ASSESSMENT OF C-BAND USAGE IN ASIAN COUNTRIES

BY EUROCONSULT

FINAL REPORT

June 10, 2014

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BACKGROUND, SCOPE OF WORK AND METHODOLOGY

Background and scope of work

On 3 March 2014, we were appointed by CASBAA to perform this independent assessment of the effective utilization of C-band, as defined herein, for satellite services in Asia.

The purpose of this study is to inform CASBAA and its members, in advance of the World Radiocommunications Conference scheduled by the International Telecommunication Union on 2-27 November 2015, and of the latter's consideration of proposals to modify spectrum allocations in a sense which could be detrimental to the continued utilization of C-band by satellite services. To this end, and as per our terms of reference, the study assesses the number and characteristics of user antennas operating in C-band in Asia, and more specifically in India, Indonesia and Papua New Guinea (the study's three "focus countries"), as well as the economic value and socio-economic benefits which accrue from the services these antennas are used to provide.

This final report delivered on 10 June 2014 provides complete results from our research.

Methodology and technical information

GENERAL METHODOLOGY

To prepare this report, we reviewed publicly available information on market trends, including third-party publications and our own past research, including interviews with end-users, satellite service providers and equipment manufacturers.

In addition, we performed interviews or received written data from 48 organizations, with the list and distribution presented below. We questioned these officials on the current use of C-band by their customers or themselves, on their views of the broader market, and on the feasibility of alternatives to C-band.

LIST OF ORGANIZATIONS THAT PROVIDED INFORMATION THROUGH THE INTERVIEW PROCESS

India

Bharti Airtel Ltd.	Cellular carrier and VSAT service provider
Dish TV	Pay-television operator
Gilat Satellite Networks	VSAT manufacturer
HCL Comnet and Services	VSAT service provider
Hughes Communications India Ltd.	VSAT service provider
Indiasign Pvt. Ltd.	Television services provider
Mahdi Bagh Computers	VSAT installer
MCBS International	Antenna manufacturer
MCCS India	Television broadcaster
Ministry of Information and Broadcasting	Television regulator
Space Link Systems Pvt. Ltd.	Antenna manufacturer
TataNet	VSAT service provider
Telecommunications Regulatory Authority of India	Telecommunications regulator

Indonesia

PT. Aplikanusa Lintasarta	VSAT service provider
PT. CapRock Communications Indonesia	VSAT service provider
PT. Cipta Skynindo	Pay-television operator
PT. Duta Visual Nusantara Tivi Tujuh, d.b.a. Trans 7	Television broadcaster
PT. Indosat Tbk	Telecommunications carrier and VSAT service provider
Orange TV	Pay-television operator
PT. Pasifik Satelit Nusantara	Satellite operator and VSAT service provider
PT. Patra Telekomunikasi	VSAT service provider
SkyPerfect JSat Corp.	Satellite operator
PT. Stella Satindo, d.b.a. Matrix Parabola	Antenna manufacturer
Trust Management, d.b.a. DMC TV	Television content provider

Papua New Guinea

Bmobile	Cellular carrier
Department of Meteorology and Geophysics	Meteorological and natural hazards agency
Digicel Group	Cellular carrier and VSAT service provider
Harris CapRock Communications	VSAT service provider
Hitron Ltd.	VSAT service provider and cable television operator
Japanese International Cooperation Agency	Aid agency
Media Niugini Ltd., d.b.a. EMTV	Television broadcaster
National Broadcasting Corp.	Radio and television broadcaster
National Information and Communications Technology Authority	Telecommunications regulator
Oceanic Broadband	VSAT service provider
PNG Air Navigation Services Ltd.	Air traffic control authority
SpeedCast Ltd.	VSAT service provider
Talisman Energy	Oil and natural gas producer
TE (PNG) Ltd.	Antenna installer
Telikom PNG Ltd.	Telecommunications carrier and VSAT service provider

Others

ASIX Asia	VSAT service provider, Bangladesh
BBC World Service	Radio and television broadcaster, UK
Encompass Digital Media (Asia) Pte. Ltd.	Television service provider, Singapore
GlobeCast Asia	Television service provider, Singapore
Group M	Advertising agency, Australia
Solar Entertainment Corp.	Television broadcaster, Philippines
Supernet Pvt. Ltd.	VSAT and Internet service provider, Pakistan
TerraSat Communications	Antenna manufacturer, USA

Specific sources used to perform the analysis are referenced in the report

LIMITATIONS

Our analysis relies in part on public information which cannot always be corroborated, as well as on interviews with third parties made independently of this study on the condition that such parties not be identified, or made without their explicit consent to be identified, or made subject to non-disclosure agreements. The report also examines questions on which we find prior research or available statistics to be extremely limited or non-existent; the specific uncertainties which result are detailed in this report.

As such, Euroconsult disclaims liability for any harm which may result from use of this report. However, we believe that the information at our disposal was sufficient to support our analysis within our normal standards of accuracy and for the purpose of our engagement.

CONTRIBUTORS

This project was managed by Pacome Revillon, Euroconsult CEO. The analysis was principally researched and written by Stéphane Chenard, Senior Associate Consultant, with additional research by Deepu Krishnan, Senior Consultant and Dimitri Buchs, Consultant.

CASBAA executive directors or members have facilitated some of the interviews we have conducted or are planning to conduct. However they did not otherwise take any part in them, and our research and conclusions remain ours alone.

TECHNICAL TERMS AND ACRONYMS

ACM: Adaptive Code Modulation

ADS-B: Automatic Dependent Surveillance-Broadcast

AIMS: Amrita Institute of Medical Sciences

ARPU: Average Revenue Per Unit

ATM: Automatic Teller Machine

BCA: Bank of Central Asia

BKMG: Badan Meteorologi, Klimatologi, dan Geofisika; Meteorological, Climatological and Geophysical Agency

bn: Billion

BRI: PT. Bank Rayat Indonesia Tbk.

BSNL: Bharat Sanchar Nigam Ltd.

BSP: Bank of South Pacific Ltd.

C-band: Radio frequencies at approximately 4-7 GHz

d.b.a.: Doing business as

dB: Decibel

DTH: Direct To Home (television)

e-KTP: Kartu Tanda Penduduk elektronik; electronic Identity Document

EQUITV: Enhancing Quality in Teaching through TV programs

FIFA: Fédération Interationale des Football Associations

FM: Frequency Modulation

GDP: Gross Domestic Product
GHz: Gigahertz
GPRS: General Packet Radio Service
HD: High definition (television)
INAFIS: Indonesia Automatic Fingerprint Identification System
ISRO: Indian Space Research Organization
ITU: International Telecommunication Union
K: PNG kina
Ka-band: Radio frequencies at approximately 17-40 GHz
Ku-band: Radio frequencies at approximately 11.45-14.5 GHz
LLG: Local Level Government
LNB: Low Noise Blockconverter
m: Million
Mbps: Megabit per second
MCPC: Multiple Channel Per Carrier
MHz: Megahertz
NBC: National Broadcasting Corp.
O3b: O3b Networks Ltd.
PNG LNG: PNG Liquid Natural Gas (plant)
PNG: Papua New Guinea
PNGAS: PNG Air Services Ltd.
RF: Radio Frequency
Rp: Indonesian rupiah
SD: Standard definition (television)
SLA: Service Level Agreement
TRAI: Telecommunications Regulatory Agency of India
TVRO: Television Receive Only (antenna)
UHF: Ultra High Frequencies; radio frequencies at approximately 0.3-3 GHz
VHF: Very High Frequencies; radio frequencies at approximately 30-300 MHz
VRC: Village Resource Centre
VSAT: Very Small Aperture Terminal
YE: Year end (unless noted, 31 Dec.)

EXECUTIVE SUMMARY

Overview

As previously stated, we assessed the usage of C-band in three focus countries, namely India, Indonesia and Papua New Guinea. Those three countries differ significantly in terms of size, geography and organization.

In all three cases, we find that C-band is extensively used for communication networks, often of critical importance to these countries' economy, society or security, across a great variety of applications, for both private companies and government organizations, and in both rural areas and city centres. Most of these networks rely on C-band because of stringent requirements for reliable and uninterrupted communications, which could not be met using higher frequency bands with greater susceptibility to rain fade.

C-band communication services themselves constitute a high-technology industry, supported in the user countries by a local ecosystem of companies and highly qualified personnel:

- In India and Indonesia, C-band capacity is provided in large part by one or more national satellite operator, in addition to foreign operators;
- In each focus country, at least 10 to 20 specialized service providers manage the C-band links and networks of end-users;
- In India and Indonesia, local companies produce a significant fraction of C-band television antennas;
- Finally, significant numbers of distributors and installers benefit directly from the deployment of C-band solutions.

In total we estimate that 17-30 million C-band antennas are being used for individual television reception in the Asian countries we have examined in South and Southeast Asia, including 12-17 million in Indonesia, 4-12 million in Thailand and about 500,000 in India, along with up to 60,000 antennas at cable head-ends, including about 8,000 in India. In addition, we identify over 175,000 C-band VSATs, using for a variety of critical telecommunication applications, including about 41,000 in India, over 124,600 in Indonesia and about 1,000 in Papua New Guinea.

Public services and contribution to policy objectives

The governments of India, Indonesia and Papua New Guinea all have invested in various C-band networks to optimize the efficiency of their operations and to support key development and security policies. In total, we identify approximately 19,500 VSATs already installed as part of these networks, along with a number of additional development projects.

These include in particular networks for:

- **Disaster management**: In all three countries, networks using C-band are deployed to manage emergency communications, in particular as part of extremely time-sensitive systems built to warn coastal populations of impending tsunamis;

- **Better access and efficiency of education and medicine**: More than 1 million citizens benefit from public or private distance learning services provided over C-band antennas in India and Papua New Guinea;

- **National security**: Over 7,000 C-band antennas have been deployed by Indian police and defence forces;

- **Air navigation and safety**: Airports and air traffic control centers in all three countries are interconnected by C-band networks. These, in particular, are critical to large investments made by India in new navigation satellites, and by Papua New Guinea to permit airlines to transit its air space more efficiently;

- **e-Government:** Indonesian citizens depend on a C-band government network to obtain and renew their new biometric identity documents; so do civil servants in Papua New Guinea to receive their salaries in rural areas;

- **Rural communications:** Efforts to bridge the digital divide and to provide better communications in rural areas depend in significant part on thousands of C-band antennas, deployed in India in Village Resource Centres and in Indonesia under the Universal Service Obligation program. Cellular telephone carriers are also major users of C-band capacity, used to connect millions of subscribers in areas with insufficient terrestrial backbones.

Impact on economic sectors

The availability of C-band satellite links is of clear, direct and often considerable importance to a variety of economic sectors, in all three focus countries.

C-band contribution feeds directly underpin the television industries of India and Indonesia, and even the much smaller television market of Papua New Guinea, nearly in their entirety. Tens of thousands of households in India, and millions in Indonesia (as well as in certain other Asian countries, notably Thailand) use their own C-band antennas; in total, over 50 million households in India and Indonesia, or over 50% of these countries' total television audience, depend directly or indirectly on C-band networks to receive television. Many channels in India in fact have no other distribution, making entire linguistic or cultural communities dependent on C-band.

The second largest user community is the financial sector. Nearly 100,000 C-band antennas have been installed – and more continue to be rolled out – by banks in India, Indonesia and Papua New Guinea, in both urban and rural locations, to support ATMs and interconnect branch offices, as well as by Indian stockbrokers to conduct their daily trading. The ATMs alone now perform close to 4.5 billion transactions per year over C-band links.

Others include some of the principal economic sectors and exporters of Indonesia and Papua New Guinea – notably their oil, gas and mining industries – as well as critical infrastructures, including much of India's electric grid, and the most widely deployed retail chains of Indonesia. In most cases, the reliability inherent to C-band is indispensable to meeting operational requirements, with considerable economic stakes in cases such as Papua New Guinea's liquid natural gas industry.

OVERVIEW OF C-BAND CAPACITY USAGE IN ASIA

1. Overview and rationale for C-band usage

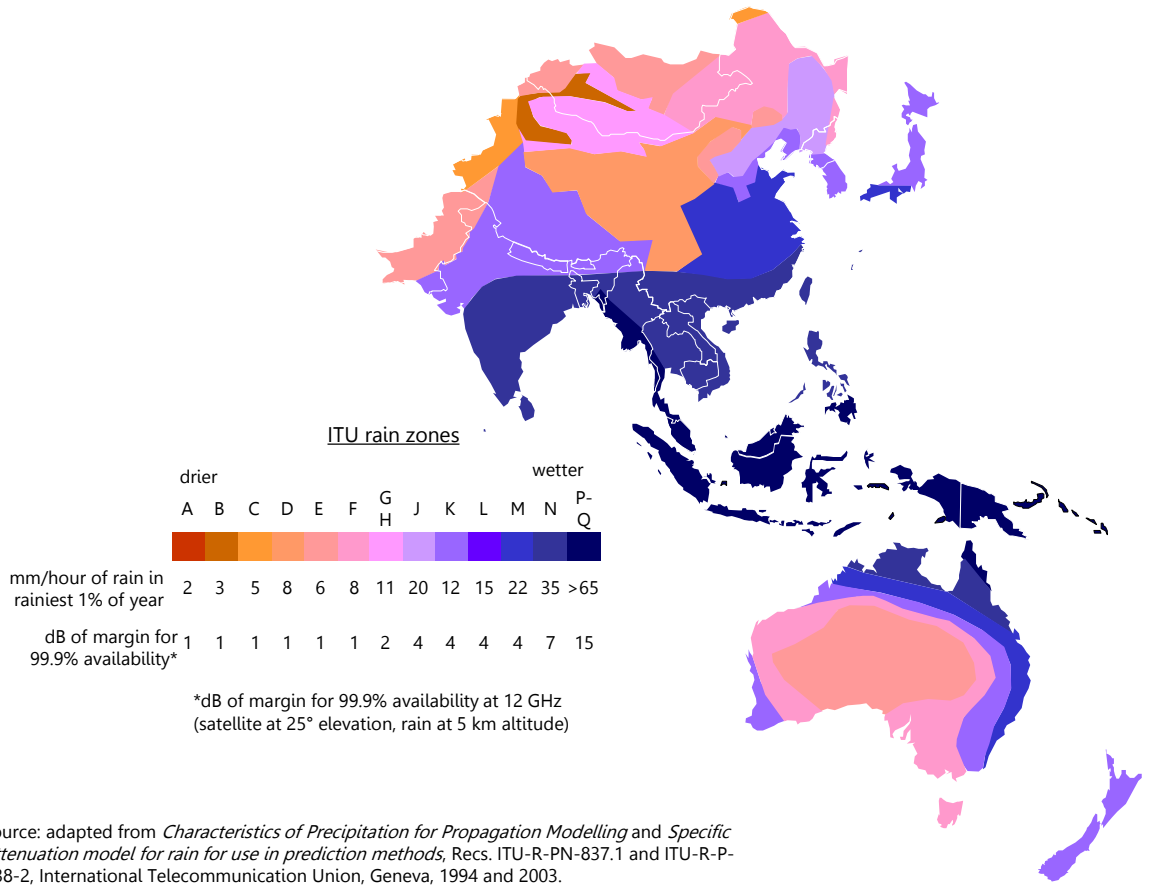
The C-band corresponds to frequencies of 5.8-6.4 GHz for transmission and 3.6-4.2GHz for reception. In addition, satellite systems can also make use of the "extended-C-band" (transmission 6.4-6.7GHz, reception 3.4-3.6GHz) and in the case of India of bands 6.7-7GHz for transmission and 4.5-4.8Ghz for reception.

The C-band has historically been the first frequency band used by FSS satellite systems on a large scale. FSS systems are currently using primarily the C-band and the Ku-band with also an increasing use of the Ka-band. When compared to other types of spectrum used by satellite communication systems, the C-band benefits from two principal physical characteristics that are particularly well suited to Asia's environment, and which explain why the C-band continues to be preferred in key satellite applications in a large part of the region.

Resistance to rain fade

Unlike higher frequencies, C-band is not significantly attenuated by atmospheric moisture. This matters particularly in Asia, where an estimated 2 billion people live in areas subject to monsoons or to frequent heavy rainfall: 14 countries in their entirety – including Indonesia and PNG, as well as other major markets such as Malaysia, Vietnam, Thailand and the Philippines – along with over half of India's population, perhaps one-third of China's, and the south end of Japan. Exhibit 1 shows a simplified map of precipitation and rain fade patterns.[1]

Exh. 1: Asia: Rain attenuation



source: adapted from *Characteristics of Precipitation for Propagation Modelling* and *Specific attenuation model for rain for use in prediction methods*, Recs. ITU-R-PN-837.1 and ITU-R-P-838-2, International Telecommunication Union, Geneva, 1994 and 2003.

Rain fade can be overcome in part, by increasing signal power to the extent possible on a given satellite. ITU standards define the "rain margin" which may be applied, which, with reasonable assumptions on meteorological conditions,[2] would typically, for a link at 12 GHz, be in the range of around 7-15 dB in the areas in question (shown at Exhibit 1 as part of ITU rain zones N to Q). This is a very substantial amount, implying either a drop in the available data rate, or a drawdown on satellite power which may not always be possible. Even then, however, a Ku-band signal would not be expected to be more than 99.9% available on average, equivalent to approximately 40 minutes of outage per month. Larger antennas also help reception conditions, but only up to a point. In Papua New Guinea, one cable television operator which also uses Ku-band to receive programming said it loses connectivity to rain fade even with an 11-meter antenna.[3]

Other mitigation techniques exist, but provide only partial remedies and may not be applicable. They include the use of backup uplinks, which may allow a broadcaster to bypass a rain cell over its primary teleport but do nothing for the rain which affects its viewers' antennas. Adaptive Coding and Modulation (ACM), a technique which allows a satellite network to adjust to increased rain fade, has also been available for VSAT applications for about 10 years. However it still results in some loss of throughput, may not completely prevent outages, and to the extent it requires user antennas to report how much rain fade they experience ACM is not applicable to receive-only television antennas. One major provider of video uplinks, operating in Singapore with ample technical resources, commented on the rain-fade compensation techniques it has been shown that "no matter what the manufacturers say, it does not work here... it is mainly talk".[4] ACM also requires VSAT modems to be compatible and individually configured, as well as the payment of a royalty of up to $1,000 per modem to the technology's owners, which of course can be problematic in a network of several thousand nodes.

In practice rain fade is thus a fact of life in much of Asia, where it limits the usefulness of Ku-band and makes Ka-band systems even more difficult to implement (the only system effectively used there in this band, the O3b constellation, can do so only because it uses low-altitude satellites and relatively large user antennas, and specializes in markets which omit television and part of VSAT services).

This remains tolerable, though inconvenient, for applications such as pay-television, for which consumers have proven willing to trade off occasionally poor signals for the advantage of a smaller

antenna. Astro, the Malaysian satellite platform, also provides reruns of some of its programs affected by rain, but explains to its viewers on its online help page that it can ultimately not do much:

"We understand how frustrating it can be when you're watching your favourite Astro programmes on a rainy day and the screen starts to pixelate or go blank altogether. [...] Sometimes, even the most reliable satellite communications technology can be affected by the forces of nature. [...] This condition tends to be brief, lasting only as long as the heavy cloud condition persists."[5]

Malaysia's minister of Information, Communication and Culture, to whom this issue had been raised in Parliament, acknowledged it was "difficult to resolve" at the level of subscriber antennas.[6] While this has not stopped Astro and other Ku-band platforms from signing up millions of subscribers, many other applications cannot tolerate this level of outage and rely on satellites, in part, precisely because they are less susceptible to disruption than terrestrial networks. Moreover, while rain fade may just cause a television picture to pixelate, a data network may just stop working, then require a substantial effort to restart.

Examples of the added value offered by C-band included the following:

- A bank operating tens of thousands of ATMs, an oil company monitoring production rigs or a ministry of Defense receiving live information from a battlefield cannot suspend work for a 20-minute thunderstorm, and if at risk of experiencing rain fade will prefer using C-band.
- Content delivery to broadcasters and local networks is still one of the satellite industry's most demanding industrial segments. While viewers in tropical areas may understand rain fade, broadcasters expect their content providers to furnish them a high-quality, uninterrupted

feed. The latter may ultimately be received by viewers far from any rain, or connected by cable, and who would likely not accept rain in some distant area as an excuse for losing their picture. Television content, such as footage from the Olympics or a channel broadcasting from its studios, travels around the world on a succession of satellites and cables. Just as a cut cable can interrupt this chain, rain fade over some remote antenna in Asia could be felt by viewers from Europe to Brazil. Advertisers would react even more strongly. Intense competition between the companies which transmit content to broadcasters, and between the satellite operators on which these companies rely, ensure that very high standards of reliability are maintained. If anything the increasing prices paid for broadcasting rights to sports events are only making broadcasters less tolerant of outages. One of the principal measures which broadcasters take to this end is to rely on C-band in rainy regions such as tropical Asia. In one of many available examples, a tender issued in 2013 by the BBC World Service for up to £25m worth of global satellite capacity thus specified Ku-band in Europe, but C-band in Asia, the Pacific, Africa and the Americas.[7]

Availability of wide beams

The very wide beams which satellites can form in C-band are also well suited to covering very large countries such as India, Indonesia or China, to providing maritime communications across entire oceans, or to delivering television content to the entire Asian landmass. The latter has become one of the television industry's key requirements, as channels seek carriage on (and thus, distribution to) as many pay-television platforms as possible.

While full coverage of India or Indonesia is certainly also done in Ku-band, delivering a robust signal over such areas is so power-intensive that the few satellites which do so are limited to just a small number of transponders (six in each polarization on Measat satellites over Indonesia or Malaysia or on Insat satellites over India, 4-5 on Palapa satellites over Indonesia). In the end this rare and expensive capacity has proven affordable only to pay-television platforms, which can recoup their cost across millions of subscribers. Fully covering Asia, at the power and quality levels required by the users which now do so in C-band, is not possible in Ku-band with current satellite technology.

While these considerations alone are often overwhelmingly favourable to C-band, costs are also a factor. Low noise block-converters – LNBs, the RF electronics placed in front of a VSAT antenna, which account for the greatest part of its cost – require more precise fabrication at higher frequencies, and according to one leading manufacturer cost 20-100% more at Ku-band than at C-band for similar power levels.[8] As noted, Ku-band capacity, while in Asia it can trade at lower prices than C-band because of the shortcomings discussed above, also tends to be substantially more expensive for the high-power transponders capable of partly overcoming rain fade.

2. The use of C-band in Asia

2.1 DYNAMICS IN CAPACITY SUPPLY AND USAGE

Satellite operators have made use of C-band capacity in Asia for several decades. C-band currently represents an important part of the satellite business in Asia. The 2013 edition of the annual report we publish on satellite capacity demand and supply reported the following indicators:

Capacity supply

Close to 60 satellites covered at least part of Asia with C-band capacity in 2012. Our databases further report that the total number of satellites offering capacity in Asia stood at 96 for that year. This implies that around 61% of satellites active in the region carry a C-band payload.

Overall, satellite operators supplied a total capacity of more than 33 GHz in C-band in 2012 in Asia. This figure further discounts part of the C-band capacity carried on satellite offering coverage of both Asia and other world regions. In such cases, the C-band capacity of the satellite is partly allocated in the report to other target markets of the satellite[9].

C-band capacity supply represents approximately 43% of the capacity currently supplied by satellites qualified as regular in our regular annual report, which include all satellites covering the region outside of the IPSTAR satellite.

Capacity demand and revenues

Satellite capacity usage in C-band stood over 27 GHz in Asia in 2012. This corresponds to a fill rate of more than 80% of capacity supplied, and to around 47% of the total satellite capacity used in the region.

Although most operators do not provide detailed figures on their satellite usage, several public records give additional evidence of a large use of C-band capacity in the region.

- The 24 C-band transponders of Thai national satellite operator Thaicom, used principally for television, were 99% utilized at YE 2010 and 98% utilized as last reported for YE 2011-12.[10]
- Indonesian operator Indosat last reported that about 82% of its C-band and extended C-band capacity was utilized at YE 2012 – a fairly high figure considering that over one-third of this capacity resides on an aging satellite, Palapa C2, due to be retired in mid-2014 and thus difficult to market.[11]
- APT Satellite, one of two regional operators based in Hong Kong, reported over 81% utilization in mid-2013 across its three principal satellites, two-thirds of whose capacity is at C-band.[12] Asiasat, the other operator based in Hong Kong, last reported 71% utilization at YE 2010 across the three satellites it had at the time, 56% of whose capacity was in C-band.[13]
- A steady stream of industry announcements testify to sustained demand, with an average of two transactions each month deemed large enough to justify a press release. Exhibit 2 lists the deals announced by satellite operators, capacity resellers and equipment manufacturers over 2013-14 alone. Of course this list omits the many procurements which are not made public, or for which the frequency band involved could not be determined.[14] Many are from broadcasters who renew or increase their existing C-band leases, in particular to transmit more valuable high-definition channels.

We estimate that the C-band capacity market stands at more than $800 million in Asia, under a conservative assumption of global average of around $2,500/MHz/month for leased capacity. Capacity prices, as further detailed in the report, can significantly vary depending on applications supported and different other factors, with a range of $1,250-8,000/MHz/month observed in the market.

Estimated revenues from the leasing of C-band capacity represents approximately 30% of total satellite capacity revenues in Asia and a share equal of higher than 50% when excluding Oceania, Korea and Japan. Any impact on the services supplied in C-band would consequently have a large impact on satellite operators in the region.

Exh. 2: ASIA: REPORTED SALES OR LEASES OF C-BAND EQUIPMENT OR CAPACITY, JAN. 2013 – MAR. 2014

MONTH OF RELEASE	VENDOR	CUSTOMER	TYPE OF SERVICE
Apr 2014	Asiasat	Arqiva	Capacity on Asiasat 5 for sports content
Mar 2014	Asiasat	Manwin Media S.A.R.L.	Capacity on Asiasat 5 for LifeStyle TV
	Measat	TV5 Monde	Additional capacity on Measat 3 for upgrade to HD
Feb 2014	SatLink Comm.	Fashion TV	~10 MHz of capacity on AsiaSat 3S
Jan 2014	Measat	Telered Technologies & Services Corp.	Capacity on Measat 3a for Viva TV and Pinoy Box Office
Dec 2013	Asiasat	Phoenix TV	1 C-band transponder on AsiaSat 3S for Phoenix Chinese, Phoenix Infonews, Phoenix Hong and Phoenix Movies
	Measat	Globecast Asia	Capacity on Measat 3 for Mezzo Live HD Asia
Oct 2013	Asia Broadcast Satellite	Fashion One TV	Capacity on ABS-1 with C-band feed from Munich and Ku-band feed from Hong Kong
Sept 2013	Asiasat	LEO Television Network	Capacity on Asiasat 3S for Filmazia, Film World and Aruj TV
	Intelsat	Discovery Communications	"Multi-transponder" lease on Intelsat 19
	SatLink Comm.	i24 News	Capacity on Asiasat 5
	AV Comm	Telekom Television	Installation of a Prodelin 1451 4.5m C-band antenna for television uplinks
July 2013	SatLink Comm.	Fashion TV	Capacity and playout on Asiasat 5
June 2013	Asia Broadcast Satellite	Fox International Channels Philippines Corp.	"Multi-year and multi-million dollar" capacity lease and MCPC and playout agreement on ABS-1 and ABS-2
	Asiasat	Encompass Digital Media	Capacity on Asiasat 5 for Edge Sport HD
	Intelsat	TVBI Co. Ltd.	Renewal of multi-year lease on Intelsat 19
	Measat	Encompass Digital Media	Capacity on Measat 3 and Measat 3a for A+E Networks channels SEA Venture, Lifetime and H2
	Measat	Encompass Digital Media	6-year extension of lease signed in 2009 for capacity on Measat 3a for Li TV HD
	SES	Supernet	"Multi-million dollar " renewal of C-band capacity on NSS 12 for Internet backhaul
May 2013	Measat	Hermes Datacommunications	Capacity on Measat 3 for VSAT links to oil sites in Malaysia
	Measat	Level 3 Communications	Additional capacity on Measat 3 and Measat 3a to upgrade the Setanta Sports channel to HD
Apr 2013	Measat	Martial Arts Networks	Capacity on Measat 3a for Martial Arts TV HD
Mar 2013	Paksat International	SpeedCast	C-band capacity on Paksat 1R for VSAT links
Feb 2013	Eutelsat	Defence Acquisition and Logistics Organization	$194,880; 1-year lease of 2 Mbps of C-band capacity for military communications in areas including Afghanistan, Pakistan and the Indian Ocean
	SatLink Comm.	Apostolic Oneness Network	Capacity on Asiasat 5
Jan 2013	SES	DigiCel	Capacity on NSS 9 for Internet access and cellular backhaul in Papua New Guinea
	SES	Pactel International	"Multi-year, multi-transponder" lease on NSS 9 for VSAT services in Asia

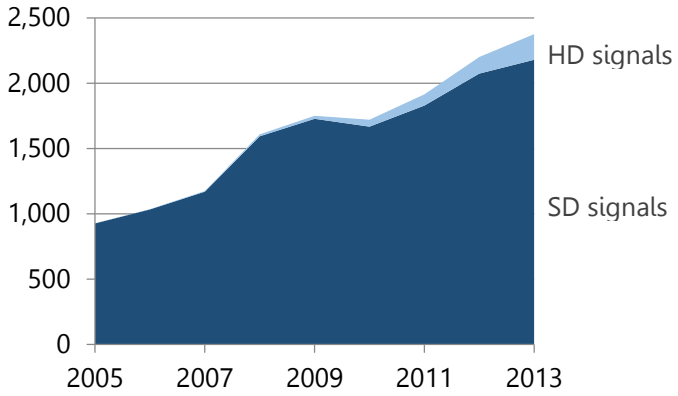
2.2 VIDEO DISTRIBUTION

The distribution of TV channels through C-band satellite capacity has been a fast growing market over the years across Asia. Reported usages include:

- As primary application, the transmission of TV channels to the head-end of terrestrial networks, and in particular cable networks,
- The broadcast of TV channels direct-to-home (or to individual sites such as hotels) either for free-to-air or pay-TV reception.

The number of TV signals distributed in C-band in the Asia-Pacific Region reached around 2,375 in 2013, compared to around 950 in 2005. This corresponds to a 12% CAGR over the eight-year period.

Exh. 3: TV SIGNALS DISTRIBUTED BY SATELLITE IN C-BAND IN ASIA PACIFIC[15]



Source: Euroconsult analysis of transponder monitoring by Lyngemark Satellite [Lyngby, Denmark; www.lyngsat.com]

While the distribution of TV signals in standard definition currently represents the largest part of transmissions, the number of high definition TV signals transmitted in C-band has increased in recent years, reaching close to 200 HD signals in 2013.

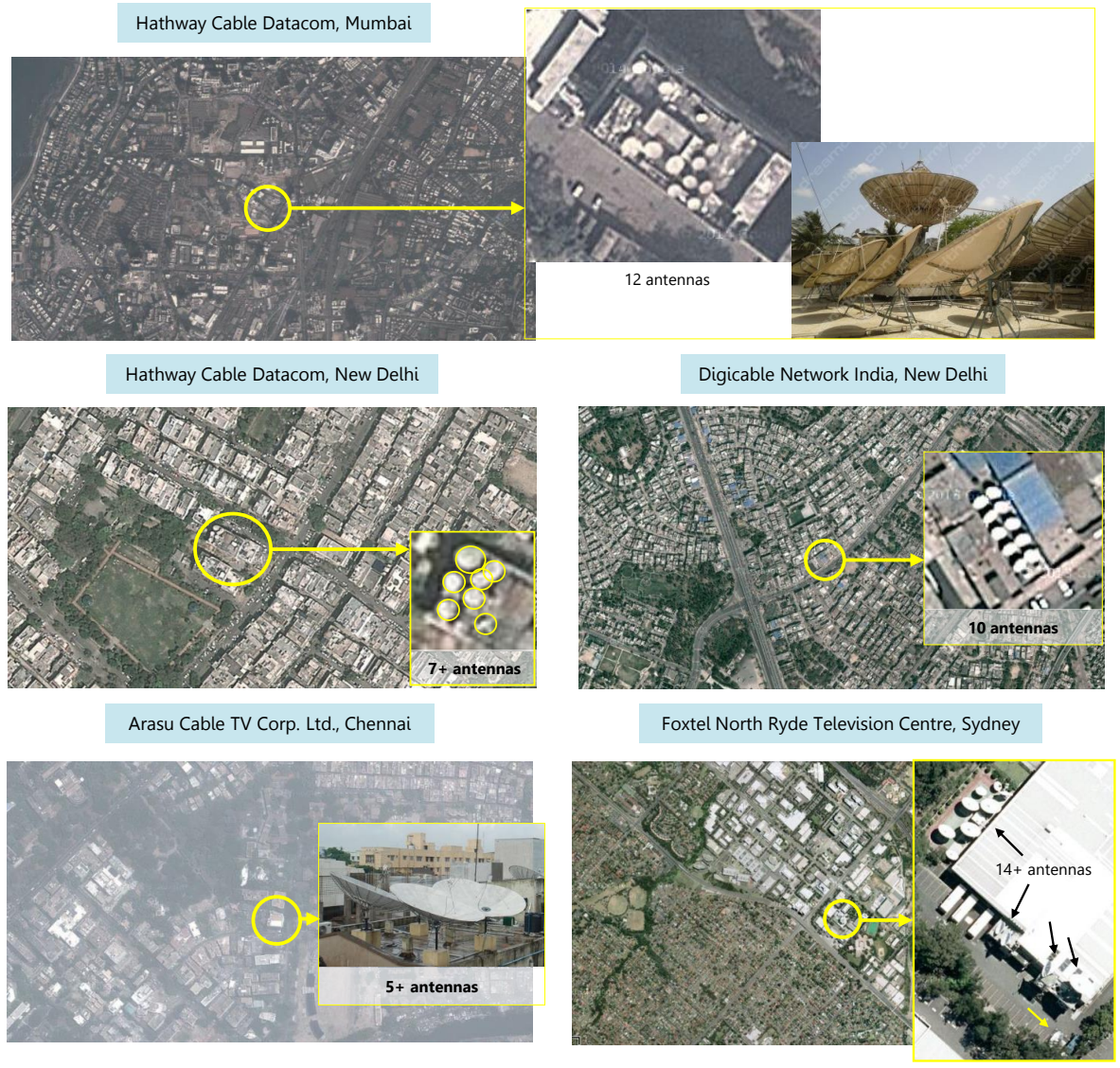
Cable market

Cable systems represent one of the primary networks for TV distribution across Asia. Estimates of cable TV reception stand at around 350 million homes in 2013[16]. Although national situations differ, the cable market is fragmented in most countries, with a limited number of large cable operators being completed by a large number of small, entrepreneurial operators.

Cable networks are essentially built around head-ends that gather video content, which is then transmitted through the local network to reach connected homes. Because of its fragmentation and of the vast population it covers, the Asian cable TV industry operates a large number of head-ends:

- Pakistan has licensed over 2,500 cable operators (though not all are likely to be active);[17]
- At the end of 2013 India had over 150 licensed operators, plus a grey market of up to 6,000 others, operating an estimated 8,000 head-ends;[18]
- Thailand had at least 900 cable networks in 2012;[19]
- The Philippines had at least 700 cable networks, operating an estimated 900 head-ends.[20]
- One service provider in Bangladesh estimates there may be 100-200 head-ends and broadcaster uplinks in that country.[21]

Exh. 4: C-band antenna farms at cable head-ends



source: Euroconsult research; "Hathway MSO dish antenna farm and digital head-end control room pics", posting by "Vinay" on DreamDTH.com, 29 June 2012 [http://dreamdth.com/Thread-Pics-Hathway-MSO-dish-antennas-farm-and-digital-head-end-control-room]; DigitalGlobe, Spot Image satellite photos via Google Earth.

Cable head-ends include antenna farms where cable network operators receive satellite channels and redistribute them to their subscribers. The use of multiple C-band antennas allows cable operators to access MCPC platforms (including several TV channels) from as many satellites. Content providers to Asian cable networks said head-ends come in many sizes, but on average are typically equipped with 5-6 antennas.[22] A large broadcaster or national pay-television provider, however, may have much larger facilities; Australia's Foxtel, for instance, uses 27 downlinks to import content into its main earth station in Sydney.[23]

The preference given to C-band as opposed to other frequency bands for the transmission of TV channels over satellite for cable networks is justified by at least three factors:

> The delivery of TV content to cable networks is a business-to-business activity, requiring a high level of quality of service. Cable operators would not accept for the vast majority of them the reception of degraded TV signals,

- Large coverage beams allowed by the C-band offers the opportunity to deliver each TV channel to many local cable networks through a single signal, thus optimizing transmission costs,
- Cable operators have used C-band for the reception of TV signals for several decades, and currently have widespread equipment. Migrating to another frequency band or other transmission options would require significant capital expenditure from cable operators.

While they are professional installations, cable head-ends are normally located in city centres and residential neighbourhoods to keep cables short and limit transmission losses. Exhibit 4 shows examples of cable head-ends in India and Australia, and illustrates the size and the dense urban setting of these facilities.

Consolidation is under way in some of these countries, e.g. in Thailand where CTH, the largest operator, has said it would cut its affiliates from 170 to 100.[24] In India, better connections via fiber networks have also made a number of cable head-ends redundant – however only the largest operators have been able to lay their own fiber in a few major cities, and even then the size of the cities and population to be covered are such that several head-ends are still necessary in each of these cities. Thus, even having done this and in India's most modern cities, cable operators still maintain 15 head-ends in New Delhi and seven in Mumbai.[25] This consolidation also results in larger facilities with more antennas.

In parallel, the still numerous entrepreneurial operators, usually of a limited size, may usually not be in a position to replace or make costly adjustments to their antennas, which represent a critical link between their subscribers and content owners.

Assuming an average of six antennas per head-end, information cited above on India, Thailand, the Philippines, Pakistan and Bangladesh suggests to the presence of more than 60,000 large C-band antennas receiving satellite channels in those countries for cable operators that serve a total of more than 100 million households.

Direct-To-Home reception of Free-to-air and pay-TV services transmitted through C-band

Exact counting of the number of television receive-only C-band antennas (referred to as "TVROs" below) installed by individuals to receive free-to-air television through C-band signals is not available, due to the nature of the service and to the absence of official measurement by national statistical offices. However, a significant amount of market data completed by our own research allows qualifying the overall market size.

TVROs appear to still be widespread – and growing – despite the rapid development of satellite services in Ku-band for pay-television. Drivers and segments include the following:

- Because they ensure high-quality reception, C-band dishes are also widely used by broadcasters in some Asian countries to reach their home audience, or to complement cable distribution outside of city centers. Several pay-television platforms have emerged in Indonesia (see our separate profile of that country) and in Thailand.
    - In Indonesia, where the very limited development of cable television has long encouraged consumers to install satellite dishes, our research (as detailed below) identifies a population of at least 12m, and possibly up to 17m C-band antennas;
    - Thailand is the region's other major C-band market for free-to-air C-band reception. C-band dishes are reported to have grown from 2.3m in early 2010 to at least 4.2m in mid-2013.[26] In 2011 manufacturer PSI Holdings had said it expected to sell 3.5m of these dishes over 2011-13.[27] PSI, which sells dishes together with decoders and some programming and can thus track active users, has claimed an even larger viewer base of 9m homes in mid-2012 and over 12m in mid-2013.[28] Exhibit 5 shows the relatively high density of C-band antennas commonly observed on Bangkok rooftops (C-band antennas are recognizable as such, there and in Exhibit 6, from their size and in some

cases from the use of mesh reflectors, a low-cost technology which is not usable at Ku-band).

The factors underpinning this growth are multiple, including cheaper dishes and the launch of over 200 new channels since satellite broadcasters were permitted to sell advertising in 2009. Since 2010 the upheavals which Thai political life has undergone have also played out largely on live television and appear to have directly contributed to dish sales, as opposing parties launched their own channels – free to air and to the broadest possible audience, and thus in C-band.[29]

This video neighborhood, but also the pressure put on free-to-air television by a morose advertising market, have now led three of Thailand's largest C-band broadcasters to move to pay television – two of them in the wake of major investments in sports rights: cable operator CTH, to expand beyond its slow-growth terrestrial network and broadcast English Premier League football matches, with an objective of 2m new subscribers during 2014;[30] RS, for Spanish Liga and FIFA World Cup matches;[31] and Grammy Entertainment, which took at least four C-band transponders on Thaicom 6.[32]

- Another segment of TV viewers benefiting from C-band satellite transmissions include minorities and foreign visitors across Asia.
  - In all, a comparison of migration statistics and channel listings suggests that at least 6.5m migrants live in Asian countries where cable and Ku-band satellite platforms do not offer any channel in their home language, and thus to have no alternative to C-band antennas (Appendix 1). Thanks to the very wide coverage of coverage beams, C-band antennas may represent one of the only connections to their original culture, as some as the considered minorities would be too widely scattered, too small or too mobile, and often too poor to be of much interest to pay-television operators

    The actual figure is likely to be larger, if one includes foreign-born citizens (as opposed to immigrant foreigners) who may want to keep using their mother tongue. This linguistic diversity has sustained large numbers of C-band dishes even in countries with an abundant offer of Ku-band and cable channels, such as India and Australia. Space Link, the largest of about 20 manufacturers supplying the Indian market, estimates annual sales of C-band antennas in that country at ~20,000 units and the total installed base at 500,000 antennas.[33] In Australia, in 2007 a regulatory consultation identified up to 200,000 antennas.[34]
  - A related category of C-band users are hotels, which install collective antennas to provide channels to their foreign guests that local cable or Ku-band platforms are not carrying – such as the 1.7m Russians who visited Thailand in 2013, or the 4.4m others whose native language is not available on Thai pay-television, or the 329,000 Japanese who visited Australia.[35] In 2007 Television Oceania, a company which licenses Japanese channels, reported providing C-band feeds to about 100 hotels and corporate clients.[36] More recently Deluxe, a company which distributes digital movies to cinemas, put the number of C-band receive antennas at "many hundreds" in Sydney alone.[37] Likewise BBC World News has direct agreements to provide C-band feeds to nearly 50 hotels, cruise lines and language schools in India and Thailand, as well as to over 80 hotels in the major cities of South Korea and Taiwan, even though the latter are abundantly served by cable networks.[38]

- Several DTH pay-TV platforms operating in C-band are also active in Asia and more specifically in Indonesia and Thailand, with three of these services created in the last couple of years. Based on their subscriptions figures and our estimates, total homes receiving pay-TV services in C-band exceeds one million.

Exh. 5: SATELLITE BASED PAY-TV PLATFORMS BROADCASTING THEIR CHANNELS IN C-BAND

PAY-TV PLATFORM	COUNTRY	YEAR OF LAUNCH	TV CHANNELS	ESTIMATED SUBSCRIBERS
CTH	Thailand	2013	13	200,000
GMMZ	Thailand	2013	38	100,000
K Vision (Kompas TV)	Indonesia	2014	28	n.a.
SkyNindo	Indonesia	2010	62	100,000
Sky Pacific	Pacific Islands	2005	18	30,000
Topas TV	Indonesia	2012	61	40,000
TransVision	Indonesia	2008	86	600,000

Source: Euroconsult research and Euroconsult report DTH Platforms, Key Economics and Prospects, 2013 Edition

Synthesis on video distribution

We estimate that the 2,376 TV channels distributed in C-band in the Asia Pacific region were broadcast over approximately 8.6 Ghz of leased satellite capacity in 2013, which corresponds to an average of approximately 3.6 MHz leased per channel.

In average, the price of satellite capacity for the distribution of channels to terrestrial (in particular cable) networks tends to be higher than for other applications. In particular, some C-band transponders with full regional coverage, on which satellite operators provide adjacent frequency slots to make it more convenient for cable networks to receive channels, are in fact leased at some of the highest prices reported in the Asian market. Known as MCPC platforms, or as C-band multiplexes, such transponders are priced high in part because cable networks can then receive their content as a package, with a single antenna, and redistribute it as such to their subscribers. Cable networks will naturally prefer the multiplex whose channels are likely to attract the largest audience to their system, which in turn increases these channels' value, and encourages others to find carriage in the same multiplex – what broadcasters know as the "video neighbourhood effect".

In 2011-12 video service providers interviewed on the pricing of C-band capacity in MCPC platforms put it in the range of $5,000-8,000 per MHz/month, or at least 2-3 times higher than for other C-band transponders, and on par or higher than the Ku-band capacity used by DTH television platforms.[39] In 2013 one Asian purchaser told us prices on one of the principal C-band MCPC platforms had gone up by over 40% in the past two years, to $8,000 per MHz/month.[40] More recently a European broadcaster, who was then managing a global procurement of C-band capacity, said he had found it to be the most expensive in Asia.[41]

Considering once again a conservative pricing assumption of an average price per channel of $2,500/MHz/month, the capacity cost for the transmission of channels represented an investment of more than $225 million in 2013. This seems a clear sign that C-band, and the associated cable head-ends and other receiving antennas, retained all their value for broadcasters even as Ku-band platforms were also developing rapidly. A BBC World News official who manages the channel's distribution to Asian affiliates said "no one is asking us to distribute in Ku-band".[42]

Essentially, the entire television industry and viewership are indirectly dependent on C-band, which broadcasters use to source much of the content they show.

2.3 COMMUNICATION SERVICES

Usage of C-band capacity for communication services is diverse, with reception through very small aperture terminals (VSATs).

Three types of segments can be highlighted, which are further detailed in the country analyses conducted in the present report:

- Connectivity in support of professional services,
- Backhaul of traffic for mobile networks,
- Government networks.

Exh. 6: SAMPLE OF C-BAND COMMUNICATION SERVICES

SAMPLE OF MARKET VERTICALS / SEGMENTS	EXAMPLES OF USES
Connectivity in support of professional services	
Oil and gas sector	Data & Voice connectivity to remote oil exploration sites. Linking retail gas stations and also monitoring pipelines. E.g.: ONGC, BPCL, Reliance Petroleum (India); PT PERTAMINA EP (Indonesia).
Mining sector	Data & Voice connectivity to remote exploration sites and for personnel welfare. E.g.: Newcrest mining (PNG).
Banking/financial sector	Providing core banking solutions. Providing regular and backup connectivity to ATMs. E.g.: SBI, Dena Bank (India); Central Bank of Indonesia (Indonesia). Real-time sharing of trading information between stock exchanges and terminals. E.g.: BSE, NSE (India).
Maritime sector	Data and voice connectivity to passenger and commercial vessels. Welfare connectivity to crews. E.g.: SeaCast, AJN Solusindo (Indonesia); Daltron (PNG).
Education	Voice, data and video connectivity to establish virtual class room networks, connected to a central studio. E.g.: Educomp, Pearson (India).
Backhaul of traffic for mobile networks and rural connectivity	
Cellular backhaul	Connecting remote mobile towers (BTS) to base stations (BSC). E.g.: Airtel, Aircel, Vodafone (India); Telkom, Indosat (Indonesia); Telikom PNG Ltd (PNG).
Communication terminals/kiosks for villages	Connectivity to internet and telephone kiosks in villages. Trunking connectivity to telephone exchanges in remote regions. E.g.: BSNL (India); Telkom (Indonesia).
Government networks	
e-government	Computer Connectivity, data and video broadcasting solutions for e-Governance applications. Also for providing connectivity between villages, district capitals and state capitals. E.g.: Village Resource Centres (VRC), ISRO Net (India).
Education	Voice, data and video connectivity to establish interactive satellite based distance education system for the country. E.g.: Edusat network (India).
Health	Voice, video and data connectivity to network rural hospitals and mobile medical vans with speciality hospitals. Provide continuing medical education and disaster management support. E.g.: Telemedicine network (India).
Civil security	Broadband connectivity from police/customs district headquarters to local police stations, outposts and port of entries. E.g.: POLNET, Customs network (India).
Defense	Voice, video and data connectivity between army/navy user terminals and headquarters for providing network centric ware fare (NCW) capability. E.g.: Army network, Project Rukmani for Navy (India).

Satellite networks are currently deployed using different frequency bands, including the C-band and Ku-band. Large Ku-band networks do exist, in Australia and even in Thailand, Malaysia and Indonesia, but are used in these countries primarily to provide Internet access to schools or to consumers, for whom the size of terminals and the price of equipment – derived from models mass-produced for the drier markets of North America and Europe – are a primary driver.

For many satellite communication networks for which the quality of transmissions can be critical, C-band has been the frequency band of choice. For such organizations, the risk of rain fade outweighs

the inconvenience which may result from the larger size of antennas required for C-band transmissions.

The fragmentation of the VSAT market, into dozens of service providers and hundreds of users who rarely disclose the details or even the existence of their networks, makes difficult an exhaustive quantification of the number of installed terminals.[43] However it is clear that C-band accounts for a large, and sometimes dominant, share of the market. Overall, information gathered for the present study suggests a number of terminals higher than 170,000.

A sample of indicators support that estimate:

- One manufacturer of LNBs said it sells more C-band equipment "than any other band" in Asia.[44]
- Overall, our interviews with service providers and other research suggest that C-band accounts for up to 20% of India's 193,000 VSAT sites – or ~40,000 sites – for most of Australia's ~2,500 enterprise sites, for most of over 3,000 cellular backhaul sites in China, Indonesia and Pakistan, and for over 5,500 identified enterprise and cellular backhaul sites in Malaysia.
- In Pakistan, one of the larger service providers reports maintaining C-band satellite links to 375 cellular base stations, each serving an average of 2,200 subscribers, as well as almost 250 VSATs for enterprise customers. The latter market has been dynamic, with sites growing at an average of 10% p.a. over the past 5 years.[45]
- Indonesian satellite operator Indosat estimates that its Palapa C satellite alone supports about 25,000 C-band VSATs.[46]
- Research on the cellular backhaul market has shown that over 6,000 satellite sites are currently installed to carry traffic from cellular networks over satellites in South and South East Asia. Available information suggests an average of approximately 1,500 users may be served per site, leading to a served population of at least 9 million mobile users. Research further showed that approximately 75% of the stations and capacity would currently be in C-band.[47]
- A growing number of VSAT terminals now operate in C-band from mobile platforms. This includes the majority of over 12,000 maritime terminals, many of them on ships which visit Asian ports at least occasionally, and antennas on satellite newsgathering trucks. The latter are far less numerous: one service provider in India operates 75 trucks and fly-away antennas, another has six in Sydney alone; Indonesian broadcasters are believed to have about 20 in total.[48] However these terminals tend to operate principally in cities and under stringent requirements for availability; if anything, the rising value of the sports content which these trucks relay is making broadcasters even more reluctant to take risks with rain fade, especially as usable Ku-band capacity is in short supply and would offer little or no savings. As of 2011 Fox Sports was deploying its trucks to over 600 events per year in Australia alone, and was thus using their C-band allocation in a permanent manner.[49]

It is noteworthy that part of the deployments is driven by political priorities of governments. These can either be the result of regulatory constraints, such as universal service obligations for telecom operators, or correspond to direct investment programs from governments (for civil security, defence, education etc.). In the three focus countries, a total of around 19,500 VSATs are related to government programs. Although those networks tend to be of a limited size in terms of VSATs installed, they usually correspond to important national stakes.

C-BAND USAGE IN INDONESIA

3. Country overview

Indonesia is the world's fourth most populated country, accounting for approximately 3.5% of the global population of over 246 million people in 2012[50]. The country's population has been growing at ~1.1% p.a. over the past five years and is expected to grow to around 269 million by 2020 and 321 million by 2050[51].

Indonesia is an archipelago comprising more than 17,500 islands out of which around 6,000 are inhabited. It encompasses 33 provinces and one special administrative region. Indonesia's average population density is 136 people per km^2, although Java, the world's most populous island, has a population density of 940 people per km^2. According to the population census-2010, around 50% of the population lives in rural areas comprising around 75,000 villages. The 65 million households in Indonesia have an average size of ~4 people. In terms of demographics, more than 26% of the country's population is below the age of 14, and more than 42% currently fall into the working age group of 25-54.

At 1.9 million square kilometers, Indonesia is the world's 15th-largest country in terms of land area and world's 7th-largest country in terms of combined sea and land area. Indonesia shares land borders with Malaysia, Papua New Guinea, and East Timor and maritime borders with Singapore, Malaysia, the Philippines, Palau and Australia. Indonesia's location on the edges of the Pacific, Eurasian, and Australian tectonic plates makes it the site of numerous volcanoes and frequent earthquakes with at least 150 active volcanoes. The country falls in the tropical climate zone with a high average annual precipitation that varies from 1,780 to 3,175 mm in the low land areas and up to 6,100mm in mountainous regions. The monsoon season typically last from November through March every year.

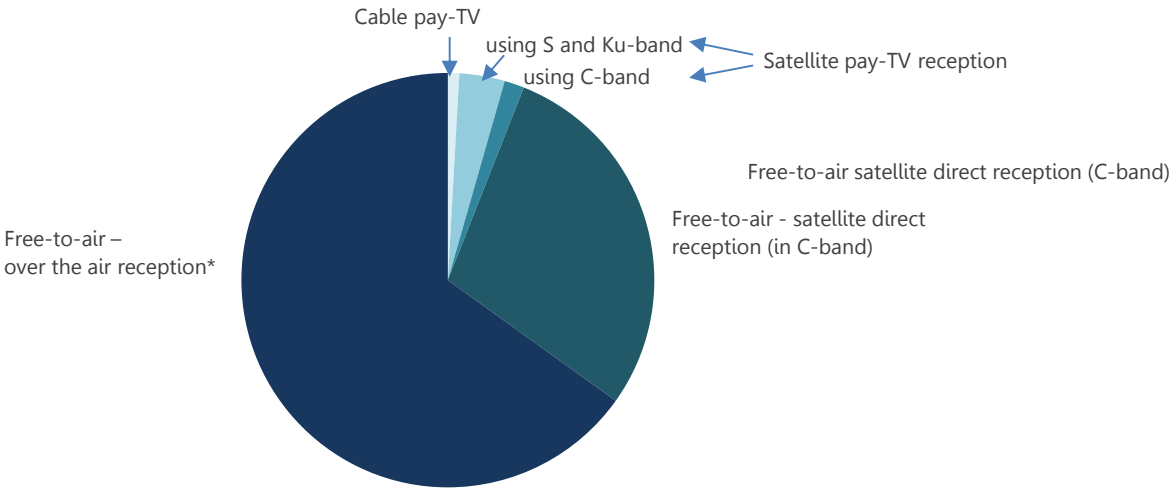
The economic growth rate was 5.78% in 2013, slowest in the past 4 years as the end of a commodities boom undermined exports and higher interest rates dragged on consumption[52]. The industry sector is the economy's largest and accounts for 46.4% of GDP (2012), followed by services (38.6%) and agriculture (14.4%)[53]. Indonesia's main industries remain petroleum and natural gas, mining, textiles, automotive, as well as telecommunication, transportation, banking, finance and insurance sectors. The country's main export markets are Japan, Singapore, the United States, and China while it receives imports mainly from Singapore, Japan and China.

4. Television broadcasting

4.1 OVERVIEW OF THE TV BROADCASTING MARKET

Estimates vary on the actual number of households receiving TV services in Indonesia, as further detailed in the following sections. Overall, a total of approximately 45 million households would own a TV set, correspond to a 69% penetration of total households in Indonesia. Available sources further confirm a sustained growth in TV penetration, with the addition of around 5 million TV households over 2007-2012. Penetration of total households should further increase in the coming years with the decrease in prices of TV screens and robust macroeconomic outlook in the country.

Exh. 7: BREAKDOWN OF TV HOUSEHOLDS BY TYPE OF RECEPTION (2012)



*A limited part of the reception may be through illegal cable systems receiving free-to-air channels

Free-to-air TV is dominant in Indonesia, as around 93% of TV households did not pay for TV services[54] in 2012 (87% if we include unlicensed cable networks which retransmit over-the-air channels and serve an estimated 2-3 million subscribers). Available data suggest that:

- Approximately less than 500,000 households receive pay-TV services through cable networks, this excluding the reception of free-to-air content through illegal cable systems,
- Around 2.3 million subscribed to satellite pay-TV services in 2012.

Revenue information on the TV sector is not complete. Still, the following estimates are available:

- TV advertising revenues stand at around $5 billion (see next sections),
- Pay-TV revenues stand at around $450m[55]

4.2 C-BAND UTILISATION FOR THE BROADCAST SECTOR

The Indonesian television market is highly reliant on C-band satellite capacity, not only for contribution links between content providers and broadcasters as in the rest of Asia, but for distribution to a large fraction of its viewers as well.

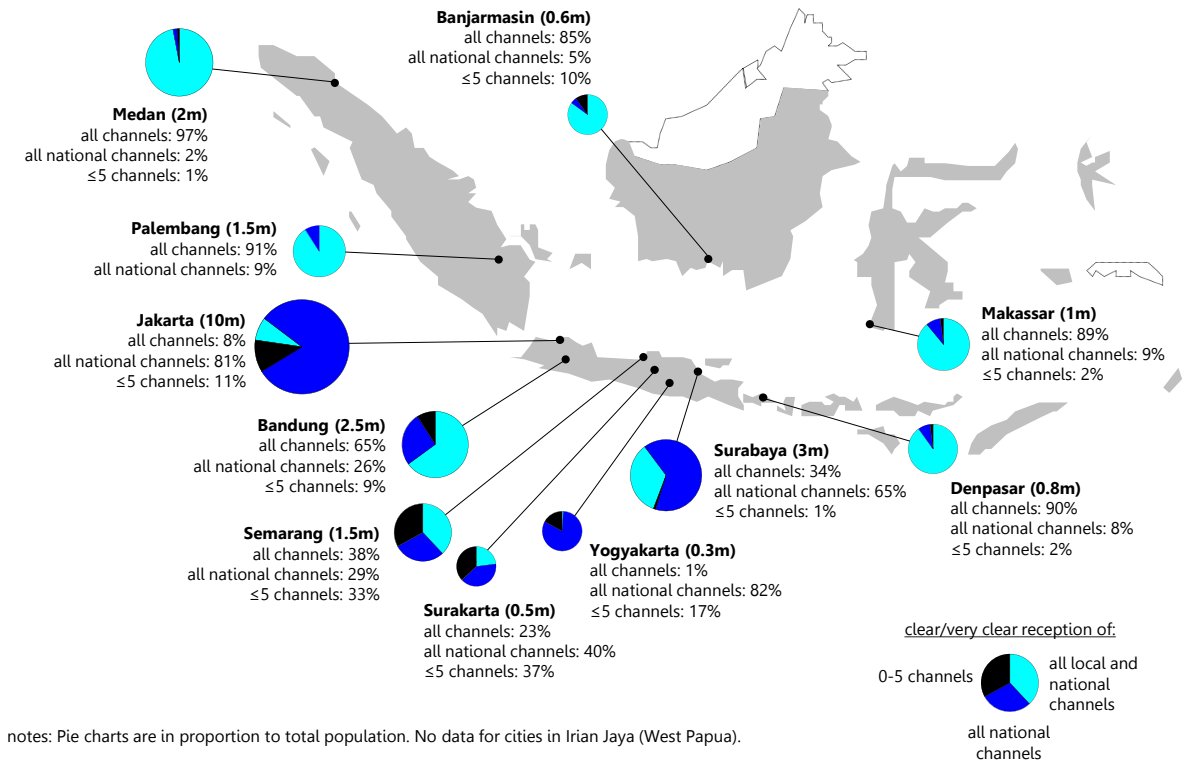
Limited reach of alternative delivery networks

As highlighted in the previous section, cable television and Ku-band TV platforms are little developed. In the case of satellite Ku-band services, constraints associated with rain fade impacting the quality of signals, and the very limited capacity available over Eastern Indonesia may represent limiting factors.

In parallel, terrestrial UHF transmitters that distribute over-the-air television also cover only a fraction of the population, especially in areas with lower incomes or population densities, in Eastern Indonesia and outside of major cities. We understand that the cost of UHF transmitters, averaging $300,000 plus operational expenses, is problematic for broadcasters to recoup in rural areas where low incomes make the population, within the 50-100 km which such equipment can cover, unattractive to advertisers.

AGB Nielsen, who monitors the reach and quality of UHF signals, estimates that about 40% of the population in Java, the country's most densely populated island, is adequately covered by transmitters, as even are about 30% of Jakarta's inhabitants due in particular to the many high-rises which block out signals. The situation depicted by Nielsen's monitoring is uneven, but shows that even in major cities a large fraction of population is unable to receive (in good conditions) most local channels, and often not even all national channels (Exhibit 8). Thus one-third of inhabitants of Jakarta are limited to one-third of local channels theoretically available there, and 11% receive only five of the national channels or less – in this case mainly due to blockage by the city's many high-rises.

Exh. 8: INDONESIA: POPULATION WITH GOOD UHF TV RECEPTION IN MAJOR CITIES, FEB. 2014[2]



notes: Pie charts are in proportion to total population. No data for cities in Irian Jaya (West Papua).

source: adapted from AGB Nielsen reception quality monitoring.

Coverage is even more limited outside of the major cities on which Nielsen reports. One broadcaster, whose strategy is precisely to target these poorly covered viewers, estimates that up to 35m out of Indonesia's 45m television households have no alternative to satellite antennas to receive television.[56]

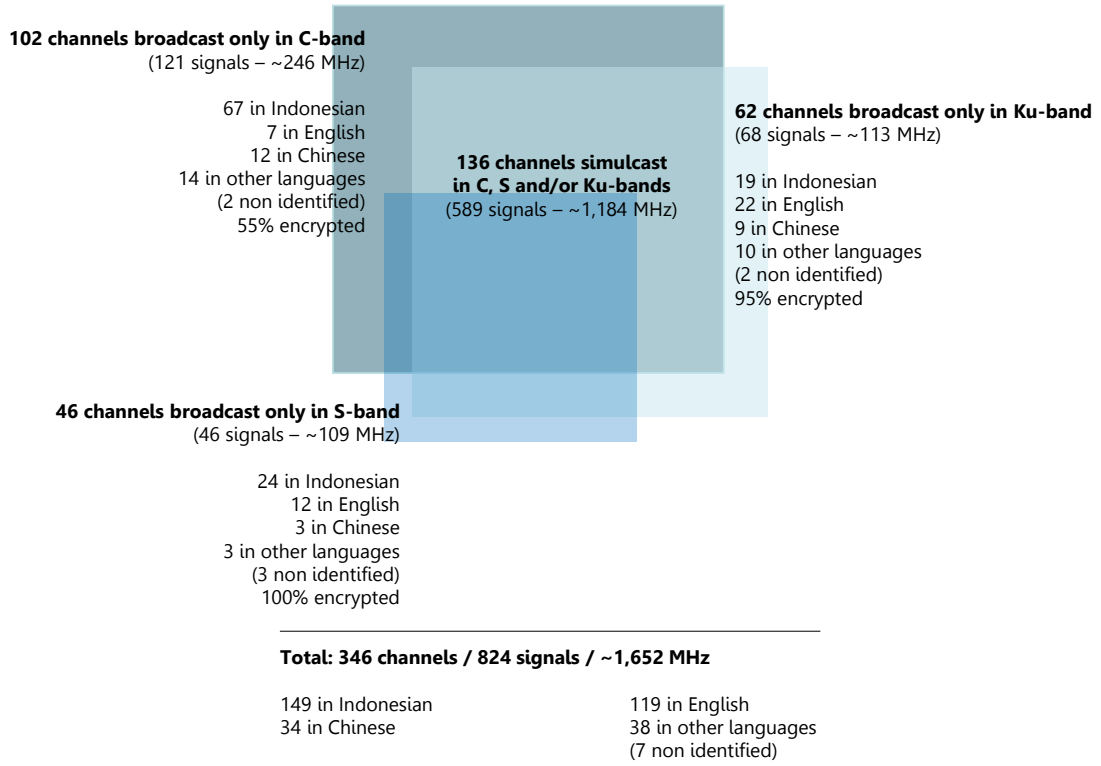
This situation will change as Indonesian broadcasters phase out analog channels and deploy new digital transmitters, as they are required by the government to do gradually from 2015. However this change will be limited and relatively slow. The government is currently auctioning digital TV licenses, and for this has divided the country into 15 zones for which broadcasters are invited to bid individually. Licensees will then be required to cover at least 70% of the population in all or part of 25 areas, into which each zone is subdivided. At this stage of the process, however, bidders have made such commitments for only 9-14 of these 25 areas in all but one of the 15 zones, and for all 25 areas only in Zone 1, covering Java. By 2020, when these commitments must be implemented, up to 30% of Java's population, and at least 35-40% of Indonesia's overall population, would then still not be covered by terrestrial transmitters, and continue to depend on satellite reception. Note also that in any case the thousands of digital television transmitters which are to be deployed will continue to receive television signals over satellite and in C-band.

Dynamic market for C-band broadcasting

This situation, the result in large part of Indonesia's geography and of its population's low incomes, has produced a large and dynamic market for C-band broadcasting, which as detailed below we estimate will directly contribute $200-300m to the Indonesian economy in 2014, and is at least indirectly required for almost the entire Indonesian television industry to operate.

Considering content, over two-thirds of the television channels carried by the satellites serving Indonesia (those carrying mainly Indonesian-language programming, or with beams only or principally covering the country) are transmitted in C-band (Exhibit 9). While pay platforms have developed in the adjacent S-band, and more recently in Ku-band, in each of these alternative bands they total only about half as many channels as are available solely in C-band.

Exh. 9: INDONESIA: SATELLITE TELEVISION CHANNELS BY FREQUENCY BAND, MAR. 2014



source: Euroconsult analysis of transponder monitoring by Lyngemark Satellite, Lyngby, Denmark [www.lyngsat.com; accessed 26 Mar. 2014].

Moreover, as free-to-air television continues to make minimal use of Ku-band and S-band is wholly occupied by Indovision, a pay platform, C-band also provides most of the unencrypted channels freely accessible to viewers. It also carries significantly more Chinese-language programming, into a market which, while it may total about 3m people, seems to be of little interest to most pay platforms.

In total, transponder shows 372 C-band television signals (including rebroadcasts of some channels on more than one satellite, and test cards), using an estimated 778 MHz.[57] On current lease rates of about $2,700 per MHz/month this corresponds to $25m of annual income for satellite operators.

This has also led to a very large installed base of C-band television antennas, which in turn drove economies of scale which still make this the most affordable way for Indonesians to receive the most popular over-the-air channels in good conditions.

As an illustration Appendix 2 shows a view of rooftops in central Jakarta, with an apparent density of antennas on the order of 90/km2; C-band dishes are recognizable at their diameter of approximately 2 meters or more, about twice the size of S-band antennas and several times that of Ku-band antennas.

The data available on the size of this audience, while not fully convergent, all place it at well over 10m households:

- In 2009 a study by audience researchers AGB Nielsen, cited by (and apparently produced for) pay-television operator TelkomVision, put the number of C-band antennas at 12m.[58]
- In 2012 a Gallup survey of over 2,700 households found that 23% of them used a satellite antenna, including 28% of respondents in rural areas, 55% in Sumatra or Sulawesi, and 65% in Kalimantan.[59] Given that official surveys in 2012 indicated that 92% of the population then watched television, including 88% in rural areas, this would suggest that about 50m Indonesians, or 13m households, used satellite antennas to do so.[60] Even if this figure included antennas used to receive DTH platforms in other frequency bands, the largest of them by far, S-band platform Indovision, had only about 1.57m subscribers when the survey was made, while Ku-band platforms came to well under 1m subscribers altogether, leaving about 11m C-band antennas.[61]
- PT. Stella Satindo (trading as Matrix), which manufactures about 50 % of the C-band television dishes sold in Indonesia, estimates current total monthly sales – including its own and that of a dozen smaller competitors – at approximately 100,000 units, with year-on-year growth of around 10% in 2013 and 2014.[62] Given the durability and slow replacement cycle of such antennas, this would suggest a current audience in the range of 12-17m C-band homes, depending on which of the estimates cited above is taken as reference level. This would place the penetration of C-band television dishes in the range of 21-30% of total television homes, and still 18-23m homes short of the addressable market, leaving a sizable opportunity for local industry.

The reach of C-band is clearly large enough to determine a large part of the audience and advertising impact of Indonesia's over-the-air broadcasters. The latter accounts for the vast majority of total viewership.[63] In 2013 television generated 68% of Indonesia's total advertising revenue, or about $5bn.[64] Indonesian television is, in turn, especially dependent on advertising revenue – and thus on free-to-air distribution – as the low penetration of credit cards, and the general difficulty of collecting subscription fees, have made pay-television very difficult to implement so far.

Television also matters particularly in Indonesia, where surveys have shown it to be the primary news source for 79% of respondents, and to be trusted as a news source by 98%.[65] The Indonesian government long considered it important enough to be distributing free C-band dishes in rural areas, and political parties still use dedicated C-band channels and free dishes as part of electoral campaigns, giving this medium a significant role in the country's democratic process.

The C-band audience has in fact become large enough to attract pay-television broadcasters, who so far have launched five platforms (TransVision, Skynindo, Orange TV, Kompas TV and Topas TV), totalling about 750,000 subscribers, and several more are believed to have applied for licenses. Subscriber counts and ARPUs are not known in enough to detail to permit a precise estimate of this sector's revenue, but on an average monthly price of ~Rp80,000 ($7) it would come in 2014 to $63m.[66]

The C-band satellite dishes themselves constitute a significant consumer market. On the current annual sales of approximately 1.2m units, given a breakdown into 30% of solid reflectors typically priced at about $35 and 70% of cheaper mesh reflectors priced at $20, imply a market value of over $29m in the 12 months to mid-2014.[67] Set-top boxes, being less durable than dishes and not always capable of receiving all channels, sell in even larger quantities of 250,000-300,000 per month and, at a minimum price of $10, add at least $30m of market value.[68]

This large consumer market sustains an ecosystem of numerous vendors and service providers, many of them small or individual enterprises. These include:

- Antenna and set-top box manufacturers: At least four Indonesian companies produce satellite television dishes, with total employment on the order of 1,000 people. The largest, Matrix, has 250 employees and currently depends for 97% on C-band antennas and set-top boxes (Appendix 3 illustrates the scale of its manufacturing operation). Its chief executive noted that, should C-band become unavailable to satellite television in Indonesia, "for us, that would be the end".[69]
- Antenna dealers and retailers: Most of the country's electronic retailers sell C-band dishes. Matrix itself relies on 50 dealers, totalling about 1,000 shops, including eight dealers and several hundred shops in rural areas which only or principally sell satellite antennas. Skynindo distributes set-top boxes for its C-band service through over 300 dealers, which generally have on the order of 20 employees; Orange TV, which operates in more rural areas, uses about 4,000 dealers with typically only 2-3 employees. C-band satellite television thus provides an important part, and in many cases all, of the income of another ~60,000 Indonesians in this part of the market.
- Installers: The technicians who install satellite dishes on customer premises (when the buyers do not do so themselves) are generally employed by the retailers. According to Matrix, Indonesian broadcasters and advertising seen in Jakarta, they generally charge the equivalent of $10 per installation in urban areas, but this can reach $30 in rural areas with greater transportation costs.[70] Assuming 1-2 installations per day and that 10% of antennas are self-installed, consumer demand in 2013-14 would require at least 1,700-3,500 installers, generating a total of ~$22m (part of which, however, may be included in the antennas' sales price).[71] The $250-500 which an installer can generate (and earn in part) in a month also seems far from negligible, given that on average Indonesian retail workers earned only about Rp1.15m per month (~$100) in 2013.[72]

In addition, at least 4,500 cable networks, serving 2-3m subscribers, exist to retransmit the over-the-air channels available in C-band to households which cannot or prefer not to buy their own antennas. Most of these networks being small, with 3-5 antennas per head-end they may account for another ~22,000 antennas. As in India, cable television tends to be the cheaper option, with subscription rates in the range of $2-4/month; this would correspond to $48-144m of annual revenue. While over 90% of these networks are unlicensed, they can be significant contributors to local economies.

5. Connectivity

5.1 OVERVIEW OF THE C-BAND SATELLITE CONNECTIVITY MARKET IN INDONESIA

Indonesia, because of the difficulty of deploying terrestrial infrastructure across its rugged and highly fragmented territory, is one of the world's largest markets for satellite communications and, since many of these requirements demand much greater reliability than rain fade would allow in other bands, this relies primarily on C-band.

VSATs are particularly widespread, as land lines remain unavailable or insufficiently reliable for business applications even in city centers. Exhibit 11 shows examples commonly viewed in Indonesian cities, ranging from the nearly ubiquitous antennas visible on ATMs and convenience stores, to large hub facilities which the absence of adequate fiber connections require some corporations to maintain at their downtown headquarters. Exhibit tallies the networks we were able to identify from interviews with some of the 15-20 service providers which share this market, coming to a minimum of about 125,000 terminals.

Exh. 10: INDONESIA: REPORTED ACTIVE C-BAND VSAT TERMINALS, 2014

USER	TERMINALS
Banks (fixed ATM networks)	**~75,000**
Bank Rayat Indonesia	18,000
Bank Central Asia	~15,000
Bank Mandiri	9,000
Bank Negara Indonesia	7,000
ATM Bersama (shared network)	6,000
Bank Danamon	~1,000
Bank Niaga	~1,000
Other banks	~19,000
Banks (other networks)	**~4,350**
Mobile ATMs	~350
Clearing and back-office	4,000
Retail	**~30,000**
Alfamart	6,000
Indomart	6,000
Others	~18,000
Industrial and utilities	**>750**
Oil and gas production	~30
Oil and gas exploration*	>260
Plantations*	>260
PLN (electric utility)	200
Rural communications	**>6,850**
Telkomsel private network	**800
Universal Service Obligation network	5,700
Indosat	200
XL Axiata	**>150
Public safety and security	**831**
INAFIS (criminal police forensic service)	35
Indonesian Army	200
InaTEWS tsunami warning network	161
BMKG weather and geophysics networks	400
BKMG disaster response terminals	35
Other public services	**~6,780**
Ministry of Home Affairs (e-KTP service)	6,000
Ministry of Health	400
PT Pos (postal service)	200
Directorate General of Civil Aviation	<100
Ministry of Forestry	80
Total	**~124,561**

Notes: (*) Total shown from identified networks only. (**) Each Indosat earth station serves about 3 BTS.

Sources: see main text

Exh. 11: INDONESIA: VSATS IN JAKARTA, MAY 2014

Convenience store with ATMs

Australian embassy

Convenience store

Small business

Bank Mandiri building

ATMs and convenience store

source: Euroconsult photographs.

We further detail below the largest application segments for C-band usage.

5.2 FINANCIAL AND BANKING SECTOR

The largest market in terms of VSATs deployed is banking, and specifically communications for ATM terminals, with an estimated 75,000 installed antennas. All of these are using C-band, to meet service-level agreements (SLAs) which usually require links to be available at least 99.5% of the time.[73] The largest network belongs to State-owned PT. Bank Rayat Indonesia Tbk. (BRI) and comprises 18,000 VSATs, or nearly all of the bank's 18,479 ATMs. Assuming that this ratio scales directly to the traffic generated by these ATMs, BRI's VSAT network may have supported as many as 1.1bn transactions in 2013, with a value equivalent to over $70bn, or about $2,200 per second – again illustrating the value of minimizing network outages.[74] The second and third largest users, Bank Central Asia (BCA) and Bank Mandiri, are similarly reported by service providers to operate about as many VSATs as they had ATMs in total as of mid-2013.[75] In total, these 75,000 satellite-linked ATMs are estimated to handle on each day an average of 15m transactions, with an aggregate value of more than $400m.[76]

Some Indonesian banks are known to have sought cheaper terrestrial alternatives, but so far do not seem to have found them, at least on the scale of they require. BCA thus said in 2006 it was about to migrate its data communication system from VSATs to a new fiber network, but has evidently not done so on the full scale of its operations.[77] Others, notably BRI, also migrated a small proportion of their ATMs to cellular-based GPRS networks around 2010, but found the latter to be so unreliable that, according to the service providers which support them, they have since returned all of them to VSATs. One issue was the very low volume of communication traffic which ATMs generate, which, compared with their overall telephone traffic, cellular carriers did not find large enough to warrant offering SLAs or priority routing.

On 28 April, BRI took the remarkable step of procuring its own satellite, BRISat, which from 2016 will provide it with up to 36 C-band transponders to support its network, at a reported cost of $250m.[78] As the only bank with its own satellite, BRI could also provide a broader range of specialized clearing and data management services to other banks. Far from treating this project as a necessary evil or an obscure part of its infrastructure, BRI has promoted BRISat as the means it will use to "reach people in all corners of the country in support of the financial inclusion program" (Appendix 4).

Financial inclusion, in this context, refers to an array of government efforts aimed at bringing into the formal banking system the approximately 60% of the population which, as of 2011, still had no formal bank account or credit card, and relied instead on cash, moneylenders and various intermediaries, often more expensive and less reliable than commercial banks. The banks themselves, in areas without good communications, are often required to have documents hand-carried. Modernization efforts, in this case, aim both at alleviating poverty and at preventing financial crises such as Indonesia experienced in 1997 and 2000.[79]

These policies, and the banks' own interest, have now led the number of ATMs and bank branches to increase rapidly. Over 2013-14, the monthly volume of credit-based withdrawals was on average 19% above that of a year before.[80] BRI deployed 4,000 new ATMs in 2013[81] and Bank Mandiri alone is expected to deploy another 2,500-4,000 ATMs during 2014.[82]

Banks, and some government bodies, have also fielded mobile ATMs, mounted on vans or buses, for use in rural areas where population density may not justify a full-time branch. Over 300 are now in service, all equipped with C-band antennas (Exhibit 12).[83] One manufacturer and service provider, Lintasarta, said in 2013 it had sold 54 mobile ATMs during the year and expected orders for another 100 in 2014.[84]

In addition an estimated 4,000 C-band VSATs connect the banks' branches to their headquarters for clearing and back-office purposes, corresponding to about one-fifth of total bank branches.[85]

Exh. 12: INDONESIA: EXAMPLES OF MOBILE C-BAND VSATS

Mobile ATM

INAFIS vehicle for crime scene forensics

source: top: reproduced from M. Chandrataruna and T.A. Wibowo, "Ini Mobil Internet Keliling ala Lintasarta", *op.cit.;* center: LENSAcimed photo posted at http://forum.kompas.com/teras/81064-kartu-inafis-polri-vs-e-ktp.html.

5.3 RETAIL SECTOR

A related, and similarly fast-growing market, is that of convenience stores, which use VSATs on a large scale to connect ATMs installed on their premises. Indonesia's two largest, and fiercely competitive chains, Indomaret and Alfamart, are each reported by their service providers to operate about 6,000 C-band VSATs, equivalent to two-thirds of their total outlets at the end of 2013.[86]

More will be added, as consumers continue to adopt credit cards and as both chains continue to expand. Indomaret has in particular announced plans for opening 2,000 new stores in 2014.[87] Retail chains should also introduce new in-store applications such as digital signage, which will allow them to deliver advertising and implement price changes and promotions more quickly and effectively.

According to one service provider, Indomaret in particular plans to replace the disparate communication links it still maintains alongside VSATs with a unified network based entirely on 10,000 C-band VSATs.

5.4 NATURAL RESOURCES

Two other key economic sectors, oil/gas extraction and plantations, also rely on C-band VSATs for critical communications.

Oil and gas production contributed approximately 4.5% of Indonesia's GDP in 2013.[88] While this production has tended to decline in recent years as legacy oilfields matured, the resultant growth of imports have added urgency to exploration efforts, and probably to making production more efficient. The oil and gas industry is generally one of the most demanding VSAT users because of the high availability and reliability which the cost of exploration and production make necessary. One service provider said the oil companies it serves in Indonesia require at least 99.5% availability, and specify Ku-band antennas only in the limited cases where they can tolerate availability in the range of 95-99%.[89]

The two service providers whom we interviewed, out of the three which share most of this market in Indonesia, reported operating about 260 C-band VSATs, principally at exploration sites (some sites may have more than one antenna). About two-thirds of these facilities are offshore, but generally at distances of less than 50 km which may be too short to prevent interference from terrestrial C-band emitters if any were deployed at coastal locations.[90]

As deep-sea exploration efforts in recent years have tended to yield disappointing results, oil companies are also reported to place greater emphasis on land-based fields. Finally most exploration activity is currently in Eastern Indonesia, where terrestrial connectivity is the most limited.

While about 70% of production sites are connected by optical fiber laid along pipelines, those using VSATs have tended to require higher data rates in recent years as oil companies seek to better monitor wells and to reduce on-site personnel.[91]

Agriculture, another of Indonesia's major economic sectors and a key exporter, has also begun to adopt VSATs at the largest of its tens of thousands of plantations to better monitor their processes, and in some cases to provide Internet access as an inducement for workers. Thus one service provider reported installing 40 C-band VSATs for a palm-oil producer which had installed video cameras to inspect produce before shipment, as well as various sensors to better track volumes and storage times.[92] Two others, Smart Group and GMT, have installed about 100 C-band VSATs each.[93]

5.5 GOVERNMENT NETWORKS

Several essential public services rely extensively on C-band VSATs, to provide a uniform quality of service to the population in areas where terrestrial networks may be unavailable or too poor or fragmented to be of use.

The largest is e-KTP. The program is managed by the ministry of Home Affairs, under which most Indonesian voters received biometric identity cards over 2011-12. The cards are eventually to replace most printed identity documents and are a key part of efforts to reduce fraud in national elections and in social benefits programs. Operating under tight deadlines as most voters had to be enrolled in time for the presidential elections due in July 2014, e-KTP entailed collecting digital photographs, signatures, fingerprints and iris patterns from over 172m people within 2 years, and was thus critically dependent on its communication network.[94] To this end 6,000 out of 7,000 enrolment locations were equipped with VSATs, which the government specified to use C-band.[95] The network will remain in use, as e-KTP cards must be renewed every 5 years.

A much smaller C-band network, but one for which uninterrupted communication is clearly of even greater importance, is the Indonesia Tsunami Early Warning System (InaTEWS) run by the Meteorological, Climatological and Geophysical Agency (BMKG).

Greatly expanded after the tsunami of December 2004, InaTEWS connects 160 seismometers, 500 accelerometers, 80 tide gauges and other sensors via 161 VSATs to a monitoring centre in Jakarta (Exhibit 13). The centre analyses this data and can disseminate warning messages to the population within 5 minutes of an earthquake.[96]

BMKG operates approximately 400 additional C-band VSATs as part of its other meteorological and geophysical networks, as well as 35 mobile terminals for use in emergencies.[97]

These networks are clearly quite sensitive given the high incidence of seismic and other natural risks in Indonesia. Some, such as landslides, often occur in precisely the same conditions as rain fade.

Other identified C-band government networks include:

- A reported 200 military terminals,
- About 400 terminals installed at hospitals for office use (though not for telemedicine),
- About 500 terminals used by various other administrations, and
- 35 van-mounted terminals acquired by Indonesian police to support forensic investigations on crime scenes as part of the Indonesia Automatic Fingerprint Identification System (INAFIS).[98]

Exh. 13: C-BAND ANTENNAS IN THE INATEWS TSUNAMI EARLY WARNING NETWORK

Remote terminal connecting a tide gauge in Sadeng, E. Java

Rooftop of main operational center, Jakarta

arrows indicate 5 C-band antennas

source: top: reproduced from *InaTEWS Konsep dan Implementasi*, Badan Meteorologi Klimatologi dan Geofisika, Jakarta, Mar. 2010, p. 14; bottom: adapted from *Development of InaTEWS Towards Regional Tsunami Watch Provider*, presentation by Dr. P. J. Prih Harjadi, Badan Meteorologi Klimatologi dan Geofisika, at the DEWS Midterm Conference, Postdam (Germany), 7-8 July 2009, p. 10.

Other police networks are believed to exist and to be supported by as much as 1-2 C-band transponders on Indonesian satellites.

Additional networks are likely, and in the short term could include 120 naval terminals (some in Ku-band) said by one service provider to be included in the current defense budget for acquisition within the next 3 years. Applications such as telemedicine and distance learning remain essentially undeveloped despite being quite clearly relevant to Indonesia, and have elicited some government interest (though no funding, so far).

5.6 CELLULAR BACKHAUL AND RURAL CONNECTIVITY

A key use of C-band satellite capacity in Indonesia is in support of the backhaul needs of cellular carriers and for public telephony in remote areas. Vigorous competition among operators – in particular from Telkomsel, which in 2006 adopted a strategy of offering the broadest possible coverage – and licensing requirements to cover rural areas, have produced spectacular gains in

teledensity, increasing it over 2006-12 by about one-third in urban areas (to around 91%) and doubling it in rural areas (to around 76%).[99]

The rapid pace at which this happened often left carriers with no alternative to backhaul over satellite, which as of mid-2013 used nearly 50 transponders on Indonesian satellites alone, or 55% of their capacity.[100] The three largest carriers, Indosat, Telkomsel and XL, currently operate an estimated 1,030 C-band terminals to connect base stations.[101]

Each of these terminals is estimated, on average, to provide connectivity to 1,000-5,000 cellular subscribers, depending on equipment, network design, traffic patterns and the surrounding population density. On this basis, and given that detailed data were obtained for only the three largest of Indonesia's eight cellular carriers, we estimate that at least 6-15m cellular subscribers may thus depend on C-band satellite terminals for their satellite service, or 7-16% of rural subscribers.[102] On average reported revenue per subscriber, the corresponding cellular traffic may have generated $224-558m of cellular service revenue in 2013.[103]

The need for C-band links to cellular networks is expected to persist for some time, despite the slowly increasing reach of terrestrial backhaul. Though carriers are working to extend fiber networks to reduce costs and provide more capacity for fast-growing data traffic, so far their rural subscribers have grown faster. Thus, while in 2011 Indosat migrated about 100 of its 300 satellite-linked base stations to fiber, and was planning to do so again in 2012, it also added about as many new stations in rural areas, beyond the reach of its fiber network.[104]

The nationwide Palapa Ring, a government-funded fiber optic backbone network to connect over 400 cities, will meet part of this requirement when it enters into service (normally by the end of 2014), but it offers little inland connectivity except outside of Java and Sumatra and will likely not reach many of the remote locations which currently require VSATs. A further project, Palapa Ring II, was due to be tendered in June 2014 and would extend the network to over 50 locations in Eastern Indonesia.[105] However its timetable remains uncertain and even this is unlikely to eliminate satellite backhaul, if only to provide backup.

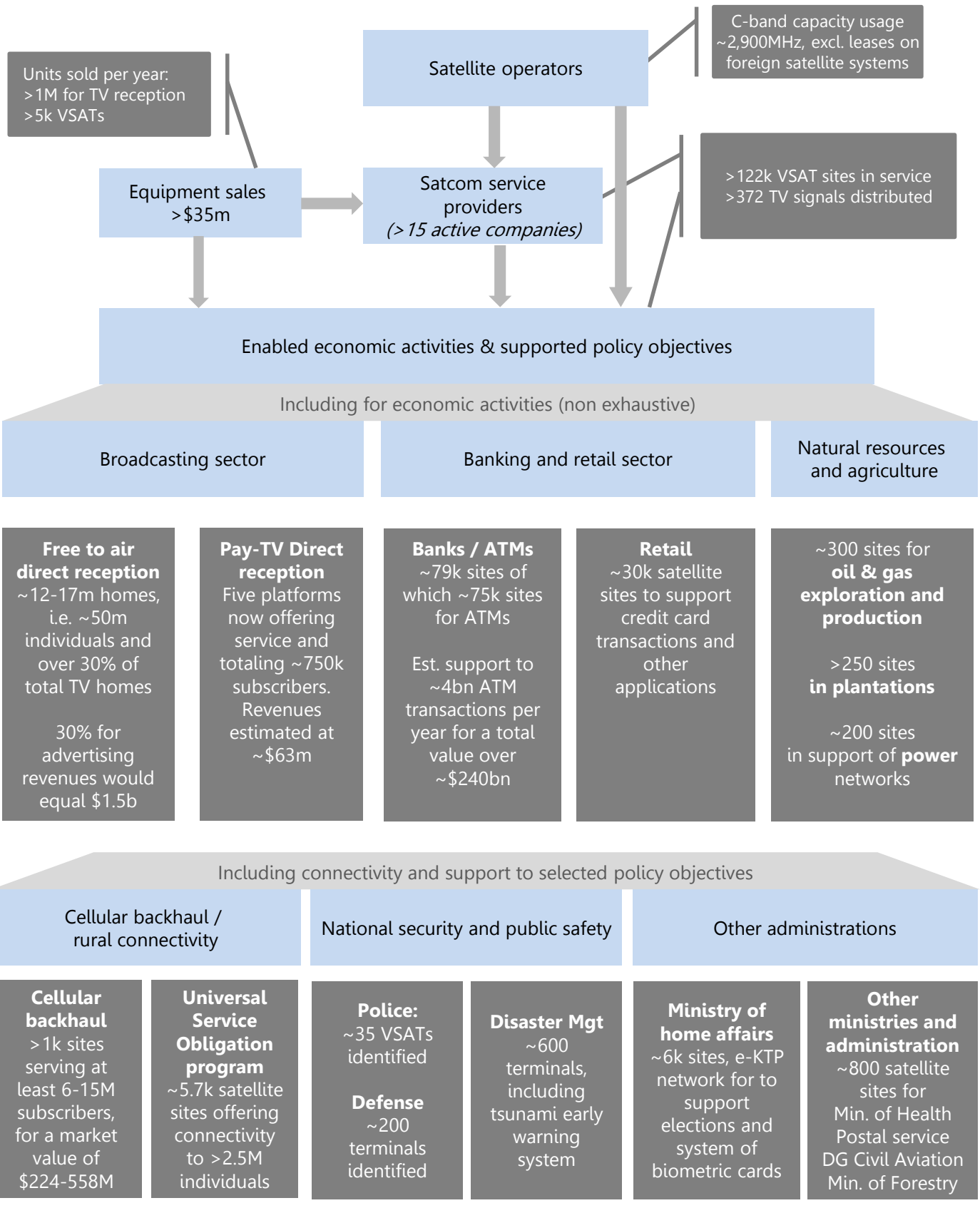
Another 5,700 C-band terminals have been deployed by Telkomsel, and in the Eastern provinces of Sulawesi and Irian Jaya by a second contractor, PT. Indonesia Comnets Plus, to provide public telephony in rural areas as part of the government-sponsored Universal Service Obligation (USO) program, funded by a 1.25% tax levied on all communication services. In this case the terminals support fixed wireless telephones, managed by local retailers who are allowed to retain all service revenue.[106] Though Telkomsel's operating contract expired in March, the company is permitted to continue providing the service from its approximately 4,400 terminals on a commercial basis. Another service provider, Lintasarta, has deployed Ku-band terminals for public Internet access under this program, and reports achieving an average availability of only 95%.[107]

6. Socio economic benefits

The previous sections have highlighted both the diversity and importance of satellite C-band usage in Indonesia. The reported usage involves both the public and private sector, and ultimately underlies services touching a very large part of the population - over 30% on a daily basis and potentially more in exceptional circumstances such as natural disasters.

Exhibit 14 provides a synthesis of the findings of our research on current C-band usage. It does not include findings on the potential development of C-band usage for several segments such as the broadcasting and banking sectors, as well as for certain government networks.

Exh. 14: INDONESIA: SYNTHESIS OF SOCIO ECONOMIC IMPACT OF SATELLITE C-BAND USAGE



Four particular impacts can be highlighted:

- The presence of a **specific ecosystem of companies** specialized in satellite communication services, with a direct investment in C-band capacity. Many of these companies, and their employees, are at the top of the country's high-technology sector;

- The role of C-band as **enabler of major economic activities**, notably television, banking, retail, natural resources and energy;

- The importance given to C-band in efforts to bridge the digital divide, provide **uniform connectivity** and to **improve government efficiency**;

- The presence of several networks supporting **critical communications** for the country, including for disaster management, defence forces and police units.

The following table summarizes sources for key assumptions supporting Exhibit 14.

SEGMENT	NOTES ON ASSUMPTIONS
Satellite operators	Derived from separate Euroconsult research [108]
Satcom service providers and grey box	Channels – see page 22; VSAT sites see Exh. 10
Equipment sales	See pages 21-22 and assumption of less than 10% of installed VSATs being sold on average per year either for replacement of new installations.
Broadcasting sector	See pages 17-22
Banking and retail sector	See pages 24-26
Natural resources and agriculture	See page 26
Cellular backhaul / rural connectivity	See pages 27-28
National security and public safety	See pages 26-27
Other administrations	See pages 26-27

C-BAND USAGE IN PAPUA NEW GUINEA

1. Country overview

Papua New Guinea (PNG) has population of approximately 7 million people in 2012[109]. The population increased by approximately 1.9 million or 30% between 2000 and 2011. This corresponds to an average population growth of 2.8% p.a. over the 11 year period.

PNG is divided into 22 administrative provinces, with each province comprising of one or more districts with a total of 87 districts. According to preliminary results of the 2011 Census, it has an average population density of around 11.2 people per km^2. Around 88% of the population lives in rural areas. PNG has over 820 indigenous languages, but most have fewer than 1,000 speakers.

Covering 462,840 km2, Papua New Guinea includes the mainland and 600 islands. The mainland of the country is the eastern half of New Guinea Island, where the largest towns are also located, including Port Moresby (capital) and Lae. Other major islands within PNG include New Ireland, New Britain, Manus and Bougainville. The country shares ~800km land border with Indonesia in the east. The country's geography is diverse and extremely rugged, comprising of mountains, highlands, islands, dense rainforests, wetlands and coastal areas. This terrain has made it difficult for the country to develop communication and transportation infrastructure. There are a number of active volcanoes, and eruptions are frequent. Earthquakes are relatively common, sometimes accompanied by tsunamis. The country falls in the tropical climate zone with an average rainfall varying between 2000mm and 5000mm. The monsoon season typically last from December to March and May to October every year[110].

The economic growth rate was 8%, with GDP reaching over US $15.5 billion in 2012.[111] Growth was supported by a recovery in mining output, and construction activity connected with the Exxon Mobil-lead Papua New Guinea LNG project[112]. Agriculture, both for subsistence and cash crops provides a livelihood for 85% of the population and continues to provide around 30% of GDP. Mineral deposits including gold, oil, and copper, account for 72% of export earnings. PNG's main export markets are Australia (29%), Japan (9.6%) and China (5%), while it receives imports mainly from Australia (36%), Singapore (14%) and Malaysia (8.4%).

2. Television broadcasting

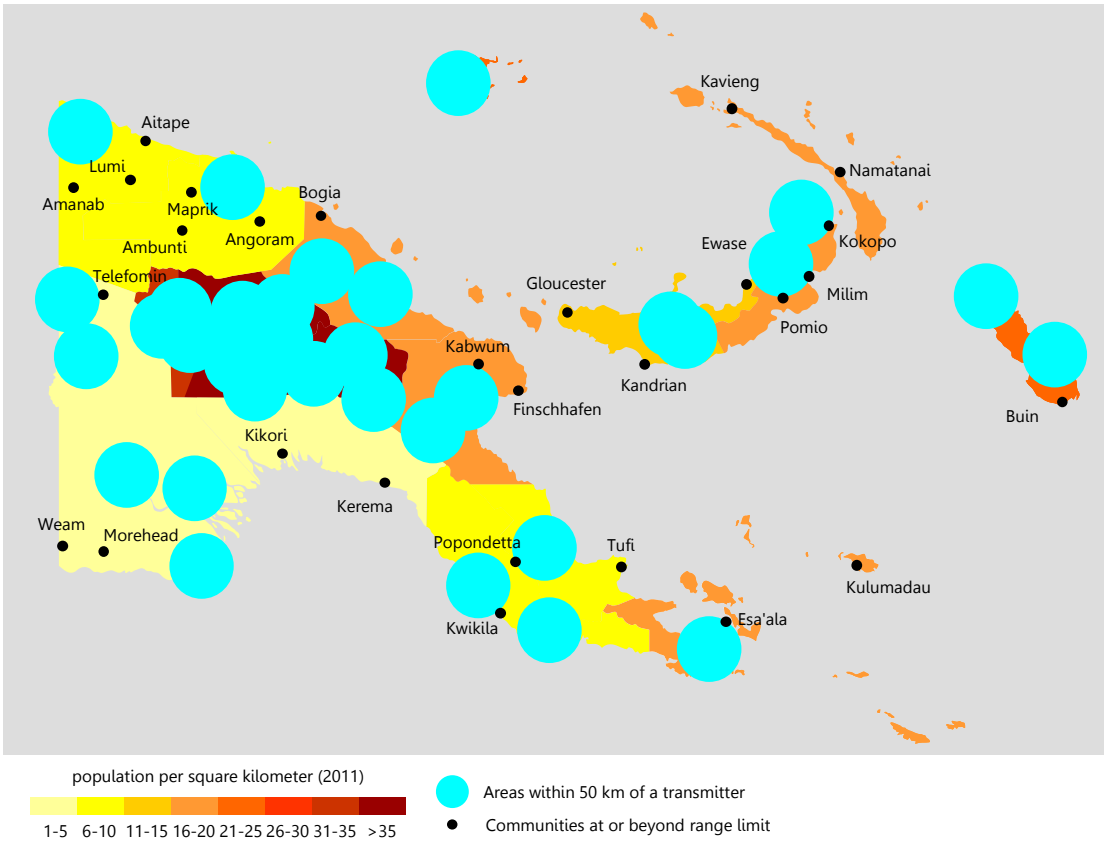
2.1 OVERVIEW OF TV RECEPTION IN PNG

The high incidence of rain fade in Papua New Guinea, and its limited cable infrastructure, make C-band satellite links essential to the country's broadcasters both for acquiring content from abroad, for contribution links to retransmitters, and, given the latters' limited coverage, for distribution to viewers.

PNG currently has two television broadcasters, EMTV (a commercial channel of privately-owned Fiji Television), and Kundu, produced by the State-owned National Broadcasting Corp. (NBC). While both rely in part on a network of about 34 UHF or VHF transmitters to serve PNG's principal cities, their coverage omits a fairly large fraction of the territory, due in particular to relief and to low population densities. This includes at least 18 district capitals and 10 other communities, some large enough to serve as local government headquarters, with a combined population in excess of 1.2m people, or 17% of PNG's total population (Exhibit 15). Applying each province's last reported population density (for 2011) to the area left uncovered by these terrestrial transmitters, to capture the many small villages not figured on the map, suggests an unserved population of 2.1m people, or about 30% of the country's total.[113]

While these estimates encompass uninhabited areas, they also assume that each transmitter effectively covers its surroundings up to its maximum theoretical range of 50 km. This is clearly not the case given the many shadow areas created by relief. Actual coverage is in fact much more limited, and so far has not even been measured precisely because much of PNG's territory is roadless and only accessible by air. Moreover, because of their cost, several of the transmitters used by the NBC in the less populated areas are less powerful versions with a range of just 10 km.[114]

Exh. 15: PAPUA NEW GUINEA: MAXIMUM COVERAGE OF TERRESTRIAL TV TRANSMITTERS, MAY 2014



source: transmitters: private communication from broadcaster; Euroconsult analysis. Population map: derived from *Preliminary Figures: Papua New Guinea Census 2011*, National Statistical Office of Papua New Guinea, Port Moresby, Apr. 2012, pp. 10-34.

A survey performed in 2012 by audience researchers Nielsen Co. for EMTV, which uses the most transmitters, put their reach at about 4m people, or just 56% of the population.[115] Significantly, even the reach of the NBC's radio service, whose FM and shortwave signals can propagate over greater distances than television, was estimated at the time at just 75% of the territory.[116] Moreover a relatively large number of these radio transmitters are currently out of service, and some are so remote that repairs have been pending for a year or more.[117]

At least 50% of PNG's population thus seems to have no alternative to satellite dishes for receiving television. Though some resellers offer Indonesian S-band or Ku-band services, they are not widespread, often operate illegally (making their decoders liable to be deactivated if found), offer no local content and, in the case of Ku-band, are subject to heavy rain fade. As will be seen, the latter makes C-band by far the frequency of choice for both PNG's broadcasters and consumers.

2.2 IMPORTANCE OF C-BAND FOR THE BROADCAST SECTOR

A large spread and reach of C-band antennas

Indications from broadcasters on their viewership and authorized decoder counts, and from distributors and retailers on antenna sales, all converge towards an estimate of around 2,000 installed C-band dishes.[118] While this may seem a relatively low figure, most of the approximately 50% of PNG's population which needs a satellite dish to watch television does so using communal antennas, installed in locations such as schools and churches where popular shows may attract audiences of hundreds.

In 2011, 44% of respondents to a survey of media consumption habits said they regularly watched television in town halls, sports fields or stores.[119] 2,000 antennas would correspond to one-third of PNG's ~6,000 wards (the smallest administrative unit).[120] The collective antennas thus have a high impact in terms of their social importance, especially in rural areas where illiteracy is still high and satellite television may be the only source of outside news and entertainment.

Relatively few households own television sets in any case, as a result of low incomes and, in many areas, because a satellite dish and – in the absence of an electric grid – a solar or petrol generator are also required. Surveys in 2011 found only 36% of households with a working television set, and less than 20% in rural areas.[121] The government has set the objective of increasing television penetration to 44.5% by 2015 and to 63% by 2020, which in view of the difficulty of adding terrestrial transmitters seems only feasible using satellite antennas.[122]

About 400 of these antennas have been installed at schools by the Department of Education, to receive educational programming, which it produces with Japanese assistance and which EMTV uplinks as part of its daily schedule. The project, called EQUITV, has benefited tens of thousands of students since 2005 and is to be expanded to another 3,500 of PNG's 9,800 schools by the end of 2015.[123]

In 2008 an independent evaluation confirmed the project's usefulness, with 80% of participating teachers calling it helpful or very helpful, a positive effect on students' scores, and local communities and parents willing to share in the costs. Significantly, one of its principal limitations was cited as "weak or no TV signals".[124] Though so far the government has been able to provide only a small part of the approximately $3m this requires, the program has broad support and some provincial government, as well as some of the schools themselves, have purchased antennas and other equipment.

Most other communal antennas also appear to have been procured and installed by local elected officials – and then constitute one of the tangible benefits they provide to constituents – or by churches or businesses such as mines or plantations for their parishioners, employees and neighbours. For instance New Britain Palm Oil Ltd., one of PNG's largest employers, bought at least 22 antennas for its workers. Other plantations have tried to build private UHF or cable networks, but are said to have only found this to be much more difficult than installing satellite antennas.[125] Several hundred hotels have also installed one or more C-band antenna to provide television for guests, including foreign channels for tourists.

An economic ecosystem around C-band transmission and reception

Aside from their social value, despite their limited number these C-band antennas also support a broader ecosystem, comprising the two broadcasters, at least 4-5 retailers, installers, and the transporters needed to bring this equipment to remote communities. On average C-band antennas retail in PNG at K2,000-2,500 ($720-900). Most are likely to be self-installed, but given the difficulties of access a professional technician may charge up to $1,000.

EMTV, for the needs of its upcoming pay service (see below), is considering to train local installers, whose rate is expected to be under $10 but would then contribute more directly to local economies. Transportation costs can also be substantial, ranging from about $180 for short-distance hauling on the country's very limited road network, to $500-900 per dish in the more frequent cases where airfreight is required.

A single, self-installed dish may thus amount to an investment in the range of $900-1,800 – a substantial amount, on the same order as PNG's per-capita income. Correspondingly, assuming that the current installed base either developed over 10 years or currently grows at around 10% p.a., an annual market of 200 antennas may be valued at just $180,000-360,000. To put this estimate in context, however, PNG's entire communication services sector was valued in 2011 at about $10m.[126]

Indirect economic returns from the C-band antenna base include most of the revenue of EMTV, which came in 2013 to about $9m, and certainly much of the approximately 75% of PNG's advertising market which comes from television.

Moreover, PNG's two principal broadcasters are now preparing to substantially expand their operations. Not only will they rely extensively on C-band to do so, but in one case this will explicitly be made possible mainly by relocating from Ku-band to C-band:

- EMTV has made substantial investments since 2012, including in rehabilitating transmission sites.[127] in July 2014 it plans to introduce a 17-channel, PNG version of its parent group's C-band regional DTH television platform, Sky Pacific. EMTV, which at the time of research was still awaiting a license, projects that it may acquire up to 300,000 subscribers over the first 4 years, increasing the market's value several fold.[128]

- Kundu has attempted to broadcast in Ku-band, using capacity it leases from telecommunications carrier Telikom which, apart from exposing it to rain fade, effectively requires viewers to buy a VSAT terminal. Few if any have done so, and in June 2014 Kundu will migrate to C-band capacity on Intelsat 19. As a result, it expects to at least double its audience by 2015, and is engaged in a series of investments to prepare for the nationwide reach it will finally achieve. This includes a $500,000 new television studio and hiring and training 20 new employees, including 10 producers to allow Kundu to provide more of its own content, rather than the acquisitions on which it still mostly relies. The more attractive channel this would allow Kundu to produce is expected in the longer term to allow the NBC to sell advertising, rather than to rely solely on the government budget.[129]

Cable television is less well structured but also relies on C-band programming feeds. About 20 wireless cable networks are in operation, often in disregard of copyright regulations but with a subscriber base which EMTV tentatively estimates at 20,000.[130] The largest operator, Hitron Ltd., is credited with about 10,000 subscribers paying the equivalent of $2.5-5/month.[131] Exhibit 16 shows Hitron's antenna farm, including its C-band cable head-end.

Radio, an even more decisive medium in PNG with a reach of about 60% - and, to many rural homes without access to television, their only medium – also depends on satellite feeds to remote transmitters, all provided in C-band. In total NBC and PNG's approximately 10 private broadcasters use 150-200 antennas to receive programming at retransmission sites.[132]

In NBC's case, the additional capacity it has secured in C-band will allow it to broadcast nationally several of its channels which so far have only been available locally (and then only within the limited range of their terrestrial transmitters).

The latter will allow listeners working far from their home communities, e.g. in the mining, construction or natural gas projects which generate much of PNG's employment, to maintain a connection with them, but is also aimed by the government at ensuring that electoral campaigns are not overly dominated by local interests with their own stations.

NBC is also considering an expansion of its content, in particular with news broadcasts in at least two local languages, pidgin and moti, which are widely spoken but still have little or no representation in the country's radio or television. None of this would be possible in the limited Ku-band capacity available to NBC, even if the associated rain fade was not an issue.[133]

Exh. 16: PAPUA NEW GUINEA: C-BAND VSATS AND EARTH STATIONS IN CENTRAL PORT MORESBY, MAY 2014

Hub, Bank of South Pacific

Office park, adjacent to airline and ISP head offices

Top of office tower

Hub, Daltron

Hub and cable head-end, Hitron

Construction site

source: Euroconsult photographs.

3. Connectivity

3.1 OVERVIEW OF THE C-BAND CONNECTIVITY MARKET IN PNG

Critical sectors of PNG's economy are dependent on VSAT services, which provide the only connectivity usable for enterprise communications outside of a fiber optic ring in Port Moresby – which apparently has not kept many corporate users from turning to VSAT solutions – and of limited and unreliable microwave networks. Issues with the latter include overloaded circuits and frequent vandalism, usually stemming from disputes with private landowners over the towers' rental fees, which at least in the case of State-owned carrier Telikom PNG reduce its network's average availability to only 60-80%.[134]

The resulting market is fragmented into as many as 12 service providers and into a number of generally small networks, generating combined service revenues in the range of $40-50m p.a. At least 80% of this revenue is believed to come from C-band networks, which apart from consumer-grade Internet access services account for nearly all enterprise services.[135] The supporting capacity leases, in excess of 390 MHz, are estimated to represent over $14m of annual revenues for satellite operators.[136] Exhibit 17 lists the networks we were able to identify, totalling about 995 C-band terminals.

By comparison about 200 Ku-band terminals appear to be in use for Internet access, principally by small businesses and consumers, which may choose these services on their slightly lower price but receive no service-level guarantee.[137]

Though some service providers maintain teleports outside of Port Moresby, the concentration of business in the capital city (such as the airport, located well within city limits) and the lack of terrestrial connections to outlying areas are such that many C-band hub antennas are installed in the city centre. The exposure of even relatively short cables to vandalism is a key concern and has encouraged antenna owners to keep them on premises, as public security remains far from settled in the Port Moresby area. Exhibit 16 also shows a few examples of such antennas.

3.2 OIL AND GAS SECTOR

The single largest commercial user group, with an estimated 80 C-band sites, is the oil and gas industry, which along with mining account for a major share of national income and for two-thirds of PNG's exports.[138] As already noted, the oil industry tends to impose particularly stringent requirements for communication service quality. One service provider said its oil industry customers require links to be available 99.5-99.95% of the time, which in practice is only achievable in C-band.[139] Users include the oil companies themselves, specialized contractors such as OilSearch or Parker Drilling, and the logistics companies which manage their accommodation camps. The PNG Liquid Natural Gas (PNG LNG) plant, a $16bn Exxon Mobil facility and by far the country's largest industrial site, is reported to operate about 20 C-band terminals, as does InterOil, a Canadian company with extensive exploration, refining and retail operations.[140]

The LNG plant's C-band network, as described by the service provider which supports it, is especially critical and sensitive to outages, as it constantly relays data from sensors, installed at the gas wells and along the pipeline which carries gas to the plant, on the latter's flow, temperature, chemical composition and other parameters. Even a short interruption in this data is liable to trigger an emergency shutdown at the production sites and at the plant itself, which then would require up to a day to restart.

Exh. 17: PNG: REPORTED ACTIVE C-BAND VSAT TERMINALS, 2014

USER	TERMINALS
Oil and gas	**>81**
Interoil	>20
Exxon Mobile (LNG project)	~20
Talisman Energy	9
High Arctic Energy Services	6
Oilsearch	5
Parker Drilling	1
Others	>20
Mining	**~50**
Frontier Resources	~10
Other mining companies	~40
Banks	**~55**
Bank of South Pacific	~30
ANZ	~20
WestPac	~5
Other industry and services	**213**
Ela Motors (car dealerships)	70
Air Niugini	25
IPI Group (camp management)	7
NCS Holdings (camp management)	6
New Britain Palm Oil Ltd.	6
PNG Power (electrical utility)	4
Others	95
Rural communications	**~161**
BeMobile	59
Telikom Foundation	50
DigiCel	32
Churches and religious missions	~20
Public safety and security	**~84**
National Disaster Center	60
Public and private hospitals	~10
Earthquake monitoring networks	5
PNG Defence Force	5
Offshore Processing Center*	3
Department of Meteorology	1
Other public services	**326**
Local Level Governments	260
Department of Finance and Treasury	60
PNG Air Services Ltd.	6
Aid organizations	**~25**
New Tribes Mission	5
Others	~20
Total	**~995**

Notes: (*) The OPC is a joint facility with Australia to provide temporary accommodation for refugees

Sources: see main text

The latter would be extremely expensive, with consequences cascading down the LNG distribution chain, as the plant cannot store a day's worth of its gas input and is designed to deliver gas to large LNG carrier ships rotating every three days. The cost of delaying a single of these shipments for a day clearly justifies using extremely reliable communication links, for which Exxon Mobil specifies 99.9% availability and uses multiple, redundant C-band links.[141] As an indication, the LNG plant's operations and maintenance were projected in 2011 to cost on the order of $520,000 per day – and may since have increased – while LNG carrier vessels are currently chartered for about $85,000 per day.[142] Though we have not reviewed legal agreements, it seems conceivable that PNG authorities could be held liable for some of these costs if they were to result from a regulatory change reassigning the plant's communications to less suitable frequencies. Repeated stoppages could also damage equipment.

Oil companies in PNG also use their satellite links for real-time transmissions of seismic exploration data, to experts and data centres at their central facilities in Australia or Europe. The savings achieved by not having to keep experts at remote sites for extended periods are substantial, as is the convenience of access to the large-scale computing facilities on which oil prospection now depends. While such data are usually too abundant for using satellite links when collected at sea, this is possible with the simpler exploration campaigns done on land, and is now done regularly in PNG by contractors such as Halliburton, Nabors or Schlumberger.[143] Such campaigns are still expensive, however, and rain outages are again not acceptable.

Finally, C-band links are provided to workers at their accommodation camps, often large facilities with populations of several hundreds, managed by logistics providers such as NCS Holdings or Gamma Logistics. In this case rain outages may not have operational consequences, but could deprive employees of connectivity during their limited leisure time. Talisman Energy, for instance, operates five camps totalling about 1,000 workers, and nine VSAT sites which, in 2012, it migrated from Ku-band to a more expensive but more dependable C-band lease.[144] The PNG LNG plant's Camp B uses a 10-Mbps C-band link to provide connectivity to 3,000 workers.[145] These communication facilities, at least in the case of the PNG LNG project, are generally made available to local communities.[146]

As of 2011 about 13 oil/gas exploration or production sites were active, but a total of 72 exploration permits have been granted for oil alone. At least two major projects, a second LNG plant awarded to Total and a network of oil and gas pipelines under construction in Western PNG, will require additional C-band terminals in the next few years.[147]

3.3 MINING SECTOR

Mining is PNG's other major export industry; though the mix of PNG's exports is changing as its oil and gas production increases, mining still contributed nearly 60% of the country's total exports in mid-2013.[148] At the time the sector comprised at least 32 large or mid-sized foreign concerns, operating 108 active mines.[149] About half, judging from service providers' estimates of around 50 active sites, appear to rely on C-band VSATs for communications.

Like the oil industry, mining companies use satellite communications to connect remote mines to their corporate headquarters and to provide Internet access and phone lines to large worker colonies. While mining companies may operate on a slower cycle than oil production, the scale of their investments and logistical challenges are such that they do expect good communications. Mining companies such as Newcrest, and contractors such as High Arctic Energy Services, have also begun to use seismic exploration techniques similar to those employed by the oil industry for prospection, and send the data in real time over C-band links.[150] The mining industry has also begun to introduce remotely operated or monitored machines that require uninterrupted communications, though these are apparently not yet used in PNG.

Despite a drop in metal prices, and consequently in exploration, one of the most active service providers in PNG's mining sector said its demand for satellite communications grew by around 30% p.a. over 2011-13, and expects it to still grow at over 20% p.a. in 2014-15.[151] The largest identified C-band user, Australian concern Frontier Resources, operates 10 C-band terminals at its copper mines in the central highlands and New Britain island. In 2013 it earned A$4.3bn from these operations.[152]

3.4 OTHER ECONOMIC SECTORS

Banks use VSATs in PNG's principal cities to connect microwave networks which, in turn, connect their ATMs, as well as for back-office purposes. PNG's three principal retail banks, Bank of South Pacific and national branches of Australian banks Westpac and ANZ, operate a total of about 55 C-band terminals (plus some in Ku-band). At this time they have also deployed a total of 385 ATMs, including over 50 outside of Port Moresby, all or most of them dependent on the banks' C-band long-haul connectivity, if not for their last-mile connections.[153] Competition may now drive these banks further into rural areas, where VSATs (and possibly C-band) will often be the only option for connecting ATMs. BSP, in particular, has opened 41 rural locations and considers this, and the resultant nationwide coverage, to be a key strength.[154]

A number of other economic sectors, and of smaller businesses, also rely on C-band VSATs for Internet access. Examples include PNG's principal airline and car dealership, but also a humbler, 10-employee company selling mattresses.[155] In the latter case, while consumer-grade cellular services or Ku-band antennas may have been options, the greater data allowance of a VSAT service and the reliability of C-band were decisive factors.

3.5 MOBILE NETWORKS

Even in areas where terrestrial cellular coverage exists, or is being introduced, C-band satellite links underpin efforts to provide better connectivity by supporting most of the networks' backhaul requirements in rural areas. Digicel, believed to be PNG's largest cellular carrier, uses C-band antennas to connect 32 of its reported approximately 700 base stations.[156] Though Digicel is also testing the Ka-band service of O3b Networks Ltd. for possible future backhaul use, if eventually adopted this solution would be provided with a C-band backup.

Bmobile, a smaller network spun off by Telikom, uses C-band links for 46 base stations (plus two gateway terminals), and plans to migrate another 11 to C-band from Ku-band links whose availability can be as low as 50%. The availability it normally requires from backbone providers is 99%. Significantly, about half of Bmobile's 48 existing C-band terminals are in city centres. Many of the 200 base stations which Bmobile plans to add to its network by 2015 will presumably use C-band satellite links.[157]

While the proportion of satellite backhaul in these networks can seem low, assuming (as for India and Indonesia) that base stations each support 1,000-5,000 subscribers the 80 that already use C-band backhaul links may still serve 80,000-400,000 subscribers, which even at the low end of the range is certainly a large fraction of the carriers' rural subscribers.

The rural areas where these C-band links are most used are also where the two carriers are now trying to expand, and in fact are being directed to expand by government policy. The National Broadband Policy, whose ambitious objectives for schools and hospitals were already noted, has the more general goal of bringing Internet access (at 512 kbps) to 70% of rural areas, and within reach of 90% of the population by 2018.[158] In a country with 80% rural population this can only be achieved with a substantial proportion of satellite links.

In 2013 the government also took steps to establish a universal service fund to promote rural communications.[159] While the fund and other universal access policies are still being established, the World Bank has already approved a $15m credit line for a demonstration network that would provide Internet access and telephony at 60 rural locations (one in each district), many of them unlikely to be served by the carriers themselves without subsidization. As currently structured, the project would bring another 285,000 people to within 5 km of a communications center, down from the 50 km (or greater) which are still commonplace.[160] A call for tenders was issued in 2013 and, while it favours no technology in particular, it specifies a 98% minimum probability of call completion.[161] Judging from the experience of the two cellular carriers (both understood to have bid) and others, implementing this over satellite links using another band than C-band would be difficult or impossible, and may only increase what the World Bank already considers to be a high level of project risk.[162]

3.6 PUBLIC SERVICES

The use of C-band VSATs by PNG's public services is less developed or remains on a smaller scale, but this seems to result from a lack of funds or poor co-ordination rather than from any deliberate technical choice. The two largest government networks, in particular, are understood to have fallen into some disrepair, but under agreements reach in May with Telikom PNG are being restored to full operational condition:

- a network of 260 sites installed for the Local Level Governments (LLG) which manage each district, and
- around 60 sites installed by the Department of Finance and Treasury (DF&T) to ensure that civil servants receive their pay on time, are understood to have fallen into disrepair.[163]

In any case, and whatever their current condition, a sizable investment has been made in these two networks, which would be nullified if the frequencies it was designed for became unavailable. At least two other government concerns, PNG Ports and State-owned electric utility PNG Power, are also understood to have issued or prepared calls for tenders for a number of sites, and to specify the use of C-band.

Confirmed networks are smaller but clearly of critical importance, and clearly requiring uninterrupted communications:

- One includes five C-band sites maintained by the Department of Meteorology and Geophysics to monitor earthquakes and some of the country's ~15 active volcanoes. One of the seismic monitoring sites is part of PNG's contribution to the Comprehensive Test Ban Treaty Organization, which watches for violations of a 162-nation nuclear test ban treaty. The National Disaster Centre separately maintains a larger network with 60 C-band sites.[164]

- Another, operated by air traffic control authority PNG Air Services Ltd. (PNGAS), comprises six C-band terminals located at the principal airports. While this network currently only supports voice communications, PNGAS from 2016 plans to use it to implement the new air navigation technology known as Automatic Dependent Surveillance-Broadcast (ADS-B). ADS-B, already used in Australia and adopted by many other nations, allows aircraft, instead of being tracked more or less accurately by radars, to transmit their own GPS position fixes to air traffic control centres, such as those of PNGAS. The more accurate picture of air space which is then assembled permits to reduce the separation between aircraft, thereby allowing significant fuel savings. PNGAS expects that it would then allow it to charge higher fees to airlines for its international air navigation service; as most flights between Australia and North America transit through PNG's air space, such fees already constitute most of its revenue (it 2010 they came to around $7m).[165]

ADS-B, however, requires communications to be more than 99.99% reliable, which is clearly only achievable in C-band (and even then only with redundant VSATs and backup microwave links). Under international standards, any rain outage, in this case, would force PNGAS to direct incoming aircraft to reduce their altitude from around 14,000 meters to around 8,000 meters while overflying the country.[166] This would cost the airlines time and fuel, deprive PNG of ADS-B revenue, void at least part of a substantial investment made by PNGAS since 2001 (along with assistance by Air Services Australia), make PNG airspace less competitive, and harm efforts to improve regional air safety.

- The Telikom Foundation, a philantropy of the State-owned carrier, has deployed about 50 C-band terminals at rural schools to provide a filtered Internet service called Clean IT. The program is funded in part by the government but also by the schools themselves, by local administrations and apparently by individual members of Parliament.[167] Telikom's monthly charge, equivalent to around $50, and equipment costs, which average $15,000 per school (including computers), are quite substantial investments, and would seem to demonstrate the value, both educational and possibly political, which stakeholders see in this effort.
  A National Broadband Policy currently under development tentatively sets the objective of providing Internet access to 80% of rural schools (and all urban schools) by 2018 – clearly a difficult target, but which seems another indication of support for ongoing initiatives.[168] Private universities such as the Pacific Adventist University – one of the region's largest, but located 21 km outside of Port Moresby – also use C-band VSATs to provide Internet access for students.

- Telemedicine is still little developed in PNG, with only about 10 VSATs installed at hospitals for office requirements. These operate in C-band, however, and larger projects are being considered by Telikom PNG and by private companies. The draft National Broadband Policy sets the goal of providing a broadband connection to all hospitals by 2018.[169] In the nearer term, one service provider, in particular, said it is currently in talks with two Australian companies which operate X-ray machines at the Mount Hagen hospital (in one of PNG's rainiest areas) and seek a C-band link to transmit the imagery to doctors in Australia.[170] The practice may become more common, as the spread of tuberculosis is of concern both to authorities and to large employers such as the PNG LNG project.[171]

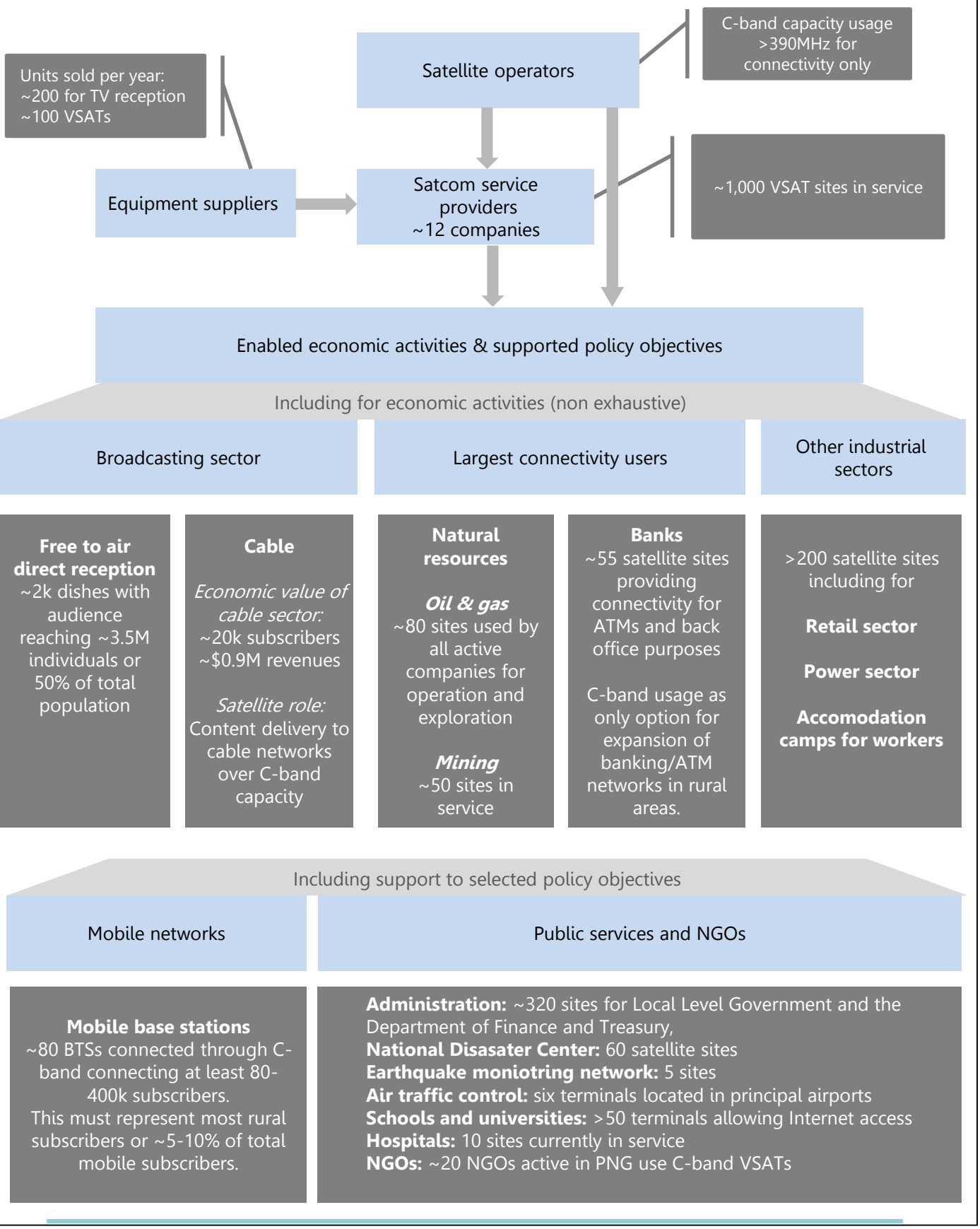
- In a related category, about half of the around 25 non-governmental aid organizations active in PNG use C-band VSATs, including CARE, Save the Children, Oxfam, Wildlife Conservation, the New Tribes Mission and eight catholic dioceses; another, the Sisters of Mercy, is in procurement discussions. The principal service provider active in this field noted that about half have migrated from cheaper Ku-band systems to C-band.[172]

4. Socio economic benefits

We summarize in Exhibit 18 the indicators on the socio-economic impact of C-band that we identified through our research and analysis. As in the case of Indonesia, we identified both a number of public and private networks offering a variety of services.

Overall, this synthesis highlights that the use of satellite based services, and primarily of C-band, is the only option to offer a number of services on a national scale.

Exh. 18: PAPUA NEW GUINEA: SYNTHESIS OF SOCIO ECONOMIC IMPACT OF SATELLITE C-BAND USAGE



In particular, we find that C-band is used to:

- **distribute TV channels** to approximately 50% of the population;
- provide critical communication links to two of the country's principal economic sectors, **oil/gas and mining**, as well as to one sector in which the government has invested substantial amounts to maintain its revenue potential, **air navigation**, and in the **banks** on which these and all other economic sectors depend;

The use of C-band also allows **cellular carriers** to operate in rural areas.

C-band communication networks also support a number of government activities and public policies, including programs to **improve education**, **connect local government offices** and **manage natural risks and disasters**.

The following table summarizes sources for key assumptions supporting Exhibit 14.

SEGMENT	NOTES ON ASSUMPTIONS
Satellite operators	See page 37
Satcom service providers and grey box	See page 37 and Exh. 17 page 38
Equipment sales	See pages 34-35; we assume that 10% of installed VSATs are being sold on average per year either for replacement of new installations
Broadcasting sector	See pages 32-36
Natural resources	See pages 37,39
Banks	See page 40
Other industrial sectors	See page 40
Mobile networks	See pages 40-41
Public services and NGOs	See pages 41-42

C-BAND USAGE IN INDIA

1. Country overview

India is the world's second-most populated country, accounting for approximately 17% of the global population with around 1.23 billion people in 2012[173]. The country's population has been growing at around 1% p.a. over the past five years. The population density stood at 382 people per km² as of 2011 with very strong concentration in major urban areas like Delhi, Mumbai, Bangalore, Chennai, Kolkata and Hyderabad. Around 68% of the population is, however, still living in approximately 640,000 rural villages according to Census-2011.

Around 246 million households in India include an average of around 5 people, out of which close to 170 million are in rural areas. In terms of demographics, more than 29% of India's population is below the age of 14, and more than 58% currently fall into the working age group of 25–54[174]. Around 41% of Indians speak Hindi, which is also the official national language, while the rest speaks around 28 other native languages.

Area wise India is the 7th largest country in the world with a surface area of 3.2 million sq. kilometers. The country shares a 15,000km long land border with China, Pakistan, Bangladesh, Burma, Nepal and Bhutan. The geography of the country comprises a wide variety of topological patterns including mountains, plateaus, plains, coastal areas, wetlands, deserts and islands. India falls in the tropical climate zone with high average annual precipitation. The monsoon season in India, typically last for around four months starting from June every year.

The Indian GDP grew at a CAGR of ~6.5% between 2007 and 2012, but has slowed down to around 3.2% in 2012, compared to 10.5% in 2010[175]. The slowdown was mainly due to a contraction in the mining, manufacturing, and agriculture sectors. India's main industries remain textile manufacturing, retail, mining, banking, and finance as well as energy and power, which include oil and gas. Around 43% of the country's GDP is derived from exports, mainly to the USA, the UAE, China, Singapore, and Hong Kong. Service sectors, including finance, banking, and insurance, attract the majority of FDI inflows, followed by construction and telecommunications.

2. Television broadcasting

2.1 OVERVIEW OF THE TV BROADCASTING MARKET

A total of 155 million households[176] owned a TV set in India in 2012 according to the Telecommunications Regulatory Authority of India (TRAI), with 28 million TV households added in the country since 2008. Approximately 14 million TV sets were sold in India in 2012 alone[177]. Penetration of total households reached more than 65% in 2012 and it is expected to grow in coming years with the decrease in prices of TV screens.

The Indian television industry has been witnessing strong growth in the past five years with pay-TV households reaching approximately 132 million in 2012[178] and approximately 26 million net new pay-TV subscribers added since 2010. TV channels in India are distributed through cable, satellite Direct to Home (DTH), terrestrial TV services provided by Doordarshan, the public broadcaster and Internet Protocol Television (IPTV) networks. A large majority of the distribution is currently through cable and DTH platforms. Most of the growth was driven by satellite DTH services in the last five years but cable remains the leading delivery network.

Cable reception:

The Indian pay-TV market remains dominated by cable TV platforms. Estimates of cable subscribers range relatively widely, due to the industry's fragmentation and to under-reporting by operators. KPMG estimated the adoption of cable TV services at about 77 million households in 2012, up from 73 million in 2010. TRAI reports an estimated 94 million subscribers[179]. This represents a 50-60% penetration of TV households depending on the source. Analogue cable is still the dominant cable TV platform in India, with 75% of total pay-cable TV subscribers watching TV channels via analogue networks in 2012. The share of analogue subscribers is expected to rapidly decrease over the next few years as more people switch over from analogue to digital services. The digitization of networks should have a limited impact on the number of cable subscribers, with the total number of cable subscribers expected to experience limited growth in the next 2-3 years.

In November 2011, the Cable TV Act was amended, making it obligatory for each cable operator to transmit or re-transmit programs of any channel in encrypted form through a digital addressable system. At the time, the government notified cable operators of the final schedule for a four phase migration to Digital. The sunset date for analogue cable TV is currently set for the end of 2014. The first phase began in 2012, with mandatory Digital Access System (DAS) implemented in the four metropolitan areas of Delhi, Mumbai, Kolkata and Chennai. Some delays have been observed, with most players continuing to focus on Phase I and Phase II cities. According to KPMG[180,] the industry estimates December 2016 for achieving significant levels of digitisation throughout the Indian territory, which would represent a 2 year delay.

Key entities in cable TV services are broadcasters, Multi System Operators (MSOs) and Local Cable Operators (LCOs). TRAI estimates that 6,000 MSOs and 60,000 LCOs are active in India[181]. Some MSOs operate at the national level while others operate either on a regional level or in a smaller area. Leading national MSOs include DEN Networks, Digicable, Hathway Datacom, IndusInd Media and Communication and Siti Cable. They all have between 8.5 and 13 million subscribers. Leading MSOs operating in regional markets notably include Fastway, GTPL, Ortel, and Asianet.

India's largest MSOs have recently started focusing on Head-end-In-the-Sky (HITS) platforms for phase III and IV regions that constitutes rural and semi-urban towns and villages. These are meant to to provide digital signals throughout the country via satellite. With the analogue switch-off, LCOs would be required to install a reception dish at their premises. The first two groups to show interest in HITS platforms are Hinduja Venture's entity GHITS and Jain TV group's NSTPL which have obtained licenses from the government. The latter has tied up with Motorola, KIT Digital and Intelsat for their pan-India HITS operations branded as JAINHITS. NSTPL pre-ordered 30 million set-top boxes in 2013[182]. HITS are expected to emerge as cable's answer to satellite DTH for digitization in Phase III and IV cities, as well as for Phase II cities where some of the large MSOs may not have presence.

DTH reception:

India is the world's largest national satellite DTH market (in terms of subscriptions), with 63 million registered subscribers including 35.8 million active subscribers at the end of 2013 according to TRAI[183.] The number of registered subscribers has increased at a CAGR of approximately 41% between 2008 and 2013. Six DTH pay-TV services are currently active, with Dish TV being the leader with 14.7m subscribers in 2012, ahead of Tata Sky (10.4m), Sun Direct (8.4m), Airtel (7.9m), Videocon d2h (7.4m), and Reliance Digital TV (4.6m).

DD Free Dish is the only free DTH platform operated by national broadcaster Doordarshan. An estimated 18 million households watch DD Free Dish channels according to Media Partners Asia. In coming years, the Indian DTH market is expected to drive pay-TV growth in the country. Euroconsult expects the number of Indian pay-DTH subscribers will reach 79 million in 2017 (2012-17 CAGR: 8%)[184].

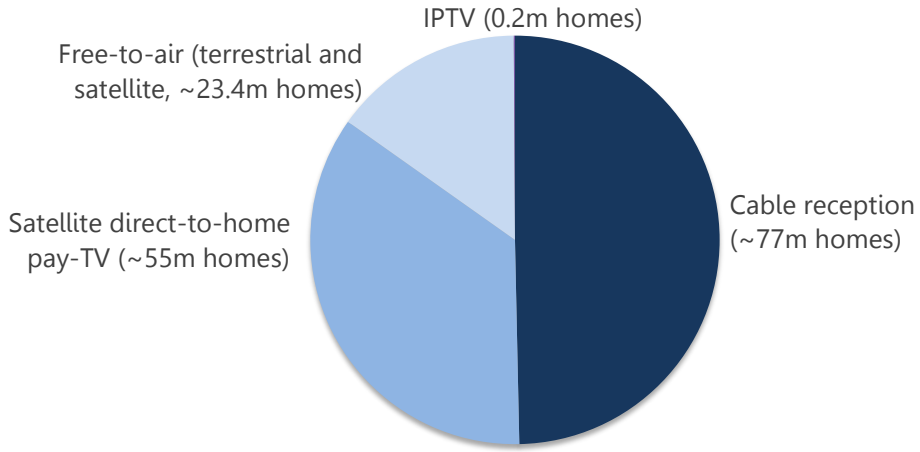
Other TV networks and services

IPTV penetration is currently limited in India. In 2012, the country had 153,000 IPTV subscribers according to Digital TV Research. Strong growth is expected in coming years, with Digital TV Research forecasting 4.7 million IPTV subscribers by 2018 in the country[185].

Audiences that do not receive cable, satellite or IPTV services receive TV channels through an ordinary terrestrial antenna. They can watch two channels - DD1 (national) and DD News.

Online TV is still relatively limited in India but it has gained ground in recent years. According to KPMG, online video viewership increased by 45% between December 2011 and December 2012[186]. Indian broadcasters are expanding across digital platforms such as online portals and video platforms, with the availability of robust networks enabling secure delivery of live and on-demand content on multiple platforms.

Exh. 19: INDIAN TV HOUSEHOLDS BY TYPE OF DELIVERY (2012)



Source: TRAI for DTH pay-TV, KPMG for cable, DigitalTV Research for IPTV and TRAI for number of TV households.

Overview of channels broadcast

The number of licensed TV channels in India has doubled since 2008 and exceeded 820 channels at the end of 2012 according to TRAI[187]. Of the 820 channels, only 660 were operational in 2012 according to PwC[188]. The number of channels broadcast by pay-TV providers can vary significantly depending on the delivery network:

- In December 2013, the maximum number of digital TV channels (Pay, free-to-air and Local) carried by reported MSOs was 231 whereas in conventional analogue form, the maximum number of channels carried by the reported MSOs was 100 channels according to TRAI[189]. Analogue transmission is an issue for cable operators as it imposes capacity constraints and limits the number of channels/services offered to TV households. The digital switchover should largely contribute to an increase in channels distributed by each individual cable operator in coming years. Cable operators usually place a higher focus on local channels than DTH platforms, as they often target local/regional markets. The digital switch-over is expected to allow them to broadcast more channels, including a higher number of national channels.

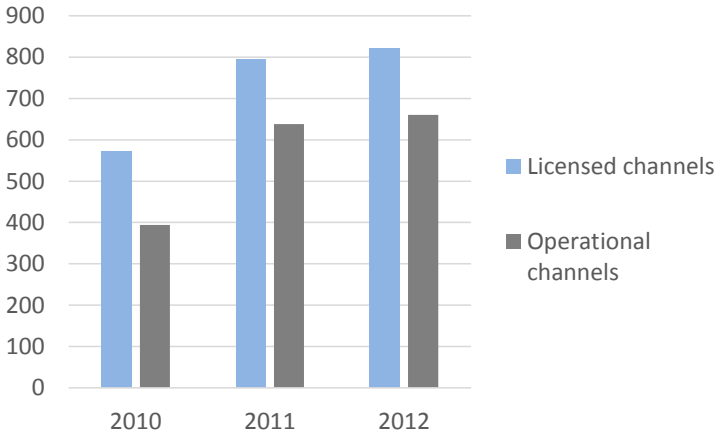
- The total number of private satellite TV channels permitted by the Ministry of Information & Broadcasting in December 2013 was 782[190]. DTH services operate on a national basis and transmit all channels throughout the country irrespective of variations in demand of channels

in different markets. In India, pay-DTH platforms broadcast between 140 and 300 channels in 2013, with Dish TV offering the most. Free-to-air DTH platform DDFree Dish distributed 58 channels at the end of 2013. The total number of DTH pay-TV signals doubled between 2008 and 2013, from 750 to close to 1,500[191]. Most TV channels are distributed multiple times as all DTH platforms have a comparable channel line-up. This explains the higher number of TV signals in comparison with channels permitted in India. All free-to-air and pay-DTH channels are distributed using Ku-band capacity. Meanwhile, the number of channels uplinked to satellite for cable distribution reached over 720 channels in 2013, up from 274 in 2008 (2008-13 CAGR: 20%)[192]. C-band is the only frequency band used for video distribution to cable head ends and MSOs in India.

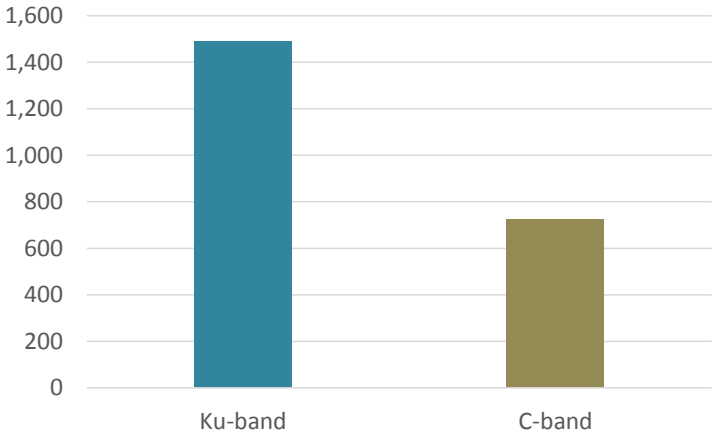
Following the strong growth observed in recent years, the Indian market still has a strong potential for the channel count to increase significantly in coming years. Growth is expected to be driven by both cable TV and DTH platforms. Euroconsult anticipates that the number of satellite TV signals distributed in India could reach 2,660 in 2017 (including more than 800 signals in C-band), up from 2,040 in 2012[193], for a 5.5% average growth p.a. and PwC expects the country to have about 1,600 licensed channels (+770 vs. 2012) and about 1,300 operational channels (+620 vs. 2012) by 2017[194]. Some of the key growth drivers include:

- Growth in pay-TV subscriptions coupled with cable digitisation;
- Growth of local and regional channels in various genres;
- Larger entry of foreign players;
- Expected growth in advertising revenues.

Exh. 20: NUMBER OF LICENSED AND OPERATIONAL CHANNELS IN INDIA (2010-2012)



Exh. 21: NUMBER OF SATELLITE TV SIGNALS DISTRIBUTED IN INDIA BY FREQUENCY BAND (2013)



Source: PwC for licensed and operational channels and Euroconsult based on LyngSat monitoring for the number of satellite TV signals distributed in India.

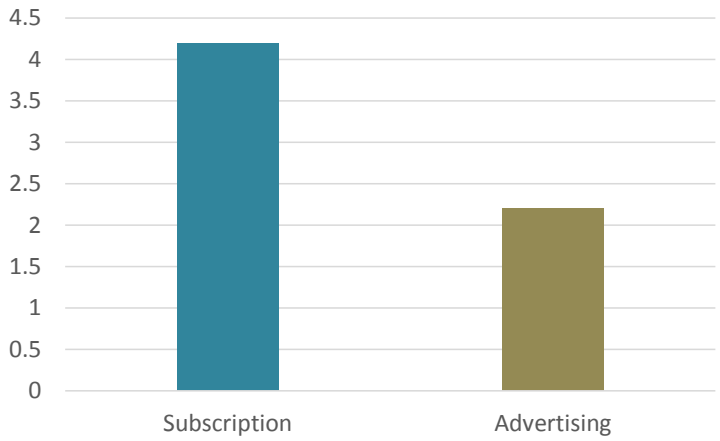
Economic value of the TV sector

The size of the Indian TV industry increased from INR241 billion (US$4.2 billion) in 2008 to INR370.1 billion (US$6.4 billion) in 2012 according to KPMG[195]. This represents an average 11.3% growth p.a. during the 4-year period. These figures take into account subscription and advertising revenues, with the former accounting for 2/3 of revenues in 2012.

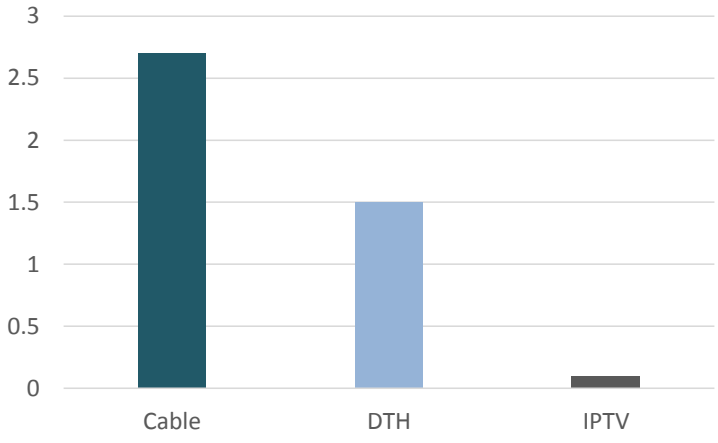
- Subscription revenues increased from INR159 billion (US$2.75) in 2008 to INR245.3 billion (US$4.2b) in 2012, i.e. 4-year CAGR of 11.5%. They were largely driven by the increase in pay-TV subscribers as ARPUs experienced limited growth during the period. ARPU levels in India are among the lowest in the world: INR170/month (US$3) for DTH and INR166/month for cable TV[196]. This is notably explained by the race to acquire subscribers. In 2012, cable TV was the leading delivery platform in terms of revenues (US$2.7 billion), ahead of DTH ($1.5 billion). Subscription revenues are expected to experience strong growth by 2017, when they should reach over INR600 billion (US$10.5 billion) according to KPMG. Subscription revenues should be driven by both the increase in subscribers and ARPUs, with the latter reaching a pay-TV industry average of INR303 (US$5.2) in 2017 according to PwC[197]. ARPUs should be driven by cable digitisation and the launch of value-added services, including VoD and HDTV.

- Advertising revenues increased from INR82 billion (US$1.42 billion) in 2008 to INR125 billion (US$2.2 billion) in 2012, i.e. 4-year CAGR of 11%. The advertising market was notably driven by the increase in TV channels broadcast in India in the last four years, as well as by sports events such as the Cricket World Cup held in India in 2011. Broadcasters are largely dependent on advertising revenues, which contribute almost 60-70% to their top-lines according to PwC[198]. Advertising revenues should continue to grow in coming years, with both PwC and KPMG forecasting a market value of around INR240 (US$4.2 billion) billion in 2017. Revenue growth should be favored by nominal GDP growth which is expected to remain strong, by increasing advertising from sectors such as telecom and automotive and by expected growth in the number of channels broadcast in India. The number of channels will likely be driven by regional and niche channels.

Exh. 22: REVENUES OF THE INDIAN TV INDUSTRY IN BILLIONS OF US$ (2012)



Exh. 23: SUBSCRIPTION REVENUESBY DELIVERY NETWORK IN BILLIONS OF US$ (2012)



Source: KPMG for TV industry revenues, KPMG for cable TV revenues (based on ARPU), MPA for DTH revenues and Euroconsult estimates for IPTV.

2.2 C-BAND UTILISATION FOR THE BROADCAST SECTOR

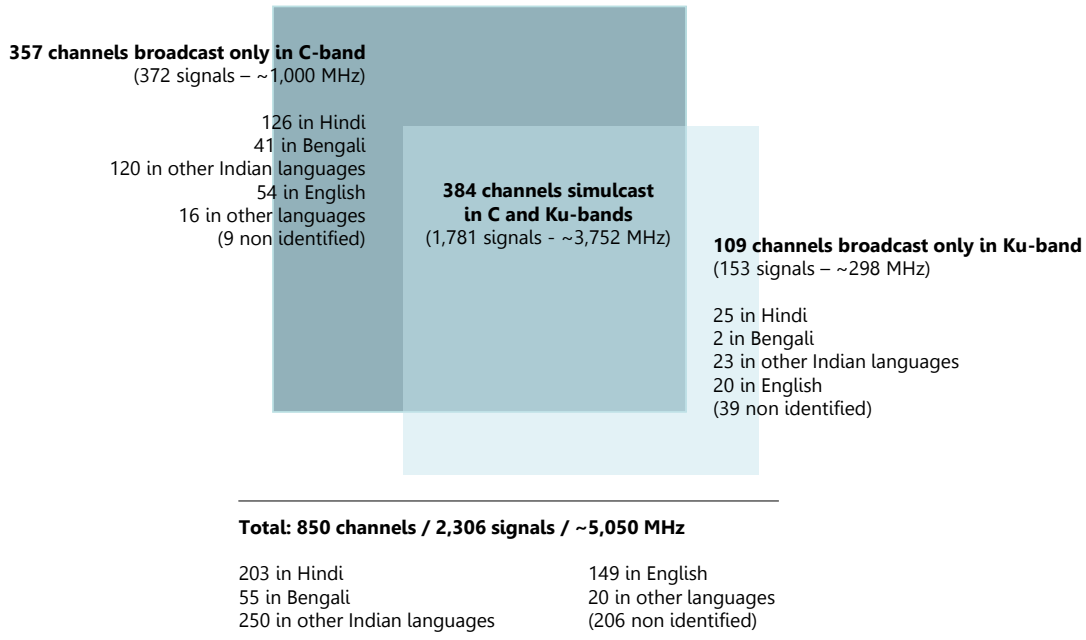
C-band satellite services are essential to the TV industry, as already suggested above, both for direct distribution to household antennas and for programming feeds to cable head-ends and other pay-television operators, including Direct-to-Home pay-TV platforms[199]. The entire subscriber and revenue base of India's cable and satellite television industry effectively depend on them.

Considering the reception of C-band signals, several indicators confirm the importance of reception by both video distribution systems (primarily cable) and direct-to-home reception.

- Manufacturer Space Link estimates that a total of about 500,000 C-band antennas are currently installed throughout India, and that about 20,000 are being sold annually by the around 25 vendors active in the market.[200] Space Link's website puts its own manufacturing capacity at 3,000 C-band antennas per month.[201] Even allowing for up to ~50,000 antennas in cable head-ends, this implies that at least 450,000 C-band antennas are still being used by individual consumers, as well as hotels and various businesses.
- In more indirect evidence of a sizable market for direct reception, one broadcaster, who produces three news channels, said it distributes them in C-band to over 8,000 set-top boxes. While its audience data cannot distinguish individual antennas, its reach appears to encompass only about half of India's cable homes, and thus at most half of its 6,000 cable head-ends. At least 5,000 subscribers may thus have made the effort of acquiring a set-top box and a C-band dish to receive content from this single, average-sized broadcaster – even though its channels are also available on all Ku-band platforms.[202]

A close examination of the transmission of TV channels in India, and in particular of the various satellites covering the country, provides further evidence of the importance of C-band for the broadcast sector. Out of a total of 850 channels observed to be broadcast into India, 741 are transmitted in C-band as well as in Ku-band[203], and over 40% are only transmitted in C-band – in itself an investment on the order of $25m p.a., at the current reported price of C-band capacity – and are thus unavailable on any of the Ku-band DTH platforms. In addition India's dynamic television industry keeps adding new channels; as of February another 250 were awaiting licenses, most of them presumably expecting to transmit in C-band.[204]

Exh. 24: INDIA: SATELLITE TELEVISION CHANNELS BY FREQUENCY BAND, MAR. 2014



source: Euroconsult analysis of transponder monitoring by Lyngemark Satellite, Lyngby, Denmark [www.lyngsat.com; accessed 25 Mar. 2014].

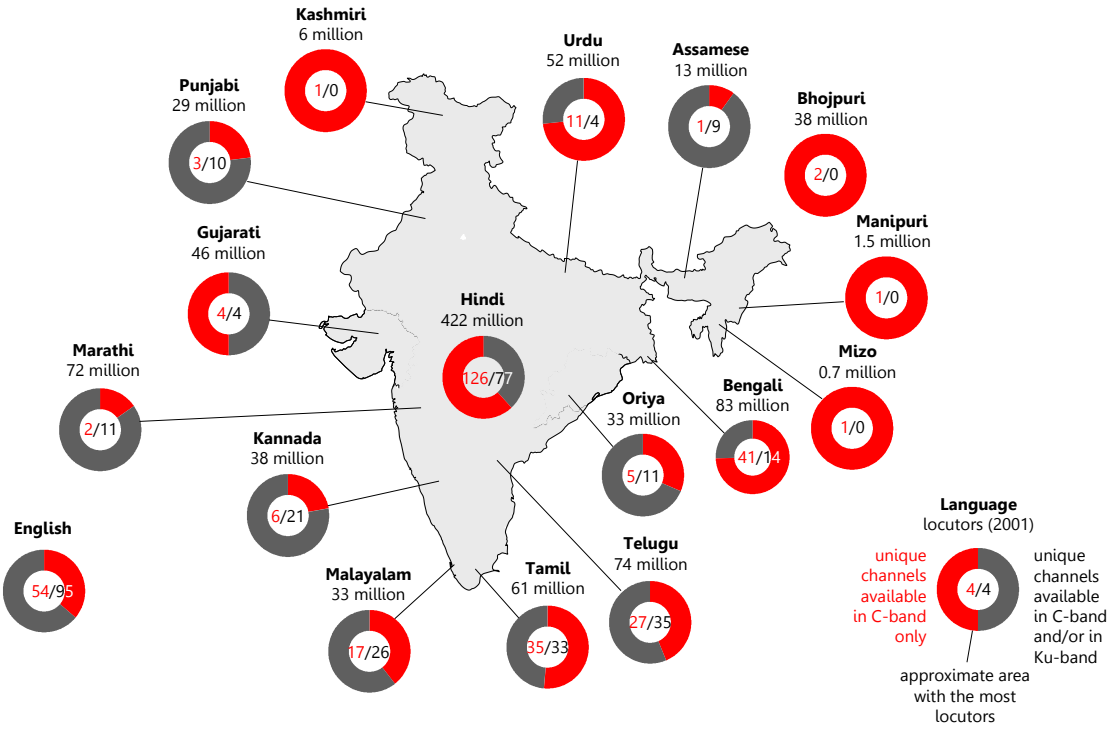
The climate, in many parts of India, leaves no choice to broadcasters and cable operators but to uplink their channels in C-band. The fact that most Indian channels are funded by advertising makes them especially sensitive to outages, and Ku-band satellite capacity is in fact essentially not available in the country's island states, the Andaman and Nicobar and the Lakhdasweep islands. Moreover, though the DTH platforms – which receive channels in C-band, but re-transmit them to subscribers in Ku-band –

can mitigate the impact of rain fade on their uplinks by using more than one teleport, most individual channels cannot afford this.

The resultant market for C-band satellite capacity and uplink services is quite substantial. In total, given that many channels are broadcast on more than one transponder, and including promotional test cards for which bandwidth also has to be paid for, Lyngemark Satellite currently lists about 825 C-band satellite signals; given the bandwidth they appear to use and the prices currently reported by Indian broadcasters for C-band capacity, this suggests a minimum annual expenditure on the order of $35m on transponder leases.[205] Note that about 230 of these signals are carried by India's Insat national satellites, suggesting that around $10m p.a. of this spending is directly contributed to the national budget (and in practice, to its space program), not counting tax revenue.

Assembling these channels from raw content and uplinking them to satellites also require a fairly large number of playout facilities and antennas. In total the ministry of Information and Broadcasting (MIB) has licensed 90 teleports, of which at least 60 are known, or recognizable, as primarily active in the television market.[206] These include 13 independent service providers, which one of them estimates to each operate about 15 C-band uplink antennas spread across multiple facilities, and about 50 smaller facilities owned and operated by the broadcasters themselves, to a total of about 300-350 antennas.[207] The independent teleport operators, which uplink about 60% of India's satellite television channels, are estimated to collect a minimum of $25m p.a. for value-added services in addition to the cost of bandwidth.

Exh. 25: INDIAN TV CHANNELS: DEPENDENCE ON C-BAND BY BROADCAST LANGUAGE, MAR. 2014



source: channels: Euroconsult analysis of transponder monitoring by Lyngemark Satellite, Lyngby, Denmark [www.lyngsat.com; accessed 25 Mar. 2014]; language data: derived from *Distribution of the 22 Scheduled Languages*, *op.cit.*, and M. Paul Lewis, *et al.*, *Ethnologue: Languages of the World*, SIL International, Dallas, TX, 2014 [http://www.ethnologue.com].

Ku-band platform operators of course have their reasons for being selective with respect to the channels they carry: Their satellite capacity is limited and, critically, only provides nationwide coverage, which makes them less efficient than cable in serving most local markets. It also gives them a strong incentive to offer content with the broadest possible reach – i.e., in India's fragmented

linguistic territory, channels in Hindi or in English, rather than in less widespread languages. This economic incentive is compounded by regulation requiring DTH platforms to carry channels on a "non-discriminatory" basis, which in practice makes it difficult for any of them to specialize and has encouraged all platforms to offer more or less the same content.[208]

Thus the few channels broadcast in Bhojpuri, in Manipuri or in Mizo – languages rarely spoken outside of Northeast India – or in Kashimiri, spoken by only 2% of the population outside of Jammu and Kaskmir state, are all available in C-band only. This, however, is also the case with more widely distributed languages, notably for 11 of 15 channels broadcast in Urdu, three quarters of channels in Bengali, over half of channels in Tamil, half of channels in Gujarati and 40% of channels in Malayalam or in Telugu (Exhibit 25).

Possible explanations to these trends are multiple. Thus the output of Tamil Nadu's prolific television industry may well exceed what Ku-band operators feel is warranted even by the around 5m Tamil speakers who reside outside of the state. Tamil broadcasters may also be targeting the large Tamil diaspora which exists in Sri Lanka and Southeast Asia, beyond the reach of Ku-band platforms. Many channels in Bengali also originate in Bangladesh, where rain fade and low disposable incomes have so far prevented the emergence of a Ku-band platform; in this case Indian platforms may also not be permitted to distribute foreign-originated channels if they fail to satisfy certain content requirements, including being "designed specifically for Indian audiences".[209]

It remains that much of the linguistic diversity of the Indian television audience is only satisfied by C-band signals, or by the cable networks which redistribute them, with programming menus more closely tailored to the tastes of their local audiences. Cable networks also have limited capacity, however: the largest networks currently carry only about 220 channels,[210] and even with a more localized offering are bound to leave some of their audience unsatisfied, and with no other recourse than putting up its own C-band antenna.

Some language groups may also be considered less economically interesting by pay-television operators: Four of the five states with the most Urdu speakers, accounting in 2001 for around 50% of their total number, thus happen to also be India's poorest, in terms of per-capita GNP.[211] Cable television, which depends solely on C-band for its programming feeds, also tends to be priced slightly lower than DTH services and consequently to be more accessible to lower income groups.[212]

Finally, as for the broader Asian market, few if any languages not generally spoken in India, but relevant to foreign visitors, are represented on Ku-band platforms, leaving hotels, many expatriates and others wholly dependent on C-band.

3. Connectivity

Because of the country's size and of continuing gaps in its terrestrial infrastructure, India and Indian industry rely extensively on satellite communications to connect cellular telephone networks, deliver public services such as telemedicine, and meet the communication needs of consumer businesses, notably banks and their networks of ATMs.

Although the satellite connectivity market in C-band may be considered as a limited size (in terminals) when compared to the overall telecom sector, this market presents two key specificities that we will further detail below. These include:

- The use of C-band to support several key national policies,
- The use to support critical communications for different key economic sectors,

3.1 OVERVIEW OF THE C-BAND SATELLITE CONNECTIVITY MARKET IN INDIA

A partial breakdown by frequency band of VSAT terminals, and of bandwidth used to support them, provided by the Indian telecommunications regulator, TRAI, shows a minimum of 20,661 C-band terminals, corresponding to at least 10% of licensed sites.

Exh. 26: INDIA: REPORTED ACTIVE C-BAND VSAT TERMINALS, 2014

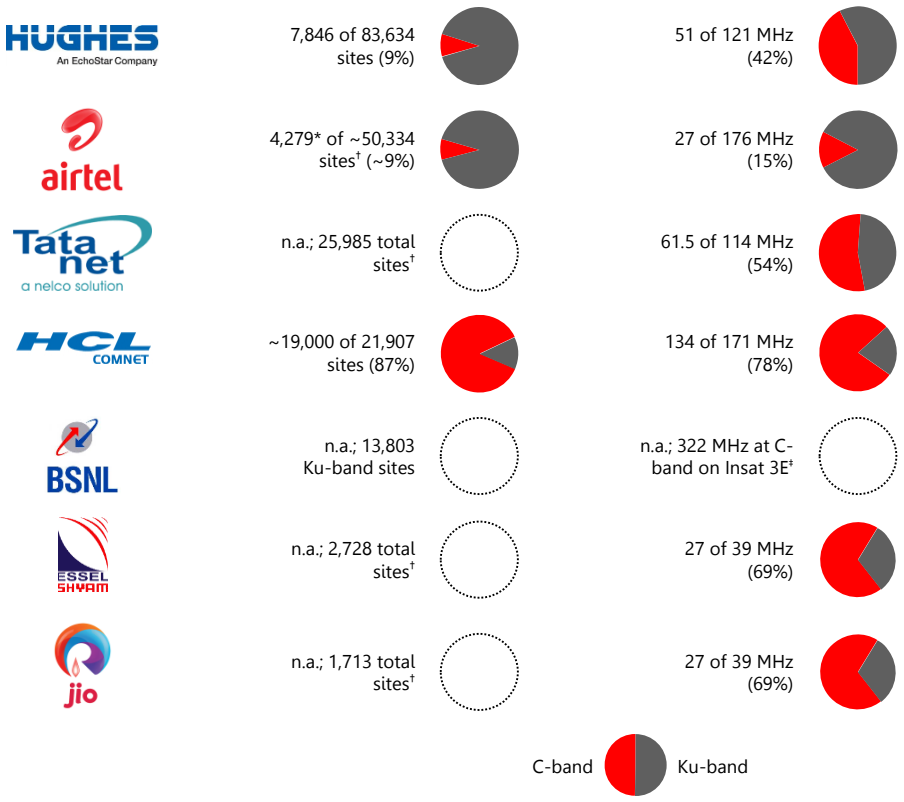
USER	TERMINALS
Financial services	**~18,000**
National Stock Exchange	3,200
Bombay Stock Exchange	1,850
Other stockbrockers	~3,000
State Bank of India	~4,500
Dena Bank	300
Oriental Bank of Commerce	200
Other banks	~5,000
Education	**~8,000**
Edusat	441
Educomp Solutions Ltd.	180
SOVTECH	37
Others	~7,500
Telemedicine	**~4,000**
ISRO telemedicine network	389
OncoNET	135
Amrita Institute of Medical Sciences	>60
Integrated Disease Surveillance Program	559
Others	~2,900
Public safety and security	**~7,000**
Indian Army (identified networks)	>347
Indian naval vessels	30
Other military networks	~5,500
Indian police	961
Disaster Management Support Network	36
Real Time Seismic Monitoring Network	17
Utilities and industrial	**~2,900**
Oil and Natural Gas Corp.	339
Other oil and gas companies	>800
Karnataka Power Transmission Co.	1,305
Airports Authority of India	80
GAGAN	15
ERNET India	317
Rural communications	**~100**
Village Resource Centres	~100
Total	**~40,000**

Source: see main text

Exhibits 26 recapitulates data available from TRAI and some service providers.[213] A more comprehensive estimate by an industry official puts the number of C-band VSATs at around 40,000, or about 20% of the ~193,000 active as of late 2013.[214]

Most significantly, TRAI data also show, across the six service providers whose satellite bandwidth is detailed by frequency band, that C-band accounts for about 50% of the satellite capacity they lease to support their VSAT sites (around 327 MHz out of 630 MHz). In at least three cases, C-band accounts for a substantially greater share of their bandwidth than of their VSATs, indicating that their C-band sites are disproportionately valuable, in terms of the traffic carried and revenue they must generate.

Exh. 27: INDIAN VSAT SERVICE PROVIDERS: USE OF C-BAND, APR. 2014



source: Euroconsult research; private communication, Telecommunications Regulatory Authority of India, Apr. 2014. (*) Not including another 119 C-band sites separately licensed to Bharti Broadband Ltd. (†) Total sites as of Sept. 2013 cited in *The Indian Telecom Services Performance Indicators*, *op.cit.*, p. 34. (‡) "BSNL, ISRO spar over satellite bandwidth", *Business Line* (New Delhi), 16 Apr. 2014.

The following sections provide further details on the main usage segments of C-band for connectivity.

3.2 EDUCATION AND HEATLH

Education

The Government of India has formulated a National Policy on Education (NPE) to promote education amongst Indians, which covers elementary education to colleges in both rural and urban areas. The first NPE was released in 1968 and subsequently expanded over the years. Overall, it emphasizes three aspects in relation to elementary education[215]:

- Universal access and enrolment,
- Universal retention of children up to 14 years of age, and
- Substantial improvement in the quality of education to enable all children to achieve revival of Sanskrit and other classical languages for contemporary use

The latest Right to Education (RTE) law came into effect on April 1, 2010. The RTE law promises free and compulsory education to all children aged 6 to 14 years. According to 2009-10 data compiled by the Indian government, 8 million children in India never having stepped inside a school and 80 million dropping out without completing basic schooling. Recent surveys by UNICEF show that the state of education has not improved much since then[216]. One of the main factors contributing to this relatively low literacy rate is the lack of proper school facilities as well as the quality and absenteeism of teaching staff across the government run education sector. Across India, teacher absenteeism varied from 15% in Maharashtra and 17% in Gujarat – two richer states – to 38% in Bihar and 42% in Jharkhand, two of the poorest states.[217] As a result, the average student-teacher ratio can be as high as 60:1 in the poorest states.

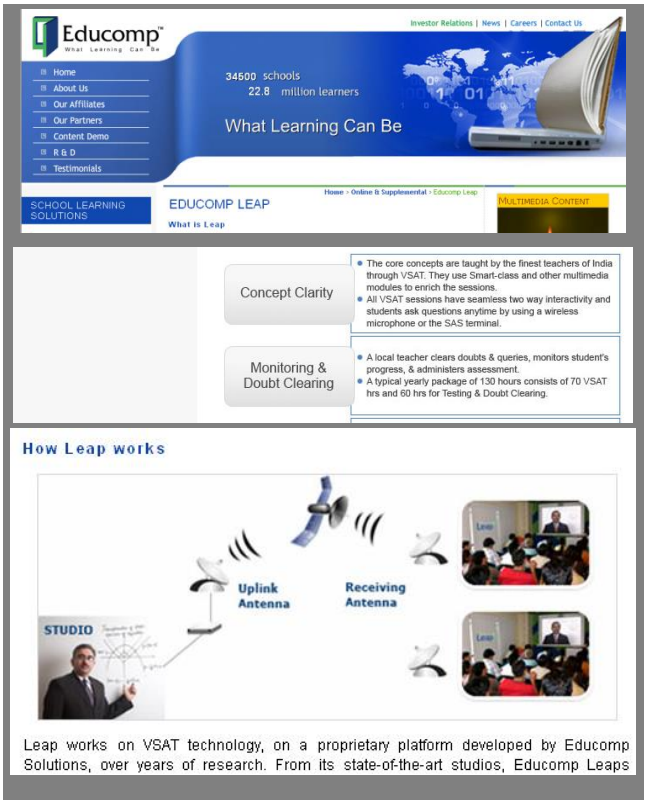
Digital classrooms are increasingly considered a complement to teachers. The Digital Study Hall project in India provides digital video recordings of live classes taught by expert teachers, which are shown by DVD in schools located in rural and poor areas. An evaluation of four schools in Uttar Pradesh found that, after eight months, 72% of pupils had improved test scores.[218]

Education is the country's second-largest user of C-band VSATs. One service provider put this sector's total C-band sites at about 8,000, and said it has added up to 2,000 in a single year.[219] Many of these are part of public education and professional training networks, such as the Atomic Energy Education Society and parts of the Edusat program.

Edusat, a nationwide network of satellite-linked classrooms managed by the Indian Space Research Organization (ISRO) and a consortium of universities, provides a wide range of basic and vocational training services to remote and disadvantaged communities. It mainly operates in Ku-band except in Rajahstan, the Lakshadweep islands and the Andaman and Nicobar islands, where it uses C-band. As of 2013 Edusat operated a total of 120 interactive terminals and 321 receive-only antennas in these three states.[220] The flow of students who receive educational content through these terminals, assuming their utilization is close to the Edusat program's average, would be on the order of 118,000 p.a.[221] Edusat also uses C-band, which accounts for half of its satellite capacity, for nationwide content distribution.[222] Finally some other public institutions operate their own C-band distance learning programs, such as the 37-site network of the Society for Promotion of Vocational and Technical Education, in the Andaman and Nicobar islands.[223]

Other sites support India's booming private education and training industry. Educomp Solutions Ltd., one of India's fastest-growing

Exh.28: INDIA: VSATS SHOWCASED IN EDUCOMP SOLUTIONS' PROMOTION OF ITS EDUCATION SERVICE, 2014



Leap works on VSAT technology, on a proprietary platform developed by Educomp Solutions, over years of research. From its state-of-the-art studios, Educomp Leaps

source: excerpted from *What is Leap*, Educomp Solutions Ltd., New Delhi [http://www.educomp.com/products/EducompLeap.aspx, accessed 30 Apr. 2014].

companies and the largest in this sector, with revenue in excess of $220m in 2012-13, uses C-band for its Educomp Tele Education Network (ETEN), established in 2008 to coach chartered accountants. By 2012 ETEN had trained over 54,000 students, at 158 satellite-connected centres.[224] The company also provides a personalized tutoring service, called Educomp Leap, at 22 facilities around India.[225] The reliability of C-band is likely to be of particular value to distance learning, because of the importance of quality standards in private education, and of maintaining maintaining a smooth, natural communication between classrooms and their distant teachers; Educomp's promotion of its services even emphasizes that they use VSATs (Exhibit 28).

Health

First policy initiative regarding telemedicine in India were taken up during 11th Five Year Plan (2006-12) followed by 12th Plan (2012- 2017). The government's 11th Five-Year-Plan (2007-2012) allocated 2,000 million rupees (about US$50 million) for the development of telemedicine in the country. The goal envisioned by India is: "Access all the Inaccessible parts" of the country in the next five years. According to ministry of health data, there is only one doctor per 1,700 citizens in India; where the World Health Organisation (WHO) stipulates a minimum ratio of 1:1,000. Only 25 percent of India's specialist physicians reside in semi-urban areas, and a mere three percent live in rural areas. As a result, rural areas, with a population approaching 700 million, continue to be deprived of proper healthcare facilities. Further the availability of hospital facility is very low in rural areas.

The focus of 11th plan was to establish the telemedicine facilities at the block level (cluster of villages). Out of the 2,000 million rupees allotted, 1,500 million rupees were allocated to ISRO for establishment of satellite network for the programme. INSAT/GSAT system in 11th plan will meet the transponder requirement for country-wide expansion of Telemedicine.

The 12th Five Year Plan (2012-2017) is still under development but is anticipated to include the following actions for the Health sector

1. Access to continuing medical education (CME) and skill up-gradation programmes, as well as back-up support on Telemedicine
2. Deployment of Countrywide Hospital Management Information System (HMIS)
3. The use of ICT in health education, public health status analysis and expansion of health related research
4. All District hospitals linked by telemedicine channels to leading tertiary care centres
5. m-Health, the use of mobile phones to speed up transmission

Telemedicine is another critical C-band user segment, and the second of three application areas, with education and rural communications, where the Indian government has sought to focus its investment in satellite communications in the past 15 years because of the benefits this could bring to society.

Uninterrupted communication in this case can clearly be a crucial requirement, and while telemedicine's key beneficiaries may be in rural areas – where most of India's population, but only about 25% of its doctors reside – the medical specialists to which VSATs allow them to be connected are in city hospitals. So, consequently, are many of the C-band antennas used for telemedicine. Many Indian telemedicine networks also include truck-mounted mobile terminals. Exhibit 29 shows examples, in which the antennas' size alone would indicate the use of C-band.

ISRO's C-band telemedicine network currently provides and manages free bandwidth, and some equipment, to 311 rural, district or college hospitals throughout India and 18 mobile units, which it connects to 60 specialty hospitals, particularly in remote parts of Jammu and Kashmir, the rain fade-prone Northeastern and island States, and tribal areas.[226]

Exh. 29: INDIA: C-BAND ANTENNAS ON MOBILE TELEMEDICINE UNITS

Chunampet Rural Diabetes Prevention Project, Tamil Nadu

Amrita Institute of Medical Sciences, Kerala

Sankara Nethralaya tele-ophtalmology unit, Tamil Nadu

Apollo Telemedicine Network Foundation, Gujarat

Gangaram Hospital, New Delhi

Malabar Cancer Care Society, Kerala

source: clockwise from top: reproduced from *Telemedicine*, Madras Diabetes Research Foundation, Chennai [http://mdrf.in/telemedicine.html]; *The Department of Telemedicine*, *op.cit.*; *Mobile Teleophthalmology Camp Routine work*, Sankara Nethralaya, Chennai [http://www.sankaranethralaya.org/mobile_tele_camp_routine_work.html]; Mohamed Nazeer, "Mobile tele-medicine unit to help in early cancer detection", *The Hindu* (Chennai), 15 June 2009; *Current status of Telemedicine Network in India and Future perspective*, *op.cit.*, p. 35; *Surat Telemedicine Camp*, Apollo Telemedicine Network Foundation, Hyderabad, Feb. 2012 [http://www.telemedicineindia.com/photogallery/Surat.html].

Several other C-band medical networks exist, such as:

- OncoNET, specialized in cancer care and linking 135 sites;[227]
- 60 sites operated by the Amrita Institute of Medical Sciences (AIMS), with specialties such as ophtalmology and surgery;[228] or
- a 559-site network for the ministry of Health's Integrated Disease Surveillance Program.[229]

In total one service provider estimates that about 4,000 C-band terminals support telemedicine networks in India.[230]

All indications are that these networks are heavily used and make a significant contribution to health care: the AIMS has provided over 5,000 tele-consultations in its first 10 years, OncoNET referred over 13,000 patients in seven years in Kerala alone, and by 2009 – after eight years of operation - the ISRO network had carried over 300,000 consultations.[231] Among other benefits – notably that of bringing quality medical advice to disadvantaged areas – telemedicine is credited with saving substantial travel costs to patients; one study on OncoNET estimates these savings to average about Rp700 per consultation, a very substantial amount in rural Kerala.[232]

3.3 NATIONAL SECURITY AND PUBLIC SAFETY

Defense and security

Large C-band networks support important national security and public safety services. In total the Indian Army, Navy and police are estimated to operate about 7,000 C-band terminals, either themselves or through service providers.[233] Many are undisclosed, but the Army, for instance, is known to have commissioned a 198-site network in 1999, and another comprising 149 sites in 2012-13.[234]

The Indian Navy operates its own satellite – GSat 7, launched in 2013 – with three of its transponders operating in C-band.[235] As part of Project Rukmani, it has procured C- and Ku-band terminals for over 100 of its surface vessels and submarines, and in particular sought bids in 2013 for the installation of C-band terminals on 12 of its ships based in Mumbai.[236] In early 2014 it was said to have outfitted at least 30 ships with C-band antennas.[237] While these naval vessels may use their C-band terminals predominantly at sea, they will presumably also require them to be usable near shore and, at least for testing, in the Indian ports where they will call. The Army and Navy are also known to rely on C-band for connectivity to the Andaman and Nicobar islands, which host some of India's most strategic military facilities.[238]

Beyond initial installations, operational activities involving satellite communications have already been reported. During the recent Theatre-level Readiness and Operational Exercise (Tropex) in the Bay of Bengal, about 60 ships and 75 aircraft seamlessly were reportedly connected through the Rukmini satellite. The Indian Navy should use the satellite to cover activities up to the Malacca Straits in the east and the Hormuz Strait to the west. The satellite has apparently also been used as part of search and rescue (SAR) operations for Malaysian Airlines flight 370.[239]

The Indian police operates POLNET, a C-band network with 961 terminals as of 2012 (with 3.8m antennas). POLNET is dimensioned for up to 1,500 terminals, but was due in 2013-14 to be upgraded so terminals could eventually be installed in all police stations – potentially over 15,000 locations, most of them in urban areas, where the government has separately been investing in IT networks and digital databases.[240]

Disaster management

India is vulnerable in varying degrees to a large number of natural disasters. The Centre for Research on the Epidemiology of Disasters (CRED) has reported 239 natural disasters since 2012 that caused a total economic damage of over 30 billion dollars to the country[241]. Statistics from National Disaster Management

The government of India has developed and expanded a national policy for disaster management over the last decade, due to the exposure of India of its population to a number of natural and human-induced hazards. Extracts from this national policy update of 2009 and of associated plans are presented in the table below.

As stated in the table, the use of the space is explicitly cited as one of the tools constituting the National Emergency Communication Network, which is still partly under development.

Exh. 30: EXTRACTS FROM THE NATIONAL POLICY ON DISASTER MANAGEMENT 2009[242]

Items	Quotes
Context	> Efficient management of disasters, rather than mere response to their occurrence, has in recent times, received increased attention both within India and abroad. This is as much a result of the recognition of the increasing frequency and intensity of disasters, as it is an acknowledgement that good governance in a caring and civilised society, needs to deal effectively with the devastating impact of disasters. > India is vulnerable, in varying degrees, to a large number of natural as well as man-made disasters. 58.6 per cent of the landmass is prone to earthquakes of moderate to very high intensity; over 40 million hectares (12 per cent of land) is prone to floods and river erosion; of the 7,516 km long coastline, close to 5,700 km is prone to cyclones and tsunamis; 68 per cent of the cultivable area is vulnerable to drought and hilly areas are at risk from landslides and avalanches. > On 23 December 2005, the Government of India (GoI) took a defining step by enacting the Disaster Management Act, 2005, (…) which envisaged the creation of the National Disaster Management Authority (NDMA) (…), State Disaster Management Authorities (SDMAs) (…), and District Disaster Management Authorities (DDMAs) (…), to spearhead and adopt a

	holistic and integrated approach to DM. There will be a paradigm shift, from the erstwhile relief-centric response to a proactive prevention, mitigation and preparedness-driven approach for conserving developmental gains and to minimise loss of life, livelihood and property.
Approach and objectives	> To build a safe and disaster resilient India by developing a holistic, proactive, multi-disaster oriented and technology driven strategy through a culture of prevention, mitigation, preparedness and response. > Disaster management (…)involves a continuous and integrated process of planning, organising, coordinating and implementing measures which are necessary or expedient for: o Prevention of danger or threat of any disaster, o Mitigation or reduction of risk of any disaster or its severity or consequences. o Capacity building including research and knowledge management. o Preparedness to deal with any disaster. o Prompt response to any threatening disaster situation or disaster. o Assessing the severity or magnitude of effects of any disaster. o Evacuation, rescue and relief. o Rehabilitation and reconstruction.
Communications and Information Technology (IT) Support	> The basic communications and IT support requirements for disaster management correspond to the following three levels: o Decision makers and disaster managers at all levels. o Real time dissemination of advance warnings and information to the authorities concerned at various levels and the threatened community. For dissemination of advance warning and information, broadcasting mediums such as television and radio shall be used significantly as they have higher geographical reach. For coastal and hilly regions, the network of the Meteorological Department may be used. o Last mile connectivity at the disaster site for control and conduct of rescue and relief operations. > Communication and sharing of up-to-date information using state-of-the-art IT infrastructure remain at the heart of effective implementation of the disaster management strategy. Reliable, up-to date and faster sharing of geo-spatial information acquired from the field or the affected areas is a pre-requisite for effective implementation of disaster management strategies. Efforts should be made for setting up IT infrastructures consisting of required IT processes, architecture and skills for quick upgradation and updation of data sets from the PRIs or the ULBs. A National Emergency Communication Network, involving contemporary space and terrestrial-based technologies in a highly synergistic configuration and with considerable redundancy, will be developed. This Network will ensure real time dissemination of warnings and information to the affected community and local authorities.

ISRO operates the Disaster Management Support Network (DMSN), a C-band network which as of 2012 comprised 36 terminals with 1.2-4.5m antennas. At the time the DMSN was due to expand to another 100 after local governments identified hazardous areas where to emplace them, and was ultimately dimensioned for up to 600 terminals.[243] The India Meteorological Department has at least one C-band VSAT network for disaster warning, the 17-site Real Time Seismic Monitoring Network, which in particular provides early warning of tsunamis;[244] in this case, given the brief time window available to disseminate alerts, it would seem that even a brief rain outage – a common occurrence on coastal sites exposed to monsoon rains – could have particularly far-reaching consequences.

Plans to expand and modernize the DMSN have been under discussion for some time, and in 2011 were allocated over $150m with the aim of establishing a more coherent, nationwide network by 2017.[245] While the National Disaster Management Authority has described Ku-band as potentially an easier solution given the smaller antennas it permits, according to service providers ISRO has since taken position in favor of C-band. One key factor was the positive experience which responders had with the Indian Army's C-band network, which played an essential role in relief efforts in 2013 after a major rainstorm caused floods, landslines and several thousand casualties in Uttarakhand state.[246]

3.4 RURAL CONNECTIVITY

The Indian government's policy and programs for rural development have particularly focussed on poverty alleviation, generation of employment and income opportunities and provision of infrastructure and basic facilities. The National Telecom Policy 2012 has been formulated to address the digital divide In India. Some of the key objectives include[247]:

- Provide secure, affordable and high quality telecommunication services to all citizens.
- Increase rural teledensity from the current level of around 39 to 70 by the year 2017 and 100 by the year 2020.
- Provide affordable and reliable broadband-on-demand by the year 2015 and to achieve 175 million broadband connections by the year 2017 and 600 million by the year 2020 at minimum 2 Mbps download speed and making available higher speeds of at least 100 Mbps on demand.
- Provide high speed and high quality broadband access to all village panchayats through a combination of technologies by the year 2014 and progressively to all villages and habitations by 2020.

The strategy section of the national telecom policy particularly highlights the use of a combination of technologies including fiber, wireless, and VSAT. The government is currently undertaking a National Optical Fiber Network (NFON) project to connect around 250,000 village panchayats. Latest news reports indicated that the NOFN project already suffered a two-year time overrun, which would derail the broadband penetration target of 175 million by 2017[248]. According to TRAI, India had 15 million broadband customers at the end of June 2013[249].

An estimated 100 C-band terminals are deployed to provide connectivity to rural India. A number of these C-band terminals have been deployed as part of two ISRO projects known as Gramsat and the Village Resource Centres (VRCs). The ISRO projects provide Internet access to local administrations as well as a range of training and specialist information to farmers and fishermen, such as tele-consultations to help diagnose crop diseases. A large number of the 473 VRCs installed by ISRO are known to have been deactivated after the agency retired the satellite on which they initially relied, or due to insufficient local support and maintenance. According to service providers C-band VRCs remain active mainly in Orissa, where ISRO had built 44 of them.[250]

However studies indicate that the VRCs had been found quite useful.[251] In Orissa, VRCs were used by the local government to train over 12,000 local officials in topics such as local law, financial management and transparency in administration.[252] In 2013 ISRO estimated that about 400,000 people had availed of their services, and had the objective of reactivating 373 of the centres.[253]

Indian telecommunication carriers also still use a substantial amount of C-band capacity to backhaul traffic from areas with limited terrestrial connectivity, such as the Andaman and Nicobar islands, Jammu and Kashmir and the Northeastern States, using approximately 100-150 earth stations.[254] State-owned BSNL, one of the largest, used 322 MHz of C-band capacity on Insat 3E to connect the Andaman and Nicobar islands when this satellite was retired in April, and had sought additional capacity to nearly triple its traffic, from 350 Mbps to 1 Gbps.[255]

3.5 FINANCIAL AND BANKING SECTOR

The financial and banking sector is the largest vertical market, representing nearly half of all enterprise VSAT sites dependent on C-band. The high reliability of C-band compared to higher frequency bands has been a key determinant.

A large use of C-band capacity in support of stock trading

India's two principal stock exchanges, the National and Bombay Stock Exchanges, operate a total of 5,050 C-band VSAT sites in over 375 cities to connect stockbrokers.[256] In itself this is a substantial number, corresponding to about half of all stockbrokers registered in India.[257]

More to the point, trades being very time-critical, such users evidently require extremely reliable connections. As an indication, over the 12 months through March 2014 the combined turnover of these two stock exchanges – the total volume of trades handled by their stockbrokers – came to ~$553bn, or about $90,000 per second of trading time.[258]

While some brokers have fiber connections to the exchanges and consequently not all of this volume of business is handled over satellite links, the latter's penetration of India's financial sector, as noted, is high enough that even a few seconds of rain outage could result in substantial losses, and to make the use of frequency bands vulnerable to rain fade – i.e., for VSATs, other than C-band – an untenable proposition. Indeed HCL Comnet, a unit of IT group unit of IT group HCL Technologies which supports about 70% of Indian stockbroking VSATs, is the second-largest user of C-band capacity among the country's VSAT service providers.

C-band as large contributor to the expansion of banking networks

Banks, India's other major corporate VSAT market, use at least another 5,000 C-band VSATs for their backroom and clearing operations, which have similarly stringent requirements for reliable communications. The State Bank of India alone, according to the service provider which services it, has a C-band network of about 4,500 terminals.[259] The market appears to be expanding quite robustly, with an increase by approximately 10% in C-band banking sites expected from just two tenders issued in early 2014 by other State-owned banks:

- Dena Bank for 300 terminals, and
- the Oriental Bank of Commerce for 200 terminals– including, interestingly, 80 to replace previously installed Ku-band antennas.

Other tenders from Indian banks, even when not so specific, mandate the use of C-band antennas where rain fade may compromise the desired link availability, generally put at 99.5% or higher.[260]

In the same market, VSAT have played a considerable role in helping Indian banks expand beyond city centers and into suburbs, the country's smaller towns and rural areas, notably by connecting ATMs. The Indian government has encouraged this, noting in 2008 that nearly two-thirds of the country's 611 districts were "under-banked", with less bank branches per unit of population than the national average.[261] Though the service levels required for ATMs tend to be less strict, and the size of antennas to be more of a constraint, the leading vendor in this market still estimates that ~5,000 use C-band VSATs.[262] The total number of ATMs in India is uncertain (and growing), but on the last count available from the International Monetary Fund this would correspond to about 6% of the total as of 2011, and to considerable monetary flows.[263] C-band is also baselined for a mobile banking terminals currently awaiting approval by the Indian government.[264]

3.6 OTHER PROFESSIONAL USE

A variety of industrial users use C-band networks to manage their operations. ISRO alone supports dozens of networks, whose number, diversity and closed nature often make their characteristics – let alone a comprehensive list - difficult to establish. Some, however, are clearly of strategic importance:

- **The Oil and Natural Gas Corp.**, for instance, operated 339 C-band terminals as of mid-2013, all but 19 onshore and most with antennas in the range of 1.8-3.8m.[265] in early 2014 it was

reported to be seeking another 150 installations.[266] HCIL maintains approximately another 800 C-band terminals for other customers in the Indian oil and gas industry.[267]

> **The Karnataka Power Transmission Co.**, an electric utility, uses over 1,300 C-band VSATs to control its electric grid – a particularly delicate application, as current imbalances within electric grids can rapidly escalate and cause blackouts.[268]

> **The Airports Authority of India (AAI)** operates the Dedicated Satellite Communication Network, which uses C-band satellites to exchange air navigation and other data between two national hubs and 78 airports, equipped with 3.8-7m antennas.[269]
A second air navigation and safety network, the GPS Aided GEO Augmented Navigation (GAGAN) system, is also critically dependent on C-band. Initiated by ISRO and AAI in 2008 and one of India's largest satellite programs, GAGAN transmits reference signals which, combined with those of GPS satellites, increase the accuracy of satellite navigation in India and make it usable for air navigation in its air space. By 2015 this is to be augmented by seven new navigation satellites which would make India self-reliant, with a total investment of about $400m. GAGAN's reference signal is created by integrating data from 15 "reference stations", usually located within or near airports, which monitor the quality of GPS signals, and transmit these measurements over C-band VSATs to two master stations. 45 stations are planned ultimately.[270] These signals must of course be transmitted without interruption and be themselves of very high integrity.

> **ERNET India**, a government agency which connects scientific research organizations, operates 317 C-band terminals.[271]

4. Conclusions on the socio economic impact of C-band

We summarize on Exhibit 31 the findings or our research and analysis on the use of C-band capacity in India. Important findings include again the large spread of services leveraging on the use of satellite transmissions in the C-band, including for several key economic sectors and for most of the primary public services.

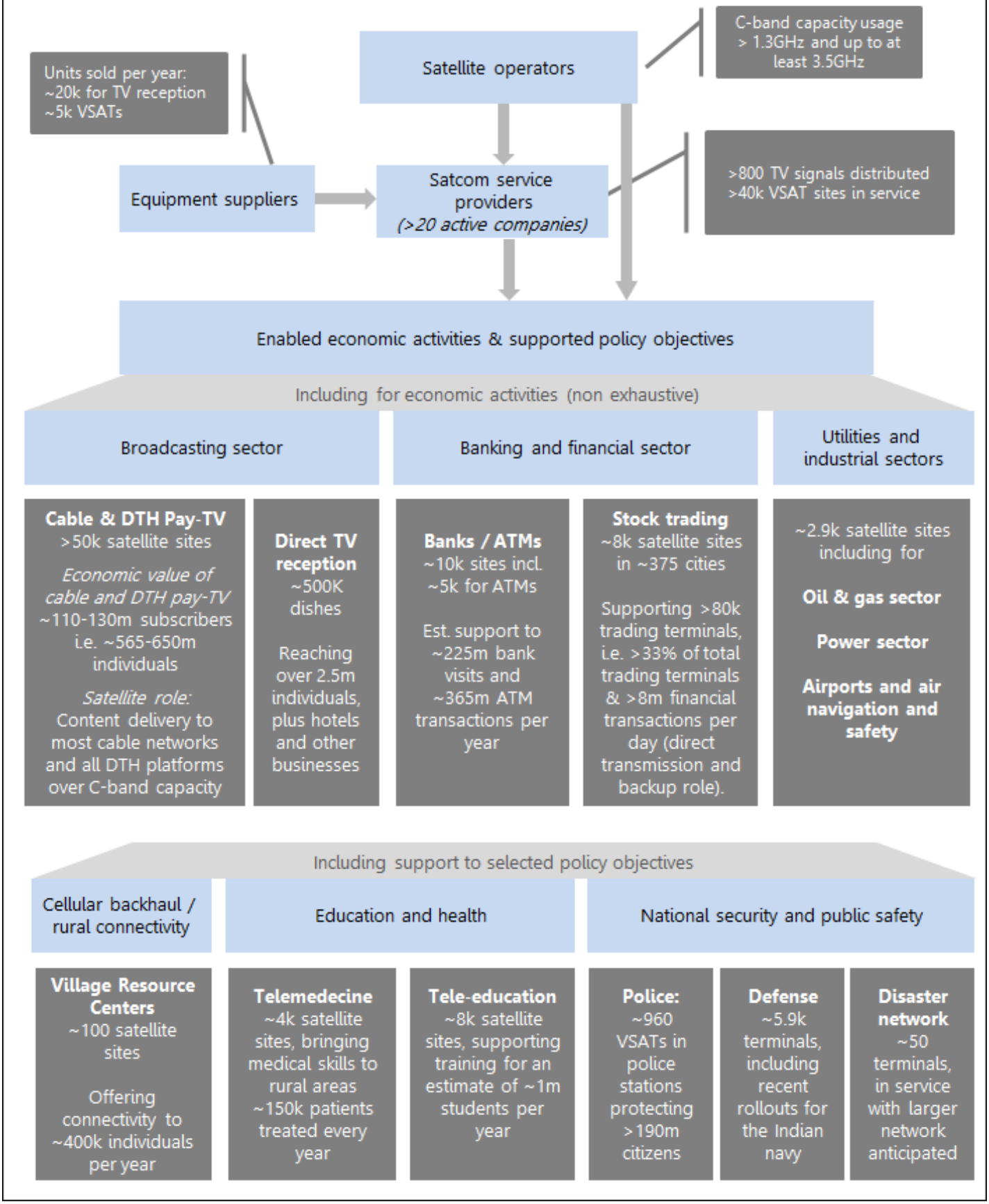
Overall, over 400 million Indian citizens are found to benefit from services that are directly enabled, or at least made more efficient, by C-band communication links. The key beneficiaries are:

> **Television**, which depends directly on C-band to feed content to cable networks and satellite DTH platforms, themselves serving around 110-130 million homes on a daily basis;

> The **financial sector**, both for retail banking and for trading activities, with a direct incidence on the daily operation of India's two principal stock exchanges;

> A number of other user industries, some also constituting critical infrastructures, such as **energy**, **cellular carriers** and **air navigation**.

Exh. 31: INDIA: SYNTHESIS OF SOCIO ECONOMIC IMPACT OF SATELLITE C-BAND USAGE



In addition, we have identified large deployments of networks, including a total of more than 10,000 VSATs supporting different key government policies. These include networks:

- Offering nationwide services to the population, and often to its most disadvantaged segments, including **telemedicine**, **distance learning** and **rural communications** via Village Resource Centre;
    - Or supporting national security and public safety, including the **police**, **armed forces**, and **disaster response** organizations.

The following table summarizes sources for key assumptions supporting Exhibit 31.

SEGMENT	NOTES ON ASSUMPTIONS
Satellite operators	Minimum includes assumptions mentioned in the broadcast and connectivity sections. The higher value corresponds to previous research published in the report *India Satcom Markets 2014* (Euroconsult, Paris, 2014).
Satcom service providers and grey box	See pages 52-54 and Exh. 26
Equipment sales	See page 51 and assumption of slightly over 10% of installed VSATs being sold on average per year either for replacement of new installations
Broadcasting sector	See pages 46-53
Natural resources	See pages 37,39
Banks	See page 61-62. For trading, sources identify the number of trading terminals and number of communication lines and terminals for the National Stock Exchange and the Bombay Stock Exchange, as well as the number of transactions per day
Other industrial sectors	See pages 62-63
Rural connectivity	See pages 61
Education and health	See pages 55-58
National security and public safety	See pages 58-60. The average population per police station is extrapolated from statistics of Hyberabad City Police.[272]

APPENDIX

App 1. SELECTED ASIAN MARKETS: ESTIMATED MIGRANTS SPEAKING LANGUAGES NOT AVAILABLE ON CABLE OR KU-BAND TELEVISION

	Australia	New Zealand	Hong Kong	Japan	Korea	Indonesia	Philippines	Thailand	India	Nepal	Pakistan	Total
Languages available on cable or Ku-band systems	A C E F Gr Hi Hu I J K Po Se Sp V	C E F Hi J K	C Ca E F Hi J K Ru Sp	E J K	E C J K	A Bur C E F G Hi In J K	C E Hi SpTag	B C E F G Hi J K La M Th	Be E F Hi Ne Ur	E C Hi Ta Ur	E Ur	
Bangladesh	9,078	1,187	34,977	5,548	5,319	-	10,062	1,949	-	203,616	1,508,256	1,779,992
India	-	-	-	5,771	1,686	-	-	-	-	-	606,424	613,881
Indonesia, Malaysia	126,016	15,252	15,803	20,459	11,175	-	194,661	-	15,915	4,464	33,070	436,815
Russia, Ukraine, Belarus, Central Asia	30,724	4,081	-	3,058	254	6,702	21,851	12,949	11,472	40,669	301,245	433,005
Spanish-speaking Latin America	-	2,855	-	44,185	301	7,159	-	11,737	12,723	36,592	271,059	386,611
China	-	-	-	253,096	-	-	-	-	30,195	-	85,439	368,730
Sri Lanka	53,461	6,168	5,429	3,540	35	1,983	3,308	10,164	186,264	10,826	80,190	361,368
Nepal	2,626	345	5,369	2,511	1,484	2,898	6,107	13,492	-	-	256,125	290,957
Arabic-speaking Middle East or Africa	-	10,766	32,273	1,349	123	-	47,609	3,967	39,724	12,894	95,509	244,214
Brazil	4,713	666	1,233	188,355	719	2,199	18,498	455	493	1,421	10,523	229,275
Germany, Austria	127,544	9,600	2,895	3,704	956	-	17,956	-	2,735	7,233	53,576	226,199
French-speaking Africa	-	-	-	1,057	18	-	12,258	-	-	17,760	131,545	162,638
Thailand	23,600	5,154	5,342	23,967	4,772	24,867	29,939	-	749	1,223	9,062	128,675
Myanmar	10,973	702	1,770	3,676	21	-	18,018	-	60,714	3,528	26,131	125,533
Netherlands	83,324	22,242	477	604	5	357	1,667	406	268	1,180	8,741	119,271
Vietnam	-	3,946	13,371	12,965	8,950	17,017	23,243	8,336	678	3,111	23,045	114,662
Turkey	-	397	18,380	915	78	809	2,388	1,383	128	4,255	31,519	60,252
Pakistan	11,917	1,321	21,377	4,666	3,369	4,567	11,645	2,921	-	-	-	61,783
Italy	-	1,455	1,996	1,128	17	34	6,823	658	1,118	4,948	36,650	54,827
France, Belgium, Switzerland	-	-	-	4,778	1,170	-	9,191	-	-	4,060	30,089	49,288
Poland	-	1,946	1,246	468	10	533	1,949	995	697	3,089	22,883	33,816
Romania	12,821	922	631	1,004	8	325	1,482	505	353	1,562	11,568	31,181
others	174,808	24,367	60,947	13,679	323	17,235	117,257	30,843	38,798	43,200	337,422	858,879
Total	**496,797**	**90,486**	**163,988**	**588,621**	**40,493**	**70,380**	**441,271**	**70,913**	**365,010**	**367,946**	**3673,500**	**6,369,405**

A: Arabic. B: Burmese. C: Chinese. Ca: Cantonese. E: English. F: French. G: German. Gr: Greek. Hi: Hindi. Hu: Hungarian. I: Italian. In: Indonesian. J: Japanese. K: Korean. La: Lao. M: Malay. Ne: Nepali. Po: Polish. Ru: Russian. Se: Serbo-Croatian. Sp: Spanish. Ta: Tamil. Tag: Tagalog. Th: Thai. Ur: Urdu. V: Vietnamese.

source: derived from Global Migrant Origin Database, op.cit., and channel listings from Lyngemark Satellite (www.lyngsat.com) and cable network operators.

App 2.: INDONESIA: C-BAND ANTENNAS ON CENTRAL JAKARTA ROOFTOPS, MAY 2014

note: Numbers indicate number of visible antennas when greater than one; orange circle indicates a VSAT.

source: Euroconsult photographs and analysis..

App. 3: INDONESIA: C-BAND ANTENNA MANUFACTURING FACILITY OF PT. STELLA SATINDO, 2014

source: reproduced from *Tentang PT Stella Satindo*, PT. Stella Satindo, Jakarta [http://matrixparabola.com/index.php/content/index/2].

App. 4: BANK RAYAT INDONESIA: ADVERTISEMENT ON THE BRISAT SATELLITE PROJECT

source: reproduced frrom economic newspaper *Kompas*, 29 Apr. 2014, p. 3.

[1] Note that the ITU standard on which Exhibit 1 is based in part, Rec. ITU-R-PN-837.1, has now been superseded by another which no longer divides the world into "rain zones" and relies on more recent and detailed precipitation maps. This does not alter the basic facts as presented here, and the rain zones are still widely used as a convenient shorthand.

[2] These are primarily the height of the rain clouds, set in the ITU model at 5 km in tropical areas, and the satellite's elevation, set here at 20°, which together determine how long a column of rain the radio signal has to traverse. Higher clouds or a higher elevation would result in less attenuation, requiring a slightly lower rain margin.

[3] Email interview with PNG service provider, 14 Apr. 2014.

[4] Telephone interview with service provider, 1 Apr. 2014.

[5] *Rain fade*, notice on the Astro Help Center web page [http://support.astro.com.my/HelpCenter/Article.aspx?CategoryID=af2cc6af-3b23-41ea-b0e3-cdf39269771d, accessed 2 Apr. 2014].

[6] "Astro Broadcast Disruption During Rain Cannot Be Eliminated Completely – Salang", Bernama, 13 Dec. 2012.

[7] "United Kingdom-London: Satellites", contract notice No. 2013/S 145-252307, *Supplement to the Official Journal of the European Communities*, 27 July 2013, p. S145.

[8] Telephone interview with U.S. manufacturer, 2 Apr. 2014.

[9] Derived from Euroconsult research report *World Satellite Communications & Broadcasting Markets Survey,* 2013 Edition. Regions taken into account in cited figures include South Asia, North East Asia, China Area, South East Asia and Oceania & Pacific. It excludes the Russia & Central Asia region.

[10] *Annual Report 2012*, Thaicom plc, Bangkok, Mar. 2013, p. 63.

[11] Annual Report on Form 20-F For the Year Ended December 31, 2012, PT Indosat Tbk., Jakarta, Apr. 2013, p. 48.

[12] *Interim Report 2013*, APT Satellite Holdings Ltd., Hong Kong, 26 Aug. 2013, pp. 3-4.

[13] *2010 Annual Results*, presentation to analysts, Asia Satellite Telecommunications Holdings Ltd., Hong Kong, Mar. 2011, p. 10.

[14] Note also that some important vendors, such as video service provider Encompass Digital Media or cable head-end equipment manufacturer Globecomm Systems, have a policy of not announcing individual sales or of not identifying customers.

[15] Figures as of 31 December. Channels are assigned to each region based on the coverage of each transponder reported to carry them; on the language in which they broadcast; and in case of doubt, on their country of origin or on further research on their target territories; channels from other regions, broadcast in Chinese, Japanese or European languages by transponders covering both regions are counted only once and split evenly between South and Southeast Asia. HD: High definition. SD: Standard definition.

[16] Digital TV Asia Pacific, Digital TV Research, 2013

[17] *PEMRA Annual Report 2010*, op.cit., p. 20

[18] *Details of Multi System Operator (MSOs) Registered With Ministry of Information & Broadcasting to Operate in Digital Addressable System (DAS)*, Ministry of Information and Broadcasting, New Delhi, 30 Dec. 2013; *COFI Additional Comments on Consultation paper on Distribution of TV Channels from Broadcasters to Platform Operators dated 06 August 2013*, COFI/TRAI/13/2013, Cable Operators Federation of India, New Delhi, 19 Sept. 2013, p. 19.

[19] Suchit Leesa-Nguansuk, "NBTC faces legal threat", *The Bangkok Post*, 7 Dec. 2012.

[20] *The Philippines in View*, Cable & Satellite Broadcasting Association of Asia, Hong Kong, May 2010, p. 3; email interview with Philippine broadcaster, 16 Apr. 2014. More recently an industry official put the number of Philippine cable operators at 800 [telephone interview, 14 Apr. 2014].

[21] Email interview with service provider in Bangladesh, 2 May 2014.

[22] Telephone interviews with service providers, 1 and 14 Apr. 2014.

[23] *Earth Station Siting: Foxtel Response to ACMA Discussion Paper*, Foxtel, Sydney, 21 Oct. 2011, p. 3.

[24] Watchiranont Thongtep, "CTH to drop some cable-TV partners in move towards satellite broadcasting", *The Nation*, 5 Feb. 2014. The reasons underlying these consolidations are multiple and somewhat beyond our scope, but include economies of scale, the cost of digitization in markets such as India, Thailand and the Philippines where analog networks remain widespread, as well as, in Thailand, the cost of complying with new must-carry rules and increases in the fees which utilities charge for laying cables on their electric poles [Saengwit Kewaleewongsatorn, "Murky future seen for small cable firms", *The Bangkok Post*, 2 Mar. 2013].

[25] "Cable DAS and the head-end factor", *Indian Television*, 5 Nov. 2013.

[26] AGB Nielsen Media Research estimate cited in Wanchai Rungfapaisarn, "Surge in satellite TV viewers", *The Nation* (Bangkok), 7 Apr. 2010 (citing AGB Nielsen Media Research); Saengkit Kewaleewongsatorn, "CTH offers new set-top box for satellite-TV users", *The Bangkok Post*, 7 Sept. 2013 (citing cable and C-band operator CTH).

[27] "Leaders bullish on cable and satellite TV growth", *The Nation* (Bangkok), 21 Jan. 2011.

[28] "TrueVisions to widen satellite viewership", *The Bangkok Post*, 14 Sept. 2012; "RS partners with PSI", press release, RS plc, Bangkok, 12 July 2013; "PSI Unveils High Definition Satellite Program in Thailand Using ALi Set-Top Box Chipset Solution", press release, ALi Corp., Taipei, 17 Aug. 2013. PSI also leases two Ku-band transponders, but said in 2012 it had only 500,000 customers in this band ["In Multi-million Baht deal, Thaicom books first customer for Thaicom 6", press releasae, Thaicom plc, Nonthaburi (Thailand), 9 Sept. 2011; "TrueVisions to widen satellite viewership", *op.cit.*]

[29] W. Rungfapaisarn, "Surge in satellite TV viewers", *op.cit.*

[30] Saengkit Kewaleewongsatorn, "CTH teams up with PSI to expand subscribers", *The Bangkok Post,* 23 Jan. 2014.

[31] Watchiranont Thongtep, "RS, PSI jointly offer new receiver for international soccer matches", *The Nation* (Bangkok), 12 July 2013.

[32] Grammy also leases three Ku-band transponders [*Thaicom 6*, Lyngemark Satellite, Lyngby (Denmark), http://www.lyngsat.com/Thaicom-6.html]; a press report in 2013 put Grammy's lease at "eight transponders" [Saengkit Kewaleewongsatorn, "GMM Z focuses on pay television service", *The Bangkok Post*, 29 Nov. 2013.]

[33] Telephone interview with Space Link official, 26 Mar. 2014.

[34] *Strategies for Wireless Access Services: Spectrum Access Options - Consultation Outcomes*, Spectrum Planning Discussion paper SPP 08/08, Australian Communications and Media Autority, Canberra, Oct. 2008, p. 14.

[35] *International Tourist Arrivals to Thailand by Nationality*, Ministry of Tourism and Sports, Bangkok, 10 Mar. 2014; *Overseas Arrivals and Departures*, Australia, Series 3401.0, Australian Bureau of Statistics, Canberra, Feb. 2014, table 5.

[36] *Strategies for Wireless Access Services: Spectrum Access Options*, comments filed with the Australian Communications and Media Authority, Television Oceania Pty. Ltd., Ultimo (Australia), 4 Apr. 2007, p. 2.

[37] *Earth station siting*, Submission to the Australian Communications and Media Authority, Deluxe Entertainment Servics Group Inc., Sydney, 6 Oct. 2011, p. 9.

[38] Telephone interview with BBC World News official, 10 Apr. 2014.

[39] Interviews with industry officials, Singapore, June 2011 and June 2012.

[40] Interview with industry official, Singapore, June 2013.

[41] Telephone interview with European broadcaster, 10 Apr. 2014.

[42] Telephone interview with BBC World News official, 11 Apr. 2014.

[43] Note also that a large part of our own information on this topic derives from confidential interviews, which often prevents us from identifying sources or breaking up aggregate totals.

[44] Telephone interview with U.S. manufacturer, 2 Apr. 2014.

[45] Email interview with Pakistani service provider, 14 Apr. 2014.

[46] Telephone interview with PT. Indosat Tbk official, 11 Apr. 2014.

[47] Euroconsult research report *Prospects for Cellular Backhaul in fast growing Economies*, June 2013

[48] Telephone interviews with service provider, 1 and 14 Apr. 2014.

[49] Letter to the Australian Communications and Media Authority, filed in response to Consultation IFT 27-211 on Earth station siting, Fox Sports, Sydney, 27 Oct. 2011, p. 1.

[50] data.worldbank.org/

[51] World Population Prospects: The 2012 Revision (2012) United Nations

[52] http://www.reuters.com/article/2014/02/05/indonesia-economy-gdp-id

[53] data.worldbank.org/

[54] Based on *TELKOMVision Business Prospects*, presentation by PT. Indonusa Telemedia at the Workshop Koperasi TELKOM, Yogjakarta, 29 June 2009, p. 6., *Statistik Sosial Budaya 2012*, Badan Pusan Statistik, Jakarta, Interview with PT. Stella Satindo official, Jakarta, 7 May 2014 and Euroconsult estimates.

[55] *Asia Pacific Pay-TV & Broadband Markets 2013*, Media Partners Asia

[56] Interview with Orange TV official, Jakarta, 5 May 2014.

[57] As for India, we estimate this bandwidth usage from symbol rates reported by Lyngemark Satellite AS [www.lyngsat.com], divided by 1.35 to account for bandwidth roll-off.

[58] *TELKOMVision Business Prospects*, presentation by PT. Indonusa Telemedia at the Workshop Koperasi TELKOM, Yogjakarta, 29 June 2009, p. 6.

[59] *Media Use in Indonesia 2012*, Broadcasting Board of Governors, Washington, D.C., Oct. 2012, pp. 10-11.

[59] *Statistik Sosial Budaya 2012*, Badan Pusan Statistik, Jakarta, 2013, p. 36. The last available census, in 2010, put Indonesia's population at 237.6m, including 50.2% in rural areas, and the number of households at 61.1m [*Trends of Selected Socio-Economic Indicators of Indonesia*, Badan Pusan Statistik, Jakarta, Nov. 2012, tab. 2.1 and 2.15].

[60] *Statistik Sosial Budaya 2012*, Badan Pusan Statistik, Jakarta, 2013, p. 36. The last available census, in 2010, put Indonesia's population at 237.6m, including 50.2% in rural areas, and the number of households at 61.1m [*Trends of Selected Socio-Economic Indicators of Indonesia*, Badan Pusan Statistik, Jakarta, Nov. 2012, tab. 2.1 and 2.15].

[61] "MNC Sky Vision (MSKY) Booked 38% Increase in Revenue and 38% Increase in EBITDA as of Third Quarter of 2012", press release, PT. MNC Sky Vision Tbk., Jakarta, 18 Oct. 2012.

[62] Interview with PT. Stella Satindo official, Jakarta, 7 May 2014. These figures are given for 12-month periods through June, as sales generally peak between January and June.

[63] See for instance AC Nielsen data cited in *Public Expose 2014*, PT Media Nusantara Citra Tbk, Jakarta, 29 Apr. 2014, p. 7, showing the nine top over-the-air channels to share 97% of the audience.

[64] AC Nielsen and Zenith Optimedia data cited in "Advertisement Spending in Indonesian Media Grows 25% in First Half 2013", *Indonesia Investment*, 26 Aug. 2013, and *Advertising Age's Marketing Fact Pack 2014*, Crain Communications Inc., Chicago, 30 dec. 2013, p. 15.

[65] *Survey of Indonesia Public Opinion*, International Republican Institute, Washington, D.C., 17 Sept. 2013, p. 57; *BBC/Reuters/Media Center Poll: Trust in the Media*, GlobeScan Inc., Toronto, 2 May 2006, pp. 13-14.

[66] Interviews with Skynindo and Orange TV officials, Jakarta, 5 May 2014; *TV Berlangganan*, Topas TV, Jakarta [http://www.topas.tv/id/paket-tv-berlangganan]; *Paket Berlangganan*, Orange TV, Jakarta [http://www.orangetv.co.id/product/paket_berlangganan]; *Skynindo Paket*, Skynindo, Jakarta [http://www.skynindo.tv/index.php?option=com_content&view=article&id=99&Itemid=82]. Kompas TV launched in March and does not yet generate significant revenue.

[67] Interview with PT. Stella Satindo official, op.cit., 7 May 2014.

[68] Interview with PT. Stella Satindo official, op.cit., 7 May 2014. Note that this estimate may be low, as Orange TV alone claims to sell 30,000-40,000 set-top boxes per month, of a more advanced model priced at $30.

[69] Interview with PT. Stella Satindo official, op.cit., 7 May 2014.

[70] Interviews with Orange TV and PT. Stella Satindo officials, op.cit., 5 and 7 May 2014.

[71] Note that we assume six-day working weeks without holidays. This may be a simplification, though broadcasters sais installers are currently in short supply. Indonesian labour regulations permit six-day weeks but require 12 days of paid holidays [*Employing Workers in Indonesia*, The World Bank, Washington, D.C., 2014; http://www.doingbusiness.org/data/exploreeconomies/indonesia/employing-workers]. Antenna installers may also install a variety of other electrical equipment, though it would seem that television antennas provide enough revenue to keep them fully employed.

[72] *Laborer Situation in Indonesia*, Badan Pusan Statistik, Jakarta, Aug. 2013, tab. B5.

[73] Interviews with PT. Pasifik Satelit Nusantara official and with an adviser to BRI, Jakarta, 6 and 8 May 2014.

[74] Interview with Indonesian official, Jakarta, 8 May 2014; *Q1-2014 Financial Update Presentation*, PT Bank Rakyat Indonesia (Persero) Tbk., Jakarta, 23 Apr. 2014, pp. 28, 39.

[75] See Exhibit __. BCA had 11,514 ATMs as of 31 Mar. 2013, while Bank Mandiri last reported having 11,514 as of 31 March [Sri Wiyanti, "Jumlah ATM Indonesia masih kalah dibandingkan China dan Brasil", *Merdeka*, 3 May 2013; *PT Bank Mandiri (Persero) Tbk 1Q 2014 Results Presentation*, PT. Bank Mandiri Tbk., Jakarta, 28 Apr. 2014, p. 4].

[76] BRI last reported data on its ATMs' utilization for 2012, when its 14,292 tellers (less then than it now has VSATs) supported 789.2m transactions with a value equivalent to $46bn [*2012 Annual Report*, PT Bank Rayat Indonesia Tbk., Jakarta, July 2013, pp. 89-90]. Bank Mandiri last reported 11,514 ATMs in 1Q 2014, with a total of 231.3m transactions valued at $3.1bn over the quarter [*PT Bank Mandiri (Persero) Tbk 1Q 2014 Results Presentation*, *op.cit.*, pp. 4, 23]. We use averages of 200 transactions and $6,000 per ATM/day.

[77] *Annual Report 2006*, Bank Central Asia, Jakarta, May 2006, p. 68.

[78] "Contract signing between BRI with Space Systems/Loral, LLC and Arianespace for BRI Satellite Program", press release, PT Bank Rakyat Indonesia (Persero) Tbk., Jakarta, 28 Apr. 2014. On BRI's comments on the program's cost see for instance Nidia Zuraya, "SBY: BRI Bank Pertama di Dunia yang Memiliki Satelit Sendiri", *Republika*, 28 Apr. 2014.

[79] For an overview of these efforts see for instance *Developing a financial inclusion strategy: The case of Indonesia*, presentation by Muliaman D. Hadad, deputy governor, Bank of Indonesia, at the 2010 AFI Global Policy Forum, Bali, 27-29 Sept. 2010.

[80] Derived from *Indonesian Banking Statistics*, Otoritas Jasa Keuangan, Jakarta, Feb. 2014, tab. 4.19a.

[81] *Q1-2014 Financial Update Presentation*, op.cit., p. 39.

[82] *PT Bank Mandiri (Persero) Tbk 1Q 2014 Results Presentation*, *op.cit.*, p. 40.

[83] Interview with PT. Pasifik Satelit Nusantara official, *op.cit.*, 6 May 2014.

[84] Muhammad Chandrataruna and Tommy Adi Wibowo, "Ini Mobil Internet Keliling ala Lintasarta", *Viva News*, 13 Apr. 2013.

[85] Interview with PT. Patra Telekomunikasi official, *op.cit.*; *Indonesian Banking Statistics*, *op.cit.*, tab. 1.

[86] At YE 2013 Alfamart had 8,557 stores [*Management Presentation Full Year 2013*, PT Sumber Alfaria Trijaya Tbk, Banten, 10 Apr. 2014, p. 10]; Indomaret currently reports having 9,096 stores [*Sejarah Perkembangan Perusahaan*, PT. Indomarco Prismatama, Jakarta, http://indomaret.co.id/profil-perusahaan].

[87] Muhammad Sarwani, "Alfamart, Indomaret Issue Bonds to Finance Business Expansion", *Bisnis Indonesia*, 24 Mar. 2014.

[88] *Gross Domestic Product at Current Market Prices By Industrial Origin (Billion Rupiahs), 2004-2013*, Badan Pusan Statistik, Jakarta [http://www.bps.go.id/eng/tab_sub/view.php?kat=2&tabel=1&daftar=1&id_subyek=11&notab=1].

[89] Interview with Harris CapRock Communications official, Jakarta, 7 May 2014.

[90] Interviews with Harris CapRock Communications and PT. Patra Telekomunikasi officials, *op.cit.*, 7-8 May 2014. We did not interview the third principal service provider in this sector, PT. Primacom.

[91] Interview with Harris CapRock Communications official, *op.cit.*

[92] Interview with PT. Pasifik Satelit Nusantara official, *op.cit.*

[93] Interview with PT. Patra Telekomunikasi official, *op.cit.*

[94] For background see for instance *e-KTP*, KTP Elektronik Indonesia, Jakarta [http://www.e-ktp.com]; *National Electronic ID Card (e-ktp) Programme in Indonesia*, presentation by Unggul Priyanto, deputy dhairman, Badan Pengkajian dan Penerapan Teknologi, at the 2012 ID World Conference, Abu Dhabi, 18-19 Mar. 2012.

[95] *Indonesian National ID Card (EKTP)*, Biomorf Lone, Jakarta [http://www.biomorf.com/ektp.html]; *The Electronic ID (e-KTP) Program in Indonesia 2011-2012*, presentation by Dr. Husni Fahmi, head of e-KTP Technical Team, Ministry of Home Affairs, at the 2012 Biometric Consortium Conference, Tampa, FL, 18-20 Sept. 2012, pp. 10, 12; interview with Indosat official, Jakarta, 5 May 2014.

[96] For a current description of InaTEWS see *Indonesia Tsunami Early Warning System*, Badan Meteorologi Klimatologi dan Geofisika, Jakarta [http://inatews.bmkg.go.id/new/index.php]. An official of Indosat, which provides the satellite connectivity, confirmed that the network operates in C-band [interview, *op.cit.*]

[97] Interview with PT. Pasifik Satelit Nusantara official, *op.cit.*, 6 May 2014.

[98] Interviews with Indosat and PT Pasifik Satelit Nusantara officials, *op.cit.*, 5-6 May 2014. INAFIS has proven controversial due in particular to the potential for duplication with e-KTP, and its development was reportedly suspended in 2012 [see for instance Farouk Arnaz, "Indonesia's National Police Suspend Inafis ID Card Program", *Jakarta Globe*, 26 Apr. 2012].

[99] *Percentage of Households with Mobile Cellular Telephone by Urban Rural Classification, 2005-2012*, Badan Pusan Statistik, Jakarta [http://www.bps.go.id/eng/tab_sub/view.php?kat=2&tabel=1&daftar=1&id_subyek=02&notab=5].

[100] Interviews with Indosat and PT. Pasifik Satelit Nusantara officials, op.cit., 6 May 2014; presentation by Budi Hardjono, head of Network Planning, XL Axiata, at the 2011 International Conference on Asia-Pacific Satellite Communication Systems, Jakarta, 15-16 June 2011.

[101] Interviews with Indosat and PT. Pasifik Satelit Nusantara officials, op.cit., 6 May 2014; presentation by Budi Hardjono, head of Network Planning, XL Axiata, at the 2011 International Conference on Asia-Pacific Satellite Communication Systems, Jakarta, 15-16 June 2011.

[102] We assume that each earth station supports 3 cellular base stations in the networks of Telkomsel and XL, each in turn supporting 2,000-5,000 subscribers, and that each earth station in the Indosat network supports one base station, each supporting 1,000-5,000 subscribers given a proportion of so-called pico-BTS which the company has deployed. We further assume 90.6m rural cellular subscribers based on demographic and teledensity statistics [interviews with Indosat officials, June 2011 and *op.cit.*, 6 May 2014].

[103] The average revenue per subscriber of Indonesian cellular carriers is taken at Rp32,413 ($3.1) per month in 2013 [*Global Wireless Matrix 1q14*, Bank of America Merrill Lynch, New York, 21 Apr. 2014, p. 237].

[104] Interview with PT. indosat official, Jakarta, 14 June 2012.

[105] Though limited information is yet available on Palapa Ring II, press reports suggest some slippage and a recent revision of the number of points of presence, from 66 to 51 locations ["Tender Palapa Ring Tahap II Dibuka Desember", *Indonesia Finance Today*, 6 Oct. 2013; Rezza Aji Pratama and Hadijah Alaydrus, "Palapa Ring II Project to be offered in July-September", *Bisnis Indonesia*, 10 Mar. 2014].

[106] *Indonesia: Policy to Overcome Digital Divide, presentation by Pr. Kalamullah Ramli, director general of Posts and Information Technology, at the 2014 Luxembourg International Satellite Conference, Luxembourg, 6-8 May 2014, p. 15; USO dan Telkomsel Merah Putih, PT. Telkomunikasi Selular, Jakarta [http://www.telkomsel.com/program/uso-dan-telkomsel-merah-putih/9152-USO-dan-Telkomsel-Merah-Putih.html].*

[107] Interview with Lintasarta official, *op.cit.*, 6 May 2014.

[108] Company profiles – Analysis of FSS operators, 2013 Edition

[109] Preliminary Figures, Papua New Guinea Census 2011, p.6

[110] http://www.weather-and-climate.com/average-monthly-Rainfall-Temperature-Sunshine-in-Papua-New-Guinea

[111] http://data.worldbank.org/country/png

[112]Australia govt. department of foreign affairs. https://www.dfat.gov.au/geo/png/png_brief.html

[113] Derived from Exhibit 15 and population data cited in *Preliminary Figures: Papua New Guinea Census 2011*, National Statistical Office of Papua New Guinea, Port Moresby, Apr. 2012, pp. 10-34, and *Papua New Guinea District and Provincial Profiles*, The National Research Institute, Boroko (Papua New Guinea), Mar. 2010.

[114] Interview with National Broadcasting Corp. (NBC) official, Port Moresby, 13 May 2014.

[115] Interview with EMTV official, Port Moresby, 12 May 2014.

[116] *Independent Evaluation Report*, Media for Development Initiative, Port Moresby, Mar. 2012, p. 15.

[117] Interview with TE (PNG) Ltd. official, Port Mortesby, 14 May 2014.

[118] Interviews with EMTV, NBC and TE (PNG) officials, *op.cit.*, 12-14 May 2014; email from Hitron Ltd. official, 14 Apr. 2014.

[119] *Citizen Access to Information in Papua New Guinea*, Australian Broadcasting Corp., Sydney, June 2012, p. 49. Note however that only 25% of the survey's sample was located in "remote" rural areas (ibid., p. 68), which may have biased it against communal viewing.

[120] *Papua New Guinea District and Provincial Profiles*, *op.cit.*, p. 1.

[121] *Citizen Access to Information in Papua New Guinea*, *op.cit.*, p. 33; Zahid Hasnain, *et al.*, *How Capital Projects are Allocated in Papua New Guinean Villages*, The World Bank, Washington, D.C., Aug. 2011, p. 33.

[122] *Papua New Guinea Medium Term Development Plan 2011-2015*, Department of National Planning and Monitoring, Port Moresby, Aug. 2010, p. 73.

[123] *EQUITV (Enhancing Quality in Teaching through TV Programs) Phase 2*, Japan International Cooperation Agency, Tokyo [http://www.jica.go.jp/project/english/png/001]; *Public Investment Program 2013-2017*, Department of National Planning and Monitoring, Port Moresby, Nov. 2012, vol.3, pp. 161-162; interview with EMTV official, *op.cit.*, 12 May 2014; *2008 Education Statistics*, Department of Education, Port Moresby, 2008, p. 13; interview with the Japanese International Cooperation Agency project leader for EQUITV, Port Moresby, 15 May 2014.

[124] *Papua New Guinea Project for Enhancing Quality in Teaching Through TV Program: Third Endline Survey Report, 2008*, Department of Education, Port Moresby, Oct. 2008, pp. 7-8, 11.

[125] Interview with Hitron Ltd. officials, Port Moresby, 16 May 2014. Hitron is one of PNG's largest C-band dish retailers.

[126] *Papua New Guinea Services Sector Analysis*, International Trade Center, Geneva, June 2013, p. 3.

[127] *Annual Report 2013*, Fiji Television Ltd., Suva, Oct. 2013, p. 15.

[128] Interview with EMTV official, *op.cit.*, 12 May 2014.

[129] Interview with NBC official, *op.cit.*, 13 May 2014.

[130] Interview with EMTV official, *op.cit.*, 12 May 2014.

[131] *Papua New Guinea: Telecoms, Mobile and Broadband*, Paul Budde Communications Pty. Ltd., Bucketty (Australia), 9 Mar. 2013, pp. 15-16.

[132] *Citizen Access to Information in Papua New Guinea*, *op.cit.*, p. 38; interview with TE (PNG) Ltd. official, *op.cit.*, 14 May 2014.

[133] Interview with NBC official, *op.cit.*, 13 May 2014.

[134] Interview with Telikom PNG Ltd. officials, Port Moresby, 15 May 2014. Such incidents are rarely publicized, but for one example see "Disgruntled PNG Landowners Attach Digicel Tower", *The National* (Port Moresby), 25 Nov. 2008.

[135] Interview with SpeedCast Ltd. officials, Port Moresby, 12 May 2014.

[136] Estimated from interviews with Telikom PNG, Digicel and Oceanic Broadband officials, Port Moresby, 15 May 2014, assuming an average price of $3,000 per MHz/month. The resulting figure is an under-estimate as it omits several other service providers which declined to comment on their leased capacity or were not interviewed.

[137] Interview with Telikom PNG and Hitron officials, *op.cit.*, 15-16 May 2014.

[138] *Papua New Guinea*, World Trade Organization, Geneva, Mar. 2014 [http://stat.wto.org/CountryProfile/WSDBCountryPFView.aspx?Language=E&Country=PG].

[139] Interview with SpeedCast Ltd. officials, *op.cit.*, 12 May 2014.

[140] *ibid*, " InterOil hooks up with satellite technology", *PNG Industry News*, 21 Aug. 2008.

[141] Interview with Harris CapRock Communications official, Port Moresby, 16 May 2014.

[142] Plant costs inferred from *2011 National Budget*, Ministry of Treasury, Finance and Public Service, Port Moresby, Nov. 2010, vol. 1, p. 143; ship costs are a market average cited in Mark Odell, "LNG carriers provide bright spot to gloomy shipping sector", *Financial Times*, 24 Nov. 2013.

[143] Interview with Harris CapRock Communications official, *op.cit.*, 16 May 2014.

[144] Interview with Talisman Energy official, Port Moresby, 14 May 2014.

[145] "Pactel and Rural Tech Development Implement Innovative PNG LNG Worker Welfare Solution", press release, Pactel International, Botany (Australia), 25 Mar. 2013. Pactel confirmed that this link uses C-band [email from Pactel International official, 15 May 2014].

[146] *PNG LNG Project Environmental Impact Statement*, Exxon Mobil PNG Ltd., Port Moresby, Jan. 2009, p. 15-36.

[147] *Petroleum in PNG*, PNG Chamber of Mines and Petroleum, Port Moresby [http://pngchamberminpet.com.pg/petroleum-in-png].

[148] "Export Commodities Review", *Quarterly Economic Bulletin* (Port Moresby: Bank of Papua New Guinea), June 2013, pp. 13-16.

[149] *Mining in PNG*, PNG Chamber of Mines and Petroleum, Port Moresby [http://pngchamberminpet.com.pg/mining-in-png]; *Granted Exploration Licenses*, Mineral Resources Authority of Papua New Guinea, Port Moresby, Mar. 2013.

[150] Interview with Harris CapRock Communications official, *op.cit.*, 16 May 2014.

[151] Interview with SpeedCast Ltd. official, *op.cit.*, 12 May 2014.

[152] *Annual Report for the Year Ended 30 June 2013*, Frontier Resources Ltd., West Perth (Australia), Sept. 2013, p. 55.

[153] *ATM*, Bank of South Pacific Ltd., Port Moresby [http://www.bsp.com.pg/Personal/Ways-to-Bank/ATM/ATM.aspx]; *Find a Branch or ATM*, Westpac Banking Corp. , Sydney[http://www.westpac.com.pg/pacific/find-branch-atm]; *Find a Branch/ATM*, Australia and New Zealand Banking Group Ltd., Melbourne [http://www.locate.anz.com/anz/international].

[154] *BSP Rural*, Bank of South Pacific Ltd., Port Moresby [http://www.bsp.com.pg/Personal/BSP-Rural]; *2013 Annual Report*, Bank of South Pacific Ltd., Port Moresby, Apr. 2014, p. 13.

[155] Interview with Oceanic Broadband official, *op.cit.*, 15 May 2014.

[156] *Papua New Guinea: Telecoms, Mobile and Broadband*, *op.cit.*, p. 19; interview with Digicel official, *op.cit.*, 15 May 2014. PNG cellular carriers do not disclose their subscriber counts.

[157] Interview with Bmobile official, Port Moresby, 13 May 2014.

[158] *National Broadband Policy*, *op.cit.*, p. 13.

[159] *Draft UAS Regulations for NICTA Review and Comment*, National Information and Communication Technology Agency, Port Moresby, 20 Nov. 2013.

[160] *Restructuring Paper on a Proposed Project Restructuring of PG: Rural Communications Project*, 76858-PG, The World Bank, Washington, D.C., 27 May 2013, p. 11.

[161] *Demonstration Project for Voice Telephony Network Services Under the Universal Access Scheme*, CSTB Tender 2832, Central Supply and Tenders Board, Port Moresby, July 2013, schedule 2, §3.

[162] *Implementation Status & Results - Papua New Guinea - PG: Rural Communications Project (P107782)*, ISR13418, The World Bank, Washington, D.C., 18 Apr. 2014.

[163] Interviews with service providers, Port Moresby, May 2014.

[164] Interview and email from Telikom PNG officials, op.cit., 15 and 22 May 2014.

[165] *2010 Annual Report*, PNG Air Navigation Services Ltd., Port Moresby, June 2011, p. 28.

[166] Interview with PNG Air Services Ltd. official, Port Moresby, 13 May 2014.

[167] See for instance Elias Nanau, "'Clean' internet for school", *The National* (Port Moresby), 25 June 2013, on a contribution of 150,000 kina paid by the administration of Telefomin district to equip two schools, equivalent to 10% of the district's education budget; "SHP schools go hi-tech", *Post Courier* (Port Moresby), 30 May 2013, on the governor of Southern Highlands province presenting 500,000 kina to equip 12 schools; and similar examples in "Lae Schools to get Clean IT" and "Bugandi Secondary School gets clean IT", *Papua New Guinea Education News*, 8 Jan. and 8 Apr. 2014; Freddy Mou, "Schools win from 'clean internet'", *PNG Loop*, 5 May 2014; interview with Telikom PNG officials, *op.cit.*, 15 May 2014.

[168] *National Broadband Policy, Papua New Guinea* (public draft), National Information and Communication Technologies Agency, Port Moresby, 22 Apr. 2013, p. 14.

[169] *ibid.*, p. 14.

[170] Interviews with Telikom PNG and another service provider (name withheld for competitive reasons), *op.cit.*

[171] *PNG LNG Project Environmental Impact Statement*, *op.cit.*, p. 15-18.

[172] Interview with Oceanic Broadband official, *op.cit.*, 15 May 2014.

[173] http://data.worldbank.org/country/india

[174] Census India-2011

[175] http://data.worldbank.org/country/india

[176] *Consultation paper on Monopoly/Market dominance in cable TV services,* 3rd June 2013, Telecom Regulatory Authority of India (TRAI), p.12.

[177] *The power of a billion: Realizing the Indian dream - FICCI-KPMG Indian Media and Entertainment Industry Report 2013, KPMG, Mumbai, Mar. 2013, p. 9, and India Entertainment and Media Outlook 2013, PricewaterhouseCoopers, New Delhi, 2013, p. 14.*

[178] Euroconsult estimates based on *The power of a billion, op.cit., p. 22. and The Indian Telecom Services Performance Indicators, TRAI, October-December, 2012, p.76.*

[179] *The power of a billion*, *op.cit.*, p. 22 and *Consultation Paper on Monopoly/Market dominance in Cable TV services*, op.cit, p. 12.

[180] *The power of a billion*, *op.cit.*, p. 21

[181] *Consultation paper on Monopoly/Market dominance in cable TV services,* op.cit, p.3.

[182] *India's MSO to focus on HITS platform for Phase III and IV*, NexTV Asia Pacific, March 22, 2013 (http://nextvasia.com/1-cable-dth/indias-mso-to-focus-on-hits-platform-for-phase-iii-and-iv/)

[183] *The Indian Telecom Services Performance Indicators, TRAI, October-December, 2013, p.78.*

[184] *DTH platforms: Key Dynamics and Prospects*, Euroconsult, November 2013

[185] *IPTV to add 100 million subscriptions*, Digital TV Research, 4th September 2013 (http://www.digitaltvresearch.com/press-releases?id=67)

[186] *The power of a billion*, *op.cit.*, p. 37

[187] *The Indian Telecom Services Performance Indicators, TRAI, October-December, 2012, p.72*

[188] *India Entertainment and Media Outlook 2013*, op.cit, p. 12.

[189] *The Indian Telecom Services Performance Indicators, op.cit, p.77*

[190] *The Indian Telecom Services Performance Indicators, op.cit, p.78.*

[191] Euroconsult based on LyngSat monitoring of TV signals.

[192] Euroconsult based on LyngSat monitoring of TV signals.

[193] *Indian Satcom Markets 2014 Country Profile*, Euroconsult, 2014 edition

[194] *India Entertainment and Media Outlook 2013*, op.cit, p. 12.

[195] *The power of a billion*, *op.cit.*, p. 14

[196] *The power of a billion*, *op.cit.*, p. 22

[197] *India Entertainment and Media Outlook 2013*, PricewaterhouseCoopers, New Delhi, 2013, p. 15.

[198] *India Entertainment and Media Outlook 2013*, op.cit, p. 13.

[199] An interview with an official from Esselshyam Communications, 26 May 2014, confirmed that DTH platforms receive C-band contribution channels at their broadcast teleports, which further get uplinked in Ku-band for DTH distribution,

[200] Telephone interview with Space Link official, *op.cit.*, 26 Mar. 2014.

[201] *Strengths*, Space Link Systems Pvt. Ltd., New Delhi [http://www.spacelinkindia.com/strength.htm]

[202] Email and telephone interviews with Indian news broadcaster, 5 and 16 Apr. 2014

[203] Note that this includes some channels observed on satellites covering India, but not licensed by the ministry of Information and Broadcasting (MIB). As of September 2013 the MIB had licensed 784 channels [*The Indian Telecom Services Performance Indicators*, *op.cit.*, p. 78]. We did not match them against Lyngsat channel lists, but the numbers are close enough that the proportion carried in C-band clearly has to be about the same.

[204] Interview with Ministry of Information and Broadcasting official, New Delhi, 5 Mar. 2014.

[205] Signals count derived from transponder monitoring by Lyngemark Satellite, Lyngby, Denmark [www.lyngsat.com, accessed 25 Mar. 2014]. For most signals the same source provides a symbol rate, taken to be equivalent to bandwidth divided by ~1.35 to account for bandwidth roll-off (some modulation techniques permit lower roll-offs, but may not be widely used by Indian broadcasters); this suggests ~2 MHz per channel, a low bandwidth allocation, which service providers confirm to be the average but which may well be unsustainable if substantial rain fade is added to the link budget. Interviews with broadcasters and service providers indicate that C-band capacity is currently leased in the range of $2,500-3,000 per MHz/month in India.

[206] *The Indian Telecom Services Performance Indicators*, *op.cit.*, pp. 130-134.

[207] Interview with Indiasign Pvt. Ltd. official, Gurgaon, 3 May 2014.

[208] *Guidelines for Obtaining License for Providing Direct-to-Home (DTH) Broadcasting Service in India*, Ministry of Information and Broadcasting, New Delhi, 15 Mar. 2001, §7.6.

[209] "New Policy Guidelines for Downliking of Television Channels issued", press release, Ministry of Information and Broadcasting, New Delhi, 11 Nov. 2005.

[210] *The Indian Telecom Services Performance Indicators*, *op.cit.*, p. 79.

[211] Derived from *Distribution of the 22 Scheduled Languages*, *op.cit.*, and *State-Wise GSDP*, Data table No. 62, Planning Commission, New Delhi, Mar. 2014 [http://planningcommission.gov.in/data/datatable/1203/table_62.pdf]. Unfortunately the available statistics seem to provide no further insights. Obviously there are affluent Urdu speakers, in these or other states, and their geographic distribution may have evolved since the data were last compiled in 2001. On balance however the available socio-economic data are unlikely to encourage DTH operators to invest much in Urdu programming.

[212] *The power of a billion*, *op.cit.*, p. 22.

[213] As shown at Exhibit 26, this omits the C-band sites of four service providers (TataNet, BSNL, Essel Shyam and Reliance Jio Infocomm, formerly known as Infotel Satcom), for which their number was not provided to us by TRAI, as well as Infinium India, which operates only seven sites of undetermined characteristics.

[214] Interview with Hughes Communications India Ltd. (HCIL) official, New Delhi, 5 Mar. 2014.

[215] National policy on education, http://en.wikipedia.org/wiki/National_Policy_on_Education, May 6, 2014

[216] UNICEF, Global Initiative on Out-of-School Children, South Asia Regional Study, January 2014

[217] UNICEF, Global Initiative on Out-of-School Children, South Asia Regional Study, January 2014

[218] UNICEF, Global Initiative on Out-of-School Children, South Asia Regional Study, January 2014

[219] Interviews with HCIL official, New Delhi, 5 Mar. and 30 Apr. 2014.

[220] Interview with HCIL official, *op.cit.*, 30 Apr. 2014; *Union Government (Scientific and Environmental Ministries/Departments)*, Report No. 22/2013 on Compliance Audit, Comptroller and Auditor General of India, New Delhi, 6 Sept. 2013, pp. 41, 43.

[221] ISRO last reported that the overall Edusat program totalled about 56,000 terminals and trained ~15m students p.a., or 167 students per terminal p.a. [*Annual Report 2012-2013*, Department of Space, New Delhi, Mar. 2013, p. 37].

[222] *CEC's EDUSAT Network*, Consortium for Educational Communication, New Delhi, [http://cec.nic.in/EDUSAT/Pages/default.aspx].

[223] *Request for Proposal (RFP) For Implementation of Andaman & Nicobar Network (AN.net)*, Tender No. OV/1-65/AN.net/2012/05, Society for Promotion of Vocational and Technical Education, Port Blair, 4 Apr. 2012, p. 12.

[224] "Educomp launches programme for CA coaching", *Business Standard* (New Delhi), 31 July 2008; *Annual Report 2011-12*, Educomp Solutions Ltd., New Delhi, Sept. 2012, p. 20.

[225] *What is Leap*, Educomp Solutions Ltd., New Delhi [http://www.educomp.com/products/EducompLeap.aspx]. HCIL, which operates the Educomp networks, confirmed that they use C-band.

[226] *Annual Report 2012-2013*, *op.cit.*, pp. 38-39.

[227] *Current status of Telemedicine Network in India and Future perspective*, presentation by Pr. S K Mishra, Sanjay Gandhi Postgraduate Institute of Medical Sciences, at the 32nd Asia-Pacific Advanced Network Meeting, New Delhi, 22-27 Aug. 2011, pp. 6-8; *OncoNET*, National Informatics Centre, New Delhi [http://onconet.nic.in].

[228] *The Department of Telemedicine*, Amrita Institute of Medical Sciences, Ernakulam (India), 2014 [http://www.aimshospital.org/get-help/our-departments/centers/centre-for-digital-health/telemedicine]; *Tele-Health in India: Landscape of tele-health infrastructure at points of service in India*, International Telecommunication Union, Geneva, 2011, pp. 31-33.

[229] *Current status of Telemedicine Network in India and Future perspective*, *op.cit.*, p. 14.

[230] Interview with HCIL official, *op.cit.*, 30 Apr. 2014.

[231] *The Department of Telemedicine*, *op.cit.*; *Current status of Telemedicine Network in India and Future perspective*, *op.cit.*, p. 7; A. Bhaskaranarayana, *et al.*, *Bridging Health Divide Between Rural and Urban Areas – Satellite Based Telemedicine Networks in India*, in P. Olla, *ed.*, *Space Technologies for the Benefit of Human Society and Earth* (Dordrecht: Springer Netherlands, 2009), p. 159.

[232] *OncoNET Kerala*, presentation by N. Neelima, systems manager and head nodal officer for telemedicine, Regional Cancer Centre, at the Jawaharlal Institute of Postgraduate Medical Education and Research, Pondicherry, Jan. 2014, p. 20. A recent income survey puts monthly consumption in rural Kerala at Rp2,669 per month [*Key Indicators of Household Consumer Expenditure in India*, National Sample Survey Office, New Delhi, June 2013, p. 10].

[233] Interview with HCIL official, op.cit., 5 Mar. 2014.

[234] Interview with Indian service provider, Apr. 2014.

[235] Few technical descriptions of GSat 7 have been published; see *RFD (Results-Framework-Document) for Department of Space (2011-2012)*, Department of Space, New Delhi, 17Apr. 2012, p. 33.

[236] Tali Tsipori, "Satellite co Orbit triples size of Indian Navy order", *Globes* (Tel Aviv), 25 July 2010; *Installation of Rukmani C Band Satcom Terminal On Board Twelve WNC Ships*, Tender No. DYT/INCOD/1314/106(a)/PLWEA/IN

SHIPS RUKMANI/208, Indian Navy, Mumbai, 10 Oct. 2013. This request for proposals mentions for the terminals in question a mass of 1,200 kg, suggesting a fairly large antenna (*ibid.*, p. 12).

[237] Interview with Indian service provider, New Delhi, Mar. 2014.

[238] Interview with service provider to the Indian Army, Apr. 2014.

[239] *Indian Navy joins search for missing Malaysian plane in the Malacca Straits*, Jayanta Gupta, TNN, The Times of India, 11 March 2014

[240] *National Disaster Management Information and Communication Systems*, National Disaster Management Authority, New Delhi, Feb. 2012, pp. 18-19; "15000 Police Stations & 7000 Higher Offices to be Covered Under CCTNS", press release, Ministry of Home Affairs, New Delhi, 2 Aug. 2011. Not all 15,000 locations, however, would necessarily be outfitted in C-band. For detailed network maps see *POLNET*, Ministry of Home Affairs, Directorate of Coordination Police Wireless, New Delhi, http://dcpw.nic.in/?0400.

[241] Emergency Events Database EM-DAT, May 2014

[242] *National Policy on Disaster Management 2009*, Government of India, Ministry of Home Affairs, National Disaster Management Authority, approved by the Union Cabinet on 22nd October, 2009

[243] *National Disaster Management Information and Communication Systems*, *op.cit.*, pp. 17-18.

[244] See *Real time earthquake monitoring for early warning of tsunamis*, presentation by R.S.Dattatrayam, India Meteorological Department, at the 2nd India Disaster Management Congress, New Delhi, 4-6 Nov. 2009, p. 14, for a network diagram which shows this system to rely on an ISRO satellite with C-band transponders only.

[245] For a summary see *National Disaster Communication Network*, National Disaster Management Agency, New Delhi [http://www.ndma.gov.in/en/ongoing-programmes/ndcn.html, updated Sept. 2013].

[246] Interview with Indian service provider, New Delhi, 7 and 29 Apr. 2014.

[247] National telecom Policy 2012, Ministry of Communications & IT, Department of telecommunications, June 2012

[248] The Economic Times, http://articles.economictimes.indiatimes.com/2014-01-22/news/46463062_1_nofn-bbnl-bharat-broadband-network-ltd, January 22, 2014

[249] TRAI, Press Release No. 65/2013

[250] Interview with HCIL official, op.cit., 30 Apr. 2014; "Village Resource Centres", press release, Ministry of Science and Technology, New Delhi, 12 Feb. 2014.

[251] For instance see A. Shamna, *et al.*, "Performance of Village Resource Centres (VRCs) in Karnataka : An Analysis", *Indian Research Journal of Extension Education*, 13(3), Sept. 2013, pp. 1-8.

[252] *GRAMSAT Project*, Orissa Panchayati Raj Department, Bhubaneswar [http://www.orissa.gov.in/panchayat/state.htm].

[253] *Outcome Budget of the Department of Space*, Government of India 2013-2014", Department of Space, New Delhi, Mar. 2013, p. 62; *RFD (Results-Framework-Document) for Department of Space (2011-2012)*, *op.cit.*, p. 25.

[254] Interview with HCL official, *op.cit.*, 7 Apr. 2014.

[255] "BSNL, ISRO spar over satellite bandwidth", *Business Line*, 16 Apr. 2014; "Andaman demands one GBPS bandwidth from ISRO's new Satellites", United News of India, 20 Apr. 2014.

[256] Interview with HCL Comnet Systems & Services official, New Delhi, 7 Apr. 2014.

[257] *Handbook of Statistics on Indian Securities Market 2012*, Securities and Exchange Board of India, New Delhi, Jan. 2014, table 1.

[258] Derived from turnovers reported at *Equity Turnover*, Bombay Stock Exchange, Mumbai [http://www.bseindia.com/markets/keystatics/Keystat_turnoverequity.aspx?expandable=0] and *Business Growth in CM Segment*, National Stock Exchange, New Delhi [http://www.nse-india.com/products/content/equities/equities/historical_equity_businessgrowth.htm], based on the average exchange rate over the period, 251 trading days and 7 hours of market activity per day (the latter from *Market*

Timings & Holidays, National Stock Exchange, New Delhi, http://www.nseindia.com/global/content/market_timings_holidays/market_timings_holidays.htm).

[259] Interviews with HCIL and HCL Comnet Systems & Services officials, New Delhi, 5 Mar. and 7 Apr. 2014.

[260] For instance *Request for Proposal for Wide Area Network with MPLS Technology and VSATs for Regional Rural Banks sponsored by Andhra Bank*, Tender No. 666/35/RRB-RFP/2009-2010/15, 2 Feb. 2010, pp. 11, 30, and *Request for Proposal for procurement of VSATs & VSAT related support services*, *op.cit.*, p. 9, specifying 99.5% reliability. Another, more detailed tender specified 99.5-99.95% network availability [*Request for Proposal: Core Banking Project*, Tripura State Co-Operative Bank Ltd., Agartala, 30 May 2012, Annexure 7, pp. 6-7].

[261] *Satellite Connectivity to facilitate penetration of banking services – Need for financial incentives to banks: Discussion Paper*, Reserve Bank of India, New Delhi, 12 June 2008.

[262] Interview with HCIL official, *op.cit.*, 5 Mar. 2014. At least as many ATMs use Ku-band antennas, in areas where rain fade is considered an acceptable burden.

[263] *Financial Access Survey*, International Monetary Fund, Washington, D.C. [http://fas.imf.org, updated 2013].

[264] Interview with HCL Comnet official, *op.cit.*, 7 Apr. 2014.

[265] G.R. Kanel, *Communication Networks in ONGC*, Oil and Natural Gas Corp., Dehradun, Apr. 2013, pp. 58-86. ONGC also operates Ku-band terminals, but principally on offshore rigs or as backups to C-band links; see for instance "Tatanet Bags ONGC order for Satellite Connectivity", press release, Nelco Ltd., Mumbai, 18 Mar. 2009.

[266] Telephone interview with Indian VSAT installer, 10 Apr. 2014.

[267] Interview with HCIL official, op.cit., 30 Apr. 2014.

[268] *One of the largest SCADA implementations in the world*, ABB, Zurich [http://new.abb.com/smartgrids/projects/karnataka]; for a technical description of the network see also T.P. Surekha, et al., "Performance Evaluation of VSAT-QPSK System", *International Journal of Emerging Technology and Advanced Engineering*, Aug. 2013, pp. 726-730. At least one other major utility, the National Thermal Power Corp. – India's largest – uses C-band to manage its smart grid, though it is not clear how many terminals this involves [*National Thermal Power Corp. upgrades SCADA systems with CMC's Osker*, CMC Ltd., New Delhi, 2013; D.S. Madhumathi, "After 10 years in orbit, INSAT-3E expires", *The Hindu*, 2 Apr. 2014].

[269] *Communication, Navigation & Surveillance Manual*, Aiports Authority of India, New Delhi, May 2010, pp. 73-76

[270] *Mutual Collaboration for Regional SBAS*, presentation by the Airports Authority of India to the 4th Meeting of the South Asia/Indian Ocean ATM Coordination Group, International Civil Aviation Organization, Hong Kong, 24-28 Feb. 2014.

[271] *Rate Contract for the Operations of VSAT Network, AMC of Hub, AMC of VSATs and Procurement of New VSATs*, Tender No. EI-D/OPS/17-28/13, ERNET India, Ministry of Communications & Information Technology, New Delhi, 11 Sept. 2013, p. 22.

[272] *Law and Order Police Stations*, Hyderabad City Police, Hyderabad [http://www.hyderabadpolice.gov.in/Index-Files/AllPsIndex.htm].