



Global: Technology

Equity Research

TD-LTE: gearing up to cover 2.7bn people in Asia by 2013

TD-LTE adoption is gaining momentum among global carriers

In our view, TD-LTE is becoming the global solution for unpaired spectrum due to its 3G interoperability, large data capacity, and leverage of the FDD-LTE ecosystem. Verizon's successful launch of FDD-LTE in the US should further accelerate the conversion of WiMAX to TD-LTE. In June, two more carriers have joined the TD-LTE camp, which now totals 12 carriers. China Mobile, Bharti, and Softbank, three major carriers covering 39% of the global population, look on track to roll out some TD-LTE services in late 2012 or early 2013, and the significant potential of these markets should attract increasing R&D investment into TD-LTE technology, in our view.

Qualcomm and ST-Ericsson lead in multi-mode LTE/3G semiconductors

Unlike TD-SCDMA, TD-LTE has broad support from various leading global technology companies and should enjoy a smoother ride, in our view. Qualcomm's newly launched MSM8960 is the first mobile processor with an integrated modem supporting TD-LTE/FDD-LTE/EVDO/WCDMA, and should significantly simplify the multi-mode LTE/3G handset design. ST-Ericsson's M7400 is a multi-mode modem that supports TD-LTE/FDD-LTE/HDPA+/TD-SCDMA. Our channel checks indicate MSM8960 and M7400 supporting TD-LTE should become commercially available in early or mid-2012. Also, we note more than 10 other semiconductor firms have invested in TD-LTE, a much strong line-up than for TD-SCDMA. We expect ZTE and Huawei to launch multi-mode TD-LTE smartphones by the end of 2012.

Potential winners/losers from a smooth TD-LTE transition by 2013

We view TD-LTE as a disruptive technology similar to FDD-LTE, and that if it gained sufficient critical mass with successful commercial launch on a quality smartphone, we think **China Mobile** could recover its market share of high-ARPU users at the expense of **China Unicom** and **China Telecom** from 2013. This scenario would be especially negative to China Unicom's long-term story of strong operating leverage after reaching 100mn 3G sub in 2014-2015. In India, **Bharti Airtel** would likely be the main beneficiary of TD-LTE due to its strong existing subs base. In Japan, **Softbank** is the only carrier adopting TD-LTE. We estimate TD-LTE capex to reach US\$15-\$20bn and 40mn terminals over 2012-2014 — with **Qualcomm** and **ST-Ericsson** benefitting as leading multi-mode LTE/3G semiconductor suppliers today. **ZTE** should enjoy higher market share in TD-LTE than in 3G, in our view.

TD-LTE HAS MUCH STRONGER SUPPORT FROM GLOBAL LEADING SEMICONDUCTOR COMPANIES THAN TD-SCDMA

Semiconductor suppliers	
TD-SCDMA	TD-LTE
Spreadtrum (BB & SOC)	Qualcomm (SOC & BB)
Marvell (SOC)	ST-E (SOC & BB)
Leadcore (BB)	Hi-Silicon (BB)
STE (BB)	Marvell (SOC)
Mediatek (BB)	Renasas
	Sequans (BB)
	Leadcore (BB)
	Spreadtrum (BB)
	Mediatek
	ZTE (BB)
	VIA (BB)
	Samsung (BB)
	Broadcom (acquired Beceem)
	Altair Semiconductor
	Wavesat
	Runcom
	Innofidei (BB)

Source: Goldman Sachs Research.

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Contents

Executive Summary: A new global standard, potential beneficiaries	2
TD-LTE is gaining momentum; timing of CM launch is the key	3
India carriers may launch TD-LTE by mid-2012; before China Mobile?	6
Japan TD-LTE to take off in FY2012-13; XGP2 needs monitoring	8
TD-LTE is the global technology of choice for unpaired spectrum	9
Commercial TD-LTE handsets might become available in late 2012	10
Winners/losers from successful TD-LTE commercial launch in 2013	13
Appendix: comparing TD-LTE, FDD-LTE and WiMAX	17

Prices in this report are based on the market close of June 28, 2011

Executive Summary: A new global standard, potential beneficiaries

In this report, we have gathered recent developments of TD-LTE among Asia carriers and global technology companies. The success of the FDD-LTE launch by Verizon in the US should accelerate further the conversion from WiMAX to TD-LTE over the last few months. On the carrier side, 11-12 carriers have announced their intention to deploy TD-LTE. We note that China Mobile, Bharti, and Softbank remain on track to launch limited TD-LTE services in late 2012 or 2013; there are nearly 2.7bn people or 39% of the world's total population in the three countries (China, India and Japan), a significant market to attract the supply chain.

TD-LTE technology has also progressed faster than our expectations. The main bottleneck of TD-SCDMA has been good smartphone and associated semiconductor chipsets due to limited global support in the early stage. In contrast, Qualcomm and ST-Ericsson, two leading global communication semiconductor companies, are early leading supporters of TD-LTE. Eighteen global semiconductor companies and equipment vendors are investing in TD-LTE semiconductors today, far exceeding six current TD-SCDMA semiconductor vendors. Qualcomm has recently announced sampling its MSM8960, a mobile processor with integrated modem for TD-LTE/FDD-LTE/EVDO/HSPA+. Similarly, ST-Ericsson also announced it would sample its M7400, a modem supporting TD-LTE/FDD-LTE/HSPA+/TD-SCDMA/EDGE in 2Q2011. We believe that MSM8960 and M7400 with TD-LTE connectivity will become commercially available in 1H2012 and early 2012 respectively. These products can greatly lower the design hurdles of multi-mode LTE phone that would allow TD-LTE to leverage on the scale of FDD-LTE and 3G ecosystem. We now expect TD-LTE to be technically ready (with a decent smartphone) for commercial launch in early 2013E, a year ahead of previous estimate of 2014E.

The potential earlier-than-expected arrival of TD-LTE should have a meaningful impact on both telco and technology stocks.

In China, China Mobile has dominated the 2G market. In the 3G era, China Unicom has benefited significantly from its superior 3G technology (WCDMA) since 2010; China Telecom has been successful in revamping the EVDO ecosystem, but China Mobile has suffered from the inferior and relatively late arriving TD-SCDMA technology. We believe that 2013 could potentially be an inflection year for CM's market share if CM can launch commercially TD-LTE with the iPhone or another good smartphone. **Under this scenario, we would potentially become more constructive on China Mobile and less constructive on China Unicom and China Telecom.**

In India, we view Bharti as the main beneficiary of TD-LTE, due to its large existing sub base. In Japan, **Softbank** is likely to be the only TD-LTE carrier.

Among the technology companies, **Qualcomm and ST-Ericsson** should benefit as leading suppliers of TD-LTE semiconductors today. **ZTE** has more IPR in TD-LTE than in overall 3G and is likely to capture significant market share in TD-LTE equipment and handsets. We are positive on ZTE's growth outlook in 2012-2013, but we remain Neutral due to its potentially challenging profitability in 1H2011. We view **Kyocera** as the major Japanese technology company to benefit from TD-LTE. In Korea, we expect a TD-LTE rollout could also be incrementally positive to **Samsung Electronics**.

Exhibit 1: Summary of carriers and related equipment vendors with TD-LTE

Company name	Ticker	Stock price	Rating	P/E		
				CY2011	CY2012	CY2013
China Mobile	0941.HK	HK\$71.9	Neutral	12.8	13.6	14.1
China Unicom	0762.HK	HK\$15.5	Neutral	57.1	30.3	22.6
China Telecom	0728.HK	HK\$5	Buy	24.4	20.0	13.7
Bharti Airtel	BRTI.BO	INR400.1	Buy*	22.3	15.7	12.2
Reliance Industries	RELI.BO	INR870.6	Neutral	14.9	12.9	12.0
Softbank Corp.	9984.T	JPY2987	Neutral	14.9	13.6	13.3
Qualcomm Inc.	QCOM	US\$55.5	Buy*	24.4	20.8	N/A
STMicroelectronics	STM.PA	EUR6.6	Neutral	14.6	10.9	10.0
Ericsson	ERICB.ST	EUR88.6	Neutral	16.1	14.7	13.5
Samsung Electronics	005930.KS	KRW832000	Buy	11.2	8.9	7.6
LG Electronics	066570.KS	KRW82100	Neutral	15.1	8.8	7.9
ZTE (H)	0763.HK	HK\$27.6	Neutral	27.3	23.0	19.2
ZTE (A)	000063.SZ	Rmb27.5	Neutral	23.9	20.2	16.8

Note: *denotes stock is on our Regional Conviction List. For important disclosures, please go to <http://www.gs.com/research/hedge.html>

Source: Goldman Sachs Research estimates, Datastream

TD-LTE is gaining momentum; timing of CM launch is the key

Unlike TD-SCDMA which is mostly confined to China, TD-LTE has been gaining traction among global carriers. In late 2012 to 2013, we expect major carriers to launch limited TD-LTE services in China, India, and Japan, three of the world's most populous countries — that together represent 39% of total global population — that we believe should add sufficient critical mass and momentum to make it a global standard.

Indeed, in recent months, TD-LTE has already been gaining momentum to become the global solution of unpaired spectrum due to the success of LTE in the US. For example, even though the Taiwan government has been a strong backer of WiMAX, Far Eastone, the third largest Taiwan carrier, has launched a TD-LTE lab to prepare for its move from WiMAX to TD-LTE on June 19, 2011. Also, another Taiwan WiMAX operator, Global Mobile Corp has recently indicated it would move toward TD-LTE in 3-5 years. On June 19, Omantel has joined GTI (Global TD-LTE Initiative) — the first carrier from the Middle East. We estimate 12 carriers have committed to deploy TD-LTE so far (Exhibit 2). According to Qualcomm, there are 17 TD-LTE trials taking place in the world today. We believe that if TD-LTE can launch commercially via good quality handsets in 2013, the technology should have sufficient momentum and support from carriers and technology companies to become a much more successful technology than TD-SCDMA.

China Mobile's commercial launch is key to support momentum

The Chinese government strongly supports TD-LTE and would not grant FDD-LTE license until the TD-LTE technology is ready for commercial launch

The Chinese government views TD-SCDMA and TD-LTE technologies as important technological innovations in China and has selected China Mobile, the largest telecom carrier in the world, to carry out development of TD-SCDMA since 2008. At a recent conference, vice-minister Xi of the MIIT indicated that TD-SCDMA has been a success so far, demonstrated by: 1) its large scale commercial deployment; 2) 20mn TD subs, representing more than one-third of 3G market share at January 2011; 3) a maturing TD supply chain; 4) acceptance of TD-LTE as one of the international 4G standards candidates in October 2010 by ITU-R (International Telecom Union – Radiocommunication Sector). He expects China Mobile and other industry participants to leverage TD-SCDMA's achievement to accelerate development of TD-LTE as the infrastructure of the former could partly be utilized for the latter. This should sustain development of TD technology and help enhance China's competitiveness. Meanwhile, MIIT requires TD-LTE terminals to be compatible with TD-SCDMA during trial tests in China, but allows Chinese vendors to export TD-LTE terminals without TD-SCDMA functions. We believe that Mr. Xi's statement indicates that Chinese government is bringing TD-SCDMA development to an end, and that this will allow CM to deploy TD-LTE as soon as possible. In addition, based on our conversation with China Mobile we believe the Chinese government views the success of TD-LTE as higher priority than the financial return of 3G investments at China Unicom and China Telecom.

China Mobile has strong incentive to develop TD-LTE. Due to its late start and limited market (China only), TD-SCDMA has faced many challenges in handset and network quality. Consequently, China Mobile has been losing high-ARPU (over RMB200) subs to China Unicom and China Telecom in the last 12 months. In our view, China Mobile needs a successful TD-LTE launch to maintain its high-ARPU market share and has been pushing the technology. During the 2010 Shanghai World Expo, China Mobile built the first TD-LTE scale trial network on the expo site, with reported UL/DL speeds reaching 25/70Mbps, or 10 times current 3G rates. In 2011, CM has launched seven TD-LTE trial tests with seven global equipment vendors in six major Chinese cities: Ericsson and Huawei have participated in tests in Shenzhen, ZTE in Guangzhou, Datang in Nanjing, Motorola in Xiamen, Nokia-Siemens in Hongzhou, and Shanghai Bell in Shanghai. According to SOHU, by Dec 31 2010, 3,060 base stations had been installed for these trials by end-June 2011. China Mobile indicated that its trial test would focus on single-mode TD-LTE tests in 3Q2011, and multi-mode LTE/3G tests in 4Q11 and 1Q12. **China Mobile hopes to start commercial trial tests in seven major Chinese cities (Beijing plus the six cities listed above) in late 2012.**

We believe the timely launch of TD-LTE by China Mobile is crucial for the success of TD-LTE technology globally. TD-LTE has been gaining support from the technology supply chain, but we believe it would be difficult to sustain the level of support unless the TD-LTE market sufficiently large in two to three years. The number and size of TD-LTE carriers are still far below FDD-LTE carriers, at least over 2011-2014. China Mobile is by far the largest and best funded carriers of all the TD-LTE carriers. Therefore, if China Mobile cannot launch a TD-LTE service commercially in China, we would expect support for TD-LTE to decline substantially relative to that for FDD-LTE.

Exhibit 2: Around 90% of the current LTE commercial/trial network is using FDD-LTE technology; major carriers are developing TD-LTE networks in China, India, Japan and Taiwan

Roadmap of LTE rollout

Region	Carrier	Target Launch/ Rollout Date	Target Footprint	Current Technology	LTE Version (FDD or TDD)	Frequency
North America	AT&T	2011	70-75mn covered POPs (USA) in mid-2011 with nationwide coverage in 2013	WCDMA	FDD	700MHz
	TEN		USA (Commercial)			
	Verizon	2010	Launched in 38 markets. Targeting 140 markets with 200mn POPs in 2012 and full coverage in 2013	EV-DO	FDD	700MHz
	MetroPCS	2010	Las Vegas, NY, SF, Boston (USA); 100mn POPs target by mid-2011	EV-DO/LTE	FDD	2.6GHz
	Lightsquared	2011	4 markets in 2011 with 100mn covered POPs (USA) by 2012 and 260mn covered POPs by 2015	NA	NA	1.4ghz/1.6GHz
	Cellular South	NA	Mississippi, Tennessee, Alabama (USA)	EV-DO	TDD	700 MHz
	Cox Communications	2011	Phoenix, Arizona, San Diego (USA)	EV-DO	TDD	700 MHz
	Bell Mobility Canada	2012-13	Canada	WCDMA/EV-DO	FDD	800MHz / 1.9GHz
	Telus	2012-13	Canada	WCDMA	FDD	800MHz / 1.9GHz
	Rogers	2012-13	Canada	WCDMA	FDD	1.7GHz/2.1GHz
EMEA	Shaw Communications	2012-13	Canada	Wireline	FDD	700MHz/1.7GHz/2.1GHz
	TeliaSonera	2009-10	Sweden, Norway, Finland	WCDMA/LTE	FDD	2.6GHz
	Telenor	2010-11	Hungry, Denmark, Norway, Sweden	WCDMA	FDD	2.6GHz, 1.8GHz, 800MHz
	Tele2	2010-11	Sweden, Netherlands	WCDMA	FDD	900MHz / 2.6GHz
	TDC Network	2011	Denmark	WCDMA	FDD	2.6GHz
	Vodafone	2010-13	Germany, Netherlands, Portugal, Spain, Egypt	WCDMA	FDD	800MHz/2.6GHz
	Scartel	2011	Russia	WiMax	TDD	2.5-2.7GHz
	Elisa	2010	Finland	WCDMA	FDD	1.8GHz/2.6GHz
	Hutchison	2011	Austria, Ireland	WCDMA	FDD	700MHz/2.6GHz
	T-Mobile	2011-12	Austria, Germany, Netherlands	WCDMA	FDD	800MHz/2.6GHz
	France Telecom/ Orange	2011-12	France, Switzerland, Austria, Senegal	WCDMA	FDD	2.6GHz
	Telefonica	2011+	Spain, Germany, United Kingdom	WCDMA	FDD	800MHz/2.6GHz
	MTS	2010+	Uzbekistan, Armenia, Ukraine	WCDMA	FDD	2.6GHz
	CenterNet	2010	Poland	WCDMA	FDD	1.8GHz
	Mobyland	2010	Poland	WCDMA	FDD	1.8GHz
	Safaricom		Kenya			
	AlMadar Aljadeed		Libya			
	Zain	2011+	Bahrain, Zordan, Saudi Arabia, Nigeria	WCDMA	FDD	2.6GHz
	Etisalat	2011	Saudi Arabia, UAE, Egypt	WCDMA	FDD	NA
	Vodacom	2011	South Africa	WCDMA	FDD	2.6GHz
APAC	MobiNil	2013	Egypt	WCDMA	FDD	NA
	NTT DoComo	2010	Japan	WCDMA	FDD	1.5GHz / 2GHz
	China Mobile	2012	China, Hong Kong	TD-SCDMA	TDD	2.6GHz
	KDDI	2012	Japan	EV-DO	FDD	800MHz/1.5GHz
	Emobile	2011	Japan	WCDMA	FDD	1.7GHz
	CSL	2010	Hong Kong	WCDMA	FDD	2.6GHz, 1.8GHz
	Maxis	2013	Malaysia	WCDMA	FDD	2.6GHz
	KT	2011	S. Korea	EV-DO	TDD	800/900MHz
	SK Telecom	2011	S. Korea	WCDMA	FDD	NA
	LG Telecom	2011	S. Korea	EV-DO	FDD	800/900MHz
	Softbank	2012-13	Japan	WCDMA	TDD/FDD	1.5GHz/2.5GHz
	MobileOne	2011	Singapore	WCDMA	FDD	2.6GHz
	Chunghwa Telecom	2012	Taiwan	WCDMA	FDD	2.6GHz
	Far Eastone	2011+	Taiwan	WCDMA, WiMax	TDD	NA
	Reliance Industries Limited	Mid 2012	Initially urban areas then expanding to pan India	Greenfield	TDD	2.3GHz
	Bharti	Mid 2012	Kolkata, Karnataka, Maharashtra, Punjab	WCDMA	TDD	2.3GHz
	Aircel	Mid 2012	AP, TN, WB, Assam, Bihar, J&K, North-East, Orissa	WCDMA	TDD	2.3GHz
	Tikona	Mid 2012	Gujarat, Rajasthan, UP (E), UP (W), Himachal Pradesh	Greenfield	TDD	2.3GHz
	Omantel	2011+	Oman	CDMA	TDD	2.3GHz
Latin America	Telefonica/Movistar	2012	Ecuador, Colombia, Mexico, Uruguay, Venezuela, Argentina	WCDMA	FDD	2.6GHz
	Entel PCS	2012	Chile	WCDMA	FDD	2.6GHz
	Telefonica/Vivo	2013-14	Brazil	WCDMA	FDD	2.6GHz
	America Movil/Claro	2011	Mexico, Chile, Argentina, Brazil, Peru, Uruguay	WCDMA	FDD	2.6GHz

Source: GSA, Iteworld.org, 4G Americas, Telegeography, Goldman Sachs Research estimates.

Exhibit 3: Asian carriers are aggressive in their TD-LTE schedules, in our view

TD-LTE progression of CM, Indian carriers and Softbank

	YE 2010	YE 2011	YE 2012	YE 2013
China Mobile		started TD-LTE trial in 6+1 cities	commercial trial in seven cities, first data card only and possible to launch handsets in 2H12	We expect CM to roll out large scale LTE network construction
Softbank	Conducted trials in some areas such as Ubiquitous since Dec 2009		plans to launch commercial TD-LTE service in late 2012E or 2013E.	
Reliance Industries	Won BWA spectrum in June 2010 auction; Conducted TD-LTE trials with Ericsson in Nov, 2010	Conducted TD-LTE trials with Ericsson, Alcatel-Lucent, Samsung and ZTE; in trial with Nokia Siemens and likely with Huawei as well according to report by Telecom Junction	Likely to launch TD-LTE service in 2012	
Bharti Airtel	Won BWA spectrum in June 2010 auction.	May acquire BWA licenses in four (complementary) circles from Qualcomm as per media reports (ET; Mar-17)		
Aircel	Won BWA spectrum in June 2010 auction.	Conducting TD-LTE trials with equipment vendors such as Huawei, ZTE, Nokia Siemens and Ericsson.	Likely to launch TD-LTE service in 2012	
Tikona	Won BWA spectrum in June 2010 auction.	Plans to start rollout with 150 Indian cities.		

Source: Company data, Telecom Junction, Telecom Asia, Lightreading and Goldman Sachs Research estimates

India carriers may launch TD-LTE by mid-2012; before China Mobile?

Based on our channel checks, we expect Reliance Industries, Bharti, Aircel and Tikona will look to launch TD-LTE by mid-2012 and are to likely focus on the nascent zero-penetrated tablet market and on complementing their existing offerings. Although doubtless, operators' strategies will differ, we would not expect any LTE rollout to lead any material increase in competitive dynamics in the telcos market as we expect LTE to complement the existing 2G/3G service.

We believe the tablet market will complement the existing cell-phone market, because at any given moment a consumer could have both a cell phone and a tablet in use. Given the low fixed broadband penetration in India, we believe that affordable and well marketed tablet offerings would open up room for another source of income for operators. Below we highlight what we consider to be the key strategies of TD-LTE operators in India.

Exhibit 4: Operators with received BWA/3G spectrum

	(Rs mn)	MTNL/BSNL	RIL-Infotel	Bharti	RCOM	Idea	VOD	DoCoMo	Aircel	STel	Qualcomm	Tikona	Augere	Data players
Metros	Delhi	3G+BWA	LTE	3G	3G		3G				LTE			6
	Kolkata	3G+BWA	LTE	LTE	3G		3G		3G					6
	Mumbai	3G+BWA	LTE	3G	3G		3G				LTE			6
Circle A	Andhra Pradesh	3G+BWA	LTE	3G		3G			3G+LTE					5
	Gujarat	3G+BWA	LTE			3G	3G	3G				LTE		6
	Karnataka	3G+BWA	LTE	3G+LTE				3G	3G					5
	Maharashtra	3G+BWA	LTE	LTE		3G	3G	3G						6
	TN (incl. Chennai)	3G+BWA	LTE	3G			3G		3G+LTE					5
Circle B	Haryana	3G+BWA	LTE			3G	3G	3G			LTE			6
	Kerala	3G+BWA	LTE			3G		3G	3G		LTE			6
	Madhya Pradesh	3G+BWA	LTE		3G	3G		3G					LTE	6
	Punjab	3G+BWA	LTE	LTE	3G	3G		3G	3G					7
	Rajasthan	3G+BWA	LTE	3G	3G			3G				LTE		6
	Uttar Pradesh (E)	3G+BWA	LTE			3G	3G		3G			LTE		6
	Uttar Pradesh (W)	3G+BWA	LTE	3G		3G		3G				LTE		6
	West Bengal	3G+BWA	LTE	3G	3G		3G		3G+LTE					6
	Assam	3G+BWA	LTE	3G	3G				3G+LTE					5
Circle C	Bihar	3G+BWA	LTE	3G	3G				3G+LTE	3G				6
	Himachal Pradesh	3G+BWA	LTE	3G	3G	3G			3G			LTE		7
	Jammu & Kashmir	3G+BWA	LTE	3G	3G	3G			3G+LTE					6
	North East (NE)	3G+BWA	LTE	3G	3G				3G+LTE					5
	Orissa	3G+BWA	LTE		3G				3G+LTE	3G				5

Note: BWA stands for Broadband Wireless Access; LTE here stands for TD-LTE

Source: TRAI, Goldman Sachs Research.

RIL: slow and steady progress; but needs an underlying network

Management comments on LTE rollout: RIL's subsidiary Infotel is the only LTE operator which has a pan-India spectrum. In an analyst meeting on July 12 2010, RIL highlighted the following points: i) it will invest Rs48 bn (US\$ 1.1bn) over the next 2-3 years to launch wireless broadband services and does not intend to enter the already crowded 2G-based telecom business. However, the company mentioned that it may enter the voice business through IP enabled voice (like VoIP); (ii) Management said the roll-out of services will be made in phases and will initially target urban and semi-urban centers; (iii) RIL expects the BWA (Broadband Wireless Access) service to achieve cash profit in three years from launch time; (iv) as per RIL, a pan-India BWA rollout would require 15,000 towers and the company plans to partner with existing infrastructure providers for most of its rollout requirements.

Sourcing tablets and leasing towers: Infotel is focusing on low-cost tablet PCs and affordable data plans. Media articles (eg; *Business Standard*, Feb 16, 2011) mentioned that Infotel has decided on seven-inch and 10-inch Android-based tablets with prices starting at Rs8,000 (US\$178) and data plans expected to start at as low as Rs1,000 (US\$22) for three to six months. Infotel has signed two-year supply contracts with four original equipment manufacturers (OEMs) based in China and Taiwan including Huawei, Samsung and Alcatel.

Infotel wants to lease towers and has invited bids from telecom tower operators. Its initial requirement is 26,000 towers, but will step that up to 60,000 in the next few months. It expects eventually to need more than 100,000 towers for pan India LTE rollout. Media articles (eg; *Business Standard*, Feb 14, 2011) mentioned that Infotel has told the tower companies that it will pay only Rs16,000-18,000 (US\$355-400) a tower/month as rent vs. the prevailing rent of Rs27-33,000 (US\$600-733).

We believe RIL will need an underlying network: We do not see a strong business case for a stand-alone pan-India LTE operator, as the cost of rolling out LTE on 2.3 GHz to cover pan-India (including sparsely populated rural areas and indoor coverage in urban areas) is high and not necessarily profitable. We therefore believe RIL needs an underlying network – which could be WCDMA or CDMA2000, or even 2G although user experience would not be great – where it could offload traffic and hence reduce uneconomical investments. We believe RIL could achieve this either by signing ICR (inter-circle-roaming) agreements with existing operators or potentially by acquiring any GSM/CDMA operator (as M&A norms relax in coming months). We remain unsure which route RIL might follow.

Bharti: LTE to complement its existing 3G offering

We believe Bharti is the best positioned operator in India to benefit from the LTE rollout as it can offer complementary and bundled offerings to its existing strong subs base. We think LTE could help Bharti in: 1) Aggressively pushing the high-speed dongle offerings which it cannot do on its WCDMA network at present, because of its network backhaul cost increases (and increases congestion for existing subs); 2) Targeting the zero-penetrated tablet market, which can complement its small screen 3G offerings; 3) LTE can handle the backhaul traffic load on 3G (we believe the current backbone on 3G would not be able to handle the data load in coming years as usage increases). We think Bharti has room to expand further its LTE footprint in India with the potential acquisition of Qualcomm licence (for details please refer to *Purchase of Qualcomm's licence? Complements 3G/LTE footprint*, Mar 17, 2011).

Tikona: the only stand-alone LTE data operator in India?

Tikona is providing wireless broadband (largest outdoor 4G WiFi network, 42,000 base stations) using 110 MHz in the unlicensed band in 36 top cities, and its product offerings are targeted towards enterprise consumers and household customers. In August 2010, the company secured LTE licences in five circles covering c. 29% of the urban population of

India. Management believes LTE will help Tikona provide “outdoor ubiquitous coverage for mobile internet devices” to complement its existing indoor high capacity–high speed WiFi offerings for Home & SMB and expand its reach further now to target mobile broadband subs (“small-screen”). Unlike RIL, Tikona does not rely on an underlying network as it already has “indoor coverage” through its current wireless broadband offerings, in our view.

Management believes Tikona is now well positioned to target all three growing broadband segments - “large-screen”, “small-screen” and “enterprise broadband”- through its high-speed offerings. In addition, Tikona may also benefit if 2G and 3G operators sign roaming agreements to offload their data traffic to LTE and /or WiFi networks, since the limited bandwidth on 3G network is not sufficient to handle incremental data load.

Aircel: Banking on the LTE ecosystem development

We think Aircel was initially inclined toward using BWA spectrum for Wimax rollout given that it had Wimax solutions (even before auctions); but with improving visibility of the LTE ecosystem it is now focusing on LTE rollout. We believe Aircel’s strategy will be similar to that of Bharti — ie; use LTE to complement its existing 3G business by focusing on tablets/dongles on LTE, and using LTE as a backbone to transfer traffic load. We do not rule out either Aircel signing ICR agreements with stand-alone LTE operators like Tikona to handle its traffic load from 3G in circles where it is not present.

Exhibit 5: Potential BWA market size in India

	FY10	FY11E	FY12E	FY13E	FY14E	FY15E
Fixed Broadband subs (mn)	9.0	11.9	15.6	20.0	25.3	31.7
Net adds (mn)	4.1	2.9	3.6	4.4	5.3	6.4
Fixed bband pent'n (Households)	4%	5%	7%	8%	11%	13%
Fixed bband pent'n (Pops)	1%	1%	1%	2%	2%	3%
3G handsets (mn)	13.9	27.8	49.0	77.7	111.8	139.8
3G subs (mn)	4.4	8.9	22.1	42.7	72.7	104.8
3G penetration (Pops)		1%	2%	4%	6%	8%
Tablet Users (mn)			6.2	12.0	25.3	38.0
Net adds (mn)				5.8	13.3	12.7
Tablet penetration (Households)			3%	5%	11%	16%
Tablet penetration (pops)			1%	1%	2%	3%
BWA ARPU (Rs)			1,200	1,080	994	924
% change				-10%	-8%	-7%
BWA Revenue (US\$ bn)			2.0	3.5	6.7	9.4

Source: Goldman Sachs Research estimates.

Japan TD-LTE to take off in FY2012-13; XGP2 needs monitoring

Softbank, the only carrier adopting TD-LTE in Japan, has said it will commence service in late FY2012 or FY2013. Among equipment vendors, we see Kyocera as a potential beneficiary although we will need to monitor this as start-up approaches. WCP (Wireless City Planning), which is using some of the infrastructure of the pre-bankruptcy Willcom, is developing XGP2. Softbank could attain an asset advantage if TD-LTE can be used on the

same bandwidth as XGP2 and capex can be held down thanks to technological compatibility. However, at this stage there are too many uncertain factors to make definitive statements about TD-LTE adoption in Japan.

Watch the timing of commercial TD-LTE service start-up by Softbank

Softbank is apparently calling on equipment vendors for speedy development. However, it has said only that the start of commercial service will be in late FY2012 or FY2013; it has not disclosed a detailed schedule. Factors in play are: (i) allocation of 700MHz/900MHz, the bandwidth assigned to LTE, has been postponed from autumn 2010 to autumn 2011; (ii) Softbank has little incentive to launch the technology until compatible iPhones are available. We are assuming spring 2013 for the launch of an iPhone that supports TD-LTE based on the typical 6-9 months lag between chipsets and handsets that adopt the technology and the iPhone's new product cycle.

Softbank to gain a spectrum asset advantage if WCP can roll out TD-LTE

WCP, in which Softbank holds a 30% stake, has taken over XGP business from Willcom. If it follows XGP2 with TD-LTE development, Softbank could gain a spectrum asset advantage, in our view, albeit with the following prerequisites:

- (i) The government permits 2.5GHz bandwidth assigned to Willcom for XGP to be used for TD-LTE: This was not a condition for Willcom rehabilitation and opposition could be expected from other carriers.
- (ii) The Softbank group is able to hold down incremental investment thanks to technological compatibility between XGP2 and TD-LTE: XGP2 resembles TD-LTE in that it uses TDD, SC-FDMA, and 20MHz bandwidth. When the TDD promotion initiative was launched, Softbank CEO Masayoshi Son said next-generation XGP is 100% compatible with TD-LTE. However, no details of shared technological features have been disclosed and it is not clear whether he was referring to full compatibility that includes, for example, parts sharing.

TD-LTE is the global technology of choice for unpaired spectrum

Verizon's LTE has had a warm reception in the US

Verizon's FDD-LTE launch in late 2010 has been a success, in our view. Our US telecom analyst, Jason Armstrong, expects FDD-LTE to benefit from its first mover advantage with rapidly expanding coverage keeping its several quarters, if not years, ahead of peers in LTE. According to our channel checks, Verizon has guided its major handset suppliers that its FDD-LTE phones could potentially make up 50% of its total smartphone procurements by the end of 2012.

The warm reception for Verizon's LTE service is not a surprise to us. Our global technology team has recently published a report on LTE (*LTE: fueling the mobile super-cycle; implications across TMT*, Feb 9, 2011). The key thesis of the report is that LTE is coming and is likely to enjoy a warmer reception by the market than WCDMA did based on the premise that its success will be driven by the "3Es":

- (1) **Ecosystem** – the current wireless ecosystem closely resembles the wired broadband ecosystem a decade ago, when we saw a fast ramp up in cable broadband subs. The rapid growth of mobile application is fueling strong demand for mobile bandwidth.
- (2) **Experience** – download speeds that are significantly higher than 3G and faster too than first generation broadband speeds, which will enable much faster browsing and

video use. LTE would offer the leading carrier a significant competitive advantage, in our view.

- (3) **Economics** – LTE offers meaningful savings to carriers. We estimate that the backhaul cost per GB in the US will decrease from \$4 in 3G and \$3.5 in 3.5G to \$2.5 in LTE.

TD-LTE enables carriers to monetize their unpaired spectrums

LTE has two versions, TD-LTE and FDD-LTE, depending on how the signal is transmitted in air. As explained in more detail in the appendix of this report, TD has superior spectrum efficiency than FDD. TD can utilize a single 15MHz spectrum to build a network while FDD-LTE would require an adjacent pair of spectrums with a buffer in the middle for uplink and downlink communication. Spectrum has been a scarce resource globally. Many carriers have had acquired WiMAX or PHS spectrum that is unpaired and do not support FDD-LTE. Meanwhile, the supply chain support and scale for WiMAX have been declining. According to a recent Qualcomm report, TD-LTE is becoming the global solution for unpaired spectrum because it complements 3G to boost data capacity, provides seamless 3G interoperability, and leverages FDD-LTE and huge 3G ecosystem.

- TD-LTE can offer up to 150Mbps data download rate. In addition, it offers flexible uplink and downlink capacity allocation.
- TD-LTE has optimized interoperability with WCDMA/HSPA+ and CDMA2000 1X/EVDO and supports circuit switched FallBack to 3G for seamless voice service
- TD-LTE and FDD-LTE have common core network and share most of FDD-LTE's designs and standards. The main difference is in RF and signal encoding. The multi-mode LTE handset should allow TD-LTE to leverage on the handset ecosystem of FDD-LTE.
- On the negative side of things, FDD-LTE covers 40% to 80% larger area than TD-LTE and is better at providing wide area coverage. This means TD-LTE might require more towers in less densely populated area.

Commercial TD-LTE handsets might become available in late 2012

Smartphone and related semiconductors have been the key technical bottlenecks of TD-SCDMA development. Compared with TD-SCDMA, TD-LTE has attracted much stronger R&D investment from leading global semiconductor companies. Qualcomm and STE have just announced the sampling of their multi-mode LTE/3G chipsets that is an important milestone in resolving such bottlenecks in TD-LTE. We expect these products to become commercially available by mid-2012. Under this scenario, we expect Huawei, ZTE, and other leading handset vendors to launch multi-mode LTE/3G smartphone by the end of 2012. We believe that the strong support from global leading technology companies should ensure TD-LTE to have a much smoother ride than TD-SCDMA.

Qualcomm leads in integrated multi-mode LTE/3G mobile processor

Qualcomm, the leader in global communication technology and semiconductors, has recently indicated that all its LTE products would support both TD-LTE and FDD-LTE. On June 1, 2011, Qualcomm announced the world's first multi-mode 3G/LTE mobile processor, **MSM8960**, which will sample in mid-2011. Our channel checks indicate that the MSM8960 version with TD-LTE connectivity will be commercially available by June 2012.

MSM8960 is a dual-core mobile processor that features 28nm, 2.5GHz per core, integrated modem for TD-LTE/FDD-LTE/EVDO/HSPA+, integrated connectivity of WLAN/GPS/Bluetooth/FM, and power management. MSM8960 would meet the multi-tasking requirements of Windows 8 and also support other OS such as Android, WebOS, BREW and Blackberry.

Current LTE handsets such as the HTC Thunderbolt uses a two-chip solution (base band and a discrete mobile application processor) that is prone to interference, consumes more power, and requires more engineering time than the one with a SOC (system on chip) solution such as MSM8960. Typically, commercial handsets sample 6-9 months after chipset sampling. In light of their experience of developing FDD-LTE handset with discrete chipsets, HTC and Samsung should therefore be able to develop a multi-mode LTE/3G smartphone in six to nine months. We believe that a TD-LTE smartphone based on MSM8960 could become available by the end of 2012 or early 2013.

Exhibit 6: MSM8960, the first integrated 3G/LTE mobile processor will be commercially available by mid 2012

Specification of Qualcomm's MSM8960

World's First Multi-Mode 3G / 4G Integrated Chipset

MSM8960



CPU UPGRADE

New micro-architecture

~5x performance,
~75% lower power

GRAPHICS UPGRADE

~4x performance

MULTI-MODE MODEM

Integrated LTE Multi-Mode
All 3G modes supported

INTEGRATED CONNECTIVITY

WLAN, GPS, Bluetooth, FM

FIRST CHIP OF THE NEW SNAPDRAGON FAMILY

Source: Company data.

In addition to MSM8960, Qualcomm offers MDM9x00 baseband chipsets that features integrated modem for TDD-LTE/FDD-LTE/EVDO/HSPA+. MDM9x00 supports OFDMA and MIMO technologies and enables uplink and downlink speeds up to 50Mbps and 100Mbps, respectively.

ST-Ericsson might lead in multi-mode LTE/3G modem

ST-Ericsson has announced sampling of its first multi-mode LTE/3G modem, THOR M7400 in May. M7400 supports TD-LTE/FDD-LTE/TD-SCDMA/HSPA and is available for sample in 2Q2011. According to Simon Schafer, our European technology analyst, the M7400 version supporting TD-LTE is due to become commercially available in early 2012, but in light of the accelerated development of TD-LTE, ST-Ericsson would potentially pull the schedule

ahead by a few months in time. In the later case, M7400 would make the deadline for Softbank's TD-LTE sampling in May 2012.

TD-LTE has broad support from global semiconductor companies

We believe that Qualcomm and ST-Ericsson are leading in TD-LTE chipsets development. In addition to Qualcomm and STE, we view Intel, Nvidia, Marvell, and Hi-Silicon as the second wave of leading semiconductor companies with multi-mode TD-LTE chipsets to sample in late 2011. Furthermore, Innofidei and Sequans have participated in China Mobile's TD-LTE trial tests, but their solutions are mostly single mode. We believe that Marvell, Leadcore, Spreadtrum, ZTE and Samsung have taped out their TD-LTE chipsets based on our industry checks. Mediatek and VIA are developing TD-LTE chipsets. Compared with TD-SCDMA, TD-LTE has garnered significantly more support from global and Chinese leading semiconductor companies (Exhibit 7). **In addition to base band and mobile processor, the industry is also making progress in RF and power amplifier (PA).** For example, Qualcomm also offers accompanying RF chipsets for multi modes including both 2.3GHz and 2.6GHz TD-LTE band. According to Qualcomm, RF should not be a challenge for multimode 3G/LTE operation. We believe that Intel (IFX), STX, and Fujitsu also have sufficient digital CMOS RFIC technology to supply multi-mode LTE RF chips. RFMD's multi band PA, PowerSmart can serve triple band operations.

Marvell - We see TD-LTE adoption as a potentially meaningful positive. Marvell already holds a commanding share (75%-80%) of the TD-SCDMA smartphone chipset market in China by virtue of its close relationship with China Mobile and key handset OEMs in the TD space. We expect Marvell to sample its TD-LTE solution to customers as early as 3Q11. Relative to TD-SCDMA, which has seen adoption only in China, TD-LTE could be a more significant driver for Marvell's wireless business to the extent that TD-LTE sees more widespread adoption in emerging markets. Although the longer term competitive landscape is unclear, we think Marvell is likely to hold a somewhat smaller share in TD-LTE relative to TD-SCDMA as we expect increased competition from Qualcomm, ST-Ericsson, and others.

Sequans – Early to market, could be a meaningful long-term player. We believe Sequans began sampling its TD-LTE baseband (SQN3010) in late 2010 or early 2011. Our channel checks indicate Sequans has already been engaged in early trials with a number of partners, including China Mobile, Alcatel-Lucent, Motorola, and others. We believe Sequans was able to come to market early as a result of its significant traction with WiMAX in emerging markets, as the WiMAX and TD-LTE standards have significant technical similarities. We believe Sequans will be able to capture some amount of share in TD-LTE as a result of its relationships with carriers in emerging markets, although we would note that TD-LTE is likely to become significantly more competitive than the WiMAX market.

Exhibit 7: TD-LTE has strong support from global leading semiconductor vendors
Comparison of semiconductor suppliers between TD-SCDMA and TD-LTE

TD-SCDMA		TD-LTE	
Early chip supplier	Current chip supplier	Current chip supplier	Potential additional chip supplier
T3G (BB)	Marvell (SOC)	Qualcomm (SOC & BB)	Leadcore (BB)
Leadcore & Mediatek (BB)	Spreadtrum (BB & SOC)	STE (SOC & BB)	Spreadtrum (BB)
Spreadtrum (BB)	Leadcore (BB)	Hi-Silicon (BB)	Mediatek
Committ	STE (BB)	Marvell (SOC)	ZTE (BB)
	Mediatek (BB)	Sequans (BB)	VIA (BB)
		Renasas	Samsung (BB)
			Broadcom (acquired Beceem)
			Altair Semiconductor
			Wavesat
			Runcom
			Innofidei (BB)

Source: Goldman Sachs Research estimates.

Eleven global and Chinese telecom equipment vendors have participated in China Mobile's TD-LTE trial test so far

According to SINA.com, on May 4 2011, some 11 telecom equipment companies participated in China Mobile's TD-LTE equipment qualification test. These companies are Ericsson, Huawei, Shanghai Bell (Alcatel-Lucent), Nokia Siemens Networks, ZTE, Datang, Putian, Postcom, Samsung, and FiberHome. Hi-Silicon and Innofidei have provided single mode TD-LTE chipsets for the qualification test. In India, all major global vendors (Ericsson, Alcatel-Lucent, Nokia-Siemens, Samsung, ZTE, and Huawei) are supporting the rollout and are competing for contracts.

For terminals, China Mobile plans to test TD-LTE dongles, Mi-Fi devices and tablets in 2011 and 1H2012; it is hopeful that TD-LTE handsets would become available in 2H2012. Our checks indicate that India carriers are asking terminal vendors for dongles, Mi-Fi devices, and tablets as well in 2011. Softbank has asked Huawei and ZTE to sample their TD-LTE smartphones in May 2012.

Winners/losers from successful TD-LTE commercial launch in 2013

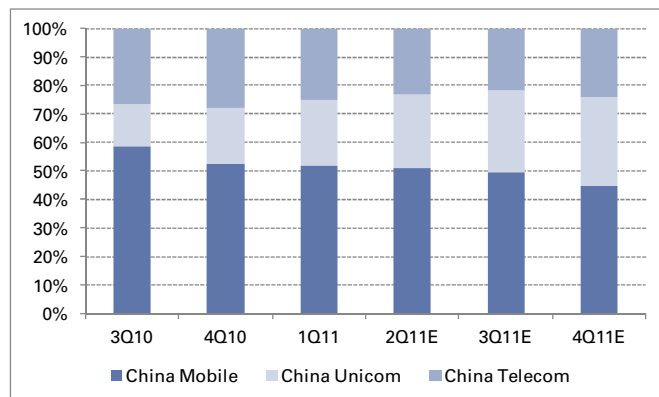
Carriers: positive for China Mobile, Bharti and Softbank; negative for China Unicom and China Telecom

In China, we expect any successful launch of TD-LTE would have significant impact on telco market share and stock performance. In the 2G era, China Mobile has captured 85% market share of the total incremental wireless service revenue in China before 2009. In the 3G era, China Unicom has benefited significantly from its superior 3G technology (WCDMA); China Telecom has been successful in revamping the EVDO ecosystem; but China Mobile has suffered from the inferior and relatively late-coming TD-SCDMA technology. Since mid 2010, China Unicom has started to gain market share in the incremental wireless service revenue (Exhibit 8). In 2010, China Mobile, China Unicom, and China Telecom had 52%, 20%, and 28% market share in 2010, respectively. We expect the \$150 WCDMA smartphone and increasing subsidy to sustain CU's momentum to capture 31% and 40% market share in 2011 and 2012, respectively. Meanwhile, CT has significantly improved the line up of EVDO smartphone and should gain 3G market share in 2011E-2012E, but CT's 2G ARPU has declined significantly in 4Q10 and should hurt its overall annual market share in 2011. For CM, we expect its incremental wireless revenue market share to shrink further to 45% and 30% in 2011E and 2012E, respectively. We believe that 2013 could potentially be an inflection year if CM can successfully launch TD-LTE with the iPhone or another good smartphone. We note that CM still has significantly more resources and larger coverage than CU or CT. For example, CM has over 53K branch offices/outlets, well above those of 19K and 17K at CU and CT. We expect CM's market share to increase gradually, recovering from 30% in 2012E to 53% in 2016E

In India, Bharti should benefit most from TD-LTE because Bharti can sell bundled and differentiated service to its relatively strong existing subs base. Specifically, LTE would enable Bharti to: 1) lower the backhaul costs and network congestion of high-speed dongle; 2) offer tablet as a new, large screen device to its sub. **In Japan,** a potentially successful TD-LTE development should benefit Softbank, the only TD-LTE operator in Japan. In addition, under the scenario that WCP (Wireless City Planning) can roll out TD-LTE, Softbank would gain valuable spectrum assets.

Exhibit 8: CU has taken most incremental market share in the last 12 months

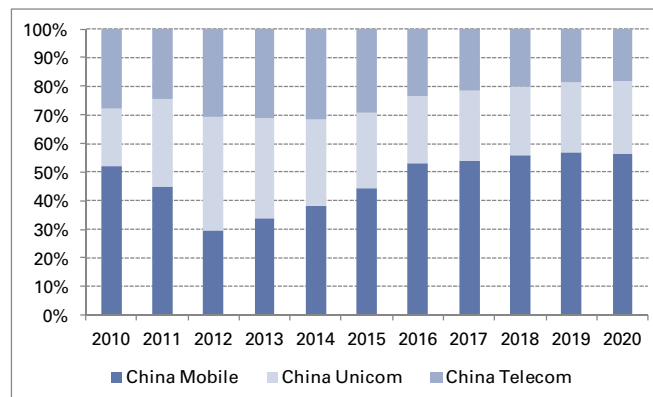
Trailing 12 month incremental wireless revenue market share



Source: Company data, Goldman Sachs Research estimates.

Exhibit 9: We expect CU's market share to peak in 2012, and CM to recover its market share afterward

Annual incremental wireless revenue market shares



Source: Company data, Goldman Sachs Research estimates.

ZTE/Kyocera would benefit from faster-than-expected TD-LTE launch

It is still too early to estimate the market size of TD-LTE equipment capex because we have not yet seen any large scale network development. From a top down perspective, TD-LTE capex should be substantial relative to 3G because: (1) TD-LTE operates at relatively high frequencies of 2.3GHz and 2.5/2.6GHz; (2) according to Qualcomm, FDD-LTE should have 40% to 80% larger coverage area than TD-LTE, and so TD-LTE will require more towers to cover the same area.

For China Mobile, total TD-LTE capex should be less than TD-SCDMA capex because its TD-SCDMA base stations can all be upgraded to TD-LTE moderately inexpensively. We estimate that CM's total capex for TD-SCDMA and TD-LTE at Rmb27bn (US\$4.2bn), Rmb46bn (US\$7.1bn), and Rmb21bn (US\$3.2bn) in 2012E, 2013E and 2014E respectively. In India, RIL is the most aggressive of the four TD-LTE carriers, with an initial US\$2bn capex. Overall, we estimate total global TD-LTE capex could reach US\$15bn to US\$20bn in 2012-2014E.

ZTE should be a major beneficiary of TD-LTE, in our view. According to *Digitimes*, ZTE holds 7% of LTE essential patents mostly in TD-LTE, well above its patent position in 3G. We believe that ZTE would be likely to capture 25% to 30% share in China TD-LTE market due to its home advantage and estimate China Mobile's TD-LTE opportunity to represent 6% and 7% of total revenues at ZTE in 2012E and 2013E. However, we recommend investors wait for ZTE's 1H2011 result announcement in late August before potentially buying ZTE shares, due to potential margin pressure from later-than-expected software tax rebate, wage inflation, and increasing interest expenses.

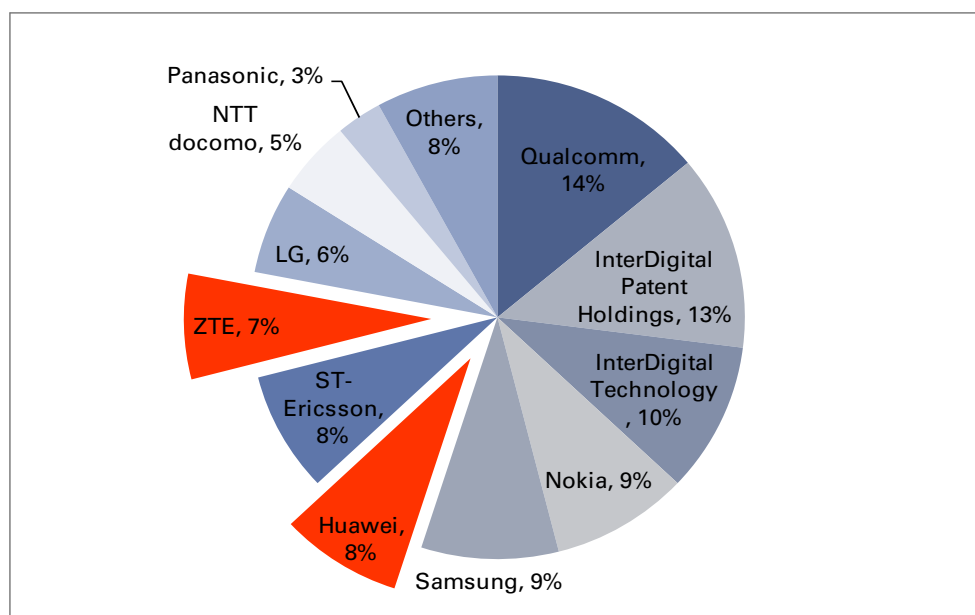
Kyocera is potentially a TD-LTE beneficiary in Japan and to a much lesser extent in China. Kyocera is the only Japanese equipment vendor that supports PHS technology, placing it in an excellent position to benefit if TD-LTE takes off as planned in 2012-2013, if PHS spectrum is being converted to TD-LTE usage. Kyocera has also been the main PHS handset supplier to Willcom in Japan. If WCP can roll out TD-LTE, Kyocera would have an advantage in being the main equipment supplier.

In Korea, we consider TD-LTE rollout to be incrementally positive to Samsung Electronics (SEC), and that a faster than expected rollout of TD-LTE could be a small incremental

positive for Samsung Electronics. We believe that SEC could benefit from TD-LTE equipment rollout as well as the upgrade replacement cycle to TD-LTE handsets as a handset vendor. As network equipment accounts for only 1.3% of SEC's overall revenue the impact from the TD-LTE handset upgrade cycle may be more meaningful in the long term. With about 10% handset market share in China, we believe that a TD-LTE handset upgrade cycle from 2H12 would also be positive for SEC's handset business, because it could help incremental market share gains and help maintain ASPs. The magnitude of the benefit for SEC would depend on if: 1) operators take an even greater role in handset distribution compared to 3G; 2) the complexity of TD-LTE handsets is able to diminish further the role of white box handset makers in China; 3) TD-LTE handsets will be able to raise the overall ASP for SEC's Chinese handset business. Meanwhile, we believe that the possibility of SEC being a TD-LTE baseband chipset supplier may be low, as we expect that SEC's System LSI business may focus more on application processors than baseband in the mid-term.

For LG Electronics (LGE), execution will decide the benefit. Our checks indicate that LG Electronics is not involved in the TD-LTE equipment trials at this stage. Meanwhile, LGE's handset market share in China is significantly lower than its global average of about 8%, due to limited distribution. There was some expectation that 3G rollout would help with operators taking a greater role in distribution, but our checks indicate that LGE's market share did not improve meaningfully. We expect LGE to roll out TD-LTE handsets as networks are rolled out, but unless LGE is able to increase market share with operators the impact on LGE's overall handset business may be limited.

Exhibit 10: ZTE held 7% of the LTE essential patents by end of 2010
LTE essential patents holders by end of 2010



Source: ETSI, Digitimes.

Qualcomm and STE lead in TD-LTE semiconductor suppliers today

We believe that Softbank should be the first carrier to issue TD-LTE handset and estimate its TD-LTE handset shipment to reach 0.5mn, 2.1mn, 3.0mn, and 4.1mn in FY2012 (ending in March), FY2013, FY2014, and FY2015, respectively. We also estimate China Mobile to add 31mn to 37mn TD-SCDMA and TD-LTE sub in 2013-2015, respectively. Both China Mobile and Indian carriers seem to focus on deploying TD-LTE dongles and MiFi devices in 2012 - 2013. Overall, we estimate 1mn, 15mn and 25mn TD-LTE terminals shipments in 2012-2014.

According to our channel checks at Chinese handset makers, Qualcomm and ST-Ericsson lead in multi mode LTE/3G mobile processor and modems. Both vendors are also including TD-SCDMA into their products to serve the China market. They should benefit from any expedited TD-LTE ramp up. Among the leading handset makers, our checks indicate that Huawei and ZTE already have R&D program in TD-LTE handset. The first milestone of TD-LTE handset seems to be Softbank's procurement, scheduled for May 2012.

Exhibit 11: Many A-share technology companies could potentially benefit from the TD-LTE launch

A list of A-share telecom-related technology companies

Sub-sector	Company	Ticker	Core business
	ZTE	000063.SZ	
Optical network hardware	Fiberhome	600498.SS	No. 3 optical hardware provider in China
Optical component	Accelink	002281.SZ	No.1 passive component supplier in China, and No.11 globally.
Test equipment and service	Dingli	300050.SZ	Over 60% share in China wireless air interface testing equipment market
	Hangzhou Huaxing	300025.SZ	Air interface testing service company
	Beijing Zhongchuang	600485.SS	Core network testing and maintainance management products
Wireless radio access equipment	Shenzhen Tat Fook	300134.SZ	RF sub system provider
	Wuhan Fingu	002194.SZ	RF sub system provider
Network enhancement	Sunwave	002115.SZ	Network coverage optimization product and solution provider
	Fujian Sunnada	002417.SZ	Network coverage optimization product provider, specialized in WLAN
	Allwin	002231.SZ	CMMB network enhancement solution provider
Physical connection equipment	Sunsea	002313.SZ	Connection equipment supplier in China
	Suzhou New Sea Union	002089.SZ	Connection equipment supplier in China
Antenna	Guangdong Shenglu	002246.SZ	Base station and microwave antenna provider
Optical fiber and cable	Jiangsu Zhongtian	600522.SS	Optical fiber and cable manufacturer
	Hengtong	600487.SS	Optical fiber and cable manufacturer
	Jiangsu Tongding	002491.SZ	Optical fiber and cable manufacturer
	Wuhan Yangtze	600345.SS	Optical fiber and cable manufacturer
Tower	Beijing Miteno	300038.SZ	Communication tower manufacturer
Chipset	Nationz	300077.SZ	Security, RF, CMMB, PA chips
Network service	Guomai	002093.SZ	Network design and maintainance service provider

Source: Goldman Sachs Research

Appendix: comparing TD-LTE, FDD-LTE and WiMAX

What are TD-LTE, FDD-LTE, and WiMAX?

LTE (Long Term Evolution) and WiMAX are both fourth generation (4G) cellular technologies. There are two versions of LTE, TD-LTE (Time Division Duplex) and FDD-LTE (Frequency Division Duplex) that differ from each other in terms of their radio transmission scheme. With FDD, the transmission (uplink) and reception (downlink) of signals are using two different channels separated by a guard band to prevent interference (Exhibit 12). In comparison, TDD uses only one single frequency for both uplink and downlink which are separated by time intervals (guard intervals) (Exhibit 13). Other than this major difference, TDD and FDD share a lot of commonalities such as all-IP based, OFDM (orthogonal frequency-division multiplexing) and MIMO (multiple input multiple output). According to Huawei's LTE product line vice-president, quoted by *Tech Daily* on September 1, 2010, 80% of the RF technologies of TDD/FDD are the same and 70% of software architecture could be shared.

As shown in Exhibit 2, most of the commercial/trial FDD LTE networks deploy the 2.6GHz band, but there are still a few rollouts including a couple of large ones using other bands such as 700MHz by Verizon, 800MHz by Vodafone Germany and 2GHz by NTT DoCoMo; while for TDD LTE, 2.3GHz and 2.6GHz are expected to be the two major bands for global TDD LTE rollouts.

WiMAX, as the other 4G technology, shares many similarities with LTE. First, both are based on similar air interface technology (OFDMA and MIMO) and could be deployed on scalable bandwidth (1.4 to 20MHz for LTE and 1.25 to 10MHz for WiMAX). Second, in terms of duplexing mode, WiMAX is primarily for TDD, as with TD-LTE. Third, from the system architecture perspective, similar functional decomposition is deployed (for example, to separate radio resource management from IP management and locating RRM (Radio Resource Management) in the BS (Base Station) and IP management in the access gateway); all RAN and core network systems are IP-based. The differences between WiMAX and LTE lie in the implementation of the above technology such as the frame duration, the uplink transmission scheme and the specific protocols used. In terms of the frequency bands, WiMAX is deployed in 2.3GHz, 2.5GHz and 3.5GHz, which are close to those for TD-LTE.

The similarities in technology between WiMAX and LTE, especially with TD-LTE, make it possible for transition between WiMAX to LTE or their coexistence. Some vendors such as Sequans, Bridgewater system and others are actively engaging in the transition process through software upgrading. According to WiMAX Forum's industry reports, by end- May, there were 583 WiMAX network deployments (including those in service and planned/in deployment) globally in 150 markets. A few WiMAX carriers have announced they will deploy LTE, in most cases TD-LTE, including Clearwire in US, Far EastOne in Taiwan, Vividwireless in Australia and Asiaspace in Malaysia. We see a large potential market for future TD-LTE deployments.

Trade-offs between TD-LTE and FDD-LTE

One reason TD-LTE is a favorable choice for more carriers is its efficient spectrum usage, given that TDD does not require paired spectrums as FDD does and spectrum is a finite and limited important resource for telecommunication services.

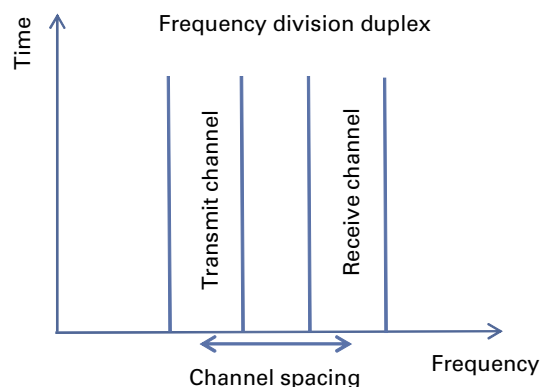
Another significant advantage of TD-LTE is that the ratio between uplink and downlink could be flexibility adjusted by changing the time slots allocated to each direction. This feature better fits the fact of uneven traffic in both directions in the real world. Mobile users usually download more content than they upload.

However, a guard interval is required between transmission and reception. When the transmission happens in short distance, the delayed caused by the interval is acceptable but this needs to be addressed as distance increases. Besides, a minor degree of latency will be caused as data may not be able to immediately routed and transmitted after being generated, though the delay will not be noticeable.

Furthermore, FDD provides better coverage than TD-LTE for reasons of power efficiency. According to one report by Qualcomm, FDD covers an 80% larger area than TDD for 2:1 downlink/uplink allocation and assumes the same transmitting power and same 2.6GHz frequency.

Exhibit 12: With FDD, two different channels are used for transmission and reception of signals while...

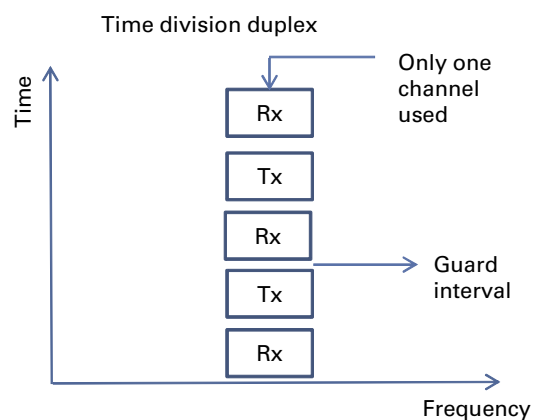
FDD-LTE transmission scheme



Source: Goldman Sachs Research estimates.

Exhibit 13: ...in TDD, uplink and downlink is through one single frequency separated by time intervals.

FDD-LTE transmission scheme



Source: Goldman Sachs Research estimates.

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Goldman Sachs Investment Research global coverage universe

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