source: Company Reports

Companies mentioned in this report

Figure 58. Company References, 29 November 2007

Company	Reference
Agere Systems Inc	(AGR.N^D07 – US$0.00K Not Rated)
Apple Inc.	(AAPL.O - US$180.22; 1H)
Alcatel-Lucent	(ALUA.PA -€5.33; 1H)
Amoi Electronics	(600057.SS - Rmb5.950; Not Rated)
Analog Devices	(ADI.N - US$32.23; 1H)
ARM Holding	(ARM.L - £1.35; 1H)
Atmel Corp	(ATML.OQ – US$4.49; Not Rated)
Austriamicrosystems	(AMS.S - €27.14; 1H)
Broadcom Corp	(BRCM.O - US$28.11; 1H)
China Mobile	(0941.HK - HK$140.10; 1L)
Cisco	(CSCO.O – US$28.05; 2H)
CSR Plc	(CSR.L - US$12.67; 1H)
Datang Telecom Technology	(600198.SS - Rmb16.940; Not Rated)
Epcos	(EPCGn.DE - €12.09; 2H)
Freescale Semiconductor	(FSL.N^L06 - US$0.00; Not Rated)
Fujitsu	(6702.T - ¥787; 2H)
Haier Electronics	(1169.HK - HK$1.78; Not Rated)
Intel Corp	(INTC.O - US$26.19; 1M)
Infineon	(IFXGn.DE - €7.98; 1H)
Konka Group	(000016.SZ - Rmb7.890; Not Rated)
Kyocera	(6971.T - ¥9,880; 2H)
Lenovo Group	(0992.HK - HK$7.07; 1L)
LG Electronics	(066570.KS - W97,000; 1L)
LSI Logic Corp	(LSI.N - US$5.75; Not Rated)
Marvell Technology Group Ltd	(MRVL.O - US$14.96; 1S)
Maxim Petsindis SA	(MAXIM.AT - €0.48; Not Rated)
MediaTek	(2454.TW - NT$405.00; 1L)
Mitsubishi Electric	(6503.T - ¥1,255; 1H)
Motorola Inc.	(MOT.N - US$15.56; 2H)
Murata	(6981.OS - ¥6,310; 1H)
Navteq Corp	GPS(NVT.N – US$74.30; Not Rated)
NEC Electronics	(6723.T - ¥3,130; 2H)
Nokia Oyj	(NOK1V.HE - €26.80; 1H)
Nortel	(NT.N – US$17.11; Not Rated)
NXP Semiconductor	Private Company
Panasonic	(MSUSF.PK - US$0.00; Not Rated)
Qualcomm Inc.	(QCOM.O - US$41.49; Not Rated)
Quorum Information Tech	(QIS.V – C$0.62; Not Rated)
RF Micro Devices Inc	RFMD.O – US$5.67; 1S)
RIM Semiconductor	(RSMI.OB - US$0.03; Not Rated)
Samsung Electronics	(005930.KS - W567,000; 2L)
Sanyo Electric	(6764.T - ¥206; 3H)
Sagemark companies Ltd	(SKCO.OB – US$0.32; Not Rated)
Sharp	(6753.T - ¥1,831; 2H)
Silicon Laboratories	(SLAB.O - US$37.18; 2H)
Sirenza Micro devices Inc	(SMDI.OQ – US$16.68; Not Rated
Skyworks Solutions Inc	(SWKS.O - US$8.84; 2S)
Spreadtrum Communications	(SPRD.O - US$10.60; Analyzed Not Rated)
STMicroelectronics	(STM.N - US$15.53; 3H)
Sunplus Technology	(2401.TW - NT$48.20; Analyzed Not Rated)
Tele Atlas NV	(TATL.DE - €27.82; Not Rated)
Texas Instruments	(TXN.N - US$31.89; 1M)
TomTom NV	(TOM2.AS - €62.50; 1H)
Toshiba	(6502.T - ¥892; 2H)
Verizon Wireless	(DYVZW - US$0.00; Not Rated)
ZTE	(0763.HK - HK$34.45; 1M)
Wolfson Microelectronics Plc	(WLF.L - US$4.72; 1H)

Source: Citi Investment Research

Appendix A-1

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