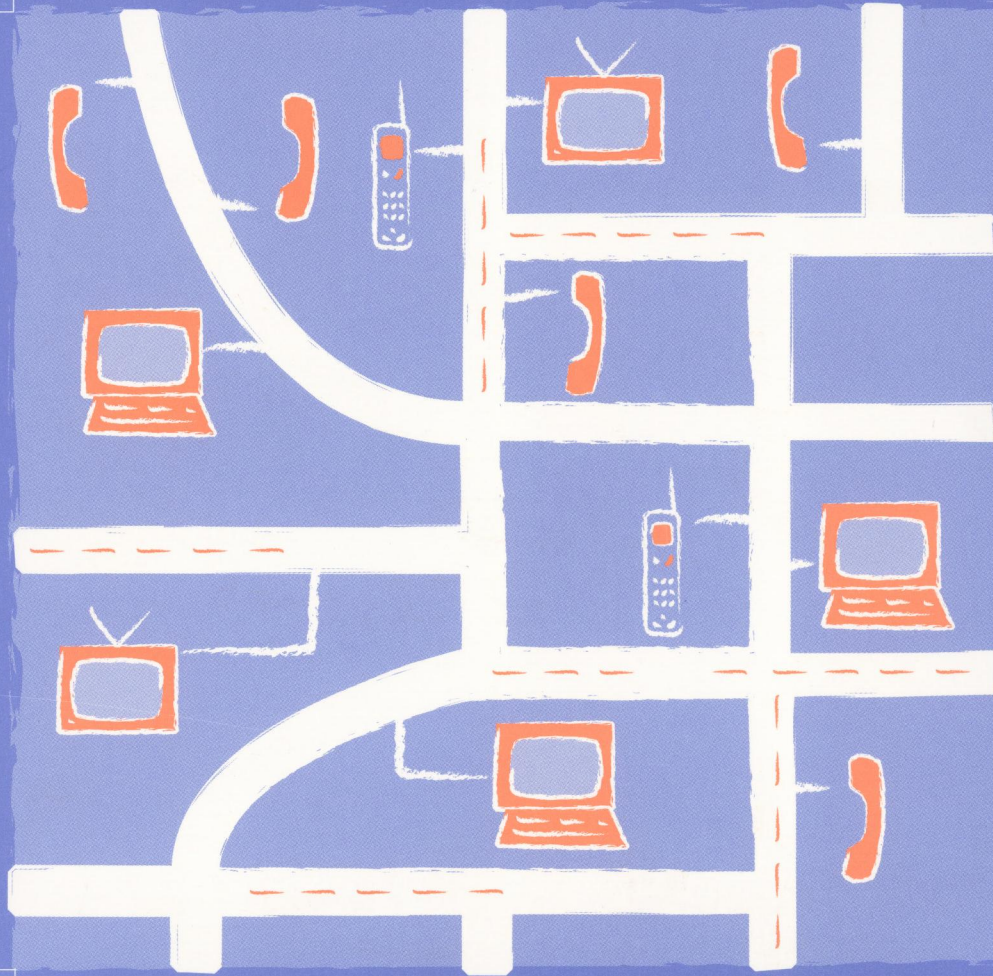


TeleGeography 2000

Gregory C. Staple, Editor



TeleGeography® 2000

Global Telecommunications Traffic Statistics and Commentary

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Preface

New Day

As we enter the new century and the new millennium, no other industry is changing our world so quickly, impacting people around the globe so profoundly, or redefining our new day so definitively as global communications. Our industry is in a state of creative upheaval, generating unbounded opportunities for both communications providers and those served by the communications industry. It is a moment when, as Albert Einstein said, "Imagination is more important than knowledge."

What was a voice-dominated business is rapidly becoming a data-dominated business. Switched circuits are morphing into routed packets, and former monopoly environments are turning competitive. Also, the mother of all disruptive technologies, the Internet, is itself continuing to undergo rapid change. A few years ago we thought of the Internet as a path to the "global village," where technologically savvy intellectuals could go to communicate cheaply. But in an amazing instant, the Internet has been transformed from a rather small community into a global metropolis—creating opportunities for people in all professions and socio-economic groups around the world. It has become a global marketplace for goods as well as ideas, growing at rates larger than anything the world has seen previously.

Fueling this rapid growth of advanced data services is bandwidth. Bandwidth availability is growing so quickly that it dwarfs the much-heralded metrics of Moore's Law. Global bandwidth is doubling every 100 days with no slow-down in sight. Futurologist George Gilder calls bandwidth the "defining abundance" of our day, playing the same role as electricity in the industrial age and transistors in the computer era. And like the "defining abundances" before it, bandwidth shows extraordinary elasticity of demand. Falling prices increase demand so rapidly that revenue rises faster than prices fall.

The bandwidth explosion on international telecommunication routes is among the fastest growing of all communications sectors. New competitors as well as existing providers are driving an increasingly robust and competitive marketplace. The new routes nearing completion across the Pacific—China-US, Japan-US, and Southern Cross—will increase by a factor of forty the total cross-Pacific capacity that existed previously. Also, across the Atlantic, bandwidth availability is increasing on a logarithmic scale. TAT-14, scheduled for completion late in 2000, will handle an astounding seven million simultaneous voice conversations. And that is just phase one—there are plans to double this capacity by 2002. Bandwidth growth just continues to create the opportunity for more applications, reaching ever-wider audiences. Ultimately, the growth of bandwidth, along with that of the Internet is creating the Golden Age of Communications.

As we go forth in these exciting and sometimes confusing times, it helps to have a reliable guide that shows a detailed snapshot of the flows of these global communications capabilities that drive this change. That is why MCI WorldCom and BCE Nexxia are proud once again to sponsor *TeleGeography 2000*. For customers and providers, for regulators and investors, and for futurologists and opportunists, this industry standard is essential reading.

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Walter Blackwell, Vice President
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BCE Nexxia

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The Editors

The Soft Network

by Gregory Staple, TeleGeography, Inc.

Broadband networks which are Internet-compatible and software-driven will change almost everything—services, routing, revenues—for today’s long distance telephone companies.

Forward

This essay is about the future of global telecommunications. It begins with a local story though—a story about one day last summer when a company named e.spire began laying fiber optic cables through my Washington, D.C. neighborhood.

Why start here? The answer has less to do with e.spire or my hometown than the fact that every global network is also a local one. It has a beginning and an end. And, as the high-speed digital capacity at the center of the global network—say between Paris and Washington or between Los Angeles and Tokyo—is brought to the last mile, tens of millions of people will have access to an integrated set of trans-national voice, data, and video services.

This will happen in a handful of countries at first, but over the next decade tomorrow’s network will be characterized by four main features. It will be: (1) broadband from end-to-end, meaning high-speed; (2) Internet-friendly, meaning that telephony and other services will use the Internet’s common packet-switched transmission protocols; (3) always on, like electricity or tap water; and (4) pervasive. On this network, like the Internet today, software applications created by thousands of different vendors will be the driving force—hence the title: “The Soft Network.”

The body of this essay explores this new terrain in more detail and describes in general terms how we may get from here to there. It is followed by a concluding section that looks at the impact high-speed Internet services will have on the revenues and products offered by major international telecom providers. Legacy carriers already face mounting economic pressure as the Internet begins to price all bits alike, whether they are voice bits or data bits, and whether they originate next door or around the world.

The closing section of this essay also briefly describes the new regulatory agenda which broadband packet networks are bringing forward. This agenda includes the terms on which competing service providers will have access to “last mile” facilities as well as network performance, privacy and consumer protection issues.

Now on with the story.

I. Rites of Passage—Asphalt Tattoos

It’s the end of the world as we know it.
It’s the end of the world as we know it.
And I feel fine”

- REM

The millennium came early to my street: on May 15, 1999. I remember the day well, having been jogged awake before 7:00 AM by a cacophony of late 20th century machines preparing the ground for their successors. Diesel engines, pneumatic drills, backhoes and concrete crushers. Who needs alarms?

The work crew began at one end of the block and by the following week, the street had been gifted with a clutch of polyethylene conduits which would soon carry more fiber optic strands than cross the Pacific Ocean.

As I watched all the commotion, I was reminded of the “clouds” engineers love to draw for the Internet—you know, those wavy-edged balloons on a white board which seem to float somewhere above the real world. But the truth was in front of me: cyberspace is less about clouds than ditches . . . miles upon miles of ditches, each wormed with strands of laser-thin glass fiber. Down one street and along the next. Across one city and on to another. City by city, country by country. Today’s public works program is tomorrow’s telegeography. Yes, I thought, almost every click of a mouse begins with a shovel of dirt.

Our local trench-and-fill caravan was led by a compact, purpose-built truck which straddled a tree trunk sized saw blade. It was a circular saw strong enough to cut through 14 inches of tire-worn macadam and concrete. The blade cut parallel incisions about two feet apart running the length of the block. The severed pavement was then unearthed by a small backhoe, after which a pick-and-shovel team dug out another two or three feet of soil and gravel. The bottom of the trench was leveled for the conduits. They came in 20-foot sections and were trussed together in sets of four: olive, blue, orange, and spring green. Joiners worked quickly; once the trench was open, it took only a few hours to put the pipes in place.

Later, I was told, another crew would carefully pull strands of fiber optic cable through two of the pipes, leaving the remaining conduits empty for the future.

Even so, the communications capacity which would thread its way down our block was enormous—enough to carry all the telephone calls in the world, the foreman assured me.

It seemed astonishing, but there is nothing like a ditch across your doorstep to drive a point home. Our tree-lined street had suddenly become a sea-front property. Last week we had been landlocked. Now we were moored in a deep-water port on the busiest waterway in the world.

The events on my block were being duplicated across Washington last summer. And, e.spire, the competitive local exchange carrier at work in our neighborhood, was only one of many new service providers active in the city. *The Washington Post* reported that nine different companies were busy laying fiber optic cable across the town.

The *Post* called it the 'Great Dig of 99': "From coast to coast, the digital age has arrived in America as dozens of companies dig up city streets to install fiber optic cables. Freed . . . from burdensome regulation, heartened by the explosion of Internet use, these companies are part of a digital gold rush."

The trench-and-fill operation that began on Capitol Hill in May had traversed much of the city by mid-summer. In July, I saw some of the same crew working their way down Pennsylvania Avenue to the White House. It led to a further thought: The Internet has put America at the center of the telecosm. Yet, in most people's minds, Washington remains far removed from the cybertribes of Silicon Valley. Now perhaps things will be different. You may not see it on television. But in January 2001, when the next President of the U.S. takes the oath of office on Capitol Hill and begins the traditional parade down Pennsylvania Avenue to the White House, that storied boulevard will have become a virtual thoroughfare to rival all comers.

The summer's long days of dry heat have now given over to a wet autumn and the construction crews seem to have melted away. The streets are still hazardous for shoe leather and car axles alike. Block-long welts of oily black asphalt ooze in the midday sun and subside with every rain. Yet, I have heard few complaints. The landscape's ritual scarification by jackhammer and steamroller seems to be a source of quiet pride. Like its urban cousins around the world, Washington has come of age. The asphalt tattoos which snake across its streets bear witness to the city's rite of passage into the new economy.

II. Code Is a Compass

"If you don't know where you're going,
you may end up somewhere else."

- Yogi Berra

Alright. Let's step back from this story to check our directions. Fiber optic communication cables are hardly novel. Most telcos have been replacing copper and coaxial cables with fiber on trunk routes for years and, in the U.S., new players such as MFS (now owned by MCI WorldCom) and Teleport (owned by AT&T) have been building fiber rings in big cities since the 1980s.

So what is the point here? How does Washington's rite of passage relate to the business of providing international telecommunications? Let me offer some short answers now and then flesh them out later on.

1. Global services need local networks. The end-to-end capacity of any network is no greater than the bandwidth available over the "last mile." Thus, so long as the high-speed capacity which now exists in the middle of the network is poorly matched at the ends, the network's potential will remain largely unfulfilled.

2. The distinction between local and long distance networks, between domestic and international ones, are becoming meaningless. Because fiber optic cables provide essentially unlimited bandwidth, the marginal cost of transmitting additional information on any portion of the route tends towards zero.[1] Long distance networks are becoming local area networks, and hence long distance and local transmission prices are converging. To which there is an important corollary: All bits soon will be priced the same, whether they are "voice" bits or "data" bits. Witness the Internet.

These new pricing rules have already begun to leave their mark in North America and will bite even deeper in the years just ahead (see Section III.A.).

3. Networks are becoming service independent. Again, look to the Internet. That is perhaps the main reason why the business of providing network capacity, of laying down conduits, has become one job; the business of providing services quite another. Put another way, so long as the Internet's open-access model prevails (more on this in Part III), one can become a major communications company—like Yahoo! or RealAudio

[1] For example, Williams Communications, one of the U.S.' new long distance carriers, reports that its longhaul fiber network will have 2 or 3 conduits for cables with the first conduit having at least 96 fibers. Using Dense Wave Division Multiplexing (DWDM), every fiber may carry data on 32 wavelengths, each operating at about 10 Gbps, thus giving the network a total capacity per fiber of over 3 Terabits per second. That is a very large throughput by any measure, and next generation WDM networks may operate at over 80 Gbps on 80 or 120 paths per fiber. By way of comparison, assuming average circuit loading (5 hours per day), and without any compression, the total volume of 1998 traffic on the U.S. interstate public switched network—some 336 billion minutes—could be sent from one point to another using less than 1/2 a Terabit of fiber optic capacity.

Networks—without owning any transmission capacity. Which leads to a final point.

4. As bandwidth becomes ever cheaper and broadband networks proliferate (see Figure 1), it is services which will largely differentiate one player from the next. In this digital age, services mean software. And software means code—code for conversations; code for painting pictures; code for routing traffic; code for authoring new codes; and code for masking old ones.

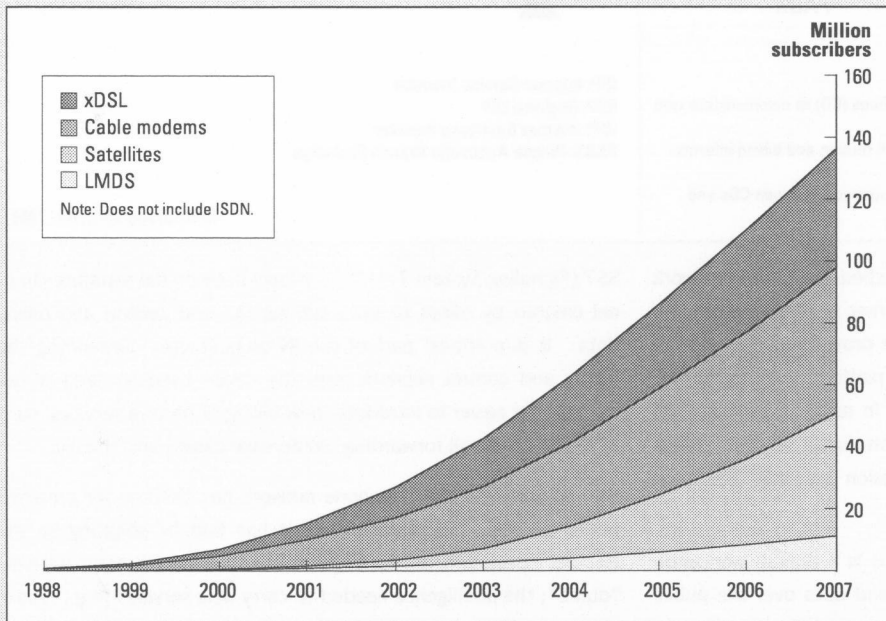
In this sense, code acts like a compass. It points toward the network's future, showing us the underground springs of traffic which today are just a trickle but tomorrow will be a Mississippi. Look at the codes if you want to forecast tomorrow's traffic booms (see Figure 4) and how they may be managed (see Figure 5). Look at the codes if you want to see where network access is open and where not (see Figure 7). Look at

the codes if you want to know whether the route forward will be private or public and, correspondingly, where (and how) regulators may intervene (see Figure 10). But I am getting ahead of myself.

It may be useful first to try and provide additional context for the "Great Dig of '99" by drawing a more complete picture of the networked world that Washington is joining.

For in so many ways, the picture is quite novel. What was once a formal garden painted in familiar hues has, almost overnight, become a jungle plot whose unchecked growth and riotous palette threaten to overwhelm us. Consider the time line which accompanies this book (see insert in the back of the book). In 1900, there were but 10 million phone lines worldwide. It took another 60 years for that number to reach 100 million (of which 40 percent were still in North America) and 30 years

Figure 1. The Broadband Future and Why It Matters

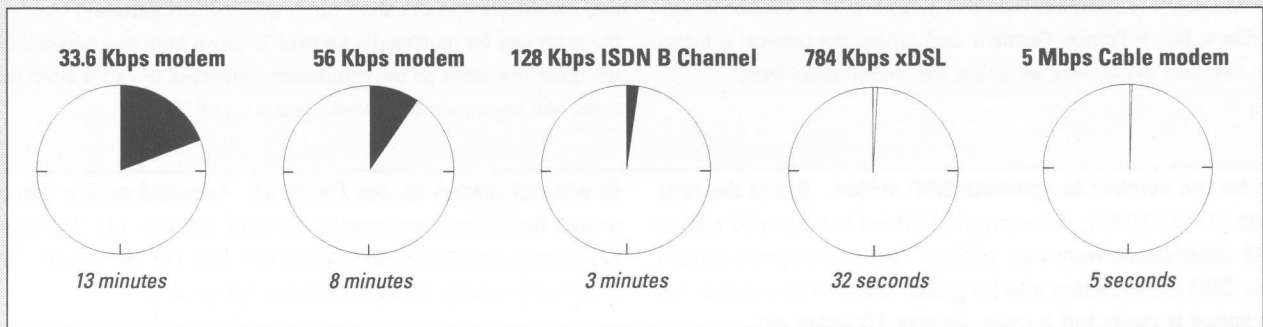


Source: Pioneer Consulting LLC, *Global Broadband Access Markets*

By mid-2000, there should be about three million broadband subscribers in North America, composing nearly half of seven million worldwide subscriptions. That may rise to over 136 million by the end of 2007, according to Pioneer Consulting, who sees cable—now the dominant broadband access technology—settling in at 30 percent of the market.

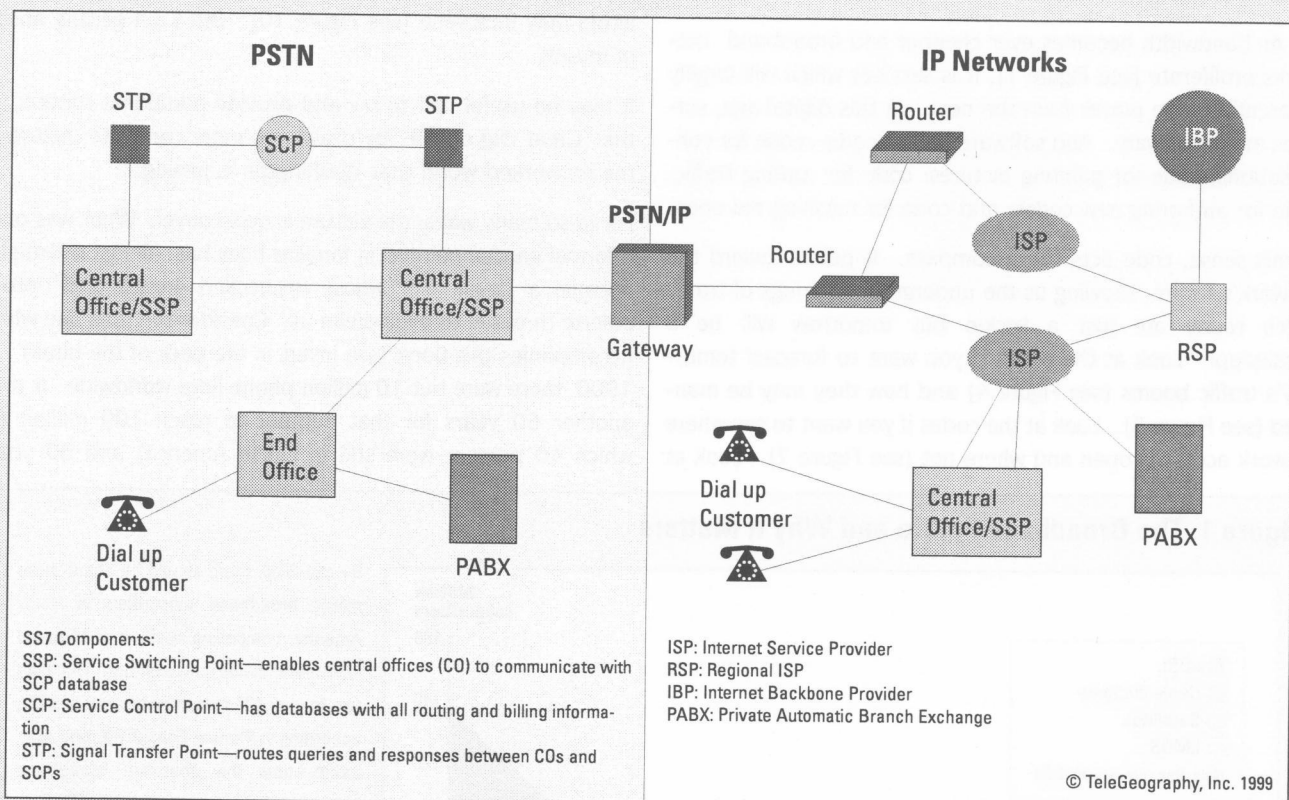
At the bottom end, Local Multipoint Distribution System (LMDS), using 28 GHz microwave signals, is expected to be the least-used technology. As a wireless broadband alternative, it's easy to install, bypassing the first-mover advantage of incumbent telecom and cable providers. But to maximize signal performance, LMDS's high frequency channel requires line-of-sight, which can be awkward.

Broadband Download Times (3 Megabyte File)



Note: Download figures are based on theoretical download times for a typical CD-quality song.

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Figure 2. Between Two Worlds: PSTN vs. Internet Architectures

The challenge of making the circuit switched telephone network compatible with the packet-switched Internet is at the top of the agenda for telephone and Internet service providers alike. Not so long ago, however, creating a multimedia platform was viewed primarily as a telephone company project. In response, telcos built today's intelligent network (IN) based upon digital switches, smart software and a new broadband transmission protocol. The main building blocks are:

ISDN (Integrated Services Digital Network) is a digital, worldwide public standard for sending voice, video and data over the public switched telephone network. There are two varieties: basic rate (128 Kbps) and primary rate (1.54 Mbps). Both are dial-up services that use existing copper wires. As yet though, deployment is limited. ISDN reaches less than one percent of U.S. telephone subscribers, but in France, Germany and Japan, the take-up is higher (in Germany alone there are about five million ISDN lines).

SS7 (Signaling System 7) is the protocol used on the separate channel created by telcos to send call set up, and control and billing data. It is a critical part of the IN architecture. Separating the billing and control network from the circuit used to carry a call makes it far easier to introduce new billing or routing services, such as free phone, call forwarding, conference calling and the like.

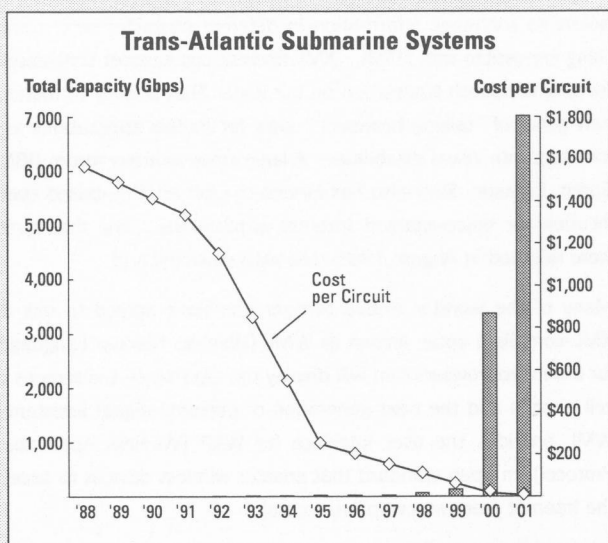
But, the smarter the telephone network has become for switched phone service, the more trouble it has had in adapting to the Internet revolution at its edges. The Internet is comparatively "dumb"; the intelligence needed to carry new services (e.g., music, video, graphics) is provided by the applications it runs, not by the network. Thus, although today engineering groups are now working to mesh the next generation architectures of the telephone network and the Internet, in the short run, Internet/PSTN gateways may be the main way for multimedia services to move from one network to the other (for more on the comparative merits of IP vs. IN architectures, see www.tndenton.com/netheads3.htm).

again for the number to approach 500 million. But in the next decade (1990-2000), the network doubled in size; 400 million mobile connections were also added. And the Internet wove a further 200 million users into its global skein. The network we know today is really but a child—barely 10 years old.

This very rapid change in the telecom landscape has nevertheless been accompanied by growing agreement about the future.

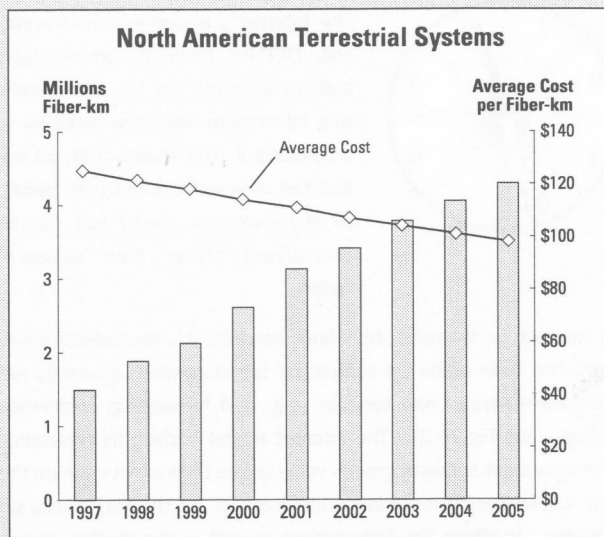
(It was not always so, see Figure 2). As noted earlier, this consensus holds that tomorrow's network will be: (1) high-speed; (2) packet-switched; (3) always on; and (4) pervasive. Let's look more closely at each of these features.

Figure 3. Fiber Optic System Cost Trends



Note: Data reflect TAT cable systems construction costs only, amortized over the expected lifetime of each system.
 Source: TeleGeography, Inc.

Successive generations of fiber optic transmission systems have sharply decreased the cost of carrying telecommunication traffic. As a recent Bell Labs review noted, “the operating speed of integrated circuits has increased by a factor of 60 in the past 10 years; the capacity of optical fiber systems grew by a factor of 200 in the same period.” The tiny core of an optical fiber may have up to 50 trillion hertz of raw bandwidth. Current commercial systems use dense wave division multiplexing (DWDM) to route data over discrete optical frequencies (“colors”) on each fiber to obtain transmission speeds of 500 billion bits per second. Laboratory experiments have doubled that speed “...enough to carry every nation’s voice traffic on a wave guide that looks for all the world like a monofilament fishing line.”



Note: Fiber deployment and cost estimates are for North American competitive local exchange carriers only.
 Source: Pioneer Consulting, LLC. *Global Broadband Access Markets*

Fiber optic transmission systems are a classic “disruptive technology,” as defined by Clayton Christensen’s popular 1997 book, *The Innovator’s Dilemma*. According to Christensen, a disruptive technology is one where the rate of improvements in the technology is faster than the increased product performance demanded in the market. Disruptive technologies give customers more than they currently need or are typically willing to pay for. That is why such technologies are usually commercialized first by newcomers serving niche markets (e.g., data networks; competitive local access providers). By the time the incumbent begins to adopt the technology for its own customers, however, those customers may have migrated elsewhere.

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A. High Speed

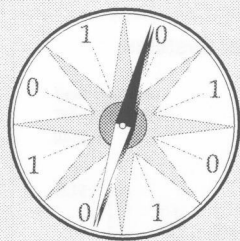
We’ll start with a definition: about 384,000 bits per second (bps) or 384 Kbps. That’s a practical definition of a high-speed communications network. With that capacity one can browse the Web and sample audio or video clips along the way as if one were flipping the pages of a book.

Definitions of high speed vary, however. The throughput of a network, and hence how quickly it can deliver data-intensive services, depends upon the bandwidth of the transmission medium (the wire or radio channel; see Figure 1). Accordingly, the definition of “high speed” and “broadband” (these terms are used interchangeably here) tend to vary depending upon the desired application, and some engineers would not consider a network to be broadband unless it operated at a speed of 1 Megabit per second (1,000 Kbps) or more.

The public telephone network is indisputably low-speed; it was designed to carry voice, not video. The transmission circuits and switches allocate just enough capacity to handle a conversation with reasonable fidelity (3 KHz for analog networks and 64 Kbps for digital ones). The long distance and local trunk facilities used by telcos operate at much higher speeds. But, over the last mile, available bandwidth is only a fraction of that although, as we shall see, the copper wires which connect most telephones to the network are able to carry over 1 Mbps using Digital Subscriber Line (DSL) technologies.

To make local access to the telephone network high-speed, one must modify (or replace) the transmission circuits available on the last mile. And one must change the electronics at end-office switches or subscriber terminals or both. Network wide, that can be very costly. Moreover, in most countries, telcos must factor in the competitive response of cable TV operators

Figure 4. Service Codes—Catching the Next Wave



The Internet's packet-switched protocols (TCP/IP) make it comparatively easy to separate the job of transmitting information from the business of originating it. This means that, on the Internet, new services need not belong to any particular carrier but can be user-driven rather than network-based.

By contrast, on the public telephone network, it is the network operators and their preferred equipment suppliers which generally are the gatekeepers of new services (e.g., call forwarding, conference calling; see Figure 2). The Internet model—driven by thousands of independent software groups vying to run their latest code on the Net—consequently has radical implications for the way telcos do business. It affects the introduction as well as the routing of new services (see Figure 5).

Perhaps the best example of how much things have changed is HTML (Hyper Text Markup Language), the standard code used to display text and graphical objects on the Internet. In the summer of 1991, when HTML was first posted on the Net, it was a rather rudimentary software tool developed by a (then) unknown British mathematician, Tim Berners-Lee, to link documents on different computers at a rather obscure research facility (CERN) in Switzerland. Seven years later, our research suggests that HTML services probably generated more international traffic than the 800 million telephones connected to the public fixed network (see *Direction of Traffic 1999* for more details).

And that is only the beginning. Each week, the Internet becomes a wider and wider space for software developers eager to roll out new services. Every new generation of codes may stimulate its own wave of traffic. Worth watching are:

XML (Extensible Markup Language)—Launched in 1998, XML offers a standard format for creating customized programming tags for Web pages. Instead of being limited to the tags available in HTML (e.g., those for displaying text as title, paragraph, row or column) with XML one can add content-oriented labels (say, for a purchase order, there may be tags for price, quantity, size, color, delivery date). Analogous content-specific tags can be defined for any number of other documents (medical records, checks, invoices). XML thus acts as a powerful language for meta-data (information about information) and it is likely to give e-commerce a big boost if only because today's HTML tags do not provide much transactional data in a form that computers can process (e.g., HTML has no tags for price or size).

As well, XML supports unicode, a standard method for encoding characters in all the world's major languages, thereby allowing com-

puters to exchange information in different character sets, something impossible with HTML. XML likewise can support style sheets for text to speech translation on the Web. That is likely to foster a new genre of "talking browsers," ideal for mobile applications and for users with visual disabilities. A large cross-industry forum (IBM, Sprint, Ericsson, Sun) also has formed to craft an XML-based specification for voice-enabled Internet applications. The first specs were released in August 1999 (see www.voicexml.org).

Many of the world's mobile carriers also have agreed to use an XML-compliant code, known as WML (Wireless Markup Language) for the microbrowsers that will display the Internet on the screens of cell phones and the next generation of personal digital assistants. WML provides the user interface for WAP (Wireless Application Protocol) an open standard that enables wireless devices to access the Internet (see www.wapforum.com).

The vast range of new XML applications now being coded has led some to herald XML as the "second coming of the Web." A list of XML development groups can be found at www.w3.org/xml.

MP3/MP4—Just as XML may drive a new wave of e-commerce and voice traffic on the Net, standard codes for downloading audio (MP3) and video (MP4) information on the Web already have forced carriers to rethink the demand for network capacity.

Streaming music and video on the Net has been possible for years. Software distributed by Real Networks Inc. is probably the best known (see www.real.com) (Microsoft also has a product known as NetShow). Today, hundreds of radio broadcast stations around the world stream their services over the Net (see www.netradio.com) and new movie and video services are announced almost daily.

But the software needed to copy and download digital music (or video) files from the Net is different from that required for streaming services because with streaming the user need not capture the original content. Uncompressed CD-quality music files are very large—about 29 megabytes for a three-minute song—and can take several hours to download over a 28.8 Kbps modem. That is where MP3 comes in or, more precisely, MPEG-1 audio layer 3.* Adopted by the Motion Picture Experts Group (MPEG) in 1992, MP3 offers a powerful open-standard code for compressing and decompressing digital files.

Using MP3, a three-minute song may still take up 3 or 4 megabytes, but as broadband access has spread (especially at universities), MP3 has sparked an Internet boomlet. Part of the attraction is that MP3 appears to deliver music for free. Using MP3, fast computers can "rip" or copy music from a CD to a hard drive, upload the tunes to the Internet, and then download them anywhere in the world—good for network traffic, but bad for copyright holders.

Figure 4. Service Codes—Catching the Next Wave (continued)

Music is big business. Worldwide sales of recorded music totaled \$38.7 billion in 1998 with the U.S. accounting for about a third of the sales. To manage the copyright issues posed by MP3 and its cousins (there are several competing codecs available), over 120 record companies have formed a secure digital music initiative (SDMI).

In August 1999, SDMI announced that it favored a digital watermarking technology known as MusiCode, developed by Aris Technologies of Cambridge, Massachusetts. With MusiCode, any SDMI-compliant music player (such as the pocket-size devices popularized by Nomad (www.nomadworld.com) would be able to identify watermarked music tracks from unauthorized MP3 sources on the Internet and refuse to play the latter. SDMI's standards also will provide for a rights management program so that artists and

record companies can be paid per tune, for details visit www.sdmi.org.

The potential for the telephone network to function as a global jukebox has not been lost on some telcos. AT&T has developed its own proprietary digital music format for the Net, known as A2B (www.a2bmusic.com). An AT&T affiliate also hosts the site of mp3.com, one of the largest sources of MP3 encoded music on the Net.

* In case you are wondering, MPEG-1 provides a digital, CD-Rom-quality video standard. MPEG-2 is the standard for digital video disks (DVD), and MPEG-4 offers a next generation multimedia standard.

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which already own a second (potentially broadband) wire to many customers.

Until recently, therefore, with the exception of Integrated Services Digital Network (ISDN) offerings in a few countries (typically operating at 128 Kbps; see Figure 2), telcos have been cautious about upgrading the "last mile." They have preferred to install fiber first on longhaul routes, where the cost per mile has fallen dramatically (see Figure 3), and secondly, on local broadband facilities for business customers who can afford premium service. Residential and small business markets were largely ignored.

Then came the Internet. As the Web transformed the Net into a mass market, by the mid-1990s the economic prospects for broadband over the last mile began to change. At last, there was a service which might actually let carriers recoup the cost of bringing high-speed access to millions of new customers. Slowly, at first, but then with increasing urgency, incumbent telcos began to respond, spurred on by tens of new market entrants.

During the last year across Europe and the Americas, there has been an unprecedented rush to buy, build or lease the facilities needed to offer end-to-end broadband services ahead of the competition. This global scramble for bandwidth has been a boon to scores of new network players in dozens of cities, including Washington, D.C.'s e.spire. Internationally, the activity has been equally frenetic. Level 3, GTS, COLT, Global Crossing and Viatel are but a few of the companies which plan to offer broadband capacity to and from the world's major cities (An authoritative survey of this new market will be pro-

vided by TeleGeography's international bandwidth guide; for a preview, see the Facilities section of this report).

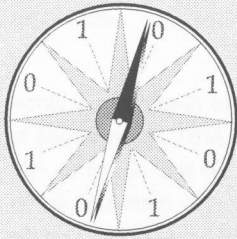
Over the "last mile," however, telcos typically have two choices: (a) to supply DSL services over their existing copper wires or (b) to provide access over the broadband facilities of third parties, i.e., cable TV systems or fixed wireless networks e.g., Multichannel Multipoint Distribution Services (MMDS).[2]

A DSL modem taps the unused frequencies available in a standard copper wire to send and receive data at speeds of 384 Kbps to 1.54 Mbps or more. However, DSL services generally are only feasible if the local loop between the subscriber and the telco's end office is less than about 2.5 miles. A cable TV modem allows two-way digital communications at 5 Mbps or more, provided the cable system is properly configured. As with DSL technologies, with cable modems the downstream speed (to the subscriber) typically exceeds the upstream rate (from the user).

Most major international players have now begun to marry their local broadband strategies with their long distance plans. For example, MCI WorldCom, whose UUNet subsidiary runs one of the world's fastest Internet backbones, has teamed with several ISPs and competitive local exchange carriers, notably Rhythms Net, to offer U.S. customers xDSL service over the last mile. MCI WorldCom also has bought several MMDS operators, as has Sprint, which recently agreed to merge with MCI Worldcom. By contrast, AT&T proposes to buy two of America's largest cable TV companies (TCI and Media One), whose 17 million subscribers would be tied to the Net exclusively via Excite@Home, AT&T's affiliated Internet Service

[2] As more governments allocate sufficient microwave spectrum for fixed wireless operators, this service may well become a preferred vehicle for delivering broadband services over the last mile to multiple dwelling units and medium-sized professional buildings, particularly where cable TV systems do not exist. In the U.S., for example, companies like Teligent and Winstar are now significant competitors in the local access market.

Figure 5. Routing Codes—Trading Places



Even as the codes for new services, such as XML and MP3, drive ever larger volumes of traffic over TCP/IP networks, other codes are being crafted to manage the flow of these new traffic streams. These new load-balancing techniques may well supplant some of the network-based traffic

management functions used by incumbent telcos. They also may affect the demand for new facilities. Early adopters of load-management software say smart codes can boost the performance of a popular Internet site more efficiently and without the fixed costs associated with acquiring additional bandwidth.

Akamai Technology in Cambridge, MA (www.akamai.com), and Sandpiper Networks in Westlake Village, CA (www.sandpiper.com), are the current market leaders in this new field of software-based load balancing. Akamai's FreeFlow service and Sandpiper's Footprint each allow Web-based content providers to improve user access speeds. Both services work by porting a subscriber's content to a private network of servers; modifying the HTML tags associated with each Web object (text, graphic, video clip); and then applying special algorithms (mathematical formulas) so that a user clicking on a given link is automatically directed to the highest performing server in the network. The key to their success lies in the way both Akamai and Sandpiper break the historical link between a network address (the domain name or URL) and the physical location of the corresponding data (servers and backbone links).

As Paul Spinrad explained in *Wired* ("The New Cool: Akamai Overcomes the Internet's Hot Spot Problem," August 1999), "the Net was originally designed [as] roads connecting distinct sources of content. . . . An address like nasa.gov would always correspond to dedicated servers located at the NASA facility. When you visited www.ksc.nasa.gov to see a shuttle launch, you connected to NASA's servers at Kennedy Space Center." But as millions of Web users began to jockey for access to the most popular sites and as audio or video clips on sites made files bigger and bigger, the Internet protocols which tied information to a given server began to cause bottlenecks and lead to event-driven "hot spots."

Most content providers have responded by asking their ISPs to add bandwidth or by mirroring and caching content at multiple sites. Akamai and Sandpiper both run their own private "mirror servers," but with one key difference—the content on their servers has been

modified to break the connection between URL and location. For instance, Akamai's customers are given a simple utility to modify the tags for every Web resource covered by the FreeFlow service. The software rewrites a file's URL so that a particular file can be routed to any one of hundreds of servers depending upon current network conditions. The location of a content file is thus a function of the dynamic routing algorithm resident in Akamai's network of servers; it is a-geographical.

Akamai has co-located servers on over 30 backbones, including networks run by Teleglobe and Singnet. Each geographical region has one mapping server that monitors the local state of the network (their job is to figure out which server should carry which file and how to distribute file requests amongst servers) and one or more content servers. Web pages themselves break down into units: the HTML page plus imbedded file—images, animations, sounds, video. Major customers of Akamai include CNN and Yahoo; Sandpiper serves MSNBC and AOL, among others.

Bob Collett, vice president of Data Services at Teleglobe, told the Cook Report (www.cookreport.com), "Akamai and Sandpiper have the potential for making some fundamental changes in the Internet business." It may presage a shift from "managed co-location services which are generally placed at key network access points or routers to intelligent mirror sites at the edges of our network, thus making performance of the mirror more directly related to the whole network, rather than a few routes." The not-so-hidden message is: Akamai is good for global networks with route diversity. Point-to-point players serving niche routes may not fare so well.

Akamai and Sandpiper are not the first to use distributed traffic management, but their software-based systems are unique. Older systems, still available and in use, do not alter the HTML code of the packets which they manage. According to *Wired*, examples include GTE Internetworking, which acquired its Hopscotch product from BBN, and the Central Dispatch solution offered by Resonate. Cisco has also developed a "tag switching" technology which identifies and tags flows of associated traffic, such as streaming video clips; instead of examining each packet, routers need only read the tag, enabling faster performance. Other router vendors have published similar technologies and the Internet Engineering Task Force (IETF) has proposed an industry standard called multiprotocol label switching (MPLS) to speed the flow of multimedia IP packets (see www.ietf.org/ids.by.wg/mpls.html).

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Provider (ISP) (This strategy is strongly opposed by other ISPs and it may ultimately prompt AT&T to divest Excite @ Home to win regulatory favor). Across the Atlantic, British Telecommunications, which has agreed to pool all of its high-speed international facilities with AT&T via the Concert joint

venture, will chiefly rely upon xDSL for the last mile (regulation bars it from using cable TV facilities in the short term).

In a similar vein, the 1998 annual report of Deutsche Telekom (DT) advises that DT "plan[s] to serve [its] international customers by seamlessly linking" the network for international traf-

fic in Germany, its domestic high performance network (a 12,000 kilometer fiber optic net joining major economic centers) and its 36 City-Netz fiber rings with a European backbone network. By 2000, DT states that this network will span 20,000 kilometers and link some 40 points in 16 countries. Over the last mile, DT will rely upon ISDN and xDSL services; regulatory pressure has led the company to divest its nationwide cable TV system, the largest in Europe with 18 million subscribers (Microsoft and Rupert Murdoch's News Corporation, among others, have reportedly made the short list of bidders).

Whatever the strategy, bringing broadband to the last mile will require time. Even in rich countries, most forecasts put high-speed access to the Internet at no more than 10-15 percent of households until 2003 or 2004. And even then, it is not at all clear that network owners will be the big economic winners. To see why, let's turn to the second main feature of tomorrow's networks—packet-switched.

B. Packet-Switched

The Internet's packet-switched protocols are likely to become the common denominator of tomorrow's networks although, as we shall see, they may "ride" on other standards such as ATM (Asynchronous Transmission Mode), a method of transmitting Internet traffic along with other digital services.

Remember first that TCP and IP are protocols—software, not hardware. As well, it bears emphasis that the TCP/IP protocols always have been open standards available without charge on the Internet—a precedent with far-reaching implications for other Internet-based applications. More on this below (see also Figure 7).

TCP (transmission control protocol) is a standard for communicating digital information as a series of packets that may be separately transmitted, but reliably reassembled at the other end. TCP thus provides the glue that binds the Internet together. It ensures that communications can be sent from one terminal on the Net to another, even though there is no direct connection between the terminals and even though the networks transited are otherwise incompatible due, for example, to the use of different hardware or operating systems.

IP (Internet Protocol) defines the structure of data packets transmitted over the Internet. It also provides the basis for assigning unique addresses (numbers) to network terminals so that data packets which are properly coded can be routed across multiple (and often incompatible) networks. An IP address consists of four numeric blocks and looks like this: 209.8.101.138 (for www.peacockmaps.com, which hosts TeleGeography's new Internet posters).

The general acceptance of TCP/IP as the network protocol for sending and receiving almost any type of information—e-mail, phone calls, music, films—has two hugely important conse-

quences. TCP/IP protocols make telecommunication services: (1) network-independent and (2) application-blind.

1. Network-Independent

The Internet is, by definition, a network of networks and, as we have seen, TCP was designed to deliver bits from one communication terminal to another regardless of the number (or type) of the networks in between. For service providers, therefore, TCP/IP is inherently pro-competitive. As well, because TCP works on a best-efforts basis—checking to be sure that all packets have been received and resending those that are missing—end-to-end performance for any given service may be improved if alternative networks are available (e.g., because one network is congested or experiences an outage).

The connectionless, network-independent routing of services which TCP/IP makes possible has cross-cutting implications for existing telephone network operators. On the one hand, by making their networks Internet compatible (e.g., by adding Internet/PSTN gateways), they can shift part of the capital costs of building out and upgrading network facilities to third parties. If the network is software-based, why own all of the hardware? Let someone else pick up the tab.

On the other hand, the competitive network model implicit in TCP/IP may radically lower the entry barriers for new network players as well as expanding service competition. In addition, if a telco must rely upon unknown third parties for end-to-end services, it may lose the ability to control the quality of the services upon which its customers have come to rely. Thus, a telco's inability to guarantee network security or to meet performance targets (Quality of Service (QoS)) may outweigh the benefits from off-loading construction costs. (Private TCP/IP networks run over a small number of dedicated facilities may offer an alternative though. See Section II.C. below.)

2. Application-Blind

TCP/IP networks are likewise application-blind. In popular terms, that means the Internet is a "multimedia platform," but this really misses the crux of the matter. The actual services provided to end users on the Internet are not defined by TCP/IP but by higher level application protocols such as HTTP (hyper text transport protocol, the basis of Web services) or SMTP (simple mail transfer protocol, for e-mail). Thus, in contrast to the public network, where new services are typically tied to network-specific software (see Figure 2), TCP/IP makes it possible to rapidly introduce a new application; the underlying software used to transmit the application across the network remains the same. That makes new code, not conduits, the driving force behind new services (see Figures 4 and 5).

This is worth saying again in a different way. Because the Internet is application-blind, if you want to have any idea of what the mix of services will be or the demand for more capacity one, three or five years out, you must closely monitor the

locales where new applications are being developed, i.e., code space, not network space. And, as with the Internet's basic TCP/IP protocols, the more open the code, the greater may be its long term impact (see Figure 7).

C. Always On

Let's move on to a third feature of tomorrow's network: "always on."

The Internet has become synonymous with "round the clock" networks. Someone is always online when you're not—trading, hacking, posting. 24/7 networks are the bane of many people's existence but the salvation of others—for instance, making vital health and public safety services available on demand.

And yet, for most people, the Internet is not really "always on" at the flip of a switch, like electricity or water. Even when a switch has been turned, the lights may flicker and the tap run dry. The 99.999 percent ("five nines") reliability we expect on the public telephone network still seems to be a distant dream on the Internet. Worse still, the more widely available broadband access becomes, the more heavily trafficked will be the network. Keeping the network "always on" under these conditions is likely to be a major challenge for years to come and will require attention from almost everyone who uses or provisions network services, from local hosts to upstream routers to backbone facilities.

Let's start with the access issue. For the Internet to appear "always on," a permanent window on your electronic desktop, a dedicated high-speed connection is required. Yet, as noted, only a small number of users (businesses and universities aside) now have such access. To access the Net today, most subscribers must first secure a telephone dial tone and then log on to an ISP, a process which may take 20 or 30 seconds on good days but very much longer when demand peaks. Then one must get to the desired Web site. In fact, this part of the trip seems to be getting easier, though it may be marked by delays along the last mile. Most indicators show the Internet's performance has improved over the last year despite adding 50

million or more users. For example, Key Note Systems has found that the average time to access the Web pages of 40 major business sites in the U.S. decreased by half to approximately five seconds during the first nine months of 1999.

Subscribers with dedicated access to the Internet have benefited accordingly. But caveat emptor: Always on does not mean "always works." TCP/IP is a best-efforts protocol. By itself, depending upon the network paths available, TCP/IP may never provide the QoS available on the public switched network where a dedicated (and, often, carrier-owned) circuit is assigned to each conversation.[3] The QoS problem thus continues to challenge many of the Internet's talented engineering and software groups. Some believe that the problem will only be solved by routing traffic over private intranets which can guarantee performance and keep unwanted traffic off their facilities. Hence, the push by several major carriers to use their own facilities to provide virtual, private TCP/IP services to large corporate clients.

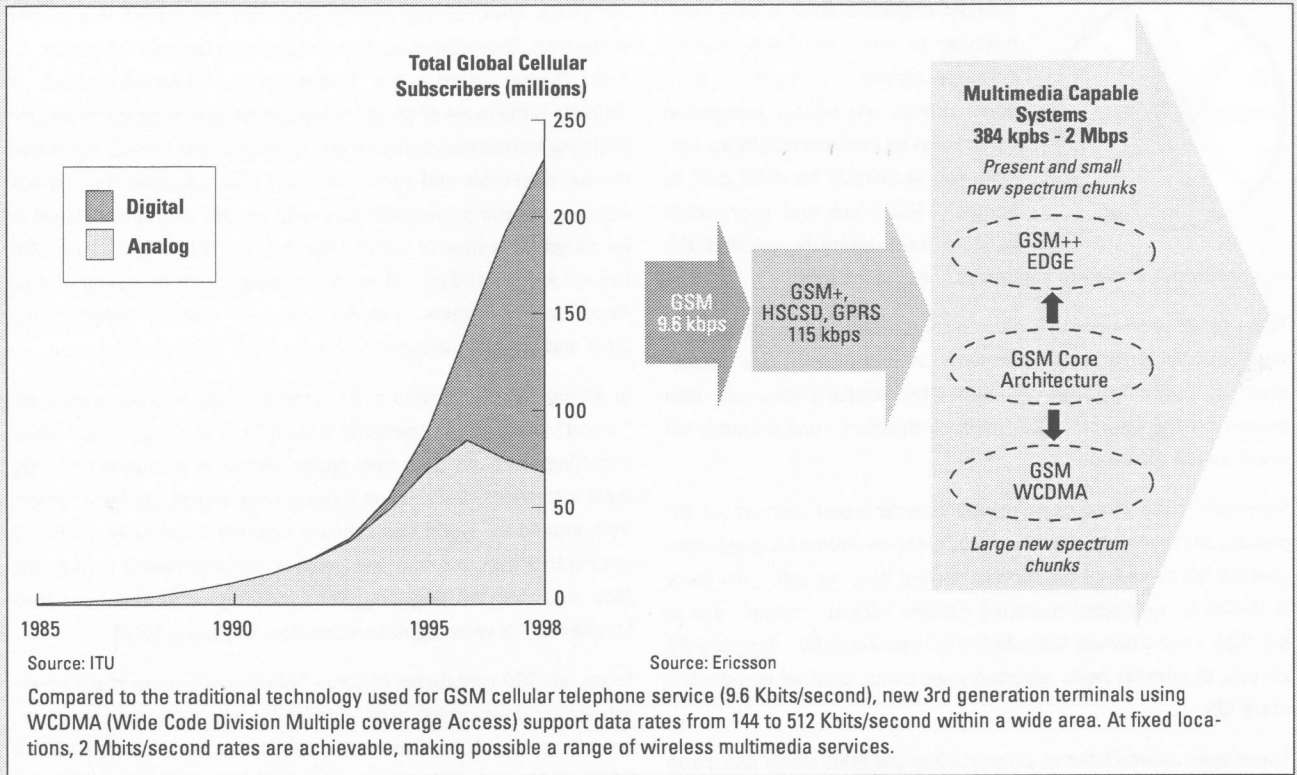
Likewise, performance standards also have led major Internet backbone operators (telco-based or not) to manage traffic flows by using other standard protocols to package and transmit IP flows with bit streams originating on other networks. A favored approach is ATM. With ATM, traffic can not only be sent at high speeds (up to 2.5 Gbps) but the network operator can accord priorities to different types of packets or cells, thus making QoS possible. In engineering terms, therefore, IP is commonly "run over ATM" and today ATM is the networking protocol of choice for convergent traffic systems. [4]

Still other engineers believe that QoS can be addressed by relying more heavily on various IP protocols such as RSVP (Resource Reservation Protocol) which essentially alerts IP network switches in advance that a certain path will be required, thus speeding the transit of the subsequent data packets. Another approach is offered by the multi-protocol label switching (MPLS) standard proposed by the Internet Engineering Task Force (IETF) to tag priority traffic. Nortel Network and Cisco both offer "tag switching" products for managing IP networks and several major companies including Concert (the AT&T-BT

[3] It is worth explaining briefly that today's public telephone networks do not usually dedicate an end-to-end circuit to a call. Rather, to increase the network's capacity, numerous calls may be multiplexed over a given channel. Thus, apart from the truly dedicated connection along the copper wire between a subscriber's terminal and the local switch, the so-called "dedicated circuit" assigned to a voice call is really a set of time slices or frequency assignments on a circuit used for multiple calls, especially on long distance networks.

[4] Some engineers nevertheless contend that whole layers of network technology, such as ATM, can be eliminated. Today, as discussed, installing a multiservice network with high reliability and QoS involves IP (at Level 3), ATM (at Level 2) and a primary layer of protocols to mesh electronic transmission streams with optical transport facilities, each of which adds something to the end-to-end solution. Yet, a new protocol is expected to emerge that combines the attributes of IP and ATM to provide for interoperability and end-to-end quality of service. The transmission and optical layers will merge to form an IP over DWDM (Dense Wave Division Multiplexing) layer, which will have the service characteristics now associated with today's optical layer, typically based on SONET (Synchronous Optical Network)—a family of fiber-optic transmission rates, frame formats and control standards that allows interworking of optical systems manufactured by different vendors. When that happens, IP will finally become, in the words of MIT's David Clark, "the great spanning layer" between the glass fiber below and the bitstream of ideas above.

Figure 6. Mobile's Broadband Future



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venture), UUNet (owned by MCI WorldCom) and Frontier (now a Global Crossing company) have announced plans to deploy some form of MPLS.

Whatever the method, the business of providing QoS and troubleshooting network failures will become a bigger and bigger industry as broadband local access delivers ever-increasing volumes of network traffic. And the demand for assistance already is making itself felt all down the line. The larger and more diverse the network becomes, the harder it will be to predict the network's weakest links or where "flash crowds" or "hot spots" may disrupt service. Much as power pools, back-up generators, and circuit breakers are a standard part of our electric world, so too will e-commerce make their digital counterparts commonplace in the online world.

TeleGeography learned this firsthand one Thursday in September 1999. At 8:20 AM, a certain "cmdrtaco"—the erstwhile Rob Malda, founder of Slashdot (www.slashdot.org)—relayed a "this is cool" post from a loyal foot soldier about peacockmaps.com. By 8:25 AM, thousands and thousands of Slashdot's faithful tried to enter our portal, overwhelming our current network resources (they have since been upgraded).

D. Pervasive

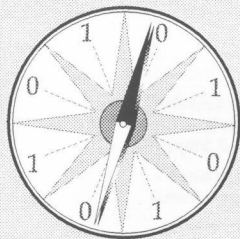
It is time to turn to the last feature of tomorrow's networks—their scope. And here something paradoxical seems to be hap-

pening. On the one hand, there is little doubt that the future networks will be more pervasive than ever, a constant helper and witness—and, yes, snoop—at work and at home. On the other hand, access to broadband services will remain limited well into the next decade for most users. Recall Section II.A. The network thus will grow faster vertically than horizontally for some time to come.

A global service vision has long animated the telecom industry's largest players. Any time, any place is also the battle cry of the mobile satellite industry, especially the proponents of next-generation systems such as Teledesic and Skybridge, which promise high-speed Internet backbones in the sky. Meanwhile, back on earth, the cellular telephone industry has its own ambitious plans to migrate its large customer base—now 400 million and growing—to a third generation (3G) service with data rates up to 2 Mbps for fixed sites (see Figure 6).

Even so, most telephone users and, indeed, the majority of non-telephone users, are likely to be affected by new high-speed networks indirectly first due to the more rapid integration of narrowband TCP/IP services into a larger economy. As Intel (and others) put the Internet inside almost every consumer device, and as software agents become more and more powerful, the Internet will be everywhere—from refrigerators to street lamps, from bar code scanners to office doors, and from

Figure 7. Open Codes—May the Source Be With You



Telecom engineers have a long commitment to open standards (though privately agreed—international standards groups are usually dominated by carriers) so that one telephone network can seamlessly hand-off calls to another. But telcos and their switch vendors have jealously guarded the custom software used to implement these standards.

The Internet grew up with a different engineering ethic: open standards openly agreed to are the norm. And the line-by-line instructions for encoding these standards—the source codes—are also posted on the Internet. The Internet therefore runs primarily on open source software.

Sendmail is the most popular mail transfer agent with about 80 percent of the market. Apache, another open-source program, runs at least 50 percent of the servers hosting Web content. The story is similar for computer operating systems (OSes). Yahoo!, one of the Web's most heavily trafficked sites, uses FreeBSD. And fully 30 percent of Internet hosts reportedly use Linux, another non-proprietary OS.

These open source Internet products and the ethic which has made them possible are likely to have a greater and greater impact on the telephone world for one simple reason: most popular services on the telephone network and the Internet will soon traverse the same computer switches and terminals. Some familiarity with the Internet's open source philosophy and its recent successes is thus essential for navigating tomorrow's net-centric world.

From GNU to Linux

Conventional wisdom holds that a world-class operating system, like a space shuttle, can be built only by a billion-dollar company under the watchful eyes of a master planner, not by a gaggle of geeks swapping code online. Hence, the success of Linux seems to defy common sense. Let's take a closer look.

Version 1.0 of Linux was released in March 1994 and is named for the young Finnish programmer, Linus Torvald, who contributed a key batch of code. Linus did not invent Linux, which has its origins in a non-proprietary OS proposed in 1984 by Richard Stallman, known as GNU (GNU's Not Unix). To ensure that his Unix-like OS could never become a commercial product, Stallman invented the GNU general public license which copyrighted the source code and released it to the world on the sole condition that any modification be covered by the same license—that is, could be freely copied and changed. Stallman described this rule as "copy-left."

For years, however, the goal Stallman set for himself was largely unrealized. Enter Torvald, then a student at Helsinki University. In 1991 Torvald posted a new "kernel" for the OS on the Internet. A "kernel" is the heart of an operating system providing microcode for shuttling instructions between the keyboard, the mouse, the monitor, the hard drive and microprocessors of a computer. But "a kernel does not run a computer by itself," as Charles Mann stressed in an insightful review of Linux (*The Atlantic Monthly*, "Living with Linux," August 1999). "It works in concert with hundreds of supplementary programs, including drivers, utilities, programming tools and window managers"—hundreds of megabytes of code.

In Mann's words, Torvald's invitation for help in transforming his "kernel" into a viable operating system "was like a group of friends decid[ing] to build their own space shuttle in a basement." Yet build it they did. Drawing on Torvald's initial post, by 1994 coders from around the world had cobbled together a complete operating system that soon became the choice of many computer enthusiasts (see, e.g., "In The Beginning Was The Command Line," by Neal Stephenson at www.cryptonomicon.com/beginning.html).

Today, all 800 megabytes of Linux (some versions are much smaller) can be downloaded from the Net for free or, if preferred, purchased on CD-ROM from non-profits and loose collectives like Debian (price: \$1.99) or from commercial enterprises like Red Hat, which bundles value-added manuals with its distribution (\$29.95).

The Cathedral and the Bazaar

The success of the global, all-volunteer programming community which birthed Linux has puzzled many. How did it happen? One answer is provided by Eric Raymond in "The Cathedral and the Bazaar" (available at www.tuxedo.org/~esr/writings). Raymond, one of the hundreds of programmers who helped to code Linux, argues that open source has a psychological edge: "Play" is a more "economically efficient mode of organizing work." There also is a practical reason, says Raymond. "Given enough eyes..." (scores of expert beta testers) "...all bugs are shallow... Open source culture will triumph not because cooperation is morally right ... but simply because... open-source communities... can put orders of magnitude more skilled time into a problem."

So what will the software world look like once the open source transition is complete? According to Raymond, the basic infrastructure of computing for the Internet—the Web, operating systems and the lower level of communication software that has to cross boundaries between competing networks (e.g., IP messaging and signaling protocols)—will almost all be open source, cooperatively maintained. But higher-level applications (e.g., work group programs) will probably remain closed.

Figure 7. Open Codes—May the Source Be With You (continued)

Ultimately, though, the line between open and closed source programs will be drawn in the marketplace by the give and take of commercial practices. The recent battle between AOL and Microsoft over Instant Messaging (IM) protocols—open source and compatible, like e-mail or closed and company specific, like Windows 95—may be a precursor of what is to come. As goes IM,

say some observers, so goes its networked cousins from voice chat to Internet telephony and beyond. If this view is right, the open source movement may soon be followed as closely by the telephone industry as it is by software manufacturers.

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cars to soft drink machines. Taken together, in fact, many observers think that the traffic generated by these “silicon cockroaches,” to use Robert Metcalfe’s term, will become the largest source of future network traffic.

In theory, almost any device with a microprocessor can be linked to the Net, provided the device has an output port and the right software. Networked vending machines and Web cameras are already popular. However, as Kevin Werbach, Editor, *Release 1.0*, observed in an April 1999 survey of Internet trends (“The Final Frontiers of Networking, Part 2: You are the Network”), virtually any company with a fleet of cars, trucks, field equipment or branch offices will benefit from tying their assets and people together over a network. That is one reason, suggests Werbach, why Sun Microsystems (among others) has devoted so much attention to its Java programming language and the related Jini technology which help to network different devices. According to Ken Arnold, a staff engineer at Sun, with the Jini software new devices (a printer, a microphone) can be quickly networked without having to pre-install the software at the device; the network does it. Says Arnold: “We want people to put little things on the network—temperature sensors, motion detectors, clocks . . . and then build more things out of them.”

The vertical reach of the network also will be extended by a new wave of business-to-business (B2B) commerce. Matthew Symonds highlighted this in a June 1999 survey for *The Economist*, “Business and the Internet”. Once large firms move their purchasing online, writes Symonds, as have IBM, GE and Ford, for example, thousands of their business partners and suppliers must follow suit or risk being cut out of the value chain. The economic worth of these transactions will soon dwarf retail e-commerce, notes Symonds. And B2B e-commerce is also likely to change the way people work across scores of fields which have almost nothing to do with such early Internet businesses as publishing and data processing. In Symonds’ words: “Because the main actors will be established rather than new businesses,” the process “will [be] more like a highly telescoped evolution than a revolution. But revolutions come and go; evolution sticks.” *Nota bene.*

III. Orienteering 101

“We are at an inflection point”

- Steven A. Ballmer, CEO, Microsoft

“Our model for conducting business and generating revenues is new and unproven”

- MP3.com IPO Prospectus

Now that we’ve looked at tomorrow’s network in more detail, it is again time to ask what it all means. What are the practical implications for the provision of international telecom services and regulation? Some further thoughts follow below, but I caution that, as with the preceding narrative, the discussion remains at a fairly general level.

Today’s networks are exceedingly complex and they vary significantly country-by-country. Network evolution also is an uneven process, punctuated by extraordinary bursts of activity in a few locales, while whole regions go about their business as usual, at least temporarily. My perspective also has been influenced by my day-to-day experience with network providers in several industrialized countries. In much of the world though, making a phone call still requires a long walk and the Internet is something you hear about on the radio. My observations thus must be applied with some care to different local circumstances.

A. Plotting a Course—Prices and Products

When Microsoft’s CEO said that the software industry was at “an inflection point,” he was referring to the challenge which Web-based software, available to any networked terminal, poses for Windows-based programs bought in shrink-wrapped boxes at shopping malls (see also note 6). But he might as well have been talking about the break point facing international telephone carriers.

In the Internet age, the old answers just don’t hold. Consider the fundamental question of what service a carrier will offer two years hence, between what points, and at what price. The answers used to be reasonably predictable. A telephone circuit was, with some exceptions (facsimile), used for voice telephony and the demand for services (and transmission capacity) on any route broadly tracked the size of the population or economic activity at each end. International transmission facilities

Figure 8. Changing International Service Models: From Half Circuit to No Circuit

Facilities	Pre-1985 Half Circuits	1985-2000 Whole Circuits	2000 and beyond No Circuits
Market Structure	Monopoly/Oligopoly	Multiple Licenses	Unlicensed
Technology Platform	Circuit Switched Public Telephony	Circuit Switched Public Telephony	Packet Switching (TCP/IP over ATM)
Service Model	Joint Venture/ Correspondent Agreements	End-to-End Services, Global Backbones/ Local Distributors	Virtual Private Networks (VPN)/ Internet
Traffic Routing	Mutually Agreed by Carriers; Proportionate Return	Least-cost Routing by Originating Carrier	Best Efforts on Public Internet/ Quality of Service (QoS) Tiers
Wholesale Pricing	Accounting Rates	Negotiated Rates; Domestic Interconnect Charges	Peering (SKA) and Packet-based Pricing
Retail Pricing	Per Minute, Distance Sensitive	Per Minute, Less Distance Sensitive	Flat Rate, Distance Irrelevant

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were resource constrained and accordingly could be priced well above cost.

The broadband, Internet-based networks described above have changed all of this. Services are user-defined not network-based, and telephony is but one of many networked traffic streams, and not the largest one. Places do not define traffic routing; servers and software do. In any case, many terminals have no fixed location—they are wireless. As well, when long-haul capacity is almost infinite, incremental transmission costs and prices approach zero. Though this landscape still may be somewhere over the horizon even in richer countries, it can make the future seem unsettled everywhere.

Let's look more closely at some of the implications for international telecom prices and products.

1. Prices

As broadband data networks carry the bulk of international traffic, the price per bit of delivering narrowband services, such as voice, must come into line with that charged per bit for carrying data. After all, the same basic transmission facilities are used for both services. Likewise, when end-to-end bandwidth is plentiful, the cost for local and long distance transmission services also begins to converge. During the last year, as the proportion of data traffic on the major networks began to eclipse the voice stream[5], the pressure to align voice and

data pricing has never been greater. Some examples suggest a magnitude of the economic challenge ahead.

For instance, in 1998 the average gross international revenue per minute earned by AT&T for originating over 10 billion minutes of traffic was \$0.68; net revenue per minute was \$0.30. By comparison, ITXC, a major provider of Internet telephone service globally, generated gross revenues of \$0.15 per minute during the first half of 1999 and operated at a loss. Similarly, FCC data shows that in 1998 roughly 47 percent of the circuits used by U.S. carriers for overseas service carried voice traffic. These circuits, however, generated \$9.4 billion in net revenue as compared to \$908 million for the remaining (53 percent) of private line circuits which were primarily used for data services. There is more.

Merrill Lynch reports that, in the U.S., the average monthly revenue per line generated by competitive local exchange carriers (CLECs), many of which entered the market to offer broadband (xDSL) services to small business and residential customers, is approximately \$55 per month. But only about 20 percent of this sum comes from data services, even though the average customer is known to spend more time (and bandwidth) each month surfing the Internet than making local and long distance telephone calls. Deutsche Telekom, Europe's largest carrier, generated only three percent of its revenues from data services in 1998, although its data portfolio included the country's largest ATM network and a range of Internet access services. In

[5] The data/voice cross-over probably occurred in 1998 on the U.S. long distance network and on many international routes. By early 1999, for example, in Hong Kong, to cite but one case, the monthly total of dial-up Internet minutes was already three times that for international phone calls. Data traffic has eclipsed voice traffic first on longhaul networks because users generally are not directly connected to the Internet; they use the public telephone network for the last mile. With broadband local networks that will change, and the price pressure on vertically integrated telcos with local and long distance services will become that much greater.

the year to June 1999, Telstra Corporation, Australia's largest carrier, reported that less than 14 percent of its communication revenues came from data services (broadly construed to include ISDN lines) and less than one percent from Internet services. Never mind that Telstra has more international transmission capacity dedicated to IP service than it does for telephony. You get the picture.

The pressure to align the prices for voice and data traffic also exists at the wholesale level. During the last decade, many large carriers sought to reduce their settlement costs at the foreign end by provisioning capacity on an end-to-end basis themselves (that is, moving from a half circuit to a whole circuit regime; see Figure 8). With the rise of the Internet, they must now cope with moving from a whole circuit to a "no circuit" regime under which traditional interconnection arrangements between long distance and local (foreign) carriers may be replaced by ad hoc "peering" arrangements between two or more tiers of Internet backbone operators. Only the top tier of operators (five or six carriers globally) exchange traffic without charge for destinations on the network. Other carriers generally must pay to have their traffic delivered on equivalent terms.

To be sure, bandwidth costs for longhaul traffic are declining rapidly, but they are still far from trivial. Thus, as more and more subscribers see Internet-based telephony as an acceptable alternative, network service providers must somehow match the revenues they receive for connecting this traffic with their bandwidth and switching costs, plus, of course, the associated administrative marketing and billing expenses. It is far from certain how this will be done.

The largest "pure" IP telephony carriers (ITXC, Net2Phone, Delta 3) are now operating at a considerable loss as facilities and marketing costs outstrip revenues (see the "VoIP Traffic and Settlements" article in this book). Retail pricing trends in the U.S. and Western Europe for long distance services are not encouraging either. Low flat rate charges seem to be the trend, and free (advertiser supported) service if you are an Internet operator. In August 1998, for example, major U.S. carriers announced that for a \$4 or \$5 monthly fee they would offer customers \$0.05 per minute long distance telephone calls and overseas calls at \$0.12 per minute to many points. By contrast, FCC data shows that in 1998 the gross domestic long distance revenue of U.S. carriers was \$0.13 per minute; for international services it was \$0.59. In these circumstances, the path ahead may well be marked by a number of unexpected "profit warnings" and "restructuring charges," as providers scramble to align their business with this new economic reality.

2. Products

Bits are bits. And as the premium for delivering voice bits between one country and another begins rapidly to decline, many international carriers will have to think hard about the business they want to be in years hence. This is particularly so

in the most competitive markets, where the pressure on prices is likely to be the sharpest.

One response is to offer a mix of different bit services to users, that is, to offer vertically integrated services by, for example, bundling international and local exchange services, where the entry barriers may be higher. Witness AT&T's cable TV strategy. Conversely, several major U.S. exchange carriers have sought to leverage their local assets with the aid of compatible international networks (the tie up of Frontier and Global Crossing is but one example).

Carriers also may be tempted to bundle international telephony with other digital services, such as mobile telephony where customers are still willing to pay a premium for convenience. Linking fixed and mobile serves also is plainly of interest to AT&T as well as to Bell Atlantic (which recently agreed to partner with Vodafone) and NTT (which has a large Internet and mobile base, but as yet, limited overseas reach). The mobile telephony business is now so large (mobile customers will exceed fixed line subscribers by 2005 in many countries) that it deserves a separate essay. Failing that, however, two points deserve emphasis.

First, as revenue per customer from mobile telephony continues to fall, mobile data services and other Internet-based offerings will become as important to the future of the wireless industry to wireline telcos. Indeed, as more and more mobile operators deploy the Wireless Application Protocol (WAP), some estimate that data traffic will eclipse voice traffic on wireless networks by 2004. Second, whereas terrestrial mobile operators have historically been viewed as "local" carriers, multi-national mergers and alliances (e.g., Vodafone-Bell Atlantic; Orange-Mannesmann) coupled with the upsurge of roaming traffic (especially on Europe's GSM networks) will give the largest mobile operators a significant international traffic base. (see the "International Mobile Telephone Traffic" article in this report for some preliminary data on international roaming traffic).

The larger question for both wireless and wireline carriers, however, is whether economies of scale (network lines) can actually be translated into economies of scope (new services), and just how broad that scope might be. In the past, when services were network-specific (there was one network for voice, one for data and one for video), the ability of any network to leverage its position into the market space occupied by another network was much more limited. But once a network's services have been digitized so that they can be networked with a common protocol (TCP/IP), that network's economies of scale may more readily be translated into economies of scope elsewhere. This is most evident, of course, in the market for basic transmission services. Smaller carriers are already quite worried that the largest ATM backbone operators, for instance, can offer better end-to-end prices for high volumes of voice and Internet traffic and further concentration of backbone facilities (a la mergers of

the AT&T and BT international networks or the proposed MCI WorldCom and Sprint merger) thus seems inevitable to many observers.

Common digital transmission standards also may expand economies of scope at the service level too. Internet telephony is a case in point. So too, notably, are streaming video and audio services. Telephone, Internet and cable TV networks all hope to be able to bill their customers handsomely for access to a common suite of services and the software interface for these service suites has already led to a growing fight among competing software developers.[6]

But bundling, like cross-market competition, has its risks. As lower value digital services are bundled with higher valued offerings, the greater may be the price pressure on the premium services. How long will users be willing to pay \$0.05 per kilobyte of traffic for one service when they are offered an "all the bits you can eat" price for another service which is delivered to the same set of terminals and over the same wires?

The uncertain economics of tomorrow's networks also is prompting a range of hybrid business models with as many different products (see Figure 9). Some telephone companies see their future not so much in providing new network services as in hosting the services provided by others by, for instance, building data centers and Web server "farms." AT&T, UUNet, Frontier, Qwest, Metromedia (which recently acquired AboveNet) and Exodus (a major IP backbone provider) all have plans in this area. Major "outsiders," such as SAP, Sibel, Hewlett-Packard and Intel, which plans to spend more than \$1 billion on 12 worldwide data centers, have entered this market as well. A new umbrella organization, the application service providers industry consortium (www.aspc Consortium.org), has been created by over 100 companies to agree upon the best practice for hosting high-end applications.

The challenge of transforming a telco into a comco (communications company) was also a prime topic at the Telecom '99 Forum in Geneva. Drawing on a background paper by Ernst & Young LLP (see the executive summary of "The Connected Society," is available at www.ey.com/publicate/tce/pdf/connectedsociety.pdf), executives from several international telcos addressed the challenge of moving up the value chain as pure transmission becomes a commodity service. Press releases aside, the plans of most telcos are still embryonic, but there are some success stories. One was recounted by Peter Nicholson, Chief Strategy Officer, BCE, parent of Bell Canada. To jump start its systems integration business, BCE acquired a 45 percent stake in an independent venture, CGI, and then transferred key staff and contracts to the company, thus giving it the commercial scale and expertise to play in the larger North American market. Likewise, BCE increased the market capitalization (and visibility) of its e-commerce business, Emergis, by more than \$1

billion by separately listing the company's stock while retaining a majority interest.

Whatever the new strategy—e-business or Web hosting, systems integration or application management—it is now clear that the core business of most international telcos has begun to enter a period of dramatic change. Whether one canvasses global consultants like Ernst & Young LLP and Pricewaterhouse Coopers (the source for Figure 9) or the telcos who hire them, there is now little doubt that the sustainable product set of most carriers 5 or 10 years hence will look quite different from what it does today.

B. Rules of the Realm—Regulating Network Access and More

Since the early 1980s, international telecom regulators have been preoccupied with market entry and prices, especially settlement rates. These are late 20th century concerns, however. The landmark 1997 WTO's Agreement on Basic Telecommunications Services, which opened the telephone service market in over 70 countries to foreign investment, resolved the main market entry issues, at least in principle. Likewise, new fiber optic cables and the Internet will soon bring both wholesale and retail prices for most international calls more into line with costs. Competitive data networks will be the name of the game worldwide.

Some regulators may try to prop up the common carrier paradigm for several more years or to manage competition, but it will be a stop-gap effort. In the main, regulators will find themselves concentrating on a new agenda brought forward by the broadband, Internet-friendly networks described above.

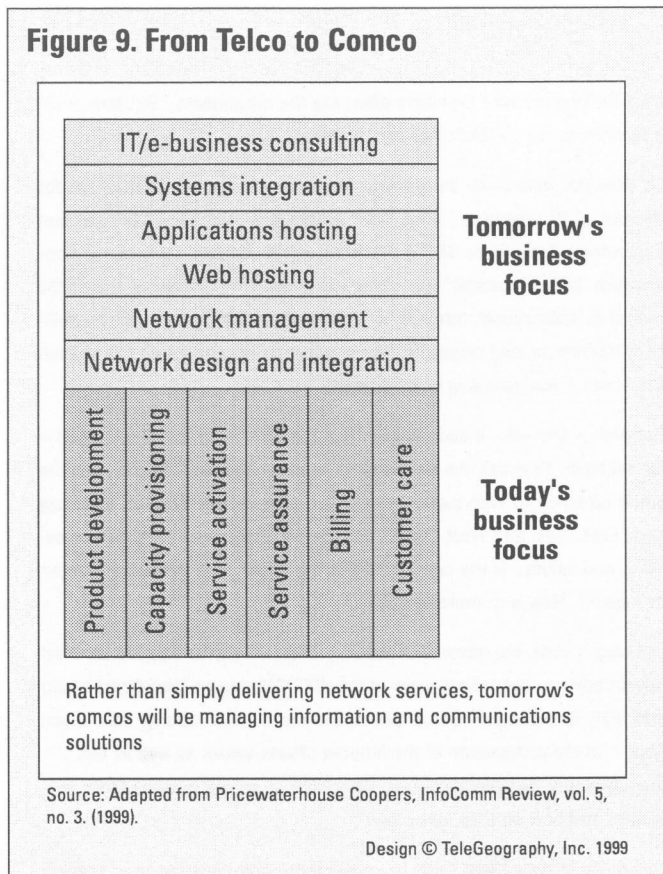
Topping this new agenda are likely to be the following:

1. Promoting Network Access

If the "last mile" is the gateway for new broadband services, then who may pass through this portal and on what terms becomes the issue of the day. Witness the widening legal and regulatory disputes in the U.S. triggered by AT&T's proposed acquisition of cable TV operators, TCI and MediaOne. Witness too the disputes in Europe and North America regarding the terms on which incumbent telephone companies must resell to their competitors local loops capable of providing xDSL and other high-speed services.

Encouraging broadband competition will require a new sensitivity, however, to the changing relationship between network owners and service suppliers. In the telephone world, these businesses are one and the same; in the Internet world (and also the cable TV universe) they typically are not. So where should regulators intervene—at the network level, e.g., with rules mandating resale and unbundling of basic elements? Or at the services level, e.g., mandating open source standards for cable TV set-top boxes so that independent producers and

Figure 9. From Telco to Comco



unaffiliated Internet service providers will have non-discriminatory access? Or both? Laws can codify access, but so can software standards and (seemingly neutral) access technologies (see Figure 10).

As importantly, who should police the new regime—the regulator, the regulated or the market? When markets were closed, the pace at which regulators moved and the remedies for inaction typically affected but one company. Not so today when there are scores of competitors in key markets and business moves on Internet time. As Kathryn C. Brown, the FCC’s Chief of Staff, recently said, governments must learn how to enforce “real world rules in real time for real businesses . . . something which is a real change for many regulators.”

That is why the FCC, among others, is encouraging warring parties (e.g., on interconnection and local access charge issues) to reach a negotiated agreement with self-executing enforcement

mechanisms, including performance audits, liquidated damages and specific financial penalties for non-performance. These types of private contracts, publicly reviewed, are likely to be more and more popular in tomorrow’s deregulated markets. Just in case, though, the FCC has asked the U.S. Congress to create a new Enforcement Bureau equal in stature to other FCC divisions.

2. Allocating Common Resources

The drive for broadband connectivity will place a new premium on networking resources that are comparatively scarce, and thus must be shared, notably the radio spectrum and network numbers.

Competing demands for radio spectrum are everywhere. Mobile carriers are bidding for G-3 licenses; other entrepreneurs want large blocks of microwave spectrum for fixed wireless networks; and satellite companies want frequencies to support their next-generation broadband systems. Spectrum auctions (including “after market” trading forums) as well as flexible, non-service-specific spectrum licenses, may put spectrum to its best use domestically. Treaty negotiations will probably remain the rule internationally for some time, however, with the ITU’s radio conferences being perhaps the most important.

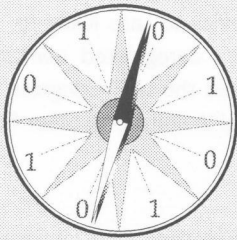
So long as a common scheme for numbering telephone terminals and computer-based resources (the Internet) are beneficial, governments will probably have a role here as well. Telephone number plans, local number portability (in markets with competitive carriers) and access to “free phone” numbers have garnered the most attention thus far. But management of IP addresses and, as importantly, the rules for PSTN-IP number convertibility, are likely to become more pressing. ICANN’s recent history underscores this. (see the Internet section for more details).

3. Monitoring Network Performance

When the world’s telephone network was largely owned by a small number of carriers, it was comparatively easy for regulators to set and verify network performance standards (call-seizure rates, set-up times, etc.). Because most engineers shared a common outlook, nationality aside, international standard setting was also a clubby affair. Today, however, in many countries a long distance call may depend on the performance of several competing carriers; on the Internet, it is not uncom-

[6] As the world’s largest software company, Microsoft, of course, is a key protagonist. It has recently spent over \$8 billion buying minority stakes in mobile telecom, wireline and cable TV businesses (see the Carriers section for more details) to advance its own soft network vision. As Microsoft Chairman, William Gates, recently explained to a Telecom ’99 audience in Geneva, the company’s growing interest in network service providers is “very similar to the collaboration that existed between the hardware industry (e.g., Intel and Compaq) and Microsoft in creating the PC business.” By providing a symmetric suite of network interfaces (for mobile devices, cable TV, web TV and PCs) and by underwriting the cost of new broadband networks, Gates argues that Microsoft will stimulate new network-based services for everyone. However, competing software providers such as Sybian (backed by Motorola and Nokia), which is promoting its own interface for wireless data, contend that Microsoft’s networking push is just a reprise of its past business practices. Once again, they say, the software giant is trying to extend its proprietary codes (DOS and, later, the Windows NT Operating Systems) into new markets by making key network interfaces into technical choke points. Open standards, not private ones, are the best way to grow the market for new networked services, say Microsoft’s opponents (see also Figure 7).

Figure 10. Encoding Law—The Future of Regulation



How do you regulate telecom networks? With laws? Court orders? Policy statements? In the digital age, these tools may be less and less effective. Network switches don't understand words, but they follow codes. A few lines of software may do more to make a network open or to keep a message private than any number of legislative edicts.

As Lawrence Lessig puts it: "Code is law." "The coming of age of this simple idea," says Lessig, a Harvard Law School professor, "is the single most significant change in the politics of cyberspace."

There are few texts, as yet, for encoding telecom law. But a new book by Lessig, *Code and Other Laws of Cyberspace* (Basic Books, 1999), offers a good starting point. (For a shorter version, try Lessig's columns in *The Industry Standard* (www.thestandard.com).

One of the book's main arguments is that the architecture of any electronic network—the hardware and software that makes it run—contains a set of embedded rules which govern the behavior of users. Lessig calls these electronic rules—typically minted in Silicon Valley or Redmond—West Coast Code, in distinction to the text-based-rules—East Coast Code—popular in Washington, D.C. In Lessig's view, West Coast Code simply works better: "It's faster, cheaper and more reliable."

Some examples may help to clarify the choice. Consider the issue of limiting access to pornography on the Internet. East Coast Code typically relies upon new criminal penalties and financial forfeitures for those who post or distribute offensive bits. In contrast, West Coast Code prefers to fight bits with bits, using software (e.g., P3P, a version of XML (Extensible Markup Language)—See Figure 4) to "tag" the content on Web pages in a standard format so that pages can be "rated" and Web browsers can filter any content a user wishes to block. The first approach relies upon government to police the Net; the second seeks to harness the power of the Net's users.

Privacy regulation is another example. Commercial Web sites often collect significant personal data from their visitors. In response, some governments want to require merchants to disclose their data collection practices and to obtain customer consent. West Coast coders, like Lessig, say this won't work. "Rather than read a privacy policy each time I enter a new site, I should be able to tell my browser what my privacy preferences are," that is, to set parameters for site access. Then my software can "negotiate" with their software. Codes, not words, will best protect privacy, says Lessig.

Regulating Internet telephony offers a third example of the problems facing East Coast Code on the Internet. Some long distance operators in the U.S. have complained that companies offering Internet telephony have an unfair advantage because Federal Communications Commission (FCC) rules classify the service as "value added," and thus exempt from the payment of local access charges to support universal service. The FCC's rules should

treat all long distance providers alike, say the incumbents. But how could a technology-neutral definition be enforced?

"It does not take much imagination to see that if there is [a new] fee for the use of IP telephony," says Scott Bradner, a member of the Internet Engineering Task Force (IETF), "people would quickly start using non-assigned [switch] port[s]" on routers to mask the identity of the traffic routed by their chosen Internet Service Provider (ISP). Given the flexibility of Internet routing protocols, "there would be no way for an ISP to even know that it was handling IP telephony."

But here is the rub. If code is law, then the ad hoc application of code—for example, to tweak the switch ports used by Internet telephony or the labels attached to Web pages—can create private laws. Hence, as Lessig says, East Coast and West Coast Code raise similar questions about procedures and values. Is the code written in the open? Is it transparent about its means? How is it implemented?

In Lessig's view, the same democratic values should be applied to West Coast Code—to the deliberations of the W3C (Worldwide Web Consortium) and IETF, for example—as to the deliberations that underlie East Coast Code. "If the architecture of the Internet affects values as well as bits . . . then as in any lawmaking context, we should be asking who are these lawmakers and how do they make law?"

The ability of West Coast Code to answer these questions has been publicly tested during the last year by the efforts of the quasi-public Internet Corporation for Assigned Names and Numbers (ICANN) to change the rules for managing Internet addresses (background on ICANN is provided in "Internet Governance: Then and Now" later in this book). For example, ICANN has recently proposed to make it harder for "cybersquatters" to use an Internet address which matches a pre-existing corporate trademark or brand. If ICANN's mandatory arbitration approach prevails, many cybersquatters could lose their "home." For unless the Internet's master directory (the root servers) encode your address, no one can reach you.

ICANN's activities have prompted considerable protest, not so much because the group's approach to cybersquatters is misguided, but because many observers fear that ICANN's actions may lead others to use the Internet's address codes to police undesirable behavior. "Domain names may provide the most efficient way of enforcing laws on the Net," commented Mike France in *Business Week* ("What's in a Name.com? Plenty"). For example, "when people buy names for their Web sites, they could be required to sign a detailed contract obligating them to comply with a certain set of rules," such as those governing obscene content or the protection of intellectual property. "And if they violated the contract, they would forfeit their address" which, of course, on the Net would be a virtual death sentence.

The outcome of the ICANN debate may thus have much wider implications about the future of regulation in a society where the codes used online may shape economic and social options even more than the bills passed by legislatures.

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mon to traverse 15 or 20 networks en route. In this environment, what QoS obligations should network service providers have to each other? To their customers? Should QoS be government-mandated or market-driven?

Likewise, how do you assign the liability amongst various service providers (or their customers) for network failures whether due to negligence or not? Should the limited liability rule applicable to North American carriers be extended to the Internet? Or should the contract law rules which now govern most data networks apply to all service providers? And what role, if any, should carrier insurance play—mandated or optional?

Recent network outages and fast-spreading software viruses have brought these questions forward, as has the Y2K issue. Tomorrow's soft networks will make any network player even more vulnerable to actions of downstream and upstream service providers (as well as their customers). That has made network security of prime concern to every major service provider. Security is also a key reason why private intranets, with sophisticated fire walls, are attractive to companies with mission-critical communication needs. Thus, with the economic costs of network outages rising daily and the uncertain remedies available to injured parties, the pressure for government action is likely to mount.

4. *Protecting Consumers and Their Privacy*

Open markets also have attracted their fair share of unscrupulous operators and almost all regulators have seen a rising level of consumer complaints. The Internet likewise has been fertile new territory for deceptive business practices and worse, many of them multi-national in scope. Getting fleeced online is one thing; letting the whole world know about it is quite another and many Internet users seem to be less troubled by the threat of "shady" Internet operators than by the inadvertent surrender of their online privacy—privacy which they take for granted on the public telephone network.

Numerous countries have laws protecting both the content of a telephone conversation from being intercepted as well as the identity of the originating and terminating numbers. Not so for Internet sessions. And the trans-national dimension of the Internet can make the matter even more complicated. There is also a flip side to this issue, of course—protecting children and non-consenting adults from unwanted invasions of their network space, whether from unsolicited banner adverts or pornographic images. The wider the network's reach and the greater

the range of services on offer, the more pressing these issues are likely to become. Which brings us to the last issue.

5. *Reconciling Telecom and Broadcasting Rules*

When all networks can carry the same types of bits, why should some networks be licensed, or be subject to price or content rules, and others not? Tomorrow's broadband networks will allow video, audio and telephone services to be delivered side by side. Internet telephony and streaming video services on the Net have already challenged traditional service definitions for regulators. However, in North America, at least for now, regulators have preferred to treat the Internet as *sui generis* and not saddle it with the market access or content regulation commonly applied to terrestrial broadcasters or telephone companies. This "hands off" policy has not always been evenly applied; interconnection terms between Internet service providers and incumbent telcos are subject to complex rules, at least at the local level.

Convergence between wireless and wireline services is also forcing regulators to rethink their rule books. When a mobile operator uses its spectrum to provide Internet services to a fixed site, how should it be treated? And who should pay? And what about competition policy: do wireless local loops or the potential for 3G services make the current telco/cable TV duopoly a temporary feature of the telecom landscape in some countries or not?

As always, new telecom technologies raise more questions than answers for those who would oversee them. In the short run, therefore, despite the clamor for action, the best approach may be "forbearance": do not apply old rules to new services and do not adopt any new rules either unless you have a clear sense of the networks' current direction.

Which brings us back to this essay's title—The Soft Network. Though it is woven from silica, tomorrow's network will be softer than ever. In the years ahead, it is lines of codes, not miles of conduits, which are likely to exert the strongest magnetic pull on the network's compass. In this shifting terrain, "know the code," however written, is likely to be the first rule of navigation for referees and players alike. 🗝️

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For Further Reading

Know the Code

For background on the cross-cutting impact of open source programs, such as Linux, see "The Open Source Revolution," edited by Tim O'Reilly, *Release 1.0*, 20 November 1998, available from www.edventure.com and *Open Sources, Voices from the Open Source Revolution*, Chris di Bona, Sam Ockman and Mark Stone, eds. (O'Reilly & Associates, Inc., 1999).

The XML revolution is profiled by Tim Bray, co-editor of the early specifications, in "XML and the Second Generation Web," *Scientific American*, May 1999, available at: www.sciam.com/1999/0599issue/0599bosak.html. See also the special report on XML in the October 1999, *Network Magazine*, available at www.networkmagazine.com. And if you wish to follow XML events regularly, visit www.xml.com.

Last, but far from least, is the new history by the man who invented the "http" in web addresses, Tim Berners-Lee: *Weaving the Web*, Harper, San Francisco, 1999.

Broadband Local Access

The roll-out of broadband capacity over the last mile in the U.S. is summarized in a recent (October 1999) report by the FCC Cable Services Bureau, titled "Broadband Today." See www.fcc.gov/Bureaus/Cable/News_Releases/1999/nrcb9017.html. For a global survey, see Pioneer Consulting LLC's *Global Broadband Access Markets*. See also the sources referenced at the Web page maintained by The ADSL Forum; www.adsl.com/adsl_forum.html.

Prices and Products

As international telcos begin to rethink their pricing and service strategies in earnest, they would do well to consult the work of two economists who have spent much of the last decade thinking through the economics of network-based services. See *Information Rules: A Strategic Niche to the Network Economy* by Carl Shapiro and Hal R. Varian (Harvard Business School Press, 1999).

The Future of Regulation

For the most complete global survey available, see *Trends in Telecommunication Reform, Convergence in Regulation*, 1999 (ITU, Geneva 1999). Also worth reviewing is the U.S. Federal Communication Commission's "Strategic Plan for the 21st Century," at: www.fcc.gov/Bureaus/Miscellaneous/News_Releases/1999/nrmc9059.html. For Europe's regulatory agenda, see the European Commission's "Fifth Report on the Implementation of the Telecommunications Regulatory Package," at: europa.eu.int/comm/dg13/5threp99.htm.

However, the book of the year on regulation is *Code and Other Laws of Cyberspace*, by Lawrence Lessig (Basic Books, 1999). Runner up: Judge Thomas Penfield Jackson's findings of fact in the Microsoft case available at: usvms.gpo.gov.

The Growth of International Services Competition

Forty Percent Growth in Competition—Again

As of July 1999, over 1,700 companies worldwide were authorized to build facilities to offer international telephone service. Three years before, there were less than 500 (see Figures 1 and 2). In the fastest growing markets (the U.S. and Western Europe), the pace is not likely to slow down. Even by conservative estimates, the world should easily have more than 2,200 international carriers by mid-year 2000.

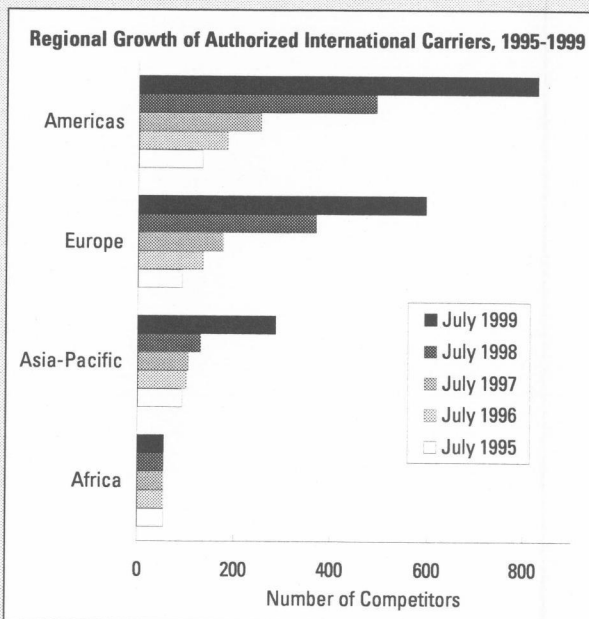
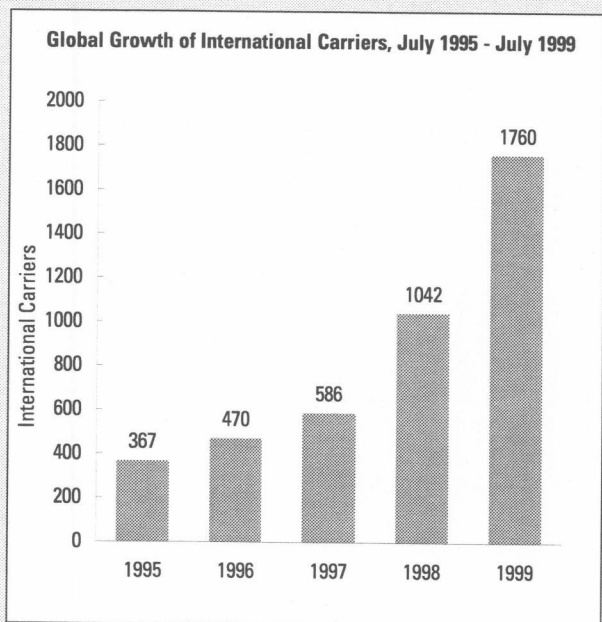
Although these carriers are all authorized to operate international transmission facilities, many of the new competitors do not own extensive submarine cable capacity and switching assets. In the U.S. especially, the hundreds of small companies which are authorized to own networks may never build them. In fact, three quarters of the carriers authorized in the U.S. do not generate more than \$10 million in international service revenues each year. On a global scale, a pattern is emerging: the world's top 20 carriers carry about 60 percent of the traffic whereas the thousands of new carriers which have started business since 1989 carry just 13 percent.

The relationship between the network builders and the swarm of "virtual carriers"—which repackage the facilities and services of the handful of network builders—is one of symbiosis. New market entrants, while they represent a competitive threat, can also be the incumbent's best customers.

The New Breed of Virtual Carrier

Although old-fashioned pure resale is still a staple (more than 30 percent of traffic originated in the U.S. was resold in 1998), virtual carriers are always looking for new ways to cut prices without shrinking profit margins. The next development in alternative traffic routing may create a new kind of packet-switched symbiosis. Once the network builders figure out how to send commercial grade traffic on IP networks reliably and also to devise a way to settle accounts properly, the ranks of international carriers will swell even more rapidly (see the "VoIP Traffic and Settlements" article in this book). Indeed, IP connectivity may lead to unregulated "international carriers" on virtually every street corner, in every corner of the world. 🗝️

Figure 1. The International Carrier Boom



Note: Figures include all carriers authorized to provide international facilities-based service or international simple resale.

Source: Adapted from TeleGeography's 3-volume directory of international carriers, *New International Carriers*.

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Figure 2. Countries with International Telephone Services Competition

Number of Authorized International Carriers						
Rank	Country	July 1999	July 1998	July 1997	July 1996	July 1995
1.	United States	679	393	175	115	65
2.	United Kingdom	215	144	100	65	35
3.	Hong Kong	80	4	1	1	1
4.	France	50	29	1	1	1
5.	Japan	50	13	3	3	3
6.	Canada	49	21	21	19	18
7.	Germany	40	32	1	1	1
8.	Switzerland	40	21	1	1	1
9.	Russia*	35	1	1	1	1
10.	Netherlands	30	23	3	1	1
11.	Australia	28	14	10	8	8
12.	Ireland	25	5	3	3	1
13.	Korea, South	24	3	2	2	2
14.	New Zealand	19	11	9	9	2
15.	Belarus	18	1	1	1	1
16.	Belgium	18	11	1	1	1
17.	Denmark	18	11	9	7	1
18.	Peru	18	1	1	1	1
19.	Austria	17	13	1	1	1
20.	Mexico	16	15	9	1	1
21.	Spain	16	9	1	1	1
22.	Sweden	16	13	11	9	7
23.	Italy	15	9	1	1	1
24.	Norway	14	7	1	1	1
25.	Philippines	12	12	9	9	9
26.	Chile	10	9	9	9	9
27.	El Salvador	10	10	1	1	1
28.	Finland	8	8	8	8	5
29.	Malaysia	5	5	5	5	4
30.	Luxembourg	4	1	1	1	1
31.	Colombia	3	3	1	1	1
32.	Dominican Rep.	3	3	3	3	3
33.	Iceland	3	1	1	1	1
34.	Israel	3	3	3	1	1
35.	Kazakhstan	3	3	1	1	1
36.	Argentina	2	1	1	1	1
37.	Bermuda	2	2	2	2	1
38.	Brazil	2	1	1	1	1
39.	Brunei	2	2	2	2	2
40.	China	2	2	2	2	2
41.	Dominica	2	1	1	1	1
42.	Georgia	2	1	1	1	1
43.	Indonesia	2	2	2	2	2
44.	Ukraine	2	2	2	2	2

Note: Figures include all carriers authorized to provide facilities-based international service or international simple resale as of July 1 for each year.

* Estimates include carriers authorized to provide service only in certain municipalities.

Source: Adapted from TeleGeography's 3-volume directory of international carriers, *New International Carriers*.

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Market Shares of International Carriers

Country/Carrier	Percentage of Outgoing Minutes									
	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Australia										
Telstra			100.0	98.0	87.0	76.3	73.4	62.0	55.0	49.0
C&W Optus				2.0	13.0	21.9	23.4	27.0	26.0	22.0
AAPT									11.0	12.0
Primus Telecom.									3.0	4.0
WorldxChange										4.0
Global One										3.0
Others						1.8	3.2	11.0	5.0	6.0
Austria										
Telekom Austria									100.0	95.0
UTA Telekom										1.5
Others										3.5
Belgium										
Belgacom									100.0	96.0
Others										4.0
Canada (Canada-U.S. route only)										
Stentor (alliance)				100.0	93.0	80.0	63.0	57.0	56.0	55.0
Sprint Canada							22.0	27.0	23.0	23.0
AT&T Canada Long Distance					2.0	8.0	8.0	8.0	9.0	13.0
ACC							3.0	4.0	5.0	5.0
Others					5.0	12.0	4.0	4.0	7.0	4.0
Chile										
CTC Mundo/Globus				<1.0	17.5	31.2	31.0	31.5	33.0	35.0
Entel Chile		100.0		80.0	57.5	40.0	40.6	37.3	33.0	31.0
Chilesat				20.0	25.0	19.7	19.4	15.2	17.0	13.0
BellSouth Chile						6.6	6.8	10.0	10.0	10.0
FirstCom (Iusatel)						1.2	<1.0	2.8	3.0	5.0
Transam						<1.0	<1.0	2.8	3.0	3.0
Others						<1.0	<1.0	<1.0	<1.0	3.0
Denmark										
Tele Danmark							100.0	92.5	84.4	67.5
Tele2								4.0	6.6	12.4
Telia A/S								3.5	6.3	9.9
Others									2.7	10.3
Dominican Republic										
Codetel				100.0	>90.0	85.8	83.0	77.0	73.8	72.2
Tricom					n.a.	6.7	7.5	12.8	12.9	15.5
AACR					n.a.	7.5	9.5	10.2	13.3	12.3
El Salvador										
ANTEL									100.0	91.5
Others										8.5

Notes

Data based on outgoing international traffic for the public switched network and International Simple Resale (ISR) covering the full calendar or fiscal year. Some data aggregated in "Others" rows include market shares for carriers shown individually in later years. Market shares may not total to 100 percent due to rounding.

Canada: Competition on non-U.S. routes commenced October 1998. Stentor alliance members include Bell Canada, BCT.Telus, SaskTel, MTS, and Aliant. By year end 1998, incumbent carrier Teleglobe held an approximate 80 percent market share on overseas routes. Sprint Canada market shares include Fonorola prior to 1998 merger. ACC merged with AT&T Canada in 1999. Source for some carrier market shares is NBI/Michael Sone Associates Inc., Toronto, Canada.

Chile: CTC Mundo/Globus market shares prior to 1998 merger aggregate CTC Mundo and Globus traffic.

Source: TeleGeography, Inc.

Country/Carrier	Percentage of Outgoing Minutes									
	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Finland										
Sonera					100.0	90.0	72.8	66.0	58.9	54.7
Finnnet International						5.0	19.1	24.2	28.2	28.0
Telia						3.0	7.7	8.8	9.3	12.0
Others						2.0	0.4	0.9	3.5	5.2
France										
France Télécom									100.0	93.0
Teleglobe										3.6
Cegetel										1.9
Siris										1.0
Others										<1.0
Germany										
Deutsche Telekom									100.0	85.7
Mannesmann										7.3
Teleglobe										1.8
MCI WorldCom										1.8
Viag Interkom										1.5
Others										1.8
Hong Kong										
C&W Hong Kong Telecom									100.0	90.0
New World										2.0
Others										8.0
Indonesia										
PT Indosat					100.0	99.5	95.4	88.5	84.8	88.3
PT Satelindo						0.5	4.6	11.5	15.2	11.7
Ireland										
Eircom								100.0	91.0	78.0
Esat Telecommunications									5.0	8.0
MCI WorldCom									3.0	3.0
Others									1.0	11.0
Israel										
Bezeq								100.0	72.5	55.0
Barak									15.0	22.5
Golden Lines									12.5	22.5
Italy										
Telecom Italia									100.0	88.6
Infostrada										4.5
Teleglobe										3.8
Others										3.0

Notes

Data based on outgoing international traffic for the public switched network and International Simple Resale (ISR) covering the full calendar or fiscal year. Some data aggregated in "Others" rows include market shares for carriers shown individually in later years. Market shares may not total to 100 percent due to rounding.

Germany: Mannesmann market shares include international traffic carried by mobile operator Mannesmann Mobilfunk and the long distance carriers Mannesmann ARCOR and o.tel.o.

Source: TeleGeography, Inc.

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Market Shares of International Carriers (continued)

Country/Carrier	Percentage of Outgoing Minutes									
	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Japan										
KDD	93.3	88.0	73.3	69.7	66.9	66.3	66.2	63.9	62.7	58.0
Japan Telecom	3.0	5.5	13.4	15.0	16.2	16.4	16.5	17.5	19.0	18.3
C&W IDC	3.7	6.5	13.3	15.3	16.9	17.3	17.3	18.7	18.4	18.2
Others										4.2
Malaysia										
Telekom Malaysia							100.0	90.0	80.0	77.0
Celcom (TRI)								8.0	11.0	10.0
Binariang										8.0
TIME Telekom										5.0
Others								2.0	9.0	<1.0
Mexico										
Telmex								100.0	83.0	78.0
Alestra									8.5	10.5
Avantel									7.5	8.5
Protel										1.0
Miditel										<1.0
Others									1.0	2.0
Netherlands										
PTT Telecom (KPN)								100.0	95.0	89.0
Enertel									2.0	2.0
Others									3.0	9.0
New Zealand										
TNZ	100.0	92.0	82.0	80.0	78.4	74.8	78.0	78.2	74.6	76.0
CLEAR		8.0	18.0	20.0	21.6	25.2	22.0	19.8	20.2	13.0
Teleglobe										7.0
Others								2.0	5.2	4.0
Norway										
Telenor									100.0	93.5
Telia										5.0
Others										1.5
Philippines										
PLDT			100.0	91.6	84.2	69.0	68.0	78.0	71.0	70.0
Globe Telecom								2.0	7.0	7.1
Eastern Telecom						7.0	6.0	5.0	7.0	6.8
Bayan Tel								<1.0	4.0	5.1
Digitel								2.0	3.0	3.7
Capitol Wireless						<1.0	<1.0	1.0	1.0	3.1
Smart							<1.0	1.0	2.0	2.5
Philippine Global Com.				8.4	15.8	23.0	23.0	6.0	3.0	1.0
Islacom								<1.0	<1.0	<1.0

Notes

Data based on outgoing international traffic for the public switched network and International Simple Resale (ISR) covering the full calendar or fiscal year. Some data aggregated in "Others" rows include market shares for carriers shown individually in later years. Market shares may not total to 100 percent due to rounding.

Japan: Japan Telecom market shares include ITJ prior to 1997 merger.

Source: TeleGeography, Inc.

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Country/Carrier	Percentage of Outgoing Minutes									
	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Republic of Korea										
Korea Telecom			100.0	79.9	74.5	68.7	72.6	73.5	69.0	66.6
Dacom				20.1	25.5	31.3	27.4	26.5	27.0	21.9
Onse									4.0	11.5
Spain										
Telefónica									100.0	95.0
Retevisión										4.5
Others										<1.0
Sweden										
Telia AB				100.0	92.0	87.0	76.0	69.0	66.0	62.0
Tele-2					8.0	13.0	21.0	22.0	22.0	24.0
Others							3.0	9.0	12.0	14.0
Switzerland										
Swisscom									100.0	93.5
Sunrise										3.0
DiAx										0.7
Others										2.8
United Kingdom										
BT	91.0	86.0	81.0	76.8	74.2	68.6	67.7	60.0	54.9	51.6
C&W Comm.	9.0	14.0	19.0	23.2	24.0	28.1	25.8	26.8	30.3	32.2
MCI WorldCom								6.6	5.1	5.1
Teleglobe										4.2
ACC								3.0	3.6	3.0
GlobalOne								3.1	1.5	1.5
Others					1.8	3.3	6.5	<1.0	4.6	2.2
United States										
AT&T	83.3	78.4	74.8	70.3	62.2	60.1	54.3	50.2	44.7	39.6
MCI WorldCom	10.2	14.6	17.8	21.2	25.4	28.6	32.0	32.9	31.2	28.8
Sprint	5.8	6.4	6.3	7.3	10.3	11.1	11.3	13.2	12.0	11.7
Teleglobe USA									1.3	3.3
Pacific Gateway Exch.								0.9	3.2	2.6
WorldxChange									1.9	2.4
STAR Telecomm.									0.5	1.8
Others	0.7	0.7	1.1	1.2	2.1	0.2	2.4	2.8	5.2	9.8

Notes

Data based on outgoing international traffic for the public switched network and International Simple Resale (ISR) covering the full calendar or fiscal year. Some data aggregated in "Others" rows include market shares for carriers shown individually in later years. Market shares may not total to 100 percent due to rounding.

United Kingdom: The figures for Cable & Wireless Communications reflect data for Mercury prior to its April 1997 merger with Bell Cablemedia, Videotron, and NYNEX CableComms.

United States: Market shares for U.S. carriers prior to 1993 exclude traffic to Canada and Mexico. MCI WorldCom market shares prior to 1998 merger aggregate MCI and WorldCom traffic.

Source: TeleGeography, Inc.

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The Top 40 International Carriers

Rank	Company	Origin Country	Outgoing Traffic (millions of minutes)			1998 Revenue (US\$ billions)	
			1998	1997	Change 97-98	Total	Int'l Service
1	AT&T (a)	U.S.	9,878.7	10,290.0	-4%	\$53.2	\$4.7
2	MCI WorldCom (a)	U.S.	7,188.5	7,307.7	-2%	\$30.4	\$2.7
3	Deutsche Telekom (a)	Germany	4,711.0	4,813.0	-2%	\$37.7	\$2.2
4	British Telecom (a, b)	U.K.	4,249.3	3,735.0	14%	\$26.3	\$2.6
5	France Telecom	France	3,825.0	3,545.0	8%	\$25.9	\$2.0
6	Sprint (a)	U.S.	2,926.0	2,758.9	6%	\$17.1	\$0.7
7	C&W Communications (a, b)	U.K.	2,646.2	2,065.0	28%	\$4.3	\$1.1 (est.)
8	Telecom Italia	Italy	2,339.4	2,352.0	-1%	\$25.7	\$1.9 (est.)
9	Swisscom	Switzerland	2,258.0	2,164.0	4%	\$6.9	\$1.2 (est.)
10	China Telecom	China	1,711.5	1,631.8	5%	\$23.9	\$2.2
11	C&W Hong Kong (a, b)	Hong Kong	1,681.6	1,718.0	-2%	\$4.5	\$2.2
12	KPN Telecom (a, c)	Netherlands	1,600.0	1,535.0	4%	\$8.5	\$0.9
13	Telefónica (a)	Spain	1,518.0	1,319.0	15%	\$19.6	\$0.8
14	Belgacom (a, c)	Belgium	1,400.0	1,340.0	4%	\$4.4	\$0.5 (est.)
15	Bell Canada (c)	Canada	1,350.0	1,250.0	8%	\$6.9	\$0.4
16	Singapore Telecom (a, b)	Singapore	1,235.0	1,161.0	6%	\$2.9	\$1.1
17	Teleglobe Canada (a)	Canada	1,145.0	1,113.5	3%	\$3.4	\$0.8
18	Telekom Austria (a)	Austria	1,100.0	995.5	10%	\$3.6	\$0.3 (est.)
19	KDD (a)	Japan	1,100.0	1,105.0	0%	\$3.3	\$1.6
20	Rostelecom (a)	Russia	1,038.3	939.0	11%	\$0.9	\$0.2
21	Teléfonos de México (a)	México	1,022.8	1,008.9	1%	\$7.9	\$0.9
22	Saudi Telecom	Saudi Arabia	932.6	801.3	16%	\$3.3	\$0.2 (est.)
23	Etisalat	U.A.E.	874.8	738.0	19%	\$1.4	\$0.2 (est.)
24	Chunghwa Telecom	Taiwan	862.0	789.0	9%	\$6.0 (est.)	\$0.6 (est.)
25	Telstra (b)	Australia	836.0	833.0	0%	\$11.9	\$0.9
26	Teleglobe USA (a)	U.S.	830.3	301.6	175%	\$3.4	\$0.1
27	Telia	Sweden	750.0	747.0	0%	\$6.2	\$0.6 (est.)
28	OTE	Greece	681.3	593.7	15%	\$3.0	\$0.6
29	FaciliCom (a)	U.S.	678.0	223.2	204%	\$184.2	\$0.1
30	Turk Telekom	Turkey	644.1	557.5	16%	\$1.9 (est.)	\$0.2 (est.)
31	Pacific Gateway Exch. (a)	U.S.	641.4	742.9	-14%	\$0.5	\$0.0
32	Eircom (a, b)	Ireland	613.0	534.0	15%	\$2.4	\$0.2
33	Korea Telecom	Korea, Rep.	604.3	610.0	-1%	\$9.1	\$0.7
34	TPSA	Poland	602.4	529.0	14%	\$2.5	\$0.3 (est.)
35	WorldxChange (a)	U.S.	595.8	430.1	39%	\$0.4	\$0.04
36	Embratel (a)	Brazil	545.8	459.1	19%	\$3.4	\$0.7
37	Telekom Malaysia (a, b)	Malaysia	525.5	588.5	-11%	\$2.0	\$0.3 (est.)
38	Telenor (c)	Norway	500.0	481.0	4%	\$3.6	\$0.3
39	Tele Danmark (a)	Denmark	479.0	513.0	-7%	\$4.8	\$0.3
40	STAR Telecom. (a)	U.S.	457.4	116.2	294%	\$0.6	\$0.04

Note: Traffic figures are for public switched telephone network (PSTN) circuits only (service resale is excluded). Data for U.S. and U.K. carriers include International Simple Resale (ISR). Carrier rankings based on originating country minutes only; when based on the aggregated traffic of all subsidiaries, the top multinational carriers include: AT&T/BT, MCI WorldCom, Cable & Wireless, and Teleglobe. International service revenues generally reflect net of PSTN service revenues after adding or subtracting for settlement payments, but may also include some private line revenue. All revenue figures converted from original currency at conversion rate current to year end reported. Some revenues figures have been estimated (est.).

a. Data based on billing point of call, not originating point.

b. Data are for the fiscal year ending 31 March. Telstra FY ends 30 June.

c. Traffic totals based on TeleGeography estimates.

Source: TeleGeography, Inc., FCC, and company reports

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The Top U.S. International Carriers

Facilities-Based Traffic

Rank	Company	Outgoing Facilities-Based Traffic (millions of minutes)		Growth
		1998	1997	
1	AT&T	9,878.7	10,290.0	-4%
2	MCI WorldCom	7,188.5	7,307.7	-2%
3	Sprint	2,926.0	2,758.9	6%
4	Teleglobe USA	830.3	301.6	175%
5	FaciliCom	678.0	223.2	204%
6	Pacific Gateway Exchange	641.4	742.9	-14%
7	WorldxChange	595.8	430.1	39%
8	STAR Telecommunications	457.4	116.2	294%
9	RSL COM USA	214.3	94.4	127%
10	Viatel	202.0	58.5	245%
11	Primus Telecom	199.5	75.2	165%
12	New Global Telecom	168.0	n.a.	n.a.
13	Cable & Wireless USA	69.0	44.0	57%
14	Tricom USA	66.1	29.2	127%
15	GTE Communications	47.7	10.8	341%

Switched Resale Traffic

Rank	Company	Outgoing Switched Resale Traffic (millions of minutes)		Growth
		1998	1997	
1	STAR Telecommunications/PT-1	2,435.5	1,350.8	80%
2	MCI WorldCom	1,887.8	600.1	215%
3	IDT Corp.	1,563.7	300.5	420%
4	Telegroup	899.3	276.9	225%
5	Cable & Wireless USA	742.9	1,228.1	-40%
6	RSL COM USA	737.2	321.1	130%
7	Primus Telecom.	658.9	158.2	316%
8	Qwest Communications	489.7	343.4	43%
9	Intermedia Communications	409.3	27.0	1418%
10	Startec	388.1	120.9	221%
11	Com Tech International	291.3	n.a.	n.a.
12	AT&T	256.7	29.0	785%
13	Tel-Save	255.8	24.4	950%
14	AmeriVision Communications	236.5	n.a.	n.a.
15	WorldxChange	188.5	n.a.	n.a.
16	DirectNet	171.9	32.4	431%
17	Excel (Teleglobe USA)	166.6	119.6	39%
18	Sprint	150.0	124.2	21%
19	GTE Communications	144.8	17.4	730%

Note: Traffic figures are for public switched network circuits based on billing point of call, not originating point. International Simple Resale (ISR) is included in facilities-based totals.

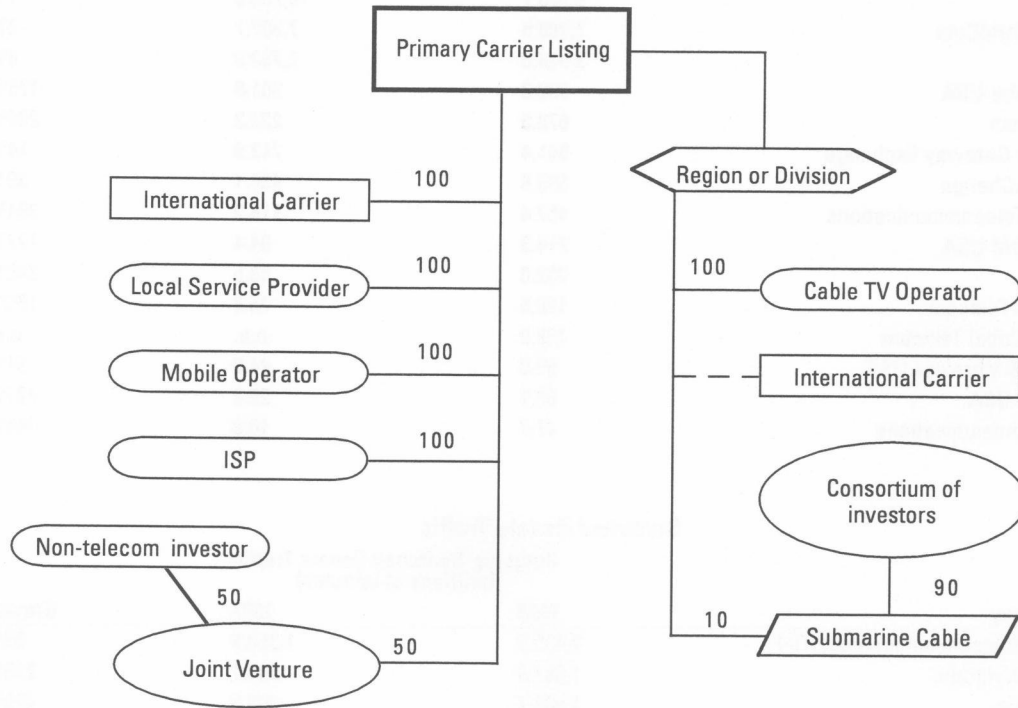
Source: TeleGeography, Inc. and FCC

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Global Carrier Ownership Charts

Guide to the Ownership Charts

Sample Ownership Chart



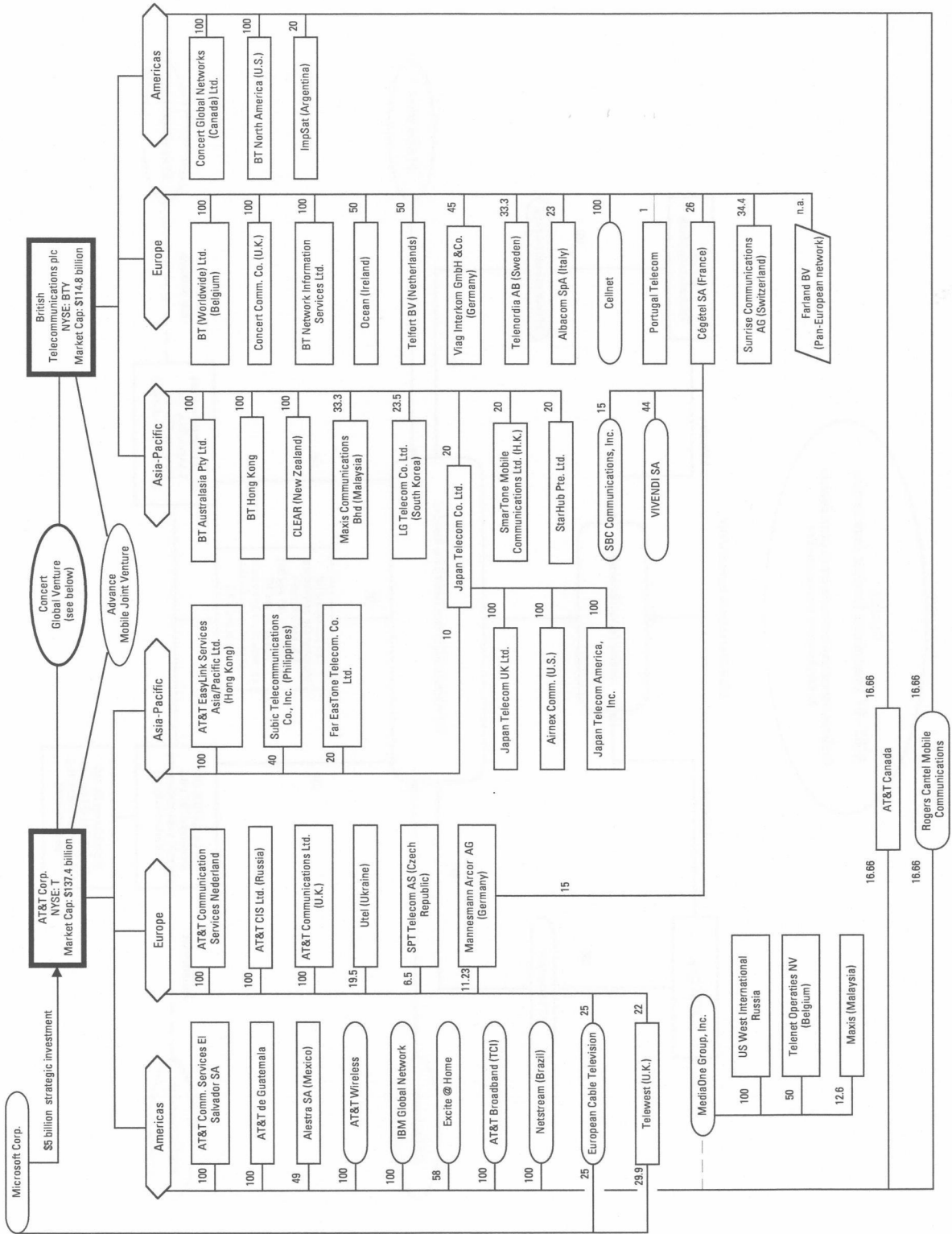
Key

-  solid lines represent ownership relationships
-  numbers indicate percent interest held
-  dashed lines show proposed acquisitions
-  arrows indicate strategic alliance or other cooperative agreements

Note: Charts include all carrier affiliates authorized to provide international facilities-based service, as well as major affiliates providing local, mobile, cable TV, or Internet service. Some communications investments have been highlighted with bold lines to denote importance; others have been omitted due to space limitations. All charts and market capitalizations are current to mid-October 1999.

Source: Adapted from TeleGeography's 3-volume directory of international carriers, *New International Carriers*.

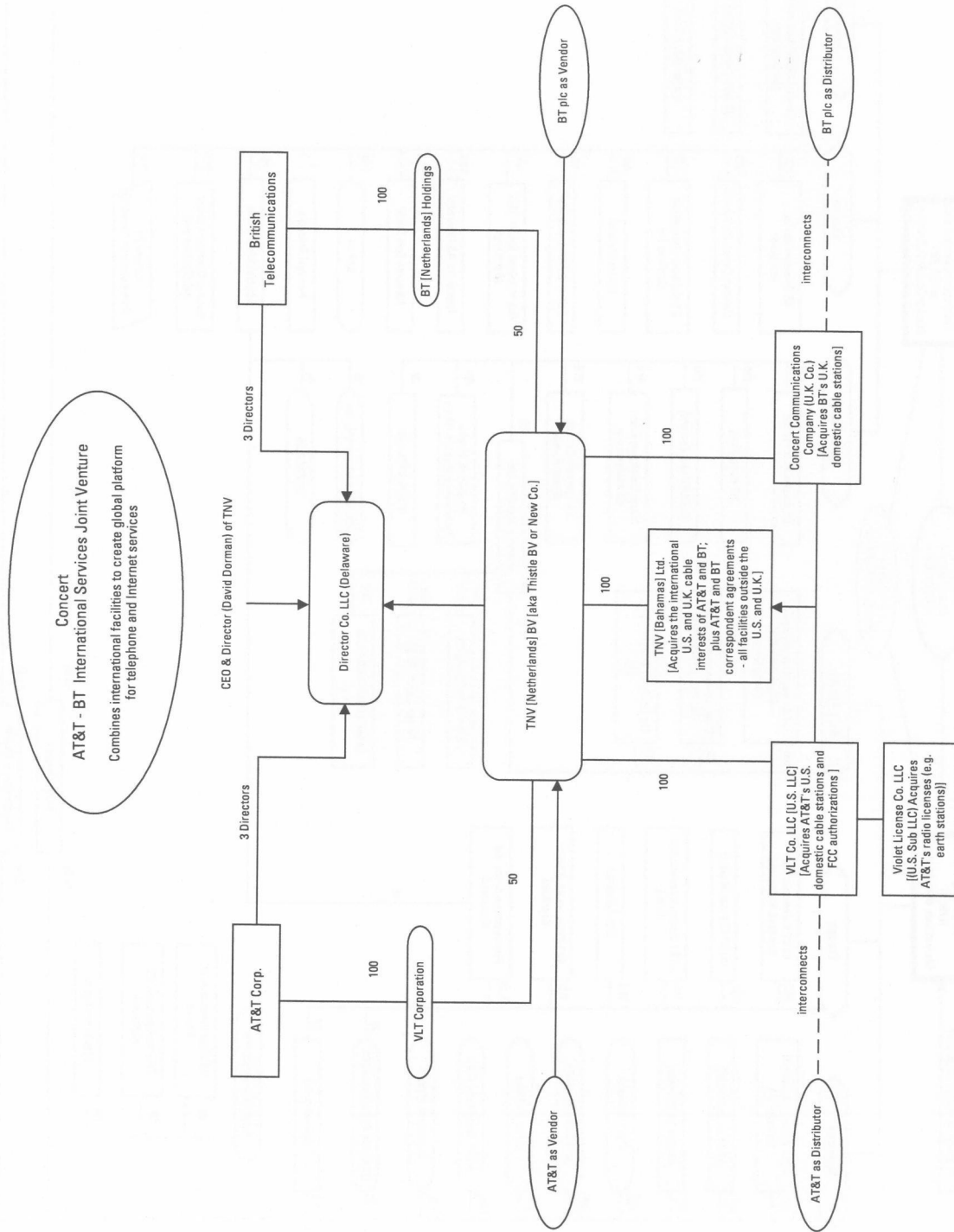
Figure 1. AT&T Corp. and British Telecommunications plc



Note: In November 1999, AT&T announced plans to reorganize its operations in Latin America into a majority-owned but separately traded company named AT&T Latin America.

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Figure 2. AT&T - BT Global Venture



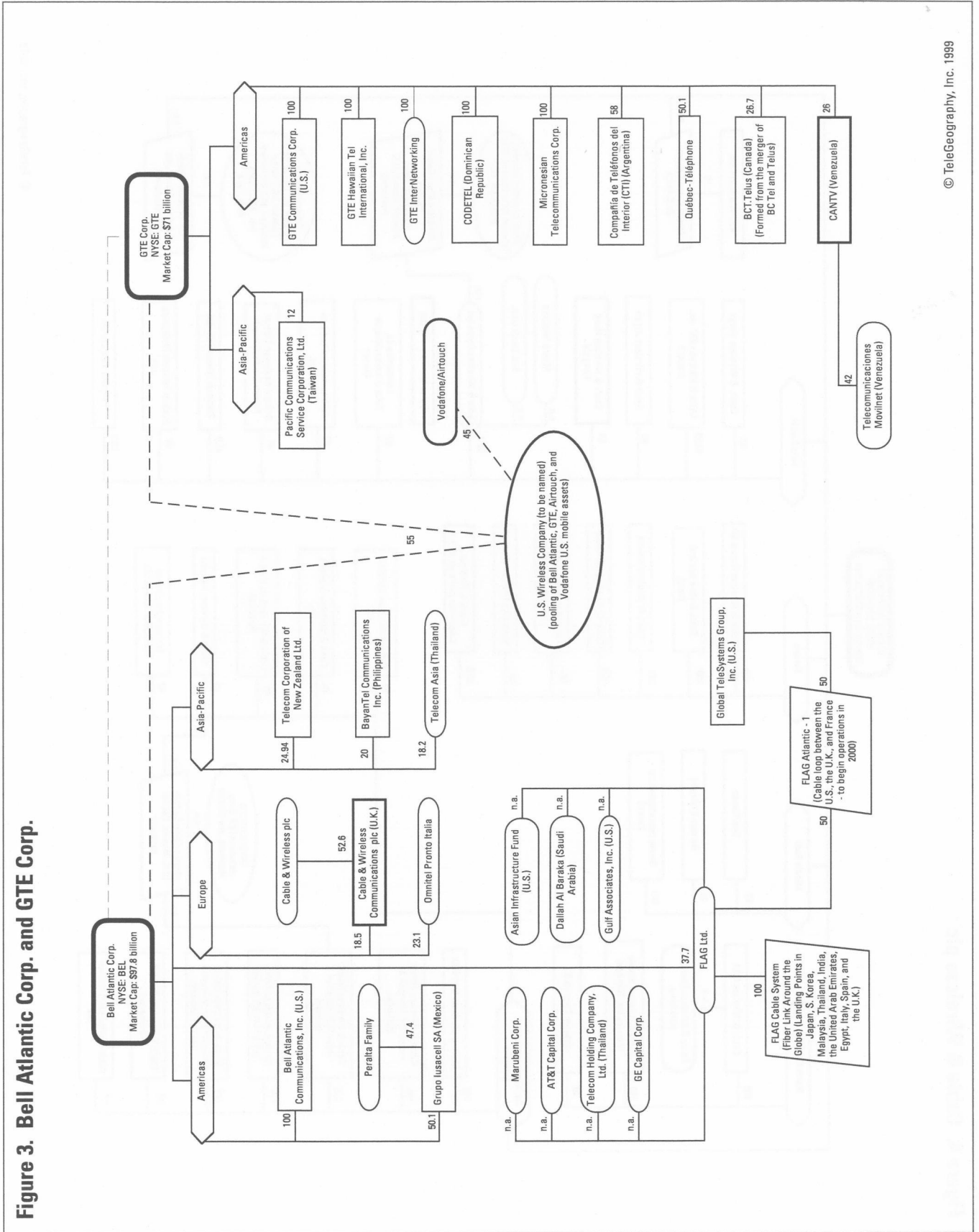


Figure 3. Bell Atlantic Corp. and GTE Corp.

Figure 4. Cable & Wireless plc

Cable & Wireless plc
 NYSE: CWZ/CWP
 Market Cap: \$15.2 billion

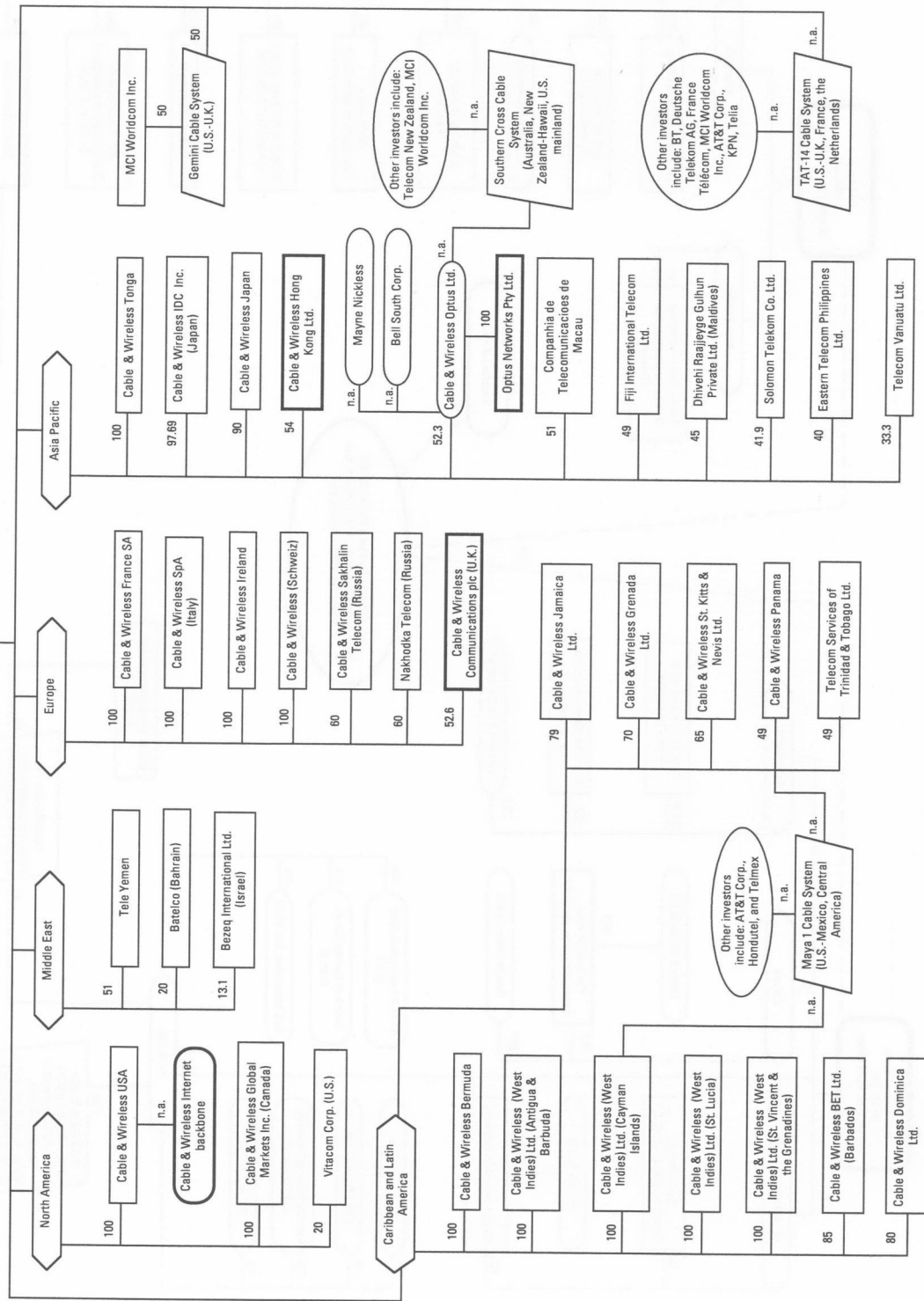
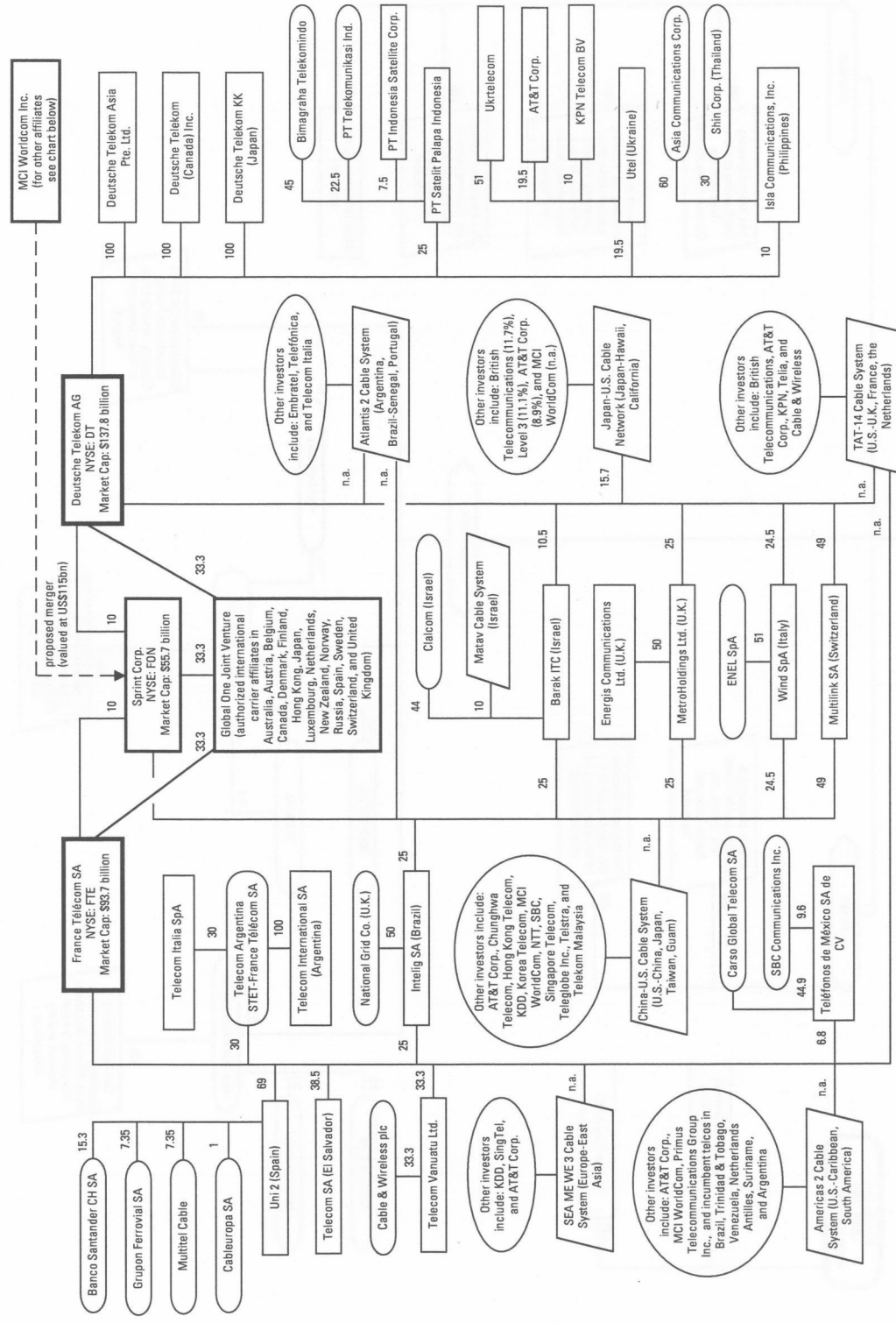


Figure 5. Deutsche Telekom AG, France Télécom SA, and Sprint Corp.



Note: Global One is in the process of disbanding as a result of Deutsche Telekom's failed takeover bid of Telecom Italia. MCI WorldCom's proposed acquisition of Sprint, and protracted management disputes. MCI WorldCom intends to sell Sprint's interest in the alliance if regulatory authorities approve the merger, leaving either France Télécom or Deutsche Telekom as the owner of Global One's operations. Also, upon consummation of the MCI WorldCom-Sprint merger, France Télécom and Deutsche Telekom are expected to sell their 10 percent interests in Sprint. Global One's network reaches 800 cities in 40 countries and has approximately 30,000 corporate customers.

Figure 6. Global Crossing Ltd.

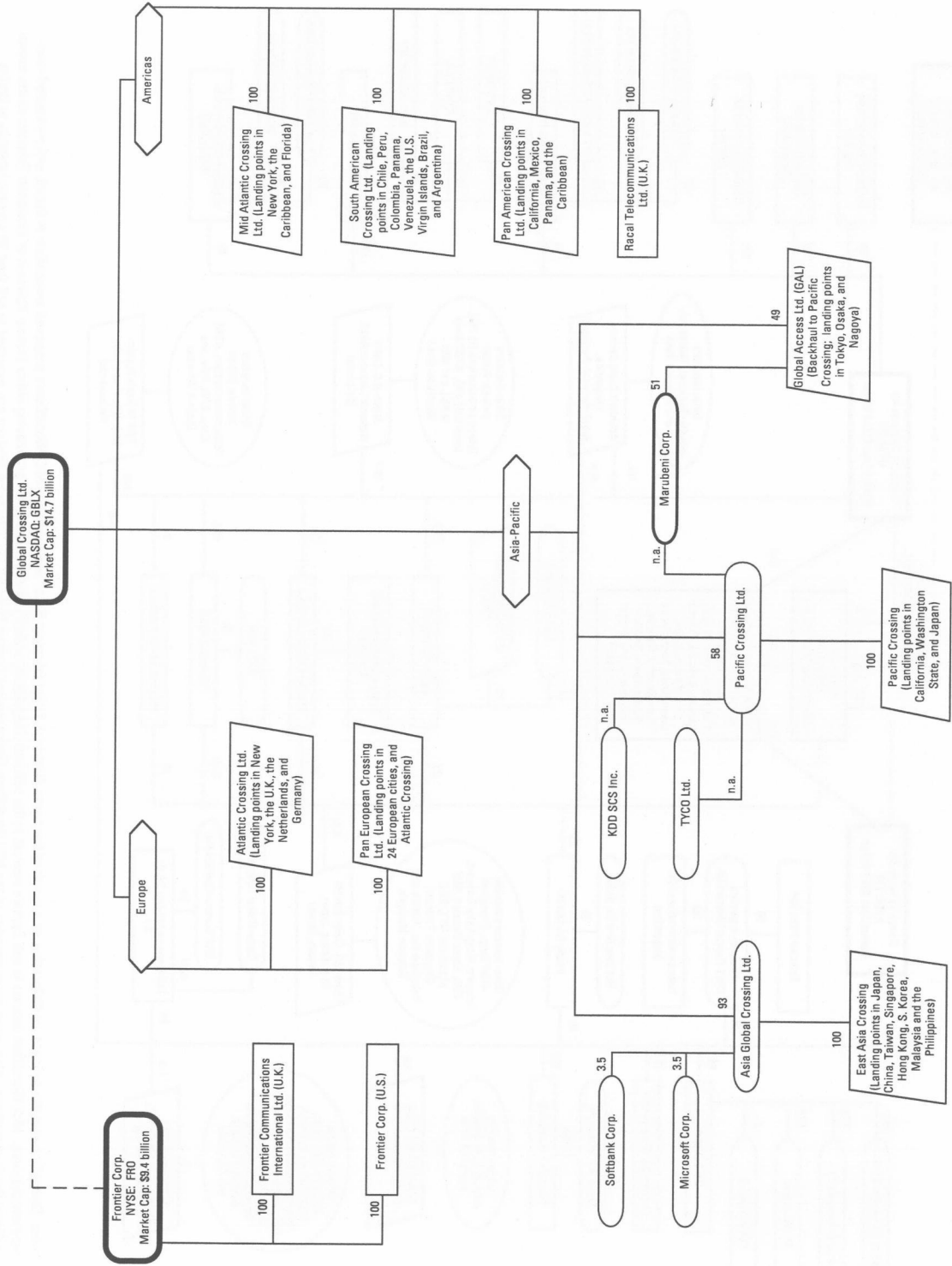


Figure 7. Global TeleSystems Group

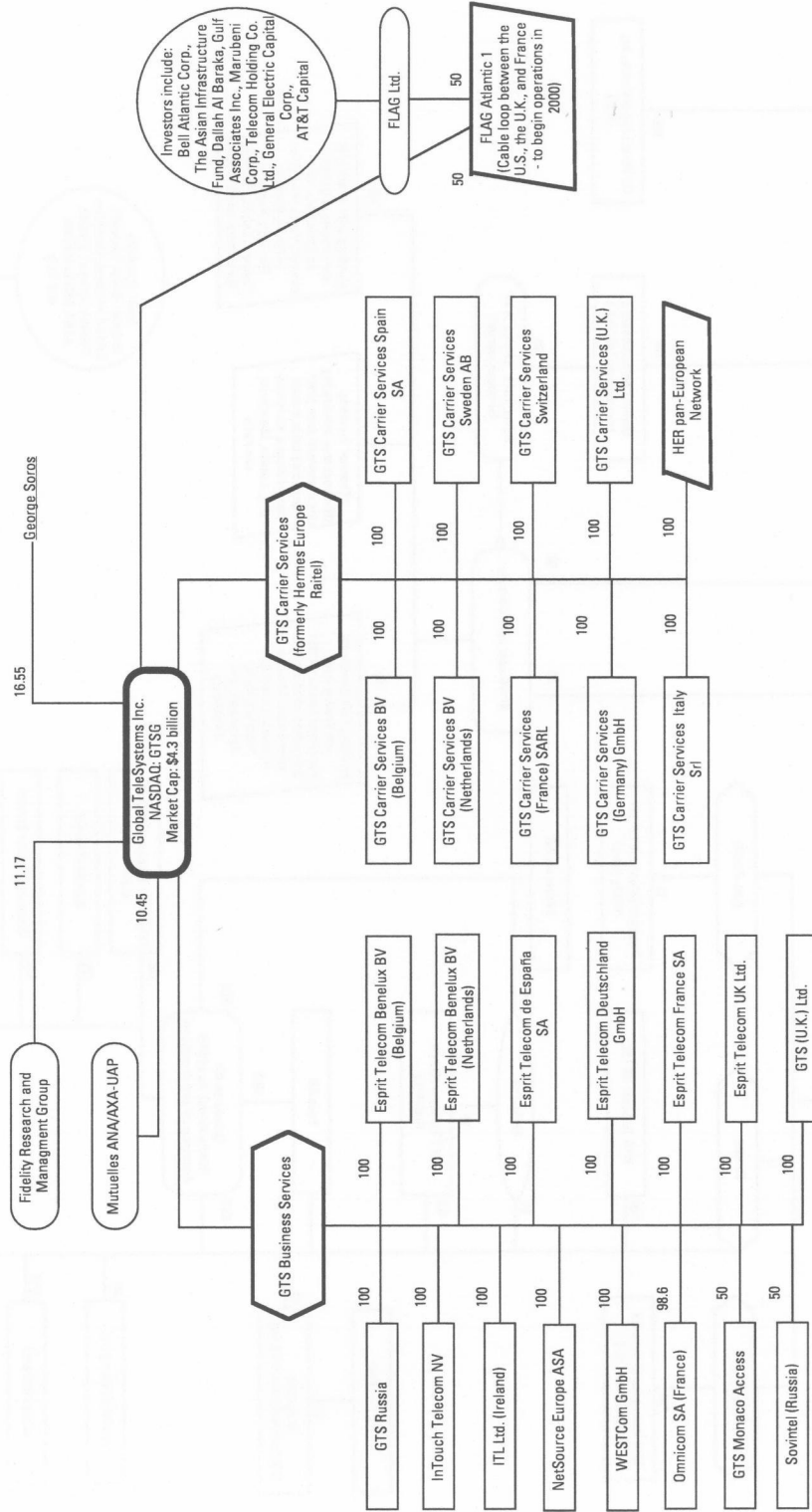
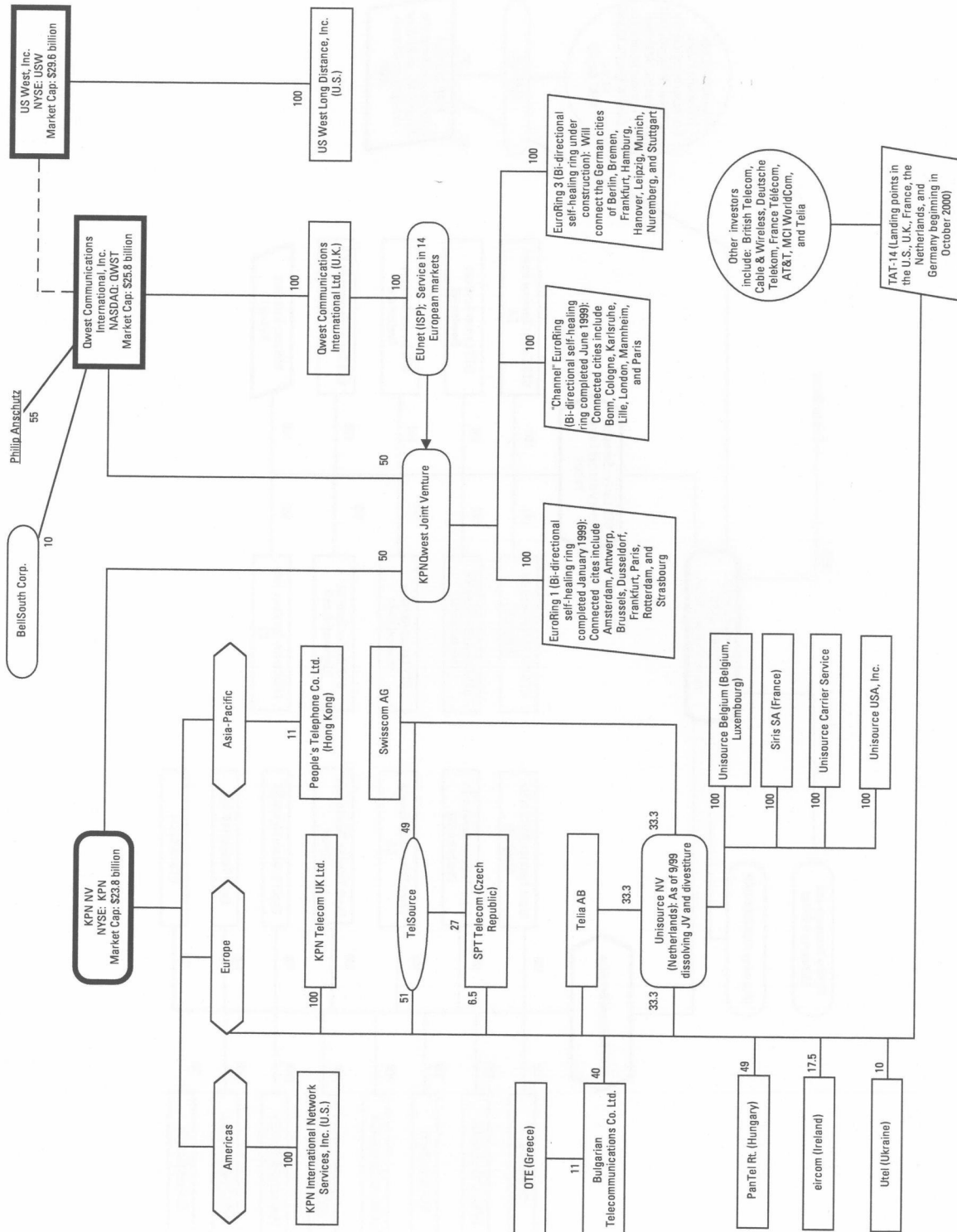


Figure 8. KPN, Qwest Communications, and US West Corp.



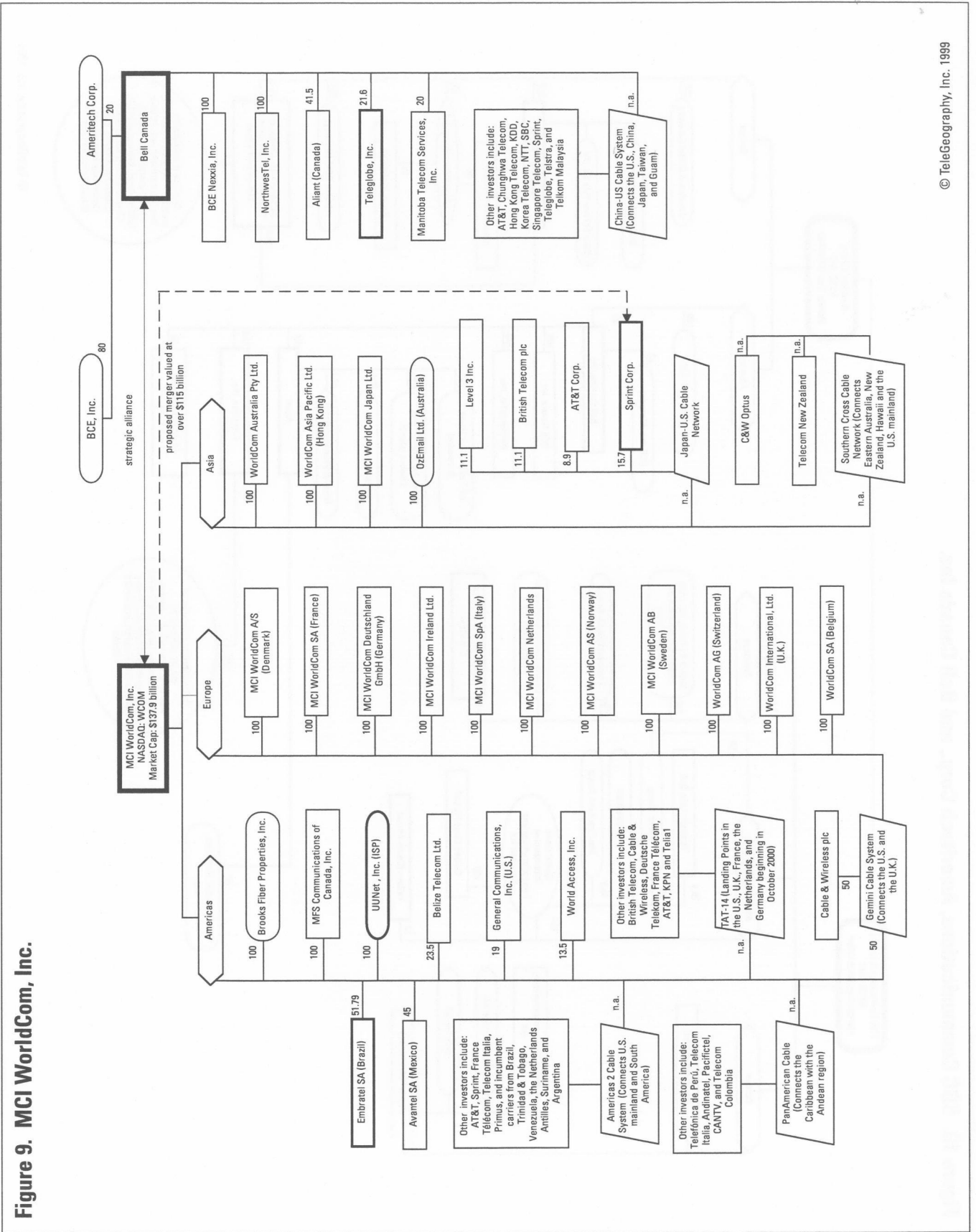
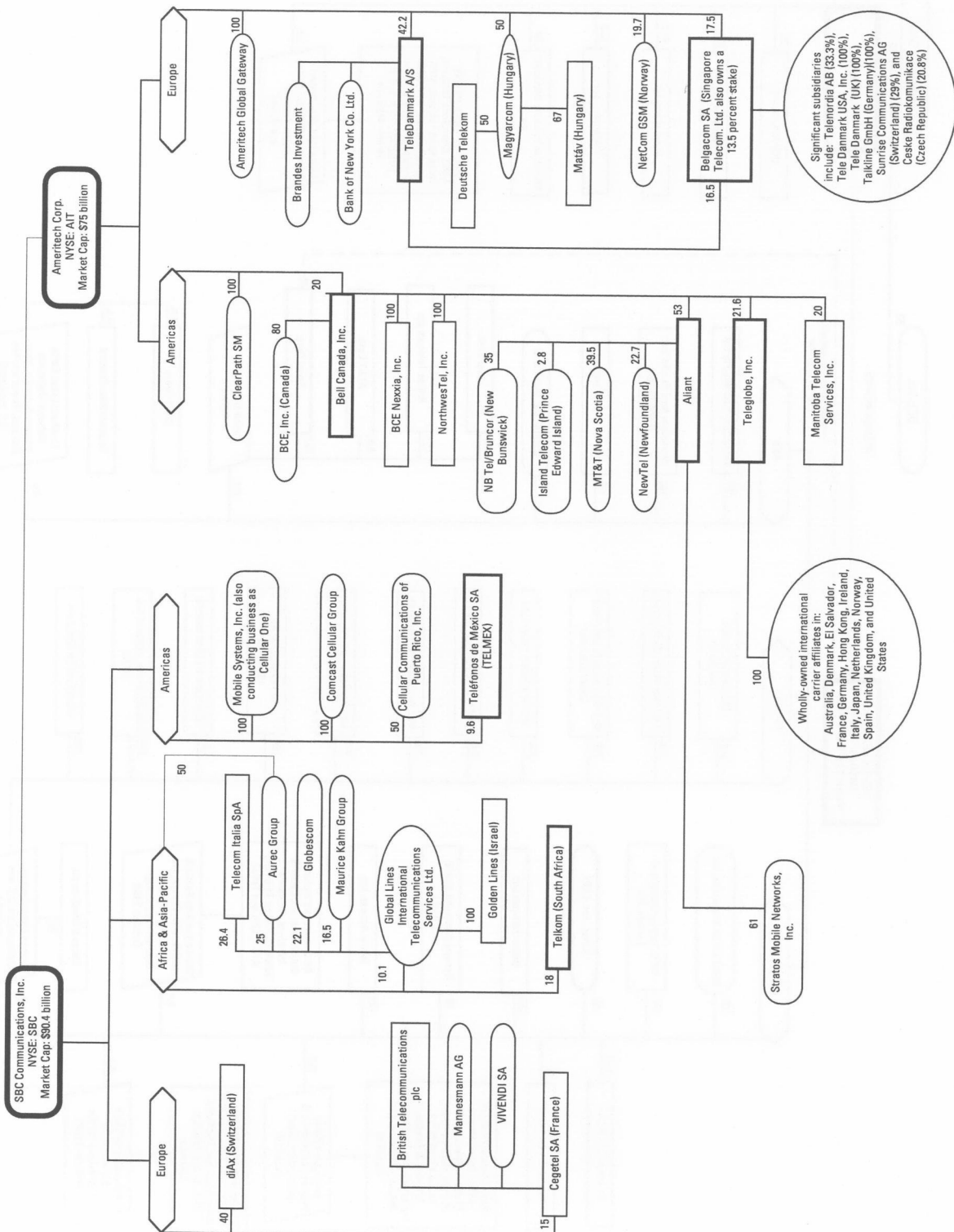


Figure 10. SBC Communications, Ameritech Corp., and Bell Canada Inc.



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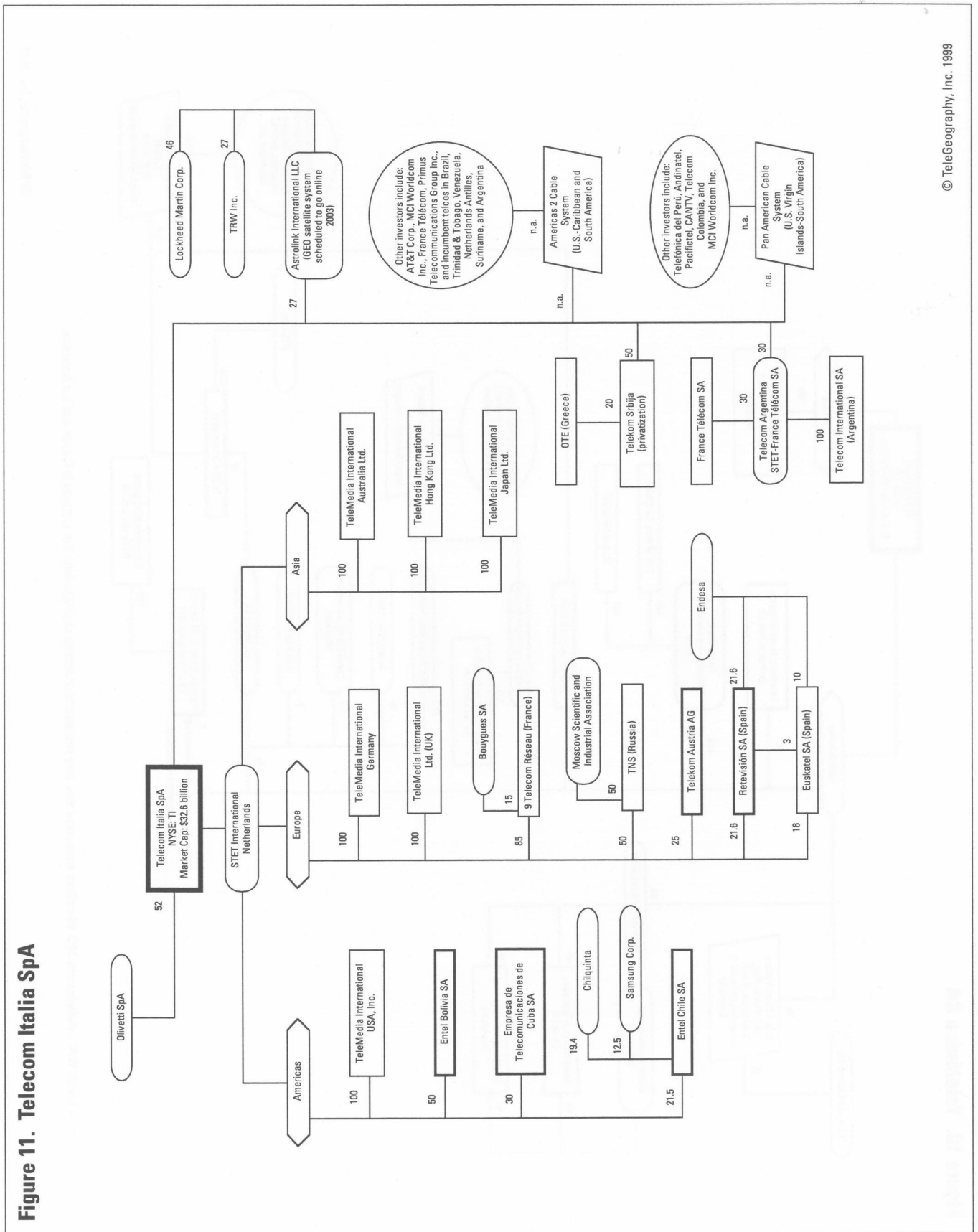
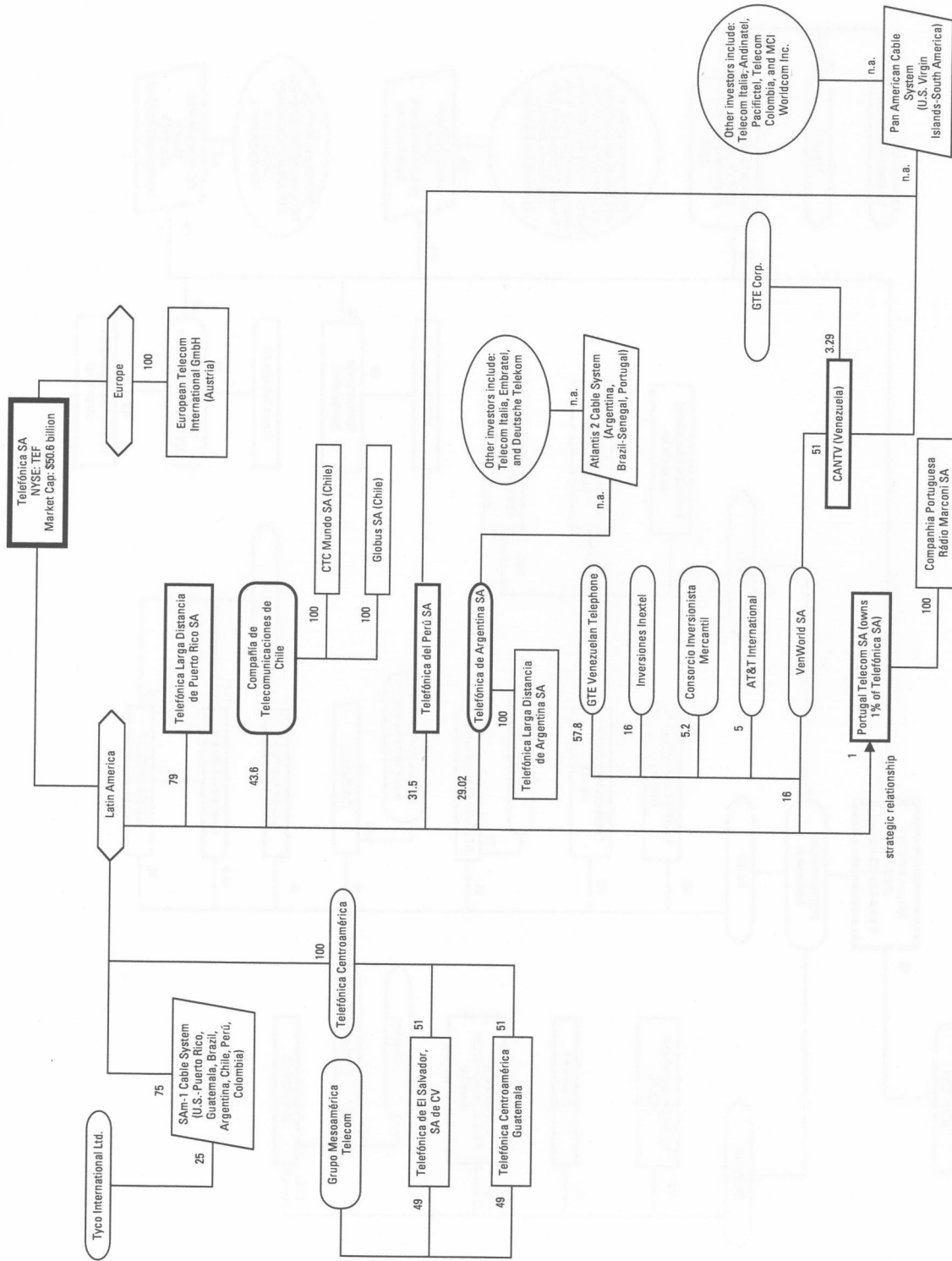


Figure 12. Telefónica SA



Note: In March 1998, Telefónica and MCI WorldCom announced that they intended to undertake strategic business ventures in Europe and the Americas.

Carrier Affiliates and Acquisitions

Figure 1. Selected Multinational Carrier Operations

Parent Carrier	Headquarters	Majority-Owned Affiliate	Foreign Affiliate Market
AT&T Corp.	United States	AT&T CIS Ltd.	Russia
		AT&T Communication Svcs Nederland BV	Netherlands
		AT&T Communications (UK) Ltd.	United Kingdom
		AT&T EasyLink Services Asia/Pacific Ltd.	Hong Kong
British Telecommunications plc	United Kingdom	BT Australasia Pty Ltd.	Australia
		BT (Hong Kong) Ltd.	Hong Kong
		BT North America	United States
		BT (Worldwide) Ltd.	Belgium
		Clear Communications	New Zealand
		Concert Global Networks (Canada) Ltd.	Canada
Cable & Wireless plc	United Kingdom	Cable & Wireless (Bermuda) plc	Bermuda
		Cable & Wireless BET Ltd. (85%)	Barbados
		Cable & Wireless Comms. plc (52.6%)	United Kingdom
		Cable & Wireless Dominica Ltd. (80%)	Dominican Republic
		Cable & Wireless France	France
		Cable & Wireless Global Markets Inc.	Canada
		Cable & Wireless Hong Kong Ltd. (54%)	Hong Kong
		Cable & Wireless IDC Inc. (98%)	Japan
		Cable & Wireless Ireland Ltd.	Ireland
		Cable & Wireless Jamaica Ltd. (79%)	Jamaica
		Cable & Wireless Optus Ltd. (52.3%)	Australia
		Cable & Wireless Sakhalin Telecom (60%)	Russia
		Cable & Wireless St. Kitts & Nevis (65%)	St. Kitts & Nevis
		Cable & Wireless (Switzerland) AG	Switzerland
		Cable & Wireless Tonga	Tonga
		Cable & Wireless USA, Inc.	United States
		Cable & Wireless (West Indies) Ltd.	Antigua & Barbuda
		Cable & Wireless (West Indies) Ltd.	Cayman Islands
		Cable & Wireless (West Indies) Ltd.	St. Lucia
		Cable & Wireless (West Indies) Ltd.	St. Vincent & Grenadines
Companhia de Telecom. de Macau (51%)	Macau		
Nakhodka Telecom (60%)	Russia		
TeleYemen (51%)	Yemen		
COLT Telecom Group plc	United Kingdom	COLT Telecom AG	Switzerland
		COLT Telecom Austria GmbH	Austria
		COLT Telecom BV	Netherlands
		COLT Telecom España SA	Spain
		COLT Télécommunications France SAS	France
		COLT Telecom GmbH	Germany
		COLT Telecom SA	Belgium
		COLT Telecom SpA	Italy
		COLT Telecom U.S. Corp.	United States
Global TeleSystems Group, Inc.	United States	Esprit Telecom Benelux BV	Belgium
		Esprit Telecom Benelux BV	Netherlands
		Esprit Telecom de España SA	Spain
		Esprit Telecom Deutschland GmbH	Germany
		Esprit Telecom France SA	France
		Esprit Telecom UK Ltd.	United Kingdom
		GTS Carrier Services	Switzerland
		GTS Carrier Services BV	Belgium
		GTS Carrier Services BV	Netherlands
		GTS Carrier Services (France) SARL	France
		GTS Carrier Services (Germany) GmbH	Germany
		GTS Carrier Services Italy Srl	Italy
		GTS Carrier Services Spain SA	Spain

Note: Affiliates include all majority-owned affiliates authorized to provide facilities-based international service or international simple resale service as of September 1999. Affiliates are wholly owned by parent carrier unless otherwise noted. All parent companies are also authorized to provide service in their home markets.

Source: Adapted from TeleGeography's 3-volume directory of international carriers, *New International Carriers*.

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Figure 1. Selected Multinational Carrier Operations (continued)

Parent Carrier	Headquarters	Majority-Owned Affiliate	Foreign Affiliate Market		
Global TeleSystems (continued)	United States	GTS Carrier Services Sweden AB	Sweden		
		GTS Carrier Services (UK) Ltd.	United Kingdom		
		GTS Russia	Russia		
		InTouch Telecom NV	Belgium		
		ITL Ltd.	Ireland		
		NetSource Europe ASA	Norway		
		Omnicom SA (98.6%)	France		
		WESTCom GmbH	Germany		
Interoute Communications Group	United Kingdom	ATI Telecom, Inc. (54.4%)	United States		
		Interoute Belgium BV	Belgium		
		Interoute Communications France	France		
		Interoute Comunicações Digitais SA (80%)	Portugal		
		Interoute Denmark A/S (88%)	Denmark		
		Interoute Ireland Ltd	Ireland		
		Interoute Netherlands BV	Netherlands		
		Interoute Networks Ltd.	Canada		
		Interoute Telecom Deutschland GmbH	Germany		
		Interoute Telecommunications Inc.	United States		
		Interoute Telecomunicaciones SA	Spain		
		Interoute Telecomunicazioni Italia SpA	Italy		
Long Distance International, Inc.	United States	Interoute SA, Switzerland	Switzerland		
		Dynamic de España	Spain		
		LDI (Sweden)	Sweden		
		LDI Telecom SA	France		
		Long Distance International Denmark ApS	Denmark		
		Long Distance International Ltd.	Switzerland		
		Long Distance International Ltd.	United Kingdom		
		NETnet AB	Sweden		
		NETnet A/S	Norway		
		NETnet Italy SpA	Italy		
		NETnet Telekommunikation GmbH	Austria		
		Televersa NETnet GmbH	Germany		
		MCI WorldCom, Inc.	United States	Embratel SA (51.79%)	Brazil
				MCI WorldCom AB	Denmark
MCI WorldCom AB	Sweden				
MCI WorldCom AS	Norway				
MCI WorldCom Deutschland GmbH	Germany				
MCI WorldCom Ireland Ltd.	Ireland				
MCI WorldCom Japan Ltd.	Japan				
MCI WorldCom Ltd.	United Kingdom				
MCI WorldCom Netherlands	Netherlands				
MCI WorldCom SA	France				
MCI WorldCom SpA	Italy				
MFS Communications of Canada, Inc.	Canada				
WorldCom AG	Switzerland				
WorldCom Asia Pacific Ltd.	Hong Kong				
WorldCom Australia Pty Ltd.	Australia				
Primus Telecom. Group, Inc.	United States			Corporate Networks Ltd.	United Kingdom
		Primus Canada	Canada		
		Primus Netherlands	Netherlands		
		Primus Telecommunications AG	Switzerland		
		Primus Telecommunications Deutschland GmbH	Germany		
		Primus Telecommunications KK	Japan		
		Primus Telecommunications Ltd.	Ireland		
		Primus Telecommunications Ltd.	United Kingdom		
		Primus Telecommunications Pty Ltd.	Australia		
		Primus Telecommunications SA	France		
		Telegroup Italia Srl	Italy		
		Telegroup Network Services Danmark	Denmark		
		RSL Communications, Ltd.	United States	European Telecom SA (90%)	Belgium
European Telecom SARL	Luxembourg				
RSL COM Asia International Services Corp.	Hong Kong				
RSL COM Australia Pty Ltd.	Australia				

Note: Affiliates include all majority-owned affiliates authorized to provide facilities-based international service or international simple resale service as of September 1999. Affiliates are wholly owned by parent carrier unless otherwise noted. All parent companies are also authorized to provide service in their home markets.

Source: Adapted from TeleGeography's 3-volume directory of international carriers, *New International Carriers*.

Figure 1. Selected Multinational Carrier Operations (continued)

Parent Carrier	Headquarters	Majority-Owned Affiliate	Foreign Affiliate Market
RSL Communications, Ltd. (continued)	United States	RSL COM Austria AG (90%)	Austria
		RSL COM Canada Inc.	Canada
		RSL COM Danmark A/S	Denmark
		RSL COM Deutschland GmbH	Germany
		RSL COM Finland Oy	Finland
		RSL COM France SA	France
		RSL COM Ireland, Ltd.	Ireland
		RSL COM Italia Srl (99.3%)	Italy
		RSL COM Japan KK	Japan
		RSL COM Mexico (80%)	Mexico
		RSL COM Nederland BV	Netherlands
		RSL COM Schweiz AG (78.5%)	Switzerland
		RSL COM Sweden AB	Sweden
		RSL COM UK Ltd.	United Kingdom
		RSL Communications Spain SA (90%)	Spain
Teleglobe, Inc.	Canada	Excel Communications, Inc.	United States
		Teleglobe Australia Pty Ltd.	Australia
		Teleglobe BV	Netherlands
		Teleglobe Communications Corp.	United States
		Teleglobe Danmark AS	Denmark
		Teleglobe El Salvador, SA de CV	El Salvador
		Teleglobe France SAS	France
		Teleglobe GmbH	Germany
		Teleglobe Hong Kong Ltd.	Hong Kong
		Teleglobe International Communications SA	Spain
		Teleglobe International (UK) Ltd.	United Kingdom
		Teleglobe Ireland Ltd.	Ireland
		Teleglobe Italia SpA	Italy
		Teleglobe Japan KK	Japan
Teleglobe Norge AS	Norway		
Viatel, Inc.	United States	America First Ltd.	United Kingdom
		American Telemedia Ltd.	United Kingdom
		Destia BV	Belgium
		Destia Canada, Inc.	Canada
		Destia France SARL	France
		Destia GmbH	Germany
		Destia Service AG	Switzerland
		Viatel Belgium SA	Belgium
		Viaphone GmbH	Germany
		Viatel Global Communications BV	Netherlands
		Viatel Global Communications España SA	Spain
		Viatel Opérations SA	France
		Viatel SRL	Italy
		Viatel UK Ltd.	Ireland
		Viatel UK Ltd.	United Kingdom
World Access, Inc.	United States	FaciliCom International BV	Belgium
		FaciliCom International BV	Netherlands
		FaciliCom International Denmark A/S	Denmark
		FaciliCom International, LLC	New Zealand
		FaciliCom International SARL	France
		FaciliCom International Ltd.	United Kingdom
		FaciliCom Telekommunikation GmbH	Germany
		FCI Austria	Austria
		FCI Finland	Finland
		FCI Italy	Italy
		FCI Norway	Norway
		FCI Spain	Spain
		FCI Switzerland	Switzerland
		Tele8/FaciliCom International Sweden AB	Sweden
		World Access Telecommunications Group Ltd.	United Kingdom
		FCI Norway	Norway
FCI Switzerland	Switzerland		
FaciliCom International Ltd.	United Kingdom		

Note: Affiliates include all majority-owned affiliates authorized to provide facilities-based international service or international simple resale service as of September 1999. Affiliates are wholly owned by parent carrier unless otherwise noted. All parent companies are also authorized to provide service in their home markets.

Source: Adapted from TeleGeography's 3-volume directory of international carriers, *New International Carriers*.

Figure 2. Major International Carrier Mergers and Acquisitions, Oct. 1998-Oct. 1999

Buyer	Country	Target	Country	Date	Value US\$
AT&T Corp.	U.S.	BT's international operations	U.K.	Oct. 99	Merger of Equals
		Japan Telecom Co. Ltd. (15%)	Japan	Pending	\$950m
Bell Atlantic Corp.	U.S.	GTE Corp.	U.S.	Pending	\$82,800m
British Telecommunications plc	U.K.	AT&T Corp.'s international operations	U.S.	Oct. 99	Merger of Equals
		LG Telecom Co. Ltd. (23.49%)	South Korea	Oct-98	\$364m
		Japan Telecom Co. Ltd. (15%)	Japan	Pending	\$950m
		Binariang Bhd (33.3%)	Malaysia	Oct-98	\$396m
Cable & Wireless plc	Japan	International Digital Communications Inc.	Japan	Sep-99	\$758m
Communications Systems International	U.S.	Primecall Inc.	U.S.	Mar-99	Undisclosed
Compañía Telecoms. de Chile	Chile	VTR Larga Distancia S.A. (now Globus)	Chile	Oct-98	\$49.9m
Deutsche Telekom AG	Germany	Hrvatska Telekom dd (35%)	Croatia	Pending	\$850m
Energis plc	U.K.	Unisource Carrier Services	Netherlands	Pending	\$95m
Esat Telecom Group plc	Ireland	Global One's Irish unit	Ireland	Apr-99	\$5m
France Télécom S.A.	France	Telecom Argentina (19.5%; 30%)	Argentina	Aug-99	\$265m
Global Crossing Ltd.	Bermuda	Frontier Corp.	U.S.	Pending	\$11,200m
Global TeleSystems Group Inc.	U.S.	Esprit Telecom Group plc	U.K.	Mar-99	\$849.9m
		Hermes Europe Railtel B.V.	Belgium	Jul-99	Undisclosed
		InTouch Telecom Belgium N.V.	Belgium	Aug-99	Undisclosed
		NetSource Europe S.A.	Norway	Dec-98	\$46.1m
		Omnicom (98.6%)	France	May-99	Undisclosed
ICG Communications Inc.	U.S.	ChoiceCom LP	U.S.	Dec-98	\$55m
Interoute Communications Group Ltd.	U.K.	Skipper Telecomunicazioni (majority %)	Italy	Nov-98	Undisclosed
		Network Telecom Services (75%)	Netherlands	Nov-98	Undisclosed
		ATI Telecom Inc.	U.S.	Mar-99	Undisclosed
		American International Telephone Inc.	U.S.	Mar-99	Undisclosed
IXnet	U.S.	Saturn Global Network Services Holdings Ltd.	U.K.	Dec-98	\$47.5m
Japan Telecom Co. Ltd.	Japan	AT&T Jens Corp.	Japan	Aug-99	\$453m
		BT Communication Services Ltd.	Japan	Aug-99	\$274.4m
KDD Corp.	Japan	Teleway Corp.	Japan	Dec-98	\$424m
Kingston Communications Group	U.K.	Teleport London International	U.K.	Feb-99	Undisclosed
Long Distance International Inc.	U.S.	NETnet International AB	Sweden	Dec-98	Undisclosed
Luca S.A.	Guatemala	Telgua (95%)	Guatemala	Oct-98	\$700m
Mannesmann AG	Germany	Infostrada SpA (50%; 100%)	Italy	Jun-99	Undisclosed
		ISIS Multimedia Net GmbH (64.9%)	Germany	Pending	Undisclosed
		Mannesmann Arcor (15%; 70%)	Germany	May-99	Undisclosed
		o.tel.o GmbH	Germany	May-99	\$542m
Metromedia International Group, Inc.	U.S.	PLD Telekom Inc.	U.S.	Pending	\$132m
MCI Worldcom, Inc.	U.S.	Sprint Corp.	U.S.	Pending	\$115m
NTL Inc.	U.S.	CWC ConsumerCo.	U.K.	Pending	\$10,000m
		Eastern Group Telecoms	U.K.	Pending	\$144.4m
Nippon Telegraph and Telephone Corp.	Japan	Philippine Long Distance Telephone Co. (15%)	Philippines	Pending	\$372m
Olivetti SpA	Italy	Telecom Italia SpA	Italy	Jun-99	\$33,000m
Pointe Communications Corp.	U.S.	Pensat International Communications Inc.	U.S.	Jul-99	Undisclosed
Primus Telecommunications Group, Inc.	U.S.	London Telecom Group Inc.	Canada	Pending	\$50.6m
		Telegroup, Inc.	U.S.	Jun-99	\$72m
		Telephone Savings Network Ltd.	Canada	Jun-99	\$5m
Qwest Comms. International, Inc.	U.S.	US West Inc.	U.S.	Pending	\$50,900m
SBC Communications, Inc.	U.S.	Ameritech Corp.	U.S.	Pending	\$60,000m
		Southern New England Telecommunications Corp.	U.S.	Oct-98	\$5,700m
Startec Global Communications Corp.	U.S.	PCI Communications, Inc.	U.S.	Dec-98	Undisclosed
		Phone Systems and Network S.A. (64.6%)	France	Feb-99	\$3.8m
Star Telecommunications, Inc.	U.S.	PT-1 Communications Inc.	U.S.	Feb-99	\$195m
Telecom Italia	Italy	Telecom Argentina (19.5%/30%)	Argentina	Aug-99	\$265m
		Entel Chile S.A. (55%; 22.5%)	Chile	Jun-99	Undisclosed
Telefónica S.A.	Spain	European Telecom International GmbH	Austria	Feb-99	Undisclosed
Teleglobe, Inc.	Canada	Excel Communications, Inc.	U.S.	Nov-98	Undisclosed
Telia AB	Sweden	Telenor AS	Norway	Pending	Merger of Equals
Telenor AS	Norway	Telia AB	Sweden	Pending	Merger of Equals
tele.ring Telekom Service GmbH	Austria	Citykom Austria Telekommunikation GmbH	Austria	Jan-99	Undisclosed
Televista, Inc.	U.S.	Allied Global Telecommunications, Inc.	U.S.	Pending	Undisclosed
		Cross Communications, Inc.	U.S.	Pending	Undisclosed
Transaction Network Services Inc.	U.S.	Transline Communications Inc.	U.S.	May-99	\$4m
Viatel, Inc.	U.S.	Destia Communications, Inc.	U.S.	Pending	\$600m
World Access, Inc.	U.S.	Comm/ Net Holding Corp.	U.S.	Jul-99	\$27m
		FacilCom International, Inc.	U.S.	Pending	\$436m
		Resurgens Communications Group	U.S.	Dec-98	Undisclosed

Note: All transactions involve 100 percent of target's shares unless otherwise noted. In cases where two percentages are listed, the first represents the amount recently acquired while the second represents total ownership share. Dates indicate time of legal completion of transaction rather than announcement of intention to merge or to acquire. All values include monies paid in cash and stock but do not include assumed debt.

Source: Adapted from TeleGeography's 3-volume directory of international carriers, *New International Carriers*.

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Figure 3. Major International Carrier/ISP Mergers and Acquisitions, Oct.. 1998-Oct. 1999

Buyer	Country	Target	Country	Date	Value US\$
Alliance Telecom Inc.	U.S.	KIVEX.com	U.S.	Jun-99	\$34.5m
AT&T Corp.	U.S.	IBM Global Network	U.S.	Pending	\$5,000m
		Netstream	Brazil	Pending	\$300m
British Telecommunications plc	U.K.	Arrakis	Spain	Feb-99	\$15.7m
		I.Net (32.5%)	Italy	Pending	\$21.5m
Cable & Wireless plc	U.K.	ECRC Network Services GmbH	Germany	Jan-99	\$43.6m
		Internet Network Services Group	U.K.	Jul-99	Undisclosed
Cable & Wireless Hong Kong Ltd.	Hong Kong	FIC Network Service Inc. (85%)	Hong Kong	Mar-99	\$5m
CoreComm Ltd.	U.S.	Internet Network Services Group	U.K.	Jul-99	Undisclosed
		MegsiNet Inc.	U.S.	Jun-99	\$16.8m
		Stratos Internet Group Inc.	U.S.	Dec-98	Undisclosed
France Télécom S.A.	France	Stratos Internet Group Inc.	U.S.	Dec-98	Undisclosed
		EuroNet Internet BV	Belgium	Nov-98	Undisclosed
		NCTech (67%)	France	Dec-98	Undisclosed
		WEB A/S (80%)	Denmark	Oct-98	Undisclosed
Global TeleSystems Group, Inc.	U.S.	Ebone A/S (25%; 100%)	Denmark	Jul-99	Undisclosed
ICG Communications, Inc.	U.S.	NETCOM On-Line Communication Services, Inc.	U.S.	Jan-99	Undisclosed
MCI WorldCom, Inc. (UUNet)	U.S.	OzEmail Ltd.	Australia	Mar-99	\$322.8m
Primus Telecommunications Group, Inc.	U.S.	GlobalServe Communications	Canada	Feb-99	\$4.3m
		TCP/IP GmbH	Germany	May-99	Undisclosed
		TouchNet GmbH	Germany	Sep-99	Undisclosed
PSINet Inc.	U.S.	Argentina On-Line	Argentina	Jul-99	Undisclosed
		AsiaNet Ltd.	Hong Kong	Dec-98	Undisclosed
		Caribbean Internet	Puerto Rico	Jun-99	Undisclosed
		Ciberia Internet	Spain	Sep-99	Undisclosed
		DataNet	Mexico	May-99	Undisclosed
		Domain Acesso e Servicos Internet Ltd.	Brazil	Aug-99	Undisclosed
		Elender Informatikai es Szamitastechnikai Rt.	Hungary	Sep-99	Undisclosed
		Global Link	Hong Kong	Aug-99	Undisclosed
		Horizontes Internet	Brazil	Apr-99	Undisclosed
		Huge Net Ltd.	Hong Kong	Dec-98	Undisclosed
		Inet Inc.	South Korea	Oct-98	Undisclosed
		Infase Comunicaciones	Spain	Sep-99	Undisclosed
		Internet de México	Mexico	May-99	Undisclosed
		Internet Exchange Europe b.v.	Netherlands	Oct-98	Undisclosed
		Internet Network Technologies	U.S.	Sep-99	Undisclosed
		Netline Comunicaciones S.A.	Chile	Sep-99	Undisclosed
		Netsystem	Argentina	Sep-99	Undisclosed
		Openlink	Brazil	Apr-99	Undisclosed
		Planete.net	France	Mar-99	Undisclosed
		Rimnet	Japan	Aug-99	Undisclosed
		Satelnat	France	Mar-99	Undisclosed
		ServNet Serv. de Informatica e Comm.	Brazil	Sep-99	Undisclosed
		Sinfonet	Panama	Aug-99	Undisclosed
		Spider Net Ltd.	Hong Kong	Dec-98	Undisclosed
		TBA Internet	Brazil	Sep-99	Undisclosed
		The Internet Access Co.	U.S.	Jun-99	Undisclosed
		The Internet Co.	Switzerland	Jun-99	Undisclosed
		Tokyo Internet Corp.	Japan	Oct-98	Undisclosed
		TotalNet	Canada	Sep-99	Undisclosed
		Transaction Network Services, Inc.	U.S.	Pending	\$720m
		Unix Support Nederland BV	Netherlands	Oct-98	Undisclosed
		Vision Network Ltd.	Hong Kong	Sep-99	Undisclosed
		Zircon Systems Pty Ltd.	Australia	Oct-99	Undisclosed
Telia	Sweden	Unisource Iberia	Spain	Sep-99	Undisclosed
Uni2	Spain	CTV-Jet	Spain	Mar-99	Undisclosed

Note: All transactions involve 100 percent of target's shares unless otherwise noted. In cases where two percentages are listed, the first represents the amount recently acquired while the second represents total ownership share. Dates indicate time of legal completion of transaction rather than announcement of intention to merge or to acquire. All values include monies paid in cash and stock but do not include assumed debt.

Source: Company reports

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Figure 4. Major International Carrier/Cellular Mergers and Acquisitions, Oct. 1998-Oct. 1999

Buyer	Country	Target	Country	Date	Value US\$
AT&T Corp.	U.S.	American Cellular Corp.	U.S.	Pending	\$370m
		Rogers Cantel Mobile Communications (16.5%)	Canada	Pending	\$478m
Bouygues SA	France	Bouygues Telecom (20%)	France	Pending	\$1,130m
Deutsche Telekom AG	Germany	max.mobil (46%; 71%)	Austria	Pending	Undisclosed
		One2One	U.K.	Oct-99	\$11,120m
		Polska Telefonía Cyfrowa SA (22.5%; 45%)	Poland	Oct-99	Undisclosed
		Russian Telecommunications Development Corp.	Russia	Oct-99	Undisclosed
		Westel 450 (49%)	Hungary	Oct-99	Undisclosed
		Westel 900 (49%)	Hungary	Oct-99	Undisclosed
France Télécom SA	France	E-Plus (77.24%)	Germany	Oct-99	\$1,091m
MATÁV Rt.	Hungary	Westel 450 (49%; 100%)	Hungary	Pending	\$442.5m
		Westel 900 (49%; 100%)	Hungary	Pending	\$442.5m
Interoute Communications Group Ltd.	U.K.	WorldWide Mobilcom Corp.	U.S.	Mar-99	\$3.5m
Lietuvos Telekomas	Lithuania	Comliet UAB (24.5%; 49%)	Lithuania	Sep-99	Undisclosed
Mannesmann AG *	Germany	Omnitel (23.4%; 55%)	Italy	Jun-99	Undisclosed
		Orange plc	U.K.	Pending	\$34,700m
SBC Communications Inc.	U.S.	Cellular Communications of Puerto Rico Inc. (50%)	Puerto Rico	Pending	\$232m
		Comcast Cellular Corp.	U.S.	Pending	\$400m
Tele Danmark A/S	Denmark	UAB Bité GSM (71.6%)	Lithuania	Sep-99	\$50m
Telefónica SA	Spain	Telebahía Celular (50%)	Brazil	Jul-99	\$30m
		Telergipe Celular (50%)	Brazil	Jul-99	\$30m
		Telerj Celular	Brazil	Jul-99	\$60m
		Telest Celular	Brazil	Jul-99	\$60m
Telefónos de México SA de CV	Mexico	Cellular Communications of Puerto Rico Inc. (50%)	Puerto Rico	Pending	\$232m
Vodafone Group plc *	U.K.	AirTouch Communications Inc.	U.S.	Jun-99	\$74,400m
		Digital Phone Group (8%)	Japan	Oct-99	\$411m
		CommNet Cellular Inc.	U.S.	Pending	\$764m
		New Zealand GSM	Australia	Feb-99	\$385m

Note: All transactions involve 100 percent of target's shares unless otherwise noted. In cases where two percentages are listed, the first represents the amount recently acquired while the second represents total ownership share. Dates indicate time of legal completion of transaction rather than announcement of intention to merge or to acquire. All values include monies paid in cash and stock but do not include assumed debt.

* At this writing, press reports indicated that Vodafone was preparing a bid to acquire Mannesmann.

Source: Company reports

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Pricing



Pricing

Elements of an International Call

An international service provider has a number of options to send its customers' calls abroad. This section compares the cost elements of those options. Referring to the table on pages 60 to 61, let's use a call from New York to Berlin as an example. Not including call-back, refile, and other forms of non-traditional traffic switching, a U.S. carrier has four basic methods of transporting its customer's call to the destination in Germany:

1. *Carrier Settlement.* To switch the call from the customer's telephone to its own long distance network, the international carrier first pays the Local Exchange Carrier (LEC) in New York an origination fee of 2.1¢ per minute. Next, the carrier moves the call along a "backhaul" route; that is, from its national network to the undersea cable landing station on the Atlantic Ocean shoreline. The carrier shifts the call onto the international "half circuit" it owns, then pays the German carrier a settlement fee to transfer the call onto its matching half circuit and to the final destination. The U.S. carrier's marginal cost of using its own backhaul and international circuit is insignificant: 0.1¢ per minute. (Note: because half circuit purchases on new cables are increasingly rare, the following tables show only whole circuit pricing to Germany.) The settlement rate, at 10¢ per minute, is far less inexpensive. Total cost: 12¢ per minute.

2. *Carrier Interconnect.* Competition rules in Germany permit foreign carriers to interconnect directly with the domestic telephone network. Rather than financing a half circuit and paying a settlement fee, a U.S. carrier can purchase a whole

circuit all the way to an international gateway in Germany, then pay the German carrier a 2.7¢ per minute fee to switch the call to Berlin. Some international carriers may own a LEC themselves, in which case this charge is simply an intra-corporate transfer. Total cost, including origination and backhaul: 5¢ per minute.

3. *International Simple Resale (ISR).* A carrier is not required to own its own circuits. Instead, it can switch traffic onto U.S.-Germany private lines leased from other carriers. Total cost, including origination, backhaul, private line lease, and interconnection in Germany: 6¢ per minute.

4. *Service Resale.* A telephone service provider may wish to avoid carrying its own traffic to Germany altogether by purchasing the minutes transported over another carrier's network in bulk and marketing those minutes as its own. The charge required for end-to-end service resale is a "wholesale rate" covering origination, U.S. domestic long distance, and the underlying carrier's international transport and termination charges. Total cost: 7¢ per minute.


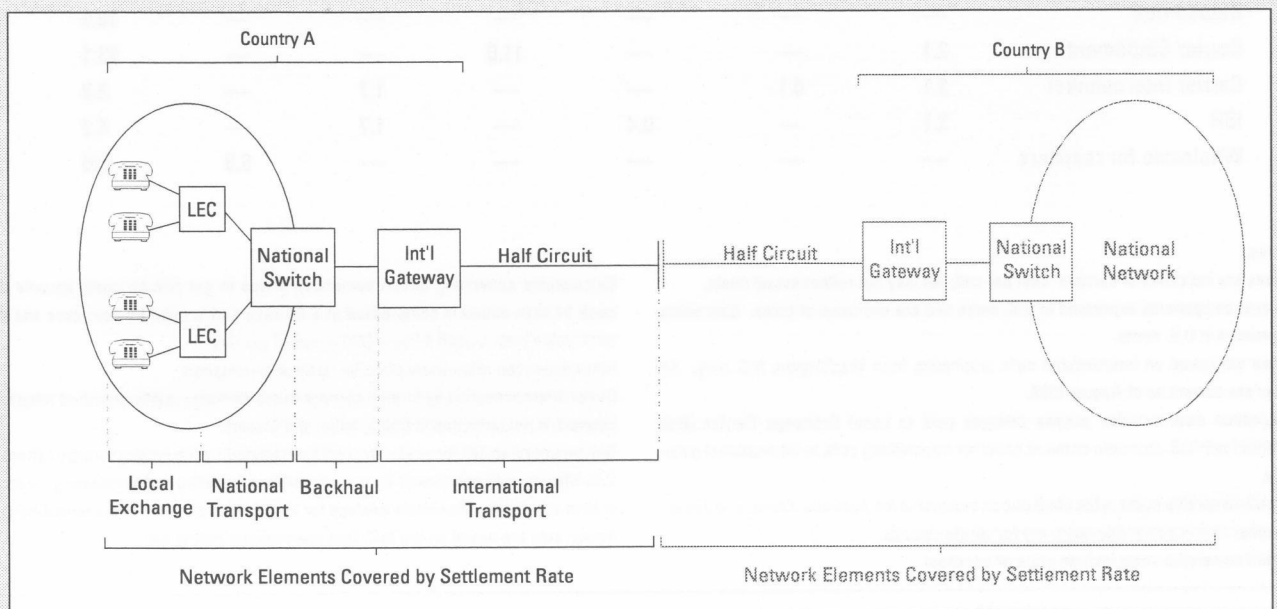
The following pages examine the component costs of provisioning an international call in more detail. Statistics on settlement rates and interconnection charges plus a review of retail prices show how carriers are passing along their costs to end users. In addition, tables and charts on telecom service trading and international call quality metrics examine the new models for purchasing minutes and bandwidth. 

Figure 1. International Call Components



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International Carrier Call Costs from the U.S.

	Per Minute Cost (U.S. Cents)						Total
	Origination Cost	Int'l Circuit Ownership	Int'l Circuit Lease	Settlement Rate	Interconnect Rate	Wholesale Rate	
Americas							
U.S.-Canada							
Retail Price	—	—	—	—	—	—	10.0
Carrier Settlement	2.1	—	—	10.0	—	—	12.1
Carrier Interconnect	2.1	0.1	—	—	0.7	—	2.9
ISR	2.1	—	0.3	—	0.7	—	3.1
Wholesale for resellers	—	—	—	—	—	4.6	4.6
U.S.-Mexico							
Retail Price	—	—	—	—	—	—	42.0
Carrier Settlement	2.2	—	—	19.0	—	—	21.2
Carrier Interconnect	—	—	—	—	—	—	n.a.
ISR	—	—	—	—	—	—	n.a.
Wholesale for resellers	—	—	—	—	—	22.9	22.9
Europe							
U.S.-Germany							
Retail Price	—	—	—	—	—	—	20.0
Carrier Settlement	2.1	—	—	10.0	—	—	12.1
Carrier Interconnect	2.1	0.1	—	—	2.7	—	4.9
ISR	2.1	—	1.1	—	2.7	—	5.9
Wholesale for resellers	—	—	—	—	—	7.1	7.1
U.S.-U.K.							
Retail Price	—	—	—	—	—	—	10.0
Carrier Settlement	2.1	—	—	11.0	—	—	13.1
Carrier Interconnect	2.1	0.1	—	—	1.7	—	3.9
ISR	2.1	—	0.4	—	1.7	—	4.2
Wholesale for resellers	—	—	—	—	—	6.9	6.9

Notes:

Prices are indicative of carriers' cost per call, but may not reflect actual costs. All cost components expressed in U.S. cents and are exclusive of taxes. Cost totals expressed in U.S. cents.

Rates are based on international calls originating from Washington, D.C. only. All rates are current as of August 1999.

Origination cost includes access charges paid to Local Exchange Carrier (Bell Atlantic) and U.S. domestic network costs for transmitting calls to international gateway.

Circuit ownership costs reflect half circuit ownership for Australia, China, and Japan. All other circuit ownership costs are for whole circuits.

Circuit ownership costs include price of backhaul.

Calculations converting circuit ownership prices to per minute costs assume that each 64 kbps circuit is compressed at a 5:1 ratio and is used for ten years and that each voice path is used 4 hours (240 minutes) per day.

Interconnection rates show price for national termination.

Direct interconnection by foreign carriers to the domestic public switched telephone network is not permitted in China, India, and Mexico.

Settlement rates are for peak rate traffic terminated by the largest foreign carrier. U.S.-Mexico settlement rates vary according to originating and terminating locations in both countries. The simple average for all U.S.-Mexico rates is presented here.

Retail rates are based on the MCI One international calling plan.

	Per Minute Cost (U.S. Cents)						Total
	Origination Cost	Int'l Circuit Ownership	Int'l Circuit Lease	Settlement Rate	Interconnect Rate	Wholesale Rate	
Asia							
U.S.-Australia							
Retail Price	—	—	—	—	—	—	25.0
Carrier Settlement	2.2	—	—	15.0	—	—	17.2
Carrier Interconnect	2.2	2.2	—	—	4.0	—	8.4
ISR	2.9	—	4.9	—	4.0	—	11.8
Wholesale for resellers	—	—	—	—	—	6.8	6.8
U.S.-China							
Retail Price	—	—	—	—	—	—	131.0
Carrier Settlement	2.1	—	—	58.0	—	—	60.1
Carrier Interconnect	—	—	—	—	—	—	n.a.
ISR	—	—	—	—	—	—	n.a.
Wholesale for resellers	—	—	—	—	—	48.2	48.2
U.S.-India							
Retail Price	—	—	—	—	—	—	122.0
Carrier Settlement	2.1	1.0	—	64.0	—	—	67.1
Carrier Interconnect	—	—	—	—	—	—	n.a.
ISR	—	—	—	—	—	—	n.a.
Wholesale for resellers	—	—	—	—	—	69.4	69.4
U.S.-Japan							
Retail Price	—	—	—	—	—	—	35.0
Carrier Settlement	2.1	—	—	14.0	—	—	16.1
Carrier Interconnect	2.1	0.1	—	—	5.5	—	7.7
ISR	2.3	—	5.5	—	5.5	—	13.3
Wholesale for resellers	—	—	—	—	—	12.4	12.4

Sources: Federal Communications Commission, European Union Commission, national regulatory agencies, and industry interviews
 Concept: TeleGeography, Inc.

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International Carrier Call Costs to the U.S.

	Per Minute Cost (U.S. Cents)						Total
	Origination Cost	Int'l Circuit Ownership	Int'l Circuit Lease	Settlement Rate	Interconnect Rate	Wholesale Rate	
Americas							
Canada-U.S.							
Retail Price	—	—	—	—	—	—	14.0
Carrier Settlement	1.3	—	—	10.0	—	—	11.3
Carrier Interconnect	1.3	0.1	—	—	1.5	—	2.9
ISR	1.3	—	0.3	—	1.5	—	3.1
Wholesale for resellers	—	—	—	—	—	4.6	4.6
Mexico-U.S.							
Retail Price	—	—	—	—	—	—	86.0
Carrier Settlement	2.6	—	—	19.0	—	—	21.6
Carrier Interconnect	—	—	—	—	—	—	n.a.
ISR	—	—	—	—	—	—	n.a.
Wholesale for resellers	—	—	—	—	—	26.0	26.0
Europe							
Germany-U.S.							
Retail Price	—	—	—	—	—	—	23.0
Carrier Settlement	1.8	—	—	10.0	—	—	11.8
Carrier Interconnect	1.8	0.1	—	—	1.5	—	3.4
ISR	1.8	—	1.1	—	1.5	—	4.4
Wholesale for resellers	—	—	—	—	—	5.5	5.5
U.K.-U.S.							
Retail Price	—	—	—	—	—	—	32.0
Carrier Settlement	1.6	—	—	10.0	—	—	11.6
Carrier Interconnect	1.6	0.1	—	—	1.5	—	3.2
ISR	1.6	—	0.4	—	1.5	—	3.5
Wholesale for resellers	—	—	—	—	—	3.8	3.8

Notes:

Prices are indicative of carriers' cost per call, but may not reflect actual costs. All cost components expressed in U.S. cents and are exclusive of taxes. Cost totals expressed in U.S. cents.

Rates are based on international calls originating from Washington, D.C. only. All rates are current as of August 1999.

Origination costs reflect regional access charges. U.K. origination costs are for BT local exchange segment and do not include trunking charges. Origination costs for Japan are estimates.

Non-U.S. carriers may own significant portions of home country local network, in which case origination costs are counted as intra-corporate transfers.

Calculations converting circuit ownership prices to per minute costs assume that each 64 kbps circuit is compressed at a 5:1 ratio and is used for ten years and that each voice path is used 4 hours (240 minutes) per day.

Circuit ownership costs reflect half circuit ownership for Australia, China, and Japan. All other circuit ownership costs are for whole circuits.

Circuit ownership costs include price of backhaul.

Direct interconnection to the U.S. domestic public switched telephone network is not permitted for carriers from China, India, and Mexico.

Settlement rates are for peak rate traffic terminated by the largest foreign carrier. U.S.-Mexico settlement rates vary according to originating and terminating locations in both countries. The simple average for all U.S.-Mexico rates is presented here.

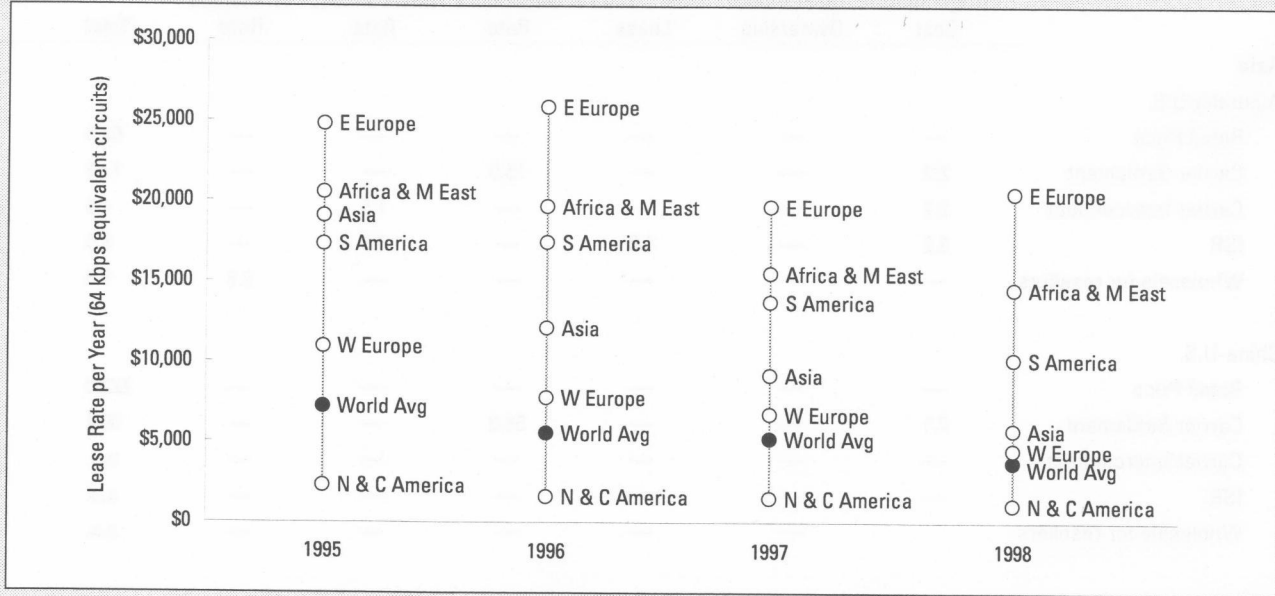
	Per Minute Cost (U.S. Cents)						Total
	Origination Cost	Int'l Circuit Ownership	Int'l Circuit Lease	Settlement Rate	Interconnect Rate	Wholesale Rate	
Asia							
Australia-U.S.							
Retail Price	—	—	—	—	—	—	53.0
Carrier Settlement	2.2	—	—	15.0	—	—	17.2
Carrier Interconnect	2.2	1.1	—	—	1.5	—	4.8
ISR	2.2	—	4.9	—	1.5	—	8.6
Wholesale for resellers	—	—	—	—	—	9.6	9.6
China-U.S.							
Retail Price	—	—	—	—	—	—	222.0
Carrier Settlement	2.1	—	—	58.0	—	—	60.1
Carrier Interconnect	—	—	—	—	—	—	n.a.
ISR	—	—	—	—	—	—	n.a.
Wholesale for resellers	—	—	—	—	—	—	n.a.
India-U.S.							
Retail Price	—	—	—	—	—	—	138.0
Carrier Settlement	2.1	—	—	64.0	—	—	66.1
Carrier Interconnect	—	—	—	—	—	—	n.a.
ISR	—	—	—	—	—	—	n.a.
Wholesale for resellers	—	—	—	—	—	—	n.a.
Japan-U.S.							
Retail Price	—	—	—	—	—	—	69.0
Carrier Settlement	1.6	—	—	14.0	—	—	15.6
Carrier Interconnect	1.6	0.1	—	—	1.5	—	3.2
ISR	1.6	—	5.5	—	1.5	—	8.6
Wholesale for resellers	—	—	—	—	—	18.4	18.4

Sources: Federal Communications Commission, European Union Commission, Philips Tarifica, national regulatory agencies, and industry interviews
 Concept TeleGeography, Inc.

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International Private Line Prices

Figure 1. International Private Line Lease Prices from U.S., 1995-1998

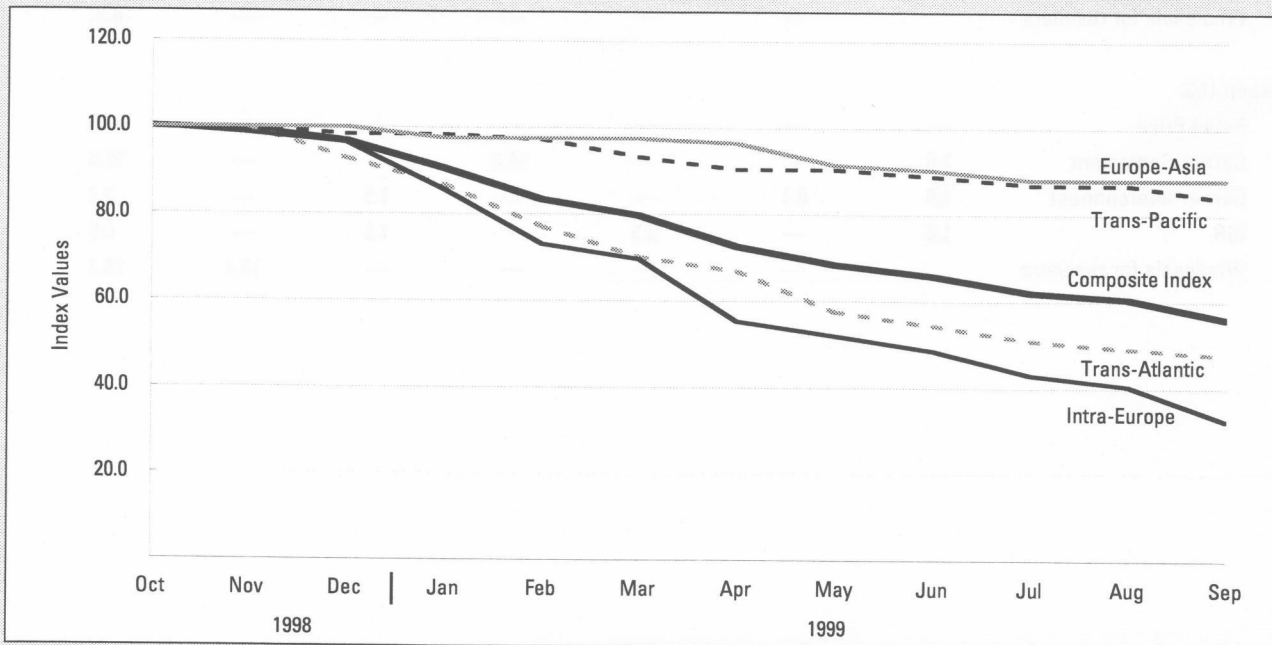


Note: Data reflect averages of annual revenue collected by U.S. international carriers for 64 kbps circuit leases to countries within each region.

Source: FCC carrier filings, TeleGeography, Inc.

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Figure 2. Band-X Bit Index, 1998-1999



Note: The Band-X Bit Index measures relative price movement for one year E1 or T1 circuit leases (depending upon the geographic area) on major routes. This chart summarizes index values into regional indices, based on simple averages for the following groupings: Europe-Asia (London to Sydney, Hong Kong); Trans-Pacific (Los Angeles to Beijing, Hong Kong, Tokyo); Trans-Atlantic (New York to Frankfurt, London, Moscow); Intra-Europe (London to Amsterdam, Brussels, Frankfurt, Madrid, Milan, Paris); Composite (all tracked routes). For Band-X index of U.K. international wholesale minute prices, see Figure 2 on page 75.

Source: Band-X (www.band-x.com)

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International Settlement Rates

Destination	United States			United Kingdom	
	1997	1998	1999	1998 (US\$)	1999 (US\$)
Andorra	0.29	0.29	0.29	0.22	0.13
Argentina	0.43	0.35	0.33	0.86	0.56
Australia	0.21	0.15	0.15	0.28/0.17	0.24/0.08
Austria	0.21	0.14	0.14	0.20	0.19
Bahamas	0.30/0.15	0.30/0.15	0.30/0.15	0.38	0.36
Bahrain	0.80	0.65	0.55	0.82	0.64
Bangladesh	0.80	0.80	0.80	0.99	0.97
Belarus	0.50	0.43	0.43	0.35	0.34
Belgium	0.19	0.14	0.14	0.10	0.10
Bolivia	0.55	0.46	0.43	0.90	0.89
Brazil	0.43	0.33	0.30	0.49	0.36
Canada	0.10/0.06	0.10/0.06	0.10/0.06	0.10/0.08	0.10/0.04
Chile	0.50	0.35	0.35	0.90	0.89
China	0.85	0.70	0.58	1.08	0.89
Colombia	0.50	0.40	0.38	0.90	0.56
Costa Rica	0.40	0.35	0.29	0.69	0.47
Croatia	0.34	0.28	0.25	0.33	0.33
Cyprus	0.48	0.38	0.37	0.25	0.20
Czech Republic	0.31	0.28	0.18	0.21	0.20
Denmark	0.14	0.11	0.11	0.10	0.07
Dominican Republic	0.35	0.30	0.26	0.67	0.56
El Salvador	0.44	0.39	0.31	1.54	1.18
Finland	0.21	0.16	0.14	0.15	0.13
France	0.13	0.11	0.10	0.11	0.10
French Polynesia	1.25	0.70	0.70	1.64	1.27
Germany	0.10	0.11	0.10	0.10/0.08	0.10/0.04
Ghana	0.50	0.50	0.50	0.66	0.52
Greece	0.43	0.28	0.17	0.29	0.24
Guyana	0.85	0.85	0.85	0.90	0.89
Hong Kong	0.40	0.36	0.07	0.45	0.42
Hungary	0.31	0.28	0.19	0.18	0.18
Iceland	0.38	0.24	0.14	0.23	0.23
India	0.71	0.64	0.64	0.95	0.87
Indonesia	0.65	0.53	0.48	1.21	0.64
Iran	1.25	1.05	0.90	1.21	1.18
Ireland	0.17	0.11	0.10	0.16	0.16
Israel	0.35	0.30	0.15	0.25	0.24
Italy	0.17	0.11	0.11	0.16	0.13
Japan	0.43	0.15	0.14	0.59	0.48
Jordan	0.75	0.68	0.50	1.21	0.97

Notes:

- All rates expressed in US\$. Equivalent dollar values are presented for accounting rates that are established in Special Drawing Rights (SDRs), gold francs, or pounds sterling.
- The average U.S. accounting rate for 1997 and 1998 is weighted by the total minutes between the U.S. and each location in that year. U.S. 1999 rates are for August 1999. U.K. rates are for July 1998 and April 1999.
- Where two rates are shown, there are peak/off-peak rates or growth-based rates (traffic above a benchmark level is eligible for a lower rate).
- Rates are for largest carrier serving the route. Different accounting rates may apply to competing carriers.

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Destination	United States			United Kingdom	
	1997	1998	1999	1998 (US\$)	1999 (US\$)
Kazakhstan	0.80	0.69	0.51	0.82	0.64
Korea, Rep.	0.49	0.43	0.36	0.64	0.50
Kuwait	0.79	0.80	0.78	0.82	0.80
Luxembourg	0.14	0.14	0.14	0.23	0.24
Macau	0.60	0.50	0.50	0.53	0.51
Malaysia	0.40	0.40	0.40	0.51	0.50
Mexico	0.35	0.37	0.19	0.45	0.44
Moldova	1.04	1.04	1.04	0.30	0.24
Netherlands	0.14	0.10	0.07	0.07	0.06
New Zealand	0.14	0.14	0.14	0.20	0.19
Norway	0.11	0.09	0.08	0.07	0.07
Oman	1.13	0.75	0.68	0.82	0.80
Pakistan	1.00/0.60	0.60	0.60	0.66	0.64
Panama	0.60	0.48	0.45	0.77	0.64
Paraguay	0.60	0.50	0.40	0.90	0.80
Peru	0.50	0.43	0.33	0.74	0.72
Philippines	0.50	0.36	0.29	0.49	0.48
Poland	0.35	0.28	0.21	0.28	0.25
Portugal	0.30	0.22	0.15	0.23	0.18/0.14
Russia	0.80	0.40	0.35	0.37	0.27
Saudi Arabia	1.02/0.81	0.87	0.68	1.27	0.89
Singapore	0.43	0.26	0.15	0.59	0.32
Slovak Republic	0.34	0.29	0.29	0.19/0.10	0.19/0.10
Slovenia	0.34	0.35	0.34	0.18/0.16	0.16/0.09
South Africa	0.50	0.40	0.35	0.66	0.48
Spain	0.24	0.13	0.14	0.16	0.16
Sri Lanka	1.00	0.80	0.60	0.90	0.89
Sweden	0.06	0.06	0.06	0.12	0.12
Switzerland	0.17	0.14	0.14	0.08/0.07	0.08/0.04
Taiwan	0.57	0.23	0.23	0.57	0.44
Thailand	0.60	0.45	0.35	0.82	0.80
Turkey	0.41	0.38	0.33	0.32	0.30
Ukraine	0.60	0.50	0.50	0.31	0.29
United Arab Emirates	1.00/0.65	1.00/0.65	1.00/0.65	0.49	0.32
United Kingdom	0.10/0.07	0.11/0.07	0.11/0.07	n.a.	n.a.
Uruguay	0.55	0.43	0.33	0.97	0.95
United States	n.a.	n.a.	n.a.	0.12/0.08	0.12/0.04
Uzbekistan	0.80	0.70	0.60	0.99	0.80
Venezuela	0.49	0.40	0.32	0.82	0.80
Vietnam	1.65/1.00/0.93/0.85	1.65/1.00/0.93/0.85	0.78	1.31	1.29
Yugoslavia	0.41	0.38	0.34	0.28	0.27

Source: FCC; Office of Telecommunications (OFTEL)

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FCC Settlement Benchmarks

Motivated by the annual multi-billion dollar settlements outflow by U.S. carriers, the Federal Communications Commission (FCC) proposed in 1996 a set of "benchmark" or model settlement rates (see Report and Order IB Docket No. 96-261, FCC 96-484, (www.fcc.gov/Bureaus/International/Notices/1996/fcc96484.txt). Beginning in 1999, these benchmarks capped the amount U.S. carriers could pay their foreign correspondents for traffic exchange at rates ranging from \$0.15 to \$0.23 per minute.

The FCC calculated benchmarks based on the price for the three network elements used to provide international phone services, as identified by recommendation D.140 of the ITU's Standardization Sector (ITU-T; see www.itu.int/intset/itu-t/d140/d140_e_rev.htm). Known as Tariffed Component Prices (TCPs), these include international transmission facilities (cable and satellite half circuits); international switching facilities; and national extension facilities (domestic transport and termination).

To obtain prices for the first and last network elements—international transmission and national extension—the FCC used 1996 rates for

the largest carrier in each country, based on standard equipment. For international transmission, this meant an international private line at 1.5 Mbps or above, a 4:1 compression ratio on each 64 Kbps circuit, and a usage level of 8,000 minutes per 64 Kbps circuit per month. For national extension pricing, the FCC relied upon national long distance tariffs, smoothing according to average expected time-of-day and distance for inbound traffic. The per minute costs for international switching were derived from the accounting rate share figures identified in ITU-T Recommendation D.300R's international exchange section (www.itu.int/intset/itu-t/d300/d300r.htm).

The FCC adopted the Benchmarks Order in August 1997, with implementation staggered over several years, based on national incomes. Settlement rates to high income countries have already been affected, following the 1999 deadline; other countries are being covered by the Benchmarks Order in turn, ending with the low income countries by 2003. As the table below demonstrates, most countries in the upper income bracket have fallen into line, with settlement rates at or below benchmarks. Settlement rates for countries that have met benchmarks are shown in bold.

Tariffed Component Prices for FCC Benchmarks (U.S. cents)

Country	International Transmission	+	International Switching	+	National Extension	=	Tariffed Component Price	FCC Settlement Benchmarks	August 1999 Settlement Rate
Upper Income Bracket: Effective 1 January 1999									
Australia	4.8		1.9		12.0		18.7	15.0	15.0
Austria	8.1		1.9		21.4		31.4	15.0	14.0
Bahamas	5.2		1.9		12.8		19.9	15.0	30.0/15.0
Belgium	3.0		1.9		9.2		14.1	15.0	14.0
Denmark	5.9		1.9		6.6		14.4	15.0	11.0
France	2.9		1.9		12.7		17.5	15.0	10.0
Germany	4.3		1.9		13.6		19.8	15.0	10.0
Hong Kong	5.1		1.9		0.0		7.0	15.0	7.0
Ireland	2.7		1.9		13.4		18.0	15.0	10.0
Israel	4.2		1.9		2.4		8.5	15.0	15.0
Italy	4.8		1.9		11.5		18.2	15.0	11.0
Japan	6.5		1.9		11.3		19.7	15.0	14.0
Kuwait	7.1		1.9		0.0		9.0	15.0	78.0
Netherlands	2.6		1.9		5.3		9.8	15.0	7.0
New Zealand	5.7		1.9		16.2		23.8	15.0	14.0
Norway	3.2		1.9		6.5		11.6	15.0	8.0
Portugal	4.6		1.9		17.4		23.9	15.0	15.0
Singapore	5.0		1.9		0.7		7.6	15.0	15.0
Spain	4.8		1.9		11.4		18.1	15.0	14.0
Sweden	3.6		1.9		4.5		10.0	15.0	6.0
Switzerland	4.4		1.9		14.3		20.6	15.0	14.0
Taiwan	5.7		1.9		6.3		13.9	15.0	23.0
United Arab Emirates	3.3		1.9		2.5		7.7	15.0	1.00/65.0
United Kingdom	2.4		1.9		8.7		13.0	15.0	11.0/7.0

Tariffed Component Prices for FCC Benchmarks (continued)

Country	International Transmission	+	International Switching	+	National Extension	=	Tariffed Component Price	FCC Settlement Benchmarks	August 1999 Settlement Rate
Upper Middle Income Bracket: Effective 1 January 2000									
Argentina	6.7		3.4		22.0		32.1	19.0	33.0
Barbados	8.6		3.4		0.0		12.0	19.0	53.0
Brazil	6.6		3.4		17.8		27.8	19.0	30.0
Chile	2.9		3.4		12.3		18.6	19.0	35.0
Czech Republic	8.1		3.4		7.5		19.0	19.0	18.0
Greece	5.2		3.4		14.4		23.0	19.0	17.0
Hungary	6.1		3.4		4.9		14.4	19.0	19.0
Korea, Rep.	5.1		3.4		4.3		12.8	19.0	36.0
Malaysia	6.6		3.4		12.4		22.4	19.0	40.0
Mexico	0.9		3.4		12.5		16.8	19.0	19.0
South Africa	5.2		3.4		8.3		16.9	19.0	35.0
Trinidad	3.6		3.4		7.6		14.6	19.0	45.0
Uruguay	12.7		3.4		6.2		22.3	19.0	33.0
Lower Middle Income Bracket: Effective 1 January 2001									
Colombia	5.1		4.8		8.6		18.5	19.0	38.0
Costa Rica	3.3		4.8		2.2		10.3	19.0	29.0
Dominican Republic	3.6		4.8		6.1		14.5	19.0	26.0
Ecuador	2.9		4.8		2.6		10.3	19.0	41.0
El Salvador	5.9		4.8		1.1		11.8	19.0	31.0
Guatemala	3.1		4.8		2.4		10.3	19.0	34.0
Indonesia	6.8		4.8		23.9		35.5	19.0	48.0
Jamaica	2.9		4.8		1.0		8.7	19.0	58.0
Jordan	15.9		4.8		2.3		23.0	19.0	50.0
Panama	4.7		4.8		9.9		19.4	19.0	45.0
Peru	5.8		4.8		5.5		16.1	19.0	33.0
Philippines	6.5		4.8		12.6		23.9	19.0	29.0
Poland	4.7		4.8		15.1		24.6	19.0	21.0
Russia	5.4		4.8		25.2		35.4	19.0	35.0
Thailand	4.0		4.8		8.3		17.1	19.0	35.0
Turkey	5.4		4.8		7.7		17.9	19.0	33.0
Venezuela	3.7		4.8		15.3		23.8	19.0	32.0
Lower Income Bracket: Effective 1 January 2002									
China	8.7		4.8		4.2		17.7	23.0	58.0
Egypt	10.4		4.8		2.0		17.2	23.0	55.0
Guyana	6.6		4.8		0.6		12.0	23.0	85.0
Haiti	8.6		4.8		17.0		30.4	23.0	55.0
Honduras	3.1		4.8		8.7		16.6	23.0	97.0
India	8.1		4.8		18.3		31.2	23.0	64.0
Kenya	25.5		4.8		12.3		42.6	23.0	55.0
Nicaragua	3.8		4.8		3.7		12.3	23.0	43.0
Pakistan	14.7		4.8		7.2		26.7	23.0	1.11
Vietnam	9.3		4.8		10.6		24.7	23.0	78.0

Source: FCC

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National Interconnection Rates

	Local Termination (US cents)		Regional Termination (US cents)		National Termination (US cents)	
	1997	1998	1997	1998	1997	1998
Australia	1.62	2.15	5.30	2.18	9.90	4.00
Austria	2.00	1.90	2.00	1.90	2.63	2.50
Belgium	1.23	1.11	2.33	1.87	3.26	2.67
Canada	n.a.	n.a.	5.33	0.78	n.a.	n.a.
China	n.a.	0.65	n.a.	0.81	n.a.	0.89
Denmark	1.09	1.03	2.02	1.92	2.46	2.33
Finland	1.56	1.67	1.58	1.67	3.12	4.12
France	0.78	0.63	1.90	1.56	2.80	2.32
Germany	1.10	1.05	1.88	2.26	2.86	2.74
Greece	2.01	2.06	2.01	2.06	2.87	2.95
Ireland	2.44	1.08	4.61	1.67	8.75	2.36
Italy	1.68	1.03	2.74	1.86	n.a.	2.69
Japan	0.71	0.65	1.73	1.60	5.98	5.55
Luxembourg	2.23	2.34	2.23	2.34	2.23	2.34
Mexico	n.a.	n.a.	n.a.	2.61	n.a.	n.a.
Netherlands	1.30	1.16	1.78	1.74	2.29	2.11
New Zealand	n.a.	1.43	n.a.	n.a.	n.a.	6.66
Norway	n.a.	1.00	n.a.	1.38	n.a.	1.63
Portugal	1.33	2.87	2.63	5.74	19.98	11.48
Spain	1.65	1.03	1.65	1.66	4.63	3.20
Sweden	1.27	1.12	1.96	1.75	2.68	2.36
Switzerland	n.a.	n.a.	2.72	1.50	3.73	2.08
U.K.	0.68	0.55	0.96	0.82	1.88	1.69
U.S. (Bell Atlantic)	n.a.	n.a.	0.79	1.46	n.a.	n.a.

Notes:
 All interconnection charges are for peak period. Rates date to July and August 1999.
 Local termination is the lowest level of interconnection, typically giving a carrier access to a single town or part of a city.
 Regional termination generally gives a carrier access to all subscribers within a metropolitan area or a North American area code.
 China's interconnection rates are for domestic operating companies only.
 Japan 1998 termination rates are estimated.
 U.S. termination fees vary according to Local Exchange Carrier (LEC). U.S. average for regional termination was 1.46¢ as of August 1999.

Source: European Union Commission, FCC, CRTC (Canada), MPT (Japan), OFCOM (Switzerland), Telmex, China Telecom © TeleGeography, Inc. 1999

Retail Prices for a Three Minute Call

From/To	Australia	Belgium	Canada	Denmark	Finland	France	Germany	Greece	Ireland	Italy
Australia	n.a.	2.23	1.60	2.07	2.07	2.07	1.90	1.76	1.58	1.55
Austria peak	1.91	0.96	1.08	0.96	0.96	0.96	0.76	1.08	0.96	0.76
Austria off-peak	1.75	0.80	0.96	0.80	0.80	0.80	0.64	1.08	0.80	0.64
Belgium	3.12	n.a.	1.56	1.17	1.56	1.17	1.17	1.56	1.56	1.56
Czech Republic peak	2.01	1.27	1.93	1.27	1.31	1.27	1.21	1.31	1.31	1.27
Czech Republic off-peak	1.25	0.79	1.20	0.79	0.82	0.79	0.71	0.82	0.82	0.79
Denmark peak	2.15	1.24	1.21	n.a.	0.70	1.23	0.87	1.55	1.24	1.21
Denmark off-peak	1.65	0.95	0.83	n.a.	0.56	0.80	0.56	1.12	1.00	0.76
Finland	2.18	1.44	1.44	0.43	n.a.	1.44	1.25	1.44	1.44	1.44
France peak	1.62	0.66	0.70	0.70	0.80	n.a.	0.66	0.80	0.80	0.66
France off-peak	1.44	0.58	0.64	0.64	0.72	n.a.	0.58	0.72	0.72	0.58
Germany peak	3.00	0.66	0.66	0.66	1.35	0.66	n.a.	1.17	1.17	0.66
Germany off-peak	3.00	0.66	0.66	0.66	1.01	0.66	n.a.	1.01	1.01	0.66
Greece	1.36	1.36	1.36	1.36	1.36	1.36	1.36	n.a.	1.36	1.36
Ireland peak	2.25	1.00	0.76	1.26	1.26	1.00	1.00	1.26	n.a.	1.26
Ireland off-peak	1.80	0.89	0.67	1.10	1.10	0.89	0.89	1.10	n.a.	1.10
Italy	2.56	1.10	1.10	1.10	1.10	1.10	1.10	1.52	1.10	n.a.
Japan peak	5.87	6.64	3.80	6.64	6.64	5.52	5.52	6.64	6.64	6.64
Japan off-peak	4.66	5.35	3.11	5.35	5.35	4.92	4.92	5.35	5.35	5.35
Korea, Rep.	2.75	2.28	3.59	2.28	2.28	2.28	2.28	2.28	2.28	2.28
Mexico peak	5.38	4.75	2.99	4.75	4.75	4.75	4.75	4.75	4.75	4.75
Mexico off-peak	3.59	3.17	2.99	3.17	3.17	3.17	3.17	3.17	3.17	3.17
Netherlands	1.15	0.36	0.36	0.41	0.72	0.40	0.33	1.02	0.77	0.52
Norway	0.79	2.21	0.57	0.40	0.40	0.57	0.48	0.87	0.67	0.63
Portugal peak	2.66	1.16	1.32	1.16	1.16	1.16	1.16	1.16	1.16	1.16
Portugal off-peak	2.66	1.16	1.32	1.16	1.16	1.16	1.16	1.16	1.16	1.16
Spain	3.40	1.16	1.94	1.16	1.16	1.16	1.16	1.16	1.16	1.16
Sweden	2.35	1.19	1.34	0.47	0.47	1.19	0.91	1.48	1.19	1.48
Turkey	3.53	1.37	2.06	1.37	1.37	1.37	1.37	0.88	1.37	1.37
U.K. peak	2.01	1.16	0.97	1.16	1.58	1.16	1.16	1.46	0.94	1.46
U.K. off-peak	1.72	1.09	0.92	1.09	1.42	1.09	1.09	1.21	0.81	1.21
U.S. (AT&T basic)	5.40	5.52	1.56	5.22	5.18	4.77	4.44	6.96	4.83	5.37
U.S. (AT&T One Rate)	0.75	0.87	0.30	0.87	0.87	0.66	0.60	0.87	0.66	0.66
U.S. (MCI basic)	5.51	5.66	2.20	5.30	5.39	4.85	4.55	7.10	4.91	5.45
U.S. (MCI One)	0.75	0.87	0.30	0.87	0.87	0.66	0.60	0.75	0.66	0.66
U.S. (Delta Three IP telephony)	0.42	0.48	0.20	0.51	0.51	0.42	0.42	1.20	0.51	0.42

Notes: 1. All rates are in US\$ and exclusive of taxes and were current on August 31, 1999.

2. Rates have been calculated in real time using meter step (rounded up to next meter step for a 3 minute call).

3. Fees are \$1 with domestic long-distance per month for AT&T One Rate and \$3 per month for MCI One.

4. Rates for calls from the U.S. to Canada and Mexico are from Washington, D.C. to Toronto and Mexico City.

Japan	Korea, Rep.	Mexico	Neth'lands	Portugal	Spain	Sweden	Turkey	U.K.	U.S.	To/From
2.19	2.00	3.23	2.01	2.91	2.54	2.25	2.45	1.58	1.60	Australia
2.39	6.22	3.67	0.96	1.08	0.96	0.96	1.08	0.96	1.08	Austria peak
2.23	5.74	3.19	0.80	0.96	0.80	0.80	1.08	0.80	0.96	Austria off-peak
3.12	4.29	5.46	1.17	1.56	1.56	1.56	2.34	1.17	1.56	Belgium
2.01	4.85	4.01	1.27	1.31	1.31	1.27	1.81	1.26	1.91	Czech Republic peak
1.25	3.75	3.11	0.79	0.82	0.82	0.79	1.41	0.74	1.18	Czech Republic off-peak
3.00	4.96	4.96	1.14	1.55	1.55	0.58	1.89	0.87	1.21	Denmark peak
2.40	3.94	3.94	0.90	1.12	1.12	0.46	1.31	0.65	0.92	Denmark off-peak
3.63	4.80	4.80	1.44	1.44	1.44	0.43	1.53	1.44	1.44	Finland
1.62	1.79	2.08	0.70	0.80	0.66	0.70	1.06	0.66	0.70	France peak
1.44	1.60	1.88	0.64	0.72	0.58	0.64	0.96	0.58	0.64	France off-peak
3.00	3.00	4.17	0.66	1.35	0.66	1.35	1.17	0.66	0.66	Germany peak
3.00	3.00	4.17	0.66	1.01	0.66	1.01	1.01	0.66	0.66	Germany off-peak
1.55	1.55	2.43	1.36	1.36	1.36	1.36	1.21	1.36	1.36	Greece
2.25	3.22	2.01	1.00	1.26	1.26	1.26	2.42	0.53	0.76	Ireland peak
1.80	3.22	1.81	0.89	1.10	1.10	1.10	2.09	0.50	0.67	Ireland off-peak
2.54	3.52	3.52	1.10	1.10	1.10	1.10	2.23	1.10	1.10	Italy
n.a.	4.06	6.30	6.64	6.64	6.64	6.64	6.64	4.75	2.07	Japan peak
n.a.	3.36	5.09	5.35	5.35	5.35	5.35	5.35	4.14	1.81	Japan off-peak
2.04	n.a.	3.73	2.28	2.28	2.28	2.28	2.28	2.28	1.74	Korea, Rep.
5.38	5.38	n.a.	4.75	4.75	4.75	4.75	4.75	4.75	2.65	Mexico peak
3.59	3.59	n.a.	3.17	3.17	3.17	3.17	3.17	3.17	2.65	Mexico off-peak
1.75	2.18	2.92	n.a.	1.02	0.52	0.41	1.39	0.30	0.27	Netherlands
1.18	1.78	2.21	0.45	0.87	0.67	0.39	1.41	0.45	0.57	Norway
3.46	3.46	3.62	1.16	n.a.	1.00	1.16	2.03	1.16	1.24	Portugal peak
3.46	3.46	3.62	1.16	n.a.	1.00	1.16	2.03	1.16	1.24	Portugal off-peak
3.40	3.40	3.18	1.16	1.16	n.a.	1.16	1.80	1.16	1.33	Spain
2.93	5.24	5.82	0.91	1.48	1.48	n.a.	2.06	0.91	0.91	Sweden
3.53	3.53	2.06	1.37	1.37	1.37	1.37	n.a.	1.37	2.06	Turkey
2.76	4.43	4.43	1.16	1.46	1.46	1.16	2.76	n.a.	0.97	U.K. peak
2.35	4.21	4.21	1.09	1.21	1.21	1.09	2.35	n.a.	0.92	U.K. off-peak
5.19	6.48	5.07	4.71	5.88	5.79	4.71	6.57	3.87	n.a.	U.S. (AT&T basic)
0.78	1.05	1.26	0.75	0.75	0.75	0.60	1.41	0.30	n.a.	U.S. (AT&T One Rate)
5.27	6.65	1.73	4.79	6.02	5.87	4.79	6.71	3.95	n.a.	U.S. (MCI basic)
1.05	1.95	1.26	0.75	0.75	0.75	0.60	1.86	0.30	n.a.	U.S. (MCI One)
0.54	0.42	1.11	0.45	0.99	0.42	0.39	1.35	0.42	n.a.	U.S. (Delta Three IP telephony)

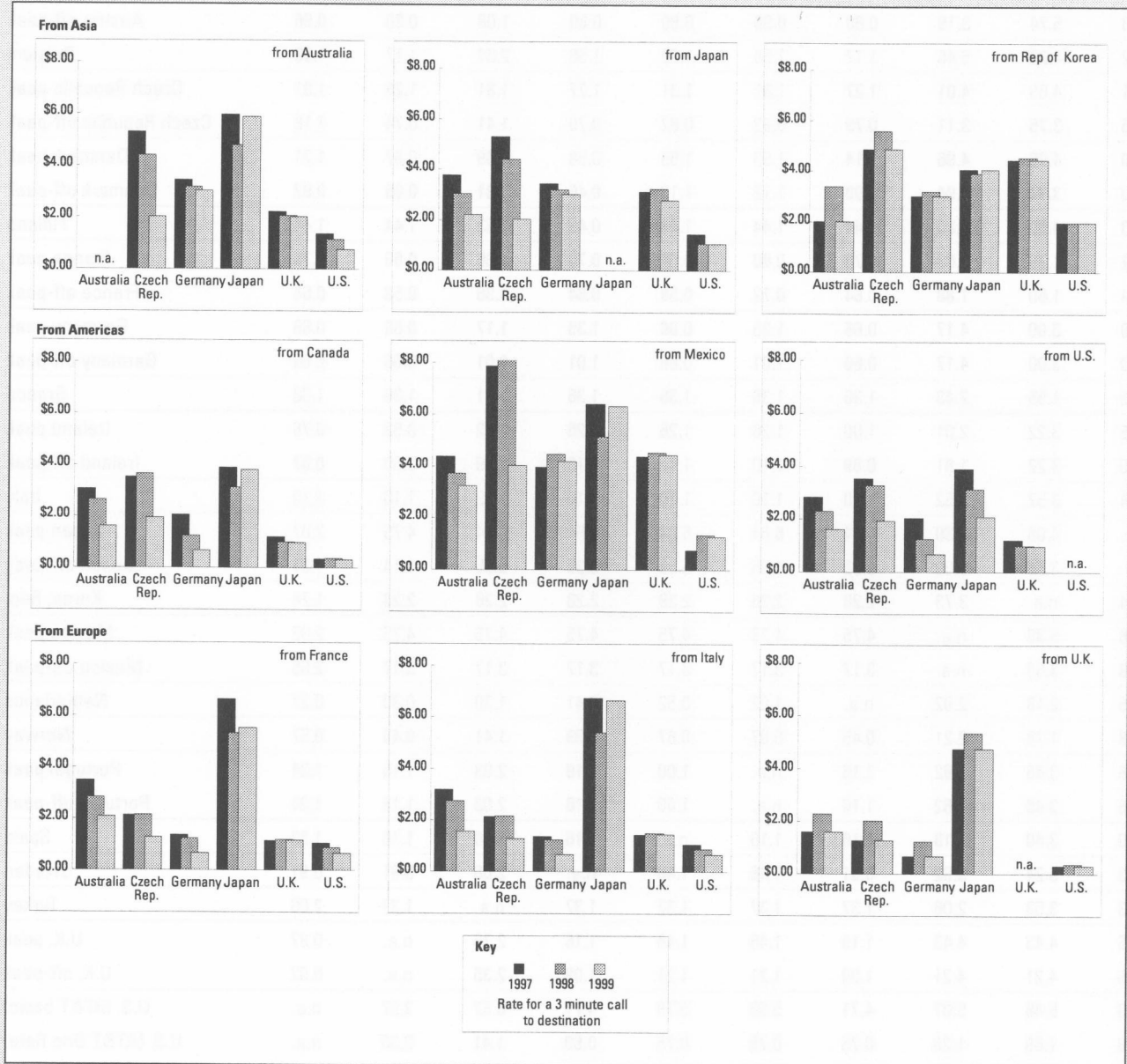
Source: The Phillips Group, 3rd Floor, 19 Thomas More St., London E1 9YW, U.K.
 Tel +44 20 7423 4500 • Fax +44 20 7423 4501 • Email: consult@tarifica.com • www.tarifica.com

Source for U.S. rates: TeleGeography, Inc.

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Retail Pricing Trends, 1997-1999

Figure 1. Retail Tariffs for Selected Countries



Source: Philips Tarifica, TeleGeography, Inc.

© TeleGeography, Inc. 1999

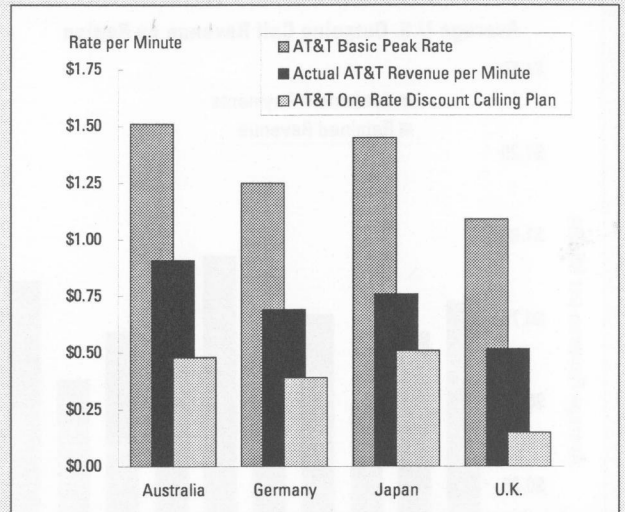
Origin of U.S. Carrier Revenues

Although useful for tracking pricing trends, advertised retail tariffs only rarely match the per minute revenues that carriers actually collect. Billed revenues often fall far short of basic rates—a result of special calling plans offered to end users and of bulk discounts awarded to service resellers (see Figure 1).

Nearly half of international voice service revenue collected from the customers of U.S. carriers flow to foreign telephone companies in the form of settlement payments (see Figure 2). In 1998, the average price of an international call billed by the three largest U.S. carriers was 63¢ per minute—of which 31¢ were passed on to foreign carriers (see Figures 3 and 4).

Because they send out far more international calls than they receive, U.S. carriers continue to incur a multi-billion dollar net settlements deficit. Yet thanks to falling settlement rates, gross settlement outpayments from the U.S. decreased in 1997 for the first time in twenty years.

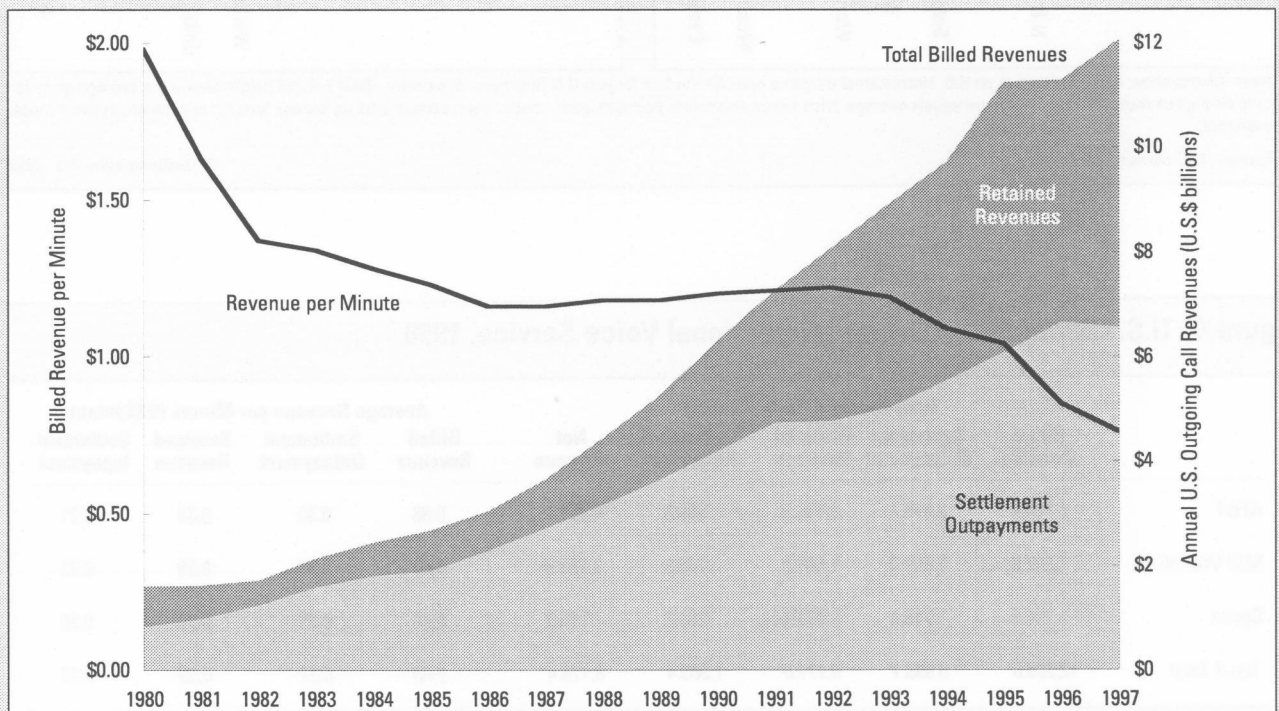
Figure 1. Advertised Tariffs vs Billed Revenues



Source: TeleGeography, Inc.

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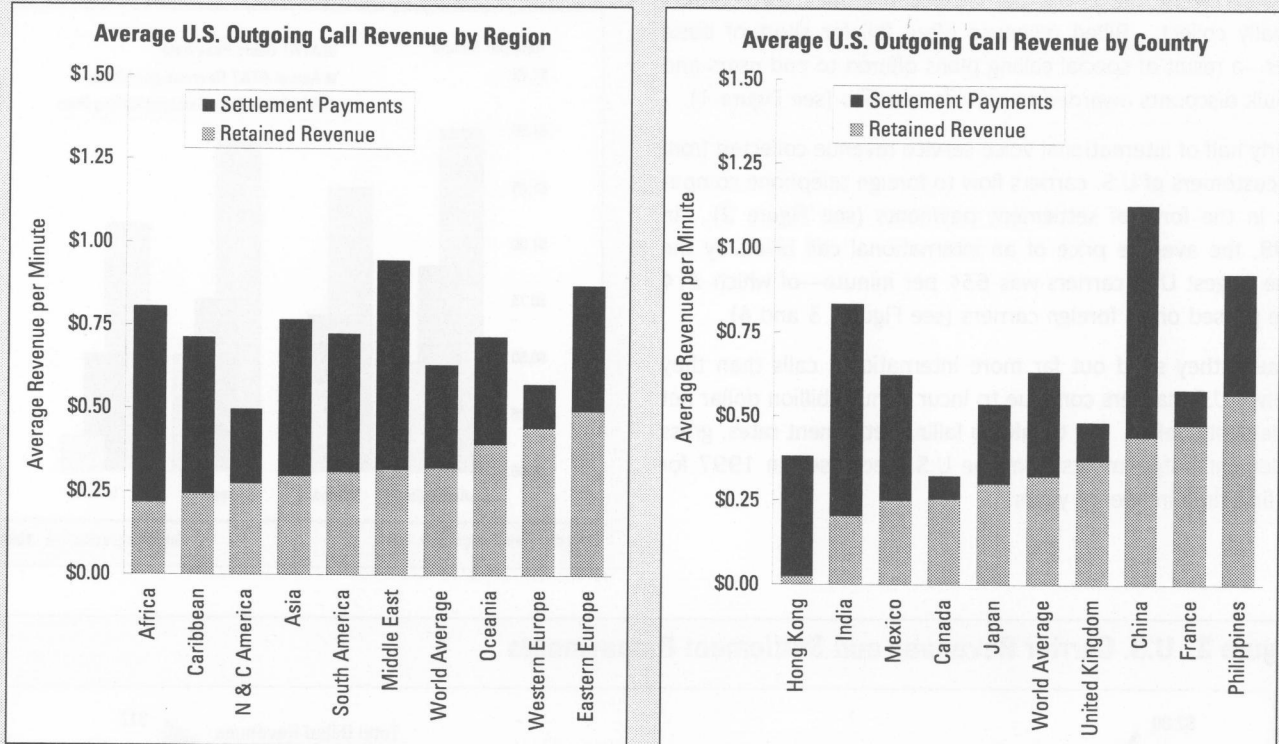
Figure 2. U.S. Carrier Revenues and Settlement Outpayments



Source: FCC

© TeleGeography, Inc. 1999

Figure 3. U.S. Carrier International Call Revenue by Destination, 1998



Note: Charts show average revenue on U.S. international outgoing calls for the four largest U.S. international carriers. Total column height shows the average price for calls on a given route. Retained revenue equals average price minus settlement payment, and includes such components as access fees for origination, network costs, and profit.

Source: FCC carrier filings

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Figure 4. U.S. Carrier Revenues for International Voice Service, 1998

	Total Receipts (US\$ millions)					Average Revenue per Minute (US\$/minute)			
	Billed Revenue	Settlement Outpayment	Retained Revenue	Settlement Inpayment	Net Revenue	Billed Revenue	Settlement Outpayment	Retained Revenue	Settlement Inpayment
AT&T	6,723.4	2,975.1	3,748.3	980.3	4,728.6	0.68	0.30	0.38	0.21
MCI WorldCom	4,292.2	2,307.4	1,984.8	748.8	2,733.6	0.60	0.32	0.28	0.25
Sprint	1,194.0	716.1	477.8	236.3	714.2	0.54	0.33	0.22	0.29
<i>Top 3 Total</i>	<i>12,209.6</i>	<i>5,998.7</i>	<i>6,211.0</i>	<i>1,965.4</i>	<i>8,176.4</i>	<i>0.63</i>	<i>0.31</i>	<i>0.32</i>	<i>0.23</i>

Note: This table breaks down international voice service revenue for the three largest U.S. international carriers in 1998. For example, AT&T collected \$6.7 billion from customers for U.S. international outgoing calls, and paid foreign carriers \$3.0 billion to terminate those calls. Thus, the company gained \$3.7 billion by carrying U.S. outgoing calls. Because FCC regulations generally entitled each U.S. carrier to terminate incoming calls based on the percentage of U.S. outgoing traffic it originates, AT&T collected a significant sum (\$980 million) on foreign settlement inpayments, netting \$4.7 billion on international voice service.

Source: FCC carrier filings

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Trading International Telecom Minutes

Figure 1. Minutes Sold on Arbinet Exchange, 1999

Lowest Matched Sell Rates (U.S. cents per minute)			
	Q1 1999	Q2 1999	Q3 1999
U.S.-Americas			
Brazil	22.0	18.9	14.7
Mexico	16.4	14.3	13.0
U.S.-Asia			
China	30.1	21.5	18.3
Hong Kong	5.5	3.3	3.4
Japan	7.1	6.2	6.1
U.S.-Europe			
France	5.7	3.8	3.4
Germany	4.8	4.1	3.7
Greece	17.1	14.5	13.9

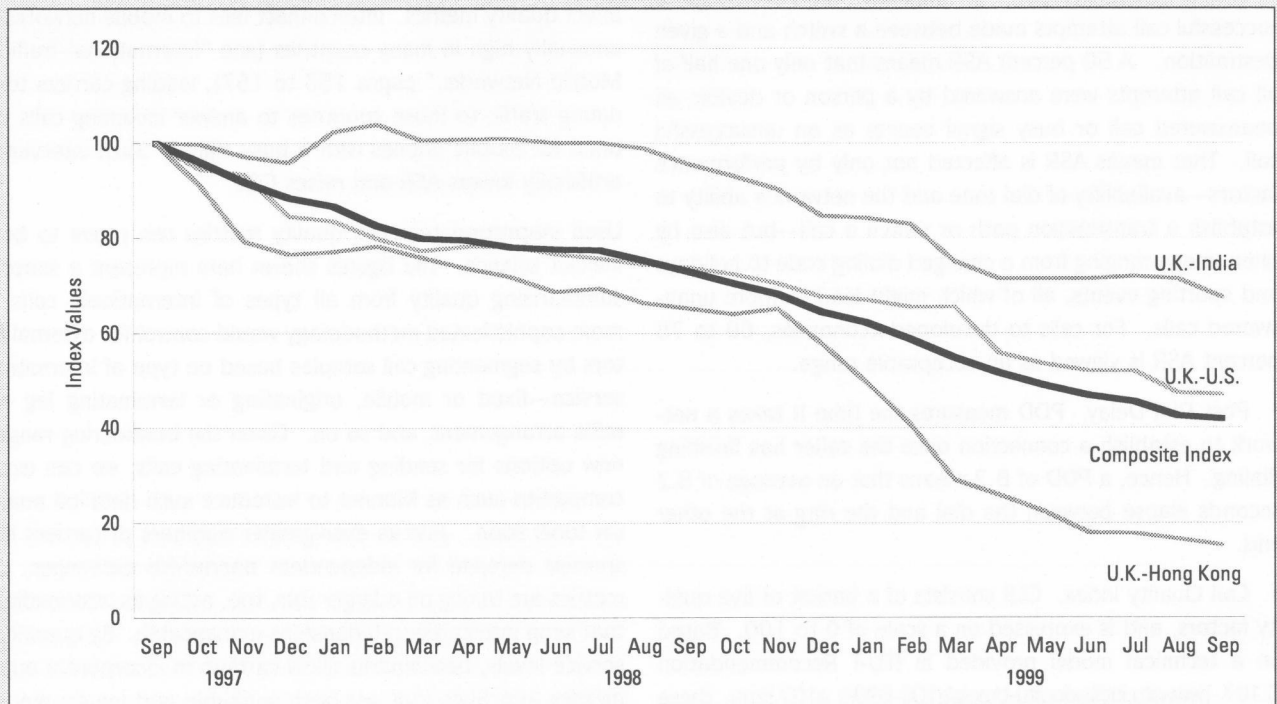
Top Routes Ranked by Minute Volumes Traded			
Volumes Traded on Arbinet		1998 U.S. Outgoing PSTN Traffic	
Rank	Destination	Rank	Minutes (m)
1.	China	14.	420.3
2.	Vietnam	28.	190.4
3.	Brazil	8.	581.3
4.	Philippines	10.	552.6
5.	Japan	5.	796.1
6.	Lebanon	67.	56.6
7.	Germany	4.	1,267.7
8.	Italy	11.	510.4
9.	Australia	12.	444.1
10.	United Kingdom	3.	1,454.5

Note: Rates show the lowest price for successful trades among members of Arbinet's exchange during the given quarter. Route rankings reflect U.S. outbound minutes sold on Arbinet exchange during 1999.

Source: Arbinet Communications (www.arbinet.com) • Tel +1 212 230 1200 • Fax +1 212 230 1216

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Figure 2. Band-X Index of U.K. International Wholesale Prices, 1997-1999



Note: The Band-X U.K. Index measures relative price movement for the top twenty U.K. outbound routes. Three of those routes are shown here. The composite index is an average of price changes to those twenty different destinations, with each route weighted according to its proportion of U.K. outgoing traffic as reported by TeleGeography.

Source: Band-X (www.band-x.com) • Tel +44 171 349 4400 • Fax +44 171 349 4401

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International Call Quality Metrics

Once ruled by monopoly PTOs, global telephony has become a competitive playing field. That makes phone calls cheaper. But price is just one determinant of purchase behavior. Another is call quality. Traditionally, telephony Quality of Service (QoS) has been used to plan and manage the transmission system. Today, QoS is being built into Service Level Agreements (SLAs) that help formalize transactions in a telephony marketplace where, confronted with an increasing array of options, many wholesale and retailer buyers would rather focus on products than ingredients. Agreeing on pricing is easy; quality, on the other hand, is subjective. So how can QoS be quantified?

A Metric Review

Monnet UK Ltd., an independent QoS arbiter, is implementing one approach. Monnet monitors call quality on its clients' networks. It also constructs industry benchmarks, pooled from data provided by participating carriers. Figure 1 shows survey results for 45 destination countries, based on a sample of one million international calls from German and U.K. carriers between June 1 and August 31, 1999.

Monnet uses three indicators to measure call quality:

- **Answer Seizure Ratio.** ASR measures the percentage of successful call attempts made between a switch and a given destination. A 50 percent ASR means that only one half of all call attempts were answered by a person or device; an unanswered call or busy signal counts as an unsuccessful call. That means ASR is affected not only by performance factors—availability of dial tone and the network's ability to establish a transmission path or switch a call—but also by phenomena ranging from a changed dialing code to holidays and sporting events, all of which might lead to more unanswered calls. For calls to developed economies, 60 to 75 percent ASR is viewed as an acceptable range.
- **Post Dial Delay.** PDD measures the time it takes a network to establish a connection once the caller has finishing dialing. Hence, a PDD of 8.2 means that an average of 8.2 seconds elapse between the dial and the ring at the other end.
- **Call Quality Index.** CQI consists of a basket of five quality factors, and is expressed on a scale of 0 to 100. Based on a technical model provided in ITU-T Recommendation G.107 (www.itu.int/itudoc/itu-t/rec/g/g100-699/s_g107.htm), these factors include signal level, noise, echo path loss, echo path delay, and speech activity. A CQI score of 90-100 translates

to a "best" ranking; a CQI of 50-60 is graded "poor." Beside reflecting basic infrastructure problems, CQI scores can decrease as a result of packet loss in IP networks, use of compression, and including many mobile calls in the traffic mix.

Toward a Better Benchmark

Monnet's benchmark provides carriers with an objective point of comparison for their QoS. But industry-wide comparisons across different originating countries can be deceiving. In the survey summarized in Figure 1, for example, refiled traffic—the reorigination of calls in a hub country—was a key factor in determining call quality. Many of the U.K. carriers participating in the survey acted as refile hubs for several other countries. Those countries' network quality proved inferior to the carriers' own networks, and as a result, a number of destinations appear to have lower call quality metrics from the U.K. than from Germany.

Mobile traffic can dilute call quality: when a call transits a mobile network, a number of the characteristics which drive down Call Quality Index scores—noise, echo, delay—tend to show up. The economics of sending calls to mobiles can also affect quality metrics. Interconnect fees to mobile networks are unusually high in many countries (see "International Traffic on Mobile Networks," pages 153 to 157), leading carriers terminating traffic to those countries to answer incoming calls destined for mobile phones with a busy signal. Such intervention artificially lowers ASR and raises CQI.

Used inappropriately, call quality metrics can prove to be an inexact science. The figures shown here represent a snapshot summarizing quality from all types of international calls. A more sophisticated methodology would control for external factors by segmenting call samples based on type of international service—fixed or mobile, originating or terminating leg of a refile arrangement, and so on. Given the bewildering range of new options for sending and terminating calls, we can expect companies such as Monnet to introduce such detailed analytical tools soon. Just as ever-greater numbers of carriers have spurred demand for independent bandwidth exchanges, QoS metrics are taking on a larger role, too, acting as intermediaries that keep intercarrier relationships manageable. By quantifying service levels, benchmarks allow carriers to incorporate quality metrics into SLAs that are both verifiable and legally binding. Alongside price, quality has become part of the equation.



Figure 1. Quality Metrics on Calls from Germany and the U.K., June-August 1999

Destination	Answer Seizure Ratio		Post Dial Delay (seconds)		Call Quality Index	
	from Germany	from U.K.	from Germany	from U.K.	from Germany	from U.K.
Australia	70%	47%	4.2	14.9	89.2	69.0
Austria	76%	39%	2.0	8.3	83.0	49.8
Belgium	68%	41%	2.0	17.7	77.1	59.4
Brazil	68%	47%	6.3	3.6	87.6	44.2
Canada	71%	75%	n.a.	1.5	n.a.	63.2
Chile	57%	17%	2.8	4.2	73.7	69.7
China	60%	45%	3.6	5.4	85.7	52.3
Colombia	52%	12%	9.2	4.5	80.5	49.1
Denmark	76%	68%	n.a.	2.1	n.a.	64.7
Ecuador	32%	15%	1.4	16.7	74.8	48.1
Finland	69%	66%	8.2	3.4	76.1	67.5
France	59%	55%	1.7	3.6	80.6	65.0
Germany	n.a.	32%	n.a.	4.6	n.a.	64.9
Ghana	33%	36%	6.6	6.7	69.9	55.3
Greece	56%	51%	3.9	3.1	73.9	43.7
Hong Kong	56%	67%	7.9	6.2	85.0	68.1
India	67%	33%	2.4	10.5	85.5	39.4
Ireland	61%	65%	6.4	1.1	62.5	67.6
Israel	71%	50%	n.a.	6.6	60.8	40.8
Italy	63%	46%	1.9	4.1	67.6	40.8
Japan	63%	67%	5.9	4.9	81.7	67.9
Korea, Rep.	64%	52%	8.6	4.1	89.3	80.1
Kuwait	n.a.	22%	n.a.	17.9	80.3	42.2
Macedonia	42%	40%	7.0	6.8	81.1	43.9
Malaysia	32%	58%	5.2	3.6	83.0	63.2
Mexico	37%	43%	2.9	7.5	82.6	80.2
Netherlands	76%	40%	1.7	8.2	82.3	33.4
Norway	69%	66%	6.7	3.2	83.7	64.3
Pakistan	55%	20%	n.a.	5.4	n.a.	40.7
Peru	79%	38%	2.2	13.0	90.0	49.6
Philippines	48%	42%	3.0	2.9	82.2	41.7
Poland	51%	51%	3.1	4.7	77.1	57.5
Romania	69%	28%	2.0	11.1	79.2	37.7
Russia	45%	35%	3.0	5.6	86.1	41.8
Saudi Arabia	72%	50%	7.6	7.6	n.a.	81.1
Singapore	70%	49%	2.8	4.0	89.3	42.0
South Africa	66%	55%	4.8	4.7	55.8	69.3
Spain	70%	48%	2.3	3.5	68.4	52.5
Sweden	n.a.	63%	n.a.	3.9	n.a.	62.3
Switzerland	61%	51%	2.0	3.7	83.9	62.2
Taiwan	n.a.	52%	n.a.	3.0	n.a.	53.2
Turkey	57%	20%	2.1	5.1	91.8	38.0
UAE	54%	42%	7.8	2.9	64.4	60.9
United Kingdom	62%	n.a.	1.7	n.a.	75.6	n.a.
United States	71%	69%	6.1	2.9	86.8	73.4
World Average	58.0%	42.9%	3.4	4.7	75.6	60.0

Source: Monnet UK Ltd., 2 Honey Lane, Cheapside, London EC2V 8BT, U.K.

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Table 1: Country Statistics by Continent

Continent	Country	Population (Millions)	Area (Square Kilometers)	Population Density (Per Square Kilometer)	Telephones (Millions)	Telephones Per 1,000 People
Africa	Algeria	29.1	2,381,741	12.2	1.2	41
	Egypt	68.9	1,001,450	68.8	1.5	22
	Morocco	28.4	446,560	63.4	1.0	35
	Sudan	38.5	1,861,484	20.7	0.3	8
	Tanzania	36.3	945,087	38.4	0.2	6
Asia	China	1,210.5	9,596,961	126.1	10.0	8.3
	India	853.7	2,973,193	287.1	6.0	7.0
	Japan	125.5	377,835	332.3	1.5	12.0
	South Korea	43.7	100,000	437.0	1.0	22.9
	Singapore	3.0	710	4226.8	0.2	66.7
Europe	Germany	82.4	357,021	230.8	1.0	12.1
	France	61.3	640,800	95.3	1.0	16.3
	United Kingdom	58.5	244,820	240.0	1.0	17.1
	Italy	57.0	301,330	189.1	1.0	17.4
	Spain	41.2	505,992	81.4	1.0	24.3
North America	USA	268.3	9,526,468	28.1	10.0	37.3
	Canada	31.1	9,970,610	3.1	1.0	32.2
	Mexico	92.0	1,972,550	46.7	1.0	10.9
	Central America	38.0	1,000,000	38.0	0.2	5.3
	Caribbean	25.0	1,000,000	25.0	0.1	4.0
South America	Brazil	160.0	8,511,965	18.8	1.0	6.3
	Argentina	36.0	2,780,170	12.9	0.5	13.9
	Colombia	38.0	1,100,000	34.5	0.5	13.2
	Venezuela	24.0	916,440	26.2	0.5	20.8
	Chile	15.0	756,102	19.8	0.2	13.3

Facilities

The facilities industry is a key sector for economic recovery. The industry is expected to grow significantly over the next few years, driven by a combination of factors including government spending, infrastructure investment, and a rebound in private sector activity. The industry is also facing challenges such as labor shortages and rising costs, which are likely to impact growth in the short term. However, the long-term outlook is positive, with many analysts predicting a strong recovery in the coming years.

The industry is also seeing a shift in focus towards sustainable and green buildings. This is driven by government incentives and a growing awareness of the environmental benefits of green buildings. The industry is investing heavily in research and development to develop new technologies and materials that will enable the construction of more sustainable buildings. This is expected to create new opportunities for growth in the industry.

The industry is also facing a number of challenges, including labor shortages and rising costs. These challenges are likely to impact growth in the short term, but they are also creating opportunities for innovation and growth in the long term. The industry is investing heavily in training and development to address the labor shortage, and it is also exploring new ways to reduce costs and improve efficiency.



The Bandwidth Wagon Rolls On

Four years ago, a true market for international bandwidth—“raw” telecommunications capacity—barely existed. For the most part, specific bandwidth products (for example, a 2 Mbps circuit between Milan and Frankfurt) were supplied as two halves by national incumbent monopoly telcos (in this case Telecom Italia and France Telecom). Prices were high, and service was often indifferent. Most of the buyers were multinational companies such as American Express and Shell, with a sprinkling of value added network service companies like SITA—the airlines’ network—and a few newly emerging ISPs.

These bandwidth buyers needed skills more usually to be found in minor foreign embassy officials—infinite patience, subtle negotiating powers, and good personal contacts inside supply companies. Negotiations focused on ensuring that a product was delivered on time, that it worked, and that when it went down (as it all too frequently did) it came back up as quickly as possible. Negotiations rarely focused on price, since the price—generally far above underlying cost—was fixed by the monopoly owners.

That was then, and this is now. An extraordinary and radical makeover of the sector is in progress, and the bandwidth market is rapidly becoming one of the most dynamic segments of the industry, at least in those regions where competition has been permitted. The number of suppliers is increasing rapidly,

new products are emerging monthly, and prices are falling faster than in almost any other sector of the market.

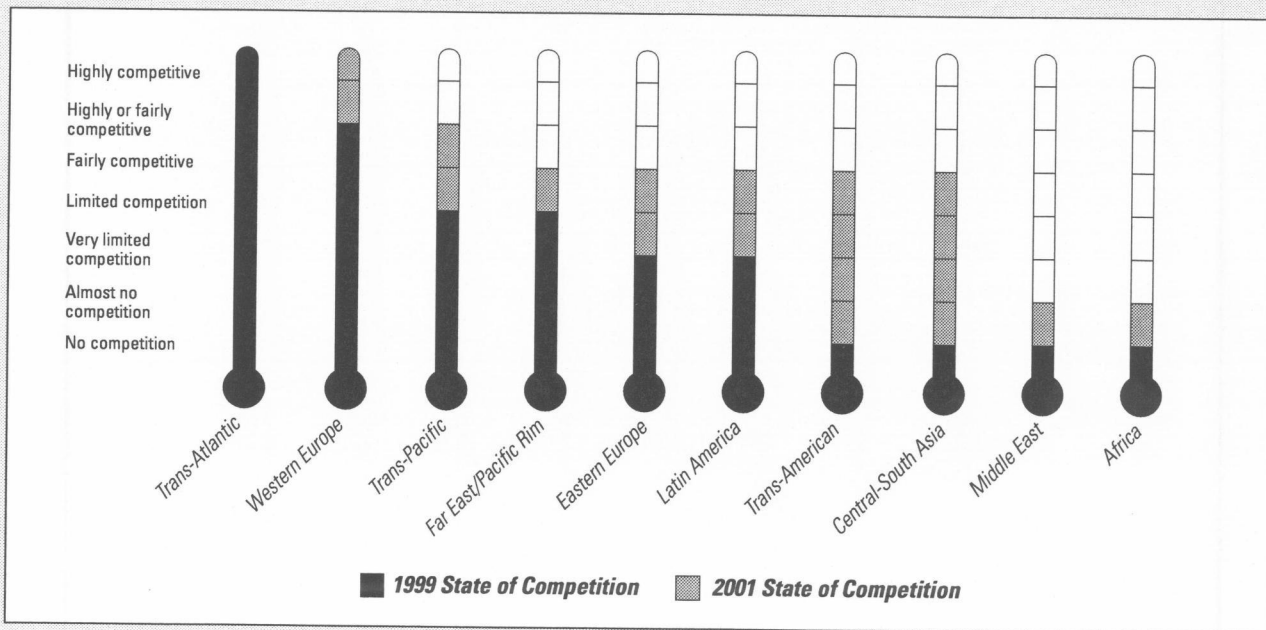
As Figure 1 shows, competition is now established in western Europe and the Atlantic Ocean region. In other key regions, it’s coming soon, and by 2002, few areas will still be without alternative suppliers of bandwidth.

Why the sudden upsurge in interest? Four primary factors are at work, each reinforcing the others to create an explosive upward momentum.

Competitive positioning: Competition is the key to the current changes. The U.S. and the European Union effectively freed up the trans-Atlantic and western European bandwidth markets in 1996, and many new providers see this as a once-in-a-generation opportunity to dominate a key emerging market. Others want to lay infrastructure or buy fibers in order to lower unit costs for other higher value or retail products. These perceptions have led to a boom in plans for new bandwidth, especially in western Europe and between Europe and the U.S. Figure 2 lists key projects in western Europe.

New technology: Dense Wavelength Division Multiplexing (DWDM) is the most disruptive technology to hit telecommunications transmission since the first communications

Figure 1. Competition for Telecommunications Bandwidth Heats Up



Source: TeleGeography, Inc.

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Figure 2. Western Europe's Fiber Frenzy

Organization	Coverage	Description of Infrastructure	Commercial Launch	Capacity	Strategy
BT	47 cities said to be covered; exceptionally dense coverage in partner countries including Germany, France and Italy	Largely based on the domestic fiber networks of partners, e.g. Cégétel in France	Initial network completed Q2 1999	160 Gbps lit initially	No plans to sell bandwidth to third parties
Carrier1	14 cities; 12 more in Germany and 12 in France planned	Building its own network in Germany with MFN. Elsewhere leasing dark fiber	1998	n.a.	Carriers' carrier which focuses on switched minutes and packets
COLT	18 city MANs will be connected by long distance network being jointly created with Level 3	All-new network with multiple ducts to ease upgrade to new fiber types	End 2000	n.a.	Full service telco focused on corporate business. Unique MAN play
Global Crossing	12 cities by December 1999; a further 6 in the first quarter of 2000, and 27 in total by the end of 2000	Pan European Crossing will be comprised of 11,000 km multiple self-healing rings connecting 24 cities	End 1999	10 Tbps theoretical capacity	Will sell full range of bandwidth products, positioning itself as a global provider
GTS Carrier Services (formerly Hermes)	30 cities covered, including many in southern Europe	70 percent leased dark fiber; own cables and ducts especially on border crossings	1996	Up to 160 Gbps, depending on routes; 2-18 wavelengths lit	First mover in many locations, e.g. southern Europe; full range of bandwidth products
iaxis (formerly Telemonde)	18 cities so far; aggressively looking to new locations, especially in southern Europe	Based primarily on dark fiber leased from utilities	May 1999	Up to 10 Gbps per wavelength; up to 192 wavelengths per link	Wholesale bandwidth only, plus value-added products such as telehousing
Interoute (i-21)	Aiming to cover 48 cities, with dense national coverage in major countries	All-new network based on Corning G.655 LEAF fiber and 144 fiber pairs per duct	May 2000	Up to 1,000 Tbps in theory; 144 fiber pairs	Seeking dark fiber sales initially; full range of bandwidth products and corporate services likely
Level 3	Initial network will cover 8 cities with long distance network, plus 5 MANs	All-new network with multiple ducts to ease upgrade to new fiber types	Sep 2000	n.a.	Will seek to sell ducts and dark fiber initially; bandwidth focus will be followed by shift to corporate service portfolio
KPNQwest	Six Euro-rings being built, with initial coverage of major cities in France, Germany, UK and Benelux; 40 cities will be covered at completion in 2001; 14 cities live in 1999	Largely new cabled networks with high fiber count and multiple ducts	Q2 1999	n.a.	Selling dark fiber and a full range of bandwidth products; strategic objectives include shift towards corporate value added services
MCI WorldCom	13 cities; denser national coverage planned in major countries. Owns MANs in some cities	Mix of mainly new cable and some dark fiber	Q3 1998	20 Gbps +	Built network primarily to meet own needs, but does sell all bandwidth products
MFN	Primarily focused on MANs, but will build regional networks in Germany and possibly other territories	All-new network based on very high fiber count (up to 840 fiber pairs)	1999	n.a.	Mainly selling dark fiber
Netsgroup	Nine cities in France, Benelux, Germany and UK already covered; a further four in Switzerland, Italy and Spain by year end	Early entrant building low-cost dark fiber network; pure carriers' carrier	Q1 1999	n.a.	n.a.

Figure 2. Western Europe's Fiber Frenzy (continued)

Organization	Coverage	Description of Infrastructure	Commercial Launch	Capacity	Strategy
Pangea	Ten cities in northern Europe	Mainly submarine cable, some terrestrial infrastructure	Q4 2000	Initial capacity 160 Gbps	Selling primarily IRUs and long leases, city to city, from STM1 upwards
Teleglobe	Initial ring connecting three cities in October 1999; further ring will connect Germany and France in December 1999; third ring to other cities in these countries plus Austria and Switzerland in 2000	Primarily dark fiber and fiber swaps; transoceanic cables planned	Q1 2000	n.a.	Full range of bandwidth products; Teleglobe reorganizing as a global carriers' carrier company
Telia	Scandinavian ring and European expansion now under construction. Network will initially cover nine cities, mainly in northern Europe	Network will comprise primarily of own laid cable, both submarine and terrestrial. Some dark fiber	2000	n.a.	Focusing on wholesale IP and IP services
Viatel	13 cities in first phase; 12 more second-tier German and French cities in second phase complete	Mainly new cable; German network a joint build with MFN	Q2 1999	160Gbps	Selling full range of bandwidth products; first to sell terrestrial IRUs

The European Union freed up the creation and sale of telecommunications infrastructure in 1996, creating a momentum that continues to build three years later, and making this region the most dynamic bandwidth market in the world.

Strategies vary widely, and the above table shows all companies who are either laying optical fiber cables, selling bandwidth products, or both.

Most entrants have focused initially on an area often called the 'Golden Triangle', which links London, Amsterdam, Brussels, Frankfurt and Paris. However, a widespread fear that this region is being over-built is leading most to seek expansion into other areas to the east and south. Many are also building dense in-country networks, reasoning that domestic telecommunications traffic will always exceed cross-border traffic.

Some like iaxis and Netsgroup have created networks based almost entirely on dark fiber leased largely from utilities, and then invested heavily in DWDM equipment. Others like Global Crossing, Interoute and Level 3 believe that laying their own cables will give them lower unit costs and lucrative additional revenues from leasing ducts or fibers.

As competition intensifies, most of the companies are seeking either to differentiate their product lines, broaden them, or both. Only a handful still say they are only interested in being wholesalers; retailing provides a second source of revenue, as well as a guaranteed 'wholesale' traffic stream. Most are also already involved in other regions, or plan to be. Some are building MANs, while others are looking at products such as telehousing, Web hosting and applications service provision.

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satellites were launched thirty or more years ago. Its most obvious impact is on capacity: transatlantic cables to be installed in 2001 will have a design capacity of 2.5 Tbps, a 30-fold increase over Atlantic Crossing-1, which went into service in 1998.

Temporarily, at least, the year on year improvement in the capacity of optical fibers is easily outpacing year on year improvements in computer memory, storage space or processing power. But this new abundance is also affecting many other aspects of the business, for example by making satellite bandwidth on some routes uneconomical. Most satellite system owners are doing well in bandwidth because of the overwhelming demand for capacity from ISPs. But that role will likely become restricted to regions that do not

benefit from the bandwidth boom. DWDM is also creating new product sets and business strategies.

New demands: the liberalization of telecommunications markets has led to a surging market for wholesale or carriers' carrier products; in the European region, the number of licensed international carriers has grown to almost 600 this year. Many do not own facilities, and most need bandwidth products of some kind, whether it be dark fiber, STM16 IRUs or annual STM1 leases. On top of that, demand generated by the continuing global boom in mobile communications and by the Internet and corporate data traffic are contributing to a much more rapid growth in the utilization of international bandwidth, and especially an increasing volatility in demand.

Figure 3. The Bandwidth Market Matrix

Element	Seller's Market	Buyer's Market
Length of contract	One, three, or five years	One to 25 years; shorter leases including bandwidth on demand are also in prospect
Discounting	Generally no more than 5 percent, mainly for length of contract	Steep discounts on volume and contract length; no published prices, so everything is negotiable
Regular Price Reviews in Longer Contracts	Did not exist	Becoming widely negotiated by major buyers, often linked to an industry index or some other independent measure
Forward Pricing	Did not exist	Beginning to be used by some suppliers (e.g. in a ten year contract, the average yearly price is based on the market price four years' hence)
Options on Future Bandwidth at an Agreed Price	Did not exist	Under consideration by some suppliers
Network-based Pricing, or Flexibility on End Points	Did not exist (only point to point pricing was available)	Becoming widely available. For example, some suppliers offer to price on the basis of the whole network, with no penalties for shifting bandwidth to different locations
Flexibility on Payment Terms	None (most contracts called for payment in advance yearly or quarterly)	Increasing; on longer ownership or IRU contracts, cash-starved buyers can often delay part of the payment

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Easy money: on the supply side, meanwhile, the huge interest in telecommunications generated by the Internet has seen investment houses chasing after opportunities to take a position in the international market. That's made it easy for new entrants to raise money, resulting in a major construction boom (nearly all the entrants are funded through venture capital, high yield bonds and IPOs).

Boom or Bust?

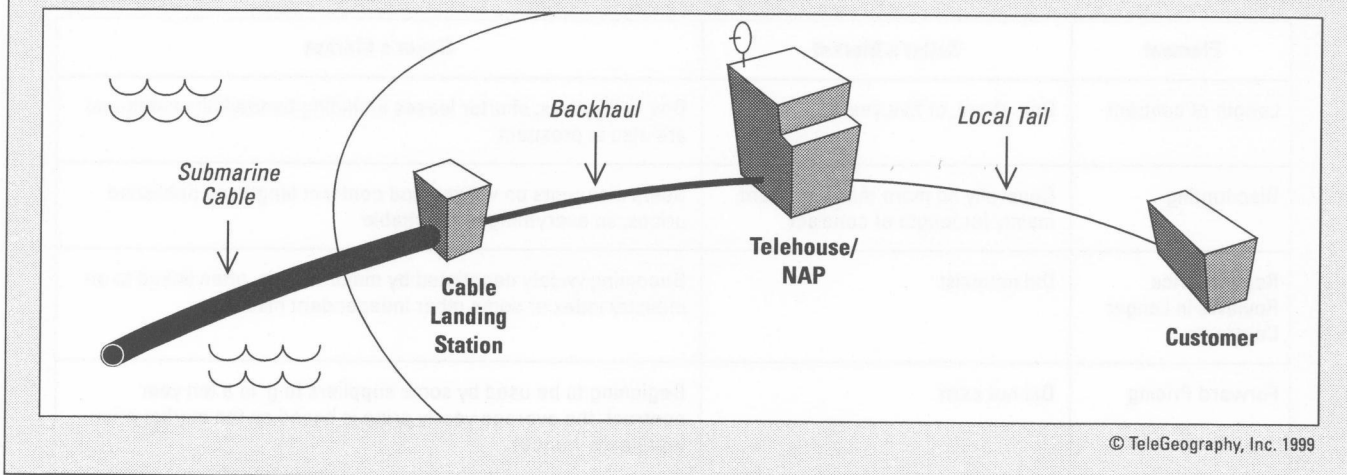
For buyers of bandwidth, all of this activity has created a bewildering landscape in which the wrong decision can fatally undermine carefully constructed business cases. In the past three years, for example, the new availability of bandwidth on long so-called 'capitalized' leases or on an Indefeasible Right of Use (IRU) basis has tempted some smaller players to take long-term positions in bandwidth that depend upon assumptions which have not stood the test of time. On the face of it, long leases are very attractive; often such leases have paid for themselves (when compared to conventional leases) in 2-3 years. And long leases appear as an asset on balance sheets, improving EBIT-DA—a crucial consideration for indebted new carriers.

The new Gemini and Atlantic Crossing-1 cables across the Atlantic made it possible for anyone to buy IRUs for the first time, and a handful of companies therefore took aggressive positions. Rather than buying to meet immediate demand, as

nearly all bandwidth purchasers had until then, they bought speculatively against an unproven end user demand that was still years away. Consequently when prices fell far faster than almost anyone anticipated, their cost base looked unsustainable. An STM1 IRU selling for \$7-8 million in 1998 sells a year later for around \$2-3 million, driving down the price of conventional leased circuits—a calamitous outcome for those who bought a lot of IRU capacity at the higher price, because these companies end up saddled with nominal costs higher than those who are leasing conventionally—often a direct competitor.

That's not the only dilemma for purchasers: creative pricing and contracting for bandwidth products is becoming widespread wherever competition has flourished. Figure 3 lists some of the options now becoming available; buyers must learn to analyze not only the deals they are actually offered, but the deals that might be on offer if they ask the right questions.

Ideally (from a buyer's viewpoint), this new volatility would have created a genuine commodity market in bandwidth, since bandwidth is after all one of the most undifferentiated products in telecommunications. In reality, though, market commoditization is taking longer than people expected, and may only impact a small part of the market in the next few years. Many of the key requirements—regulated, large-scale exchanges; for-

Figure 4. Simplified View of an International Circuit

mal, standardized contracts; international quality measures; and sufficient liquidity—are still missing. For the time being, buyers of bandwidth will be on their own, and must deal with a new set of circumstances in which the risk of making a serious error is as tangible as the advantage offered by the new opportunities of a buyers' market.

The Downside of the Upside

The new bandwidth markets have thrown up a set of new challenges, some of which are only just being resolved by suppliers and regulators.

We're on the beach—now what? In the monopoly era, cable stations at which submarine cables came ashore were operated by the national incumbent telco in the country, and backhaul—the line from the station to the nearest metropolis—wasn't really an issue. Now it is, but regulators in some cases are struggling to catch up. The so-called "club" cables in some cases have almost 100 owners, all of whom need backhaul and space at the cable station. That has provided a new opportunity for incumbents, and few are resisting it; in some cases, annual backhaul costs are higher than the cost of the transoceanic circuit.

Where shall we put that switch? In a competitive telecommunications market, a semi-formalized system is required to exchange traffic and connect networks at an agreed-upon location, and telehouses, a.k.a. carrier hotels or co-location facilities, have come into existence to meet the need. However, the extraordinary growth in new carriers has created enormous pressure on existing facilities and led to a big increase in space in cities like London and (prospectively) Amsterdam, Frankfurt and Paris. In more peripheral and second-tier cities, new carriers may be forced to create their own space and lease very expensive local access lines to connect to other carriers in the city. Or they may have to turn to their bandwidth provider, which is likely to have tied up some telehousing space for its own use in the city. Outside the biggest business metropolises,

telehousing will continue to present a problem for bandwidth purchasers for a while yet.

Forecasting Demand: Outlook Foggy

When telephony dominated telecommunications, traffic forecasting was relatively straightforward. Historical data provided a fairly reliable guide to future demand, and the sources and sinks of traffic were predictably linked to populations, wealth and commercial activity. Not so in an IP era. There are at least three new variables, which, taken together, make forecasting next year's international telecommunications demand almost as error-prone as forecasting next week's weather.

What will we be carrying? Before the Internet and the Web, networks were designed for specific applications. But the Internet is a huge, unpredictable, global machine for generating new applications, and few of those applications have a determinate bandwidth.

Where will we be carrying it? Telephone traffic is closely correlated to populations and geography, since it usually connects two people using permanently located telephones on a point to point link. Twenty-first century traffic is different: often people have no idea where they are connected to, and it's relatively easy to shift those connections—Web sites, say—to other places. That's just one uncertainty among many: for example, new carriers are often not clear about which cities they want to connect next; mobile users are not in a fixed place; Internet traffic may soon include a significant proportion of multicasting; and caching and other bandwidth-saving technologies may unexpectedly reduce demand.

What about the access network? Third, international demand depends on what end users pump into the network. That in turn depends on whether their networks are upgraded to 'higher' speeds, and that's moot today. While xDSL and cable modems are now relatively mature technologies, predicting when they'll be used depends on a close understanding of local regulation,

the attitudes of incumbents and cable TV companies, and commercial decisions by providers. That's only one local variable: forecasters must also factor in the potential of new appliances to generate demand (wireless devices, info-appliances), growing device to device (non-human) conversations, and unexpected commercial decisions (e.g., the sudden emergence of "free" Internet services in Europe).

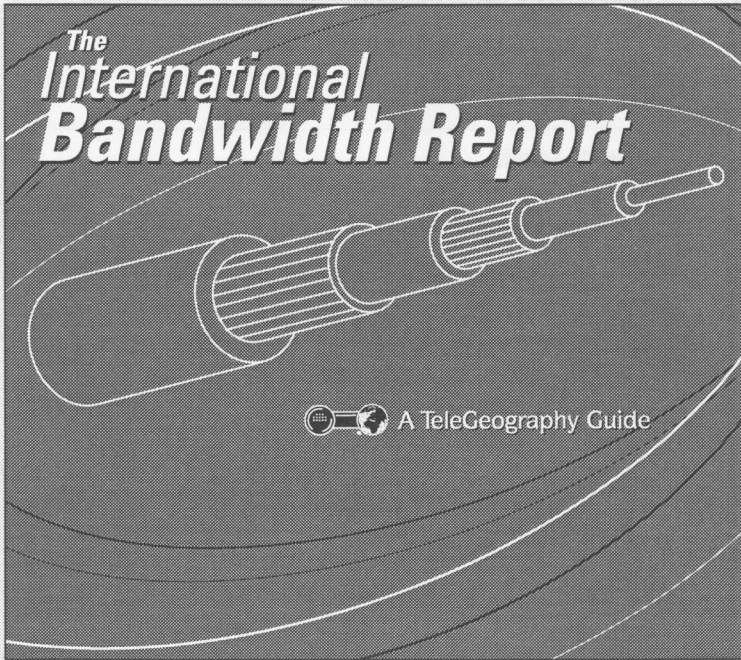
Why does this forecasting uncertainty matter? Because demand, in part, determines price, and buyers must have an opinion about likely price trends in order to make an informed deal with suppliers.

How real is that asset? Many new carriers have opted to buy bandwidth on long leases or IRUs, partly to reduce nominal annualized cost of ownership, but also because, under most accounting conventions, leases of ten years or longer generally qualify as assets on a balance sheet instead of liabilities. Where bandwidth is a major input, as it often is for new carriers, that can substantially improve EBITDA—almost irresistible for highly indebted new carriers, especially if an IPO is in the offing. But

the fashion for long leases raises several difficulties. One noted by several cynical observers is that the exact same bandwidth may appear as an asset on the balance sheets of two or even three companies as it is sold down the line—an accounting sleight of hand that may not survive a detailed audit. Moreover, leases and IRUs may be written off over periods which look more and more unrealistic. While IRUs are nominally sold over a 25 year period, few in the industry believe that a specific asset has a commercial life longer than 5-7 years. What happens when convention meets reality? Will long leases drop out of favor?

Conclusion

For bandwidth buyers, opportunities and options are multiplying. What to do? In a forthcoming report, TeleGeography will examine all the new options, region by region, and attempt to guide the unwary through the increasingly tangled web of cables. *The International Bandwidth Report* will be published early in 2000. Please check our Web site for details. 🌐



The International Bandwidth Report

A TeleGeography Guide

The International Bandwidth Report

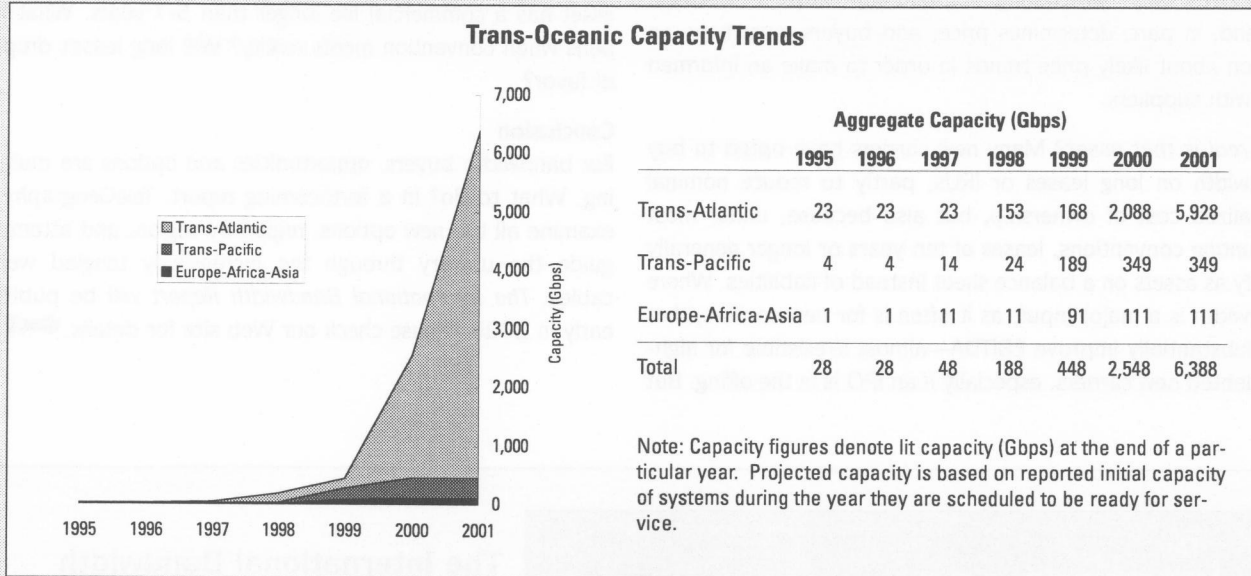
Scheduled for release in early 2000, TeleGeography's *International Bandwidth Report* will provide expert insight into the increasingly complex bandwidth market:

- clarifies supply and demand bandwidth issues;
- explains the bandwidth market and what drives it;
- describes how to be a wise bandwidth buyer;
- includes a directory of suppliers operating in the top business cities; and
- provides sample contracts.

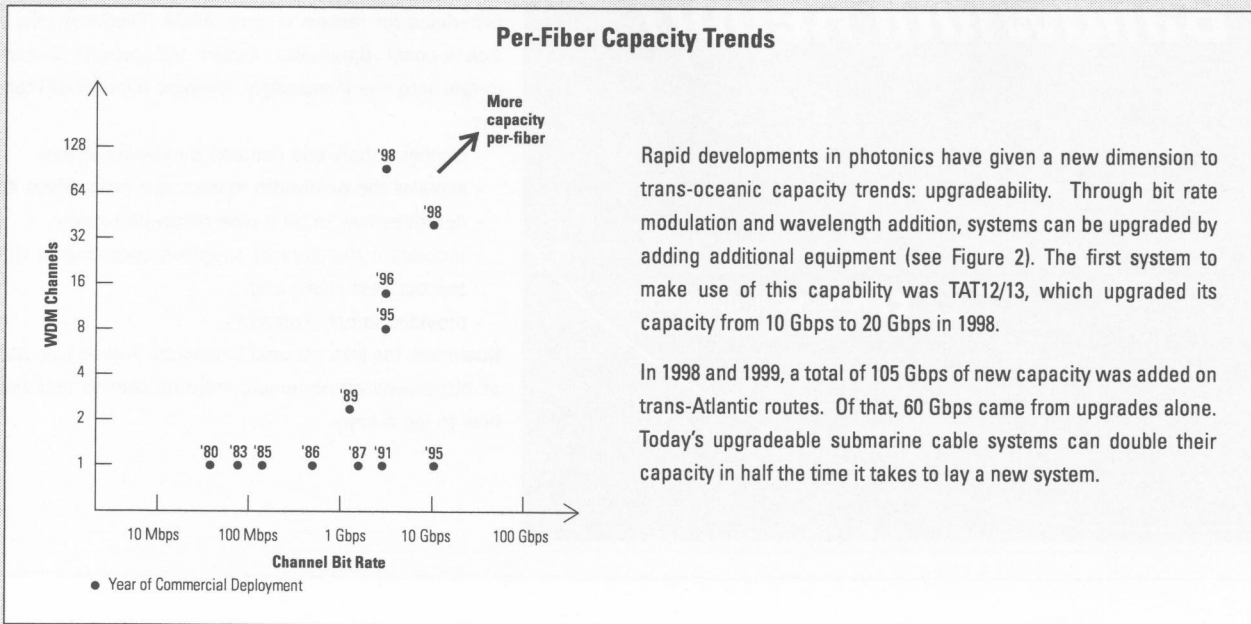
Bookmark the International Bandwidth Report web site at <http://www.internationalbandwidth.com> to find out how to get a copy.

Submarine Cable Systems

Figure 1. Behind The Bandwidth Explosion



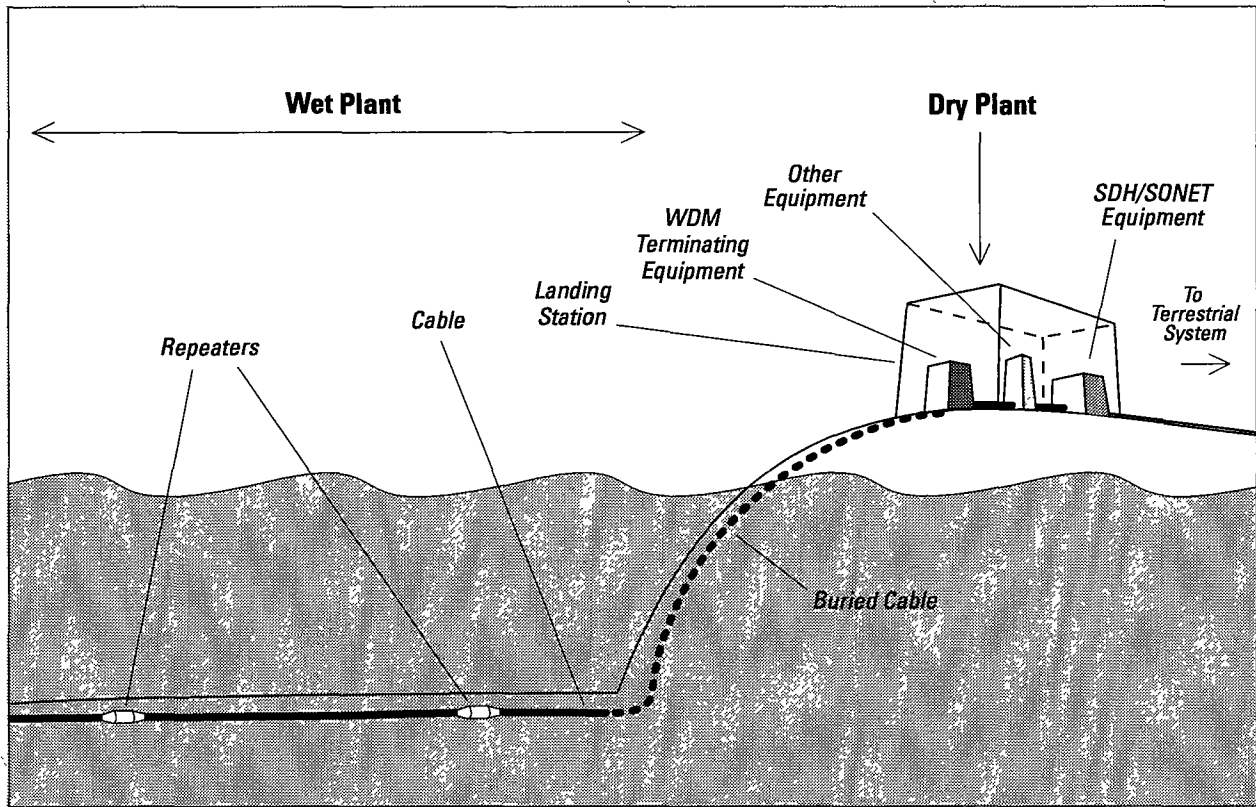
Source: TeleGeography, Inc.



Source: Adapted from Bell Labs *Technology: Trends & Developments*, Fall 1998, Vol. 2, No. 2, p. 3.

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Figure 2. Components of a Submarine Cable System



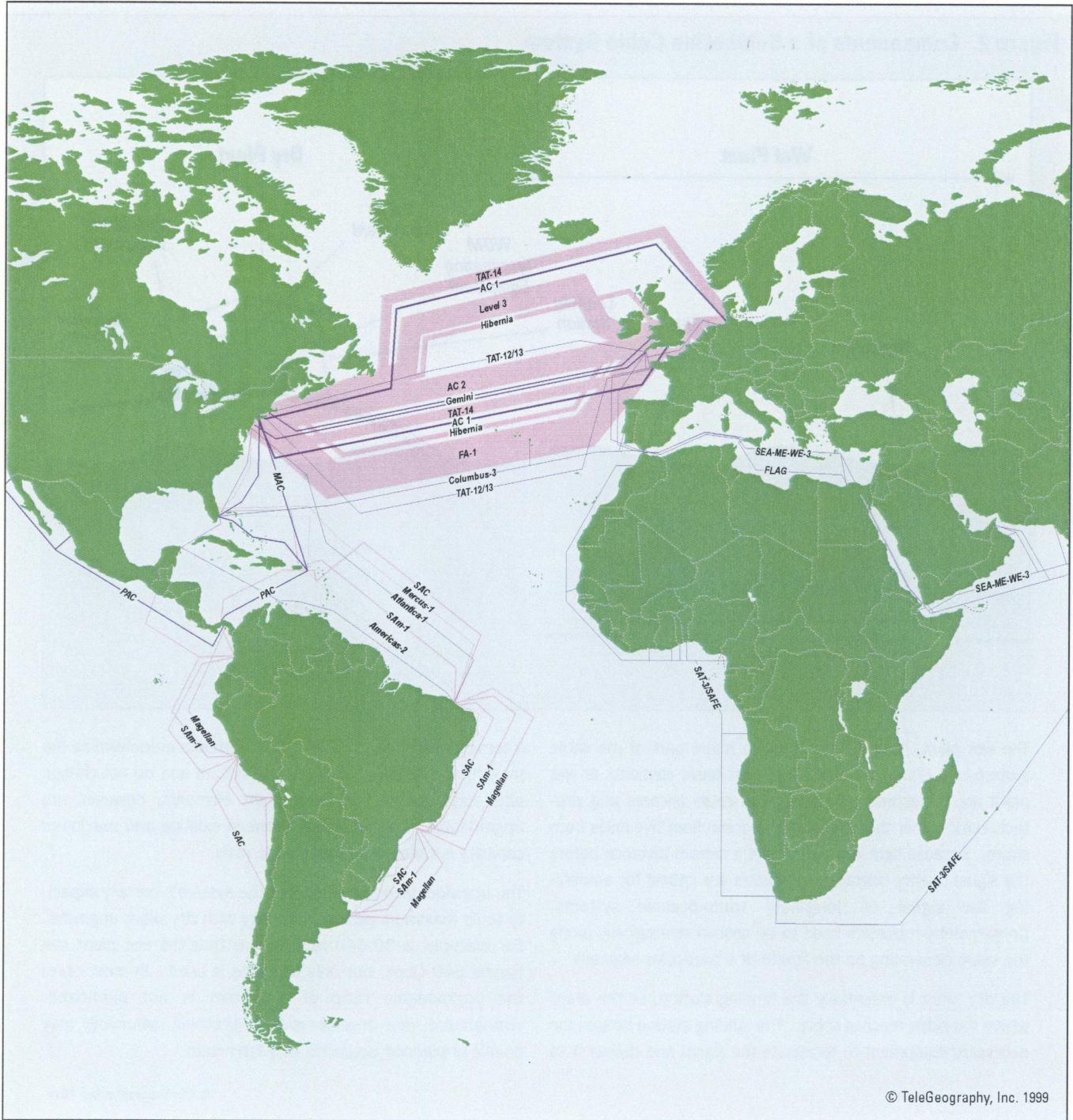
The wet plant, as the name implies, is the part of the cable system that is under water. The most basic elements of wet plant are cables and repeaters. The cable encases and protects optical fiber that is laid on the ocean floor five miles from shore. Because light can only travel a certain distance before the signal quality degrades, repeaters are critical for amplifying the signal on long-haul trans-oceanic systems. Consequently repeaters need to be spaced strategically along the cable depending on the length of a particular segment.

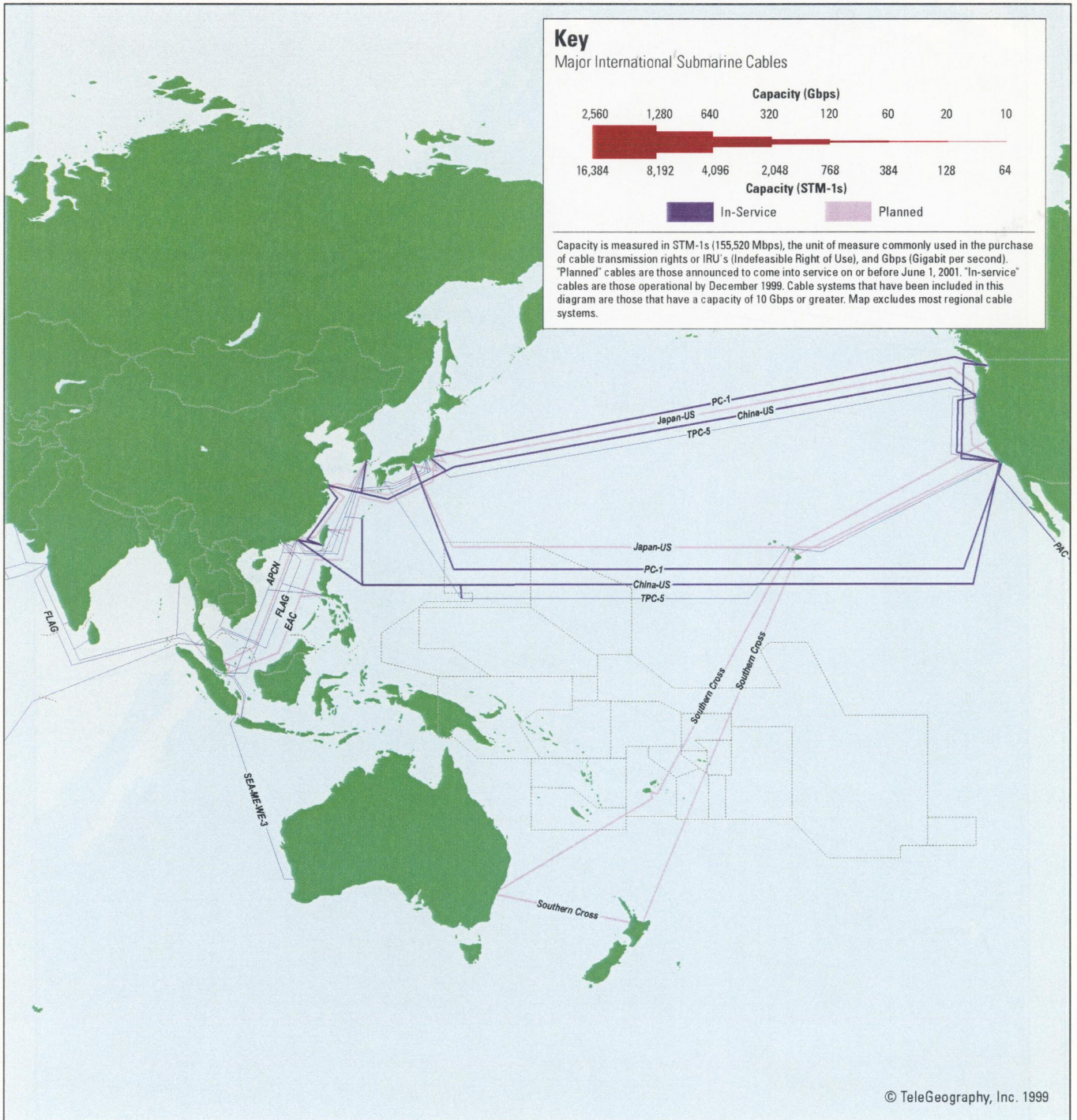
The dry plant is essentially the landing station, or the place where the cable reaches shore. The landing station houses the necessary equipment to terminate the signal and deliver it to

a terrestrial system. The wet plant elements predetermine the maximum possible capacity of the system and do not change after deployment. The dry plant elements, however, are upgradeable. The difference between existing and maximum capacity is called the upgradeable ratio.

The upgradeable ratio compares the system's current capacity to its maximum possible capacity with dry plant upgrades. For example, a 80:640 ratio means that the wet plant can handle 640 Gbps, but only 80 Gbps is used. In most cases the upgradeable ratio of a system is not publicized. Furthermore, new developments in photonic technology may enable unplanned upgrades at a later date.

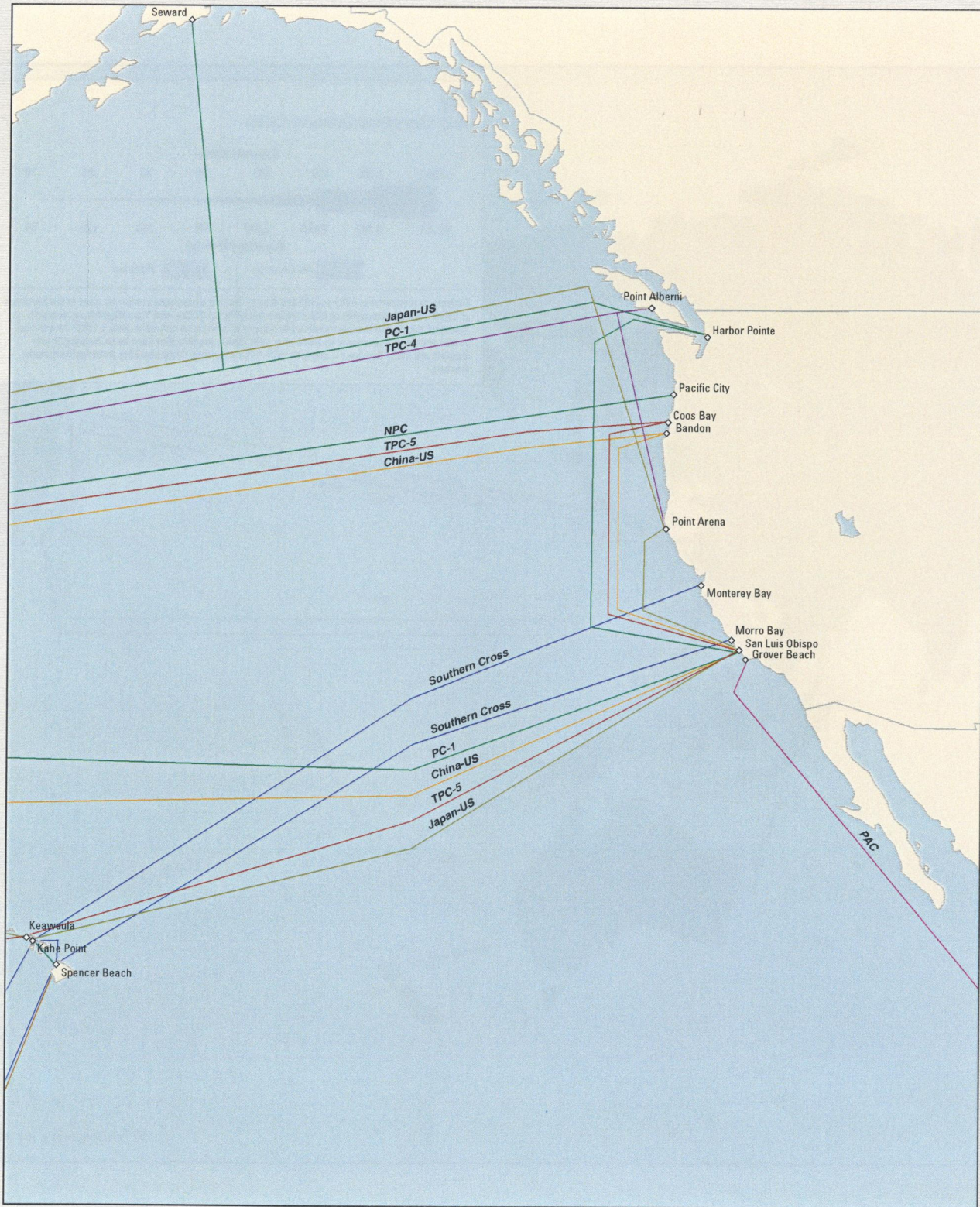
Figure 3. Map of Major Trans-oceanic Submarine Cables





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Figure 4. Map of Major Submarine Cables in the United States (Pacific Coast)

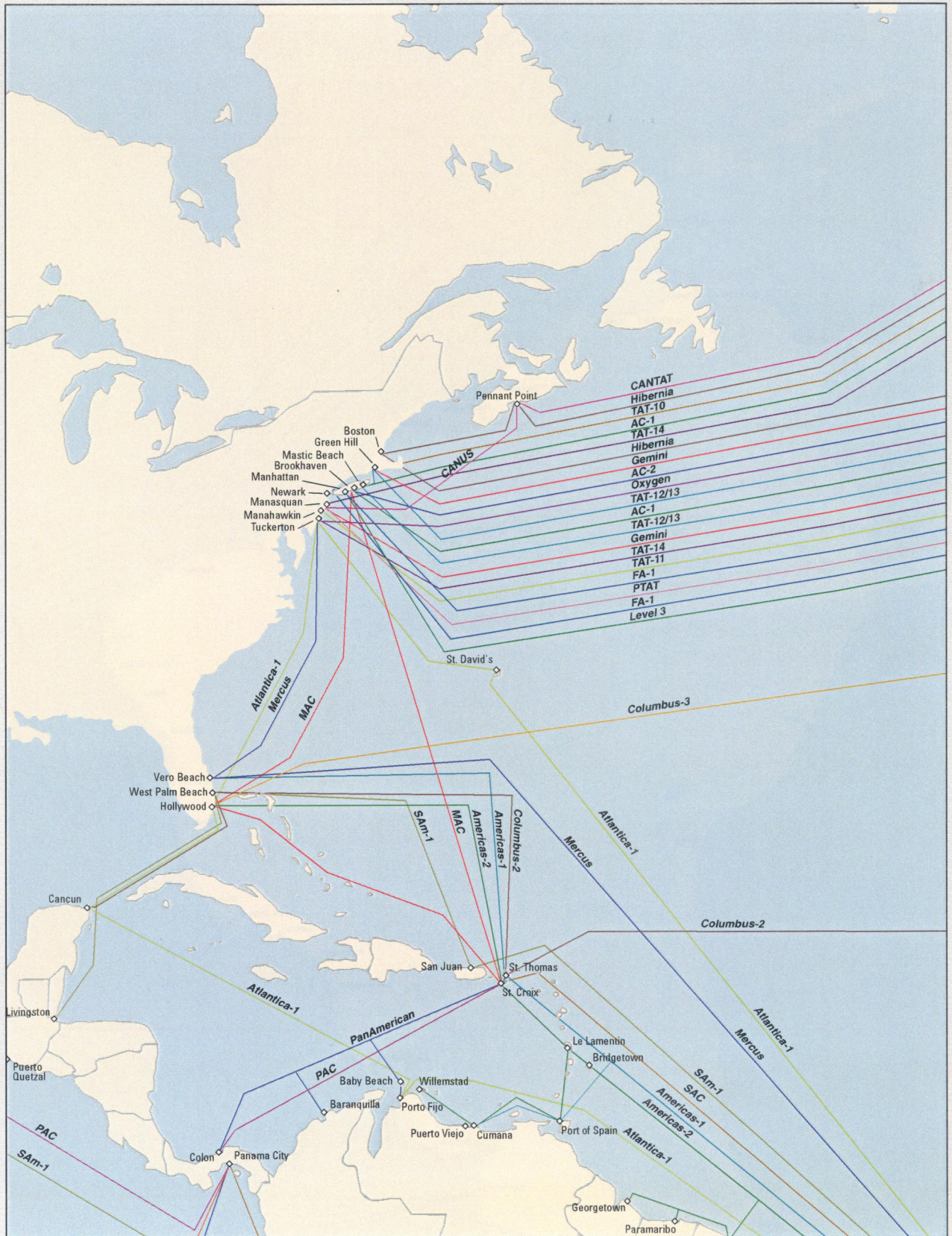


Note: The submarine cable maps on the following pages included cables that are currently operational by December 1999 or will be in service on June 1, 2001. Unlike the map on Figure 3, the cut off for inclusion on these regional maps are those cables that have a capacity of more than 1 Gbps. Most regional cables have been excluded from these maps.

Source: TeleGeography, Inc.

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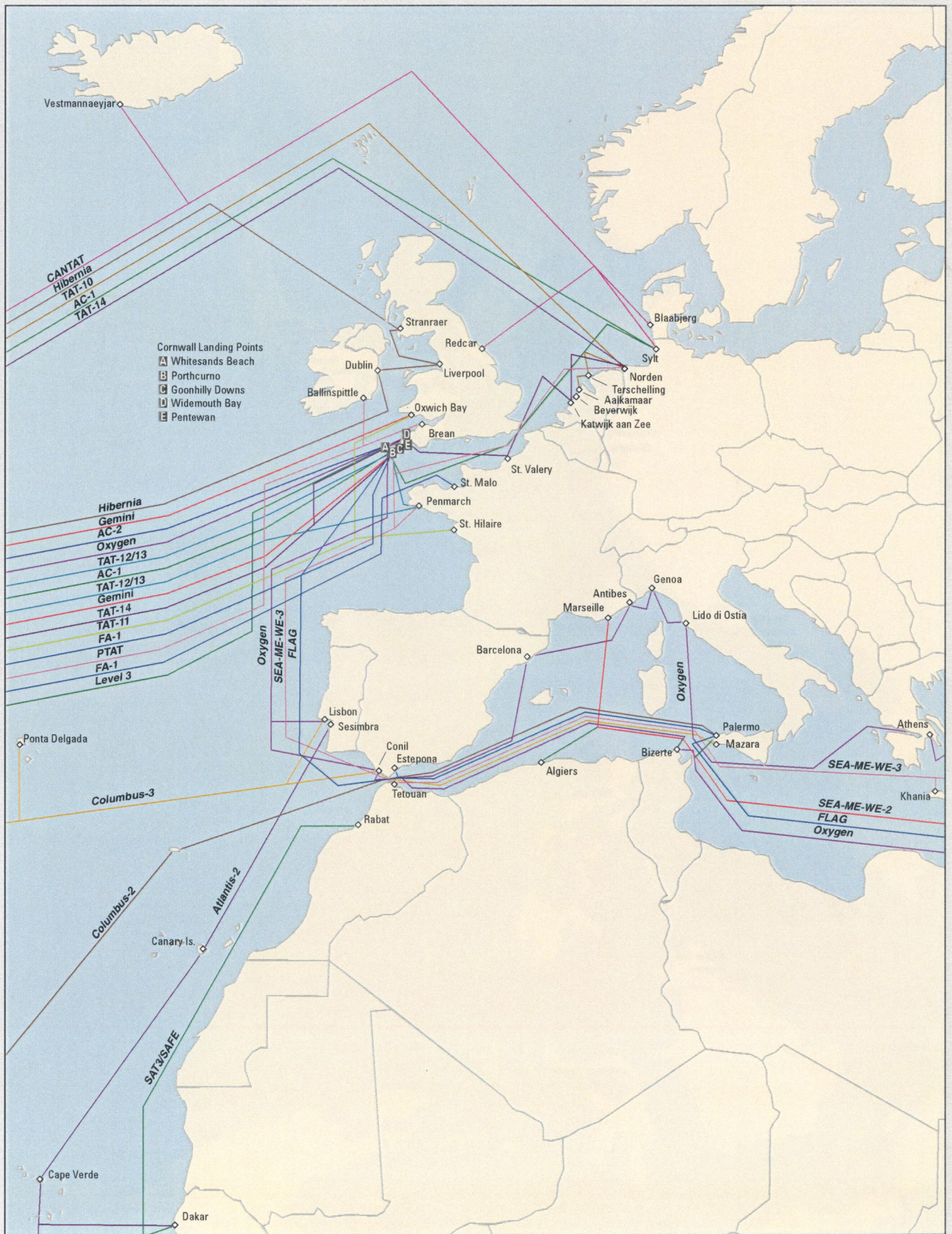
Figure 5. Map of Major Submarine Cables in the United States (Atlantic Coast) & Caribbean



Note: Please refer to the note on Figure 4 for an explanation of this map.

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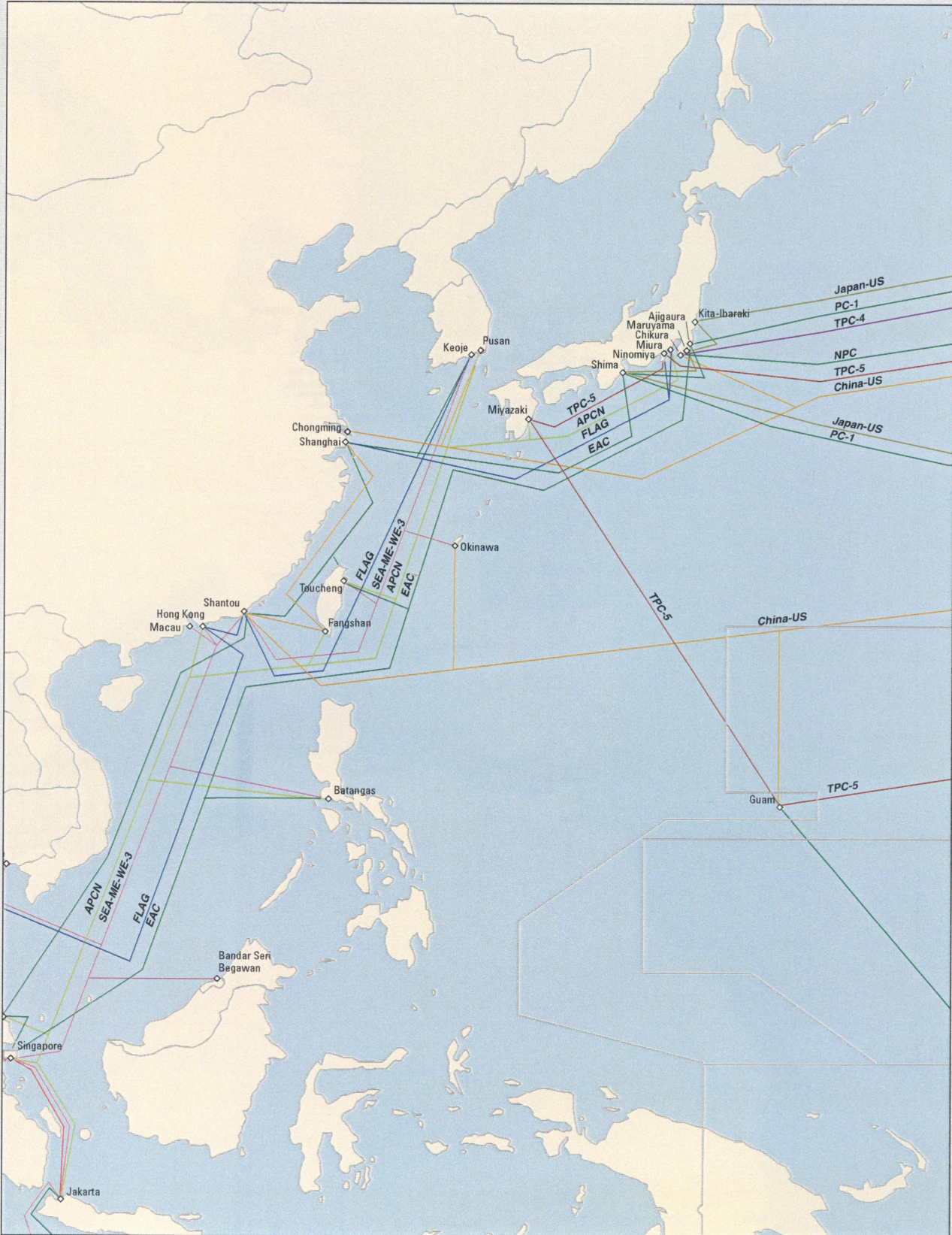
Figure 7. Map of Major Submarine Cables in Europe



Note: Please refer to the note on Figure 4 for an explanation of this map.

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Figure 8. Map of Major Submarine Cables in East Asia



Note: Please refer to the note on Figure 4 for an explanation of this map.

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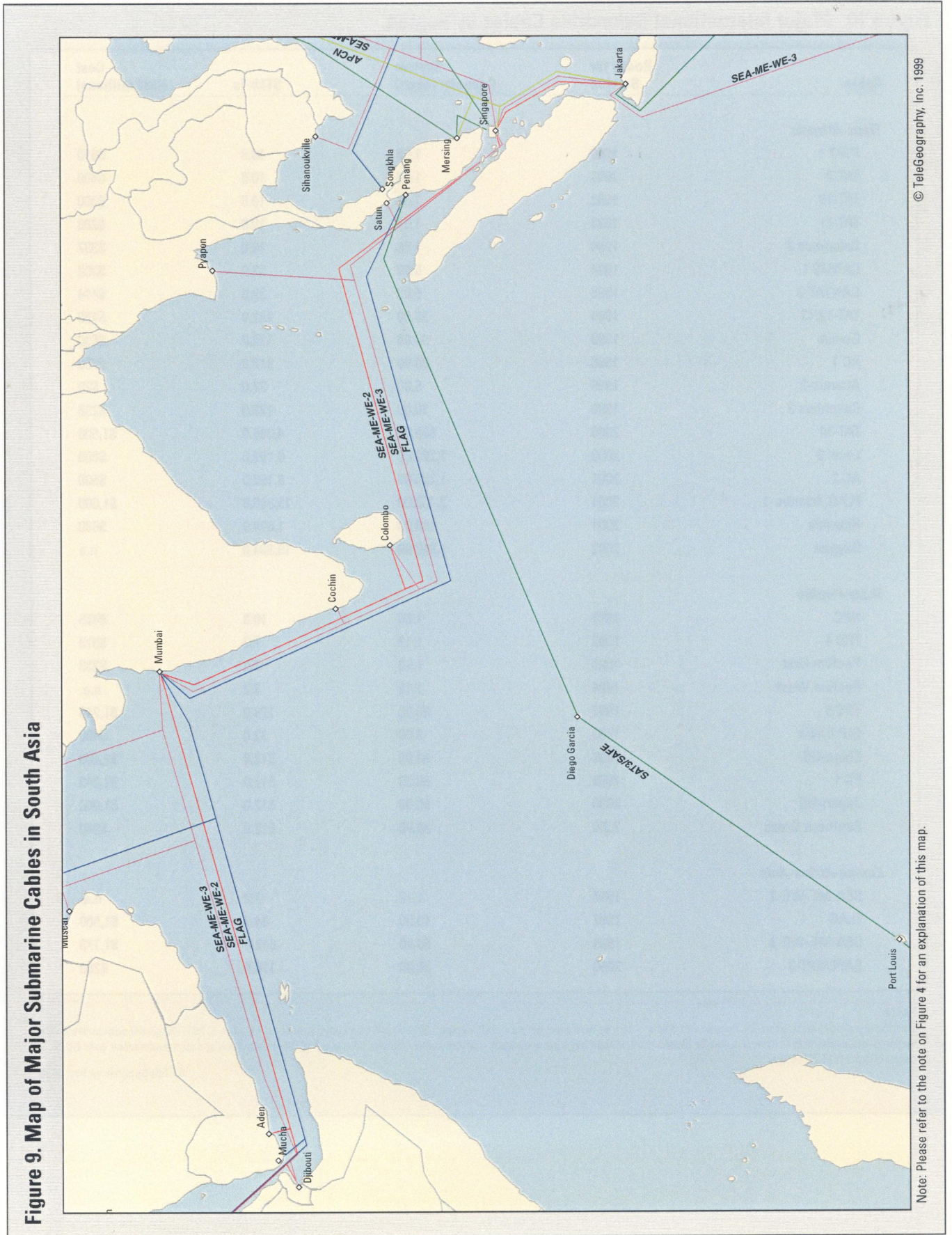


Figure 9. Map of Major Submarine Cables in South Asia

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Note: Please refer to the note on Figure 4 for an explanation of this map.

Figure 10. Major International Submarine Cables by Region

Cable	Ready for Service	System Capacity (Gbps)	STM-1s	Cost (US\$ millions)
Trans-Atlantic				
PTAT 1	1989	1.68	10.8	\$510
TAT-9	1991	1.68	10.8	\$406
TAT-10	1992	1.68	10.8	\$300
TAT-11	1993	1.68	10.8	\$280
Columbus 2	1994	1.68	10.8	\$337
CANUS 1	1994	5.00	32.0	\$302
CANTAT 3	1995	5.00	32.0	\$414
TAT-12/13	1995	30.00	192.0	\$750
Gemini	1998	30.00	192.0	\$600
AC 1	1998	80.00	512.0	\$750
Atlantis-2	1999	5.00	32.0	\$20
Columbus 3	1999	10.00	128.0	\$236
TAT-14	2000	640.00	4,096.0	\$1,500
Level 3	2000	1,280.00	8,192.0	\$800
AC 2	2001	1,280.00	8,192.0	\$500
FLAG Atlantic-1	2001	2,400.00	15,360.0	\$1,000
Hibernia	2001	160.00	1,024.0	\$630
Oxygen	2002	2,560.00	16,384.0	n.a.
Trans-Pacific				
NPC	1991	1.68	10.8	\$425
TPC 4	1992	1.12	7.2	\$373
PacRim East	1993	1.12	7.2	\$233
PacRim West	1994	1.12	7.2	n.a.
TPC 5	1997	20.00	128.0	\$1,240
G-P Cable	1999	5.00	32.0	\$100
China-US	1999	80.00	512.0	\$1,400
PC 1	1999	80.00	512.0	\$1,240
Japan-US	2000	80.00	512.0	\$1,000
Southern Cross	2000	80.00	512.0	\$940
Europe-Africa-Asia				
SEA-ME-WE-2	1994	1.12	7.2	n.a.
FLAG	1997	10.00	64.0	\$1,500
SEA-ME-WE-3	1999	80.00	512.0	\$1,173
SAFE/SAT-3	2000	20.00	128.0	\$280

Notes:

This table includes submarine cable systems that are currently in operation as of December 1999 or will be ready for service by June 1, 2001. Regional submarine cable systems and systems that have a capacity of less than 1 Gbps have been omitted. Synchronous Transfer Module-1 (STM-1) is a standard for transmission over OC-3 optical fiber at 155.52 Mbps.

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Figure 10. Major International Submarine Cables by Region (continued)

Cable	Ready for Service	System Capacity (Gbps)	STM-1s	Cost (US\$ millions)
<i>Pan-American/Caribbean</i>				
Americas-1*	1994	5.00	32.0	n.a.
MAC	1999	40.00	256.0	\$415
PanAm	1999	10.00	64.0	\$214
Americas-2	2000	80.00	512.0	\$375
ARCOS-1	2000	60.00	384.0	\$400
Atlantica-1	2000	20.00	128.0	\$1,000
Mercus-1	2000	80.00	512.0	\$900
PAC	2000	40.00	256.0	\$280
Sam-1	2001	40.00	256.0	\$900
Magellan	2001	80.00	512.0	\$500
<i>Pan-Asian</i>				
Tasman 2	1991	1.12	7.2	\$110
APC	1993	1.68	10.8	\$332
APCN	1996	10.00	64.0	\$550
Tasman 3	1999	40.00	256.0	n.a.
East Asia Crossing	2001	80.00	512.0	\$1,280

Notes:

This table includes submarine cable systems that are currently in operation as of December 1999 or will be ready for service by June 1, 2001. Regional submarine cable systems and systems that have a capacity of less than 1 Gbps have been omitted. Synchronous Transfer Module-1 (STM-1) is a standard for transmission over OC-3 optical fiber at 155.52 Mbps.

* The southern segment has a capacity of 1.68 Gbps.

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International Circuit Usage by U.S. Carriers

Figure 1. International Circuit Usage by Region, 1996-1998

		U.S. Carrier 64 Kbps Circuit Usage				
		For Private Lines	For Public Switched Network	Total Circuits In Use	Idle Circuits	Total Available
N. and C. America	1996	34,104	71,011	105,115	3,390	108,505
	1997	64,230	88,989	153,219	34,504	187,723
	1998	78,601	94,952	173,553	126,197	299,750
South America	1996	3,194	6,412	9,606	4,531	14,137
	1997	5,928	6,900	12,828	3,986	16,814
	1998	7,958	7,716	15,674	5,536	21,210
Caribbean	1996	872	5,378	6,250	1,511	7,761
	1997	1,034	6,478	7,512	4,006	11,518
	1998	1,439	7,026	8,465	4,494	12,959
W. Europe	1996	33,083	29,536	62,619	33,053	95,672
	1997	43,784	34,476	78,260	46,245	124,505
	1998	69,051	34,133	103,184	52,937	156,121
E. Europe	1996	478	3,344	3,822	1,704	5,526
	1997	1,326	3,742	5,068	1,719	6,787
	1998	1,004	4,418	5,422	1,231	6,653
Middle East	1996	908	2,836	3,744	560	4,304
	1997	1,432	3,096	4,528	479	5,007
	1998	1,920	2,807	4,727	844	5,571
Africa	1996	406	2,416	2,822	327	3,149
	1997	699	2,608	3,307	292	3,599
	1998	1,080	2,712	3,792	320	4,112
Asia	1996	15,015	16,475	31,490	27,163	58,653
	1997	23,545	19,567	43,112	30,830	73,942
	1998	30,563	19,262	49,825	45,915	95,740
Oceania	1996	3,302	3,110	6,412	2,523	8,935
	1997	5,430	4,861	10,291	1,690	11,981
	1998	6,753	4,023	10,776	6,095	16,871
Total	1996	91,362	140,518	231,880	74,762	306,642
	1997	147,408	170,717	318,125	123,751	441,876
	1998	198,369	177,049	375,418	241,052	616,470

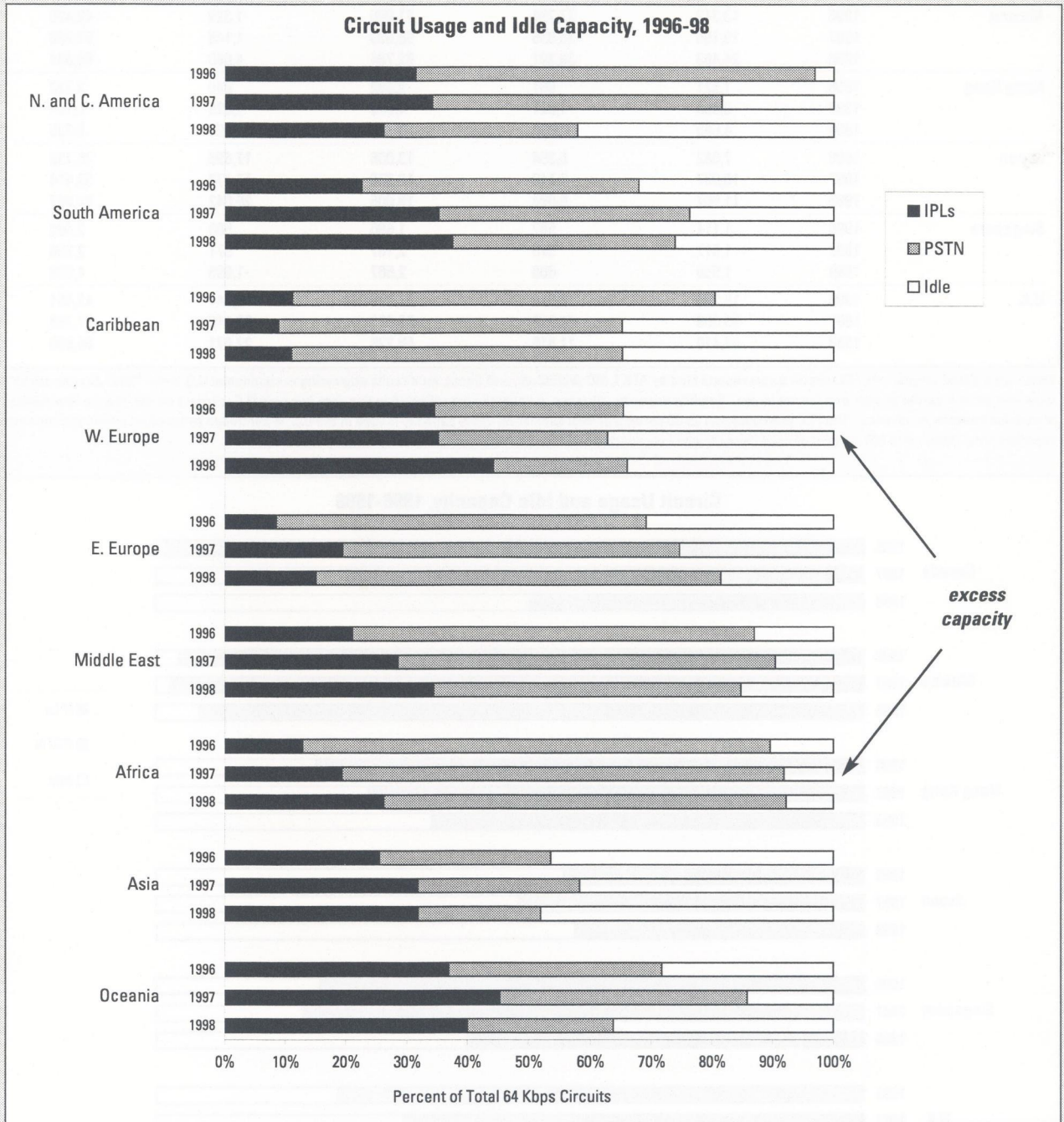
Note: Data based on year-end FCC circuit status reports filed by AT&T, MCI WorldCom, and Sprint for circuits originating in continental U.S. only. "Idle" circuits are circuits owned by a carrier at year end but not in use. Satellite capacity utilization is generally not reflected in this data because U.S. carriers do not acquire international satellite capacity in advance. The FCC estimates that 25-30 percent of total submarine cable capacity landed in the U.S. is controlled by foreign carriers and thus not reported here. Also, up to 100 percent of used capacity goes unreported because it is reserved for restoration purposes only.

There is a discrepancy with figures reported last year in *TeleGeography 1999*. One carrier had over reported the number of active private lines in Canada. The FCC has subsequently made an adjustment to these figures. The correction shifted the classification of 31,000 circuits from activated to idle.

Source: FCC

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Figure 2. Idle Circuits of U.S. Carriers by Region, 1996-1998



Note: Data based on year-end FCC circuit status reports filed by AT&T, MCI WorldCom, and Sprint for circuits originating in continental U.S. only. "Idle" circuits are circuits owned by a carrier at year end but not in use. Satellite capacity utilization is generally not reflected in this data because U.S. carriers do not acquire international satellite capacity in advance. The FCC estimates that 25-30 percent of total submarine cable capacity landed in the U.S. is controlled by foreign carriers and thus not reported here. Also, up to 100 percent of used capacity goes unreported because it is reserved for restoration purposes only.

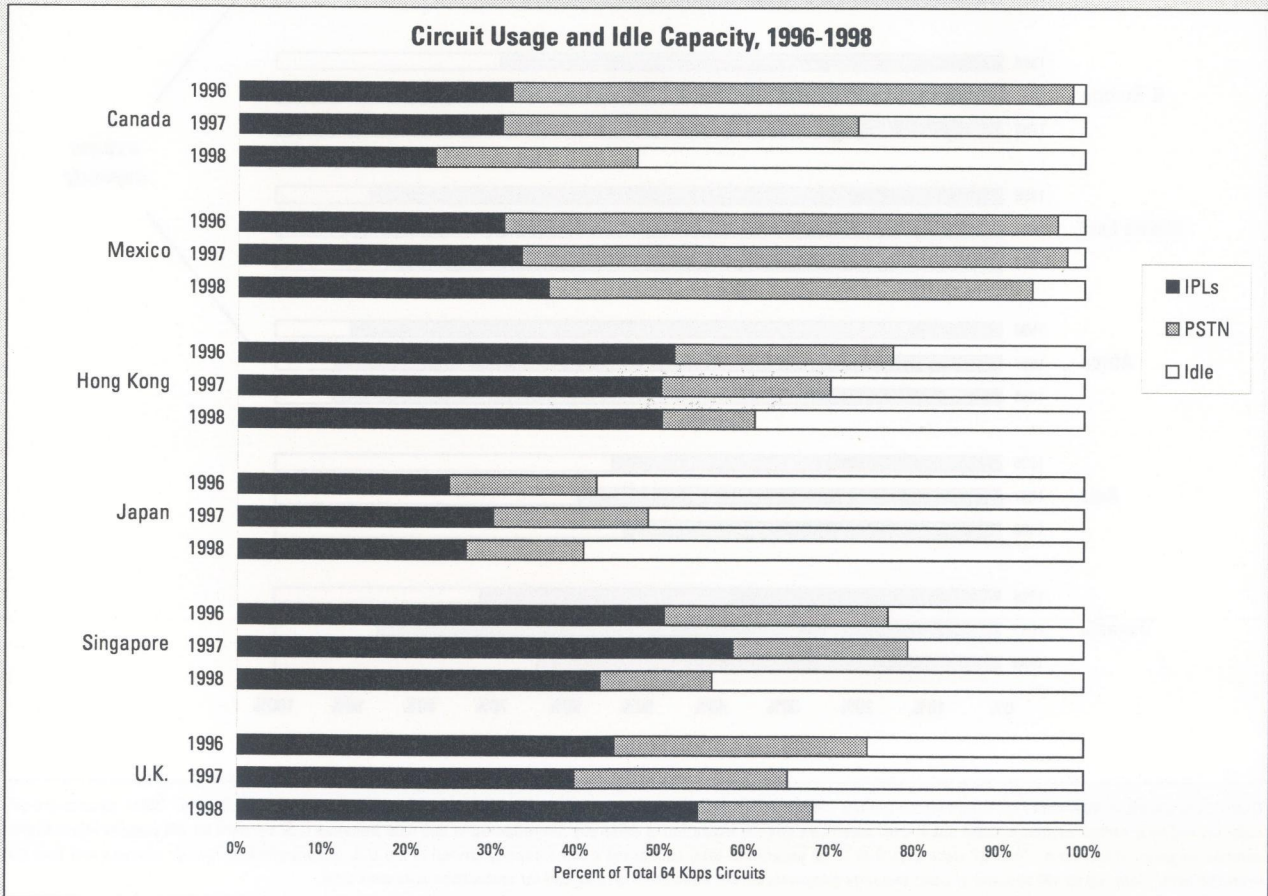
Source: FCC

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Figure 3. International Circuit Usage for Selected Routes, 1996-98

		U.S. Carrier 64 Kbps Circuit Usage				
		For Private Lines	For Public Switched Network	Total Circuits In Use	Idle Circuits	Total Available
Canada	1996	20,410	41,793	62,203	917	63,120
	1997	37,383	50,343	87,726	32,178	119,904
	1998	53,302	54,719	108,021	120,961	228,982
Mexico	1996	13,312	27,784	41,096	1,329	42,425
	1997	19,155	36,935	56,090	1,148	57,238
	1998	24,463	38,301	62,764	4,080	66,844
Hong Kong	1996	1,921	961	2,882	840	3,722
	1997	3,058	1,221	4,279	1,825	6,104
	1998	4,685	1,027	5,712	3,623	9,335
Japan	1996	7,682	5,354	13,036	17,696	30,732
	1997	10,087	6,149	16,236	17,178	33,414
	1998	11,907	6,098	18,005	26,042	44,047
Singapore	1996	1,114	582	1,696	508	2,204
	1997	1,617	570	2,187	571	2,758
	1998	1,959	608	2,567	1,999	4,566
U.K.	1996	18,959	12,648	31,607	10,844	42,451
	1997	23,008	14,662	37,670	20,118	57,788
	1998	47,410	11,818	59,228	27,671	86,899

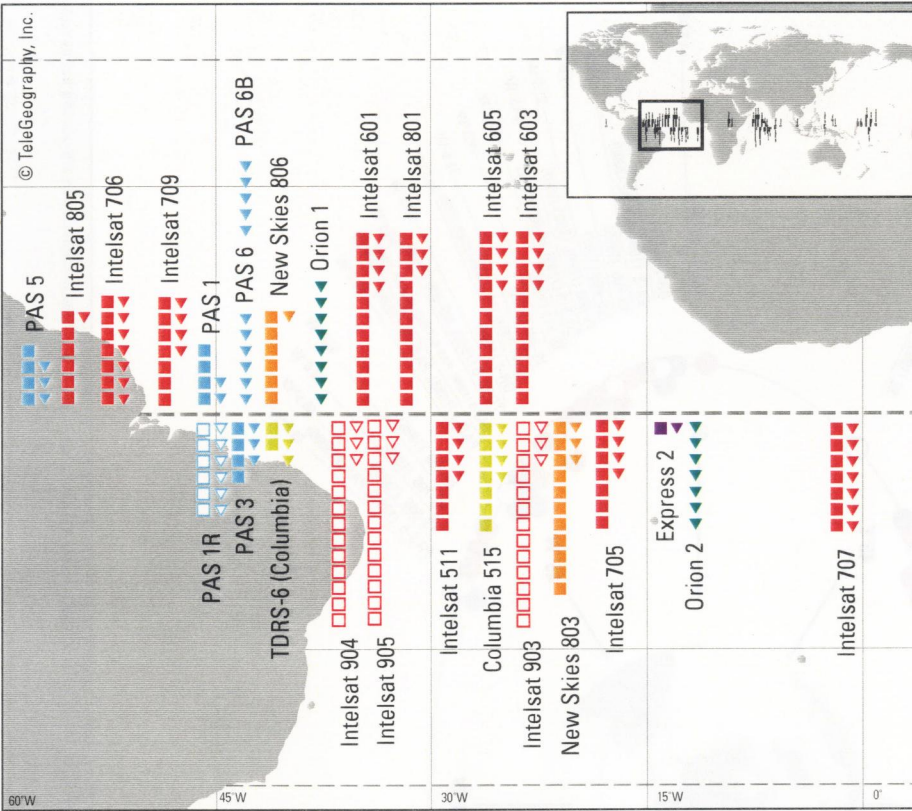
Note: Data based on year-end FCC circuit status reports filed by AT&T, MC WorldCom, and Sprint, for circuits originating in continental U.S. only. "Idle" circuits are circuits owned by a carrier at year end but not in use. Satellite capacity utilization is generally not reflected in this data because U.S. carriers do not acquire international satellite capacity in advance. The FCC estimates that 25-30 percent of total submarine cable capacity landed in the U.S. is controlled by foreign carriers and thus not reported here. Also, up to 100 percent of used capacity goes unreported because it is reserved for restoration purposes only.



Source: FCC

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International Communications Satellites



Key

- Six 36-MHz transponder equivalents for the C-band (4/6 GHz)
- ▼ Six 36-MHz transponder equivalents for the Ku-band (11-12/14 GHz)
- ▽ Outline denotes satellites under construction as of August 1998

The maps on this page show 46 of the approximately 180 commercial geostationary satellites scheduled to begin operation by January 2001. These satellites use C- and Ku-band transponders to carry voice, data, and video. On some satellites (such as Panamsat's), a majority of capacity is used for video transmission services. A 36 MHz C-band transponder can generally carry about 2,000 calls, but requires a large dish for TV reception. Smaller Ku-band dishes are increasingly the technology of choice for direct broadcast satellite reception. Intersputnik satellites carry only one (Gorizont) or two (Express) Ku-band transponders at 36 MHz, therefore the actual Ku-band capacity for these satellites is somewhat less than suggested on the maps.

Source: TeleGeography, Inc., *International Satellite Directory 1999*, company reports

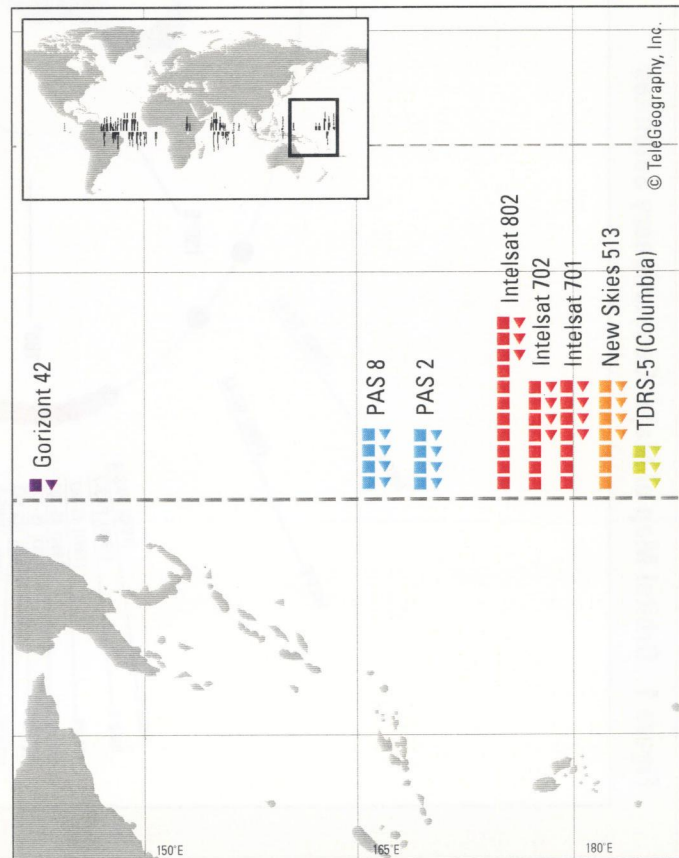
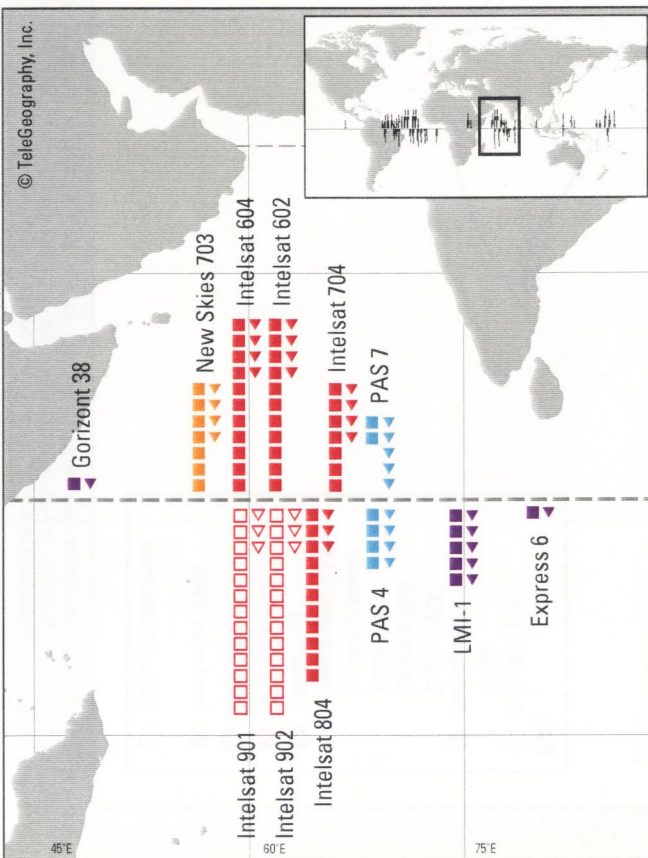
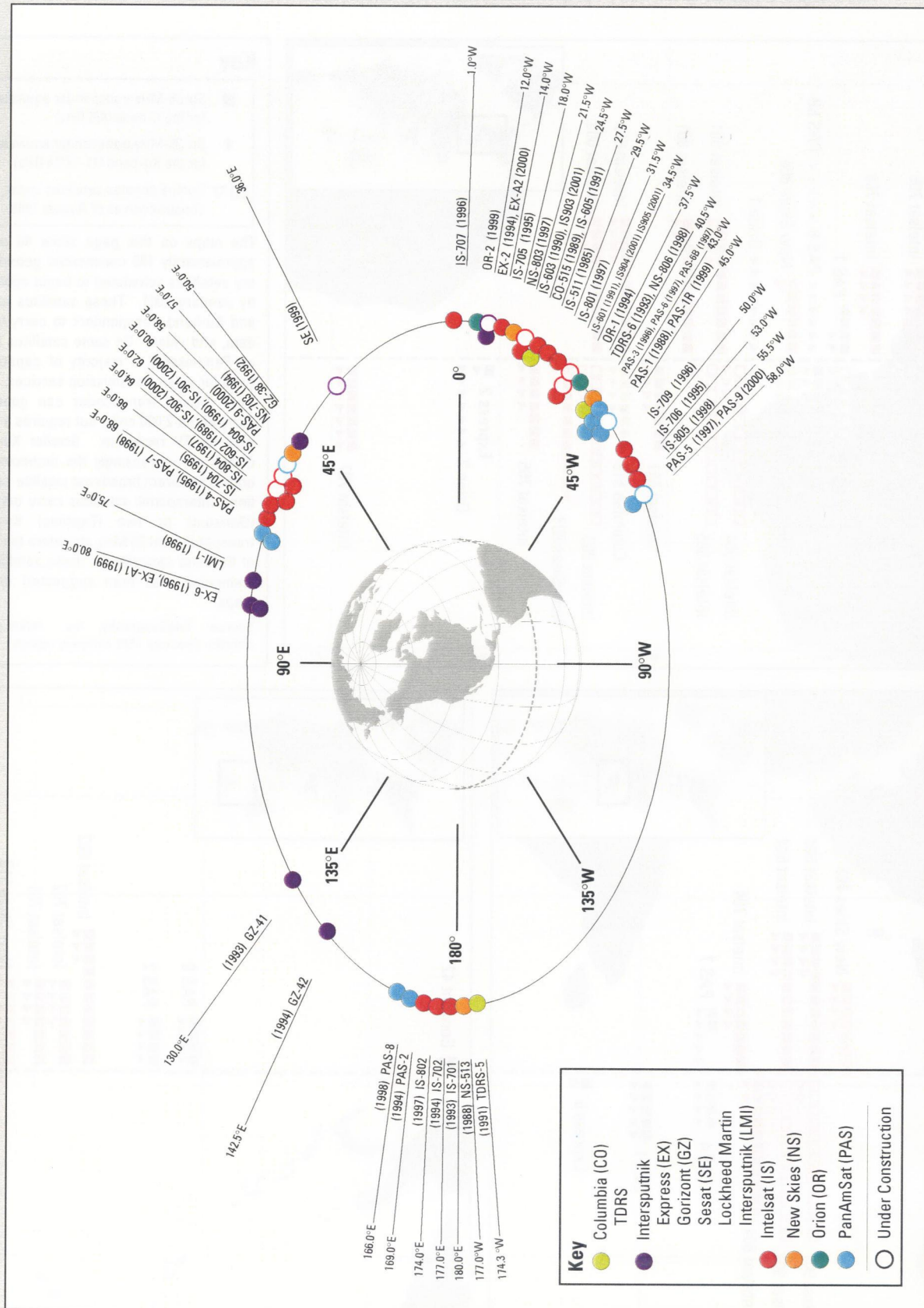


Figure 1. Orbital Map of Major Geostationary Satellites



Notes: The year next to the satellite name denotes launch date. Satellite orbits not to scale. Geostationary Earth Orbit (GEO) satellites orbit 35,785 km above the equator. Satellites that have been announced but have not specified an orbital slot have been omitted from this diagram. See Figure 2 for a list of major GEO satellites. Design adapted from "Global Marketplace 98," Merrill Lynch. Source: TeleGeography, Inc.

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Figure 2. Major International Telecommunications Satellites in Geostationary Orbit

Satellite	Bus	Launch Date	Orbital Slot	Transponders (36 MHz Equivalent)	
				C-band	Ku-band
Columbia					
Columbia 515	Ford Aerospace	January 1989	332.5 E	42.0	21.4
TDRS-5	TRW	August 1991	185.7 E	12.0	17.0
TDRS-6	TRW	January 1993	319.5 E	12.0	17.0
Intelsat					
Intelsat 511	Ford Aerospace	June 1985	330.5 E	42.0	21.3
Intelsat 601	HS-393	October 1991	325.5 E	64.2	24.6
Intelsat 602	HS-393	October 1989	62.0 E	64.2	24.6
Intelsat 603	HS-393	March 1990	335.5 E	64.2	24.6
Intelsat 604	HS-393	June 1990	60.0 E	64.2	24.6
Intelsat 605	HS-393	August 1991	332.5 E	64.2	24.6
Intelsat 701	FS-1300	October 1993	180.0 E	42.3	24.5
Intelsat 702	FS-1300	June 1994	177.0 E	42.3	24.5
Intelsat 704	FS-1300	January 1995	66.0 E	42.3	24.5
Intelsat 705	FS-1300	March 1995	342.0 E	42.3	24.5
Intelsat 706	FS-1300	May 1995	307.0 E	42.3	24.5
Intelsat 707	FS-1300	March 1996	359.0 E	42.3	44.9
Intelsat 709	FS-1300	June 1996	310.0 E	42.3	24.5
Intelsat 801	AS-7000	February 1997	328.5 E	64.2	16.7
Intelsat 802	AS-7000	June 1997	174.0 E	64.2	16.7
Intelsat 804	AS-7000	December 1997	64.0 E	64.2	16.7
Intelsat 805	AS-7000	June 1998	304.5 E	64.2	16.7
Intelsat 901	n.a.	4Q 2000	60.0 E	76.0	20.0
Intelsat 902	n.a.	1Q 2001	62.0 E	76.0	20.0
Intelsat 903	n.a.	2Q 2001	335.5 E	76.0	20.0
Intelsat 904	n.a.	3Q 2001	325.5 E	76.0	20.0
Intelsat 905	n.a.	4Q 2001-1Q 2002	332.5 E	76.0	20.0
Intersputnik					
Express 2	Express	October 1994	14.0 W	10.0	2.0
Express 6	Express	September 1996	80.0 E	10.0	2.0
Express-A1	n.a.	October 1999	80.0 E	n.a.	n.a.
Express-A2	n.a.	1Q 2000	14.0 W	n.a.	n.a.
Gorizont 38	Gorizont	November 1992	50.0 E	6.0	1.0
Gorizont 41	Gorizont	November 1993	130.0 E	6.0	1.0
Gorizont 42	Gorizont	May 1994	142.5 E	6.0	1.0
LMI-1	A2100 AX	September 1999	75.0 E	35.0	30.0
SESAT	NPO-PM	3Q 1999	36.0 E	-	36.0

Note: Table includes major commercial intercontinental systems only.

Source: TeleGeography, Inc.

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Figure 2. Major International Telecommunications Satellites in Geostationary Orbit (continued)

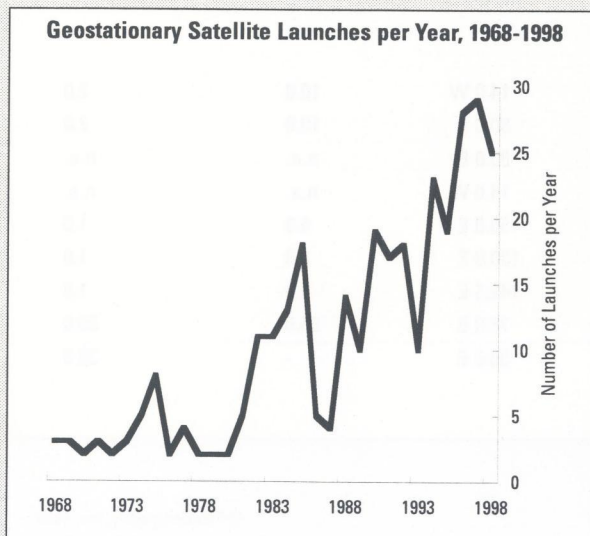
Satellite	Bus	Launch Date	Orbital Slot	Transponders (36 MHz Equivalent)	
				C-band	Ku-band
New Skies					
NSS 513	Ford Aerospace	May 1988	183.0 E	42.0	21.3
NSS 703	FS-1300	October 1994	57.0 E	42.3	24.5
NSS 803	AS-7000	September 1997	338.5 E	64.2	16.7
NSS 806	AS-7000	February 1998	319.5 E	36.0	44.0
Orion					
Orion 1	Eurostar 2000	January 1995	37.3 W	-	48.0
Orion 2	Eurostar 2000	4Q 1999	12.0 W	-	45.0
Panamsat					
PAS-1	GE 3000	June 1988	45.0 W	24.0	12.0
PAS-1R	HS-601	2Q 2000	45.0 W	36.0	36.0
PAS-2	HS-601	July 1994	169.0 E	14.0	30.0
PAS-3	HS-301	January 1996	43.0 W	25.1	25.1
PAS-4	HS-601	August 1995	68.5 E	25.1	24.6
PAS-5	HS-601	August 1997	58.0 W	24.0	24.0
PAS-6	FS-1300	August 1997	43.0 W	-	36.0
PAS-6B	HS-601 HP	December 1998	43.0 W	-	32.0
PAS-7	FS-13003	September 1998	68.5 E	14.0	30.0
PAS-8	FS-13003	November 1998	166.0 E	24.0	24.0
PAS-9	HS-601 HP	2Q 2000	58.0 W	n.a.	n.a.

Note: Table includes major commercial intercontinental systems only.

Source: TeleGeography, Inc.

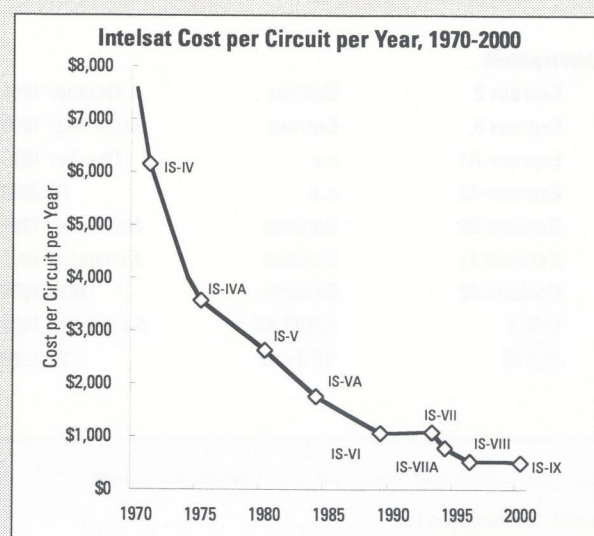
© TeleGeography, Inc. 1999

Figure 3. Geostationary Satellite Launch and Cost Trends



Note: Figure include launch failures. Most Russian satellite launches have been excluded.

Source: Via Satellite, October 15, 1999.



Source: TeleGeography, Inc. and Euroconsult (Tel. +33 1 43 38 06 00; Fax +33 1 43 38 12 40)

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International Internet Backbones

The Internet

The Internet is a global network of interconnected computers and servers that allows users to communicate and share information. It is the backbone of modern digital communication.

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International Internet Backbones

Who's Who

Approximately 300 IISPs, or International Internet Service Providers, operate long distance transmission networks that, together, form the global Internet's international backbone. They cluster around four groups:

Global IISP - A handful of IISPs operate networks that connect to multiple countries in more than one region. The global IISP sector is dominated by players with strong U.S. roots, either in origin (AT&T/IBM, Global One/Sprint, GTE/BBN, MCI WorldCom/UUNet, PSINet), or by association: Cable & Wireless, which acquired much of MCI's Internet backbone as a result of the MCI-WorldCom merger, or Canadian incumbent Teleglobe, with its origins just north of the Canada/U.S. border. Indeed, the pattern emerging in international telecom services—the twenty largest carriers carry 60 percent of voice traffic—is even more pronounced in international Internet services. The ten largest IISPs control 70 percent of international Internet bandwidth.

Regional IISP - An IISP specializing in operating inter-regional international backbones, like Carrier1, GTS/E-Bone, and Level 3, in Europe; SingNet and Telstra, in Asia; and iAfrica. An increasing number of entrants into the regional IISP space include former national incumbents seeking to leverage regional infrastructure.

National IISP - Typically, this is an Internet provider which has acquired international connectivity as part of a national or local service; acts increasingly as an upstream provider for other ISPs with little or no international connectivity; and moves to expand into neighboring countries. Examples include Demon Internet (U.K.), Wirehub (Netherlands), or Internet Initiative Japan.

Academic - Research networks often act as international connectivity providers alongside commercial IISPs. In many environments, they operate high-capacity, leading-edge systems—catalyzing regional Internet development. Examples are Europe's DANTE TEN-155 or Asia's AI3 initiatives.

America in the Middle

Last year, in *TeleGeography 1999*, we explored the geography of the Internet and discovered that although it was becoming global, steep regional bandwidth costs, a comparative lack of local content, and limited regional coordination caused the U.S. to become the Internet's central switching office, even for data flows within a region.

Our current survey shows that the Internet is still U.S.-centric. But America's role is changing. In Europe, where liberalization has

been greatest and country-to-country bandwidth prices have dropped fastest, two-thirds of international Internet connectivity now remains in-region, with hub cities like Amsterdam and Frankfurt running nine times as much bandwidth to other European countries as to the U.S. Asian IISPs, in a less integrated and more linguistically diverse region, continue to rely heavily on the U.S. west coast to exchange much of the region's traffic, but significant progress in building regional connectivity has occurred.

The result is that West Europe and East Asia are becoming secondary Internet hubs. Enormous differences still remain from country to country—differences which are reflected in the larger pattern of global connectivity. In less developed regions, intra-regional links have grown more slowly. Latin America still relies on slower satellite links for international connectivity; in Africa, just three countries (South Africa, Morocco, Tunisia) are connected to the Internet at above 10 Mbps, with Egypt due to join them shortly. The move away from a U.S.-centric architecture depends on a well-developed local infrastructure, and on a regulatory environment which neither prohibits connectivity nor prices it out of reach.

Methodology and Acknowledgements

The maps and tables on the following pages are the product of a six month study completed in September 1999. The research focused on the network topologies of 300 ISPs with international Internet links (that is, routers or switches directly connected across an international border over an internal network). These links (and their bandwidth) were then tracked through 200 cities in 100 countries, generating a database of over 1,000 city pairs. Each ISP's network routes and capacities were derived from a combination of public documents, confidential interviews, and computer-based network analysis tools.

The route-by-route figures published here represent the aggregate bandwidth for all ISPs covered in the study. Also, the specific switch and router locations have been grouped according to Consolidated Metropolitan Statistical Area, Census Metropolitan Area, or equivalent. And, finally, a disclaimer: because network architectures are complex and always changing, omissions may have occurred.


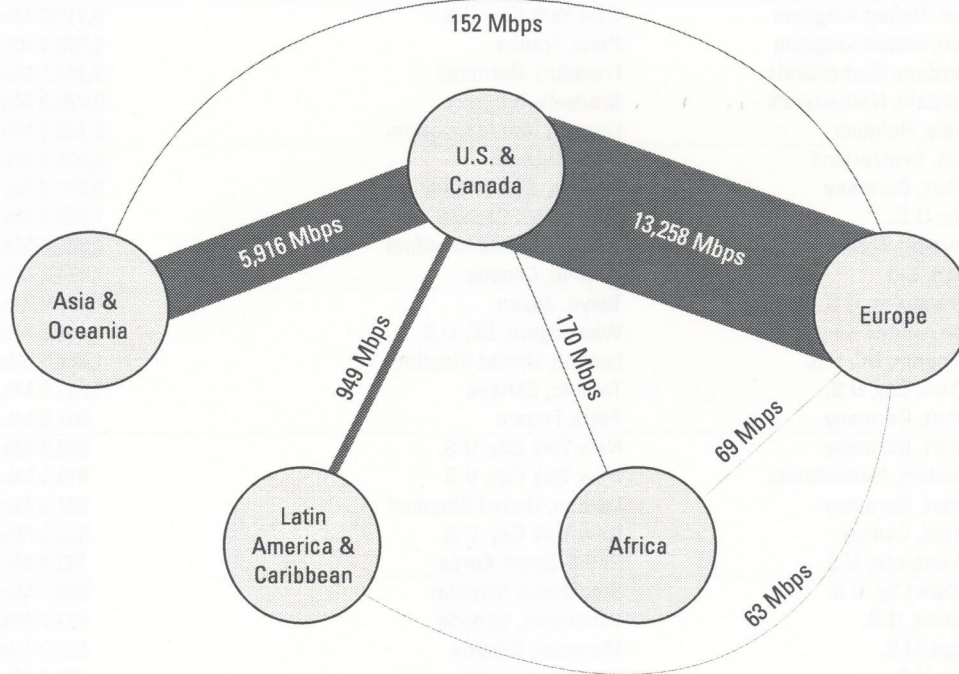
While conducting the research for this study, we received assistance from many individuals and organizations. We would like to give special thanks to Bob Cohen (Cohen Communications Group, tel: +1 212 986 7720, bcohen@mail.bway.net) and Anthony Townsend (Global Network Analysts, www.networkanalysts.com) for their advice and substantial contributions. 

Figure 1. Inter-regional Internet Bandwidth, 1999



Region 1	Region 2	International Internet Bandwidth
Africa	Africa (intra-regional)	7.5 Mbps
	Asia/Pacific	3.0 Mbps
	Europe	68.5 Mbps
	Latin America/Caribbean	n.a.
	U.S./Canada	170.0 Mbps
	<i>Region total</i>	<i>249.0 Mbps</i>
Asia/Pacific	Africa	3.0 Mbps
	Asia/Pacific (intra-regional)	398.4 Mbps
	Europe	152.2 Mbps
	Latin America/Caribbean	n.a.
	U.S./Canada	5,915.5 Mbps
	<i>Region total</i>	<i>6,469.1 Mbps</i>
Europe	Africa	68.5 Mbps
	Asia/Pacific	152.2 Mbps
	Europe (intra-regional)	31,918.3 Mbps
	Latin America/Caribbean	62.8 Mbps
	U.S./Canada	13,257.5 Mbps
	<i>Region total</i>	<i>45,452.9 Mbps</i>
Latin America/Caribbean	Africa	n.a.
	Asia/Pacific	n.a.
	Europe	62.8 Mbps
	Latin America/Caribbean (intra-regional)	48.3 Mbps
	U.S./Canada	949.1 Mbps
	<i>Region total</i>	<i>1,060.2 Mbps</i>
U.S./Canada	Africa	170.0 Mbps
	Asia/Pacific	5,915.5 Mbps
	Europe	13,257.5 Mbps
	Latin America/Caribbean	949.1 Mbps
	U.S./Canada (intra-regional)	7,841.0 Mbps
	<i>Region total</i>	<i>28,131.1 Mbps</i>

Note: Figures represent estimated Internet bandwidth between Consolidated Metropolitan Statistical Areas or equivalents. Domestic backbone routes are omitted. Data current to September 1999.

Source: TeleGeography *Global Backbone Database*

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Figure 2. The Top 50 International Internet Routes, 1999

Rank	City 1	City 2	Internet Bandwidth
1	London, United Kingdom	New York City, U.S.	5,212.0 Mbps
2	London, United Kingdom	Paris, France	4,092.3 Mbps
3	Amsterdam, Netherlands	Frankfurt, Germany	3,349.1 Mbps
4	Amsterdam, Netherlands	Brussels, Belgium	3,026.0 Mbps
5	Brussels, Belgium	London, United Kingdom	2,733.0 Mbps
6	Geneva, Switzerland	Paris, France	2,684.0 Mbps
7	Frankfurt, Germany	Geneva, Switzerland	2,677.0 Mbps
8	Seattle, U.S.	Vancouver, Canada	1,889.0 Mbps
9	Amsterdam, Netherlands	London, United Kingdom	1,883.8 Mbps
10	Chicago, U.S.	Toronto, Canada	1,754.0 Mbps
11	San Francisco, U.S.	Tokyo, Japan	1,487.0 Mbps
12	London, United Kingdom	Washington, DC, U.S.	1,449.5 Mbps
–	Washington, DC, U.S.	London, United Kingdom	1,449.5 Mbps
14	New York City, U.S.	Toronto, Canada	1,085.0 Mbps
15	Frankfurt, Germany	Paris, France	957.0 Mbps
16	Frankfurt, Germany	New York City, U.S.	936.5 Mbps
17	Amsterdam, Netherlands	New York City, U.S.	910.0 Mbps
18	Frankfurt, Germany	London, United Kingdom	827.8 Mbps
19	Montreal, Canada	New York City, U.S.	820.0 Mbps
20	San Francisco, U.S.	Seoul, South Korea	752.3 Mbps
21	New York City, U.S.	Stockholm, Sweden	668.0 Mbps
22	Cheyenne, U.S.	Vancouver, Canada	622.0 Mbps
–	Chicago, U.S.	Montreal, Canada	622.0 Mbps
–	Seattle, U.S.	Toronto, Canada	622.0 Mbps
25	Milan, Italy	New York City, U.S.	580.0 Mbps
26	Copenhagen, Denmark	Stockholm, Sweden	562.0 Mbps
27	Helsinki, Finland	Stockholm, Sweden	560.0 Mbps
28	San Francisco, U.S.	Sydney, Australia	541.0 Mbps
29	Brussels, Belgium	Paris, France	536.0 Mbps
30	London, United Kingdom	Stockholm, Sweden	506.0 Mbps
31	Frankfurt, Germany	Stockholm, Sweden	499.0 Mbps
32	New York City, U.S.	Palermo, Italy	465.0 Mbps
33	Amsterdam, Netherlands	Stockholm, Sweden	448.0 Mbps
34	Oslo, Norway	Stockholm, Sweden	443.0 Mbps
35	Amsterdam, Netherlands	Paris, France	403.0 Mbps
36	Frankfurt, Germany	Vienna, Austria	384.0 Mbps
37	Hong Kong, China	San Francisco, U.S.	361.0 Mbps
38	London, United Kingdom	Milan, Italy	345.0 Mbps
39	Ankara, Turkey	Washington, DC, U.S.	300.0 Mbps
40	Portland, U.S.	Tokyo, Japan	270.0 Mbps
41	Geneva, Switzerland	Milan, Italy	257.0 Mbps
42	Paris, France	Stockholm, Sweden	234.0 Mbps
43	San Francisco, U.S.	Singapore, Singapore	229.0 Mbps
44	Munich, Germany	Vienna, Austria	205.0 Mbps
45	Los Angeles, U.S.	Tokyo, Japan	203.5 Mbps
46	Paris, France	Washington, DC, U.S.	201.5 Mbps
47	Copenhagen, Denmark	London, United Kingdom	200.0 Mbps
–	Copenhagen, Denmark	New York City, U.S.	200.0 Mbps
49	Amsterdam, Netherlands	Geneva, Switzerland	189.0 Mbps
–	Munich, Germany	Stockholm, Sweden	189.0 Mbps

Note: Figures represent estimated Internet bandwidth between Consolidated Metropolitan Statistical Areas or equivalents. Domestic backbone routes are omitted. Data current to September 1999.

Source: TeleGeography *Global Backbone Database*

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Figure 3. The Top 50 International Internet Hub Cities, 1999

Rank	City	Country	International Internet Bandwidth
1	London	United Kingdom	17,969.1 Mbps
2	New York	U.S.	13,204.9 Mbps
3	Amsterdam	Netherlands	10,874.1 Mbps
4	Frankfurt	Germany	10,516.6 Mbps
5	Paris	France	9,687.3 Mbps
6	Brussels	Belgium	6,213.0 Mbps
7	Geneva	Switzerland	5,947.0 Mbps
8	Stockholm	Sweden	4,388.2 Mbps
9	Washington, DC	U.S.	3,998.4 Mbps
10	San Francisco	U.S.	3,949.8 Mbps
11	Toronto	Canada	3,512.0 Mbps
12	Chicago	U.S.	2,666.0 Mbps
13	Seattle	U.S.	2,607.0 Mbps
14	Vancouver	Canada	2,511.0 Mbps
15	Tokyo	Japan	2,392.7 Mbps
16	Montreal	Canada	1,690.4 Mbps
17	Milan	Italy	1,628.0 Mbps
18	Copenhagen	Denmark	1,274.0 Mbps
19	Seoul	South Korea	1,105.8 Mbps
20	Vienna	Austria	978.5 Mbps
21	Zurich	Switzerland	869.3 Mbps
22	Munich	Germany	756.0 Mbps
23	Los Angeles	U.S.	740.4 Mbps
24	Sydney	Australia	697.9 Mbps
25	Helsinki	Finland	670.0 Mbps
26	Cheyenne	U.S.	624.0 Mbps
27	Madrid	Spain	618.0 Mbps
28	Palermo	Italy	571.8 Mbps
29	Hong Kong	China	541.2 Mbps
30	Singapore	Singapore	497.3 Mbps
31	Oslo	Norway	490.0 Mbps
32	São Paulo	Brazil	329.3 Mbps
33	Taipei	Taiwan	323.8 Mbps
34	Portland	U.S.	315.1 Mbps
35	Moscow	Russia	302.3 Mbps
36	Ankara	Turkey	300.0 Mbps
37	Osaka	Japan	250.0 Mbps
38	Dublin	Ireland	239.0 Mbps
39	Nova Scotia	Canada	232.3 Mbps
40	Portsmouth	United Kingdom	213.8 Mbps
41	Dallas	U.S.	202.5 Mbps
42	Kuala Lumpur	Malaysia	188.2 Mbps
43	Vancouver Island	Canada	188.0 Mbps
44	Monaco	Monaco	187.5 Mbps
45	Cologne	Germany	180.0 Mbps
46	Prague	Czech Republic	177.0 Mbps
47	Hanover	Germany	159.1 Mbps
48	Auckland	New Zealand	155.0 Mbps
—	Leeds	United Kingdom	155.0 Mbps
50	Buenos Aires	Argentina	147.3 Mbps

Note: Figures represent estimated Internet bandwidth between Consolidated Metropolitan Statistical Areas or equivalents. Domestic backbone routes are omitted. Data current to September 1999.

Source: TeleGeography *Global Backbone Database*

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Figure 4. Map of Major Asia/Pacific International Backbone Routes, 1999



Note: Map includes international backbone routes with at least 20 Mbps of aggregate capacity. Figures represent estimated Internet bandwidth between Consolidated Metropolitan Statistical Areas or equivalents. Domestic backbone routes are omitted. Data current to September 1999.

Source: TeleGeography *Global Backbone Database*; additional research by Cohen Communications Group

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Figure 5. The Top 50 International Backbone Routes in Asia/Pacific, 1999

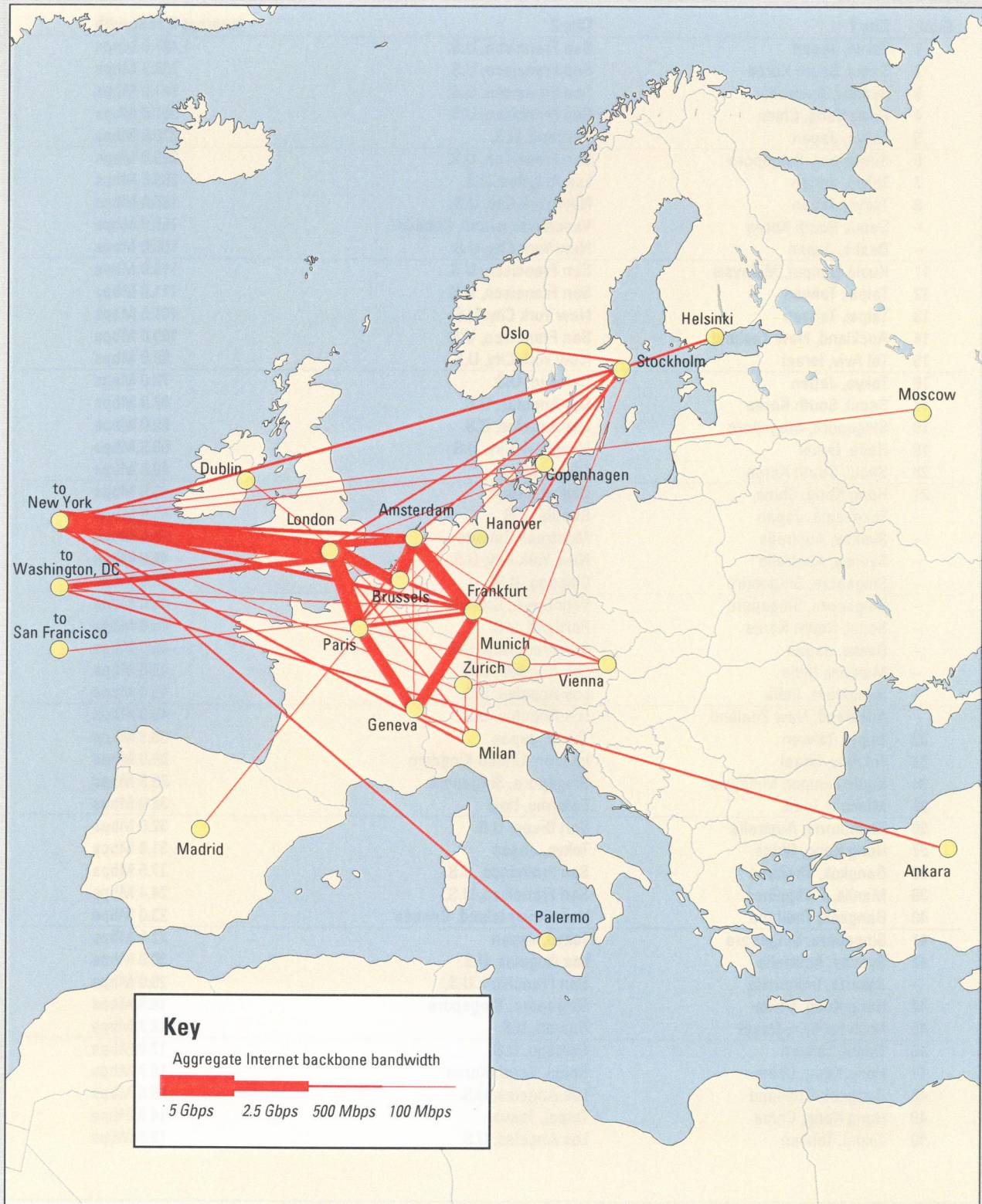
Rank	City 1	City 2	Internet Bandwidth
1	Tokyo, Japan	San Francisco, U.S.	1,487.0 Mbps
2	Seoul, South Korea	San Francisco, U.S.	752.3 Mbps
3	Sydney, Australia	San Francisco, U.S.	541.0 Mbps
4	Hong Kong, China	San Francisco, U.S.	361.0 Mbps
5	Tokyo, Japan	Portland, U.S.	270.0 Mbps
6	Singapore, Singapore	San Francisco, U.S.	229.0 Mbps
7	Tokyo, Japan	Los Angeles, U.S.	203.5 Mbps
8	Tokyo, Japan	New York City, U.S.	155.0 Mbps
–	Seoul, South Korea	Vancouver Island, Canada	155.0 Mbps
–	Osaka, Japan	New York City, U.S.	155.0 Mbps
11	Kuala Lumpur, Malaysia	San Francisco, U.S.	115.0 Mbps
12	Taipei, Taiwan	San Francisco, U.S.	111.0 Mbps
13	Taipei, Taiwan	New York City, U.S.	101.5 Mbps
14	Auckland, New Zealand	San Francisco, U.S.	100.0 Mbps
15	Tel Aviv, Israel	New York City, U.S.	96.0 Mbps
16	Tokyo, Japan	Chicago, U.S.	73.0 Mbps
17	Seoul, South Korea	Los Angeles, U.S.	67.9 Mbps
18	Singapore, Singapore	Los Angeles, U.S.	59.0 Mbps
19	Haifa, Israel	New York City, U.S.	58.5 Mbps
20	Seoul, South Korea	Tokyo, Japan	48.0 Mbps
21	Hong Kong, China	Osaka, Japan	45.5 Mbps
–	Yokohama, Japan	Seattle, U.S.	45.0 Mbps
–	Sydney, Australia	Montreal, Canada	45.0 Mbps
–	Sydney, Australia	New York City, U.S.	45.0 Mbps
–	Singapore, Singapore	Chicago, U.S.	45.0 Mbps
–	Singapore, Singapore	Vancouver, Canada	45.0 Mbps
–	Seoul, South Korea	Portland, U.S.	45.0 Mbps
–	Osaka, Japan	San Francisco, U.S.	45.0 Mbps
–	Mumbai, India	Los Angeles, U.S.	45.0 Mbps
–	Bangalore, India	Los Angeles, U.S.	45.0 Mbps
–	Auckland, New Zealand	Los Angeles, U.S.	45.0 Mbps
32	Taipei, Taiwan	Tokyo, Japan	38.9 Mbps
33	Tel Aviv, Israel	London, United Kingdom	36.0 Mbps
34	Kuala Lumpur, Malaysia	Singapore, Singapore	35.5 Mbps
35	Mumbai, India	Palermo, Italy	34.0 Mbps
36	Melbourne, Australia	San Diego, U.S.	32.0 Mbps
37	Hong Kong, China	Tokyo, Japan	31.8 Mbps
38	Bangkok, Thailand	San Francisco, U.S.	27.5 Mbps
39	Manila, Philippines	San Francisco, U.S.	24.4 Mbps
40	Bangkok, Thailand	Vancouver Island, Canada	23.0 Mbps
41	Singapore, Singapore	Tokyo, Japan	22.5 Mbps
42	Sydney, Australia	Los Angeles, U.S.	20.0 Mbps
–	Jakarta, Indonesia	San Francisco, U.S.	20.0 Mbps
44	Hong Kong, China	Singapore, Singapore	18.5 Mbps
45	Rosh ha'Ayin, Israel	Boston, U.S.	18.0 Mbps
46	Taipei, Taiwan	Chicago, U.S.	17.0 Mbps
47	Hong Kong, China	Seoul, South Korea	16.7 Mbps
48	Bangkok, Thailand	Los Angeles, U.S.	16.0 Mbps
49	Hong Kong, China	Taipei, Taiwan	14.0 Mbps
50	Taipei, Taiwan	Los Angeles, U.S.	12.6 Mbps

Note: Figures represent estimated Internet bandwidth between Consolidated Metropolitan Statistical Areas or equivalents. Domestic backbone routes are omitted. Data current to September 1999.

Source: TeleGeography *Global Backbone Database*; additional research by Cohen Communications Group

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Figure 6. Map of Major European International Backbone Routes, 1999



Note: Map includes international backbone routes with at least 100 Mbps of aggregate capacity. Figures represent estimated Internet bandwidth between Consolidated Metropolitan Statistical Areas or equivalents. Domestic backbone routes are omitted. Data current to September 1999.

Source: TeleGeography *Global Backbone Database*; additional research by Cohen Communications Group

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Figure 7. The Top 50 International Backbone Routes in Europe, 1999

Rank	City 1	City 2	Internet Bandwidth
1	London, United Kingdom	New York City, U.S.	5,212.0 Mbps
2	London, United Kingdom	Paris, France	4,092.3 Mbps
3	Amsterdam, Netherlands	Frankfurt, Germany	3,349.1 Mbps
4	Amsterdam, Netherlands	Brussels, Belgium	3,026.0 Mbps
5	Brussels, Belgium	London, United Kingdom	2,733.0 Mbps
6	Geneva, Switzerland	Paris, France	2,684.0 Mbps
7	Frankfurt, Germany	Geneva, Switzerland	2,677.0 Mbps
8	Amsterdam, Netherlands	London, United Kingdom	1,883.8 Mbps
9	London, United Kingdom	Washington, DC, U.S.	1,449.5 Mbps
10	Frankfurt, Germany	Paris, France	957.0 Mbps
11	Frankfurt, Germany	New York City, U.S.	936.5 Mbps
12	Amsterdam, Netherlands	New York City, U.S.	910.0 Mbps
13	Frankfurt, Germany	London, United Kingdom	827.8 Mbps
14	Stockholm, Sweden	New York City, U.S.	668.0 Mbps
15	Milan, Italy	New York City, U.S.	580.0 Mbps
16	Copenhagen, Denmark	Stockholm, Sweden	562.0 Mbps
17	Helsinki, Finland	Stockholm, Sweden	560.0 Mbps
18	Brussels, Belgium	Paris, France	536.0 Mbps
19	London, United Kingdom	Stockholm, Sweden	506.0 Mbps
20	Frankfurt, Germany	Stockholm, Sweden	499.0 Mbps
21	Palermo, Italy	New York City, U.S.	465.0 Mbps
22	Amsterdam, Netherlands	Stockholm, Sweden	448.0 Mbps
23	Oslo, Norway	Stockholm, Sweden	443.0 Mbps
24	Amsterdam, Netherlands	Paris, France	403.0 Mbps
25	Frankfurt, Germany	Vienna, Austria	384.0 Mbps
26	London, United Kingdom	Milan, Italy	345.0 Mbps
27	Ankara, Turkey	Washington, DC, U.S.	300.0 Mbps
28	Geneva, Switzerland	Milan, Italy	257.0 Mbps
29	Paris, France	Stockholm, Sweden	234.0 Mbps
30	Munich, Germany	Vienna, Austria	205.0 Mbps
31	Paris, France	Washington, DC, U.S.	201.5 Mbps
32	Copenhagen, Denmark	London, United Kingdom	200.0 Mbps
–	Copenhagen, Denmark	New York City, U.S.	200.0 Mbps
34	Amsterdam, Netherlands	Geneva, Switzerland	189.0 Mbps
–	Munich, Germany	Stockholm, Sweden	189.0 Mbps
36	Zurich, Switzerland	New York City, U.S.	180.0 Mbps
37	Frankfurt, Germany	Milan, Italy	177.0 Mbps
38	Frankfurt, Germany	Washington, DC, U.S.	165.0 Mbps
39	Madrid, Spain	Paris, France	159.0 Mbps
–	Munich, Germany	Paris, France	159.0 Mbps
41	Amsterdam, Netherlands	Vienna, Austria	155.0 Mbps
–	Copenhagen, Denmark	Frankfurt, Germany	155.0 Mbps
–	Frankfurt, Germany	San Francisco, U.S.	155.0 Mbps
–	Hanover, Germany	New York City, U.S.	155.0 Mbps
–	Leeds, United Kingdom	Washington, DC, U.S.	155.0 Mbps
46	London, United Kingdom	Zurich, Switzerland	153.0 Mbps
47	Dublin, Ireland	London, United Kingdom	148.0 Mbps
48	Moscow, Russia	New York City, U.S.	137.5 Mbps
49	Milan, Italy	Zurich, Switzerland	113.0 Mbps
50	Vienna, Austria	Zurich, Switzerland	102.0 Mbps

Note: Figures represent estimated Internet bandwidth between Consolidated Metropolitan Statistical Areas or equivalents. Domestic backbone routes are omitted. Data current to September 1999.

Source: TeleGeography *Global Backbone Database*; additional research by Cohen Communications Group

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Figure 8. Map of Major South American International Backbone Routes, 1999



Note: Map includes international backbone routes with at least 2.5 Mbps of aggregate capacity. Figures represent estimated Internet bandwidth between Consolidated Metropolitan Statistical Areas or equivalents. Domestic backbone routes are omitted. Data current to September 1999.

Source: TeleGeography Global Backbone Database

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Figure 9. The Top 50 International Backbone Routes in Latin America and the Caribbean, 1999

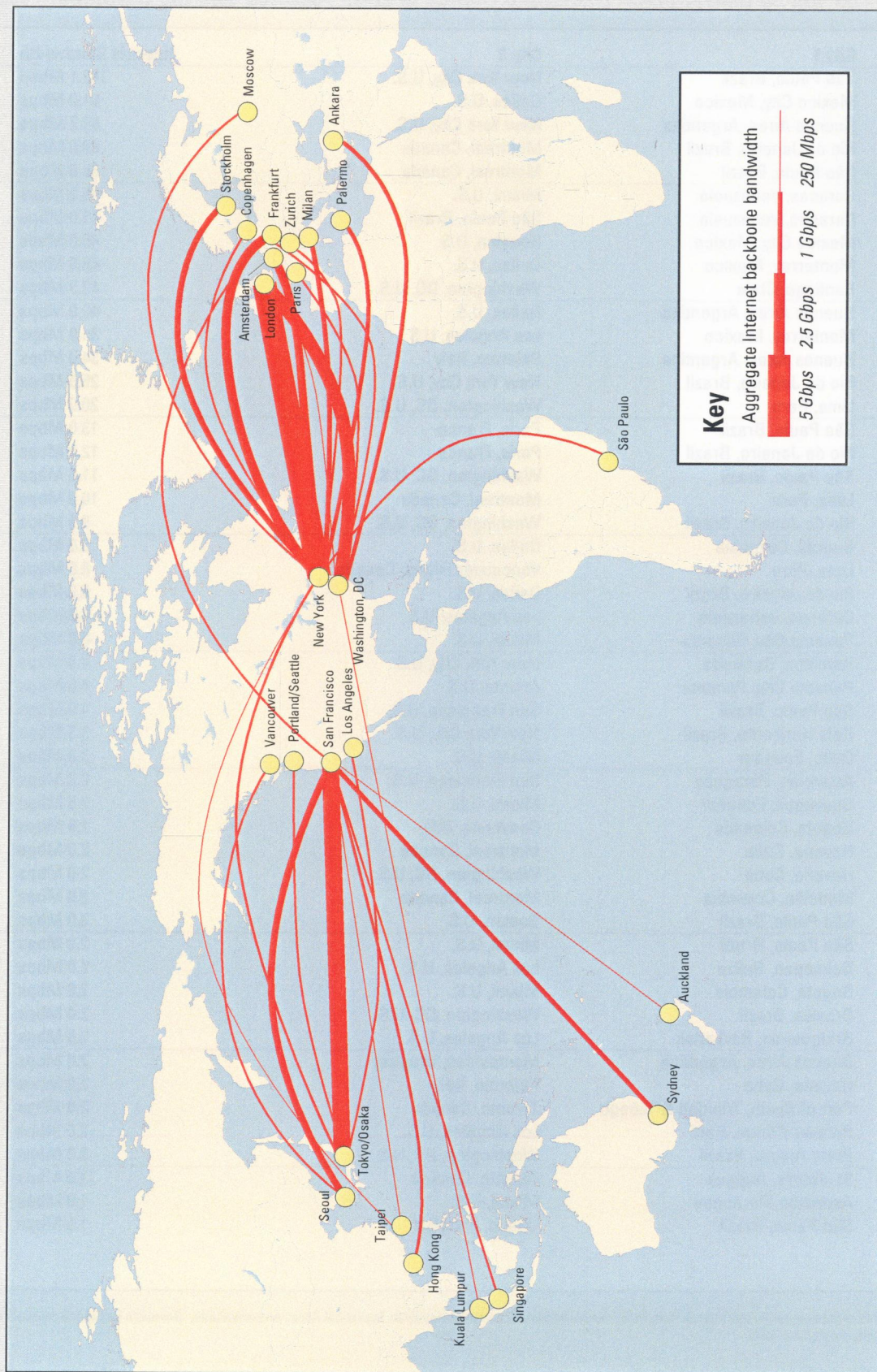
Rank	City 1	City 2	Internet Bandwidth
1	São Paulo, Brazil	New York City, U.S.	182.1 Mbps
2	Mexico City, Mexico	Dallas, U.S.	91.0 Mbps
3	Buenos Aires, Argentina	New York City, U.S.	68.2 Mbps
4	Rio de Janeiro, Brazil	Montreal, Canada	68.0 Mbps
5	São Paulo, Brazil	Montreal, Canada	68.0 Mbps
6	Caracas, Venezuela	Miami, U.S.	45.0 Mbps
-	Caracas, Venezuela	São Paulo, Brazil	45.0 Mbps
-	Mexico City, Mexico	Houston, U.S.	45.0 Mbps
-	Monterrey, Mexico	Dallas, U.S.	45.0 Mbps
10	Santiago, Chile	Washington, DC, U.S.	42.3 Mbps
11	Buenos Aires, Argentina	Dallas, U.S.	42.0 Mbps
12	Monterrey, Mexico	Los Angeles, U.S.	34.0 Mbps
-	Buenos Aires, Argentina	Palermo, Italy	34.0 Mbps
14	Rio de Janeiro, Brazil	New York City, U.S.	25.5 Mbps
15	Lima, Peru	Washington, DC, U.S.	20.0 Mbps
16	São Paulo, Brazil	Paris, France	13.0 Mbps
17	Rio de Janeiro, Brazil	Paris, France	12.0 Mbps
18	São Paulo, Brazil	Washington, DC, U.S.	11.6 Mbps
19	Lima, Peru	Montreal, Canada	10.0 Mbps
20	Rio de Janeiro, Brazil	Washington, DC, U.S.	9.5 Mbps
21	Bogotá, Colombia	Dallas, U.S.	8.0 Mbps
-	Lima, Peru	Vancouver Island, Canada	8.0 Mbps
-	Rio de Janeiro, Brazil	Dallas, U.S.	8.0 Mbps
24	Caracas, Venezuela	Los Angeles, U.S.	6.8 Mbps
25	Panama City, Panama	Miami, U.S.	6.0 Mbps
26	Hamilton, Bermuda	New York City, U.S.	4.0 Mbps
-	Panama City, Panama	Atlanta, U.S.	4.0 Mbps
-	São Paulo, Brazil	San Francisco, U.S.	4.0 Mbps
29	Belo Horizonte, Brazil	New York City, U.S.	3.5 Mbps
30	Quito, Ecuador	Miami, U.S.	3.0 Mbps
31	Asunción, Paraguay	San Francisco, U.S.	2.3 Mbps
32	Guayaquil, Ecuador	Miami, U.S.	2.5 Mbps
33	Bogota, Colombia	Cheyenne, U.S.	2.0 Mbps
-	Havana, Cuba	Montreal, Canada	2.0 Mbps
-	Havana, Cuba	Washington, DC, U.S.	2.0 Mbps
-	Medellín, Colombia	Montreal, Canada	2.0 Mbps
-	São Paulo, Brazil	Boston, U.S.	2.0 Mbps
-	São Paulo, Brazil	Miami, U.S.	2.0 Mbps
-	Belmopan, Belize	Los Angeles, U.S.	2.0 Mbps
-	Bogotá, Colombia	Miami, U.S.	2.0 Mbps
-	Brasília, Brazil	Washington, DC, U.S.	2.0 Mbps
-	Bridgetown, Barbados	Los Angeles, U.S.	2.0 Mbps
-	Buenos Aires, Argentina	Montevideo, Uruguay	2.0 Mbps
-	Havana, Cuba	Palermo, Italy	2.0 Mbps
-	Port of Spain, Trinidad & Tobago	Toronto, Canada	2.0 Mbps
-	Port-au-Prince, Haiti	Los Angeles, U.S.	2.0 Mbps
-	Porto Alegre, Brazil	Washington, DC, U.S.	2.0 Mbps
-	St. John's, Antigua	Toronto, Canada	2.0 Mbps
49	Asunción, Paraguay	Miami, U.S.	1.9 Mbps
50	São Paulo, Brazil	Lisbon, Portugal	1.5 Mbps

Note: Figures represent estimated Internet bandwidth between Consolidated Metropolitan Statistical Areas or equivalents. Domestic backbone routes are omitted. Data current to September 1999.

Source: TeleGeography *Global Backbone Database*

© TeleGeography, Inc. 1999

Figure 10. Map of Major International Backbone Routes in the U.S. and Canada, 1999



Note: Map includes overseas backbone routes with at least 125 Mbps of aggregate capacity. Figures represent estimated Internet bandwidth between Consolidated Metropolitan Statistical Areas or equivalents. Domestic backbone routes are omitted. Data current to September 1999.

Source: TeleGeography Global Backbone Database

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Figure 11. The Top 50 International Backbone Routes in the U.S. and Canada, 1999

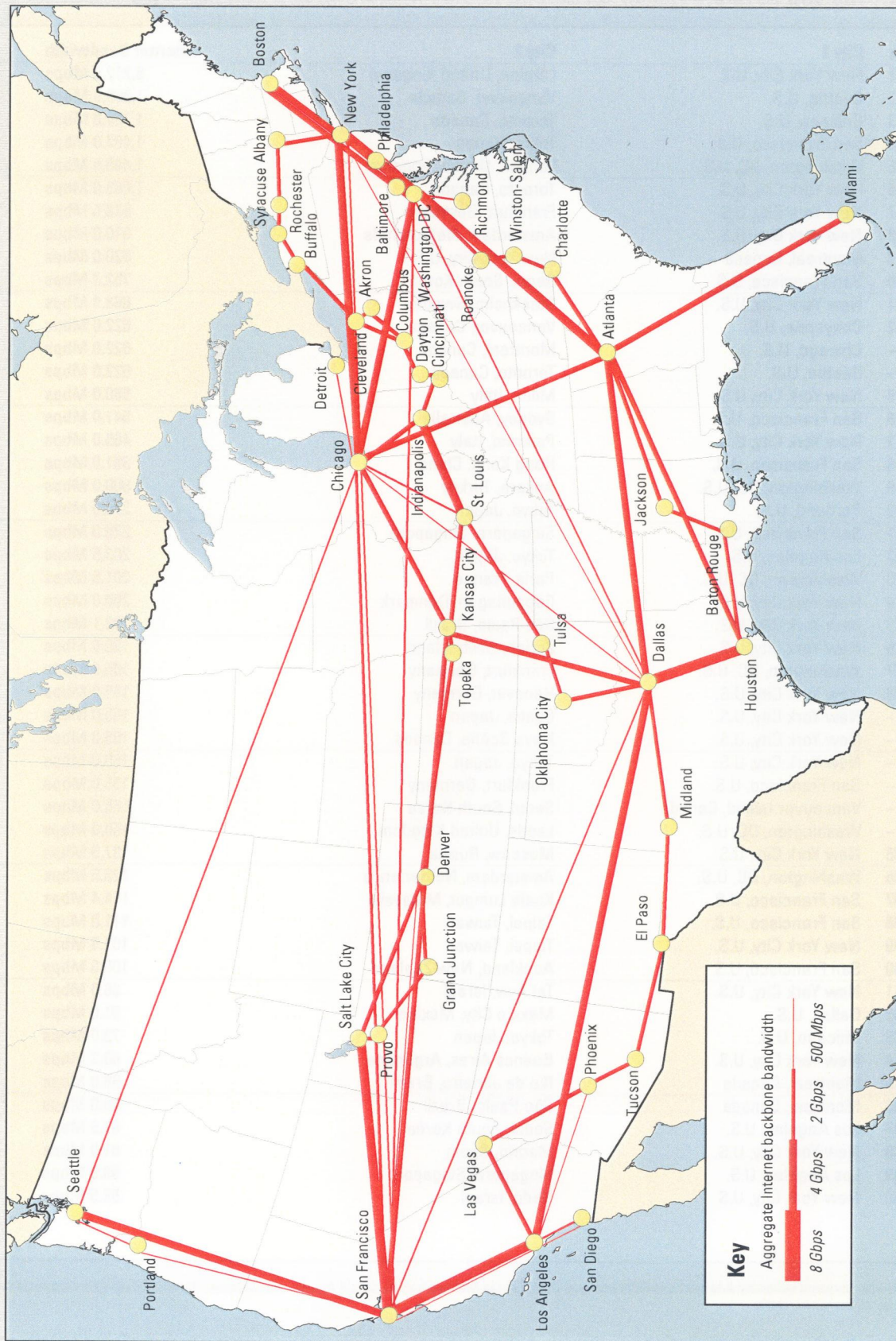
Rank	City 1	City 2	Internet Bandwidth
1	New York City, U.S.	London, United Kingdom	5,212.0 Mbps
2	Seattle, U.S.	Vancouver, Canada	1,889.0 Mbps
3	Chicago, U.S.	Toronto, Canada	1,754.0 Mbps
4	San Francisco, U.S.	Tokyo, Japan	1,487.0 Mbps
5	Washington, DC, U.S.	London, United Kingdom	1,449.5 Mbps
6	New York City, U.S.	Toronto, Canada	1,085.0 Mbps
7	New York City, U.S.	Frankfurt, Germany	936.5 Mbps
8	New York City, U.S.	Amsterdam, Netherlands	910.0 Mbps
9	Montreal, Canada	New York City, U.S.	820.0 Mbps
10	San Francisco, U.S.	Seoul, South Korea	752.3 Mbps
11	New York City, U.S.	Stockholm, Sweden	668.0 Mbps
12	Cheyenne, U.S.	Vancouver, Canada	622.0 Mbps
-	Chicago, U.S.	Montreal, Canada	622.0 Mbps
-	Seattle, U.S.	Toronto, Canada	622.0 Mbps
15	New York City, U.S.	Milan, Italy	580.0 Mbps
16	San Francisco, U.S.	Sydney, Australia	541.0 Mbps
17	New York City, U.S.	Palermo, Italy	465.0 Mbps
18	San Francisco, U.S.	Hong Kong, China	361.0 Mbps
19	Washington, DC, U.S.	Ankara, Turkey	300.0 Mbps
20	Portland, U.S.	Tokyo, Japan	270.0 Mbps
21	San Francisco, U.S.	Singapore, Singapore	229.0 Mbps
22	Los Angeles, U.S.	Tokyo, Japan	203.5 Mbps
23	Washington, DC, U.S.	Paris, France	201.5 Mbps
24	New York City, U.S.	Copenhagen, Denmark	200.0 Mbps
25	New York City, U.S.	São Paulo, Brazil	182.1 Mbps
26	New York City, U.S.	Zurich, Switzerland	180.0 Mbps
27	Washington, DC, U.S.	Frankfurt, Germany	165.0 Mbps
28	New York City, U.S.	Hanover, Germany	155.0 Mbps
-	New York City, U.S.	Osaka, Japan	155.0 Mbps
-	New York City, U.S.	Nova Scotia, Canada	155.0 Mbps
-	New York City, U.S.	Tokyo, Japan	155.0 Mbps
-	San Francisco, U.S.	Frankfurt, Germany	155.0 Mbps
-	Vancouver Island, Canada	Seoul, South Korea	155.0 Mbps
-	Washington, DC, U.S.	Leeds, United Kingdom	155.0 Mbps
35	New York City, U.S.	Moscow, Russia	137.5 Mbps
36	Washington, DC, U.S.	Amsterdam, Netherlands	125.5 Mbps
37	San Francisco, U.S.	Kuala Lumpur, Malaysia	114.4 Mbps
38	San Francisco, U.S.	Taipei, Taiwan	111.0 Mbps
39	New York City, U.S.	Taipei, Taiwan	101.5 Mbps
40	San Francisco, U.S.	Auckland, New Zealand	100.0 Mbps
41	New York City, U.S.	Tel Aviv, Israel	96.0 Mbps
42	Dallas, U.S.	Mexico City, Mexico	91.0 Mbps
43	Chicago, U.S.	Tokyo, Japan	73.0 Mbps
44	New York City, U.S.	Buenos Aires, Argentina	68.2 Mbps
45	Montreal, Canada	Rio de Janeiro, Brazil	68.0 Mbps
46	Montreal, Canada	São Paulo, Brazil	68.0 Mbps
47	Los Angeles, U.S.	Seoul, South Korea	67.9 Mbps
48	New York City, U.S.	Madrid, Spain	61.0 Mbps
49	Los Angeles, U.S.	Singapore, Singapore	59.0 Mbps
50	New York City, U.S.	Haifa, Israel	58.5 Mbps

Note: Figures represent estimated Internet bandwidth between Consolidated Metropolitan Statistical Areas or equivalents. Domestic backbone routes are omitted. Data current to September 1999.

Source: TeleGeography *Global Backbone Database*

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Figure 12. Map of Major U.S. Domestic Backbone Routes, 1999



Note: Map shows Consolidated Metropolitan Statistical Areas (CMSAs) connected by at least 500 Mbps of internet backbone capacity. Data current to March 1999.

Source: Anthony Townsend, Global Network Analysts (www.networkanalysts.com)

Design © TeleGeography, Inc. 1999

Figure 13. The Top 50 U.S. Domestic Backbone Routes, 1999

Rank	City 1	City 2	Internet Bandwidth
1	New York City, NY	Washington, DC	7,478 Mbps
2	Dallas, TX	Houston, TX	5,301 Mbps
3	Los Angeles, CA	San Francisco, CA	5,145 Mbps
4	San Francisco, CA	Salt Lake City, UT	4,566 Mbps
5	Indianapolis, IN	St. Louis, MO	4,231 Mbps
6	Washington, DC	Atlanta, GA	4,163 Mbps
7	Chicago, IL	New York City, NY	4,003 Mbps
8	San Francisco, CA	Seattle, WA	3,913 Mbps
9	Los Angeles, CA	Dallas, TX	3,780 Mbps
10	Chicago, IL	Washington, DC	3,583 Mbps
11	Atlanta, GA	Dallas, TX	3,468 Mbps
12	Boston, MA	New York City, NY	3,428 Mbps
13	Atlanta, GA	Miami, FL	3,023 Mbps
14	Chicago, IL	Atlanta, GA	2,913 Mbps
–	Washington, DC	Boston, MA	2,913 Mbps
16	Kansas City, MO	Dallas, TX	2,888 Mbps
17	Atlanta, GA	Houston, TX	2,803 Mbps
18	Chicago, IL	Kansas City, MO	2,643 Mbps
19	Chicago, IL	Indianapolis, IN	2,538 Mbps
20	San Francisco, CA	Kansas City, MO	2,533 Mbps
21	Atlanta, GA	Charlotte, NC	2,428 Mbps
22	Kansas City, MO	St. Louis, MO	2,363 Mbps
23	Cleveland, OH	Buffalo, NY	2,338 Mbps
24	Oklahoma City, OK	Dallas, TX	2,293 Mbps
25	Los Angeles, CA	Las Vegas, NV	2,273 Mbps
26	Cincinnati, OH	Indianapolis, IN	2,248 Mbps
–	Phoenix, AZ	Tucson, AZ	2,248 Mbps
28	El Paso, TX	Tucson, AZ	2,203 Mbps
–	St. Louis, MO	Tulsa, OK	2,203 Mbps
30	Columbus, OH	Dayton, OH	2,183 Mbps
31	Denver, CO	Salt Lake City, UT	2,183 Mbps
32	Cincinnati, OH	Dayton, OH	2,138 Mbps
–	Las Vegas, NV	Phoenix, AZ	2,138 Mbps
34	Akron, OH	Cleveland, OH	2,093 Mbps
–	Albany, NY	New York City, NY	2,093 Mbps
–	Atlanta, GA	Jackson, MS	2,093 Mbps
–	Cleveland, OH	Akron, OH	2,093 Mbps
38	Baton Rouge, LA	Jackson, MS	2,048 Mbps
–	Buffalo, NY	Rochester, NY	2,048 Mbps
–	Charlotte, NC	Winston-Salem, NC	2,048 Mbps
–	Dallas, TX	Midland, TX	2,048 Mbps
–	Denver, CO	Topeka, KS	2,048 Mbps
–	Grand Junction, CO	Provo, UT	2,048 Mbps
–	Kansas City, MO	Topeka, KS	2,048 Mbps
–	Roanoke, VA	Washington, DC	2,048 Mbps
–	Rochester, NY	Buffalo, NY	2,048 Mbps
–	Syracuse, NY	Rochester, NY	2,048 Mbps
–	Topeka, KS	Kansas City, MO	2,048 Mbps
–	Tulsa, OK	Oklahoma City, OK	2,048 Mbps
–	Winston-Salem, NC	Charlotte, NC	2,048 Mbps

Note: Figures represent total Internet bandwidth between Consolidated Metropolitan Statistical Areas or equivalents. All international backbone routes are omitted. Data current to September 1999.

Source: Anthony Townsend

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Internet Exchange Points

Internet eXchange (IX) points, also known as Network Access Points (NAPs) or Metropolitan Area Exchanges (MAEs), are physical installations created by third parties to facilitate traffic exchange between independent Internet Service Providers (ISPs). The table below shows a selection of IX points operating in October 1999, based on exchange size, geographical

diversity, and location in a global Internet hub city. Number of ISPs do not always correlate to traffic size, but do provide a rough benchmark for comparison. ISPs also exchange traffic at private locations which are not well publicized (for a review of private peering arrangements, see "The Old Boy's Network," *Data Communications*, Oct. 1999).

Figure 1. Major Internet Exchange Points, A-K

Internet Exchange	Connected ISPs	Location/URL
AIX (Athens IX)	8	Athens, Greece www.aix.gr
AMS-IX (AMStErdam IX)	71	Amsterdam, Netherlands www.ams-ix.net
APE (Auckland Peering Exchange/CityLink)	3	Auckland, New Zealand www.citylink.co.nz
BCIX (British Columbia IX)	7	Vancouver, Canada www.bc.net/services.html
BIX (Budapest IX)	19	Budapest, Hungary www.nic.hu/bix
BNIX (BelNet IX)	30	Brussels, Belgium www.belnet.be/bnix
BUHIX (BUCharest IX)	16	Bucharest, Romania www.buhix.ro
Chicago NAP (Ameritech)	93	Chicago, U.S. nap.aads.net/main.html
Chile NAP	9	Santiago, Chile www.nap.cl
CINX (Capetown InterNet eXchange)	11	Capetown, South Africa www.jinx.net.za/jinx/cinx
CIXP (Cern IX Point)	26	Geneva, Switzerland www.cs.cern.ch/public/services/cixp/index.html
CORE (Common Routing Exchange)	n.a.	Manila, Philippines www.ph.net/CORE.html
DeCIX (Deutsche Commercial IX)	51	Frankfurt, Germany www.decix.de
DGIX (Distributed Global Internet eXchange)	16	Stockholm, Sweden www.netnod.se
DIX (Danish IX)	21	Lyngby, Denmark www.uni-c.dk/dix
ESPANIX/PNE (ESPANa IX/Puncto Neutral Español)	13	Madrid, Spain www.espanix.net
FICIX (Finnish Commercial IX)	10	Helsinki, Finland www.ficix.fi
HKIX (Hong Kong IX)	49	Hong Kong, China www.hkix.net
IIX (Indonesia IX)	35	Jakarta, Indonesia www.iix.net.id
IIX (Israeli IX)	18	Petah-Tiqva, Israel www.isoc.org.il/iix.html
INEX (Internet Neutral EXchange)	6	Dublin, Ireland www.inex.ie
JPIX (Japan IX)	36	Tokyo, Japan www.jpix.co.jp
KINX (Korea InterNet eXchange/PSINet)	15	Seoul, Korea, Rep. www.kinx.net
KLIX (Kuala Lumpur IX)	n.a.	Kuala Lumpur, Malaysia www.klix.net

Source: TeleGeography, Inc.

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Figure 2. Major Internet Exchange Points, L-Z

Internet Exchange	Connected ISPs	Location/URL
L-GIX (Latvian Global IX)	16	Riga, Latvia www.nic.lv/gix.html
L2IX (Layer 2 Internet eXchange/DACOM-IX)	32	Seoul, Korea, Rep. www.dacomix.net
LINX (London InterNet eXchange)	82	London, United Kingdom www.linx.net
M9-IX (M9 Telehouse IX)	54	Moscow, Russia www.ripn.net/ix
MAE-East (MCI WorldCom)	92	Washington, DC, U.S. www.mae.net/east.html
MAE-FFM (MCI WorldCom)	n.a.	Frankfurt, Germany www.mfst.com/mfs-international/frankfurt.html
MAE-Paris (MCI WorldCom)	n.a.	Paris, France www.mfst.com/mfs-international/paris.html
MAE-West (MCI WorldCom/NASA Ames)	83	San Jose, U.S. www.mae.net/west.html
MIX (Milan IX)	11	Milan, Italy www.aiip.it/mixit.html
New York NAP (Sprint)	35	Pennsauken, U.S. www.sprintbiz.com/nap/
NIX (Neutral IX)	20	Prague, Czech Republic www.nix.cz
NIX (Norwegian IX)	8	Oslo, Norway 193.156.90.0
NSPIX2 (Network Service Provider IX Project 2)	n.a.	Tokyo, Japan www.wide.ad.jp
NSPIX3 (Network Service Provider IX Project 3)	n.a.	Osaka, Japan www.wide.ad.jp
NYIIX (New York International IX)	23	New York City, U.S. www.nyiix.net
PacBell NAP (Pacific Bell)	50	SF/LA, U.S. www.pacbell.com/products/business/fastrak/networking/nap
PAIX (Palo Alto IX/AboveNet)	60	Palo Alto, U.S. www.paix.net
PARIX (France Télécom)	18	Paris, France www.parix.net
PhIX (Philippine IX)	9	Manila, Philippines list.infocom.sequel.net
PIX (Portuguese IX)	16	Lisbon, Portugal www.fccn.pt
PTT-ANSP (PTT Academic Network at São Paulo)	6	São Paulo, Brazil www.ansp.br
QIX (Quebec IX)	6	Montreal, Canada www.risq.qc.ca/reseau/table/brancher/brancher_01.html
SFINX (Service for French iNternet eXchange)	47	Paris, France www.sfinx.tm.fr
SIX (Seattle IX)	24	Seattle, U.S. www.altopia.com/six
SIX (Slovak IX)	21	Bratislava, Slovakia www.six.sk
STIX (SingTel IX)	22	Singapore www.stix.net
SydNAP (AUIX/AusBONE)	15	Sydney, Australia www.ausbone.net/sydney.htm
ThaiSARN PIE (Thai SARN Public Internet Exchange)	18	Bangkok, Thailand ntl.nectec.or.th/pie
THIX (THai IX)	27	Bangkok, Thailand www.cat.net.th/Services/THIX/thix.html
TorIX (Toronto IX)	11	Toronto, Canada www.torix.net
TWIX (TaiWan IX/Chunghwa)	23	Taipei, Taiwan www.twix.net
VIX (Vienna IX)	43	Vienna, Austria www.vix.at

Source: TeleGeography, Inc.

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Global Internet Indicators

“Hosts” are computers which are connected to the Internet. Technically, this means that they respond when hailed at the IP address corresponding to their entry in the Internet’s domain name registry. The tables on the following pages present two methods for examining Internet host growth: by Top Level Domain name and by country.

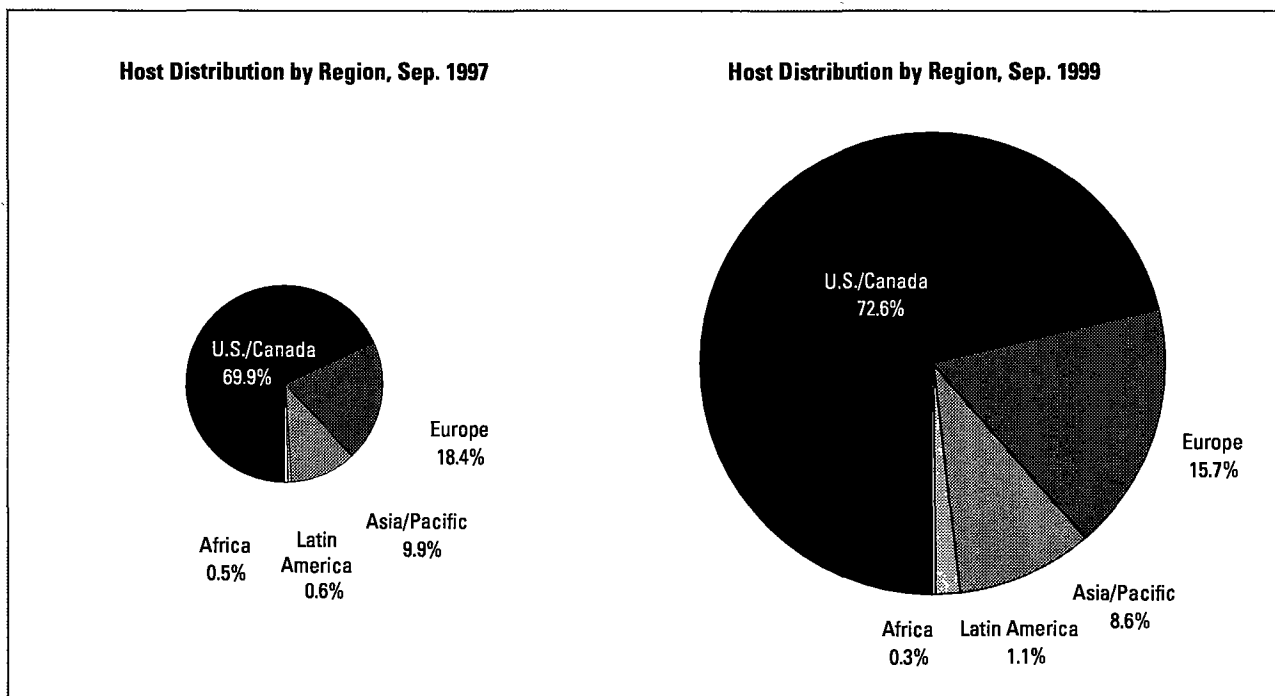
Top Level Domains (TLDs) are the domain name extensions like “.com” which are used by Internet hosts. Figure 2 shows data for 55 TLDs, including six generic TLDs (“.com”, “.net”, “.org”, etc.) as well as 49 country code or ccTLDs (“.ca”, “.jp”, “.fr”, etc.). These TLDs represent over 98 percent of the Internet’s hosts. Although country code TLDs exist for 250 economies (see the list at www.iana.org/cctld.html), most have such small host populations that data points are unlikely to be accurate.

The data shown here are based on continuous sampling by the Netsizer project team at Telcordia’s Applied Research group (www.netsizer.com), and verified against surveys undertaken biannually by the Internet Software Consortium (ISC, www.isc.org)—formerly carried out under the aegis of Network

Wizards (www.nw.com)—as well as monthly surveys of 96 countries by Réseaux IP Européennes (www.ripe.net).

Figure 3 shows TLDs broken down by country. For ccTLDs, the conversion process is straight forward: host names ending in a country code such as “.ca” are assumed to be associated with the corresponding country (in this example, Canada). Allocating countries to gTLDs is more difficult—and more important: “.com” alone represents more than a third of all hosts. The Netsizer project deals with this problem by taking numerical IP addresses as its starting point and constantly generating random combinations of available four-octet IPv4 addresses to test (such as 128.96.41.1). Then Netsizer looks them up in the domain name registries (this is called a “whois” query) to see what domain name they are associated with. The ‘whois’ query returns the registered postal address for the host’s administrator; the host is then associated with the country included in that address. This makes it easy to allocate gTLDs to single countries. 🗝️

Figure 1. Host Growth and Distribution by Region, 1997-1999



Note: Area of pies are scaled by total host growth between 1997 and 1999.
Source: Telcordia Technologies (www.netsizer.com)

Design © TeleGeography, Inc. 1999

Figure 2. Host Count by Top Level Domain, 1997-1999

TLD	Country	Sept. 97	Sept. 98	Sept. 99	CAGR, 97-99
com	—	7,600,100	11,745,000	23,732,000	77%
net	—	3,825,700	7,223,100	12,596,000	81%
edu	—	3,584,200	4,867,200	5,975,900	29%
jp	Japan	1,120,400	1,678,800	2,321,200	44%
mil	United States	902,100	1,595,900	1,957,600	47%
uk	United Kingdom	859,300	1,315,800	1,768,100	43%
us	United States	732,200	1,121,700	1,522,100	44%
ca	Canada	640,800	1,084,400	1,509,600	53%
de	Germany	834,700	1,173,500	1,439,500	31%
au	Australia	593,800	779,500	966,300	28%
org	—	537,000	677,600	879,100	28%
gov	United States	428,900	614,500	772,900	34%
nl	Netherlands	332,500	543,800	714,100	47%
fr	France	308,900	455,300	702,800	51%
fi	Finland	328,400	488,000	572,200	32%
se	Sweden	298,100	390,100	527,500	33%
it	Italy	206,500	351,300	504,700	56%
tw	Taiwan	121,700	n.a.	455,500	93%
no	Norway	181,200	324,300	378,700	45%
es	Spain	161,000	239,700	347,800	47%
dk	Denmark	135,900	211,300	311,600	51%
be	Belgium	84,100	176,000	298,500	88%
br	Brazil	87,800	177,200	298,000	84%
kr	Korea (South)	100,400	177,200	282,700	68%
ch	Switzerland	143,600	222,700	270,300	37%
nz	New Zealand	130,600	195,600	230,800	33%
at	Austria	68,700	131,500	191,300	67%
mx	Mexico	22,400	81,600	190,700	192%
ru	Russia	56,800	123,200	181,000	79%
za	South Africa	103,300	n.a.	165,900	27%
pl	Poland	74,000	112,600	154,100	44%
il	Israel	40,800	90,500	136,700	83%
ar	Argentina	17,500	41,300	109,400	150%
cz	Czech Republic	45,100	71,100	105,200	53%
sg	Singapore	73,300	78,400	102,600	18%
hu	Hungary	35,300	71,100	102,200	70%
hk	Hong Kong	55,800	73,800	96,300	31%
gr	Greece	29,400	43,900	69,400	54%
tr	Turkey	18,400	36,100	67,700	92%
pt	Portugal	29,700	51,000	64,700	48%
my	Malaysia	35,000	n.a.	58,800	30%
ie	Ireland	n.a.	39,800	48,600	n.a.
cl	Chile	n.a.	25,300	45,700	n.a.
cn	China	19,700	n.a.	38,400	40%
co	Colombia	10,100	13,800	32,800	80%
th	Thailand	14,200	23,500	29,500	44%
ee	Estonia	9,400	16,100	27,000	69%
is	Iceland	15,000	21,200	26,700	33%
in	India	3,100	9,700	21,500	163%
ua	Ukraine	9,400	15,000	21,500	51%
si	Slovenia	n.a.	n.a.	21,000	n.a.
sk	Slovakia	6,200	16,000	20,800	83%
id	Indonesia	6,100	11,900	19,500	79%
ro	Romania	5,000	10,200	16,600	82%
uy	Uruguay	1,000	8,400	13,800	271%

Note: An internet host typically represents one computer connected to the Internet, although many users may be connected through a single host and some individual computers may act as multiple hosts. CAGR is compound annual growth rate.

Source: Telcordia Technologies (www.netsizer.com)

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Figure 3. Host Count by Country, 1997-1999

Country/Region	Sept. 97	Sept. 98	Sept. 99	CAGR, 97-99
United States	16,667,000	26,167,000	44,230,000	62.9%
Japan	1,158,300	1,704,800	2,372,900	43.1%
Canada	964,400	1,665,000	2,345,500	56.0%
United Kingdom	976,200	1,487,200	2,072,700	45.7%
Germany	900,900	1,278,100	1,675,500	36.4%
Australia	616,200	825,000	1,037,000	29.7%
Taiwan	181,800	n.a.	841,700	115.2%
Netherlands	363,000	592,800	817,400	50.1%
France	330,700	492,400	778,300	53.4%
Finland	361,900	528,000	634,300	32.4%
Sweden	324,100	424,600	614,700	37.7%
Italy	217,500	361,000	533,600	56.6%
Norway	189,600	327,900	390,800	43.6%
Spain	168,600	256,300	381,900	50.5%
Korea, Rep.	108,900	195,200	318,400	71.0%
Denmark	145,400	217,700	316,600	47.6%
Switzerland	157,200	252,900	315,000	41.6%
Belgium	87,500	179,400	302,400	85.9%
Brazil	91,600	180,200	301,700	81.5%
New Zealand	134,300	196,500	241,400	34.1%
Israel	48,000	124,300	234,900	121.2%
Austria	71,800	145,400	229,300	78.7%
Hong Kong	96,800	133,500	208,100	46.6%
South Africa	120,700	n.a.	206,800	30.9%
Mexico	23,400	84,200	200,100	192.4%
Russia	61,200	135,900	196,900	79.4%
Poland	75,700	112,500	155,400	43.3%
Hungary	39,500	82,400	115,800	71.2%
Argentina	18,600	44,100	114,000	147.6%
Singapore	78,000	82,400	109,100	18.3%
Czech Republic	48,000	75,100	108,300	50.2%
Turkey	19,500	42,200	79,400	101.8%
Greece	31,100	44,800	69,700	49.7%
Portugal	31,600	53,000	65,200	43.6%
Malaysia	36,500	n.a.	59,400	27.6%
Chile	n.a.	32,200	53,600	n.a.
Ireland	n.a.	43,300	52,200	n.a.
Colombia	13,200	21,500	43,200	80.9%
China	21,000	n.a.	42,500	42.3%
Thailand	16,100	27,600	34,200	45.7%
India	4,600	14,900	31,900	163.3%
Ukraine	16,200	23,100	31,700	39.9%
Iceland	n.a.	21,000	26,900	n.a.
Estonia	8,300	14,700	25,600	75.6%
Slovenia	n.a.	n.a.	22,400	n.a.
Slovakia	7,700	16,200	20,300	62.4%
Indonesia	6,900	13,200	19,500	68.1%
Romania	6,500	10,300	17,000	61.7%
Uruguay	1,100	8,900	14,300	260.6%
<i>U.S./Canada</i>	<i>17,942,200</i>	<i>28,574,200</i>	<i>48,029,300</i>	<i>63.6%</i>
<i>Europe</i>	<i>4,699,700</i>	<i>7,218,200</i>	<i>10,049,300</i>	<i>46.2%</i>
<i>Asia/Pacific</i>	<i>2,507,400</i>	<i>3,317,400</i>	<i>5,551,000</i>	<i>48.8%</i>
<i>Latin America/Caribbean</i>	<i>162,900</i>	<i>371,100</i>	<i>726,900</i>	<i>111.2%</i>
<i>Africa</i>	<i>120,700</i>	<i>n.a.</i>	<i>206,800</i>	<i>30.9%</i>
Total	25,212,824	40,217,459	64,177,265	59.5%

Note: An Internet host typically represents one computer connected to the Internet, although many users may be connected through a single host and some individual computers may act as multiple hosts. Generic Top Level Domain (gTLD) hosts are distributed between countries according to registrations in September 1999. CAGR is compound annual growth rate.

Source: Telcordia Technologies (www.netsizer.com)

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VoIP Traffic and Settlements

The New Rules

Although the vast majority of international voice and fax traffic is still carried over the public switched telephone network (PSTN) and subject to per minute settlement payments between carriers, the rapid spread of Internet protocol (IP)-based networks has opened up new methods for transmitting international calls. Even as the old settlement rules become obsolete, however, voice over IP (VoIP) carriers are actively seeking new rules to provide a stable service and compensation scheme. The need for new standards is being driven largely by two factors.

First, as with the international PSTN, VoIP carriers typically must rely upon other networks to complete a call; but on the Internet, the number of potential correspondents may number in the thousands. Thus, a common set of ground rules is required for handing-off and metering traffic as well as for distributing revenues. Designing a viable method for sharing revenues presents a special challenge on the Internet, because large Internet service providers (ISPs) currently exchange traffic on a sender-keeps-all or peering basis, and smaller ISPs generally pay larger ISPs for carrying their traf-

fic by volume, regardless of the service (e-mail, phone calls, web pages) transmitted. As well, because most Internet phone calls terminate on the PSTN, the terminating ISP may need to pay local access charges to complete a VoIP call. Thus to provide VoIP carriers with an incentive to carry Internet calls and cover their PSTN termination costs, new Internet-based compensation schemes are needed.

The second driver of VoIP standards is related to the first: Quality of Service (QoS). To compete with the switched network, VoIP carriers must offer comparable service in the longer run and that too requires cooperation. End-to-end VoIP performance standards depend upon the quality of each network along the way.

In order to see how the new interconnection and QoS rules are developing, this essay looks at two basic questions: how are VoIP carriers currently exchanging voice traffic and how are they settling accounts with each other?

Background

The first voice conversations carried on the Internet were low quality and relied upon rudimentary PC software for

Figure 1. Major Clearinghouse Networks and Standards

Clearinghouse	Core Network	Settlement Standard	URL
Arbinet Global Clearing Network	none	proprietary	www.agcn.net
AT&T Global Clearinghouse	managed public Internet	OSP/proprietary	www.ap.att.com/clearinghouse
Delta Three	private IP links PSTN/Internet failover	proprietary	www.deltathree.com/business
GRIC	private IP links	OSP	www.gric.com
GTE Internetworking	private IP links PSTN failover	proprietary	www.bbn.com/products/voip.htm
iBasis	managed public Internet PSTN failover	OSP	www.ibasis.net
iPass	none	proprietary	www.ipass.com/services/clearinghouse
ITXC	managed public Internet private IP/PSTN failover	iNow	www.itxc.com
POPstar (IP fax only)	none	OSP	www.pop-star.net

Source: Company reports

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encoding speech at each end of the link. And although compression technology and faster computers have helped improve the quality of the experience, "PC to PC" phone calls remain a relatively low volume niche.

But the idea had caught on. First, ISPs (and their vendors) built gateways that could terminate PC-originated calls to PSTN phone numbers. Then ISPs and alternative carriers set up gateways to originate phone calls on the PSTN, carry them on the Internet, and terminate them on the PSTN through another gateway. These companies, which could connect two PSTN end users via the Internet, became the first "Internet Telephone Service Providers" (ITSPs).

Unfortunately for the ITSPs, finding a way to terminate traffic on the PSTN is much more difficult than linking two PC users. In order to complete a call in another country, you need a point of presence (POP) there. So ITSPs began

building relationships with ISPs, ITSPs, and carriers in places they did not already have a network node. This process soon became time-consuming and expensive, however, as the cost for establishing and maintaining hundreds of bilateral relationships was not something many newcomers could effectively do. Furthermore, monitoring the quality of connections was nearly impossible.

One solution to the call termination problem was to create a self-contained, privately managed IP network which looks and acts like the public Internet but is capable of high-quality voice transmission. Delta Three (now a subsidiary of RSL Com) was one of the first companies to follow this model (although it relies on additional affiliate relationships as well). But whereas Delta Three uses a combination of facilities leased from its parent company along with leased lines from other carriers, the next generation of IP carrier will own most of its capacity, offering an end-to-end transport layer

Figure 2. IP/PSTN Equipment Makers

In order to exchange voice or fax traffic on IP networks, carriers need a lot of new equipment. Not surprisingly, the two biggest players in next-generation switching technology are Cisco, the dominant maker of high-end IP routers, and Lucent, the dominant maker of high-end PSTN switches. Both have leveraged their existing products and market valuation to pay for buying sprees of smaller niche vendors that have had a jump start in the highly specialized needs of IP/PSTN gateways and associated equipment.

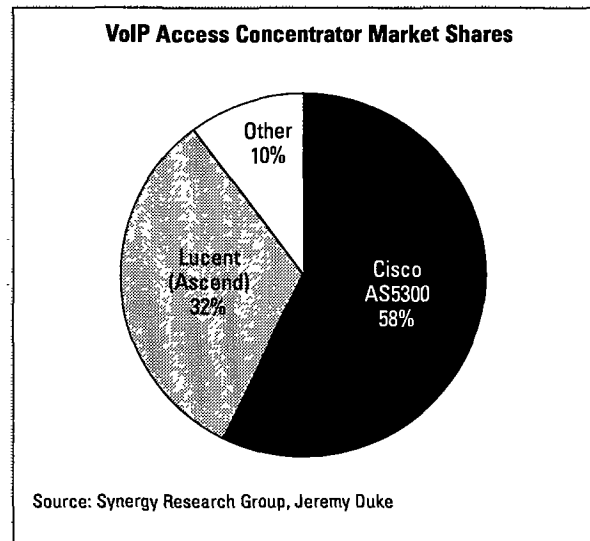
So far Cisco has acquired an impressive group of new companies, including Summa Four (for programmable switches), Lightspeed (for SS7 signaling), and Transmedia (for next generation media switches), as well as Selsius and Calista. Lucent has likewise gobbled up Ascend, Nexabit (for terabit routing), and Excel (for programmable switches).

Although both companies have used acquisitions to bolster their product offerings, the two have diverged a bit on standards. Lucent is primarily backing the iNow profile with Vocaltec and ITXC. Cisco, however, has joined the growing raft of vendors and service providers backing the Open Settlements Protocol.

But Cisco and Lucent are certainly not the only forces in the nascent market for IP/PSTN equipment. A small group of "softswitch" makers (a softswitch can handle multiple protocols and standards), including Sonus, Salix, and Convergent Networks have yet to be picked up by bigger players. Also, Vocaltec and Clarent, two of the primary IP-PSTN gateway/gatekeeper vendors, remain (mostly) independent. Nortel, 3Com, Siemens, and other established players remain on the prowl for new acquisitions.

Selected Vendor/Service Provider Alignments	
Vendor	IP Service Provider
3Com	USA Globalink
Cisco	GTE
	Equant
	iBasis
	Telstra Telecom Italia
Clarent	AT&T Global Clearinghouse
Ericsson	Delta Three
Lucent	AT&T Global Clearinghouse
	GRIC
	Level3
VocalTec	AT&T Global Clearinghouse
	Deutsche Telekom
	ITXC

Source: Philip Mutooni, iBasis, Inc.



for IP services. Level 3 has based much of its business plan on this concept, and Concert, the AT&T/BT international joint venture, will likewise rely on its own network for IP services—although Concert has yet to lay out exactly how and when it will migrate its PSTN traffic to an IP network.

The Clearinghouse

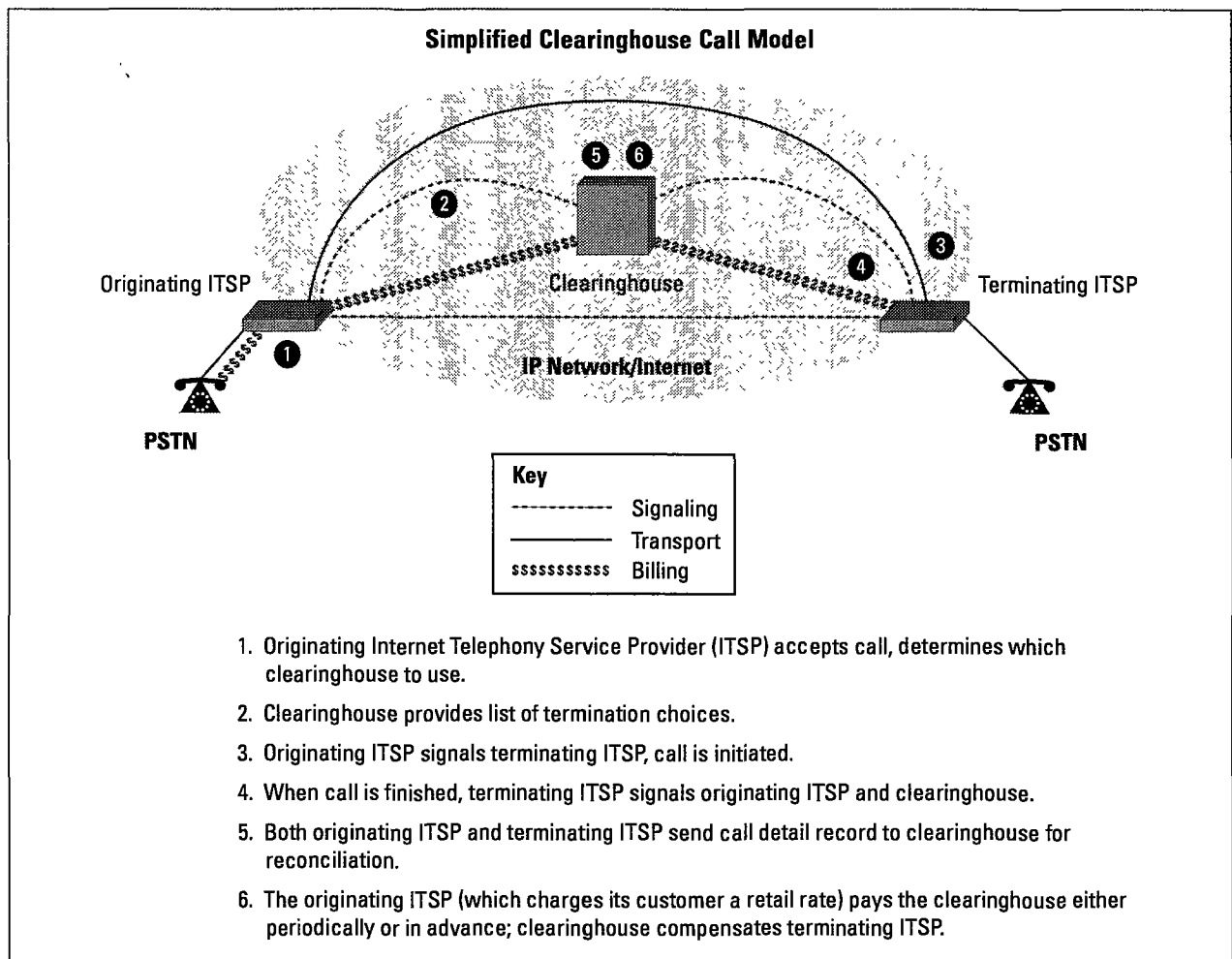
A clearinghouse provides an alternative to building a network of global POPs. A clearinghouse can take many shapes, but at its core is a common approach: connect call originators with call terminators; keep track of the minutes; and create a standard billing format for sharing the revenue. The clearinghouse model enables anyone with the appropriate gateway equipment to originate or terminate calls in their local service area. The multilateral nature of the clearinghouse also simplifies billing relationships and centralizes call monitoring.

Some clearinghouses, like those developed by GRIC and iPass, originated from alliances formed to provide global roaming for Internet access customers. Others, like those operated by iBasis (formerly VIP Calling) and ITXC, were specifically designed to offer VoIP interconnection and wholesale services. Clearinghouses differ from one another primarily in the implementation of standards and equipment as well as in the role that the clearinghouse network plays (see Figure 1, “Clearinghouse Networks and Standards”).

Standards and Protocols

On the PSTN, service providers rely on call detail records (CDRs) to resolve settlements issues. At this point, no single standard yet exists for IP call detail records, but they are still a key element to clearinghouse success. Furthermore, not all gateways used to connect IP networks to the PSTN are interoperable—which means that not all IP carriers can interconnect (see Figure 2, “IP/PSTN Equipment Makers”).

Figure 3. How a VoIP Clearinghouse Works



Note: Figure omits most ITSP network details, such as hubs, switches, gateways, gatekeepers, border elements, radius servers, and settlement servers.

Two prominent “open” clearinghouse models are iNOW (pioneered by Lucent, VocalTec, and ITXC) and OSP (backed by Cisco, iBasis, GRIC, and TransNexus). The iNOW (interoperability NOW) model (which ITXC has used with success) relies on homogenous gateway components and a limited range of services (due to its reliance on the ITU’s H.323 standard). Alternatively, the OSP (Open Settlements Protocol) model is being standardized by the ETSI

(European Telecommunications Standards Institute). The OSP system differs from iNOW primarily in its aim to host non-voice, next generation (VoIP) services and its ability to route calls between clearinghouses. In addition, the two models use different protocols to transmit calls and call detail records (see Figure 3, “How a Clearinghouse Works”).

Figure 4. A Guide to VoIP Standards, Protocols, and Vendor Forums

Standards Body	URL	Major VoIP Standards /Protocols	Notes
ETSI/TIPHON	www.etsi.org	OSP	Open Settlements Protocol provides XML-based IP traffic settlements
Internet Engineering Task Force (IETF)	www.ietf.org	SIP	Session Initiation Protocol enables voice over IP gateways and client end-points
		RSVP	Resource Reservation Protocol prioritizes packet traffic by use
		RTP/AVT	Real Time Protocol enables real-time transmission of audio and video (but doesn't promise it)
		MGCP	Media Gateway Control Protocol defines how different media (e.g., voice and video) will control data packets
International Telecommunication Union (ITU)	www.itu.int	LDAP	Lightweight Directory Access Protocol provides a universal address database for networks
		T.120	Real Time Data Conferencing (Audiographics)
		H.320	ISDN Videoconferencing
		H.323	Video (Audiovisual) communication on Local Area Networks
		H.324	Video and audio communications over low bit rate connections such as dial-up modem connections
Industry Forum	URL	Membership	Notes
International Multimedia Teleconferencing Consortium (IMTC)	www.imtc.org	Founded 1993, currently 145 members	IMTC covers H.323 (and other ITU standards), iNow, and others
Softswitch Consortium	www.softswitch.org	Founded 1999, currently 50 members	Focused on SIP/MGCP and other internetworking technologies
Internet & Telecoms Convergence Consortium	itel.mit.edu	Academic/corporate	Covers technical, economic, and policy issues
Industry Initiative	URL	Founders	Notes
Interoperability Now! (iNow)	www.imtc.org/act_inow.htm	ITXC, Lucent, VocalTec	Standards-based IP telephony interoperability profile for vendors and service providers based on H.323
IP Call Detail Record Initiative (IPDR)	www.ipdr.org	Jerry Lucas and 19 charter members	Goal is to define record protocol for IP traffic exchange and billing and submit to standards bodies for discussion
VON Coalition	www.von.org	Jeff Pulver and 22 charter members	Seeks to keep IP services as unregulated as possible and educate consumers and the media about relevant technologies

In addition to “open” clearinghouses, some IP carriers have set up proprietary systems for call routing and reconciliation. Obviously, the downside to a proprietary clearinghouse lies in its lack of interoperability with other clearinghouse systems. However, some major IP carriers like Delta Three have been willing to take that risk in order to speed their market entry.

Networks

Another factor in differentiating clearinghouses is network architecture. Some clearinghouses act only as brokers for bilateral and multilateral traffic exchange. Others add more value (and cost) by backing up the clearinghouse with managed public Internet connections or private IP networks (again, see Figure 1, “Clearinghouse Networks and Standards”). Three basic forms of clearinghouse network strategies have emerged so far:

1. *No core network:* Some clearinghouses take a “hands off” approach to the business of physically connecting clearinghouse participants, sometimes known as mediation. That is, the clearinghouse sets up the means for interconnection and reconciliation but lends no core network infrastructure to back up the clearinghouse. The Arbinet Global Clearing Network, for example, sets up VoIP minutes deals between buyers and sellers in the same way it sets up PSTN exchanges (although IP traffic only constitutes two percent of the total traffic transiting its trading floor on average).
2. *Managed public Internet network:* In addition to settlement services, other clearinghouses add value to the system with managed Internet backbones. For instance, although they differ in method, both ITXC and iBasis put

emphasis on routing traffic over monitored public Internet links (i.e., voice calls are transported simultaneously with web pages and other types of traffic). But because commercial quality VoIP calls can only be reliably terminated in a handful of countries, both companies have “failover” plans for completing calls using backup private lines, refile arrangements, or traditional PSTN correspondent relationships. In some cases, the effect of PSTN termination costs can be considerable. ITXC and iBasis have both cited the “failover” cost of terminating PSTN calls as a major short term obstacle to profitability.

3. *Private IP network:* Another, slightly different model, puts private IP links at the center of the network. In the networks implemented by Delta Three, GRIC, and GTE, traffic is primarily routed over private network infrastructure which does not compete with public Internet traffic. (Level3 and Concert may follow this course too.) Although this method is more expensive than relying on the public Internet for transport, private links are easier to monitor for network congestion problems. Again, however, supplemental PSTN routing plans are essential to account for possible private network outages.

Call Rating

Since the early days of the Internet, ISPs have exchanged traffic at public and private peering points where their networks interconnect. And, as the Net has evolved, the compensation model has moved from a “sender keeps all” system to one where network quality, breadth, and bandwidth adjust the terms of interconnection (i.e., small ISPs usually pay big ones to connect). This trend has become acute in

Figure 5. IP Carriers, Traffic, and IPOs

Company	Reporting Period	IP Traffic (minutes)	Total Revenues	IPO Date	IPO Goal	Market Cap.
Delta Three (NASD: DDDC)	1/98 - 6/98 1/99 - 6/99	n.a. n.a.	\$2.2 m \$4.3 m	pending	\$55.7 m	—
GRIC (NASD: GRIC)	1/98 - 6/98 1/99 - 6/99	n.a. n.a.	\$2.5 m \$3.1 m	pending	\$50.0 m	—
iBasis (NASD: IBAS)	1/98 - 6/98 1/99 - 6/99	1 m 48 m	\$0.2 m \$6.0 m	11/10/99	—	\$1.2 bn
ITXC (NASD: ITXC)	1/98 - 12/98 1/99 - 9/99	5 m 78 m	\$1.9 m \$14.3 m	9/28/99	—	\$1.4 bn
Net2Phone (NASD: NTOP)	8/97 - 7/98 8/98 - 7/99	42 m 229 m	\$12 m \$33.3 m	7/28/99	—	\$582.2 m

Note: Total revenue figures include services, software, and equipment in addition to per minute charges for IP voice and fax services. Market caps current to November 11, 1999.

Source: Company reports

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the case of voice traffic delivery. Because voice traffic is extremely sensitive to the speed and accuracy with which IP packets are delivered, the typical “best effort” transport of Internet traffic is insufficient to replace switched service networks.

Traditionally, long distance service providers have defined call rating within the terms of usage and distance. In order for large volumes of voice traffic to move on to IP networks, a call rating system which takes quality of service (QoS) into account is a prerequisite. And, because IP networks can also transport non-voice but equally sensitive usage-based XoIP traffic (i.e., multicast and video), some rating systems also take into account “class of service”. Currently, however, standards for exchanging XoIP traffic are still in development (see Figure 4, “A Guide to XoIP Standards, Protocols, and Forums”).

The End Game

In relative terms, VoIP is still a small business. In 1998, IP calls accounted for approximately 300 million minutes of international traffic—less than 0.5 percent of the world’s traffic—and will probably not exceed one billion in 1999. Although this high growth rate may continue in the short term, the significant technical obstacles to IP-based voice services (i.e., quality, reliability, and interoperability) ensure that VoIP will not erode PSTN traffic as fast as many analysts have predicted.

Also, it is hard to ignore the fact that the world’s established base of telephone companies have sunk billions of dollars into equipment which uses SS7—a protocol for call set up and record keeping that is not designed to work with IP networks. This means that some enhanced services integrated into SS7 (like caller ID, call forwarding, and local number

portability) will not work if part of a call is routed over existing IP gateways.

But these problems, while significant, are concerned with what happens at the ends of the IP network, and are outside the scope of this essay. We began with a question concerning what happens in the middle: How do IP carriers exchange traffic and settle accounts? Briefly, this can be answered thus:

- VoIP carriers are using a combination of self-contained networks, bilateral correspondence, and multilateral clearinghouses to exchange traffic.
- Service providers settle with one another based on non-standardized VoIP call detail records, which can (in some cases) encompass call quality, as well as distance and usage.
- Current VoIP settlement systems are still evolving, and as yet, are not profitable largely due to the cost of porting traffic to the PSTN where IP termination options don’t exist or are unreliable.

Because VoIP carriers still carry relatively low volumes of traffic, are not always interoperable with each other, and have no standard method for transmitting next generation XoIP services, much of this subject matter remains unpredictable. One thing is clear, however: the market believes IP will work, and its constituents have already put in enough time, money, and effort to guarantee that it will. 🔑

TeleGeography gratefully acknowledges the technical advice of Philip Mutooni of iBasis, Inc. in developing this article.

Internet Governance: Then and Now

Governance at the Core

Dramatic growth has transformed the Internet, once an experimental research network, into both a quasi-public global infrastructure and a very big business (see Figure 1). By going global and by going commercial, the Internet's management priorities have shifted. The result: innovation is giving way to stability and experimentation is sacrificed for predictability. Companies are less likely to take risks on untried, even if technologically superior, designs.

The Internet, now comprising thousands of distinct private networks, has always required some core management layer to track its existing interconnection standards and improve them when necessary. This "core" also has been responsible for allocating scarce resources. The registration of names, like www.telegeography.com, and network numbers, like 209.8.150.94, as well as the operation of central "root server" databases to link the names and numbers together, are part

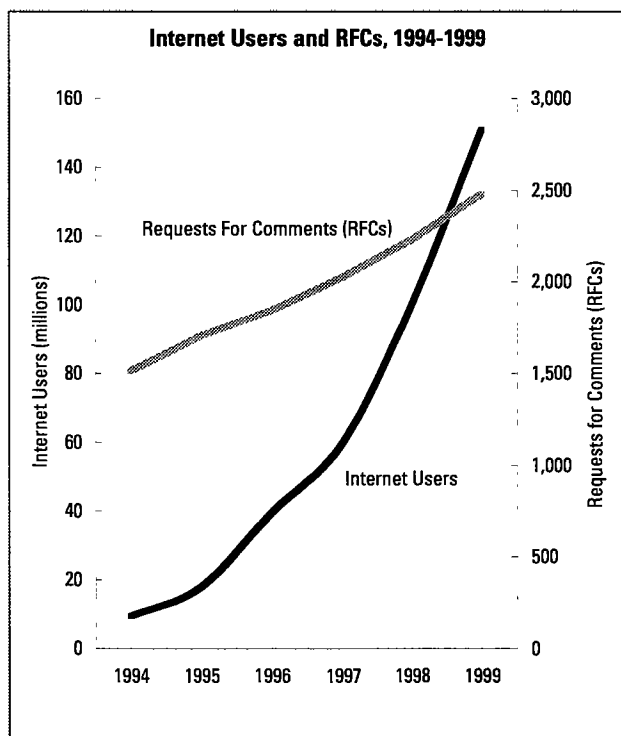
of a centrally-managed global address space. The management of these critical internetworking processes is at the heart of Internet governance.

Standards

Despite the pressure for change, the Internet still adopts technical standards much as it has since the 1970s, when a forum called the Internet Configuration Control Board (ICCB; see Figure 3) was formed to coordinate the process. The Internet Activities Board (IAB, now the Internet Architecture Board), which took the ICCB's place in 1983 and has orchestrated the Internet since, is a standards forum for the engineers which make the Net run.

A somewhat shaky scaffolding for Internet governance has grown up around the IAB. First, in 1989, the ever-growing and increasingly unwieldy Board was subdivided. The IAB, still responsible for Internet standards, yielded increased responsi-

Figure 1. Growth of Internet Users and RFCs



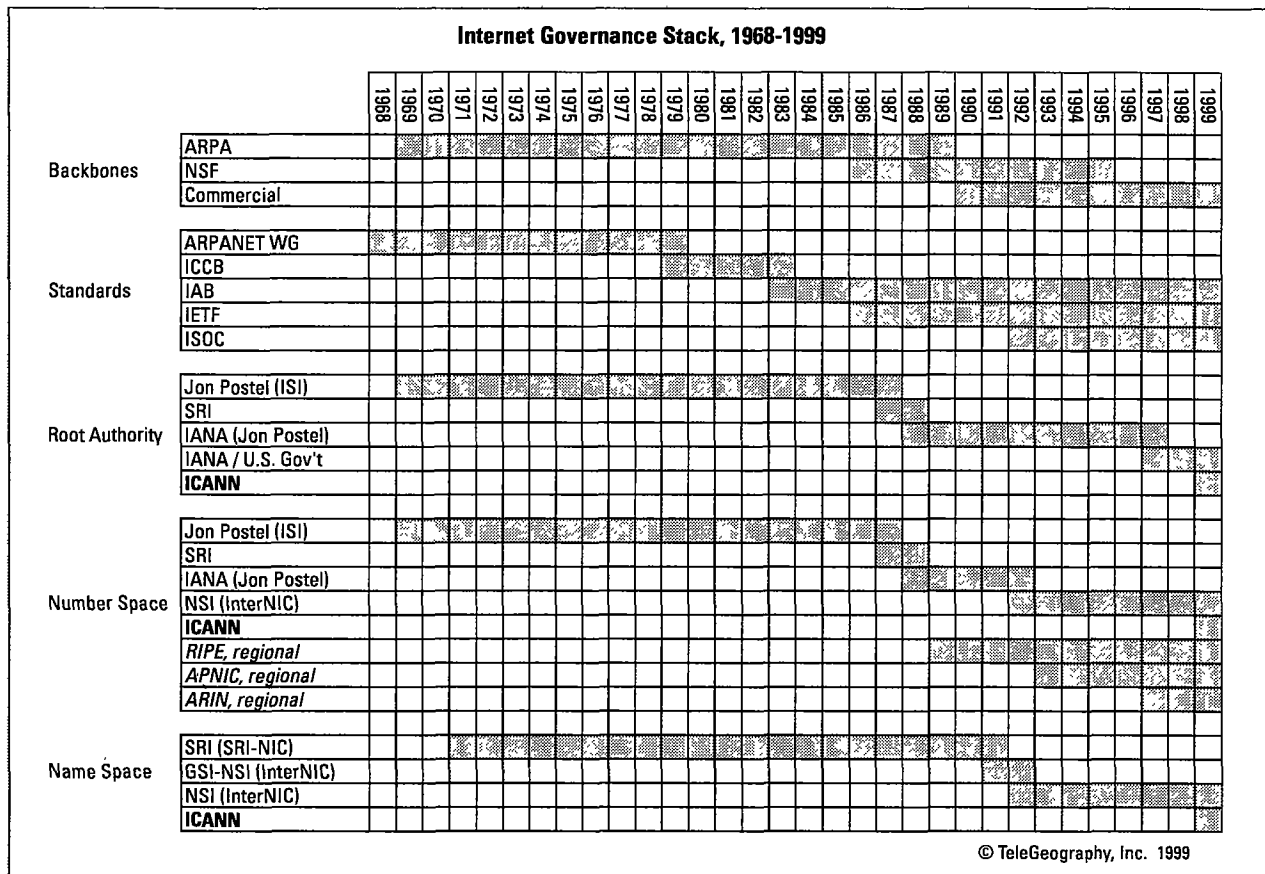
Source: Computer Industry Almanac, RFC archive

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There are many ways to chart the Internet's growth. Because they can be statistically sampled, counting Internet-connected host computers is one of the more popular ones; since 1994, the worldwide Internet user population has leapt from just under 4 million to over 160 million. The Internet's routing table provides another growth indicator. A routing table is a constantly updated road map which guides traffic between all those computers; in October 1999, the table contained as many as 70,000 routes—more than four times larger than it was in 1994. And a third handle on the expanding Internet is via the venerable UseNet feed which distributes public discussion groups around the world. UseNet has grown from 25 to 70 gigabytes in the last year alone, a far cry from the 700-odd megabytes (that's under 0.7 GB) that a full news feed demanded five years ago.

But to understand the consequences of Internet scaling, take a look at who's involved: the ratio of builders to users has changed. In the 1990s, the Internet's user population appears to have been growing at a compound annual rate of 80 percent, far outstripping the Internet's working papers, called Requests For Comments, which have accumulated at 10.8 percent annually. As a new medium, the Internet was a bubbling community of technical inventors, constantly reinventing the network. With widespread adoption, the goal for the Net's manager is to ensure a robust operating environment.

Figure 2. The Internet Governance Stack



There was a time when the Internet was accused of being anarchic. That was never quite true. Anarchy seeks to abolish central authority; the Internet disaggregated it, dividing the governance of its core functions into a series of layers—a counterpart to networking’s seven-layer Open Systems Interconnect (OSI) stack. To critics, ICANN doesn’t have the look and feel of the Internet. The Internet governance stack shows why: ICANN’s scope works against the trend, aggregating multiple governance functions within a single organization. Good corporate strategy in a competitive market, perhaps—but will it play on the Net? Here are the layers:

Backbones - Information moves across the Internet via long-haul networks, known as backbones. The first backbone was funded by the U.S. military’s Advanced Research Projects Agency (ARPA), which earned it the name ARPANET. The backbone function was taken over by the U.S. National Science Foundation (NSF)’s NSFNET in 1987. Following the creation of the Commercial Internet eXchange in 1991, commercial traffic began to play an increasing role, and by 1995, the NSFNET went back to being a research network: commercial providers had taken over the backbone function. Today, the Internet’s backbone consists of a series of interconnecting private networks. Terms for interconnection are likewise a private matter, although some governments have begun

to take a closer look at the market power of the largest backbone operators.

Standards - The Internet’s core feature is interoperability, which depends on agreeing on standards for implementing new technical features. Until Vint Cerf, then at ARPA, instigated the Internet Configuration Control Board (ICCB)’s formation in 1979, the lead role in Internet standards was played by the ARPANET Network Working Group, later known as the Internet Working Group. A series of reorganizations have replaced the ICCB with the Internet Activities Board (IAB, later the Internet Architecture Board, 1983), which was joined in 1989 by the Internet Engineering Task Force (IETF) and Internet Engineering Steering Group (IESG).

Root Authority - At the root of the Internet’s number addressing and naming system is the responsibility for coordinating their allocation and propagation through a distributed system of computer directories. For most of the Internet’s life span, that responsibility fell to the late Dr. Jon Postel, first informally from his base at the University of Southern California’s Information Sciences Institute (ISI), and then, following an attempt to aggregate this function into the activities of the SRI Network Information Center (see “Name Space”, below), formally as director of the Internet

(continued)

bility to a subcommittee called the Internet Engineering Task Force (IETF), made up of eight functional areas, and to an Internet Engineering Steering Group (IESG), made up of IETF area leaders. This symbiotic process—the IETF nominates twelve of the IAB’s thirteen members, and populates the IESG with its area leaders—took on its current institutional form in 1992 when the IAB was formally “chartered”, or recognized, by the newly-conceived Internet Society (ISOC) as the Internet Architecture Board.

ISOC is a U.S.-based professional membership society created to act as a non-governmental institutional and fund-raising umbrella group for the Internet. A self-described “international organization for global coordination and cooperation on the Internet,” ISOC’s creation marked the Internet’s first non-governmental coordinating body. As the seat for the standards process, ISOC has hinted over the years that it would like to be responsible for other areas of Internet governance, too. Its annual “Inet” conference (www.isoc.org/isoc/conferences/inet) is meant to be the world’s yearly face-to-face Internet meeting. And it has sponsored key initiatives to enable Internet access to unconnected parts of the world. But ISOC’s constituent standard-setting bodies continue to be the Society’s main contributions to Internet governance.

So how do technical standards get adopted? The process isn’t too different from an academic review process, and relies on a document series called Requests For Comments (RFCs, searchable at www.rfc-editor.org). There are four steps.

1. *Informal circulation* - RFCs begin life as Internet-Drafts, allowing the internetworking community to provide comments and criticism prior to formal submission. Anyone can propose an Internet-Draft by outlining their specification according to a well-defined format (detailed in RFC2223) and submitting it to internet-drafts@ietf.org. The draft is then circulated on a general e-mail list, abstracted on www.ietf.org/1id-abstracts.txt, and placed for a six-month period in a public archive ([ftp.ietf.org/internet-drafts](ftp://ftp.ietf.org/internet-drafts)). After that, the author may decide to revise and resubmit the proposed standard as a new Internet-Draft, or to take it to the next step—submission.

2. *RFC submission* - An author who wants to escalate the Draft to an RFC must specify an RFC category. There are two. A standards-track RFCs may either be approved as a Technical Specification (TS) or as an Applicability Statement (AS), depending on its scope. A non-standards-track RFCs must seek approval as Experimental, Informational, or Historic.

A third type of RFC is referred to as Best Current Practice (BCP). BCPs are queue-jumpers: as a mechanism for area group heads (IESG members) or IAB members to make programmatic statements, they cut through the process and head straight to approval and publication. Standards- and non-standards-track RFCs need to be reviewed first.

Figure 2. Internet Governance Stack (continued)

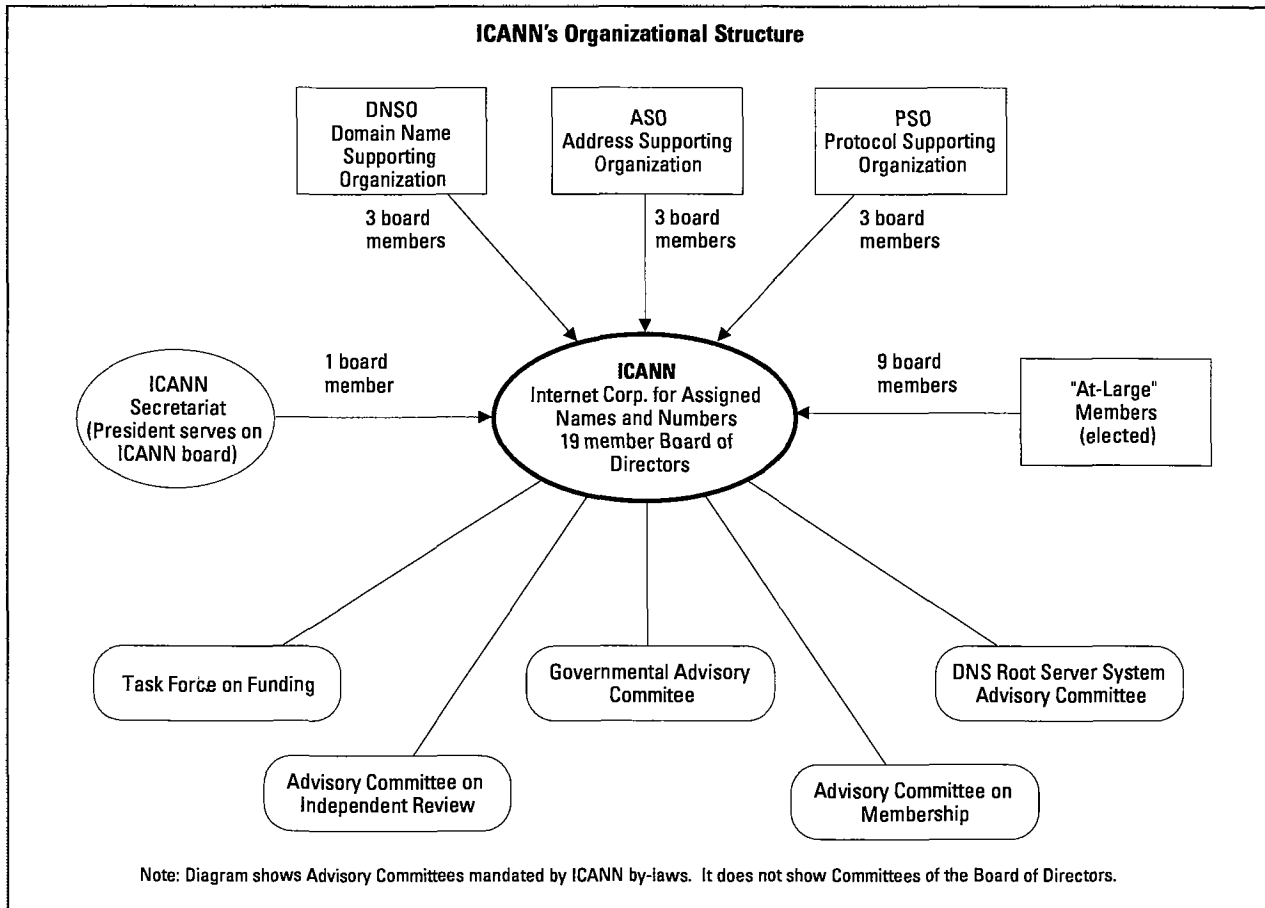
Assigned Numbers Authority (IANA; see www.iana.org/postel), which was chartered by the U.S. government (see the International Forum on the White Paper, www.ifwp.org). ICANN acquired responsibility for root authority functions in 1999, with a U.S. government transitional oversight period to end in September 2001. Beyond numbering and naming, one of the functions ICANN absorbed from IANA is to coordinate the identifiers and other constants used by the standardized protocols developed by the IETF and similar bodies. That function is helped along through the advice of the ICANN’s Protocol Supporting Organization (PSO) subcommittee, whose members include relevant standards bodies such as the IETF, W3C, ITU, and ETSI. For details on ICANN’s protocol parameters role, see www.iana.org/numbers.html and RFCs 2434 and 1700.

Number Space - The numbering registry assigns and records Internet addresses. Until 1992, numbering had been aggregated into the root authority role played by Jon Postel, SRI, and IANA. Network Solutions Inc. (NSI), a spin off of U.S. government contractor Government Systems Inc. (GSI), was then contracted to hand them out, part of NSI’s operation of the InterNIC (Internet

Network Information Center, see “Name Space”). A series of regional registries were created to delegate numbers in Europe (RIPE, 1989), Asia (APNIC, 1993), and the Americas (ARIN, 1997). ICANN was assigned the central numbering role in 1999.

Name Space - For most of the Internet’s lifetime, generic top level domain names like .com and .net—and the host tables that preceded them—were managed by government contractor SRI International (formerly the Stanford Research Institute) through the Network Information Center it operated, usually known as SRI-NIC. This was delegated to a corporation called Government Systems Inc. in 1991, who spun off Network Solutions Inc. as a subsidiary, continuing to operate the InterNIC until 1998, when it re-branded the service as Network Solutions (www.networksolutions.com) in anticipation of coming market competition and ICANN’s central role in the process. Controversy on ICANN’s role in domain names has run rampant. But the name space is only the most visible layer of the Internet’s core governance stack.

Figure 3. ICANN: The Bottom Up



ICANN Organizational Glossary

ICANN - Internet Corporation for Assigned Names and Numbers. Non-profit corporation acting as the Internet's central coordinating body; took over from the Internet Assigned Numbers Authority (www.icann.org). Decision-making power lies with the 19-member Board of Directors. Three Supporting Organizations (SOs) provide substantive policy recommendations for specialized matters, and each sends three representatives to the Board. These SOs are:

DNSO - Domain Name Supporting Organization - Members include generic and country code domain name registries, global registrars, ISPs, trademark and intellectual property interests, business interests, and non-commercial domain name holders.

ASO - Address Supporting Organization - Members include:

ARIN - American Registry for Internet Numbers. Allocates IP addresses in the Americas and southern Africa. Based in Chantilly, Virginia (www.arin.net).

RIPE NCC - Réseaux IP Européens Network Coordination Center. Allocates IP addresses in Europe, former Soviet Asia, the Middle East, and northern Africa (see list at www.ripe.net/lir/registries/indices). Based in Amsterdam.

APNIC - Asia-Pacific Network Information Center. Allocates IP addresses in most of Asia and Oceania. Based in Brisbane, Australia (www.apnic.net).

PSO - Protocol Supporting Organization - Members include:

IETF - Internet Engineering Task Force (www.ietf.org).

W3C - World Wide Web Consortium. Develops standards for the Web. Based at Massachusetts Institute of Technology in Boston, Institut national de recherche en informatique et en automatique in France, and Keio University in Fujisawa, Japan (www.w3.org).

ITU - International Telecommunication Union. Specialized agency of the United Nations for coordination of global telecom networks and services. Based in Geneva (www.itu.int).

ETSI - European Telecommunication Standards Institute. Stakeholders' forum for coordinating telecommunications equipment and services standards in Europe. Based in Sophia Antipolis, France (www.etsi.org).

3. *Review* - Here the area group heads who form the IESG, or even an IETF working group itself, swing into action. If reviewing a standards-track (TS or AS) RFC, they designate it as a Proposed Standard, Draft Standard, or full-fledged Internet Standard, based on the level of implementation and experience that stands behind the document. A non-standards track proposal is adopted under the Experimental or Informational categories, or designated as Historic.

4. *Publication* - Once approved, the document is edited and published on-line as an adopted RFC. For RFCs with the highest adoption level, this step involves a new name. Internet Standards documents are streamed into the STD series; Best Current Practices documents are designated as BCP.

There's more to it, of course. As Internet Protocol (IP) networks become a basic element of the global public network, vested interests are putting pressure on the process. Controversy erupted in October 1999 when the agenda for an upcoming IETF meeting included, for example, action on a U.S. Government proposal to use the sixth version of Internet Protocol (IPv6)—the standard for the Net's next operating system (see "Scaling," below)—to facilitate phone-tapping by law enforcement officials, based on a 1994 U.S. law which requires telecommunications network operators to accommodate lawful electronic surveillance.

Corporate maneuvering is introducing pressure, too. Witness the dramatic rise in vendor participation in the process. Nonetheless, an RFC entitled "The Tao of IETF" is still a widely read reference point on the group's spirit (RFC1718). And the ISOC-governed standard-setting process which configures the Internet remains open, asynchronous, informal, and collegial—a native Internet application.

Address Space Allocation

IP numbers are the 32-bit numeric addresses to which domain names correspond; they let routers know where traffic is coming from, or going. When a network device has an IP number, it is globally addressable, and when it doesn't, it's not technically on the Internet. While the IAB/IETF and its predecessors were taking care of standards, massive blocks of address space comprising tens of millions of numbers were being handed out by the address space's then-central governor, Jon Postel of the Internet Assigned Numbers Authority (IANA), to a few companies and universities who asked for them.

The Net's original architects first imagined around 100 hosts on the Internet, so earmarking enough space in each IP packet header to allow for about four billion addresses seemed more than safe. Yet as Net use surged in the early 1990s, engineers feared a quick depletion of addresses: not only had the Internet grown beyond all expectations, but numbers had been assigned in large blocks, many of which went unused.

To compensate, allocation of the address space is now severely restricted by the three regional registries which distribute them from headquarters in the world's three telecommunication axes: Asia (www.apnic.net), the Americas (whose registry is also responsible for sub-saharan Africa, www.arin.net), and Europe (also responsible for North Africa and the Middle East, www.ripe.net). The current distribution of IP numbers underscores the imbalance of power between the United States and the rest of the world, and between the large firms who were Internet pioneers and newer companies. Governments like China's complain that relative latecomers to the Net have fewer address resources, notwithstanding their population and economic needs.

Others retort that address allocation is based on the geography of cyberspace, not physical topography or geopolitics. But everyone acknowledges that IP addresses are hard to come by, even with techniques like Classless Inter-domain Routing (CIDR), which disaggregates some of those huge blocks of numbers, or judicious use of Network Address Translators (NATs), which hide entire private networks behind a single address. Address space is still a scarce and valuable resource.

Enter the Internet Corporation for Assigned Names and Numbers, with the reassuring acronym ICANN (see Figure 2). It is IANA's successor, and the oversight body meant to referee the address space debate and set things straight for the future. It was created in 1998 as a U.S.-chartered non-profit organization with an international board. And although it was originally funded by loans from powerful Net companies like IBM and MCI, it is committed to representing a broad Internet constituency. ICANN manages IP addressing policy, domain name policy, and the central root servers linking them. Its mandate is to be international, bottom-up, and non-governmental, a counterpart to the already-existing Internet Society.

Already, though, ICANN is facing challenges to the naming and numbering system. In August 1999, the European Telecommunications Standards Institute (ETSI) made a bold bid for a lead role on ICANN's Address Supporting Organization, proposing to harmonize IP addresses, domain names, and telephone numbers. ICANN responded with the time-honored tactics of diplomacy everywhere: it created a committee to study the issue and report back in a year.

Until now, the Internet's success has been based on its ability to continually develop in radical ways. When Jon Postel was the sole arbiter of names and numbers—a role he, and IANA, played until Postel's death in October 1998—decisions were made quickly and new ideas encouraged. The lack of formal structure freed the process from bureaucracy, and decisions were based on engineering arguments, not lobbying. But while the process was relatively straightforward as an engineering matter—little vanity or power politics were involved—it was never institutionalized until the Internet was a billion dollar

industry. ICANN's fundamental contradiction is in seeking to retain that fast-moving and free-wheeling process even as it is controlled by big business, which has an inherent interest in seeing that radical developments come slowly so that commerce can adapt.

As 2000 rolls around, corporate maneuvering and vitriolic politics have taken center stage. ICANN's Government Advisory Committee was savaged by critics who denounced it as a plan to regulate cyberspace (see summary at www.cookreport.com/icannregulate.shtml). And the United States' House Commerce Committee in July 1999 held hearings under the highly-charged title, "Is ICANN Out of Control?"

Scaling the Network

Remaining usable address space continues to shrink, while the huge routing tables which contain traffic directions continue to grow. If international IP networks are to continue to interoperate—and the resulting Internet to keep running—then ICANN, or its successor, must quickly provide an answer to the Commerce Committee's question. Partly to deal with address and routing problems, the IETF developed a new, sixth version of the Internet Protocol in 1994. Lacking incentive to compensate for the cost and time it takes to upgrade, most networks have balked at adopting it: networks on the public Internet are struggling just to keep up with growth. Guiding the difficult implementation process, and working collaboratively with its ISOC organization counterparts to do so, will be one of ICANN's biggest challenges.

IPv6 will replace the current IPv4 (IPv5 exists experimentally) with a 128-bit numbering space. That opens up more than 2^{128} addresses (that's 340 trillion trillion trillion), which should be enough to go around. IPv6 also includes a flexible, hierarchical numbering scheme to simplify routing table management, as well as security mechanisms, quality of service and multicast provisions, and other improvements. While some research networks participate in the 6bone (www.6bone.net) and other test beds, few expect widespread IPv6 deployment before 2003. Microsoft's influential Windows 2000 product, for example, is scheduled to ship without an IPv6 implementation.

Around the corner is a fleet of networks and businesses ready to deploy huge blocks of IPv6 space, however. As more and more information and communication devices link to the

Internet to reap the benefits of interoperability, mobile telephony operators are in a golden position, deploying data applications over hybrid phone/computing devices. With more than 300 million mobile telephone subscribers—dwarfing the Internet's 65 million hosts, or even its 200 million users—a simple move to equip all mobile customers would necessitate the switch to the newer protocol.

And a deluge of IP addresses could be used elsewhere, like television video game consoles and cable-passed households, automobiles, and various already-existing appliances. A lot of companies will be scrambling to get hold of huge swathes of IP address space; the process began in July 1999, when IANA delegated the first IPv6 address space to the three regional registries (see www.ipv6.org). The trend will snowball: as machine-to-machine traffic begins to move onto the Internet, the killer app for IPv6 might turn out to be the least intuitive, such as *net-enabling some alarms in every hotel room, or locks on windows and doors*. Provided the cost of obtaining IP address space is not excessive, its deployment is finally in sight.

For network operators, that holds out hope for seeing the squeeze on address space loosen, routing table overload lessen, and the U.S.-centric name space diffuse. For telegeographers, it is a numbering explosion that will complete the fusion of physical and virtual layers—an interneted globe where electronic terrain is part of the built environment.

If this scenario is to take place successfully, management of the Internet's core must adapt to its new operating environment. That will mean learning to scale the legacy governance models of the standards process as new bodies like ICANN come online. Representing the new and ever-growing cast of Internet stakeholders, ICANN was to be an entity that, unattached to traditional geopolitical diplomacy, could move more quickly than governments do. But priorities have shifted—rather than a perpetual revolution, today's Internet is moving toward slower evolution. The question is whether governance of the Internet's shared resources can or should evolve with it. 🔑

Traffic Analysis

Overview of International Traffic Trends

Telecom executives and government policy-makers heralded 1998 as a year of great change. Country commitments placed with the World Trade Organization (WTO) and liberalizing directives of the European Union (EU) were to open two dozen national markets to competition. Most believed that new carriers would drive down prices and stimulate traffic volumes.

Although prices did drop in 1998, call minutes did not increase apace. Globally, the annual growth rate of international call minutes actually fell—from 15 percent in 1997 to 12.5 percent in 1998. But this global statistic masks significant regional variations:

Regional Patterns

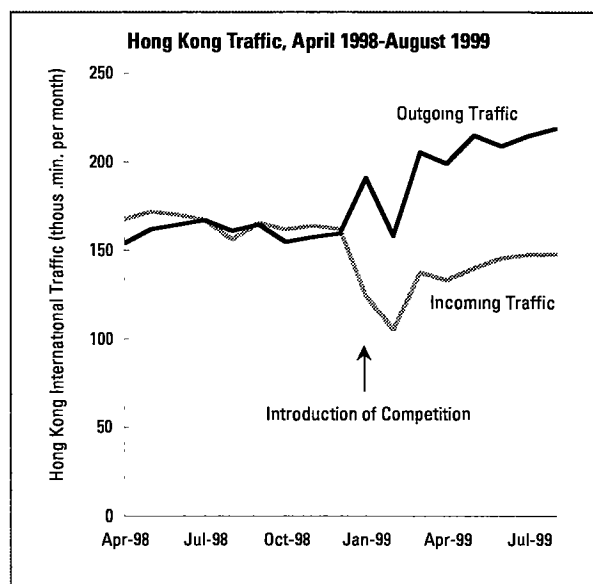
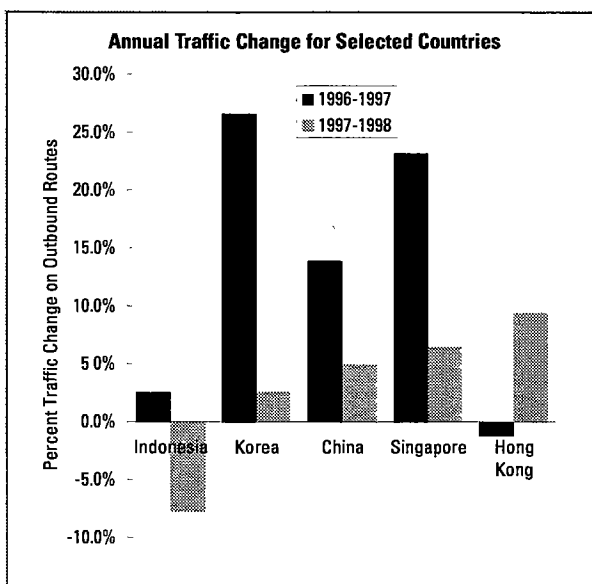
- *Europe.* For Western Europe, growth predictions did hold true. Each of Europe's major economies experienced higher rates of call volume growth in 1998 with the introduction of full scale competition. Germany served as a striking example: after a paltry 1.1 percent outgoing minute increase in 1997, the burst of competition in 1998 helped usher in growth rates above 14 percent.
- *Asia.* Compared to the wide open markets introduced to continental Europe, competition in Asia remained relatively limited. More importantly, however, the 1997 Asia financial

crisis finally hit the international telecom service industry. Nearly every major market experienced noticeable declines in outgoing traffic growth rates (see Figure 1).

Hong Kong, where outbound call minutes grew by nearly 10 percent, stands out as a significant exception. Almost all of this growth occurred during the fourth quarter of the 1998/1999 fiscal year—immediately after the introduction of competition for voice International Simple Resale (ISR). Still, overall traffic volumes to and from Hong Kong barely changed. Instead, most of the new outgoing call minutes were drawn from Hong Kong's incoming traffic flows, as customers switched from call-back to Hong Kong-based leased line resellers at the beginning of 1999.

- *Americas.* Telephone traffic from Latin America and the Caribbean increased 20 percent, mostly due to price cuts by incumbents. Call minutes from the U.S. and Canada, however, increased by a relatively anemic 9 percent. The reasons for this apparent drop are not entirely clear. Traffic statistics from the U.S. and Canada include some refile traffic; many countries may have shifted their reorigination traffic away from North America to other hubs as new markets opened in 1998. More likely, the slower growth rate reflects maturing telecom markets. With call charges already low,

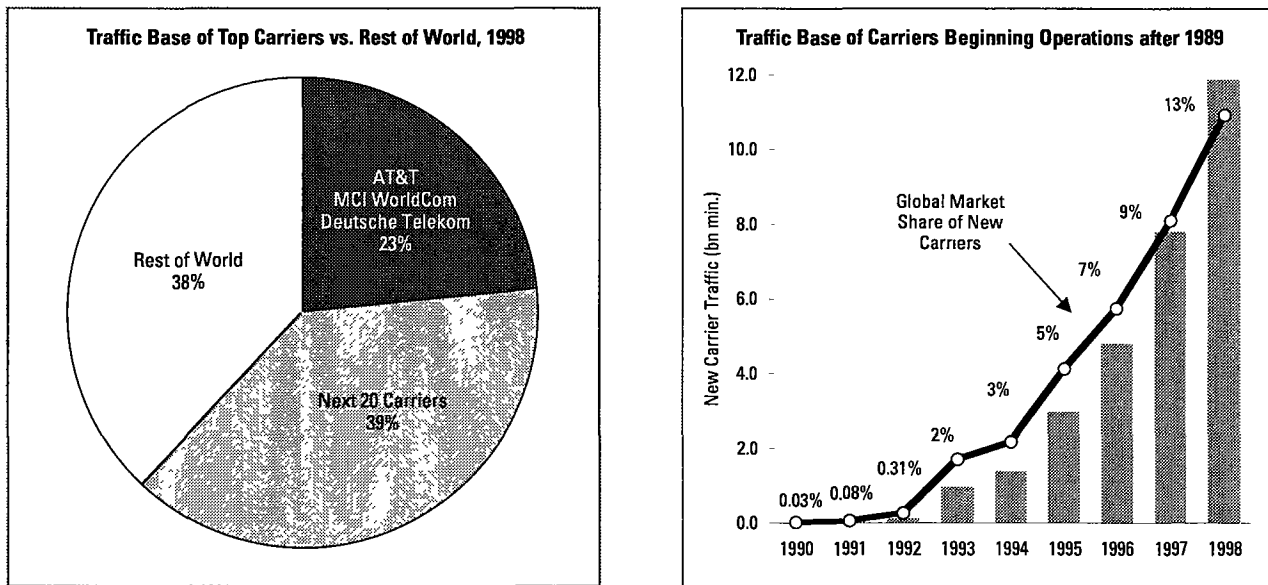
Figure 1. International Traffic in Asia, 1996-1998



Source: Office of the Telecommunications Authority (Hong Kong), TeleGeography, Inc.

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Figure 2. Traffic Base of Incumbent and New Carriers



Note: Top carriers are ranked by outgoing international call minutes. AT&T, MCI WorldCom, and Deutsche Telekom carried 27 percent of global traffic in 1997. "New Carrier Traffic" includes only carriers that began facilities-based operation after 1989.
 Source: TeleGeography, Inc. © TeleGeography, Inc. 1999

end users are no longer responding to price cuts with the same degree of increased demand as they did in previous years. Sluggish growth in the U.S. and Canada thus dampened global growth considerably. From 1990 to 1997, U.S. carriers' share of worldwide international call minutes grew from 22 to 28 percent. In 1998, the U.S. share receded to only 26 percent of global traffic.

Global Trends

Despite regional variations, a number of worldwide trends did emerge:

- *Shrinking elasticity of demand.* The phenomenon of call volume growth lagging behind the pace of price cuts was not confined to North America. Many international carriers experienced significant decreases in international service revenues as they slashed prices to meet competition. Telecom New Zealand's experience stands out as an extreme example. Although lower tariffs stimulated a 45 percent increase in outbound call minutes, Telecom's revenues on these calls dropped 24 percent.
- *Shift to new carriers.* One segment of the international telecom service industry experienced unambiguous growth in 1998: new competitors (see Figure 2). By offering low rates on specialized routes, second tier carriers began to take minutes—not merely relative market share—away from incumbents. For the first time ever, AT&T and MCI WorldCom carried fewer international outgoing minutes on

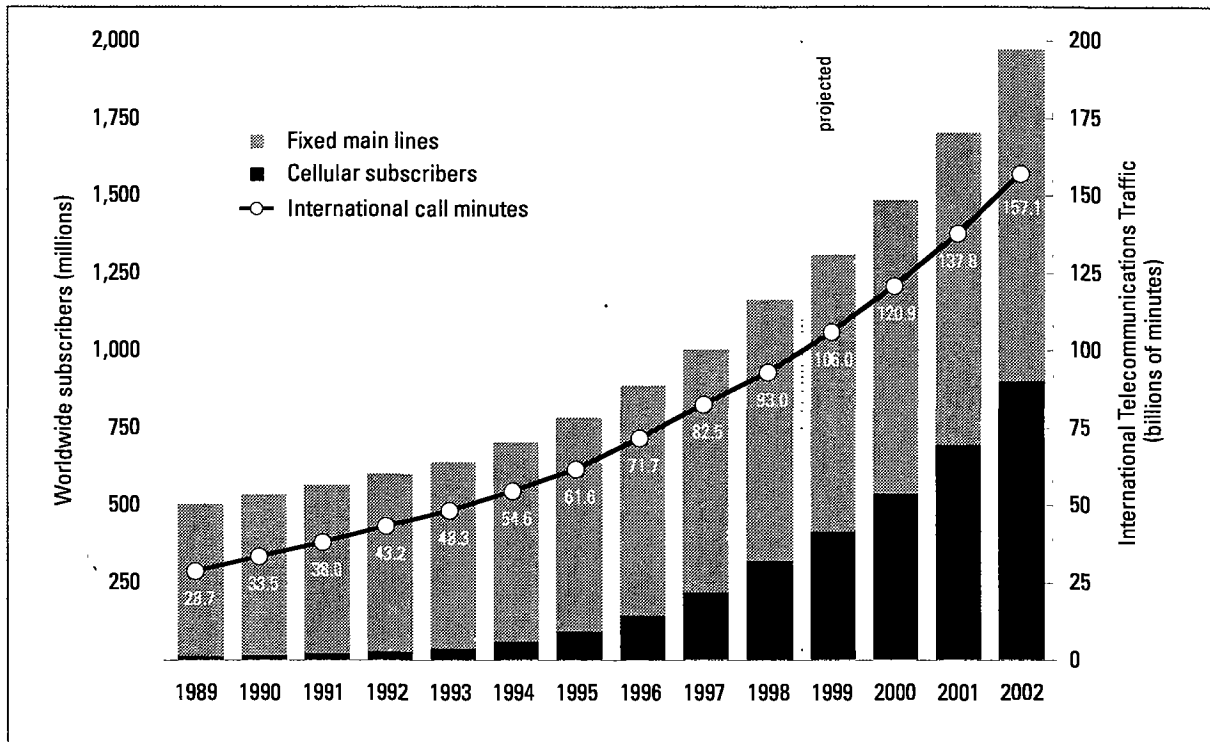
their own networks in 1998 than in 1997. Meanwhile, traffic carried by competitors and resold by AT&T and MCI WorldCom increased by 1.5 billion minutes.

- *Alternative Traffic.* The much anticipated Internet Protocol (IP) telephony boom did not happen in 1998. TeleGeography estimates that only 300 million international minutes were carried as IP traffic. ISR represented a much more significant departure from the public switched network. In 1998, carriers sent nearly 5 billion minutes over leased private lines; much of this traffic was refile. The U.S. route stands out as particularly prominent. Canadian carriers sent over 40 percent of the country's outbound call minutes as ISR or refile via the United States. It remains to be seen whether these minutes reflected a temporary phenomenon prior to Canada's full market liberalization in October 1998 or a permanent trend to be replicated elsewhere.

The following pages provide further detail on international traffic trends. Charts, maps, and tables review 1998 traffic on a global, regional, and country-by-country basis. An analysis of international calling to and from mobile networks examines some of the variables driving international traffic on cellular phones. Finally, an overview of alternative settlement arrangements offers a snapshot of refile, call-back, ISR, and IP telephony traffic. 🔑

Global Traffic Review

Figure 1. International Traffic and Main Line Growth



Note: Data include outbound international traffic on public networks only. Projections assume 14% traffic growth, 6% main line growth, and 30% mobile subscriber growth annually. Source: ITU, TeleGeography, Inc.

© TeleGeography, Inc. 1999

Figure 2. International Traffic, Revenue, and Subscriber Growth

Indicator	Historical Trend			Slow Growth		Same Growth		Fast Growth	
	1989	1998	CAGR 1989-98	2002	CAGR 1998-2002	2002	CAGR 1998-2002	2002	CAGR 1998-2002
Calls (bn)	6.1	28.8	18.7%	48.8	14.0%	52.4	16.1%	56.1	18.1%
Minutes (bn)	28.7	93.0	14.0%	146.3	12.0%	157.1	14.0%	168.4	16.0%
per main line subscriber	52.9	110.1	8.5%	139.4	6.1%	146.1	7.3%	153.1	8.6%
per main line plus mobile	52.2	80.0	4.9%	79.1	-0.3%	79.5	-0.1%	80.2	0.1%
Revenue (US\$ bn)	30.4	69.0	9.5%	73.2	1.5%	70.7	0.6%	67.4	-0.6%
Assumptions									
Call length (mins)	4.3	3.2	-3.1%	3.0	-1.8%	3.0	-1.8%	3.0	-1.8%
Price per minute (US\$)	1.16	0.74	-4.8%	0.50	-9.4%	0.45	-11.7%	0.40	-14.3%
Main lines (m)	497	845	6.1%	1,050	5.6%	1,075	6.2%	1,100	6.8%
Mobile subscribers (m)	7	318	52.3%	800	25.9%	900	29.7%	1,000	33.2%
Total subscribers (m)	504	1,163	9.7%	1,850	12.3%	1,975	14.2%	2,100	15.9%

Note: 1989-98 based on reported data. 1999-2002 based on ITU and TeleGeography forecasts. Scenarios are as follows:

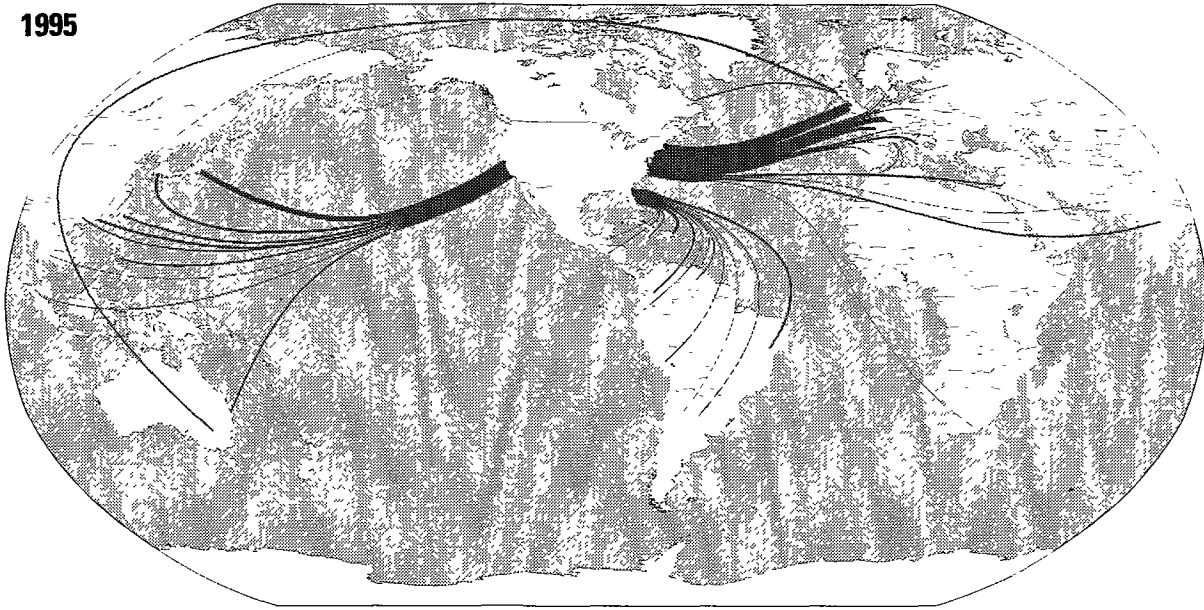
1. Slow Growth: Traffic growth slows as minutes move off the public switched network (PSTN) and large markets mature.
2. Same Growth: Traffic growth continues at similar rate of last five years, assuming that faster rates of price-cutting keep traffic on the PSTN.
3. Fast Growth: Traffic growth increases, assuming a faster growth rate of network subscribers and faster rates of price-cutting, plus a significant component of new demand created by international traffic generated from mobiles.

Source: ITU World Telecommunication Indicators Database, ITU estimates, TeleGeography, Inc..

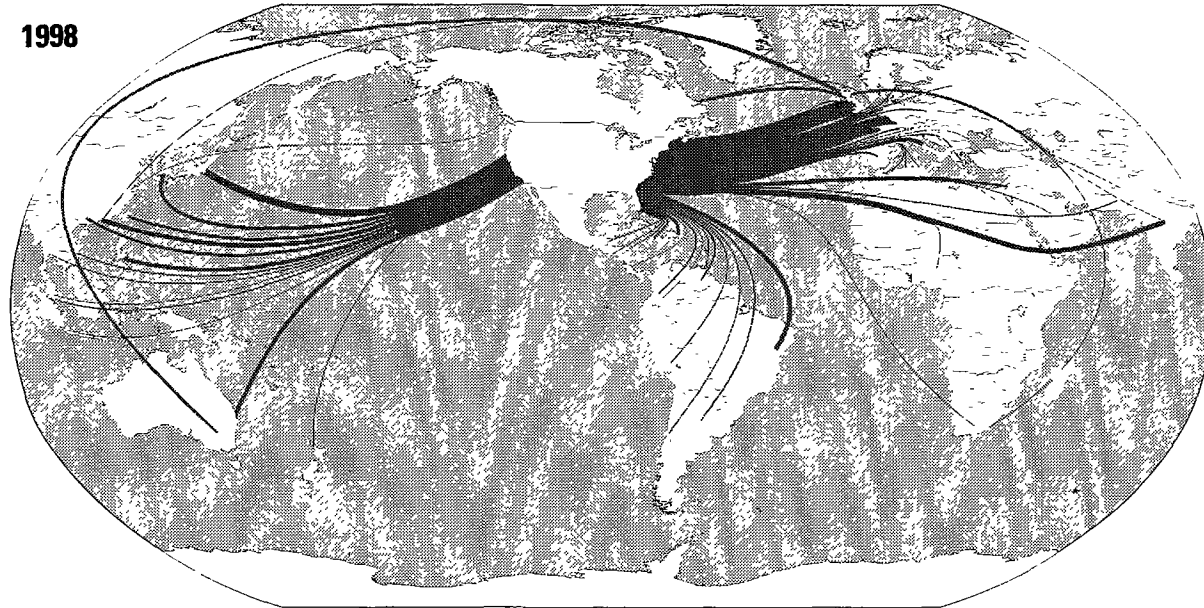
© TeleGeography, Inc. 1999

Figure 3. Intercontinental Traffic Flows, 1995 & 1998

1995



1998



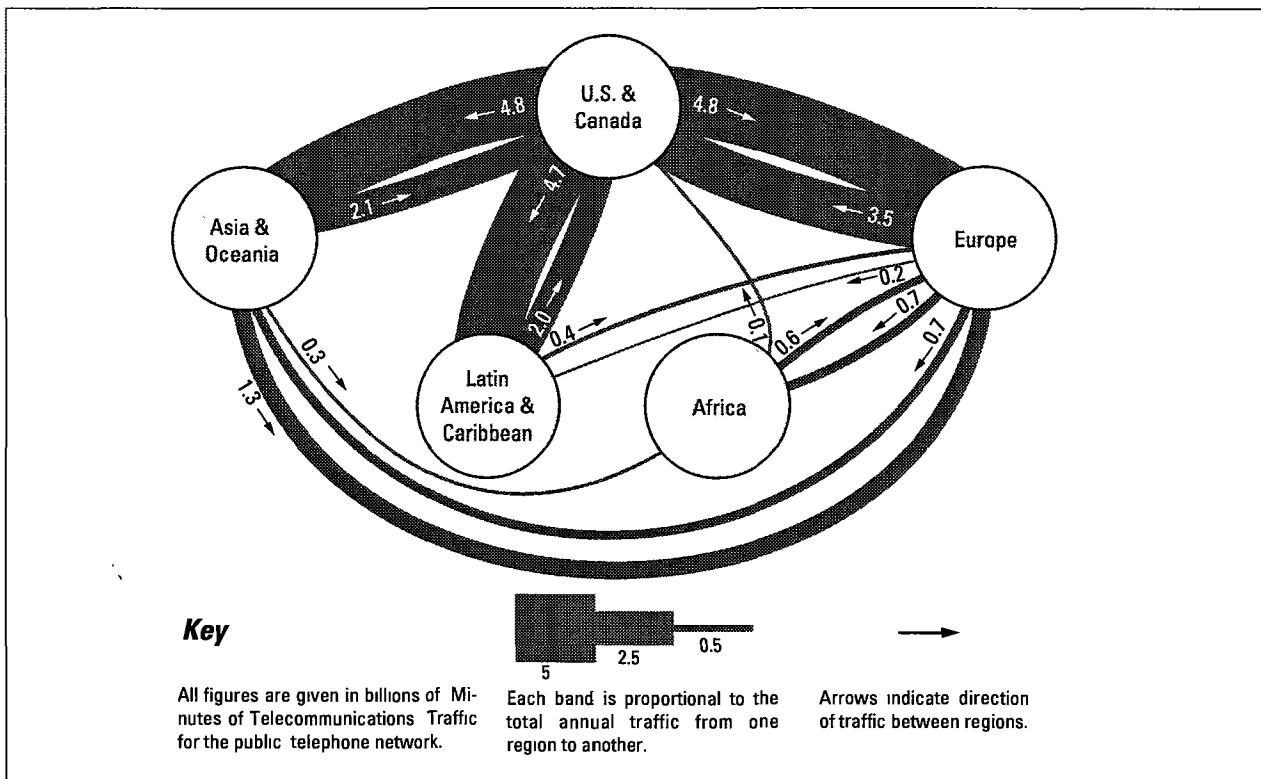
Key Traffic Flows
2,500 1,000 500 100
(Millions of MiTTs)

Each band is proportional to the total annual traffic on the public network in both directions between each pair of countries.

These maps shows all inter-continental routes with an annual volume of more than 100 million minutes. The total volume of these routes in 1998 was 27.3 billion minutes, approximately 29% of global international traffic.

International Traffic by Region

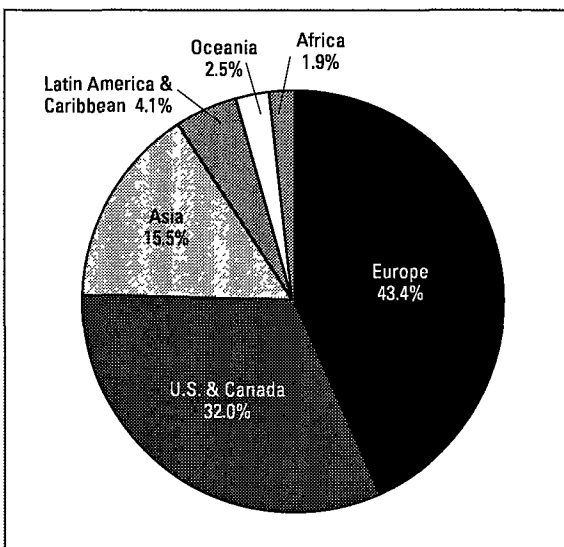
Figure 1. Interregional Traffic Flows, 1998



Note: These interregional traffic flows total 24.8 billion minutes. That sum does not equal global total of 93.0 billion minutes because (1) data set based on top 20 out-going routes for 110 largest countries only; (2) traffic within regions account for a further 45.8 billion minutes based on data set; (3) interregional routes below 100 million minutes not shown.

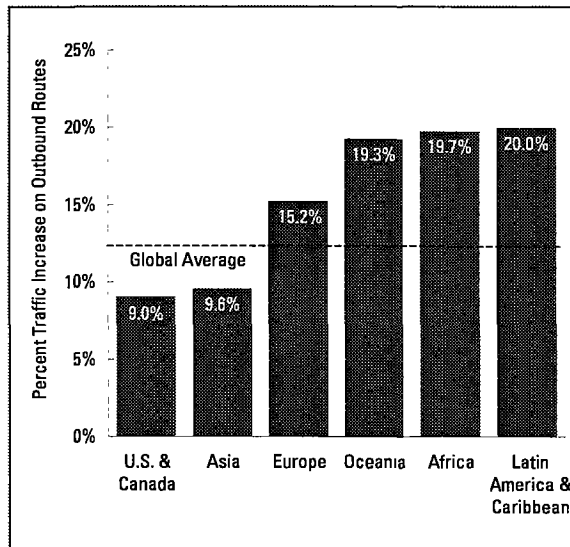
© TeleGeography, Inc. 1999

Figure 2. International Traffic by Origin, 1998



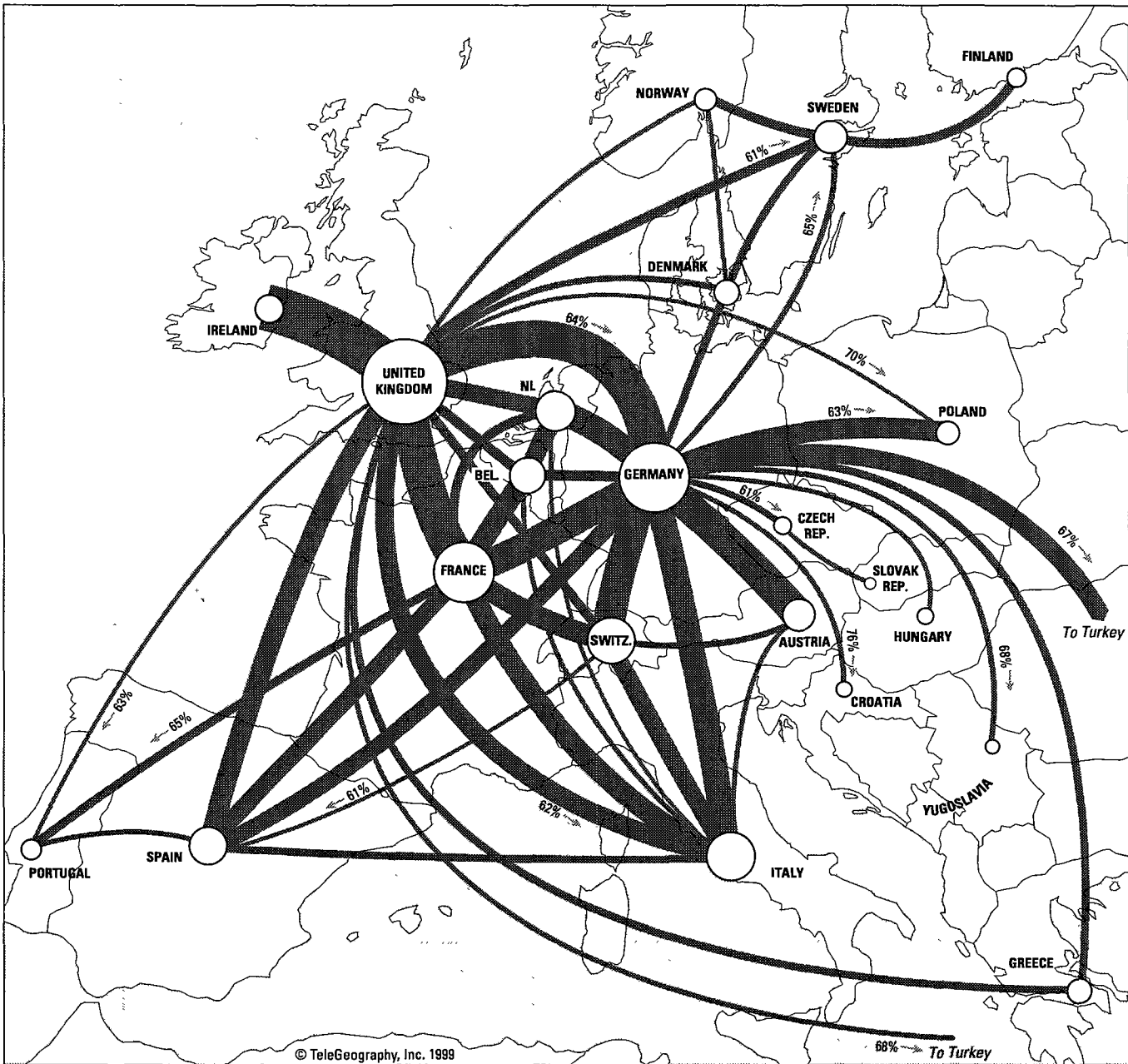
Note: Global traffic was 93.0 bn minutes in 1998. © TeleGeography, Inc. 1999

Figure 3. Traffic Growth by Region, 1997-1998



Note: Global traffic was 93.0 bn minutes in 1998. © TeleGeography, Inc. 1999

Figure 4. European Telecommunications Traffic Flows, 1998



© TeleGeography, Inc. 1999

68% To Turkey

Key

All figures are given in millions of minutes of telecommunications traffic for the public telephone network.

The map shows all intra-European routes with a combined 1998 volume of more than 120 million minutes.

 Traffic Flows



Each band is proportional to the total annual traffic in both directions between each pair of countries.

 Total Outgoing Traffic



The area of each circle is proportional to the volume of the total annual outgoing traffic from each country.

 Balance of Traffic

On routes where traffic in one direction accounts for more than 60% of the total, an arrow shows the direction most of the traffic flows.

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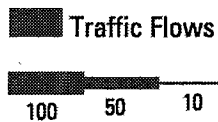
Figure 5. Latin American Telecommunications Traffic Flows, 1998



Key

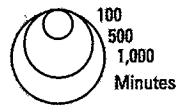
All figures are given in millions of minutes of telecommunications traffic, for the public telephone network.

The map shows all routes within Latin America with a combined 1998 volume of more than 10 million minutes.



Each band is proportional to the total annual traffic on the public telephone network in both directions between each pair of countries.

Total Outgoing Traffic

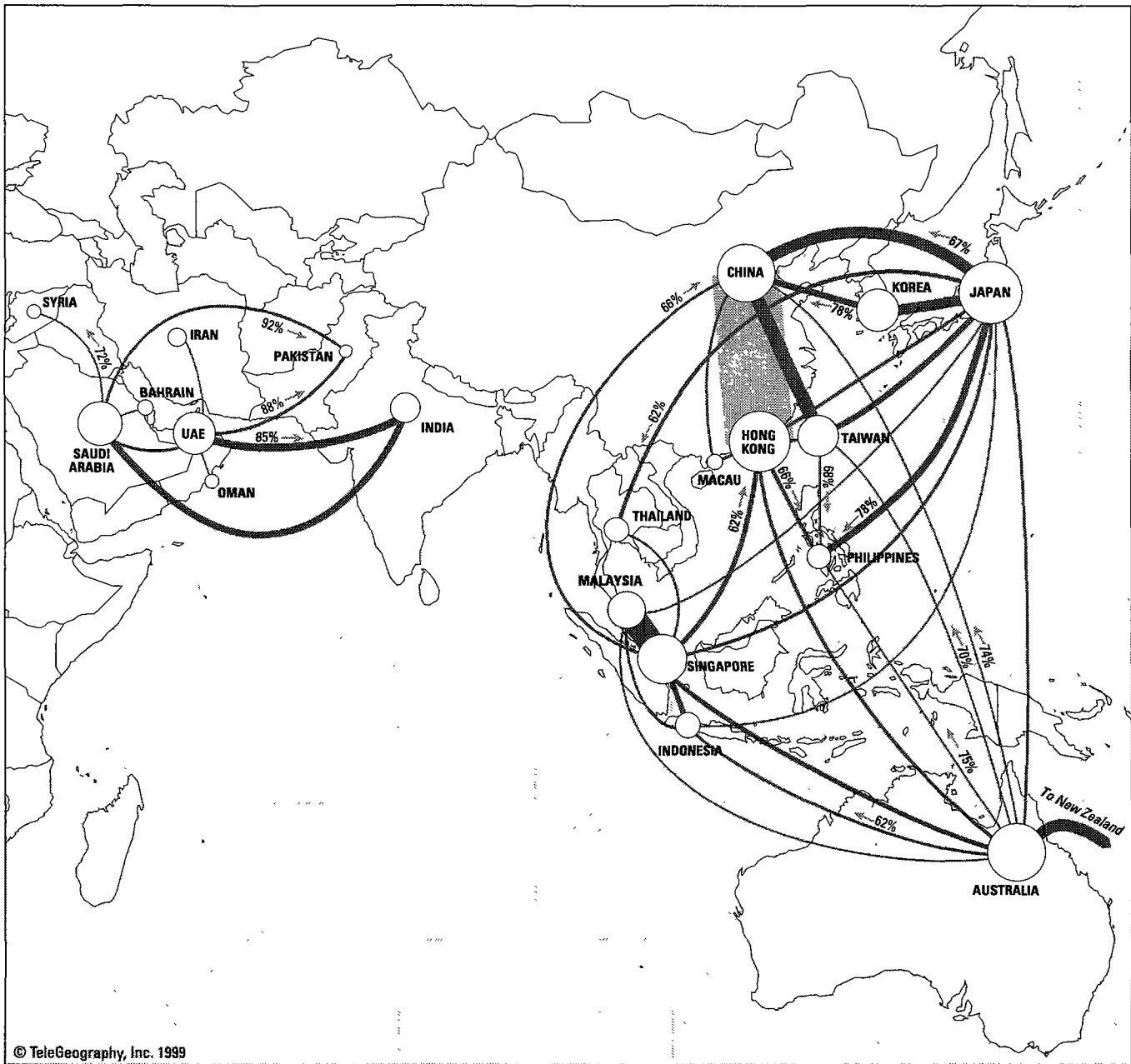


The area of each circle is proportional to the volume of the total annual outgoing traffic from each country.

Balance of Traffic

On routes where traffic in one direction accounts for more than 60% of the total, an arrow shows the direction most of the traffic flows.

Figure 6. Asian Telecommunications Traffic Flows, 1998



© TeleGeography, Inc. 1999

Key

All figures are given in millions of minutes of telecommunications traffic for the public telephone network.

The map shows all intra-Asian routes with a combined 1998 volume of more than 50 million minutes.

Traffic Flows

500 200 50

Each band is proportional to the total annual traffic on the public telephone network in both directions between each pair of countries.

Total Outgoing Traffic

100
500
1,500
Minutes

The area of each circle is proportional to the volume of the total annual outgoing traffic from each country.

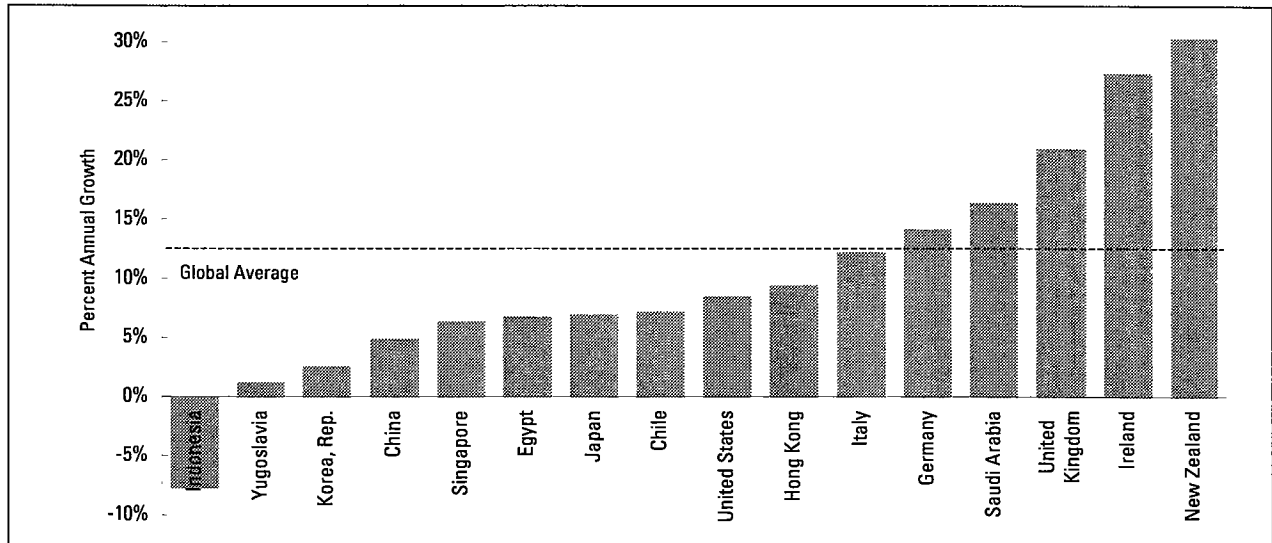
Balance of Traffic

On routes where traffic in one direction accounts for more than 60% of the total, an arrow shows the direction most of the traffic flows.

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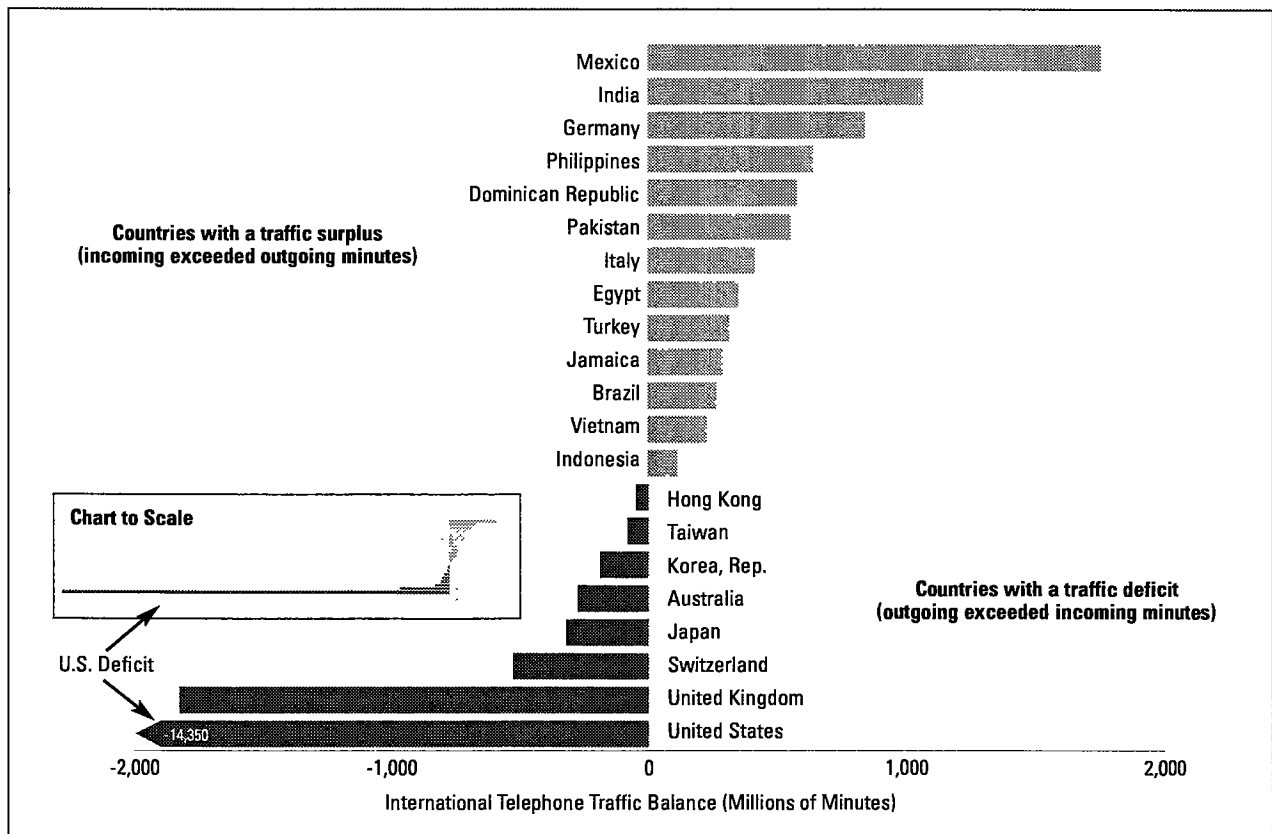
International Traffic by Country

Figure 1. Outgoing International Telephone Traffic Growth for Selected Countries, 1997-1998



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Figure 2. Telephone Traffic Balances for Selected Countries, 1998



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Figure 3. International Traffic Indicators, 1998

	International Traffic			Population (m)	Minutes (Out) per Capita	Main Lines (thous.)	Minutes (Out) per Main Line
	Outgoing (m minutes)	Incoming (m minutes)	Surplus (Deficit) (m minutes)				
Albania (a, c)	49.1	52.2	3.1	3.1	15.7	116	424.0
Algeria (c)	121.3	n.a.	n.a.	30.1	4.0	1,600	75.8
Andorra	47.4	32.2	(15.2)	0.1	632.0	33	1,432.6
Angola	27.3	22.3	(5.0)	12.1	2.3	72	378.0
Argentina	358.7	n.a.	n.a.	36.1	9.9	7,323	49.0
Armenia	56.6	94.3	37.7	3.5	16.0	556	101.8
Aruba	21.1	31.0	9.9	0.1	224.3	33	634.6
Australia (b)	1,690.0	n.a.	n.a.	18.7	90.3	9,580	176.4
Austria (c)	1,160.0	n.a.	n.a.	8.1	142.5	3,999	290.1
Azerbaijan (a, c)	42.9	46.0	3.2	7.7	5.6	680	63.1
Bahamas	63.5	90.0	26.5	0.3	214.6	104	609.1
Bahrain (a)	124.4	102.1	(22.3)	0.6	193.7	158	789.2
Bangladesh	41.8	196.2	154.4	124.8	0.3	n.a.	n.a.
Belarus (a, c)	176.1	193.5	17.3	10.3	17.1	2,490	70.7
Belgium (a)	1,460.0	n.a.	n.a.	10.1	144.0	5,073	287.8
Bolivia	31.6	76.4	44.8	8.0	4.0	535	59.1
Bosnia-Herzegovina (c)	94.9	159.2	64.3	3.7	25.8	332	285.9
Brazil (a)	545.8	806.9	261.1	165.9	3.3	19,987	27.3
Bulgaria	96.0	201.0	105.0	8.3	11.5	2,742	35.0
Canada (a)	4,805.0	n.a.	n.a.	30.3	158.6	19,241	249.7
Chile	259.4	n.a.	n.a.	14.8	17.5	2,977	87.1
China	1,711.5	n.a.	n.a.	1,255.7	1.4	87,421	19.6
Costa Rica (a)	82.7	112.9	30.2	3.8	21.5	660	125.3
Côte d'Ivoire	57.3	46.6	(10.7)	14.3	4.0	170	337.1
Cyprus (a, c)	182.0	120.6	(61.4)	0.7	263.2	405	449.8
Czech Republic (a)	317.4	406.9	89.5	10.3	33.8	3,741	93.0
Denmark (a)	710.0	n.a.	n.a.	5.3	134.0	3,496	203.1
Dominican Republic	157.5	730.5	573.0	8.2	19.1	764	206.2
Egypt	127.3	475.3	348.0	66.0	1.9	3,972	32.1
El Salvador	43.1	149.2	106.1	6.0	7.1	483	89.3
Estonia (a)	75.1	79.2	4.1	1.5	51.7	499	150.6
Finland	410.8	n.a.	n.a.	5.2	79.7	2,855	143.9
France	4,115.0	n.a.	n.a.	59.7	68.9	34,000	121.0
Germany (a)	5,495.0	n.a.	n.a.	82.1	66.9	46,500	118.2
Ghana	28.9	100.8	72.0	19.2	1.5	106	273.7
Greece	681.3	710.1	28.8	10.6	64.3	5,536	123.1
Hong Kong (a, b)	1,879.8	1,833.0	(46.8)	6.7	281.1	3,729	504.1
Hungary (a)	296.3	374.5	78.2	10.2	29.1	3,423	86.6
India (a, b, c)	436.2	1,498.8	1,062.6	982.2	0.4	21,594	20.2
Indonesia (a)	324.5	434.2	109.7	206.3	1.6	5,572	58.2
Iran	177.0	185.7	8.8	65.8	2.7	7,355	24.1
Ireland (b)	885.0	n.a.	n.a.	3.7	240.4	1,600	553.1
Israel (a)	661.0	424.0	(237.0)	6.0	110.5	2,800	236.1
Italy (c)	2,640.0	n.a.	n.a.	57.7	45.8	25,986	101.6
Jamaica (a)	60.1	349.8	289.7	2.5	23.7	419	143.3
Japan (b)	1,895.0	1,575.0	(320.0)	126.2	15.0	60,381	31.4
Jordan (a)	122.6	176.9	54.4	6.0	20.5	403	304.4
Kazakhstan	118.9	137.5	18.6	17.1	6.9	1,818	65.4
Kenya	29.2	72.5	43.3	29.0	1.0	272	107.4
Korea, Rep.	907.7	719.4	(188.3)	46.4	19.6	20,089	45.2
Kuwait (d)	160.5	n.a.	n.a.	1.8	90.1	412	389.9
Latvia (a)	55.4	87.2	31.8	2.5	22.5	741	74.7
Luxembourg	293.8	242.6	(51.2)	0.4	693.4	293	1,002.4

Notes: Data are in millions of minutes of public switched traffic.

- International minutes based on billing point of traffic.
- International traffic for year ending 31 March. Australia and Pakistan ends 30 June.
- Traffic data exclude some carriers or routes. (See country table for details.)
- Traffic data is for 1997.

Figure 3. International Traffic Indicators, 1998 (continued)

	International Traffic			Population (m)	Minutes (Out) per Capita	Main Lines (thous.)	Minutes (Out) per Main Line
	Outgoing (m minutes)	Incoming (m minutes)	Surplus (Deficit) (m minutes)				
Macau (a)	125.2	95.8	(29.4)	0.4	294.5	174	720.1
Macedonia (c)	37.1	91.7	54.6	2.0	18.6	408	91.0
Malaysia (a, b)	685.0	n.a.	n.a.	22.2	30.9	4,384	156.3
Malta	37.3	n.a.	n.a.	0.4	97.1	192	194.6
Mauritius (b)	29.7	38.5	8.8	1.1	25.9	245	121.1
Mexico (a)	1,310.0	3,060.0	1,750.0	95.8	13.7	9,927	132.0
Moldova (a)	55.8	90.3	34.4	4.4	12.8	657	84.9
Monaco	234.0	140.0	(94.0)	n.a.	n.a.	n.a.	n.a.
Morocco	158.0	460.0	302.0	27.9	5.7	1,515	104.3
Namibia	61.9	45.3	(16.6)	1.7	37.3	101	615.2
Netherlands	1,805.0	n.a.	n.a.	15.7	114.7	9,337	193.3
Netherlands Antilles	43.0	113.8	70.9	0.2	192.5	n.a.	n.a.
New Zealand (b)	580.0	n.a.	n.a.	3.9	148.8	1,868	310.5
Nicaragua (a, d)	40.4	52.5	12.1	4.4	9.3	128	316.2
Norway (a)	540.0	n.a.	n.a.	4.4	121.5	2,935	184.0
Oman (a)	92.9	74.2	(18.7)	2.4	39.0	220	422.5
Pakistan (b, c)	87.5	640.4	552.9	142.3	0.6	2,557	34.2
Palestinian Authority	27.6	16.6	(11.0)	n.a.	n.a.	n.a.	n.a.
Panama (a)	50.0	97.6	47.6	2.8	18.1	n.a.	n.a.
Paraguay	37.8	57.4	19.6	5.2	7.2	289	131.0
Peru (a, b)	90.4	272.6	182.3	24.8	3.6	1,655	54.6
Philippines (a, b)	295.0	n.a.	n.a.	72.9	4.0	2,700	109.3
Poland (a)	602.4	1,144.2	541.8	38.7	15.6	8,812	68.4
Portugal (a)	460.2	711.5	251.3	10.0	46.2	4,117	111.8
Qatar	112.5	70.0	(42.5)	0.6	194.3	151	747.5
Romania (d)	110.8	278.6	167.8	22.6	4.9	3,777	29.3
Russia (c)	1,038.3	1,029.8	(8.5)	147.7	7.0	26,875	38.6
Saudi Arabia	932.6	n.a.	n.a.	20.2	46.2	2,878	324.0
Singapore (a, b)	1,235.0	n.a.	n.a.	3.2	390.4	1,778	694.6
Slovak Republic (a)	151.8	186.4	34.6	5.4	28.2	1,539	98.6
Slovenia	129.6	137.0	7.4	2.0	65.0	722	179.4
South Africa	405.0	n.a.	n.a.	44.3	9.1	5,075	79.8
Spain (a)	1,605.0	n.a.	n.a.	39.4	40.8	16,289	98.5
Sri Lanka	39.3	146.8	107.5	18.5	2.1	524	75.1
Sudan (c)	18.4	88.0	69.6	28.3	0.7	162	113.6
Sweden (a)	1,205.0	n.a.	n.a.	8.9	136.1	5,965	202.0
Switzerland	2,425.0	n.a.	n.a.	7.1	341.0	4,803	504.9
Syria (a)	103.0	n.a.	n.a.	15.3	6.7	n.a.	n.a.
Taiwan (a)	862.0	781.8	(80.2)	21.9	39.4	11,500	75.0
Thailand (a, c)	296.4	358.6	62.2	60.3	4.9	4,827	61.4
Trinidad & Tobago (a, b)	64.4	141.5	77.1	1.3	50.2	266	242.3
Turkey (c)	644.1	955.9	311.7	66.7	9.7	16,960	38.0
Ukraine	465.9	n.a.	n.a.	50.9	9.2	9,410	49.5
United Arab Emirates	874.8	n.a.	n.a.	2.4	371.8	915	955.8
United Kingdom (a, b)	8,225.0	6,400.0	(1,825.0)	58.9	139.5	32,072	256.5
United States (a)	24,949.3	10,598.8	(14,350.5)	270.5	92.2	172,452	144.7
Uruguay	78.3	97.0	18.7	3.3	23.8	824	95.1
Uzbekistan	91.7	74.7	(17.0)	23.8	3.9	1,490	61.6
Venezuela (a)	164.5	298.1	133.6	23.2	7.1	2,712	60.6
Vietnam	56.0	334.0	278.0	77.6	0.7	2,000	28.0
Yugoslavia (a)	219.5	423.3	203.8	10.6	20.6	2,319	94.7
Zimbabwe	52.8	53.2	0.4	12.7	4.2	212	249.0

Notes: Data are in millions of minutes of public switched traffic.

- International minutes based on billing point of traffic.
- International traffic for year ending 31 March. Australia and Pakistan ends 30 June.
- Traffic data exclude some carriers or routes. (See country table for details.)
- Traffic data is for 1997.

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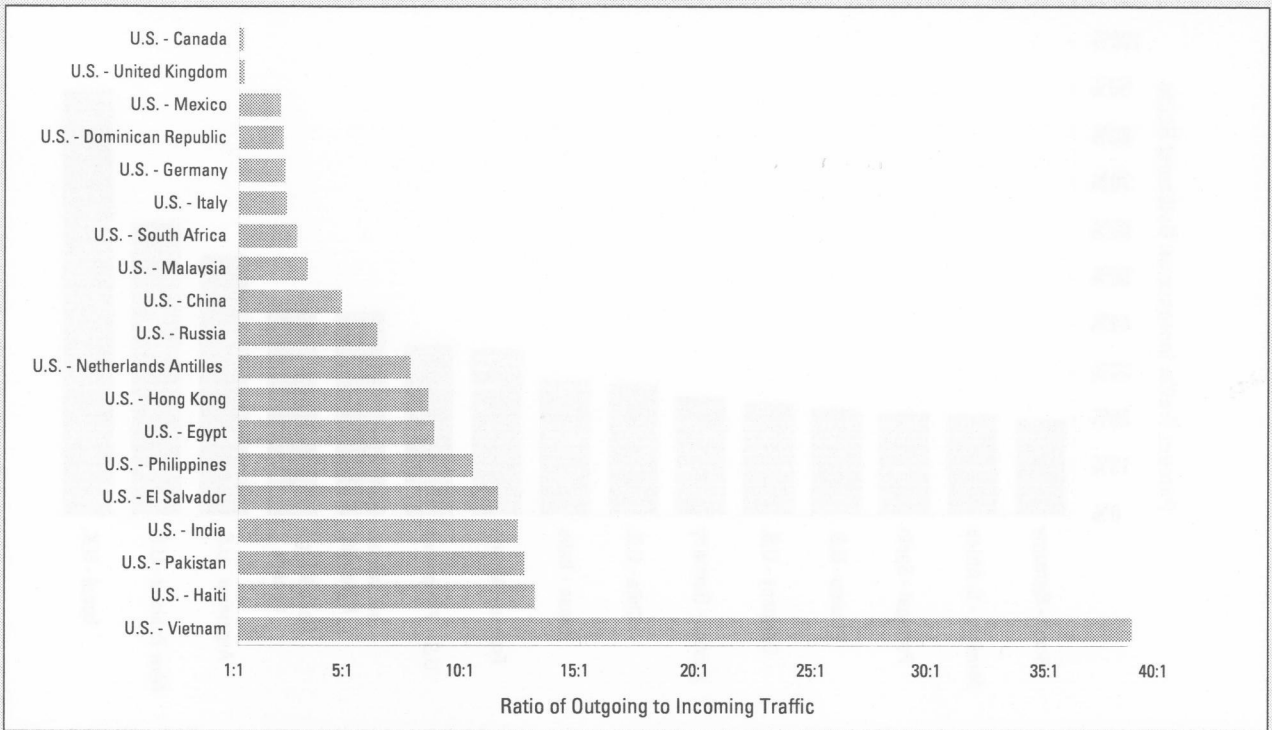
International Traffic by Route

Figure 1. The Top 50 International Routes, 1998

Countries	Minutes each way	Total Minutes
1. U.S. - Canada	3,988.0 - 3,400.0	7,388.0
2. U.S. - Mexico	3,117.6 - 1,095.0	4,212.6
3. U.S. - U.K.	1,531.4 - 1,260.0	2,791.4
4. Hong Kong - China	1,165.0 - 895.0	2,060.0
5. U.S. - Germany	1,194.2 - 395.0	1,589.2
6. U.K. - Ireland	815.0 - 605.0	1,420.0
7. U.S. - Japan	833.3 - 336.0	1,169.3
8. U.K. - France	650.0 - 485.0	1,135.0
9. U.K. - Germany	725.0 - 400.0	1,125.0
10. Austria - Germany	535.0 - 435.0	970.0
11. Switzerland - Germany	550.0 - 395.0	945.0
12. France - Germany	470.0 - 415.0	885.0
13. U.S. - France	580.2 - 290.0	870.2
14. U.S. - India	772.9 - 52.4	825.3
15. Singapore - Malaysia	437.0 - 350.0	787.0
16. Germany - Italy	410.0 - 385.0	795.0
17. U.S. - Brazil	592.3 - 179.1	771.4
18. Netherlands - Germany	395.0 - 375.0	770.0
19. U.S. - Hong Kong	635.6 - 70.0	705.6
20. U.S. - Australia	459.7 - 240.0	699.7
21. U.S. - Italy	532.2 - 134.0	666.2
22. U.S. - Philippines	573.1 - 85.0	658.1
23. Switzerland - France	380.0 - 276.0	656.0
24. France - Belgium	335.0 - 315.0	650.0
25. Germany - Poland	405.0 - 233.8	638.8
26. France - Italy	329.0 - 306.0	635.0
27. U.K. - Spain	360.0 - 270.0	630.0
28. U.S. - Korea, Rep.	397.3 - 230.0	627.3
29. Belgium - Netherlands	300.0 - 300.0	600.0
30. U.K. - Italy	360.0 - 220.0	580.0
31. Germany - Turkey	385.0 - 186.4	571.4
32. Russia - Ukraine	290.8 - 280.3	571.1
33. U.S. - Dominican Rep.	452.9 - 112.0	564.9
34. Switzerland - Italy	320.0 - 226.0	546.0
35. Canada - U.K.	230.0 - 310.0	540.0
36. U.K. - Netherlands	305.0 - 225.0	530.0
37. France - Spain	260.0 - 265.0	525.0
38. U.S. - China	434.5 - 80.0	514.5
39. New Zealand - Australia	260.0 - 245.0	505.0
40. Spain - Germany	265.0 - 235.0	500.0
41. Australia - U.K.	240.0 - 240.0	480.0
42. U.S. - Taiwan	327.9 - 143.3	471.2
43. Taiwan - China	243.1 - 180.0	423.1
44. U.S. - Israel	223.2 - 185.0	408.2
45. U.S. - Netherlands	273.2 - 120.0	393.2
46. Japan - China	253.7 - 115.0	368.7
47. Korea, Rep. - Japan	172.3 - 169.4	341.7
48. U.S. - Jamaica	282.1 - 40.2	322.3
49. Belgium - Germany	175.0 - 145.0	320.0
50. U.S. - Spain	230.9 - 76.0	306.9

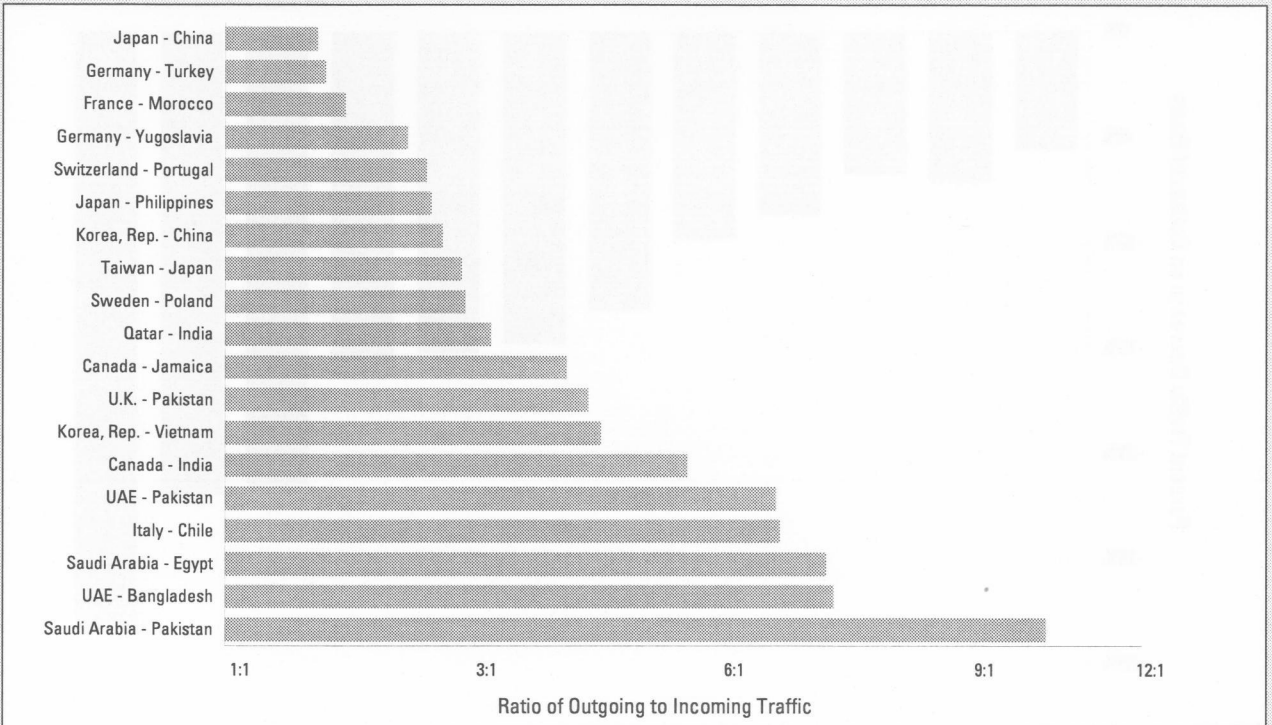
Note: All data in millions of minutes of telecommunications traffic. The country which generates more traffic on each route is listed first. The routes listed above total 47.4 billion minutes, equal to 51 percent of all international traffic. Data for Australia, Hong Kong, Ireland, Japan, Malaysia, New Zealand, Singapore, Taiwan, and the U.K. are for fiscal year 1998/99.

Figure 2. Traffic Imbalances on Selected U.S. Routes, 1998



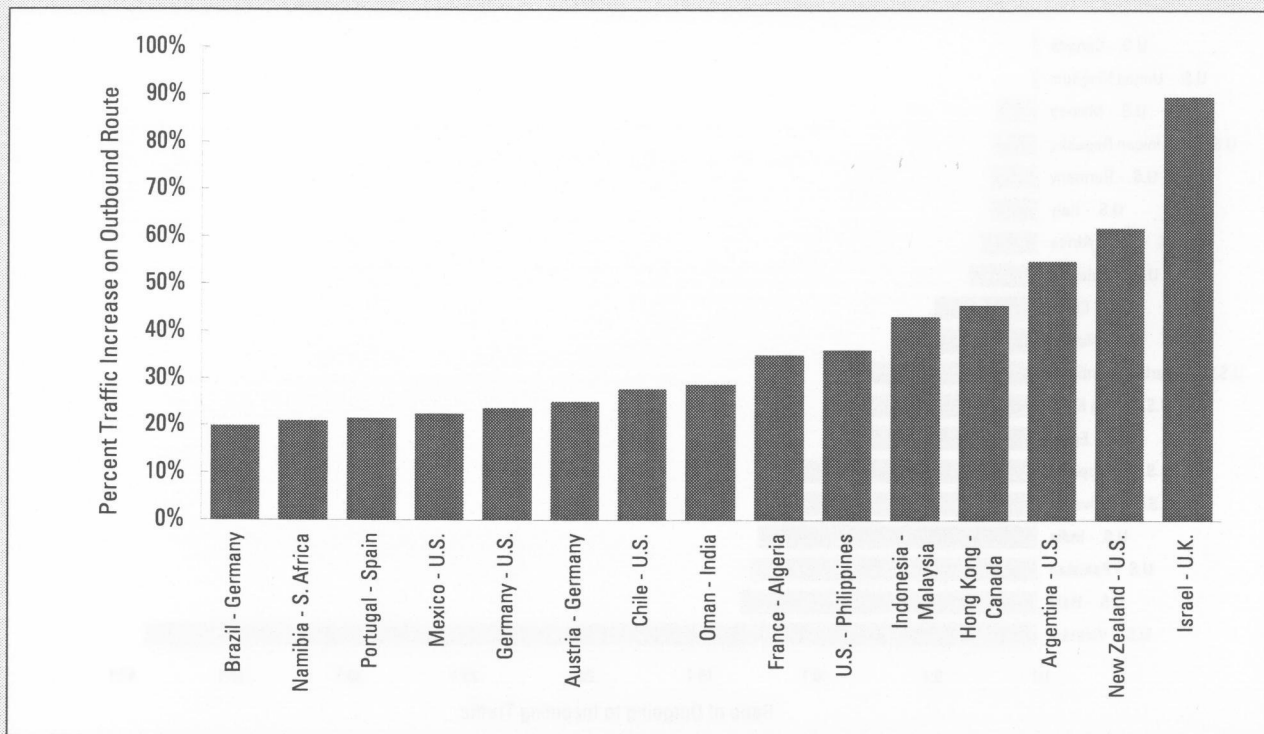
Note: Country with traffic deficit on route listed first. A ratio of 1:1 would indicate a perfect balance on a route. U.S. data based on billing point of call, and may not reflect actual call ratios due to refile and call-back. © TeleGeography, Inc. 1999

Figure 3. Traffic Imbalances on Selected Non-U.S. Routes, 1998



Note: Country with traffic deficit on route listed first. A ratio of 1:1 would indicate a perfect balance on a route. Data for some countries based on billing point of call, and may not reflect actual call ratios due to refile and call-back. © TeleGeography, Inc. 1999

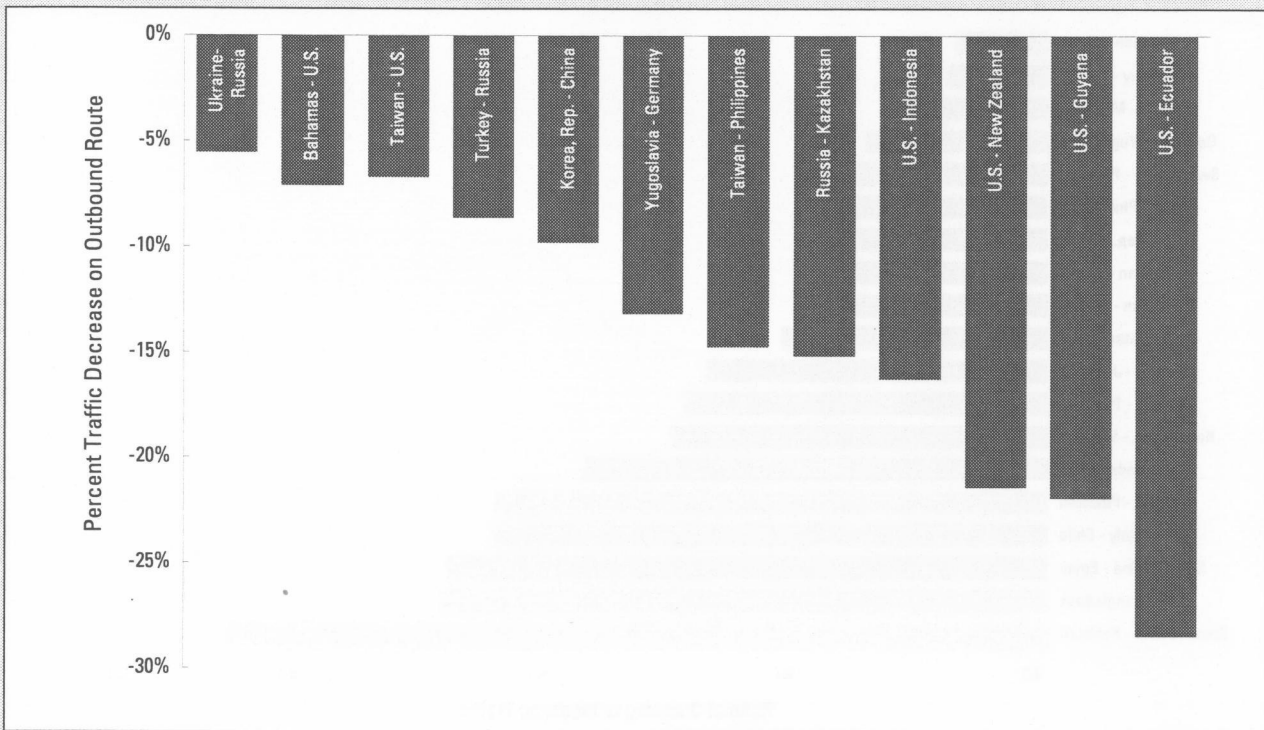
Figure 4. International Outbound Routes with Rapidly Growing Traffic, 1997-1998



Note: Country originating traffic listed first; country terminating traffic listed second. Some data based on billing point of call, and may not reflect actual route growth rates due to refile and call-back.

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Figure 5. International Outbound Routes with Declining Traffic, 1997-1998



Note: Country originating traffic listed first; country terminating traffic listed second. Some data based on billing point of call, and may not reflect actual rates at which traffic flows are changing due to refile and call-back.

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International Traffic on Mobile Networks: Current Trends and Pricing

Few communications innovations of the last quarter century have seen as much success as the cellular telephone. Although introduced as a practical consumer device only in the late 1980s, mobile phones are now used by over 300 million people worldwide. At current growth rates, mobile phones will exceed fixed lines by 2007 (see Figure 1; for a country-by-country comparison of mobile subscribers, see the Blue Pages).

As the number of wireless handsets increase, mobile networks play an ever larger role in originating and terminating international calls. Unfortunately for international carriers, high fixed-to-mobile termination fees make calling mobiles an expensive proposition. This article evaluates how international calls are made to and from mobile phones and how carriers and mobile operators are settling accounts.

International Call Volumes and Mobiles

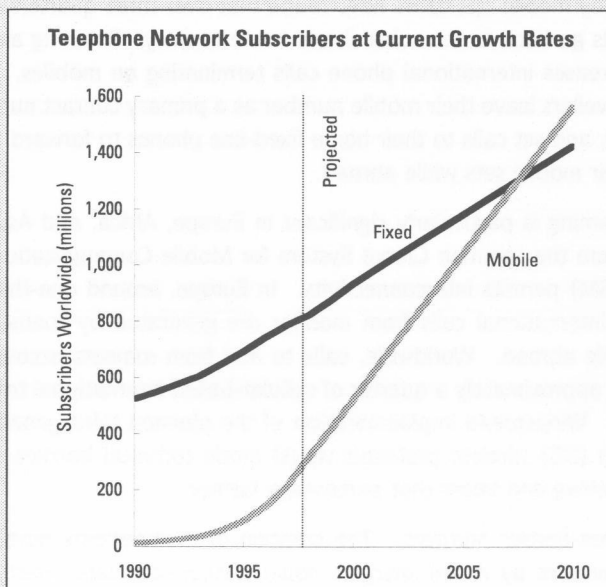
Approximately seven percent of outgoing international calls were placed from mobile phones in 1998; a slightly higher percentage of incoming international calls terminated on cellular networks. By 2001, one in ten international calls will originate on mobile terminals. A number of factors determine call volumes to and from mobile phones.

Subscribership. The recent explosion of new cellular subscribers has driven the increase of calls to and from mobiles.

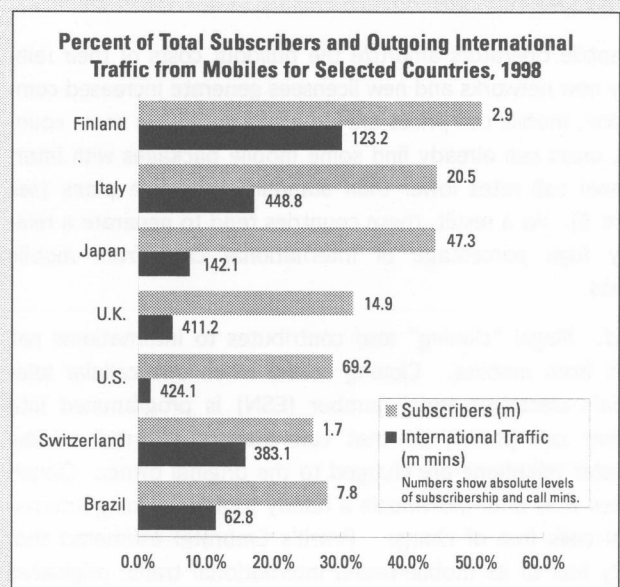
But far more important than the overall level of cellular tele-density in explaining this trend is the “substitution rate”—that is, the ratio of mobile to fixed subscribers. Many developing countries have built mobile networks as a less expensive means of providing access. For example, Cambodia now reports more cell phones than fixed-line sets. In developed countries, where individuals often perceive wireless as an optional supplement to their fixed-line set, mobile terminals are beginning to take their place as the primary instrument for voice telephony. Telephone numbers allocated to cell phones now outnumber those to fixed-line terminals in Finland, Italy, and Japan. In fact, the number of fixed connections has declined in each of these countries.

Regulation. While only 30 percent of the world’s countries have introduced competition for basic fixed-line services, over 60 percent permit competition for mobile services. In many countries, then, mobile operators serve as the sole competition to the fixed network incumbent. Subscribers in these countries appear to use mobile phones more intensively for basic telephony—including international calling—than users in countries with fixed network competition in place. In Portugal, for example, where the regulator granted mobile operators international licenses one year before fixed network competition began,

Figure 1. Mobile’s Share

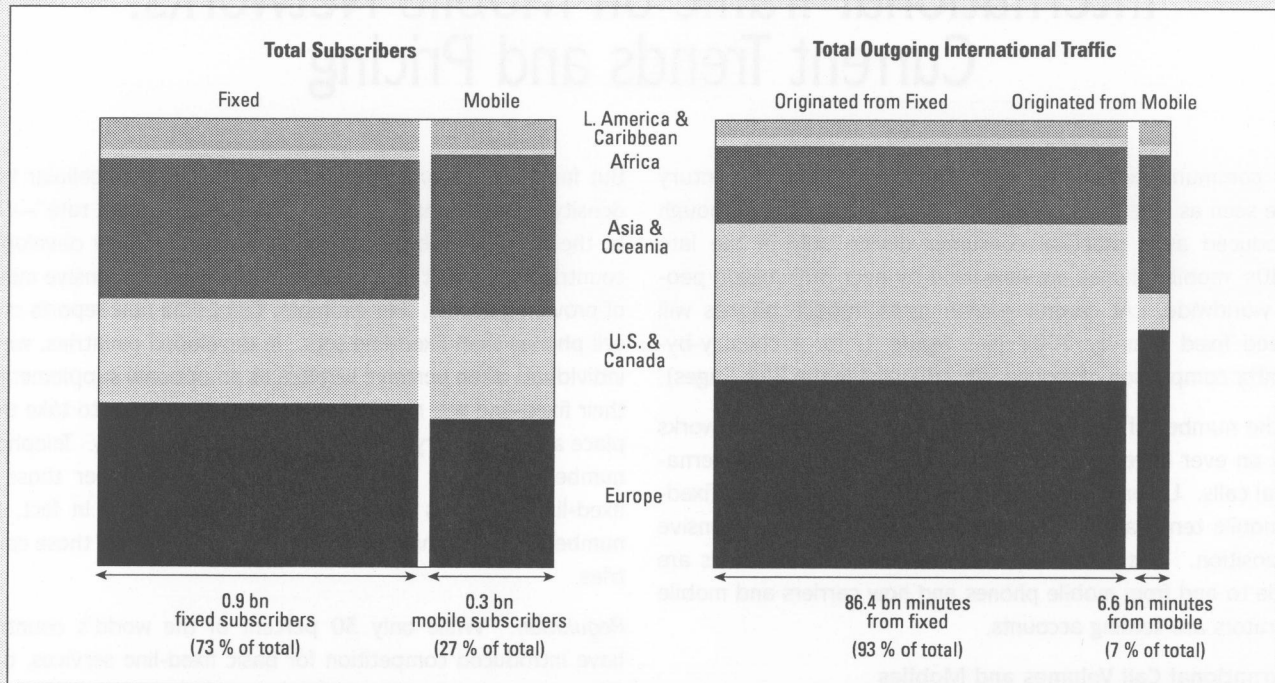


Source: ITU and TeleGeography, Inc.



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Figure 2. Fixed vs. Mobile Subscribers and International Traffic by World Region, 1998



Source: ITU and TeleGeography, Inc.

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the percentage of international calls placed from mobiles is double the world average.

Price. The relatively high cost of calling from cellular phones often limits mobile-originated international traffic. In most countries, calls from fixed-line telephones remain far cheaper than those from mobile terminals. In the U.S., for example, a three minute call to the U.K. from a fixed line phone using AT&T's One Rate plan would cost \$0.30. With AT&T's discounted high volume wireless package, that same call would cost \$1.29.

As mobile operators amortize the buildout costs of their relatively new networks and new licensees generate increased competition, mobile call prices are expected to fall. In some countries, users can already find some mobile packages with international call rates lower than standard fixed line plans (see Figure 3). As a result, these countries tend to generate a relatively high percentage of international calls from mobile phones.

Fraud. Illegal "cloning" also contributes to international call traffic from mobiles. Cloning occurs when one cellular telephone's electronic serial number (ESN) is programmed into another cell phone, so that call charges incurred on the imposter telephone are charged to the original owner. Cloned phones thus offer individuals a handy tool for placing international calls free of charge. Brazil's Embratel estimated that nearly half of its mobile-based international traffic originated from phones with cloned serial numbers. Worldwide, however,

fraud likely contributes to no more than ten percent of outgoing international calls from cellular phones.

Roaming. Mobile telephony gives subscribers the ability to use their handsets while roaming outside of their home region. At first glance, roaming should not contribute to mobile-based international calling. When a foreign visitor places a call on his or her cell phone, the call is picked up by the host operator's network like any other domestic call. However, local calls account for less than 15 percent of calls made by roamers. Many mobile operators have found that over three quarters of calls go back to the subscriber's home country. Roaming also increases international phone calls terminating on mobiles, as travellers leave their mobile number as a primary contact number, and set calls to their home fixed-line phones to forward to their mobile sets while abroad.

Roaming is particularly significant in Europe, Africa, and Asia, where the common Global System for Mobile Communications (GSM) permits interconnectivity. In Europe, around one-third of international calls from mobiles are generated by roamers while abroad. Worldwide, calls to and from roamers account for approximately a quarter of cellular-based international traffic. Widespread implementation of the planned third generation (3G) wireless protocols would erode technical barriers to roaming and boost that percentage further.

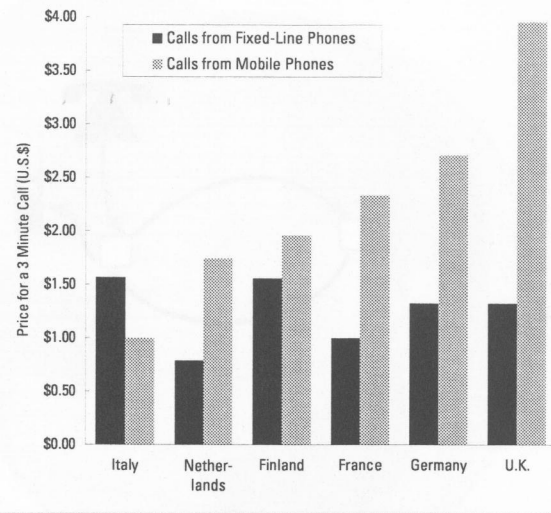
Cross-Border Mergers. The creation of multinational mobile operators by recent mergers could further stimulate international traffic to and from mobiles. These tie-ups—such as the

Vodafone-Airtouch merger and a potential Mannesmann-Vodafone deal—give operators the ability to offer end-to-end provisioning of international calls from handset to handset, circumventing any termination payments. (For a list of top mobile operators by subscribership, see Figure 4.) As long as they pass along cost savings to their customers, the new multinationals will boost cross-border traffic volumes.

Functionality. Over a third of the world's phones are cellular, mobile call prices are falling, and international roaming serves as a central feature for mobile phones. So why do less than ten percent of international calls originate on mobiles? The answer lies in how mobile phones are used. Most individuals still employ wireless handsets as a supplement—rather than replacement—to their traditional fixed-line phone. Except in developing countries with limited fixed network deployment, cellular's traditional niche has been casual, "on the go" conversations; many people prefer to place relatively expensive international calls from fixed-line phones, where they have more control over call quality and background noise. In addition, virtually all faxes originate from fixed lines rather than wireless sets—a significant gap, given that fax traffic accounts for at least 20 percent of international call minutes, depending on the country route. For the foreseeable future, then, the fixed-line telephone will remain the dominant medium for originating and terminating international calls.

Figure 3. Retail Prices for International Calls

Average Charges for Calls to European Union Countries, 1999



Note: Prices are a simple average of peak period call tariffs to other EU member states as of January 1999. Mobile charges are for high volume packages.

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International Calls to Mobiles: Who Should Pay?

The spectacular growth of mobile subscribership has not occurred without cost. To a large degree, cellular users have

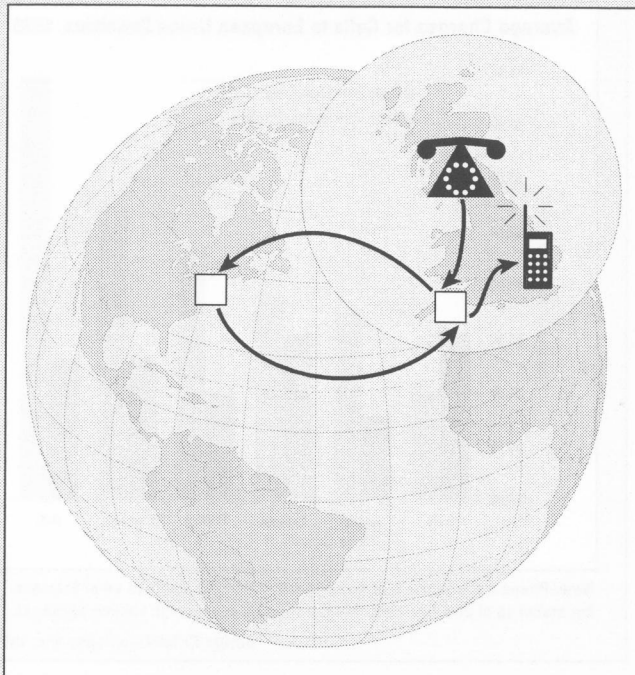
Figure 4. Top Mobile Operators

Operator	Country	Subscribers (m)		Revenues (US\$ bn)
		1998	1999	1998
1. NTT DoCoMo	Japan	25.2	26.3	26.2
2. China Telecom	China	23.6	n.a.	8.0
3. Telecom Italia Mobile	Italy	14.3	17.0	n.a.
4. Vodafone AirTouch (b,c)	U.K./U.S.	13.5	n.a.	n.a.
5. SBC Telecom (d)	U.S.	8.3	n.a.	3.7
6. AT&T	U.S.	7.2	7.6	5.4
7. Bell Atlantic NYNEX Mobile (c)	U.S.	6.6	7.0	3.5
8. Omnitel Pronto Italia	Italy	6.2	9.0	2.5
9. SK Telecom	Rep. of Korea	6.0	8.9	2.6
10. Mannesmann Mobilfunk	Germany	5.9	5.9	4.3
11. T-Mobil	Germany	5.8	7.7	3.5
12. DDI	Japan	5.6	n.a.	7.0
13. France Télécom Mobiles	France	5.5	7.0	2.8
14. Telefónica Moviles	Spain	4.9	6.7	3.1
15. BellSouth	U.S.	4.8	5.1	2.7
16. GTE (c)	U.S.	4.8	5.0	3.0
17. BT Cellnet	U.K.	4.5	5.6	2.3
18. SFR	France	4.2	6.0	2.9
19. Alltel	U.S.	4.0	n.a.	2.1
20. Telstra	Australia	3.1	3.4	2.5

Notes:
a. Subscriber and revenue figures are for domestic operations only. 1998 figures are for year end 1998; 1999 subscribers are the most recent figures released by the company.
b. Vodafone AirTouch merger was completed July 1999. 1998 subscribers are a pro forma estimate.
c. Bell Atlantic and GTE Corp expect to complete merger by March 2000. Upon completion of merger, the wireless assets of both companies will be combined with Vodafone Airtouch's U.S. wireless assets. Bell Atlantic-GTE will own 55% and Vodafone Airtouch 45% of the new company. The companies expect to complete the transaction by 2001.
d. SBC Wireless/Ameritech merger was completed October 1999 to form SBC Telecom. 1998 revenues are a pro forma estimate.

Source: ITU World Telecom Development Report 1999; company reports

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Figure 5. The Tromboning Effect

Some domestic operators have discovered a clever way of evading high fixed-to-mobile interconnect fees. Rather than sending calls directly to mobile operators, they have disguised their cellular-bound minutes as foreign calls by reoriginating this traffic via another country. Like air through the slide of a trombone, calls are routed back to the country where they began. In exchange for payment of the standard international settlement rate—plus a small fee for sending the calls abroad—a domestic carrier can stick the home country international gateway operator with an expensive mobile interconnect bill.

Somewhat anachronistically, this unusual form of refile has boosted the volume of traffic settled under the accounting rate regime at time when that regime is crumbling. But tromboning appears to be a short-lived phenomenon. Government authorities in the United Kingdom and France—where international carriers have complained vociferously about tromboning—mandated lower interconnect rates when international settlement rates fell below mobile termination charges. In addition, both British Telecommunications and France Télécom have introduced higher settlement rates for calls bound for mobile networks.

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paid the price of network buildout through subscription fees and relatively high per-minute call tariffs. More controversially, fixed-line carriers also have paid via high fixed-to-mobile interconnection fees.

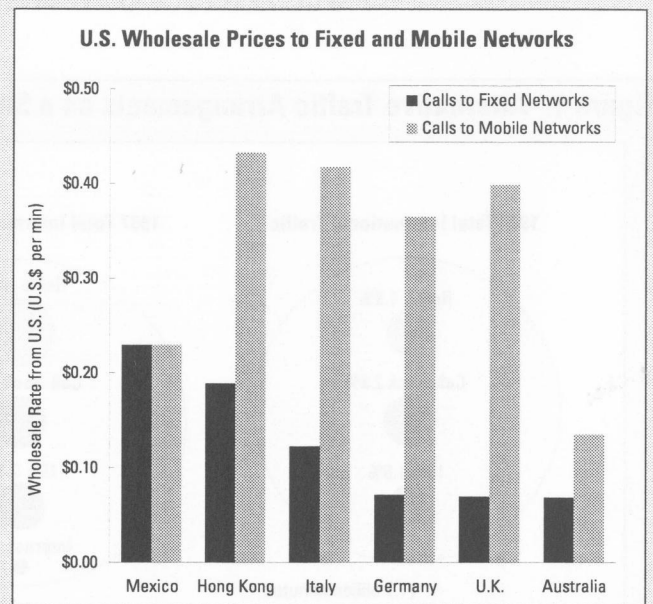
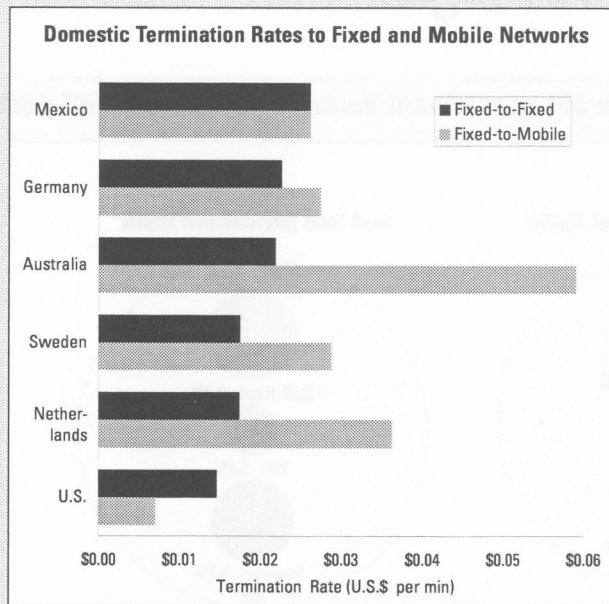
Falling international settlement rates and stubbornly high interconnect fees to mobiles have placed a squeeze on international gateway operators seeking to pass on incoming international calls to mobile operators. Settlement rates actually have fallen below fixed-to-mobile termination fees in some cases, creating unusual distortions of traffic flows (see Figure 5, “The Tromboning Effect”). International carriers face a number of options for alleviating this price squeeze:

- Negotiate lower fixed-to-mobile termination charges. Undoubtedly, this option is the first choice for international operators. However, interconnect payments are an important revenue source for mobile operators, and they have little incentive to lower termination fees. Lower charges often have required regulatory action.
- Eliminate the Calling Party Pays (CPP) system for international calls. Fixed-to-mobile fees tend to be higher in markets (such as in Europe) where callers must pay for traffic to mobiles than in countries where individuals receiving calls pay. Removing CPP would remove mobile operators’ incentive to prop up interconnect fees. As both cellular companies and their subscribers no doubt would greet any manipulation of CPP with hostility, however, such proposals stand little chance of success. Indeed, it seems possible that

CPP could spread to new markets. In the U.S., for example, where mobile users currently pay for incoming calls, the cellular industry is pressuring for a move to Calling Party Pays.

- Establish separate fixed-to-mobile termination charges for domestic and international calls. Some international carriers have entered into informal agreements with mobile operators, permitting cellular companies to maintain a relatively high termination charge for domestic calls while obtaining interconnection at a steep discount on calls from international destinations. In Finland, for example, some international gateway operators pay mobile carriers an interconnect fee at one-fifth the official rate to connect calls from abroad. A drawback to these unofficial agreements is that they require the cooperation of all parties involved. Domestic fixed network carriers could undermine the system by tromboning calls to mobiles via third party countries.
- Implement a settlement rate averaging costs for calls to fixed and mobile networks. Although carriers lose money on incoming traffic to mobiles, they recoup their losses on calls to fixed networks. The drawback is that this strategy would create an incentive for foreign carriers to use the settlement rate system only for calls to mobiles, but to abandon the system in favor of direct interconnection when sending calls to fixed-line numbers.
- Introduce two different settlement rates for calls to fixed and mobile networks. Most carriers in countries with separate mobile operators have turned to this option in 1999.

Figure 6. The High Cost of Calling Mobiles, 1999



Sources: National regulatory authorities and TeleGeography, Inc.

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Under the new agreements, international operators charge foreign carriers at the normal settlement rate as long as traffic to mobiles remains at or below a certain benchmark level (usually, five percent of total call minutes). Beyond that benchmark, foreign carriers must pay a higher settlement fee. For example, U.S. carriers must shell out 25¢ per minute—10¢ per minute over the fixed network rate—to send traffic to mobile phones in Australia.

Differentiated settlement rates protect carriers receiving international traffic from the price squeeze effect. They also pass on the high cost of fixed-to-mobile interconnection to foreign carriers. In turn, these carriers are transferring the higher costs to customers. In June 1999, one major U.S. wholesaler charged resellers a higher rate to send calls to mobiles in virtually every country where a mobile operator existed outside the fixed network incumbent (see Figure 6). Retail service providers thus face a quandary: do they incur the marketing and billing hassles required to pass on higher costs to end users, or do they absorb these costs on their own?

One Country, Many Rates

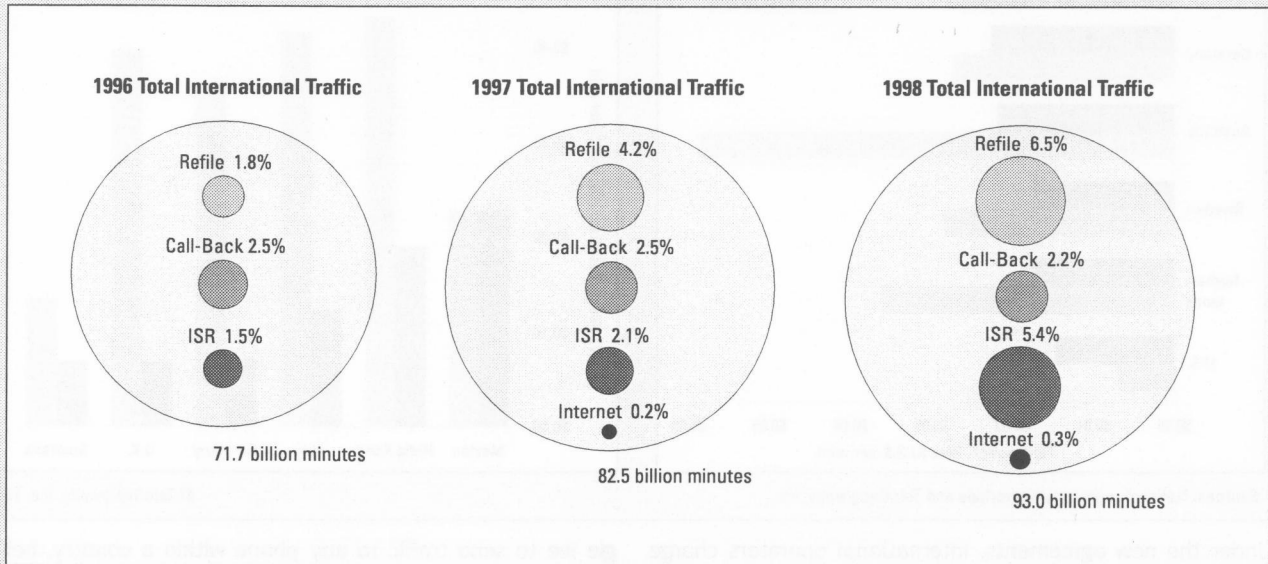
The introduction of dual settlement rates for calls to fixed and mobile networks reflects a larger trend in international telecommunications—the demise of the “one country, one rate” settlement scheme. That system, whereby foreign carriers paid a sin-

gle fee to send traffic to any phone within a country, held as long as national monopolies controlled access to all public networks. The introduction of new network operators has forced incumbents to adapt. Former monopolies have responded to direct interconnection—made available to foreign carriers at major Points of Presence thanks to fixed network competition—by offering discounted settlement rates on calls to principal cities. As options for terminating traffic increase, so too does the complexity of the international settlements regime.

The demise of the traditional settlement rate system reflects an even larger trend: termination fees on all networks are becoming more cost-based as competitors arbitrage away each others’ margins. Mobile is no exception. In the short run, mobile operators probably benefit as they face less competition than fixed-line carriers. But as regulators license more alternative mobile players, the comparatively high termination costs on wireless networks will come under pressure too. ☎

Alternative Traffic Arrangements

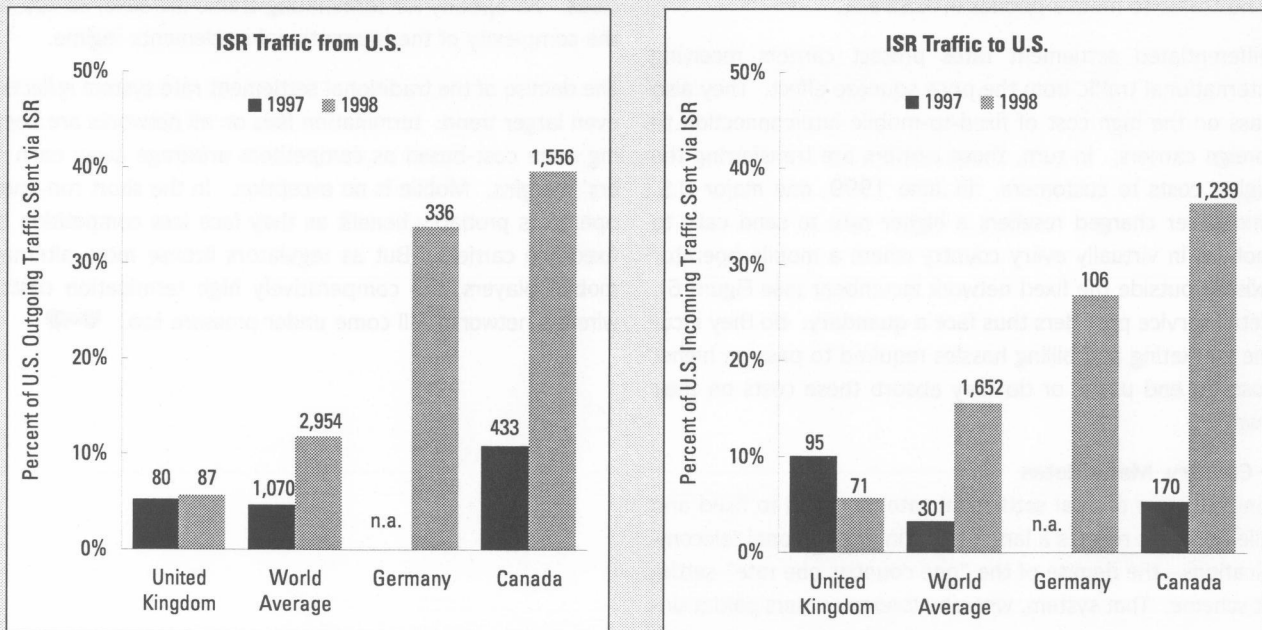
Figure 1. Alternative Traffic Arrangements as a Share of International Voice & Fax Traffic, 1996-1998



Note: Area of circles proportional to total international traffic. Refile and ISR traffic may overlap significantly.

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Figure 2. Top ISR Routes with the U.S., 1997-1998



Note: Numbers above columns indicate number of minutes sent via International Simple Resale (ISR). ISR with Germany was not legal in 1997.

Source: FCC carrier filings

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Figure 3. Call Delivery Methods

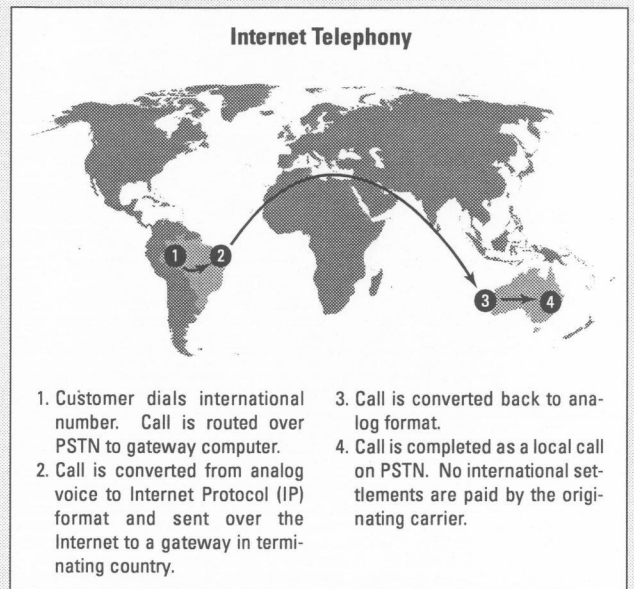
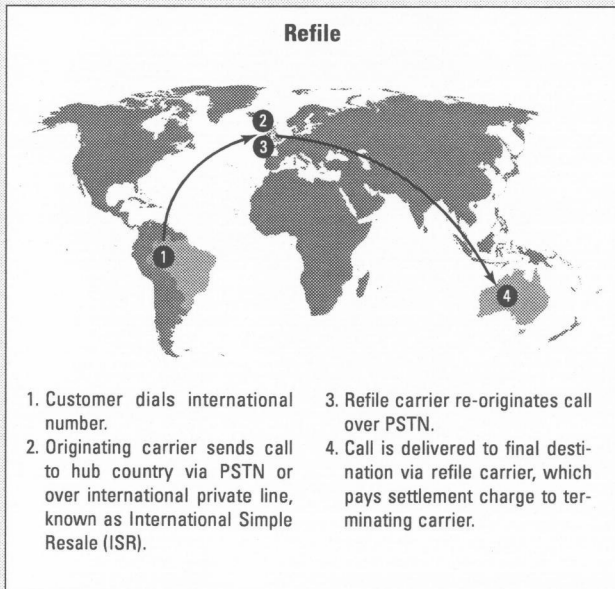
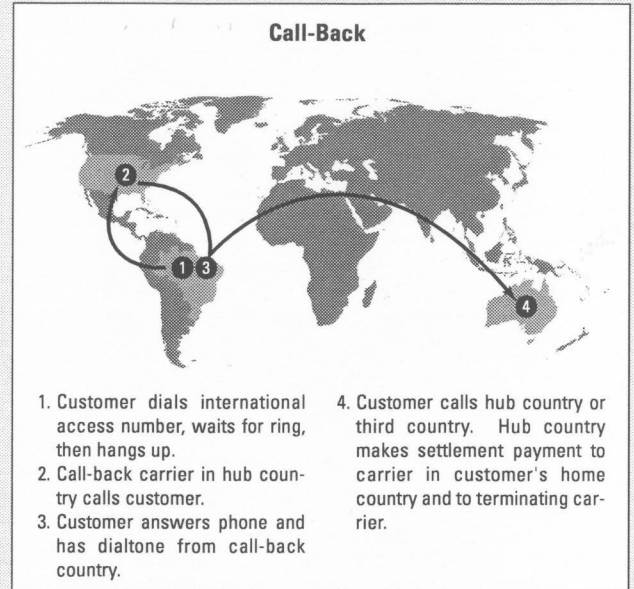
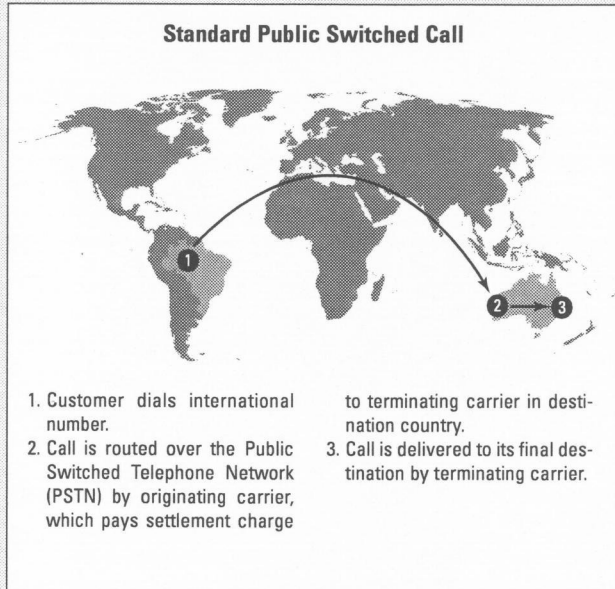


Figure 1. Global Telephony Services



International Traffic Statistics



Albania

Largest Telecommunications Routes, 1998

Destination	Minutes (millions)	Percentage of Outgoing Traffic
1. Italy	18.7	38.2%
2. Greece	17.3	35.3%
3. Germany	2.2	4.6%
4. Yugoslavia	2.2	4.6%
5. United States	2.0	4.1%
6. Slovenia	0.9	1.8%
7. Switzerland	0.8	1.6%
8. United Kingdom	0.8	1.5%
9. Turkey	0.7	1.3%
10. France	0.6	1.3%
11. Macedonia	0.5	1.0%
12. Austria	0.5	0.9%
13. Bulgaria	0.2	0.5%
14. Croatia	0.2	0.4%
Other	1.5	3.0%
Total	49.1	

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National Traffic Balance

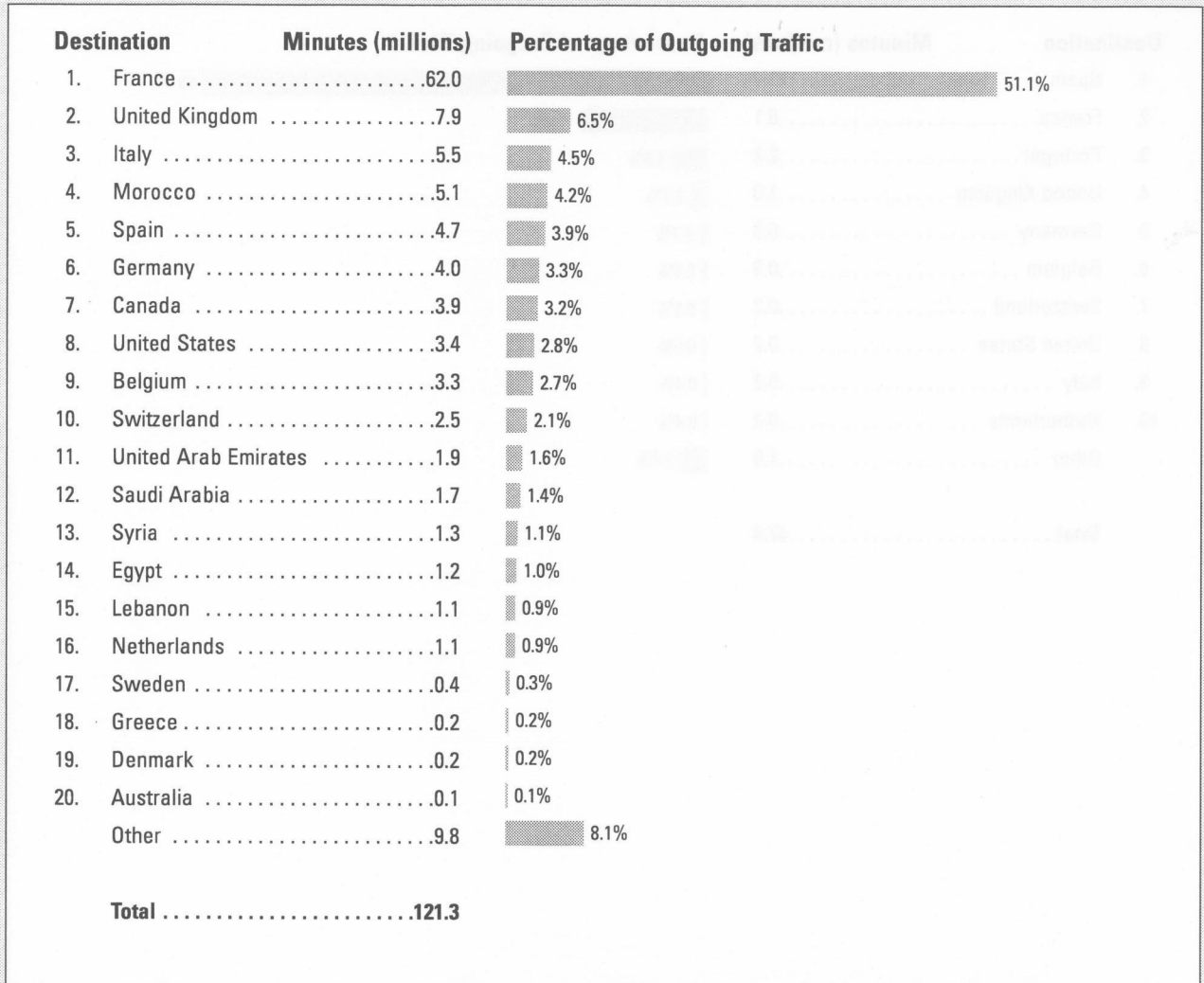
Minutes	1996	1997	1998
Incoming	46.0	n.a.	52.2
Outgoing	20.6	40.8	49.1
Surplus (Deficit)	25.4	n.a.	3.1
Total Volume	66.6	n.a.	101.2

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic. Data based on billing point of traffic.

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Algeria

Largest Telecommunications Routes, 1998



© TeleGeography, Inc. 1999

National Traffic Balance

Minutes	1996	1997	1998
Incoming	110.0	n.a.	n.a.
Outgoing	93.0	n.a.	121.3
Surplus (Deficit)	17.0	n.a.	n.a.
Total Volume	203.0	n.a.	n.a.

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic. Data exclude cross-border traffic to Tunisia.

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Andorra

Largest Telecommunications Routes, 1998

Destination	Minutes (millions)	Percentage of Outgoing Traffic
1. Spain	33.0	69.6%
2. France	8.1	17.2%
3. Portugal	2.2	4.6%
4. United Kingdom	1.0	2.1%
5. Germany	0.3	0.7%
6. Belgium	0.3	0.6%
7. Switzerland	0.2	0.5%
8. United States	0.2	0.5%
9. Italy	0.2	0.4%
10. Netherlands	0.2	0.4%
Other	1.6	3.4%
Total	47.4	

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National Traffic Balance

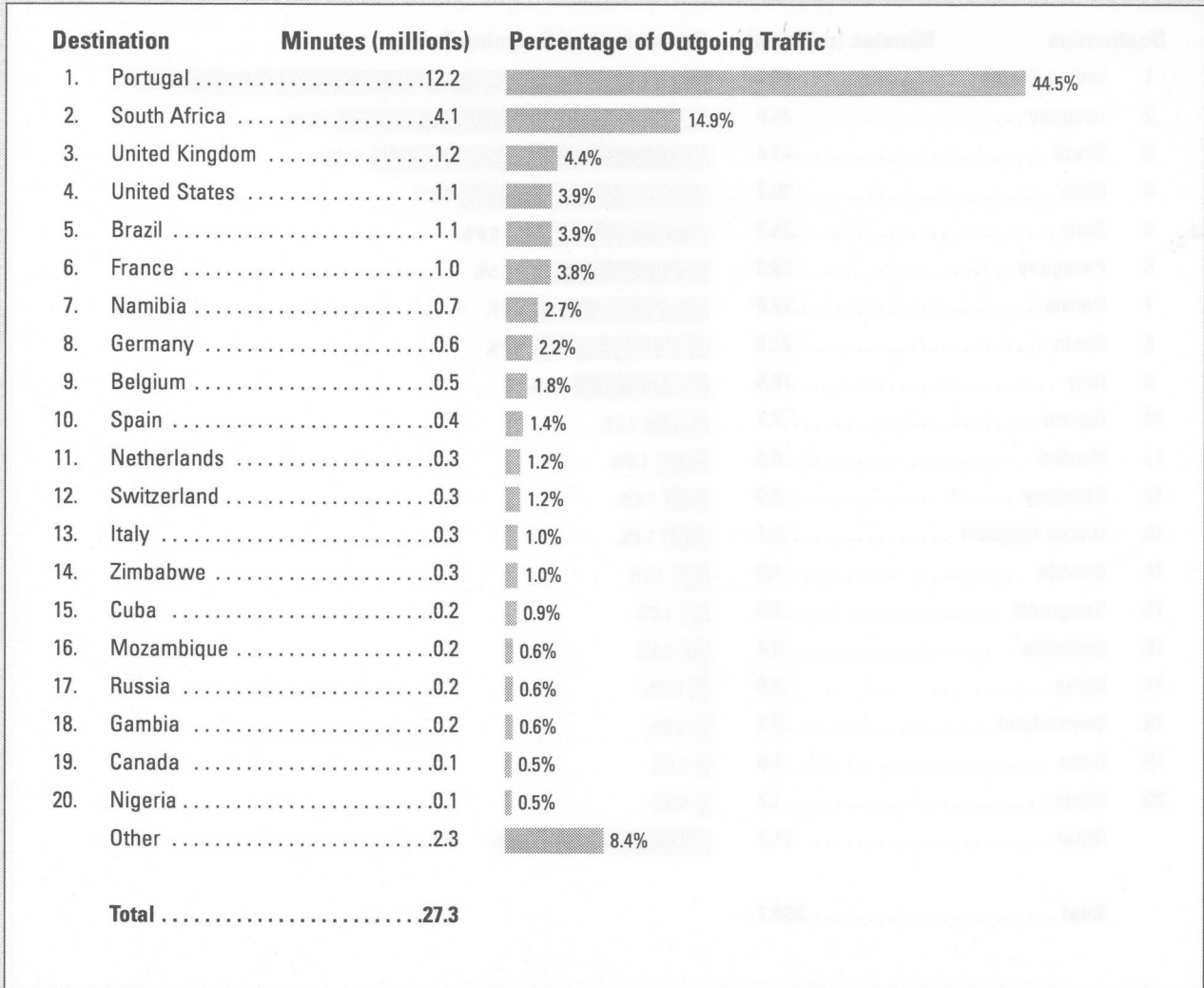
Minutes	1996	1997	1998
Incoming	27.3	30.1	32.2
Outgoing	37.8	42.2	47.4
Surplus (Deficit)	(10.5)	(12.1)	(15.2)
Total Volume	65.1	72.3	79.6

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic.

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Angola

Largest Telecommunications Routes, 1998



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National Traffic Balance

Minutes	1996	1997	1998
Incoming	17.0	18.8	22.3
Outgoing	18.1	21.9	27.3
Surplus (Deficit)	(1.1)	(3.1)	(5.0)
Total Volume	35.1	40.7	49.6

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic.

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Argentina

Largest Telecommunications Routes, 1998

Destination	Minutes (millions)	Percentage of Outgoing Traffic
1. United States	.65.5	18.3%
2. Uruguay	.45.6	12.7%
3. Brazil	.41.4	11.5%
4. Chile	.30.7	8.5%
5. Peru	.24.7	6.9%
6. Paraguay	.23.3	6.5%
7. Bolivia	.22.0	6.1%
8. Spain	.21.8	6.1%
9. Italy	.16.5	4.6%
10. France	.7.7	2.2%
11. Mexico	.6.5	1.8%
12. Germany	.5.9	1.6%
13. United Kingdom	.5.7	1.6%
14. Canada	.4.8	1.3%
15. Venezuela	.3.6	1.0%
16. Colombia	.3.4	1.0%
17. China	.2.6	0.7%
18. Switzerland	.2.1	0.6%
19. Cuba	.1.9	0.5%
20. Israel	.1.7	0.5%
Other	.21.2	5.9%
Total	.358.7	

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National Traffic Balance

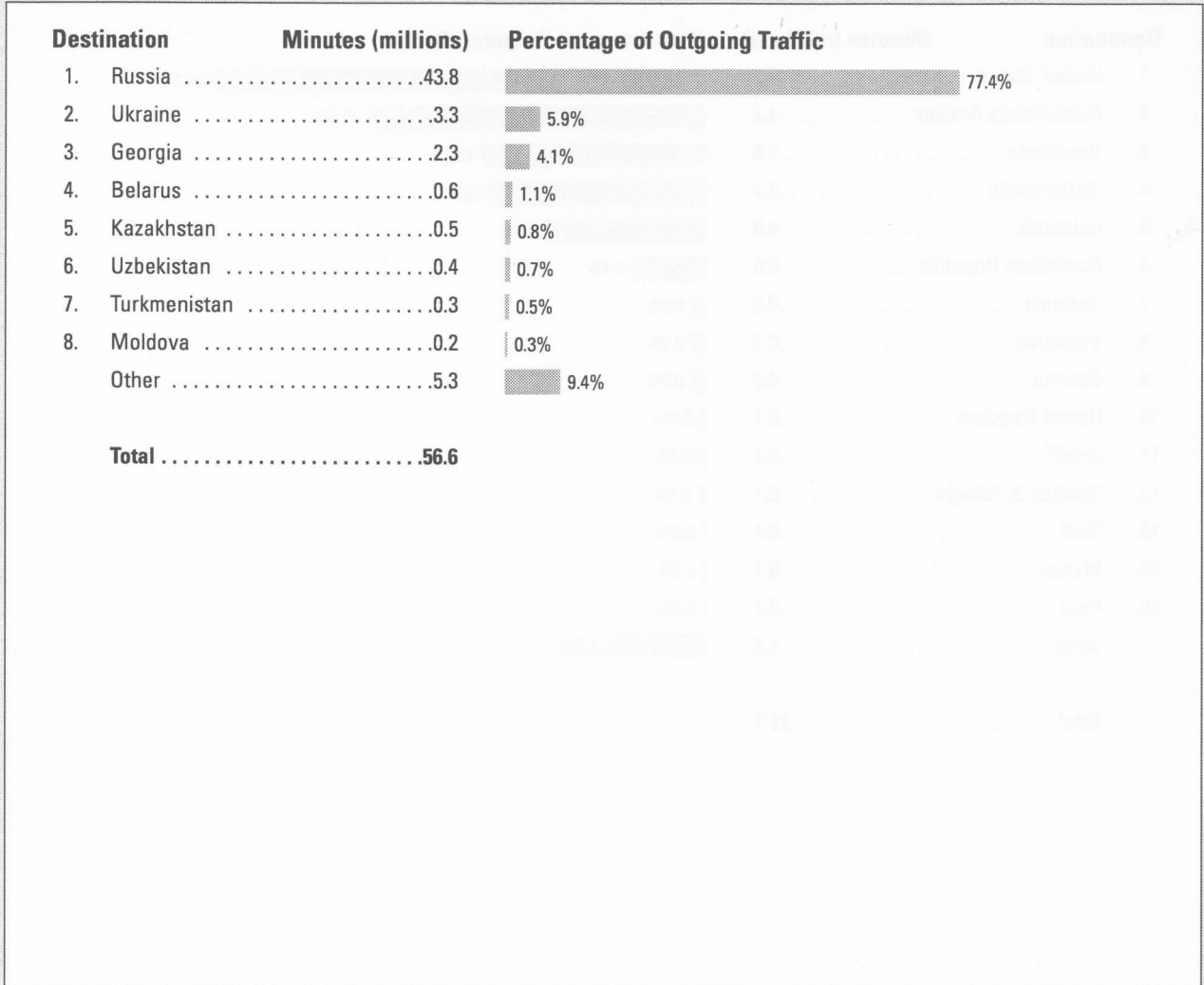
Minutes	1996	1997	1998
Incoming	390.7	444.2	n.a.
Outgoing	181.3	223.4	358.7
Surplus (Deficit)	209.4	220.8	n.a.
Total Volume	572.0	667.6	n.a.

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic. Data for 1996 based on billing point of traffic. Data for 1997 and 1998 based on originating point of traffic.

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Armenia

Largest Telecommunications Routes, 1998



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National Traffic Balance

Minutes	1996	1997	1998
Incoming	n.a.	n.a.	94.3
Outgoing	48.1	48.8	56.6
Surplus (Deficit)	n.a.	n.a.	37.7
Total Volume	n.a.	n.a.	150.9

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic. The "Other" category may include routes to non-members of the Commonwealth of Independent States, including an estimated one million minutes to the U.S., that rank among the top destinations for outgoing traffic.

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Largest Telecommunications Routes, 1998

Destination	Minutes (millions)	Percentage of Outgoing Traffic
1. United States	6.2	29.3%
2. Netherlands Antilles	4.2	20.0%
3. Venezuela	2.8	13.2%
4. Netherlands	2.7	12.8%
5. Colombia	2.0	9.5%
6. Dominican Republic	0.9	4.4%
7. Jamaica	0.2	0.9%
8. Suriname	0.2	0.9%
9. Canada	0.2	0.9%
10. United Kingdom	0.1	0.4%
11. Brazil	0.1	0.4%
12. Trinidad & Tobago	0.1	0.4%
13. Haiti	0.1	0.3%
14. Mexico	0.1	0.3%
15. Peru	0.1	0.3%
Other	1.3	6.0%
Total	21.1	

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National Traffic Balance

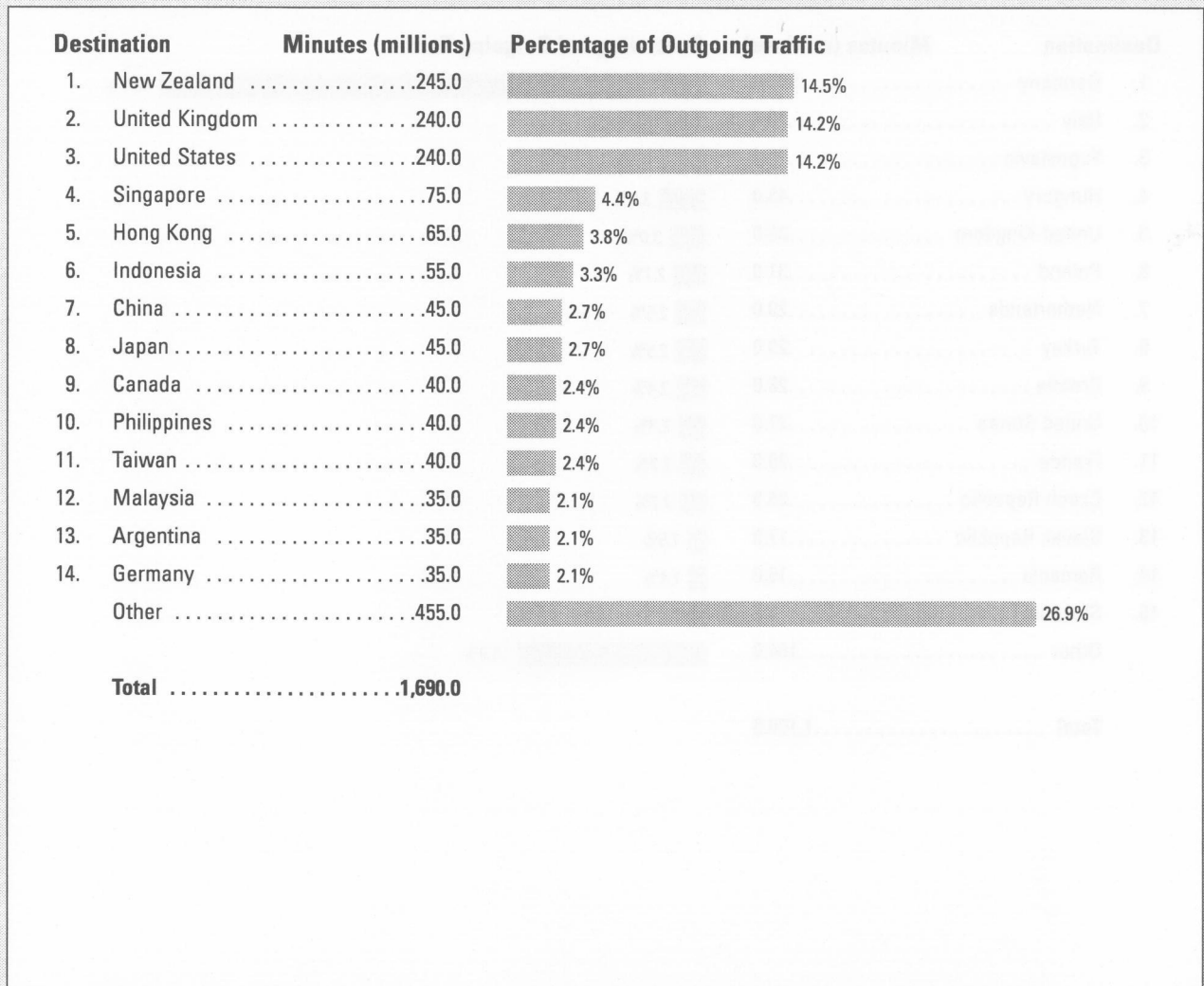
Minutes	1996	1997	1998
Incoming	21.0	25.8	31.0
Outgoing	19.2	20.3	21.1
Surplus (Deficit)	1.8	5.5	9.9
Total Volume	40.2	46.1	52.1

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic.

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Australia

Largest Telecommunications Routes, FY 1998/99



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National Traffic Balance

Minutes	FY 1996/97	FY 1997/98	FY 1998/99
Incoming	n.a.	1,250.0	n.a.
Outgoing	1,305.0	1,510.0	1,690.0
Surplus (Deficit)	n.a.	(260.0)	n.a.
Total Volume	n.a.	2,760.0	n.a.

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic. Fiscal year ends 30 June.

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Austria

Largest Telecommunications Routes, 1998

Destination	Minutes (millions)	Percentage of Outgoing Traffic
1. Germany .....	.535.0	46.1%
2. Italy .....	.70.0	6.0%
3. Yugoslavia .....	.46.0	4.0%
4. Hungary .....	.45.0	3.9%
5. United Kingdom .....	.35.0	3.0%
6. Poland .....	.31.0	2.7%
7. Netherlands .....	.29.0	2.5%
8. Turkey .....	.29.0	2.5%
9. Croatia .....	.28.0	2.4%
10. United States .....	.27.0	2.3%
11. France .....	.26.0	2.2%
12. Czech Republic .....	.26.0	2.2%
13. Slovak Republic17.0	1.5%
14. Romania16.0	1.4%
15. Slovenia16.0	1.4%
Other184.0	15.9%
Total	1,160.0	

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National Traffic Balance

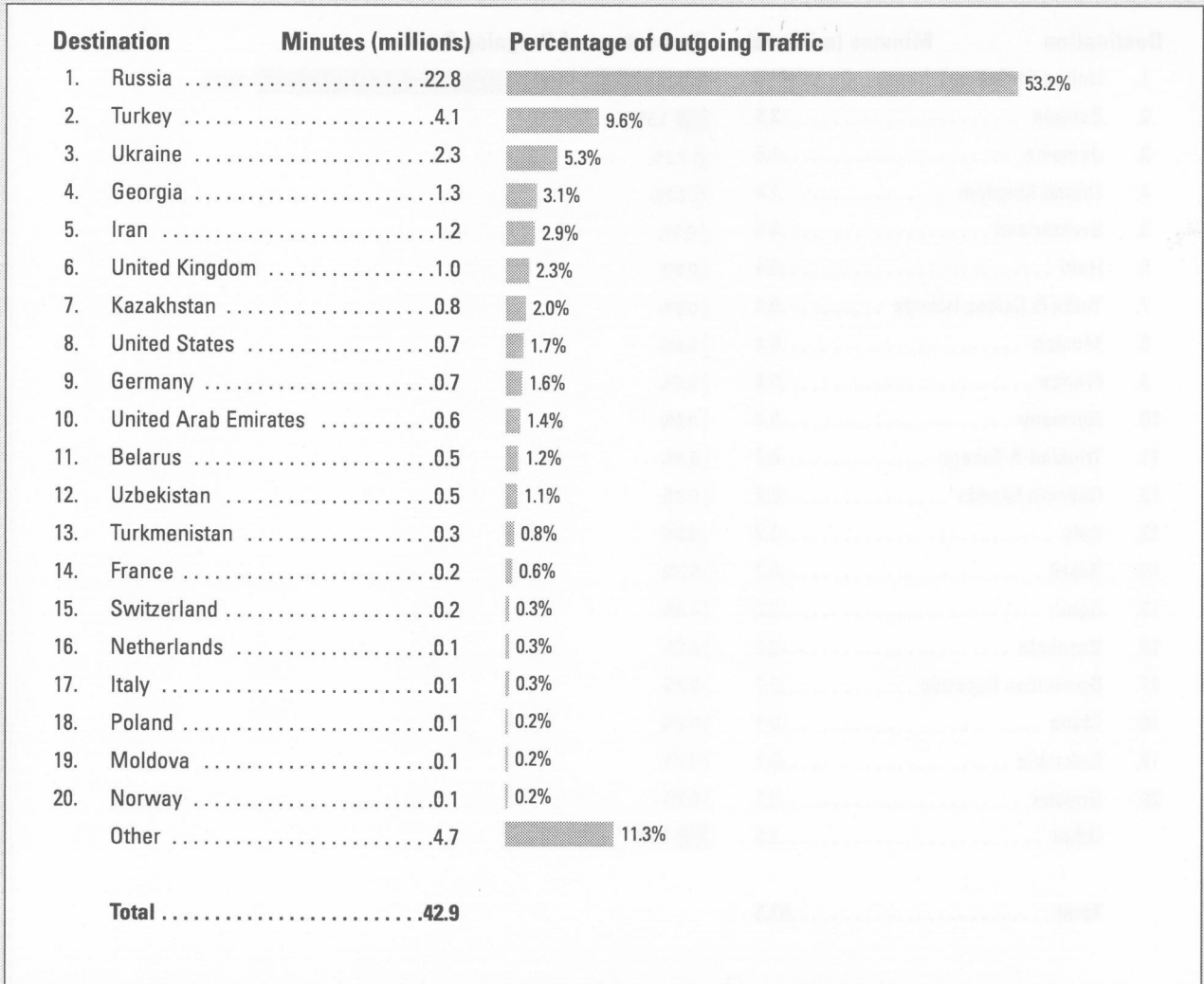
Minutes	1996	1997	1998
Incoming	n.a.	957.7	n.a.
Outgoing	960.0	995.5	1,160.0
Surplus (Deficit)	n.a.	(37.8)	n.a.
Total Volume	n.a.	1,953.2	n.a.

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic. Traffic figures exclude most cross-border traffic to Switzerland.

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Azerbaijan

Largest Telecommunications Routes, 1998



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National Traffic Balance

Minutes	1996	1997	1998
Incoming	43.0	n.a.	46.0
Outgoing	27.0	n.a.	42.9
Surplus (Deficit)	16.0	n.a.	3.2
Total Volume	70.0	n.a.	88.9

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic. Data based on billing point of traffic. Data exclude some cross-border traffic to Georgia, Iran, and Turkey.

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Bahamas

Largest Telecommunications Routes, 1998

Destination	Minutes (millions)	Percentage of Outgoing Traffic
1. United States	49.8	78.3%
2. Canada	3.5	5.5%
3. Jamaica	1.5	2.3%
4. United Kingdom	1.4	2.2%
5. Switzerland	0.6	0.9%
6. Haiti	0.4	0.6%
7. Turks & Caicos Islands	0.4	0.6%
8. Mexico	0.4	0.6%
9. France	0.4	0.6%
10. Germany	0.4	0.6%
11. Trinidad & Tobago	0.2	0.3%
12. Cayman Islands	0.2	0.3%
13. Italy	0.2	0.3%
14. Brazil	0.2	0.3%
15. Spain	0.2	0.3%
16. Bermuda	0.2	0.2%
17. Dominican Republic	0.1	0.2%
18. China	0.1	0.2%
19. Colombia	0.1	0.2%
20. Guyana	0.1	0.2%
Other	3.3	5.2%
Total	.63.5	

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National Traffic Balance

Minutes	1996	1997	1998
Incoming	n.a.	n.a.	90.0
Outgoing	56.7	62.7	63.5
Surplus (Deficit)	n.a.	n.a.	26.5
Total Volume	n.a.	n.a.	153.5

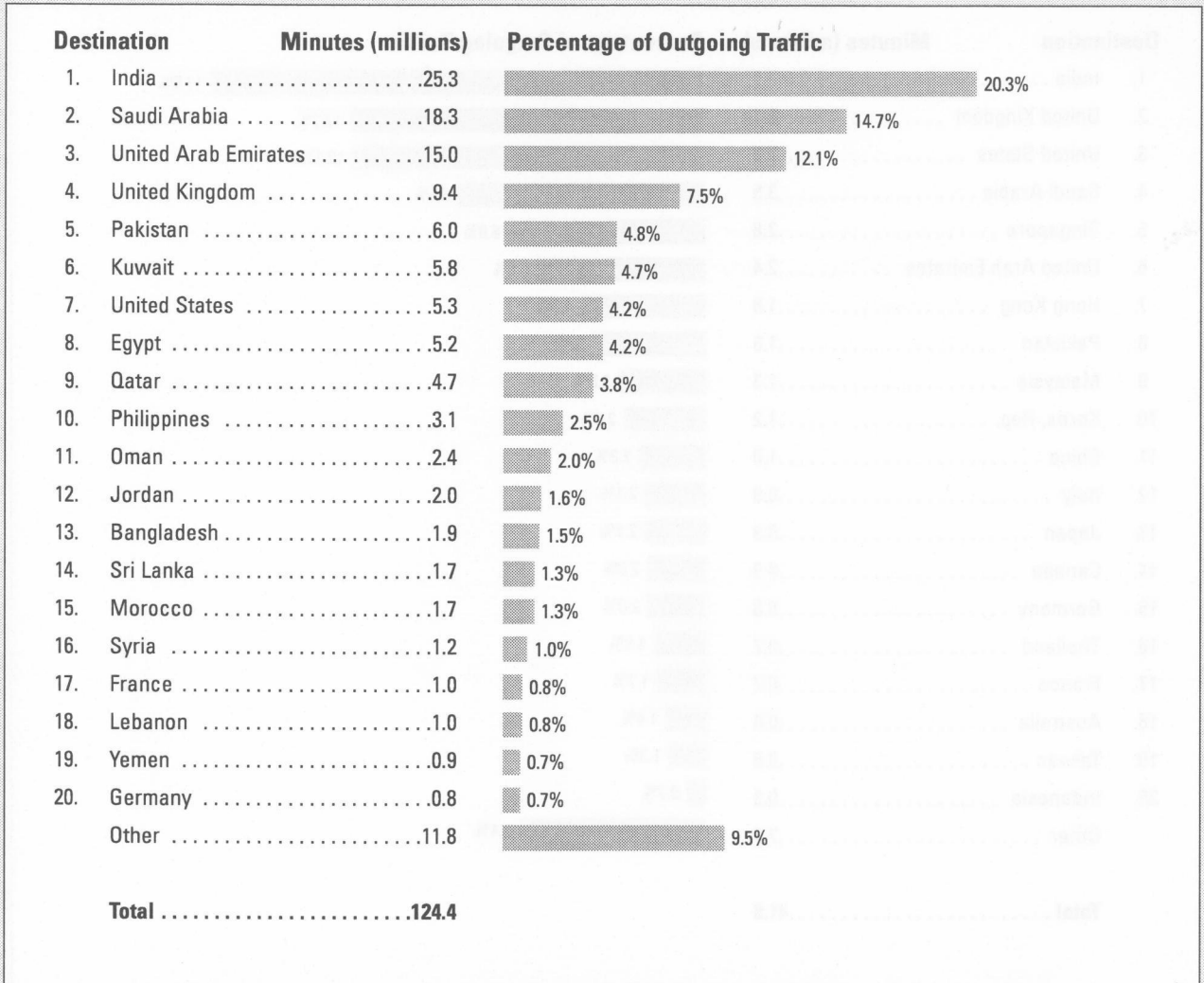
Note: Data are in millions of minutes of outgoing public switched telecommunications traffic.

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Bahrain



Largest Telecommunications Routes, 1998



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National Traffic Balance

Minutes	1996	1997	1998
Incoming	69.4	85.4	102.1
Outgoing	92.2	106.6	124.4
Surplus (Deficit)	(22.8)	(21.2)	(22.3)
Total Volume	161.6	192.0	226.5

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic. Data based on billing point of traffic.

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Bangladesh

Largest Telecommunications Routes, 1998

Destination	Minutes (millions)	Percentage of Outgoing Traffic
1. India	7.1	17.0%
2. United Kingdom	5.1	12.2%
3. United States	5.0	12.1%
4. Saudi Arabia	3.5	8.5%
5. Singapore	2.8	6.8%
6. United Arab Emirates	2.4	5.8%
7. Hong Kong	1.8	4.3%
8. Pakistan	1.6	3.9%
9. Malaysia	1.3	3.0%
10. Korea, Rep.	1.2	2.8%
11. China	1.0	2.3%
12. Italy	0.9	2.1%
13. Japan	0.9	2.1%
14. Canada	0.9	2.0%
15. Germany	0.8	2.0%
16. Thailand	0.7	1.8%
17. France	0.7	1.7%
18. Australia	0.6	1.4%
19. Taiwan	0.6	1.3%
20. Indonesia	0.3	0.7%
Other	2.7	6.4%
Total	41.8	

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National Traffic Balance

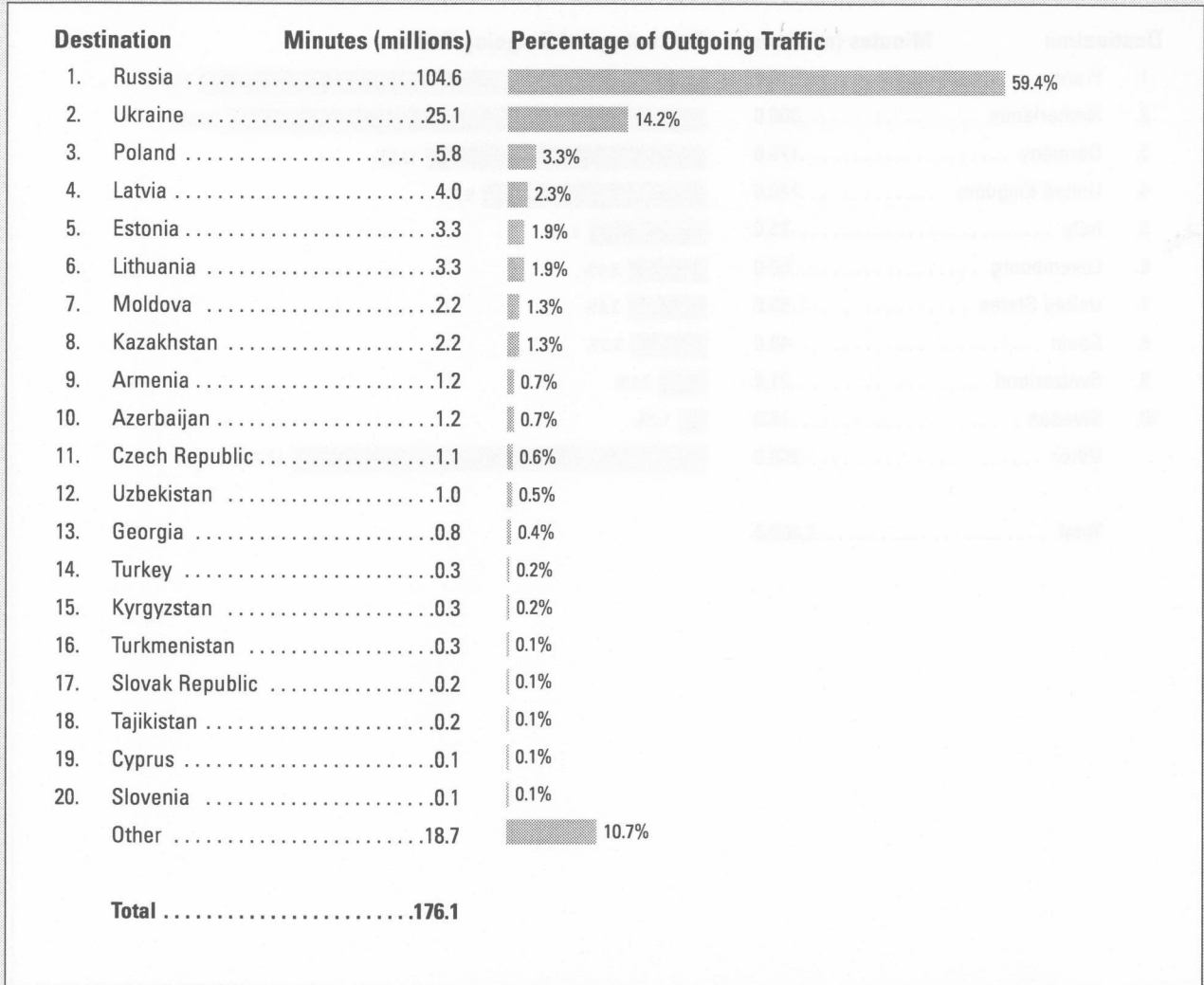
Minutes	1996	1997	1998
Incoming	129.2	187.0	196.2
Outgoing	38.3	46.9	41.8
Surplus (Deficit)	90.9	140.1	154.4
Total Volume	167.5	233.9	237.9

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic.

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Belarus

Largest Telecommunications Routes, 1998



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National Traffic Balance

Minutes	1996	1997	1998
Incoming	169.0	185.2	193.5
Outgoing	104.9	148.6	176.1
Surplus (Deficit)	64.1	36.6	17.3
Total Volume	273.9	333.8	369.6

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic. Data based on billing point of traffic. The "Other" category may include routes to Western Europe, Asia, and the Americas, including an estimated one million minutes to the U.S., that rank among the top destinations for outgoing traffic. Totals for 1996 include only traffic with other members of the CIS.

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Belgium

Largest Telecommunications Routes, 1998

Destination	Minutes (millions)	Percentage of Outgoing Traffic
1. France	.315.0	21.6%
2. Netherlands	.300.0	20.5%
3. Germany	.175.0	12.0%
4. United Kingdom	.140.0	9.6%
5. Italy	.75.0	5.1%
6. Luxembourg	.50.0	3.4%
7. United States	.50.0	3.4%
8. Spain	.48.0	3.3%
9. Switzerland	.31.0	2.1%
10. Sweden	.18.0	1.2%
Other	.258.0	17.7%
Total	.1,460.0	

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National Traffic Balance

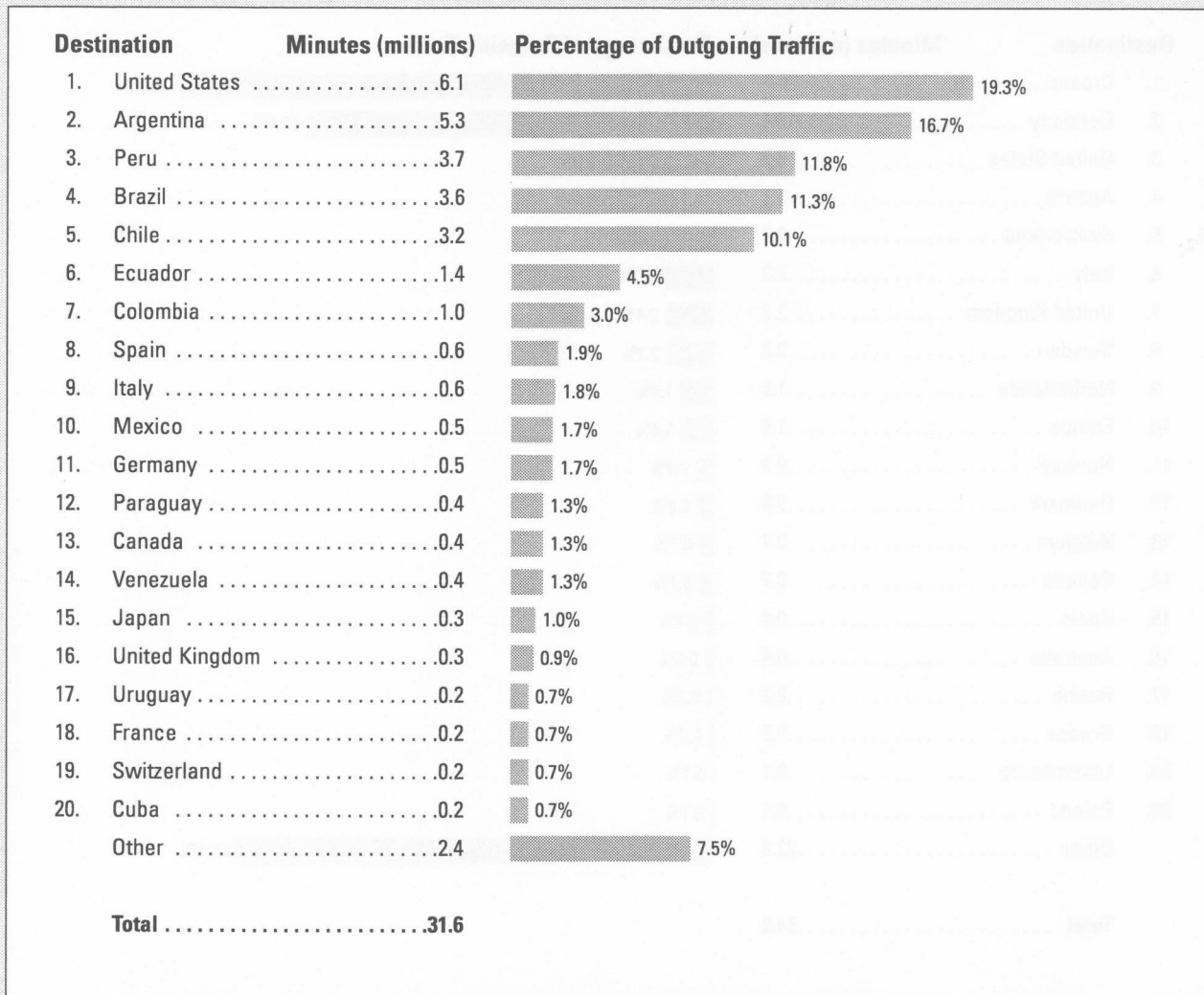
Minutes	1996	1997	1998
Incoming	1,289.1	1,420.0	n.a.
Outgoing	1,228.4	1,340.0	1,460.0
Surplus (Deficit)	60.7	80.0	n.a.
Total Volume	2,517.5	2,760.0	n.a.

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic. Data based on billing point of traffic.

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Bolivia

Largest Telecommunications Routes, 1998



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National Traffic Balance

Minutes	1996	1997	1998
Incoming	53.9	69.3	76.4
Outgoing	21.4	22.7	31.6
Surplus (Deficit)	32.5	46.6	44.8
Total Volume	75.3	92.0	108.0

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic.

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Bosnia-Herzegovina

Largest Telecommunications Routes, 1998

Destination	Minutes (millions)	Percentage of Outgoing Traffic
1. Croatia	25.5	26.9%
2. Germany	19.4	20.4%
3. United States	5.2	5.5%
4. Austria	5.1	5.4%
5. Switzerland	2.7	2.8%
6. Italy	2.3	2.5%
7. United Kingdom	2.2	2.4%
8. Sweden	2.2	2.3%
9. Netherlands	1.5	1.6%
10. France	1.5	1.6%
11. Norway	0.8	0.9%
12. Denmark	0.8	0.8%
13. Belgium	0.7	0.7%
14. Canada	0.7	0.7%
15. Spain	0.4	0.4%
16. Australia	0.4	0.4%
17. Russia	0.2	0.3%
18. Greece	0.2	0.2%
19. Luxembourg	0.1	0.1%
20. Poland	0.1	0.1%
Other	22.8	24.0%
Total	94.9	

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National Traffic Balance

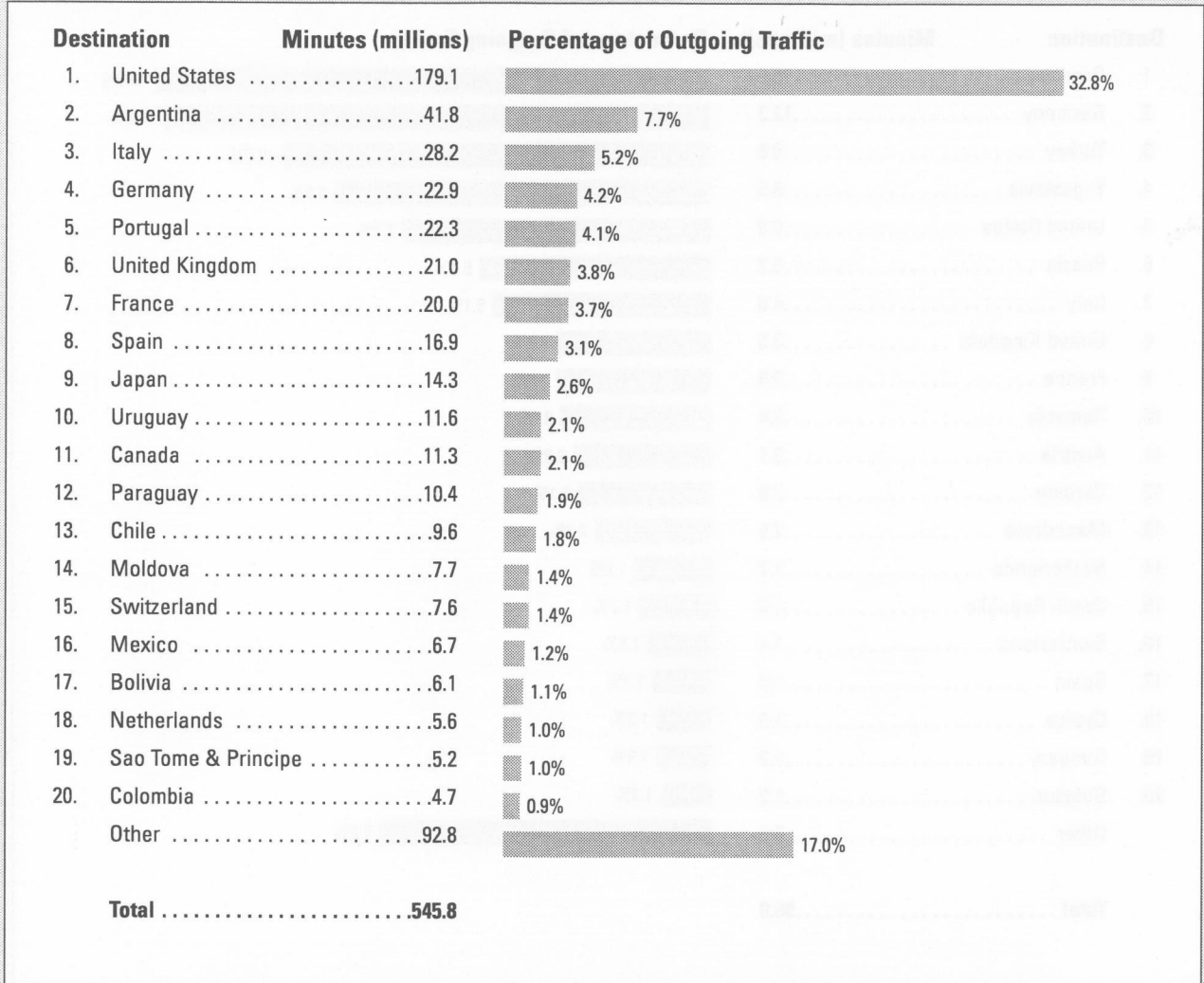
Minutes	1996	1997	1998
Incoming	n.a.	n.a.	159.2
Outgoing	63.6	66.2	94.9
Surplus (Deficit)	n.a.	n.a.	64.3
Total Volume	n.a.	n.a.	254.1

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic. The "Other" category may include routes to nearby countries, including an estimated eight million minutes to Yugoslavia and four million minutes to Slovenia, that rank among the top destinations for outgoing traffic.

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Largest Telecommunications Routes, 1998



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National Traffic Balance

Minutes	1996	1997	1998
Incoming	624.4	761.3	806.9
Outgoing	366.9	459.1	545.8
Surplus (Deficit)	257.5	302.2	261.1
Total Volume	991.3	1,220.4	1,352.7

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic. Data based on billing point of traffic.

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Bulgaria

Largest Telecommunications Routes, 1998

Destination	Minutes (millions)	Percentage of Outgoing Traffic
1. Greece	12.5	13.0%
2. Germany	12.3	12.8%
3. Turkey	9.6	10.0%
4. Yugoslavia	8.5	8.8%
5. United States	6.9	7.2%
6. Russia	5.2	5.4%
7. Italy	4.8	5.1%
8. United Kingdom	3.5	3.6%
9. France	3.5	3.6%
10. Romania	3.4	3.5%
11. Austria	3.1	3.2%
12. Ukraine	3.0	3.1%
13. Macedonia	2.6	2.7%
14. Netherlands	1.7	1.8%
15. Czech Republic	1.6	1.7%
16. Switzerland	1.4	1.5%
17. Spain	1.3	1.4%
18. Cyprus	1.3	1.3%
19. Hungary	1.2	1.3%
20. Belgium	1.2	1.2%
Other	7.5	7.8%
Total	96.0	

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National Traffic Balance

Minutes	1996	1997	1998
Incoming	109.7	135.0	201.0
Outgoing	84.0	76.0	96.0
Surplus (Deficit)	25.7	59.0	105.0
Total Volume	193.7	211.0	297.0

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic.

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Largest Telecommunications Routes, 1998

Destination	Minutes (millions)	Percentage of Outgoing Traffic
1. United States	3,400.0	70.8%
2. United Kingdom	230.0	4.8%
3. Germany	75.0	1.6%
4. Hong Kong	65.0	1.4%
5. India	65.0	1.4%
6. France	60.0	1.2%
7. Australia	40.0	0.8%
8. Italy	40.0	0.8%
9. Philippines	40.0	0.8%
10. Japan	35.0	0.7%
11. Netherlands	30.0	0.6%
12. Taiwan	30.0	0.6%
13. Vietnam	30.0	0.6%
14. Jamaica	25.0	0.5%
15. Korea, Rep.	25.0	0.5%
16. Mexico	25.0	0.5%
17. Switzerland	25.0	0.5%
18. Sri Lanka	25.0	0.5%
Other	540.0	11.2%
Total	4,805.0	

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National Traffic Balance

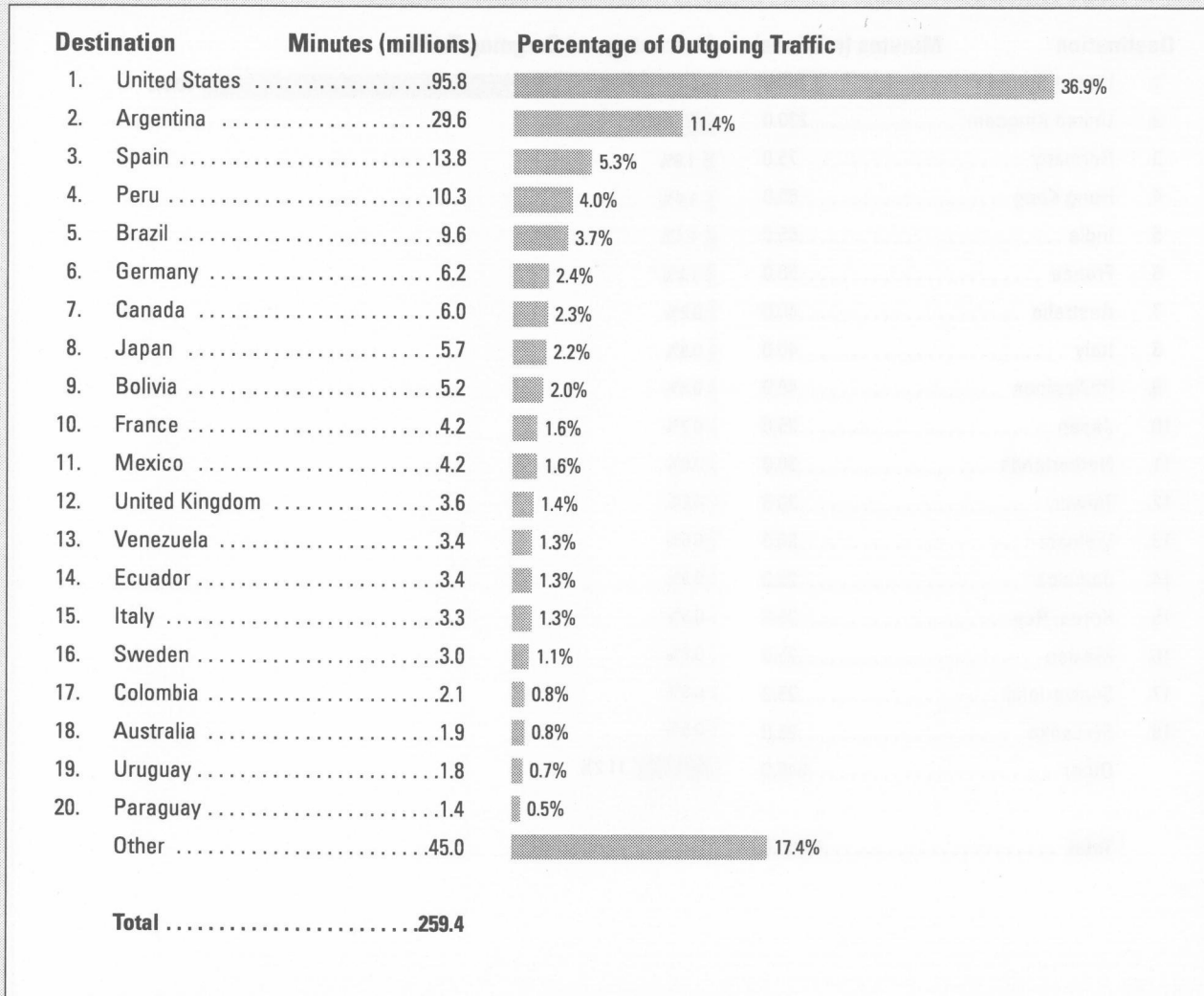
Minutes	1996	1997	1998
Incoming	4,313.3	4,635.1	n.a.
Outgoing	3,519.8	4,286.3	4,805.0
Surplus (Deficit)	793.5	348.8	n.a.
Total Volume	7,833.1	8,921.4	n.a.

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic. Data based on billing point of traffic.

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Largest Telecommunications Routes, 1998



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National Traffic Balance

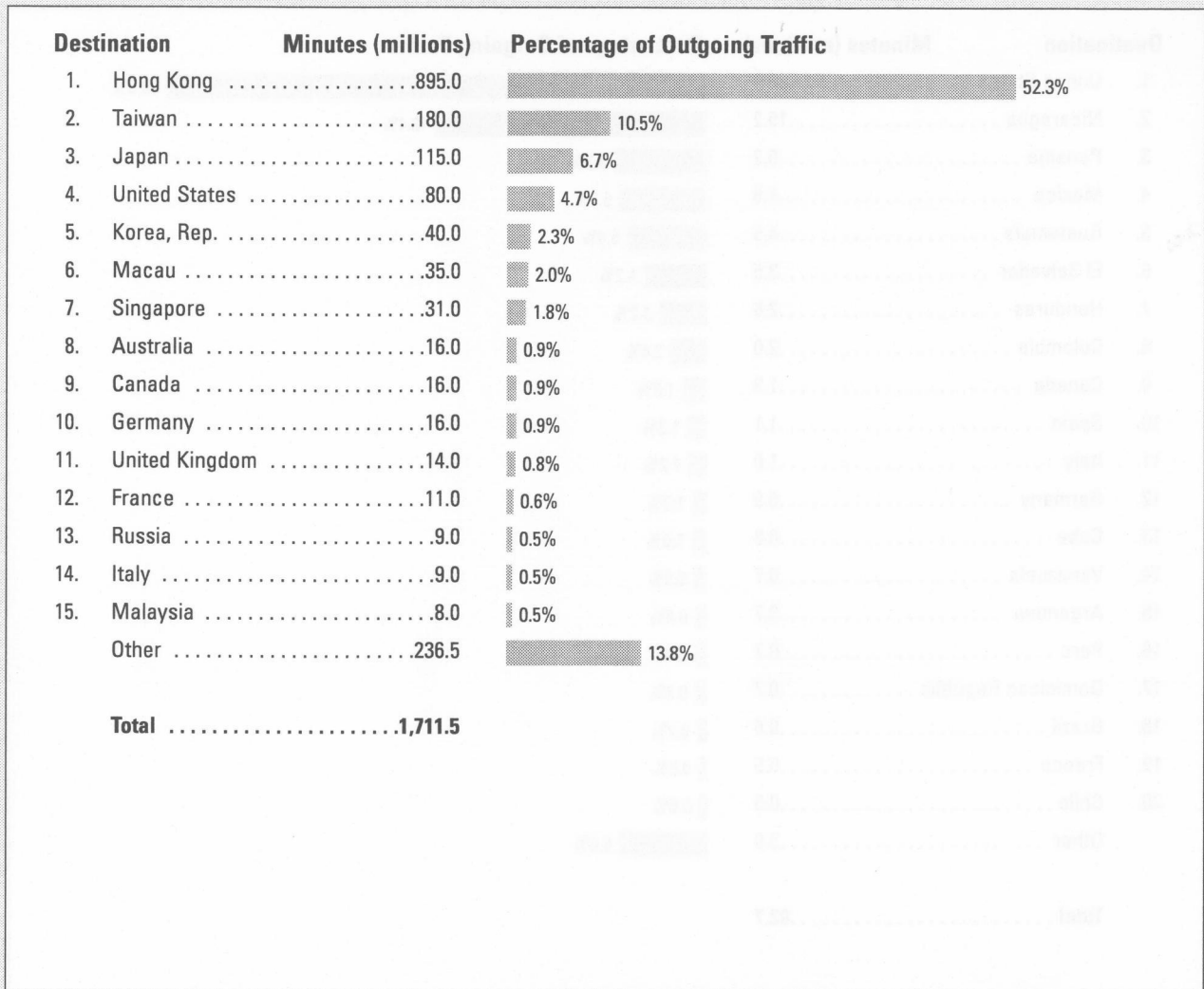
Minutes	1996	1997	1998
Incoming	n.a.	n.a.	n.a.
Outgoing	173.8	242.0	259.4
Surplus (Deficit)	n.a.	n.a.	n.a.
Total Volume	n.a.	n.a.	n.a.

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic.

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China

Largest Telecommunications Routes, 1998



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National Traffic Balance

Minutes	1996	1997	1998
Incoming	n.a.	n.a.	n.a.
Outgoing	1,433.2	1,631.8	1,711.5
Surplus (Deficit)	n.a.	n.a.	n.a.
Total Volume	n.a.	n.a.	n.a.

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic.

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Costa Rica

Largest Telecommunications Routes, 1998

Destination	Minutes (millions)	Percentage of Outgoing Traffic
1. United States	.30.6	36.9%
2. Nicaragua	.15.2	18.4%
3. Panama	.5.2	6.3%
4. Mexico	.4.9	5.9%
5. Guatemala	.4.5	5.4%
6. El Salvador	.3.5	4.2%
7. Honduras	.2.6	3.2%
8. Colombia	.2.0	2.4%
9. Canada	.1.3	1.6%
10. Spain	.1.1	1.3%
11. Italy	.1.0	1.2%
12. Germany	.0.9	1.0%
13. Cuba	.0.8	1.0%
14. Venezuela	.0.7	0.9%
15. Argentina	.0.7	0.8%
16. Peru	.0.7	0.8%
17. Dominican Republic	.0.7	0.8%
18. Brazil	.0.6	0.7%
19. France	.0.5	0.6%
20. Chile	.0.5	0.6%
Other	.5.0	6.0%
Total	.82.7	

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National Traffic Balance

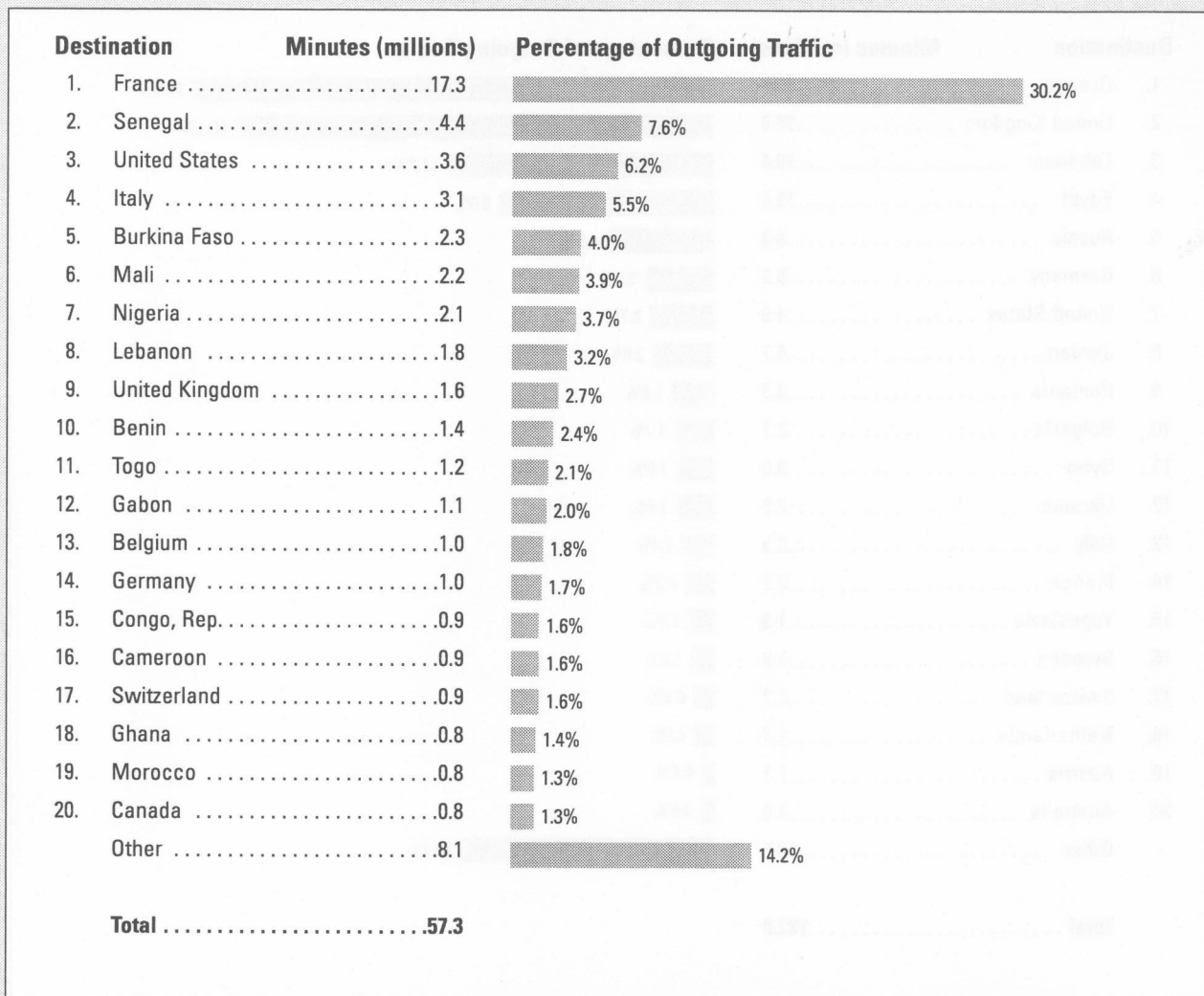
Minutes	1996	1997	1998
Incoming	87.8	111.6	112.9
Outgoing	55.0	66.9	82.7
Surplus (Deficit)	32.8	44.7	30.2
Total Volume	142.8	178.5	195.6

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic. Data based on billing point of traffic.

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Côte d'Ivoire

Largest Telecommunications Routes, 1998



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National Traffic Balance

Minutes	1996	1997	1998
Incoming	43.3	50.6	46.6
Outgoing	37.0	40.1	57.3
Surplus (Deficit)	6.3	10.5	(10.7)
Total Volume	80.3	90.7	103.9

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic.

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Largest Telecommunications Routes, 1998

Destination	Minutes (millions)	Percentage of Outgoing Traffic
1. Greece	39.8	21.9%
2. United Kingdom	36.6	20.1%
3. Lebanon	20.4	11.2%
4. Egypt	16.4	9.0%
5. Russia	8.3	4.5%
6. Germany	5.2	2.9%
7. United States	4.9	2.7%
8. Jordan	4.7	2.6%
9. Romania	3.3	1.8%
10. Bulgaria	3.1	1.7%
11. Syria	3.0	1.6%
12. Ukraine	2.9	1.6%
13. Italy	2.5	1.4%
14. France	2.2	1.2%
15. Yugoslavia	1.9	1.1%
16. Sweden	1.9	1.0%
17. Switzerland	1.7	0.9%
18. Netherlands	1.7	0.9%
19. Austria	1.1	0.6%
20. Australia	1.0	0.6%
Other	19.5	10.7%
Total	182.0	

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National Traffic Balance

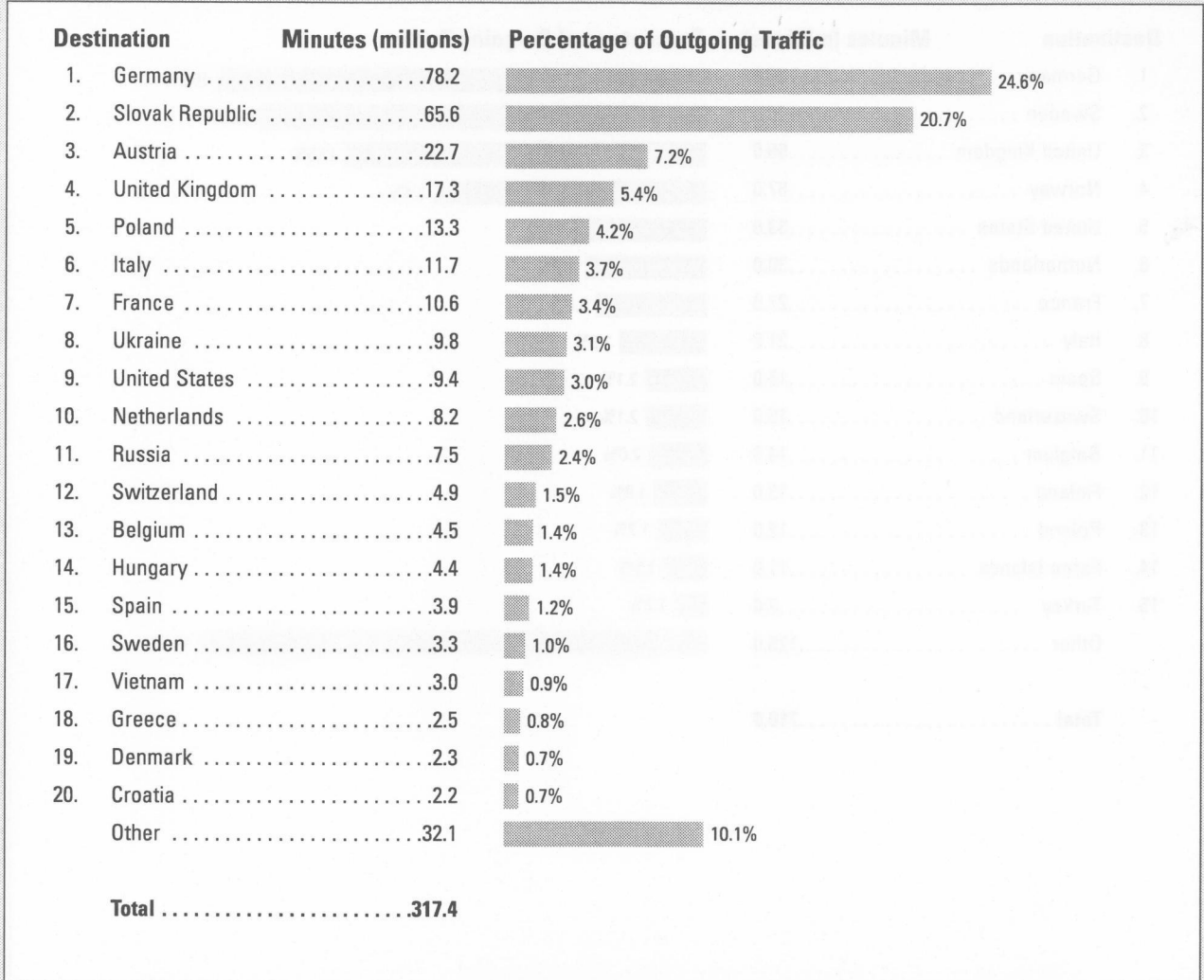
Minutes	1996	1997	1998
Incoming	92.0	115.2	120.6
Outgoing	128.6	154.4	182.0
Surplus (Deficit)	(36.6)	(39.2)	(61.4)
Total Volume	220.6	269.6	302.7

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic. Data based on billing point of traffic. Data exclude traffic to Turkey and some traffic to Greece.

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Czech Republic

Largest Telecommunications Routes, 1998



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National Traffic Balance

Minutes	1996	1997	1998
Incoming	324.4	355.0	406.9
Outgoing	281.2	306.1	317.4
Surplus (Deficit)	43.2	48.9	89.5
Total Volume	605.6	661.1	724.4

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic. Data based on billing point of traffic.

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Denmark

Largest Telecommunications Routes, 1998

Destination	Minutes (millions)	Percentage of Outgoing Traffic
1. Germany	120.0	16.9%
2. Sweden	110.0	15.5%
3. United Kingdom	89.0	12.5%
4. Norway	67.0	9.4%
5. United States	33.0	4.6%
6. Netherlands	30.0	4.2%
7. France	27.0	3.8%
8. Italy	21.0	3.0%
9. Spain	15.0	2.1%
10. Switzerland	15.0	2.1%
11. Belgium	14.0	2.0%
12. Finland	13.0	1.8%
13. Poland	12.0	1.7%
14. Faroe Islands	11.0	1.5%
15. Turkey	8.0	1.1%
Other	125.0	17.6%
Total	710.0	

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National Traffic Balance

Minutes	1996	1997	1998
Incoming	600.0	682.0	n.a.
Outgoing	573.2	607.5	710.0
Surplus (Deficit)	26.8	74.5	n.a.
Total Volume	1,173.2	1,289.5	n.a.

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic. Data based on billing point of traffic. Totals from 1996 are for Tele Danmark only.

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Dominican Republic

Largest Telecommunications Routes, 1998

Destination	Minutes (millions)	Percentage of Outgoing Traffic
1. United States	112.0	71.1%
2. Spain	5.3	3.4%
3. Germany	2.9	1.8%
4. Italy	2.7	1.7%
5. Canada	2.5	1.6%
6. Venezuela	1.9	1.2%
7. Chile	1.5	1.0%
8. Switzerland	1.5	1.0%
9. Netherlands Antilles	1.2	0.8%
10. Argentina	1.1	0.7%
11. France	1.0	0.6%
12. United Kingdom	1.0	0.6%
13. Cuba	1.0	0.6%
14. Haiti	1.0	0.6%
15. Mexico	0.9	0.6%
16. Colombia	0.8	0.5%
17. Panama	0.6	0.4%
18. Costa Rica	0.5	0.3%
19. Netherlands	0.5	0.3%
20. Brazil	0.4	0.3%
Other	17.2	10.9%
Total	157.5	

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National Traffic Balance

Minutes	1996	1997	1998
Incoming	450.9	476.9	730.5
Outgoing	126.6	142.0	157.5
Surplus (Deficit)	324.3	334.9	573.0
Total Volume	577.5	618.9	888.0

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic.

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Egypt

Largest Telecommunications Routes, 1998

Destination	Minutes (millions)	Percentage of Outgoing Traffic
1. Saudi Arabia	20.0	15.7%
2. United States	10.8	8.5%
3. United Kingdom	10.7	8.4%
4. United Arab Emirates	8.4	6.6%
5. Italy	8.4	6.6%
6. France	7.5	5.9%
7. Germany	7.3	5.7%
8. Kuwait	7.1	5.6%
9. Lebanon	4.0	3.1%
10. Jordan	3.3	2.6%
11. Switzerland	2.4	1.9%
12. Syria	2.4	1.9%
13. Libya	2.2	1.8%
14. Canada	2.2	1.7%
15. Greece	2.0	1.5%
16. Israel	1.8	1.4%
17. Qatar	1.5	1.2%
18. Sudan	1.4	1.1%
19. Turkey	1.4	1.1%
20. Bahrain	1.4	1.1%
Other	21.1	16.6%
Total	127.3	

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National Traffic Balance

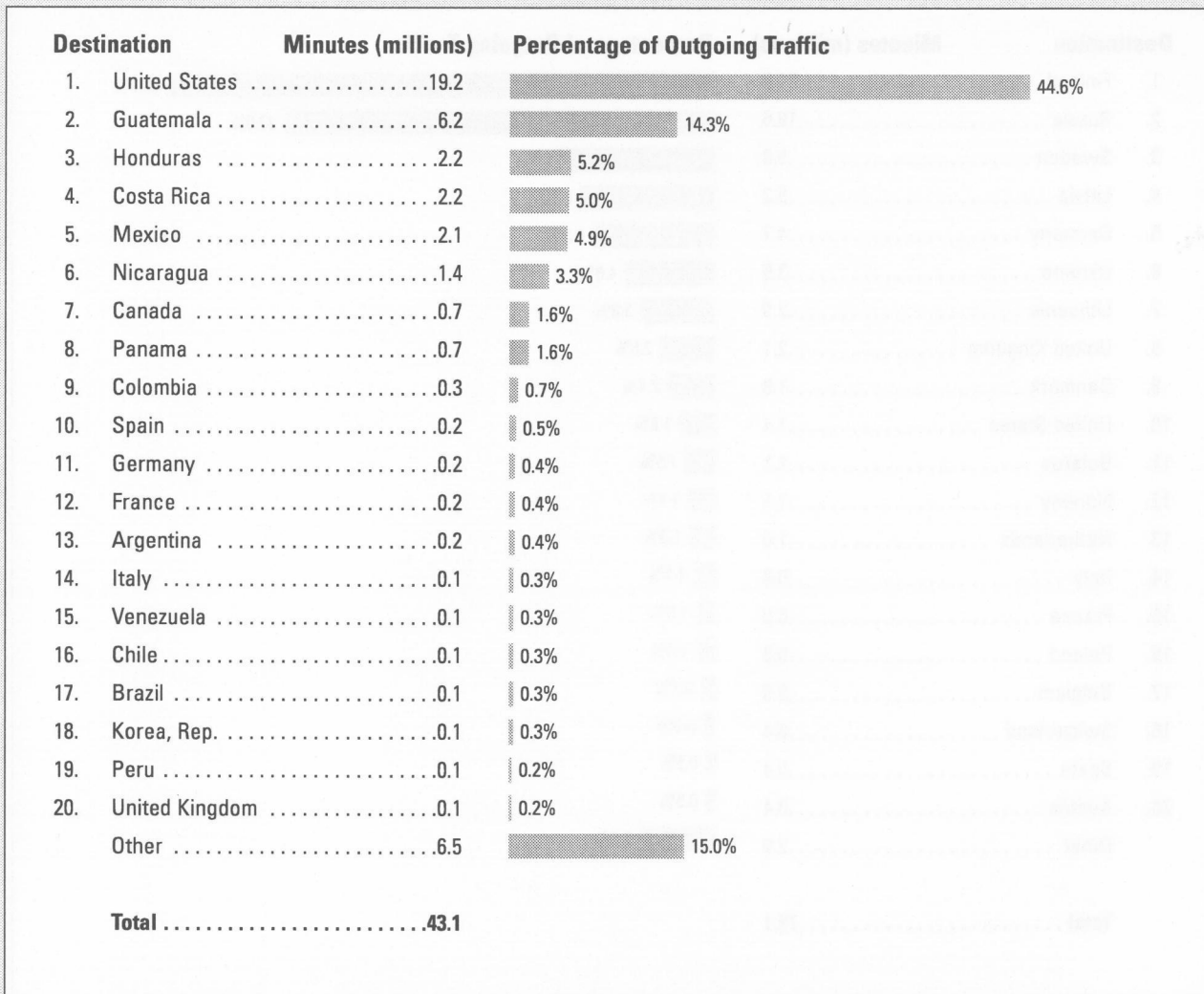
Minutes	1996	1997	1998
Incoming	417.0	451.2	475.3
Outgoing	113.0	119.3	127.3
Surplus (Deficit)	304.0	332.0	348.0
Total Volume	530.0	570.5	602.6

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic.

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El Salvador

Largest Telecommunications Routes, 1998



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National Traffic Balance

Minutes	1996	1997	1998
Incoming	160.5	168.2	149.2
Outgoing	28.6	34.3	43.1
Surplus (Deficit)	131.9	133.9	106.1
Total Volume	189.1	202.5	192.3

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic. Data are for ANTEL only. Other carriers originated an estimated 4 million minutes of traffic in 1998.

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Estonia

Largest Telecommunications Routes, 1998

Destination	Minutes (millions)	Percentage of Outgoing Traffic
1. Finland	21.0	28.0%
2. Russia	16.6	22.0%
3. Sweden	5.8	7.8%
4. Latvia	5.2	6.9%
5. Germany	4.7	6.3%
6. Ukraine	3.5	4.6%
7. Lithuania	2.9	3.8%
8. United Kingdom	2.1	2.8%
9. Denmark	1.8	2.4%
10. United States	1.4	1.8%
11. Belarus	1.1	1.5%
12. Norway	1.1	1.4%
13. Netherlands	1.0	1.3%
14. Italy	0.8	1.1%
15. France	0.8	1.0%
16. Poland	0.8	1.0%
17. Belgium	0.5	0.7%
18. Switzerland	0.4	0.6%
19. Spain	0.4	0.5%
20. Austria	0.4	0.5%
Other	2.9	3.9%
Total	75.1	

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National Traffic Balance

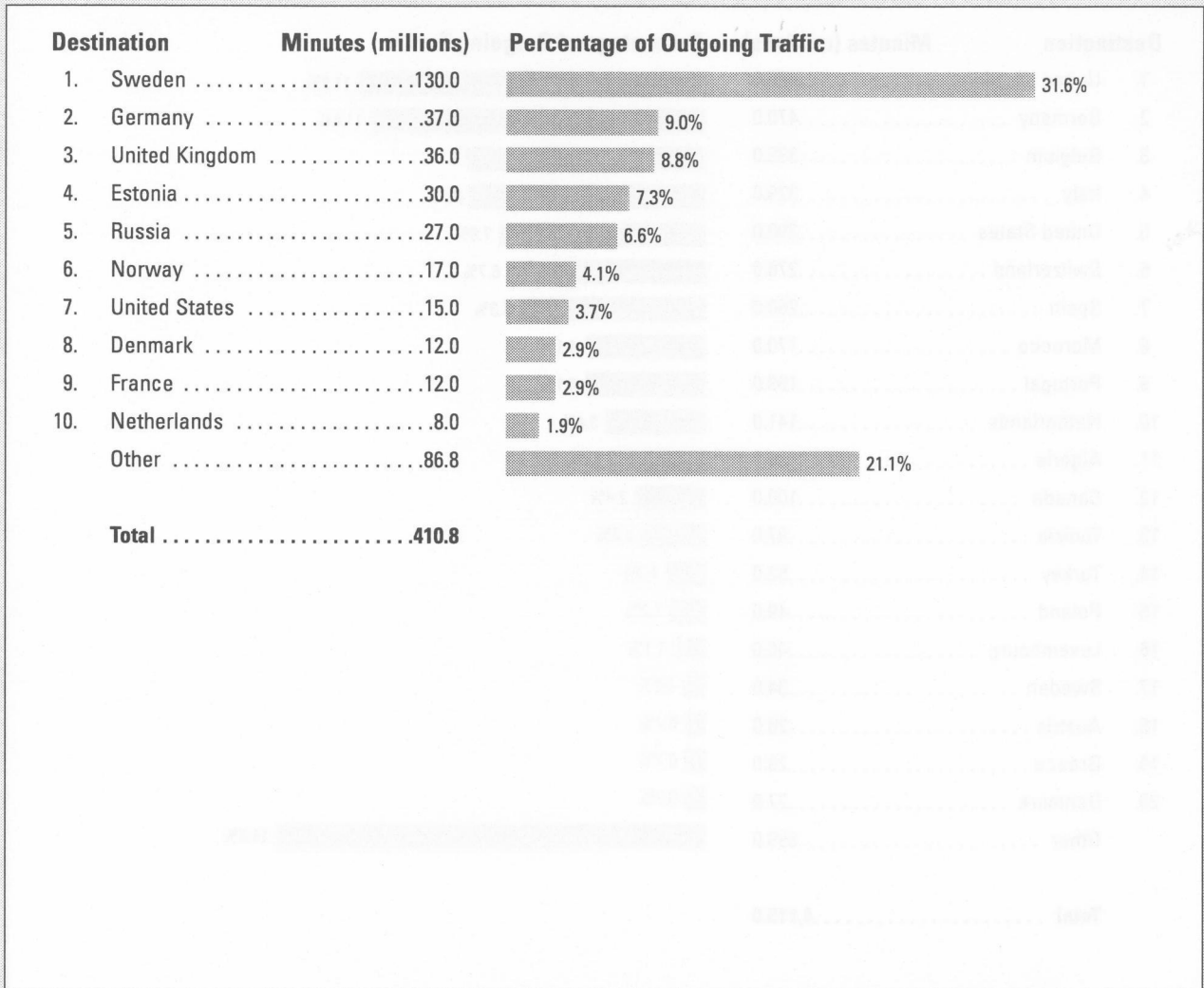
Minutes	1996	1997	1998
Incoming	60.1	67.0	79.2
Outgoing	58.5	66.3	75.1
Surplus (Deficit)	1.6	0.7	4.1
Total Volume	118.6	133.3	154.3

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic. Data based on billing point of traffic.

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Finland

Largest Telecommunications Routes, 1998



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National Traffic Balance

Minutes	1996	1997	1998
Incoming	n.a.	n.a.	n.a.
Outgoing	332.0	371.1	410.8
Surplus (Deficit)	n.a.	n.a.	n.a.
Total Volume	n.a.	n.a.	n.a.

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic.

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France

Largest Telecommunications Routes, 1998

Destination	Minutes (millions)	Percentage of Outgoing Traffic
1. United Kingdom	485.0	11.8%
2. Germany	470.0	11.4%
3. Belgium	335.0	8.1%
4. Italy	329.0	8.0%
5. United States	290.0	7.0%
6. Switzerland	276.0	6.7%
7. Spain	260.0	6.3%
8. Morocco	170.0	4.1%
9. Portugal	169.0	4.1%
10. Netherlands	141.0	3.4%
11. Algeria	135.0	3.3%
12. Canada	100.0	2.4%
13. Tunisia	92.0	2.2%
14. Turkey	52.0	1.3%
15. Poland	49.0	1.2%
16. Luxembourg	46.0	1.1%
17. Sweden	34.0	0.8%
18. Austria	28.0	0.7%
19. Greece	28.0	0.7%
20. Denmark	27.0	0.7%
Other	599.0	14.6%
Total	4,115.0	

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National Traffic Balance

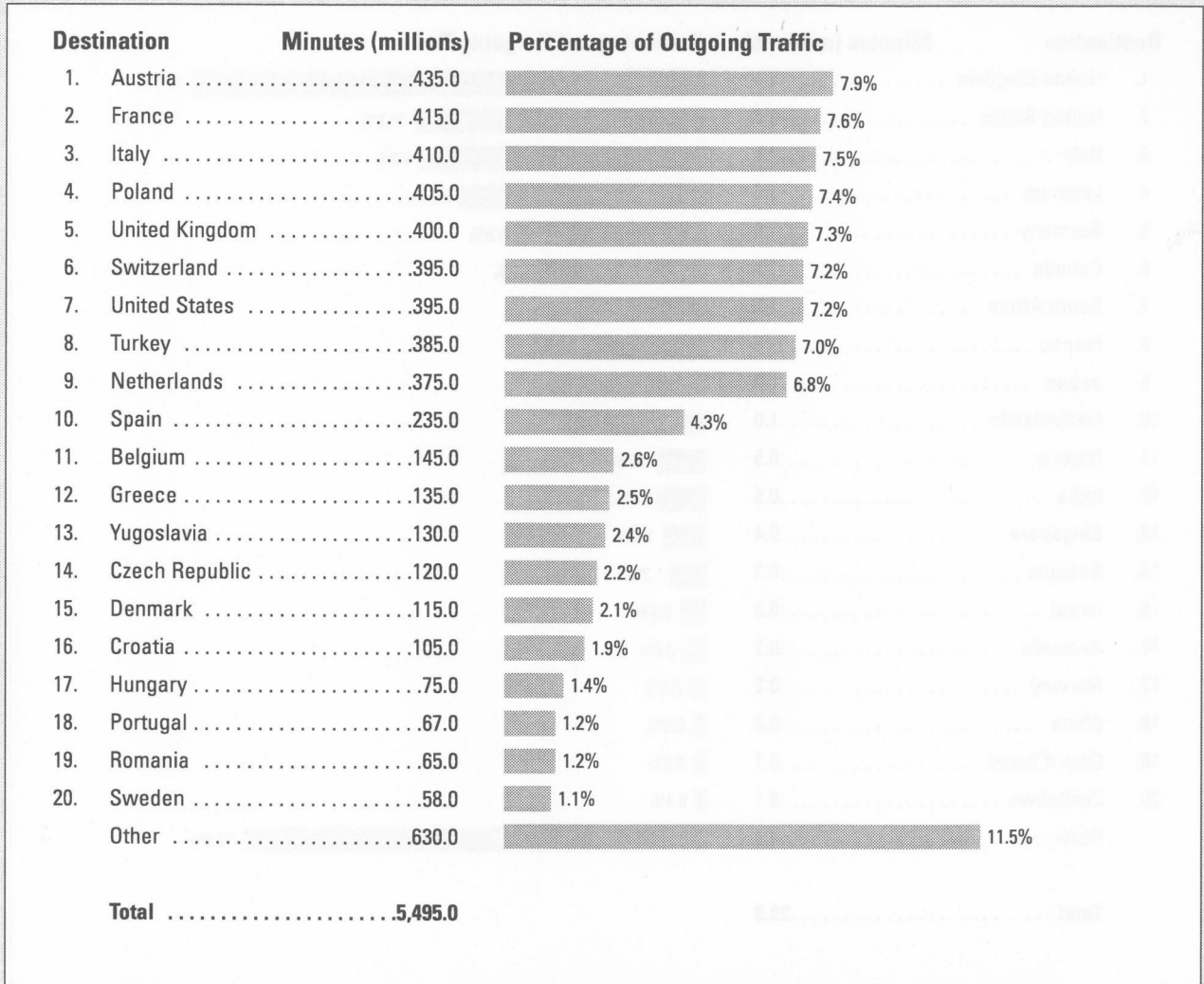
Minutes	1996	1997	1998
Incoming	3,283.0	3,609.0	n.a.
Outgoing	3,116.0	3,545.0	4,115.0
Surplus (Deficit)	167.0	64.0	n.a.
Total Volume	6,399.0	7,154.0	n.a.

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic.

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Germany

Largest Telecommunications Routes, 1998



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National Traffic Balance

Minutes	1996	1997	1998
Incoming	4,890.0	5,618.0	n.a.
Outgoing	4,761.0	4,813.0	5,495.0
Surplus (Deficit)	129.0	805.0	n.a.
Total Volume	9,651.0	10,431.0	n.a.

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic. Data based on billing point of traffic.

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Largest Telecommunications Routes, 1998

Destination	Minutes (millions)	Percentage of Outgoing Traffic
1. United Kingdom	5.1	17.7%
2. United States	2.9	10.0%
3. Italy	2.8	9.8%
4. Lebanon	2.5	8.5%
5. Germany	1.9	6.6%
6. Canada	1.7	5.8%
7. South Africa	1.3	4.5%
8. France	1.2	4.2%
9. Japan	1.0	3.5%
10. Netherlands	1.0	3.5%
11. Nigeria	0.5	1.7%
12. India	0.5	1.7%
13. Singapore	0.4	1.5%
14. Belgium	0.3	1.2%
15. Israel	0.3	0.9%
16. Australia	0.2	0.8%
17. Norway	0.2	0.6%
18. China	0.2	0.5%
19. Côte d'Ivoire	0.1	0.5%
20. Zimbabwe	0.1	0.4%
Other	4.6	16.0%
Total	28.9	

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National Traffic Balance

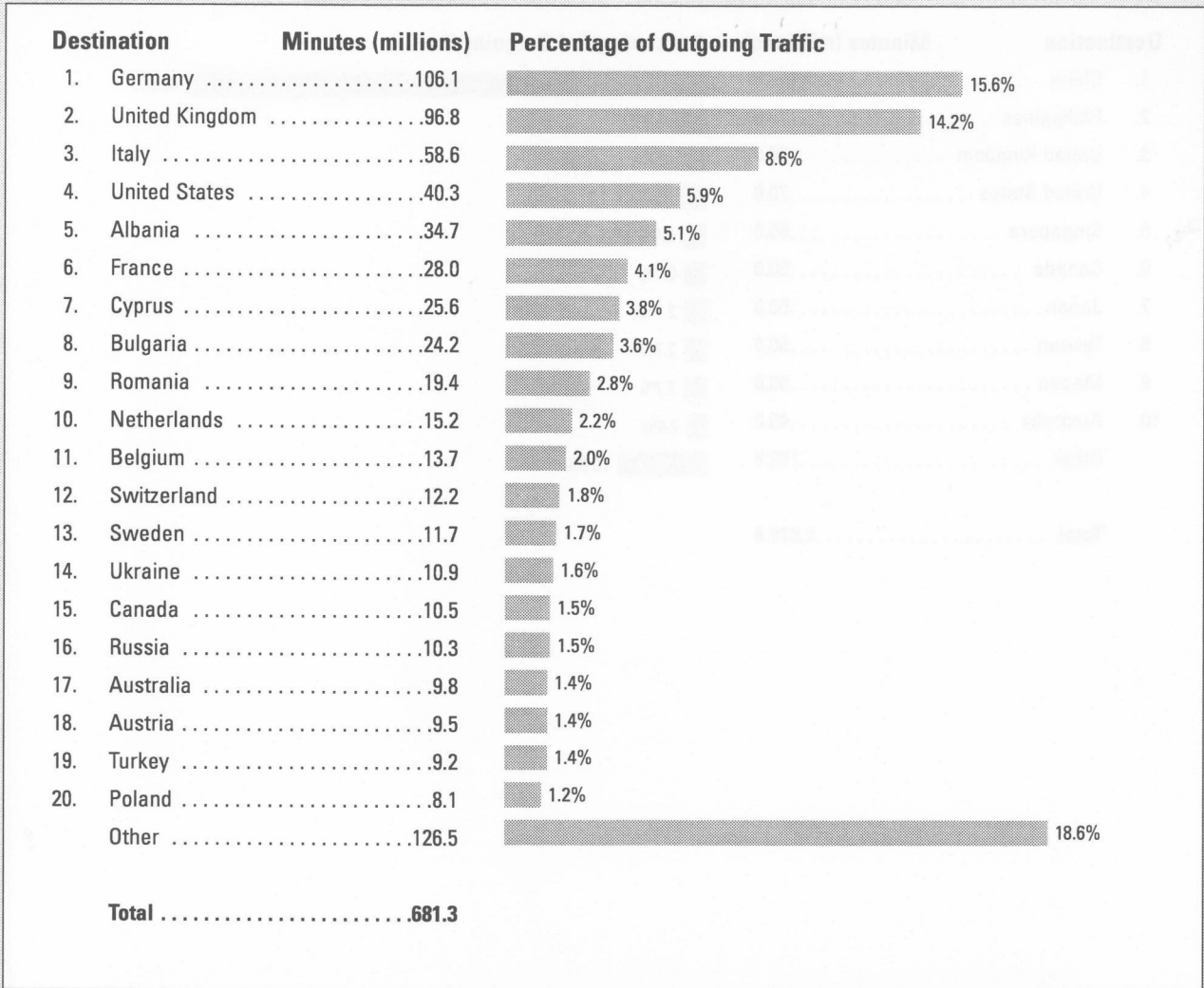
Minutes	1996	1997	1998
Incoming	n.a.	n.a.	100.8
Outgoing	16.5	21.9	28.9
Surplus (Deficit)	n.a.	n.a.	72.0
Total Volume	n.a.	n.a.	129.7

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic.

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Largest Telecommunications Routes, 1998



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National Traffic Balance

Minutes	1996	1997	1998
Incoming	557.3	634.6	710.1
Outgoing	515.6	593.7	681.3
Surplus (Deficit)	41.7	40.9	28.8
Total Volume	1,072.9	1,228.3	1,391.4

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic.

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Hong Kong

Largest Telecommunications Routes, FY 1998/99

Destination	Minutes (millions)	Percentage of Outgoing Traffic
1. China	1,165.0	62.0%
2. Philippines	75.0	4.0%
3. United Kingdom	70.0	3.7%
4. United States	70.0	3.7%
5. Singapore	55.0	2.9%
6. Canada	50.0	2.7%
7. Japan	50.0	2.7%
8. Taiwan	50.0	2.7%
9. Macau	50.0	2.7%
10. Australia	45.0	2.4%
Other	199.8	10.6%
Total	1,879.8	

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National Traffic Balance

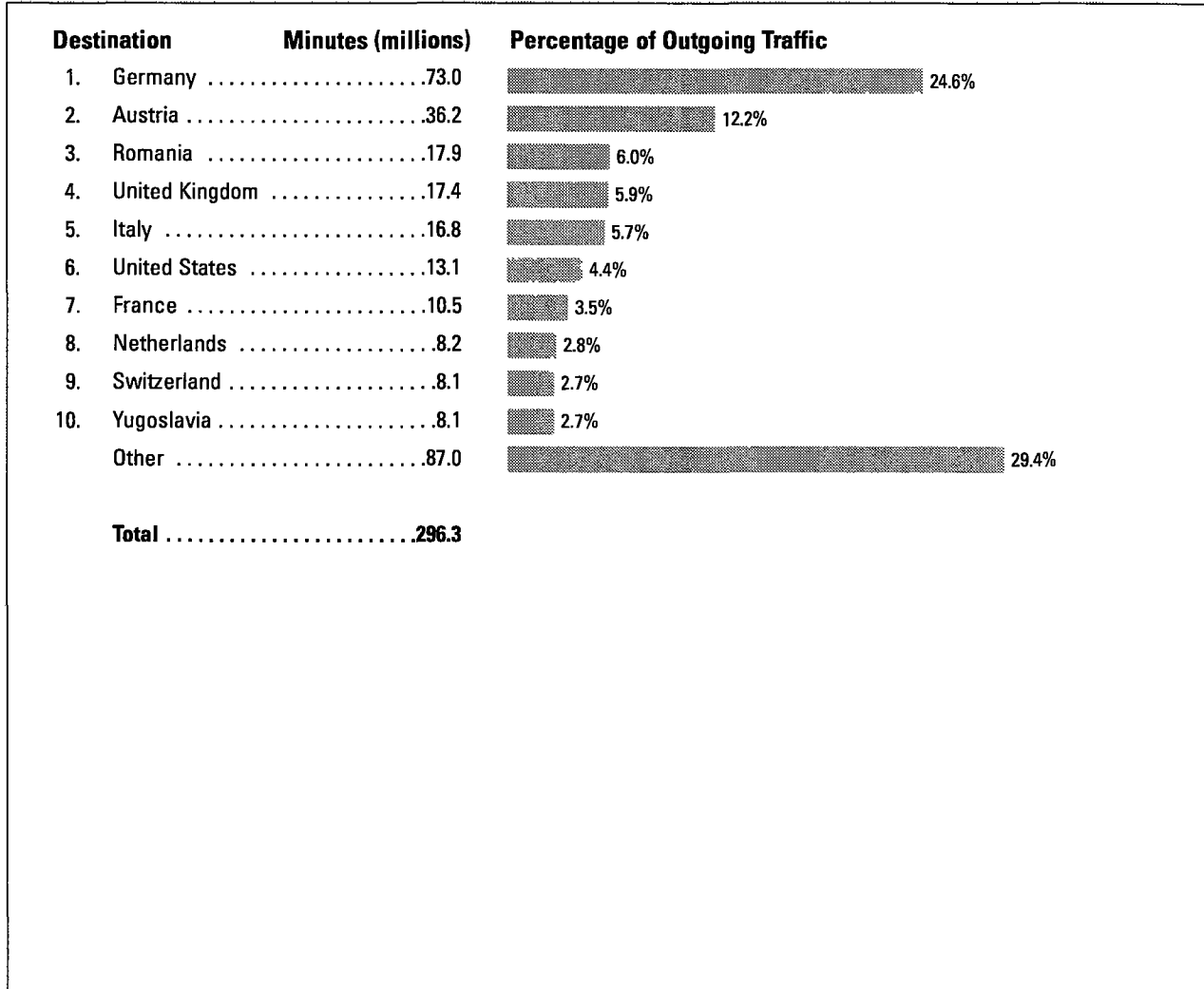
Minutes	FY 1996/97	FY 1997/98	FY 1998/99
Incoming	1,940.8	2,100.3	1,833.0
Outgoing	1,738.6	1,718.0	1,879.8
Surplus (Deficit)	202.2	382.3	(46.8)
Total Volume	3,679.4	3,818.3	3,712.8

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic. Data based on billing point of traffic. Fiscal year ends 31 March.

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Hungary

Largest Telecommunications Routes, 1998



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National Traffic Balance

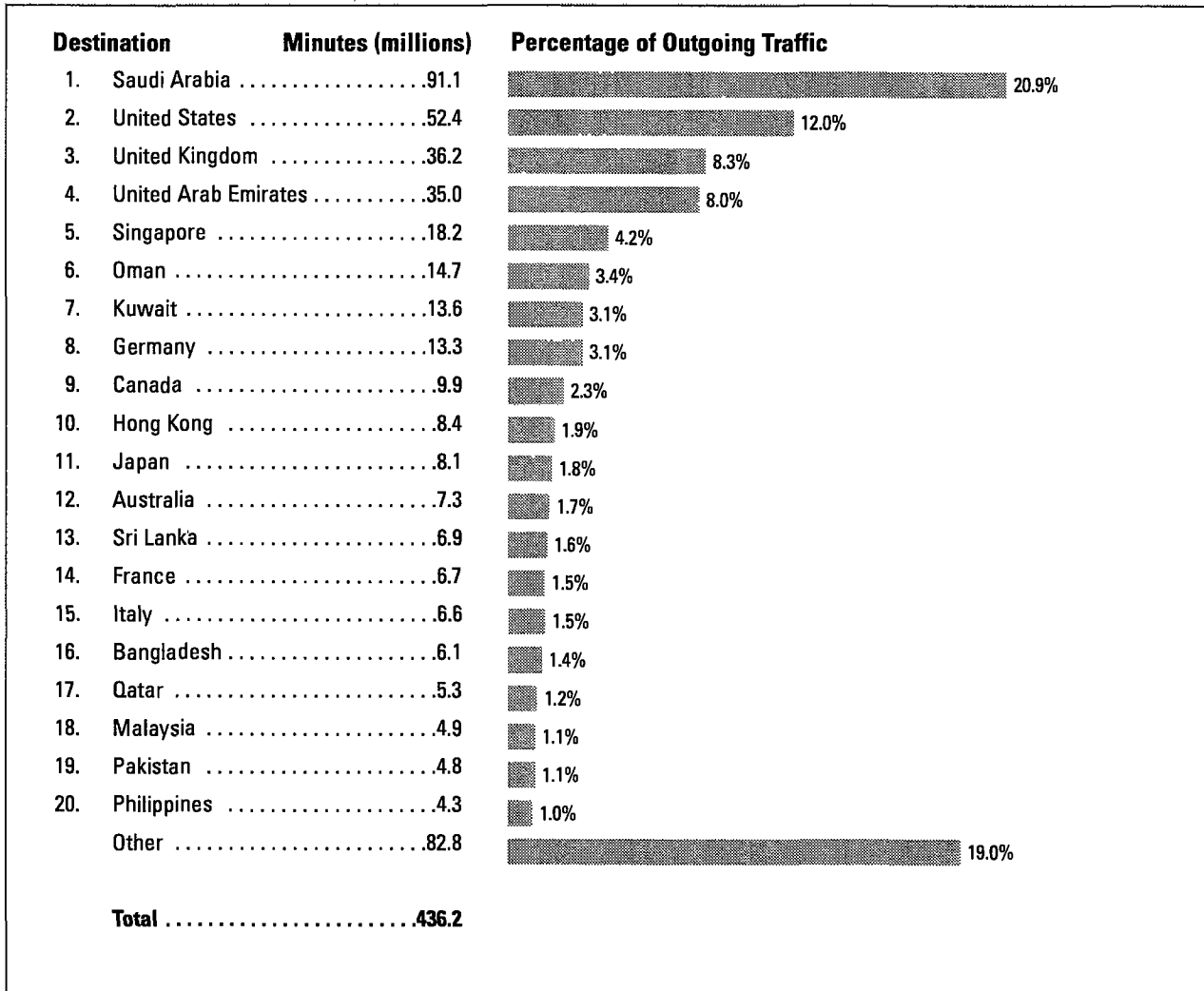
Minutes	1996	1997	1998
Incoming	281.0	324.6	374.5
Outgoing	265.0	287.1	296.3
Surplus (Deficit)	16.0	37.5	78.2
Total Volume	546.0	611.7	670.8

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic. Data based on billing point of traffic.

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Largest Telecommunications Routes, FY 1998/99



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National Traffic Balance

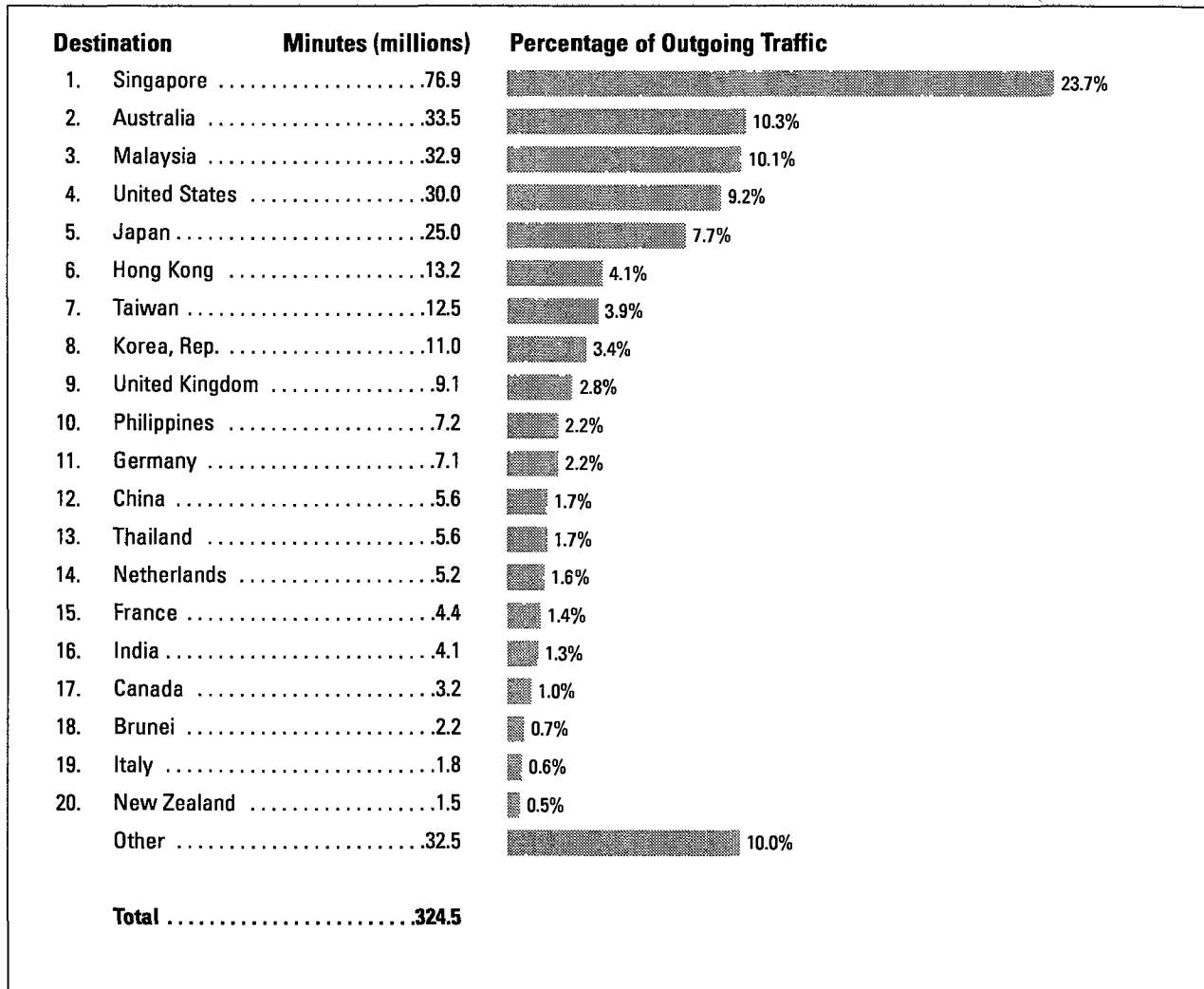
Minutes	FY 1996/97	FY 1997/98	FY 1998/99
Incoming	1,000.0	1,256.6	1,498.8
Outgoing	384.2	420.5	436.2
Surplus (Deficit)	615.8	836.1	1,062.6
Total Volume	1,384.2	1,677.1	1,935.0

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic. Data based on billing point of traffic. Fiscal year ends 31 March. Data exclude some cross-border traffic with Bangladesh, Nepal, and Pakistan.

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Indonesia

Largest Telecommunications Routes, 1998



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National Traffic Balance

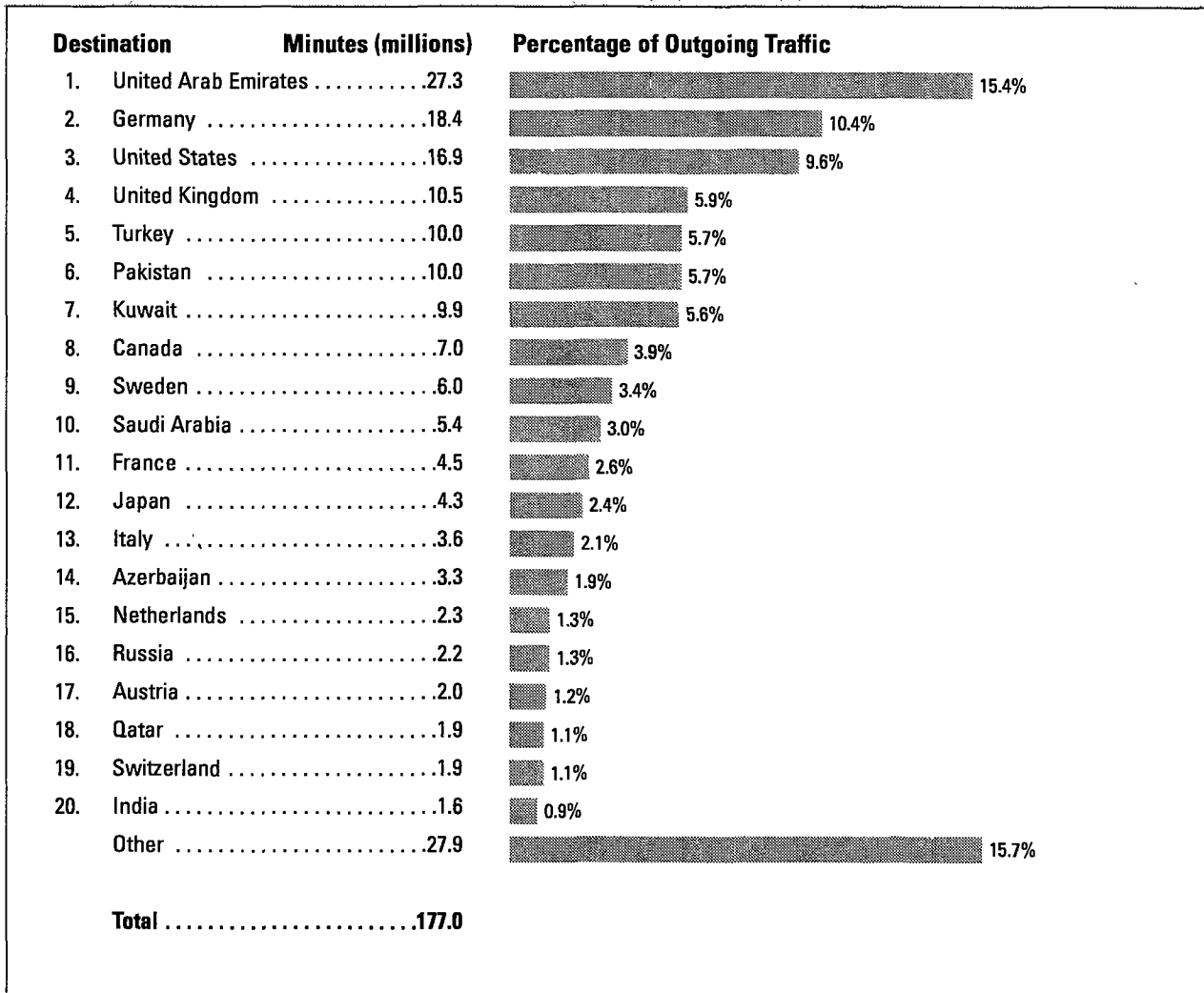
Minutes	1996	1997	1998
Incoming	356.4	456.0	434.2
Outgoing	280.2	351.6	324.5
Surplus (Deficit)	76.2	104.4	109.7
Total Volume	636.6	807.6	758.7

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic. Data based on billing point of traffic.

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Largest Telecommunications Routes, 1998



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National Traffic Balance

Minutes	1996	1997	1998
Incoming	n.a.	130.2	185.7
Outgoing	183.2	160.7	177.0
Surplus (Deficit)	n.a.	(30.5)	8.8
Total Volume	n.a.	290.9	362.7

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic.

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Largest Telecommunications Routes, FY 1998/99

Destination	Minutes (millions)	Percentage of Outgoing Traffic
1. United Kingdom	.605.0	68.4%
2. United States	.80.0	9.0%
3. France	.25.0	2.8%
4. Germany	.25.0	2.8%
5. Netherlands	.21.0	2.4%
6. Canada	.12.0	1.4%
7. Italy	.10.0	1.1%
8. Spain	.9.0	1.0%
9. Belgium	.7.0	0.8%
10. Australia	.6.0	0.7%
Other	.85.0	9.6%
Total	.885.0	

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National Traffic Balance

Minutes	FY 1996/97	FY 1997/98	FY 1998/99
Incoming	n.a.	n.a.	n.a.
Outgoing	580.0	695.0	885.0
Surplus (Deficit)	n.a.	n.a.	n.a.
Total Volume	n.a.	n.a.	n.a.

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic. Fiscal year ends 31 March. Data for FY 1996/97 exclude some cross-border traffic to Northern Ireland.

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Largest Telecommunications Routes, 1998

Destination	Minutes (millions)	Percentage of Outgoing Traffic
1. United States	185.0	28.0%
2. United Kingdom	55.0	8.3%
3. Canada	40.0	6.1%
4. France	35.0	5.3%
5. Germany	35.0	5.3%
6. Italy	25.0	3.8%
7. Russia	22.0	3.3%
8. Jordan	21.0	3.2%
Other	243.0	36.8%
Total	.661.0	

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National Traffic Balance

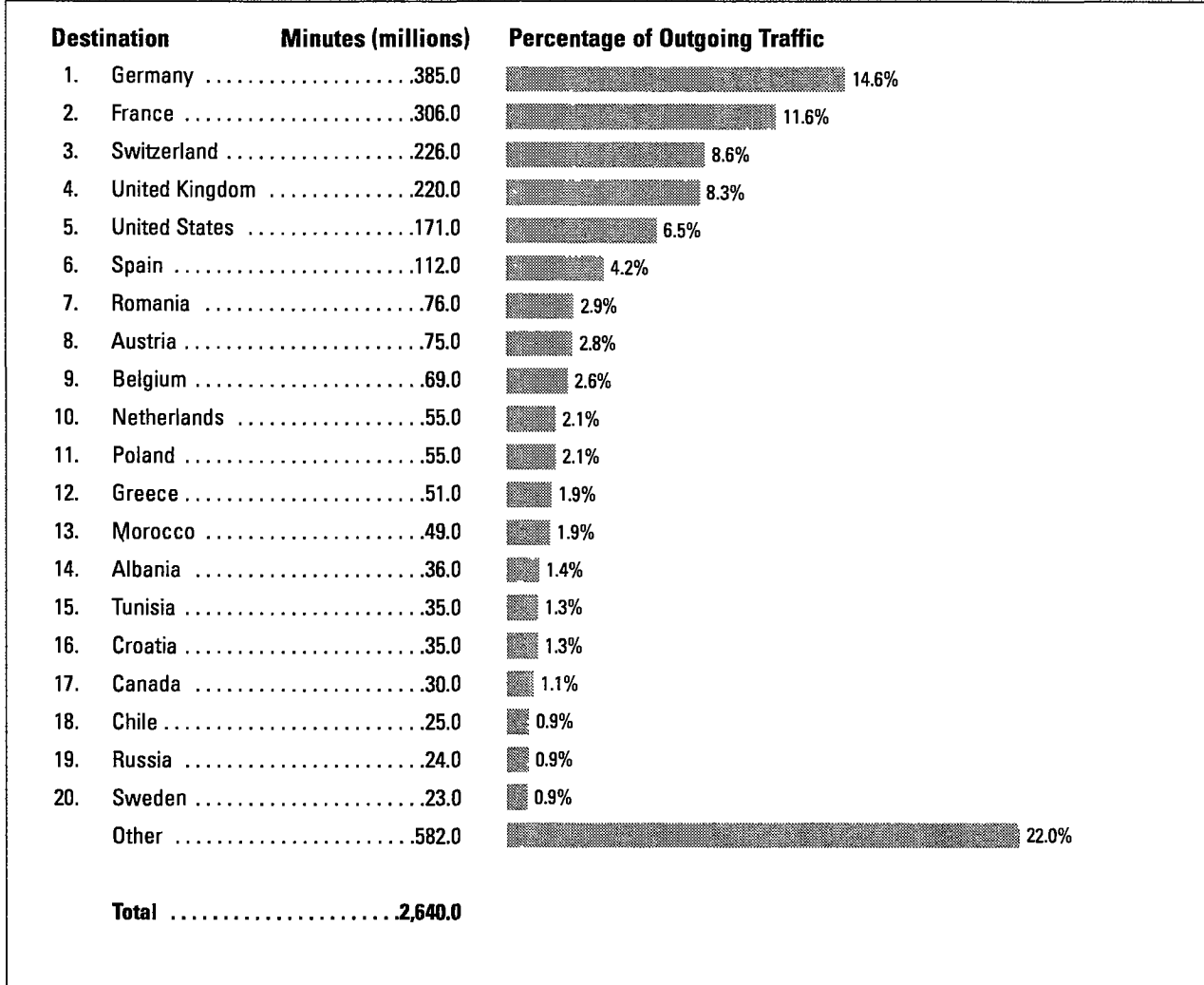
Minutes	1996	1997	1998
Incoming	468.1	425.0	424.0
Outgoing	319.7	459.0	661.0
Surplus (Deficit)	148.4	(34.0)	(237.0)
Total Volume	787.8	884.0	1,085.0

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic. Data based on billing point of traffic.

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Largest Telecommunications Routes, 1998



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National Traffic Balance

Minutes	1996	1997	1998
Incoming	2,253.5	2,475.1	n.a.
Outgoing	2,124.0	2,351.9	2,640.0
Surplus (Deficit)	129.5	123.2	n.a.
Total Volume	4,377.5	4,827.0	n.a.

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic. Data exclude some traffic to France, Slovenia, and Switzerland.

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Jamaica

Largest Telecommunications Routes, 1998

Destination	Minutes (millions)	Percentage of Outgoing Traffic
1. United States	40.2	66.9%
2. United Kingdom	4.5	7.5%
3. Canada	4.3	7.2%
4. Cayman Islands	1.5	2.5%
5. Trinidad & Tobago	1.3	2.2%
6. Barbados	1.0	1.6%
7. Bahamas	0.8	1.3%
8. Germany	0.5	0.8%
9. Turks & Caicos Islands	0.3	0.5%
10. Saint Lucia	0.3	0.5%
11. Antigua & Barbuda	0.3	0.5%
12. Cuba	0.3	0.5%
13. Guyana	0.2	0.4%
14. India	0.2	0.3%
15. Netherlands	0.2	0.3%
16. Japan	0.2	0.3%
17. Saint Vincent & the Grenadines	0.2	0.3%
18. Italy	0.2	0.3%
19. Dominican Republic	0.2	0.3%
20. Panama	0.2	0.3%
Other	3.3	5.5%
Total	60.1	

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National Traffic Balance

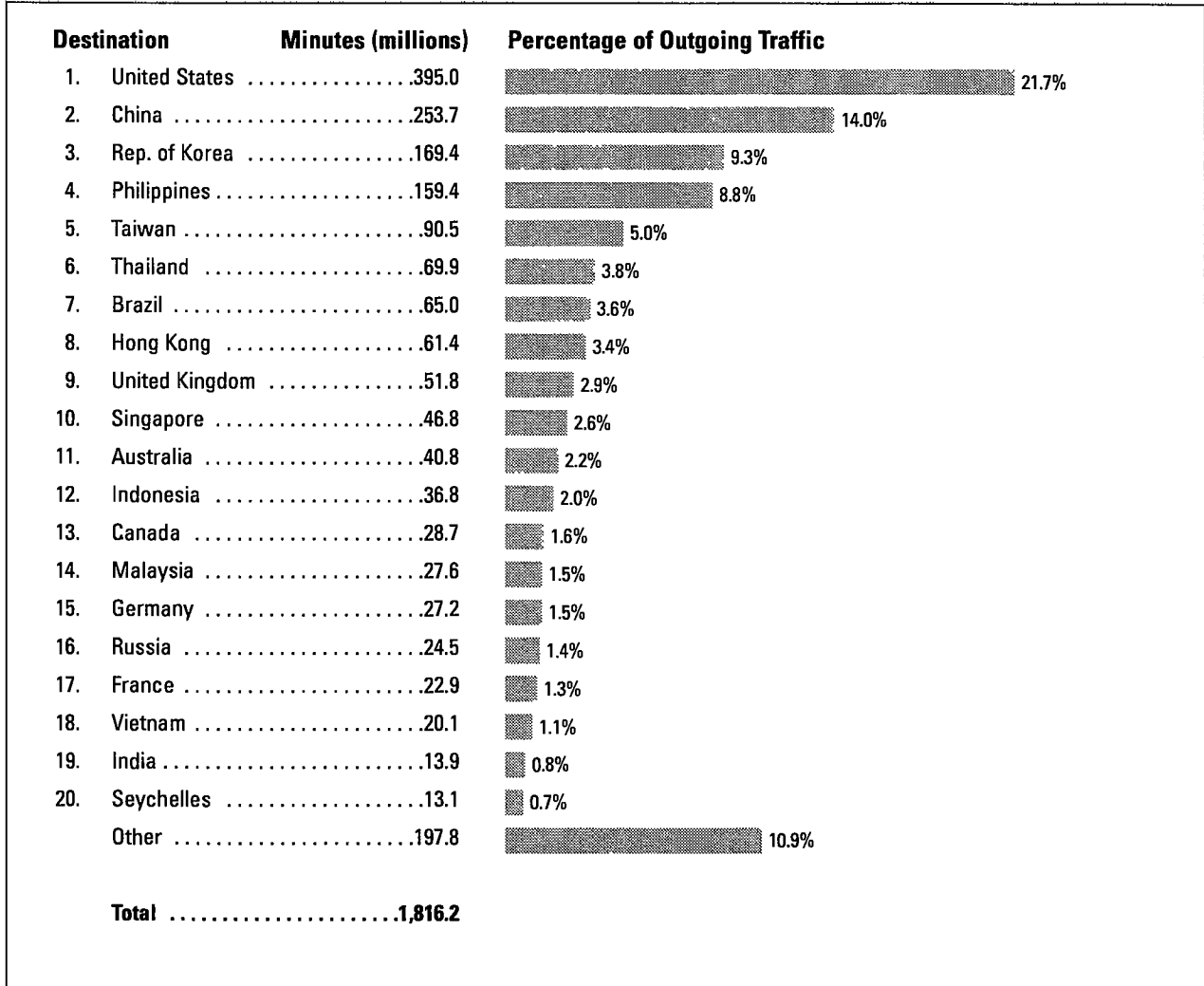
Minutes	1996	1997	1998
Incoming	288.4	n.a.	349.8
Outgoing	64.5	n.a.	60.1
Surplus (Deficit)	223.9	n.a.	289.7
Total Volume	352.9	n.a.	409.9

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic. Data based on billing point of traffic.

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Japan

Largest Telecommunications Routes, FY 1998/99



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National Traffic Balance

Minutes	FY 1996/97	FY 1997/98	FY 1998/99
Incoming	1,519.1	1,635.0	1,575.0
Outgoing	1,710.6	1,771.7	1,895.0
Surplus (Deficit)	(191.5)	(136.7)	(320.0)
Total Volume	3,229.7	3,406.7	3,470.0

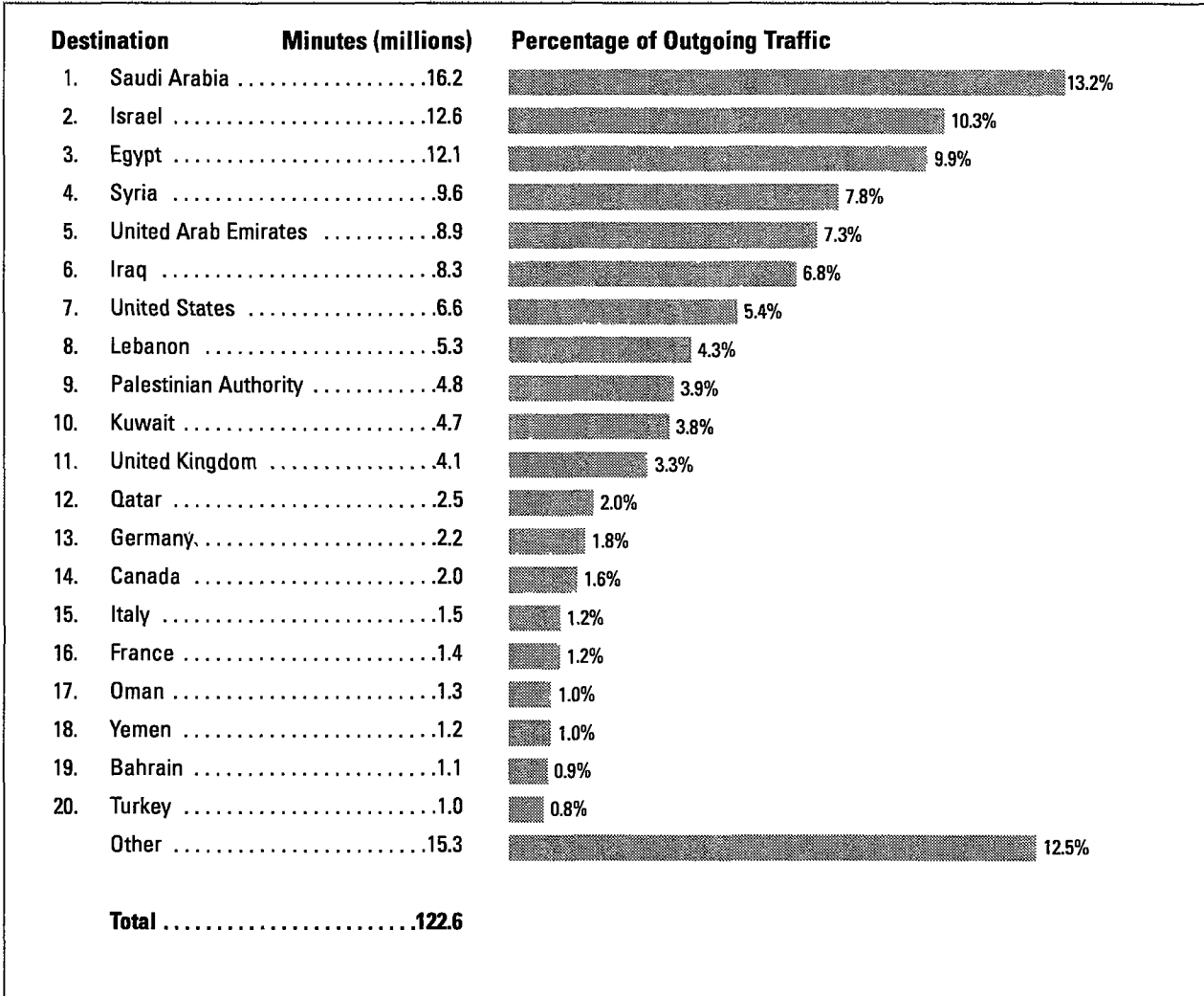
Note: Data are in millions of minutes of outgoing public switched telecommunications traffic. Route data exclude some ISR traffic included in totals.

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Jordan

Largest Telecommunications Routes, 1998



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National Traffic Balance

Minutes	1996	1997	1998
Incoming	133.1	145.0	176.9
Outgoing	74.6	91.9	122.6
Surplus (Deficit)	58.5	53.1	54.4
Total Volume	207.7	236.9	299.5

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic. Data based on billing point of traffic.

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Kazakhstan

Largest Telecommunications Routes, 1998

Destination	Minutes (millions)	Percentage of Outgoing Traffic
1. Russia	71.3	60.0%
2. Uzbekistan	9.1	7.6%
3. Kyrgyzstan	6.3	5.3%
4. Ukraine	5.4	4.5%
5. Germany	4.5	3.8%
6. Turkey	2.6	2.2%
7. Belarus	1.9	1.6%
8. Azerbaijan	1.7	1.4%
9. United States	1.5	1.3%
10. United Kingdom	1.4	1.2%
11. Tajikistan	1.4	1.2%
12. Turkmenistan	1.2	1.0%
13. Armenia	1.0	0.8%
14. China	0.8	0.6%
15. Georgia	0.6	0.5%
16. Korea, Rep.	0.5	0.4%
17. United Arab Emirates	0.5	0.4%
18. Moldova	0.3	0.3%
19. Canada	0.3	0.3%
20. France	0.3	0.2%
Other	6.5	5.5%
Total	118.9	

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National Traffic Balance

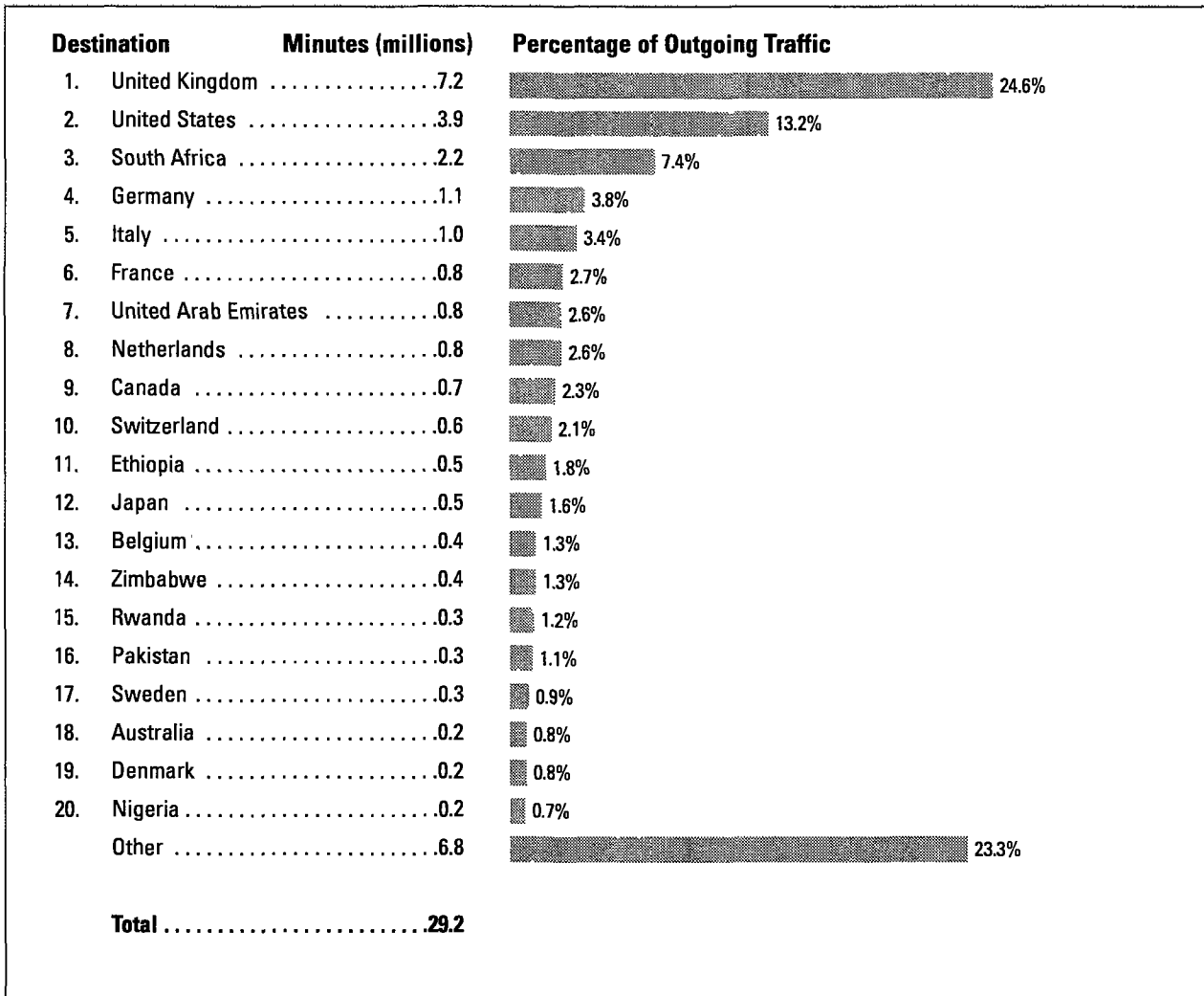
Minutes	1996	1997	1998
Incoming	75.0	n.a.	137.5
Outgoing	102.5	114.7	118.9
Surplus (Deficit)	(27.5)	n.a.	18.6
Total Volume	177.5	n.a.	256.4

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic. Totals for 1996 include only traffic with other members of the Commonwealth of Independent States.

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Kenya

Largest Telecommunications Routes, 1998



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National Traffic Balance

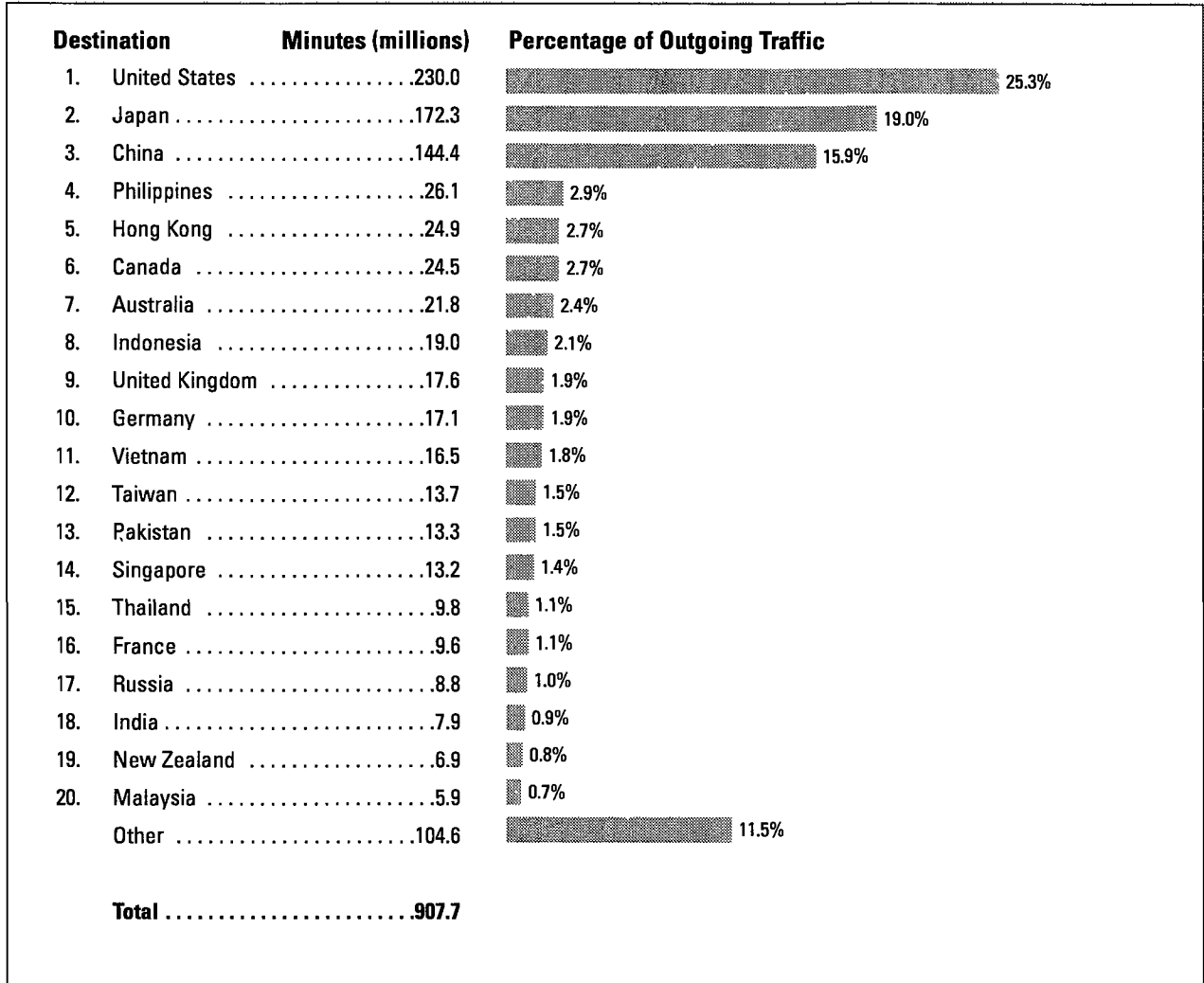
Minutes	1996	1997	1998
Incoming	65.3	69.5	72.5
Outgoing	26.1	29.0	29.2
Surplus (Deficit)	39.2	40.5	43.3
Total Volume	91.4	98.5	101.7

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic. Data exclude calls to Tanzania and Uganda.

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Korea, Rep.

Largest Telecommunications Routes, 1998



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National Traffic Balance

Minutes	1996	1997	1998
Incoming	740.6	782.0	719.4
Outgoing	699.3	885.0	907.7
Surplus (Deficit)	41.3	(103.0)	(188.3)
Total Volume	1,439.9	1,667.0	1,627.1

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic.

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Largest Telecommunications Routes, 1997

Destination	Minutes (millions)	Percentage of Outgoing Traffic
1. Egypt	27.8	17.3%
2. India	17.8	11.1%
3. Saudi Arabia	16.2	10.1%
4. Syria	10.9	6.8%
5. United Arab Emirates	10.1	6.3%
6. United States	8.8	5.5%
7. Iran	8.8	5.5%
8. Pakistan	8.5	5.3%
9. United Kingdom	8.2	5.1%
10. Jordan	5.4	3.4%
11. Lebanon	4.6	2.9%
12. Bahrain	4.3	2.7%
13. Bangladesh	2.4	1.5%
14. Philippines	1.6	1.0%
15. Canada	1.6	1.0%
16. Qatar	1.5	0.9%
17. France	1.3	0.8%
18. Germany	1.3	0.8%
19. Sri Lanka	1.2	0.8%
20. Oman	1.2	0.7%
Other	17.0	10.6%
Total	160.5	

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National Traffic Balance

Minutes	1996	1997	1998
Incoming	131.2	n.a.	n.a.
Outgoing	140.7	160.5	173.1
Surplus (Deficit)	(9.5)	n.a.	n.a.
Total Volume	271.9	n.a.	n.a.

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic.

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Largest Telecommunications Routes, 1998

Destination	Minutes (millions)	Percentage of Outgoing Traffic
1. Russia	15.4	27.7%
2. Lithuania	6.0	10.9%
3. Estonia	5.1	9.2%
4. Ukraine	4.1	7.4%
5. Germany	3.8	6.8%
6. Sweden	2.8	5.0%
7. Belarus	2.7	4.8%
8. United Kingdom	2.0	3.6%
9. Finland	1.6	2.8%
10. Denmark	1.4	2.5%
11. Poland	1.2	2.1%
12. United States	0.9	1.7%
13. Netherlands	0.8	1.4%
14. Norway	0.8	1.4%
15. France	0.6	1.1%
16. Italy	0.6	1.0%
17. Belgium	0.5	0.9%
18. Switzerland	0.5	0.9%
19. Austria	0.4	0.7%
20. Kazakhstan	0.4	0.6%
Other	4.1	7.4%
Total	55.4	

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National Traffic Balance

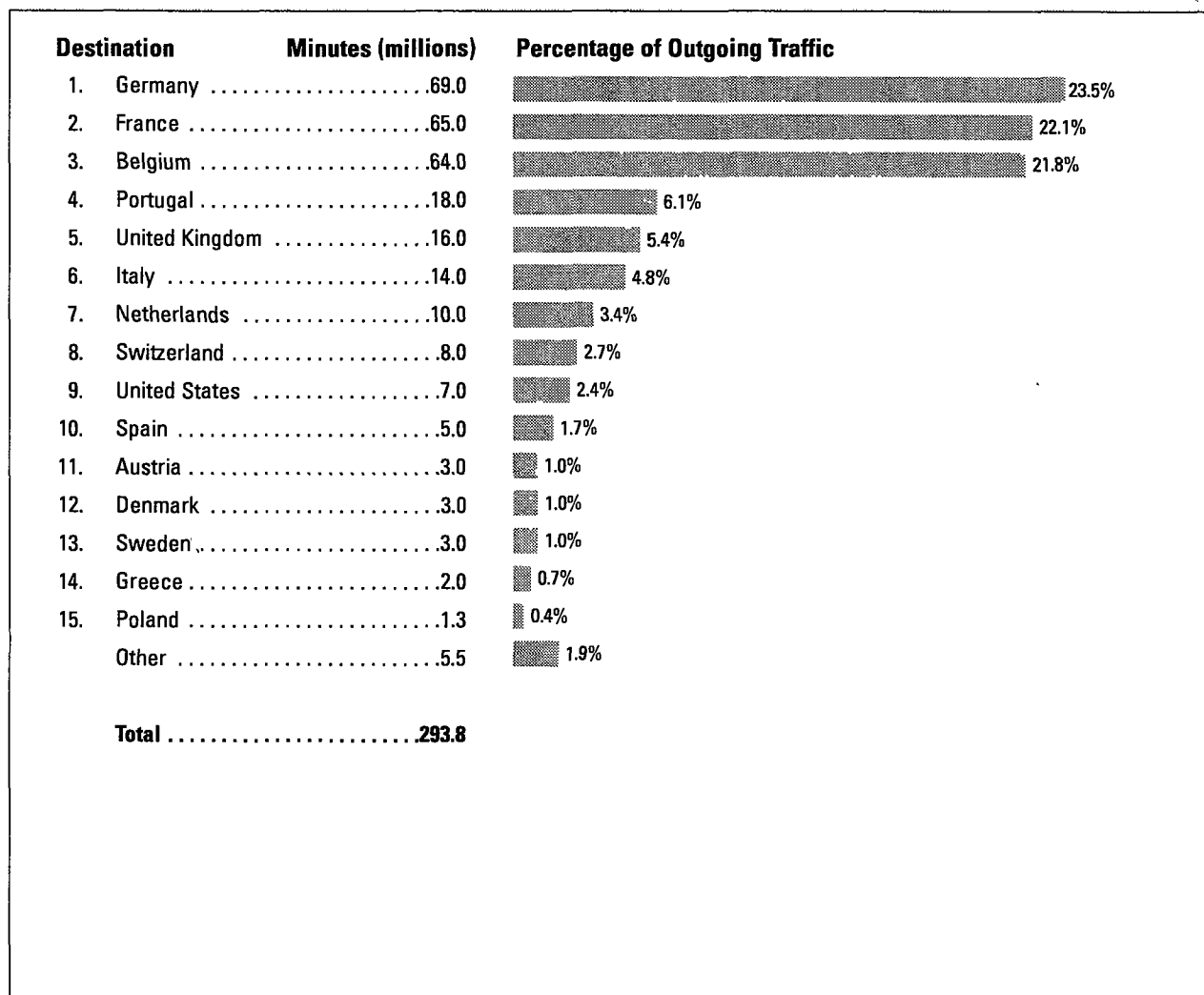
Minutes	1996	1997	1998
Incoming	69.0	81.8	87.2
Outgoing	43.0	44.0	55.4
Surplus (Deficit)	26.0	37.8	31.8
Total Volume	112.0	125.8	142.5

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic. Data based on billing point of traffic.

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Luxembourg

Largest Telecommunications Routes, 1998



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National Traffic Balance

Minutes	1996	1997	1998
Incoming	189.8	208.0	242.6
Outgoing	248.5	282.9	293.8
Surplus (Deficit)	(58.7)	(74.9)	(51.2)
Total Volume	438.3	490.9	536.4

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic.

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Macau

Largest Telecommunications Routes, 1998

Destination	Minutes (millions)	Percentage of Outgoing Traffic
1. Hong Kong	53.4	42.7%
2. China	51.3	40.9%
3. Portugal	4.1	3.3%
4. Taiwan	3.8	3.0%
5. United States	2.5	2.0%
6. Canada	1.8	1.4%
7. Philippines	1.5	1.2%
8. Thailand	1.2	0.9%
9. Australia	1.2	0.9%
10. United Kingdom	0.8	0.6%
11. Singapore	0.6	0.5%
12. Japan	0.4	0.3%
13. Malaysia	0.3	0.3%
14. Korea, Rep.	0.3	0.3%
15. France	0.3	0.2%
16. Indonesia	0.2	0.2%
17. New Zealand	0.2	0.1%
18. Germany	0.1	0.1%
19. Brazil	0.1	0.1%
20. Vietnam	0.1	0.1%
Other	1.1	0.9%
Total	125.2	

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National Traffic Balance

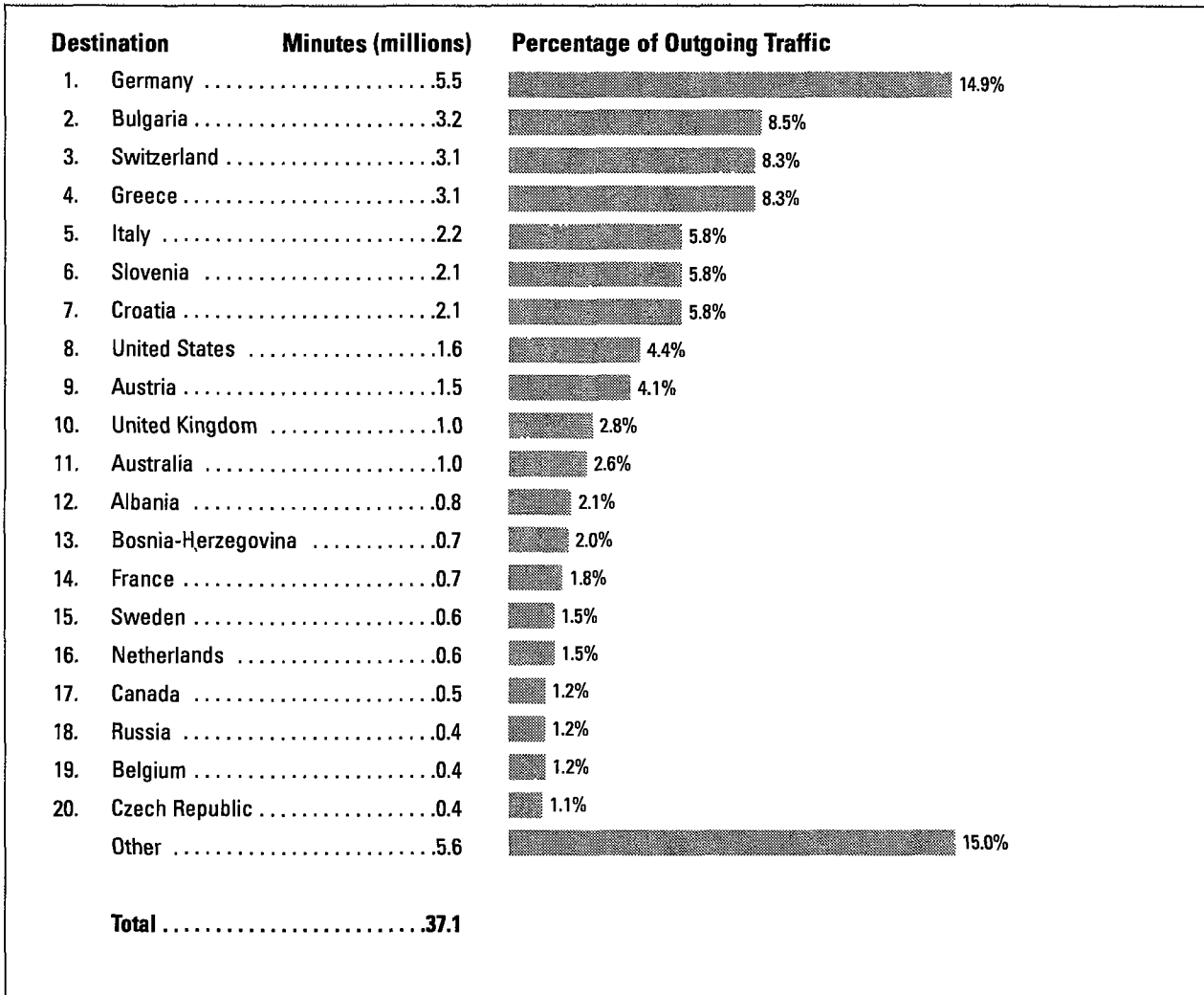
Minutes	1996	1997	1998
Incoming	92.1	92.2	95.8
Outgoing	112.5	119.0	125.2
Surplus (Deficit)	(20.4)	(26.8)	(29.4)
Total Volume	204.6	211.2	221.0

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic. Data based on billing point of traffic.

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Macedonia

Largest Telecommunications Routes, 1998



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National Traffic Balance

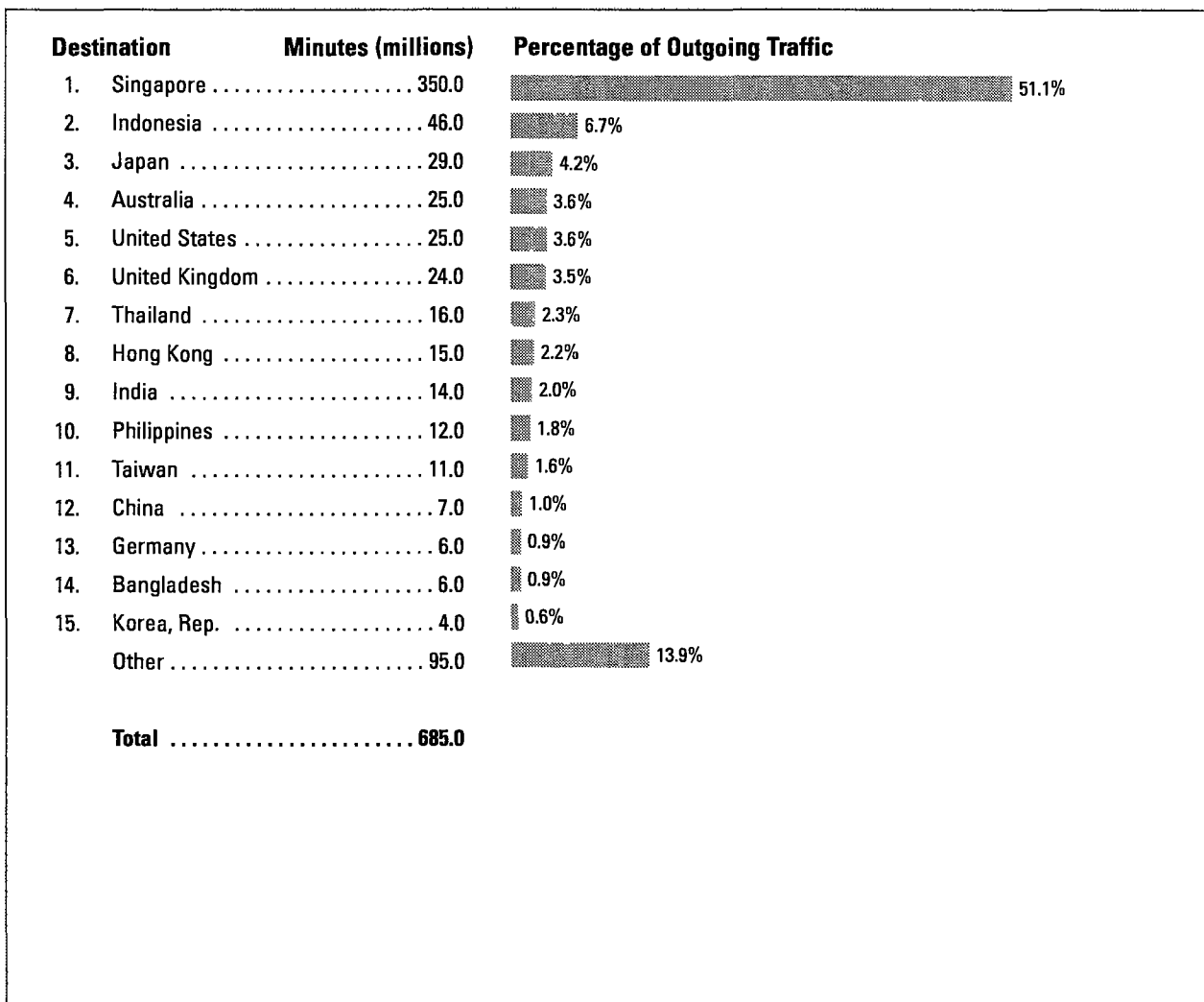
Minutes	1996	1997	1998
Incoming	82.0	85.0	91.7
Outgoing	51.0	51.7	37.1
Surplus (Deficit)	31.0	33.3	54.6
Total Volume	133.0	136.7	128.9

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic. Data for 1998 exclude an estimated 20 million minutes of traffic to Yugoslavia.

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Malaysia

Largest Telecommunications Routes, FY 1998/99



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National Traffic Balance

Minutes	FY 1996/97	FY 1997/98	FY 1998/99
Incoming	581.9	592.0	n.a.
Outgoing	570.5	588.5	685.0
Surplus (Deficit)	11.4	3.5	n.a.
Total Volume	1,152.4	1,180.5	n.a.

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic. Data based on billing point of traffic. Fiscal year ends 31 March. Totals for FY 1996/97 and 1997/98 were for Telkom Malaysia only.

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Largest Telecommunications Routes, 1998

Destination	Minutes (millions)	Percentage of Outgoing Traffic
1. United Kingdom	12.0	32.1%
2. Italy	5.6	14.9%
3. Germany	3.4	9.1%
4. Libya	1.6	4.4%
5. France	1.5	4.1%
6. United States	1.3	3.4%
7. Netherlands	1.1	3.0%
8. Australia	0.9	2.5%
9. Russia	0.8	2.2%
10. Switzerland	0.7	2.0%
11. Belgium	0.6	1.5%
12. Austria	0.5	1.3%
13. Canada	0.5	1.3%
14. Greece	0.4	1.1%
15. Spain	0.4	1.0%
16. Turkey	0.4	1.0%
17. Sweden	0.4	1.0%
18. Tunisia	0.4	0.9%
19. Ireland	0.3	0.8%
20. Egypt	0.3	0.8%
Other	4.3	11.5%
Total	37.3	

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National Traffic Balance

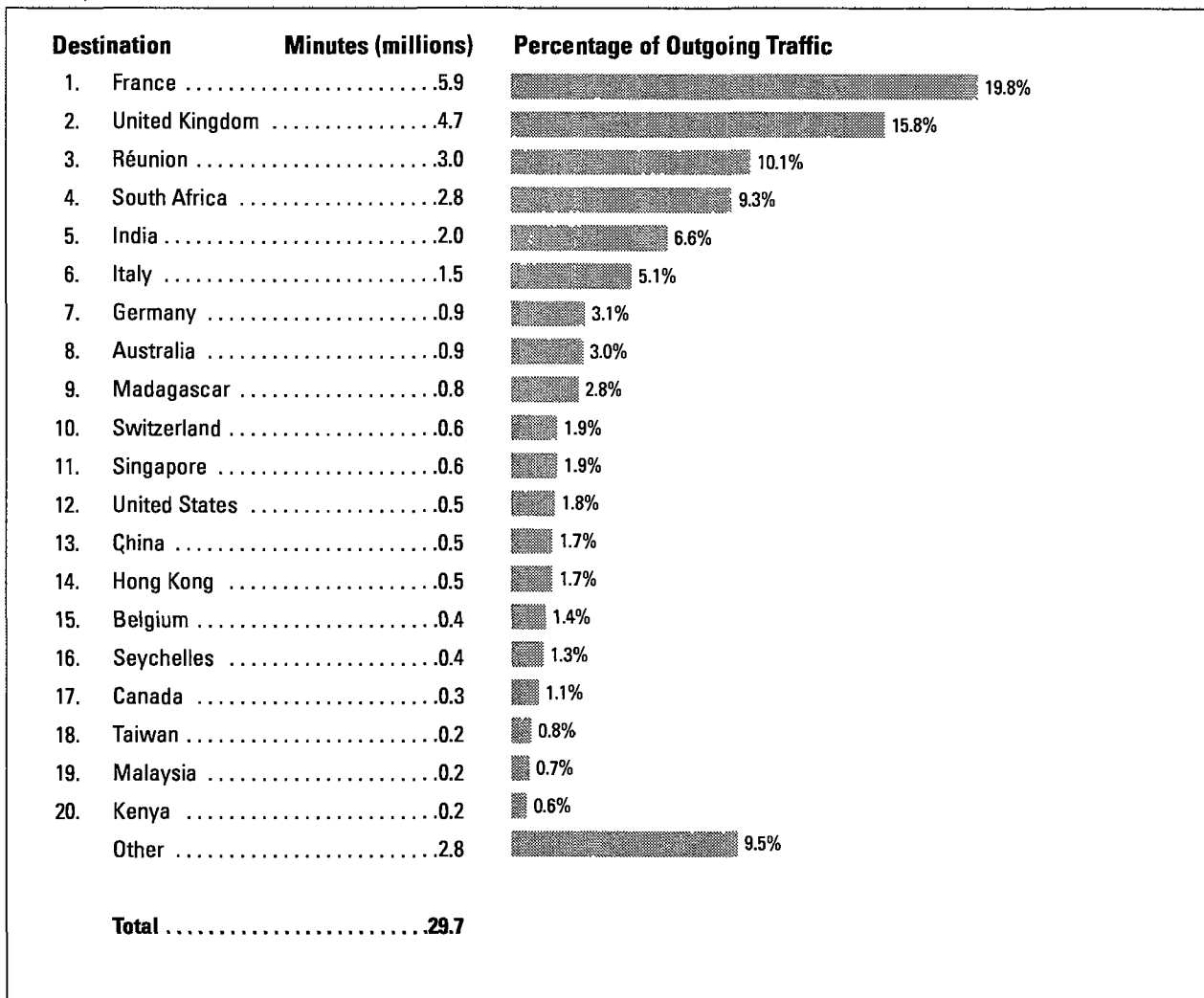
Minutes	1996	1997	1998
Incoming	34.0	37.0	n.a.
Outgoing	31.7	34.4	37.3
Surplus (Deficit)	2.3	2.6	n.a.
Total Volume	65.7	71.4	n.a.

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic.

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Mauritius

Largest Telecommunications Routes, FY 1998/99



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National Traffic Balance

Minutes	FY 1996/97	FY 1997/98	FY 1998/99
Incoming	29.4	35.0	38.5
Outgoing	21.7	24.6	29.7
Surplus (Deficit)	7.7	10.4	8.8
Total Volume	51.1	59.6	68.2

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic. Fiscal year ends 30 June.

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Mexico

Largest Telecommunications Routes, 1998

Destination	Minutes (millions)	Percentage of Outgoing Traffic
1. United States	1,095.0	83.6%
2. Canada	20.0	1.5%
3. Spain	12.0	0.9%
4. Italy	8.0	0.6%
5. Germany	7.5	0.6%
6. France	7.0	0.5%
7. Guatemala	6.0	0.5%
8. Argentina	6.0	0.5%
9. Brazil	6.0	0.5%
10. Colombia	6.0	0.5%
11. Cuba	6.0	0.5%
12. Chile	5.5	0.4%
13. United Kingdom	4.5	0.3%
14. Costa Rica	4.0	0.3%
15. El Salvador	3.5	0.2%
16. Peru	3.0	0.2%
17. Honduras	3.0	0.2%
18. Japan	3.0	0.2%
19. Venezuela	3.0	0.2%
20. Switzerland	2.0	0.2%
Other	97.5	7.4%
Total	1,310.0	

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National Traffic Balance

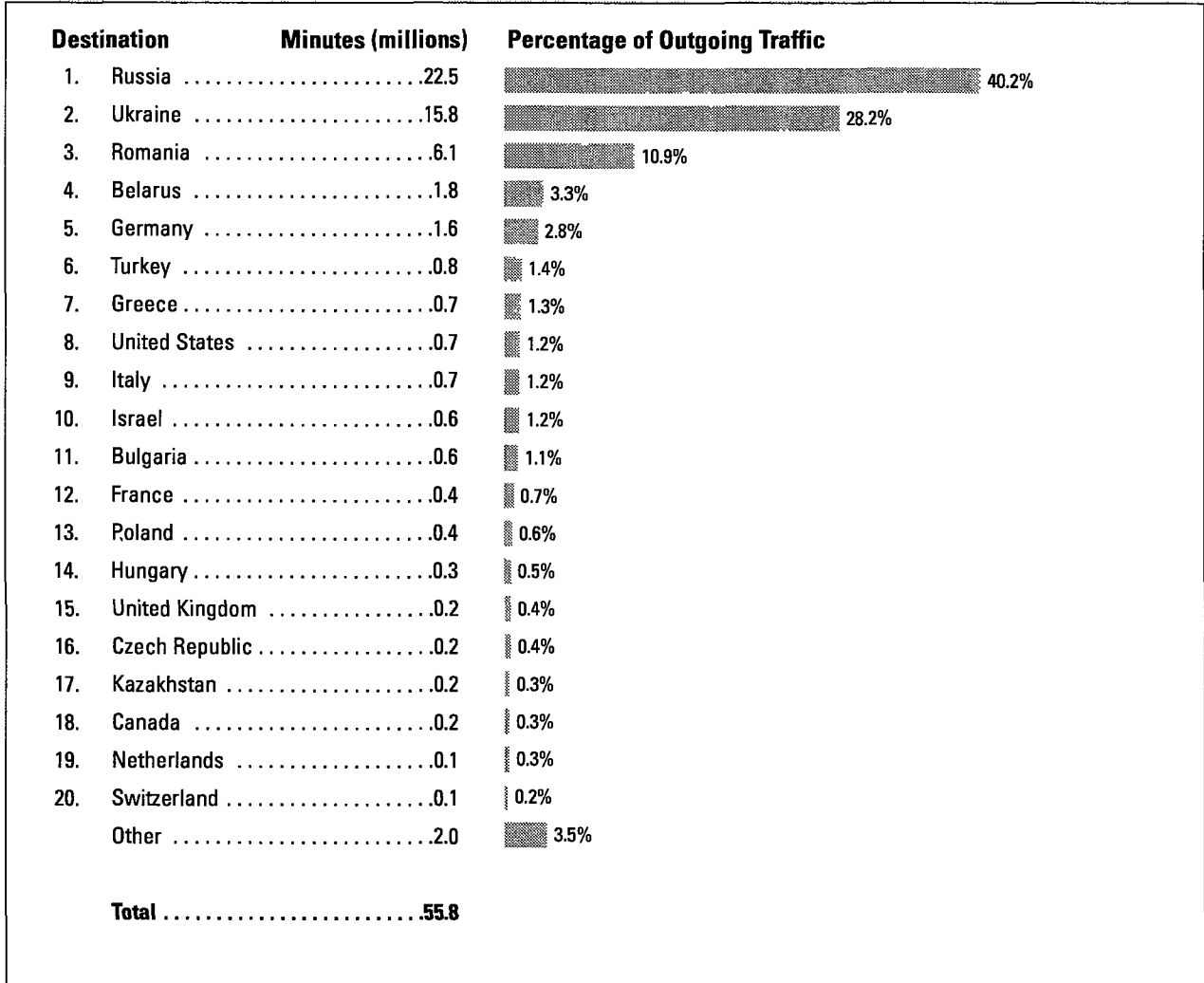
Minutes	1996	1997	1998
Incoming	2,489.7	2,819.3	3,060.0
Outgoing	1,070.7	1,213.6	1,310.0
Surplus (Deficit)	1,419.0	1,605.7	1,750.0
Total Volume	3,560.4	4,032.9	4,370.0

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic. Data based on billing point of traffic.

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Moldova

Largest Telecommunications Routes, 1998



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National Traffic Balance

Minutes	1996	1997	1998
Incoming	72.0	80.2	90.3
Outgoing	50.2	55.6	55.8
Surplus (Deficit)	21.8	24.6	34.4
Total Volume	122.2	135.8	146.1

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic. Data based on billing point of traffic. Totals for 1996 include only traffic with other members of the Commonwealth of Independent States.

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Largest Telecommunications Routes, 1998

Destination	Minutes (millions)	Percentage of Outgoing Traffic
1. France	157.0	67.1%
2. Italy	26.0	11.1%
3. United Kingdom	12.0	5.1%
4. Switzerland	7.0	3.0%
5. Germany	5.0	2.1%
6. United States	5.0	2.1%
7. Belgium	2.0	0.9%
8. Netherlands	2.0	0.9%
Other	18.0	7.7%
Total	234.0	

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National Traffic Balance

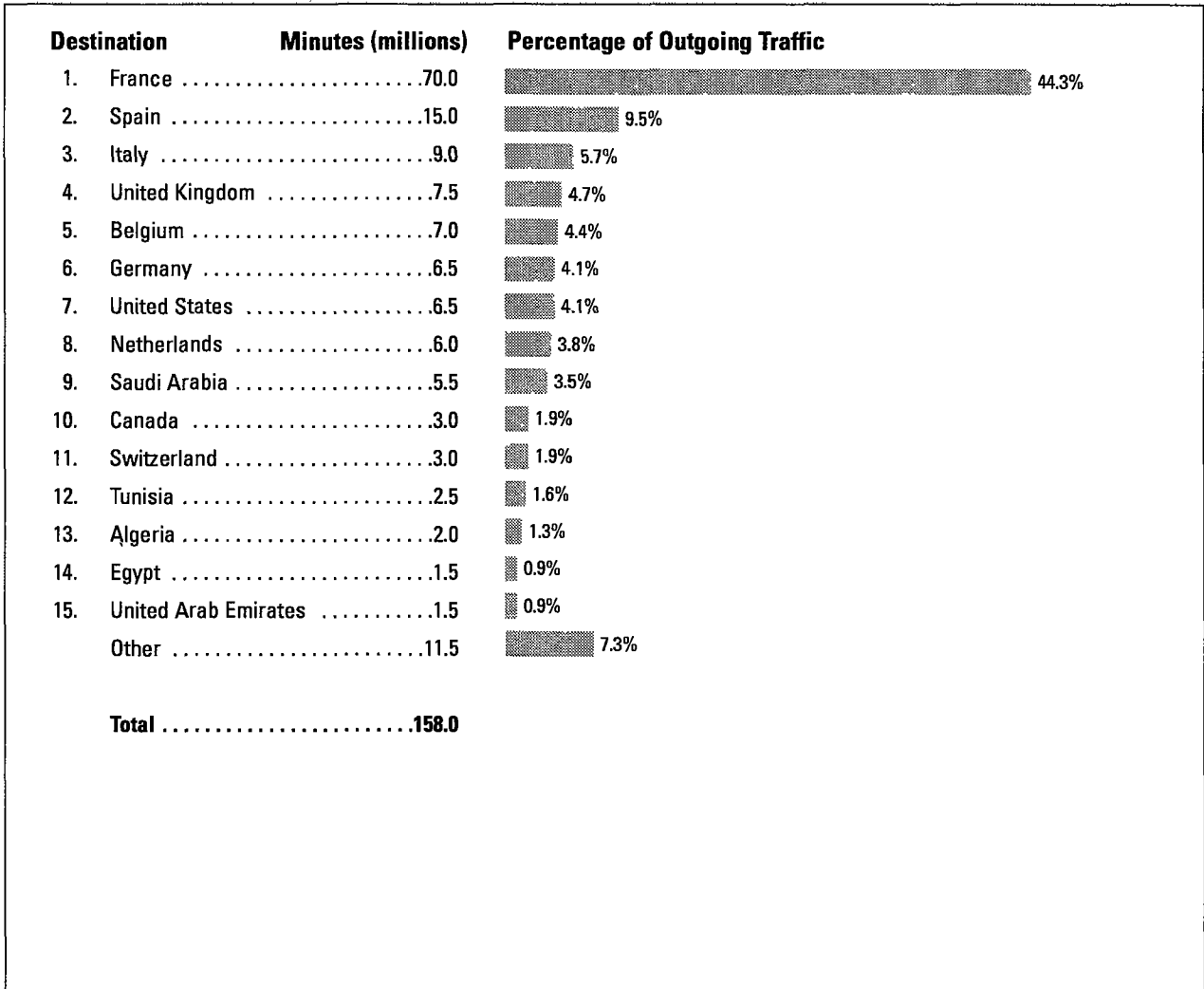
Minutes	1996	1997	1998
Incoming	n.a.	n.a.	140.0
Outgoing	n.a.	n.a.	234.0
Surplus (Deficit)	n.a.	n.a.	(94.0)
Total Volume	n.a.	n.a.	374.0

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic. Outgoing traffic includes an estimated 50 million minutes of calls reoriginated from other countries.

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Morocco

Largest Telecommunications Routes, 1998



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National Traffic Balance

Minutes	1996	1997	1998
Incoming	286.6	364.0	460.0
Outgoing	129.3	149.9	158.0
Surplus (Deficit)	157.3	214.1	302.0
Total Volume	415.9	513.9	618.0

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic.

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Namibia

Largest Telecommunications Routes, 1998

Destination	Minutes (millions)	Percentage of Outgoing Traffic
1. South Africa	51.4	83.1%
2. Germany	2.1	3.5%
3. United Kingdom	1.1	1.8%
4. United States	0.8	1.2%
5. Zimbabwe	0.6	1.0%
6. Botswana	0.6	1.0%
7. Angola	0.5	0.7%
8. Spain	0.4	0.6%
9. Zambia	0.4	0.6%
10. France	0.3	0.5%
11. Netherlands	0.2	0.3%
12. Portugal	0.2	0.3%
13. Italy	0.2	0.3%
14. Switzerland	0.2	0.3%
15. China	0.1	0.2%
16. Australia	0.1	0.2%
17. Austria	0.1	0.2%
18. Russia	0.1	0.2%
19. Belgium	0.1	0.2%
Other	2.3	3.8%
Total	61.9	

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National Traffic Balance

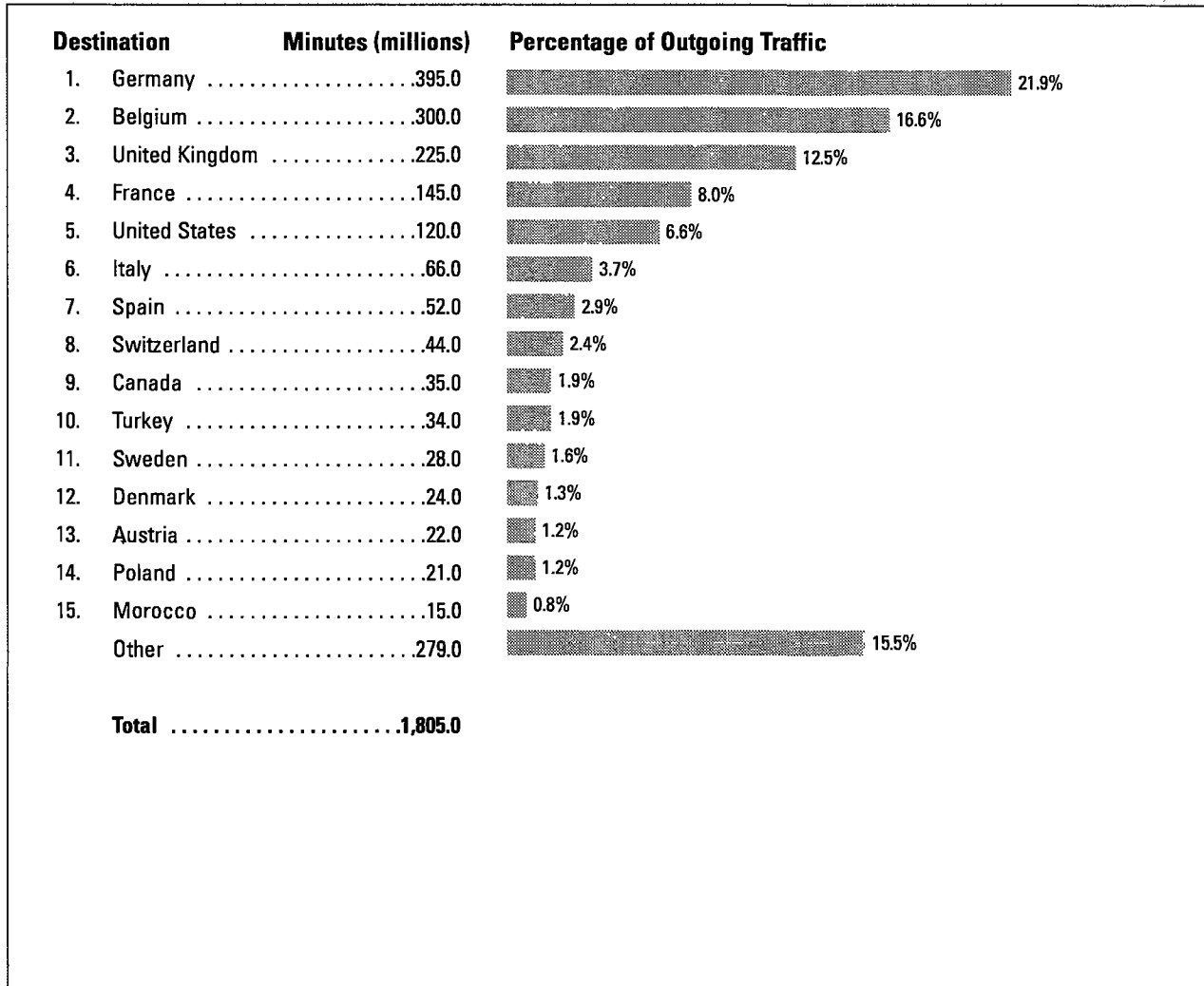
Minutes	1996	1997	1998
Incoming	41.7	42.3	45.3
Outgoing	51.4	49.7	61.9
Surplus (Deficit)	(9.7)	(7.4)	(16.6)
Total Volume	93.1	92.0	107.2

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic.

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Netherlands

Largest Telecommunications Routes, 1998



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National Traffic Balance

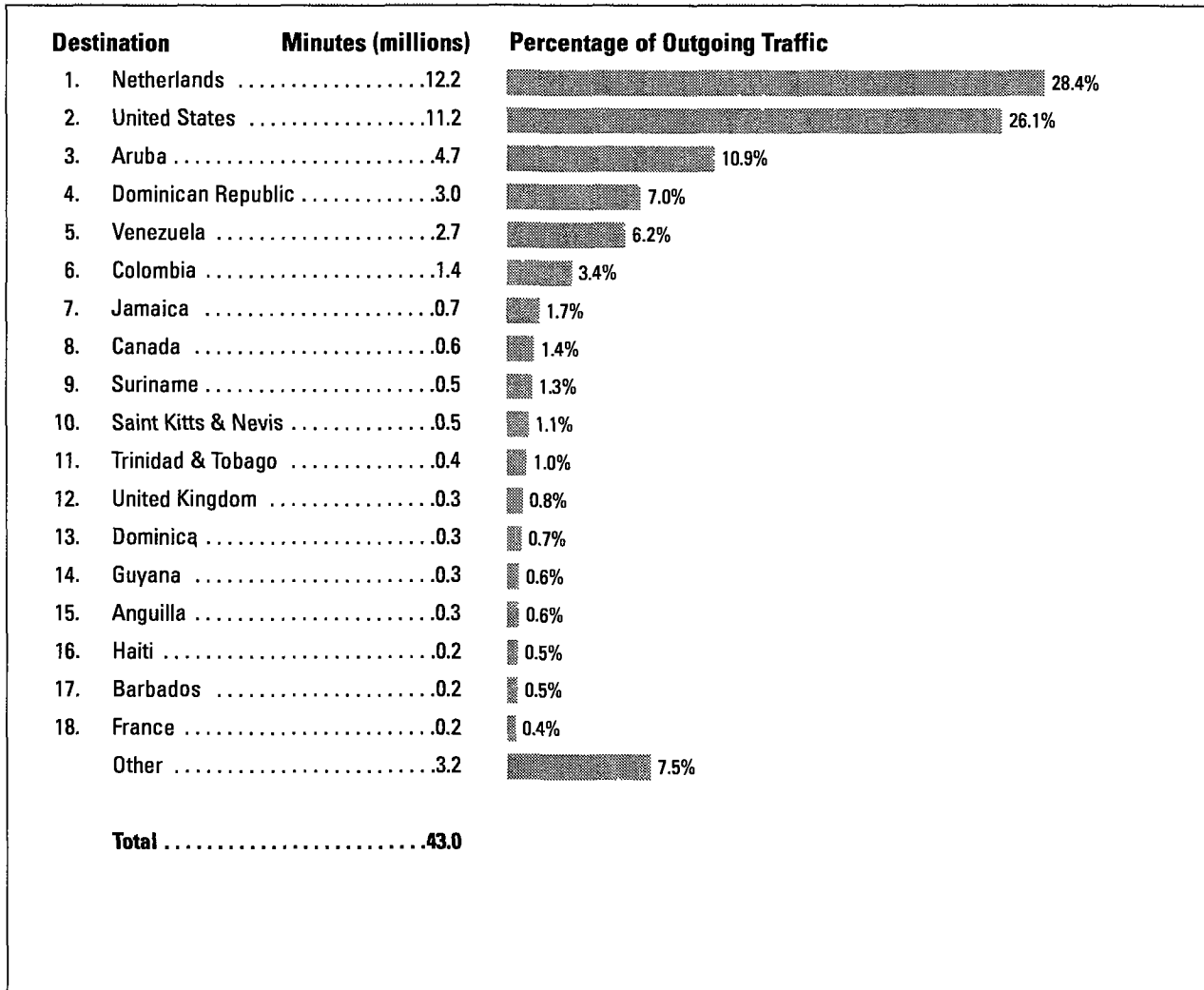
Minutes	1996	1997	1998
Incoming	1,584.6	n.a.	n.a.
Outgoing	1,534.1	1,615.0	1,805.0
Surplus (Deficit)	50.5	n.a.	n.a.
Total Volume	3,118.7	n.a.	n.a.

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic.

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Netherlands Antilles

Largest Telecommunications Routes, 1998



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National Traffic Balance

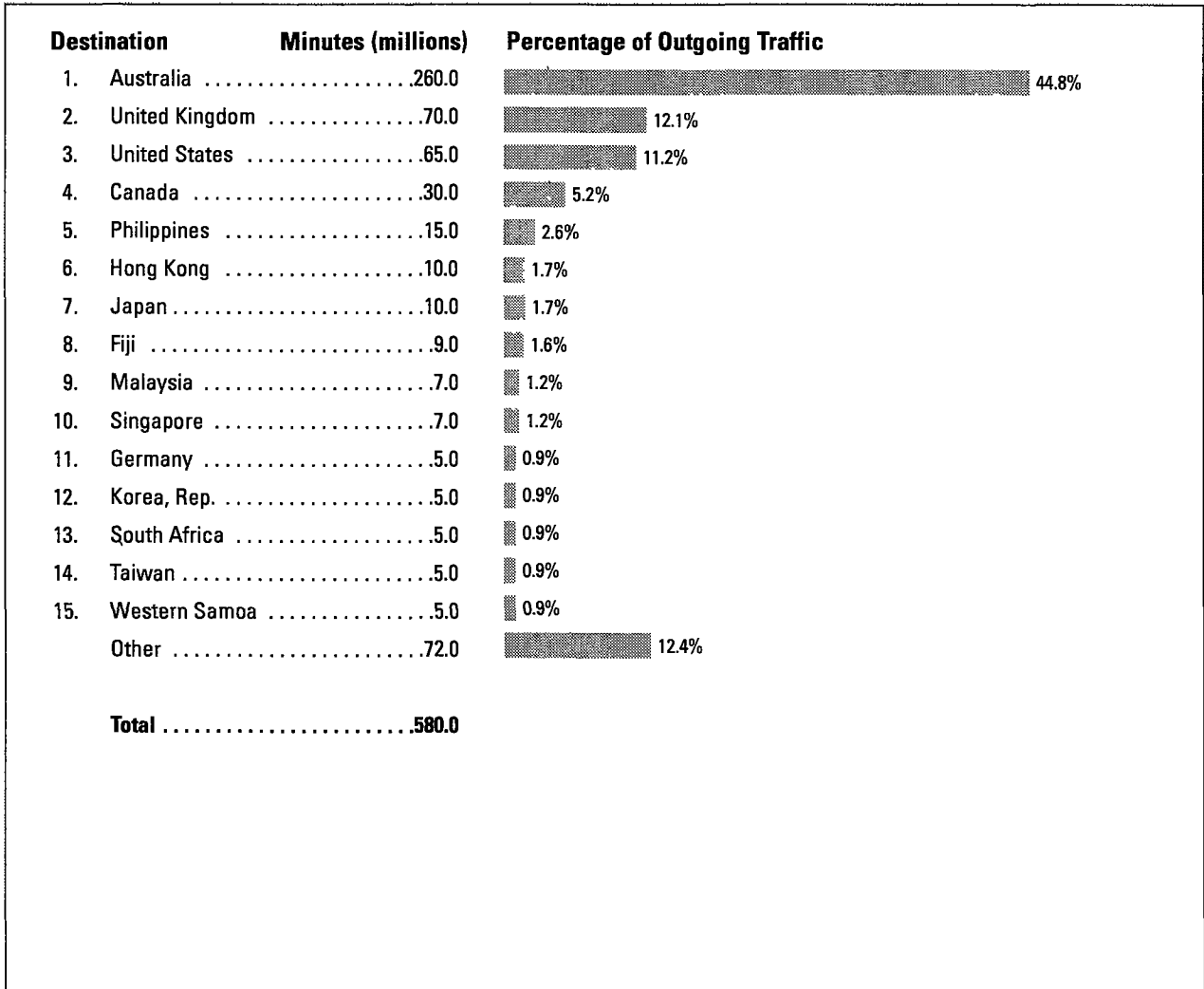
Minutes	1996	1997	1998
Incoming	n.a.	n.a.	113.8
Outgoing	40.1	n.a.	43.0
Surplus (Deficit)	n.a.	n.a.	70.9
Total Volume	n.a.	n.a.	156.8

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic. -U.S. figures include traffic to the U.S. Virgin Islands.

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New Zealand

Largest Telecommunications Routes, FY 1998/99



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National Traffic Balance

Minutes	FY 1996/97	FY 1997/98	FY 1998/99
Incoming	380.0	430.0	n.a.
Outgoing	353.0	407.0	580.0
Surplus (Deficit)	27.0	23.0	n.a.
Total Volume	733.0	837.0	n.a.

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic. Fiscal year ends 31 March.

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Nicaragua

Largest Telecommunications Routes, 1997

Destination	Minutes (millions)	Percentage of Outgoing Traffic
1. United States	16.1	39.7%
2. Costa Rica	9.2	22.8%
3. Guatemala	3.3	8.2%
4. El Salvador	3.0	7.5%
5. Honduras	2.8	7.0%
6. Mexico	1.0	2.6%
7. Panama	0.9	2.3%
8. Canada	0.7	1.7%
9. Spain	0.5	1.3%
10. Colombia	0.3	0.6%
11. Brazil	0.2	0.5%
12. Cuba	0.2	0.5%
13. Germany	0.2	0.4%
14. Argentina	0.2	0.4%
15. Italy	0.2	0.4%
16. Chile	0.1	0.3%
17. Netherlands	0.1	0.3%
18. Peru	0.1	0.3%
19. Venezuela	0.1	0.2%
20. France	0.1	0.2%
Other	1.1	2.8%
Total	40.4	

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National Traffic Balance

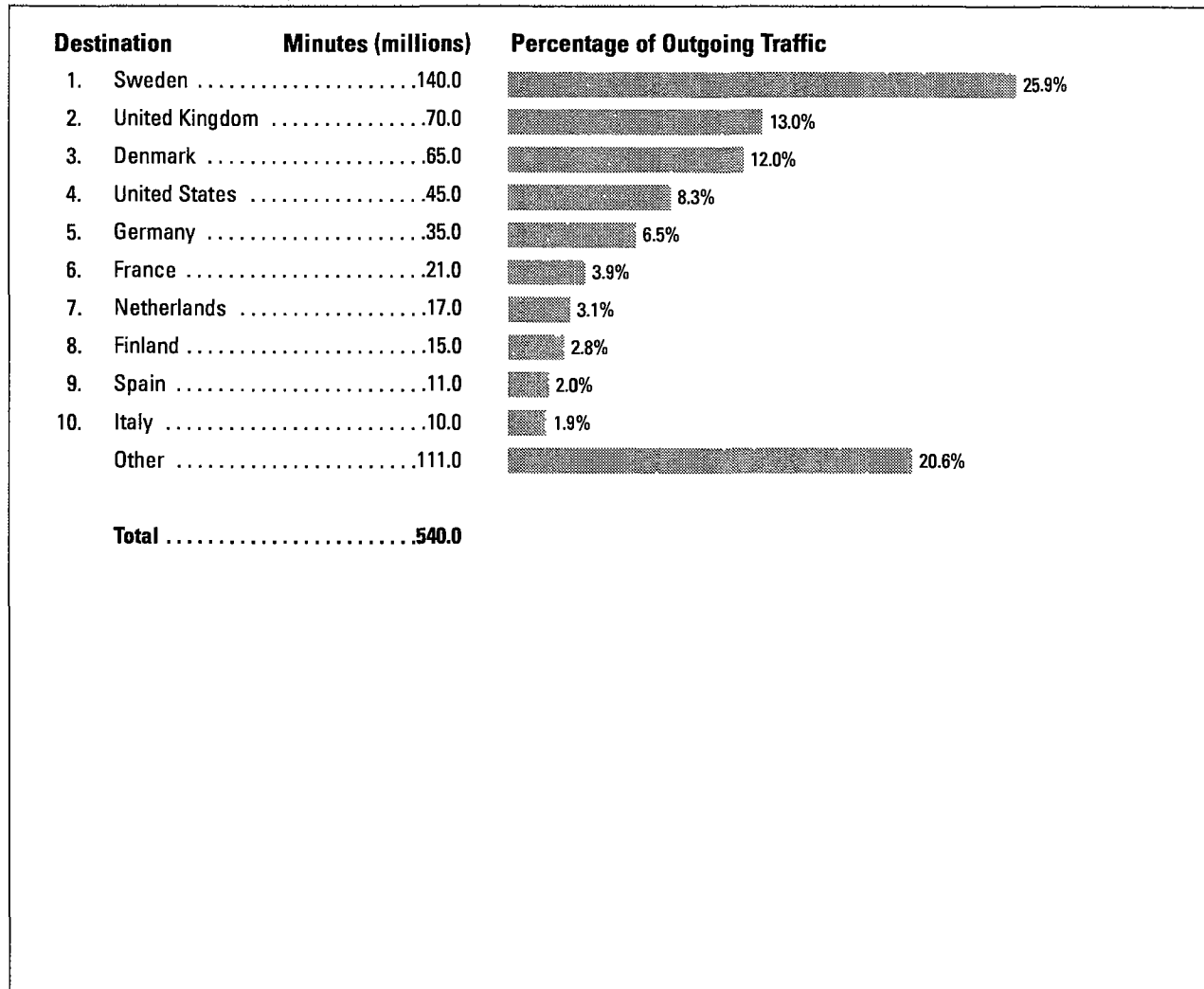
Minutes	1996	1997	1998
Incoming	47.1	52.5	n.a.
Outgoing	32.1	40.4	n.a.
Surplus (Deficit)	15.0	12.1	n.a.
Total Volume	79.2	92.9	n.a.

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic. Data based on billing point of traffic.

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Norway

Largest Telecommunications Routes, 1998



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National Traffic Balance

Minutes	1996	1997	1998
Incoming	422.3	515.0	n.a.
Outgoing	443.5	481.0	540.0
Surplus (Deficit)	(21.2)	34.0	n.a.
Total Volume	865.8	996.0	n.a.

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic. Data based on billing point of traffic.

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Oman

Largest Telecommunications Routes, 1998

Destination	Minutes (millions)	Percentage of Outgoing Traffic
1. India	25.2	27.1%
2. United Arab Emirates	25.0	26.9%
3. Pakistan	5.5	5.9%
4. United Kingdom	5.5	5.9%
5. Egypt	3.7	3.9%
6. Saudi Arabia	2.7	2.9%
7. Bahrain	2.2	2.4%
8. United States	2.1	2.2%
9. Jordan	1.6	1.7%
10. Kuwait	1.3	1.4%
11. Qatar	1.3	1.4%
12. Sri Lanka	1.3	1.4%
13. Philippines	1.3	1.3%
14. Canada	1.1	1.1%
15. Tanzania	1.0	1.1%
16. Sudan	0.8	0.8%
17. France	0.7	0.8%
18. Germany	0.7	0.8%
19. Netherlands	0.6	0.6%
20. Italy	0.5	0.5%
Other	9.0	9.7%
Total	92.9	

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National Traffic Balance

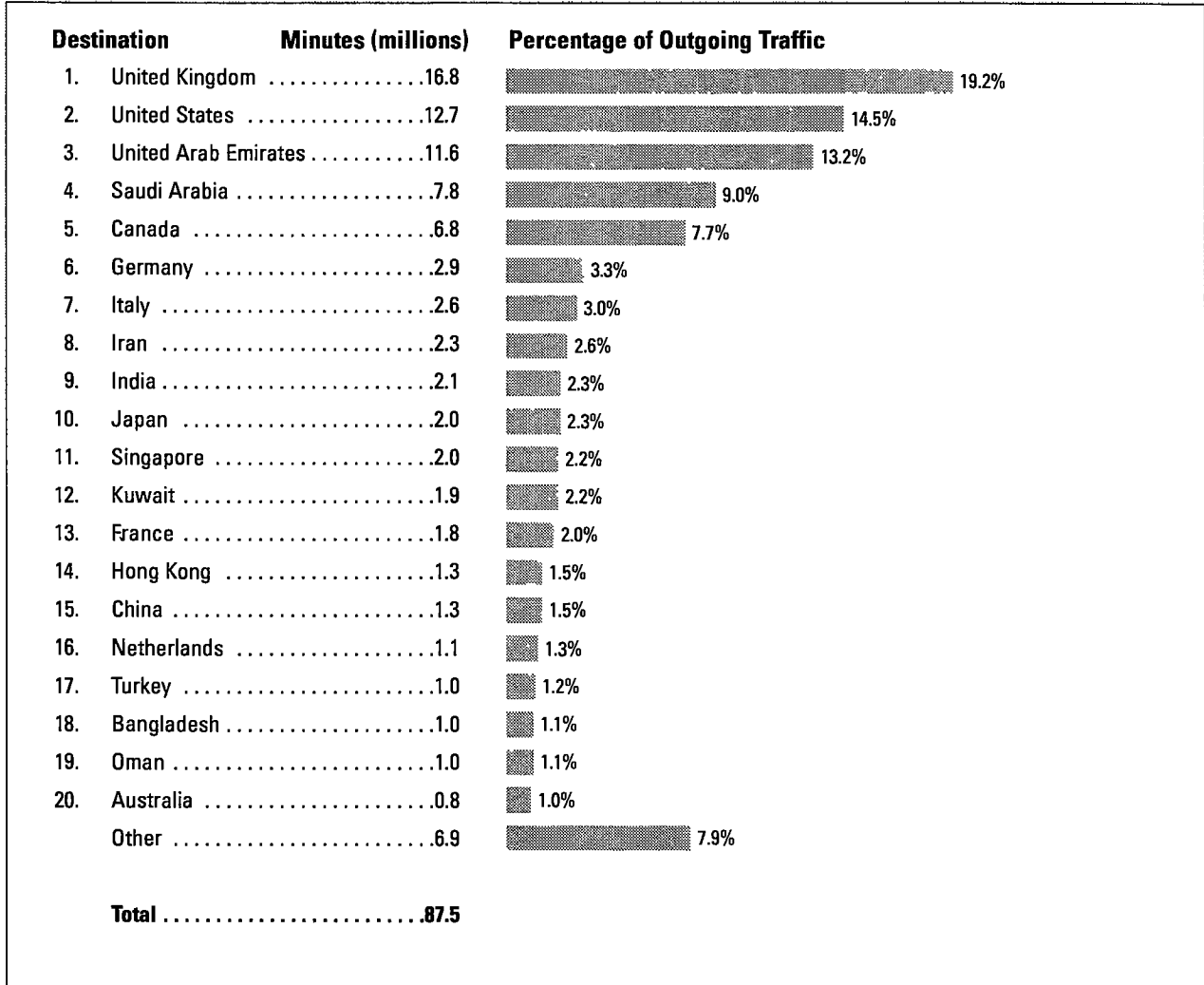
Minutes	1996	1997	1998
Incoming	58.0	70.4	74.2
Outgoing	62.6	74.3	92.9
Surplus (Deficit)	(4.6)	(3.9)	(18.7)
Total Volume	120.6	144.7	167.1

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic. Data based on billing point of traffic. Excludes some cross-border calls to the United Arab Emirates.

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Pakistan

Largest Telecommunications Routes, FY 1998/99



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National Traffic Balance

Minutes	FY 1996/97	FY 1997/98	FY 1998/99
Incoming	488.4	557.8	640.4
Outgoing	77.0	84.1	87.5
Surplus (Deficit)	411.4	473.7	552.9
Total Volume	565.4	641.9	727.9

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic. Fiscal year ends 30 June. Data exclude some cross-border traffic to India.

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Palestinian Authority

Largest Telecommunications Routes, 1998

Destination	Minutes (millions)	Percentage of Outgoing Traffic
1. Jordan	11.8	42.7%
2. United States	2.9	10.6%
3. Egypt	1.9	6.8%
4. Saudi Arabia	1.5	5.3%
5. United Arab Emirates	1.1	4.0%
6. Germany	0.7	2.5%
7. United Kingdom	0.6	2.0%
8. Italy	0.5	1.9%
9. Canada	0.4	1.4%
10. Ukraine	0.3	1.3%
11. Syria	0.3	1.2%
12. Turkey	0.3	1.1%
13. France	0.3	1.0%
14. Lebanon	0.3	0.9%
15. Russia	0.2	0.8%
16. Qatar	0.2	0.7%
17. Morocco	0.2	0.7%
18. Norway	0.2	0.7%
19. Tunisia	0.2	0.6%
20. Kuwait	0.2	0.6%
Other	3.6	13.1%
Total	27.6	

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National Traffic Balance

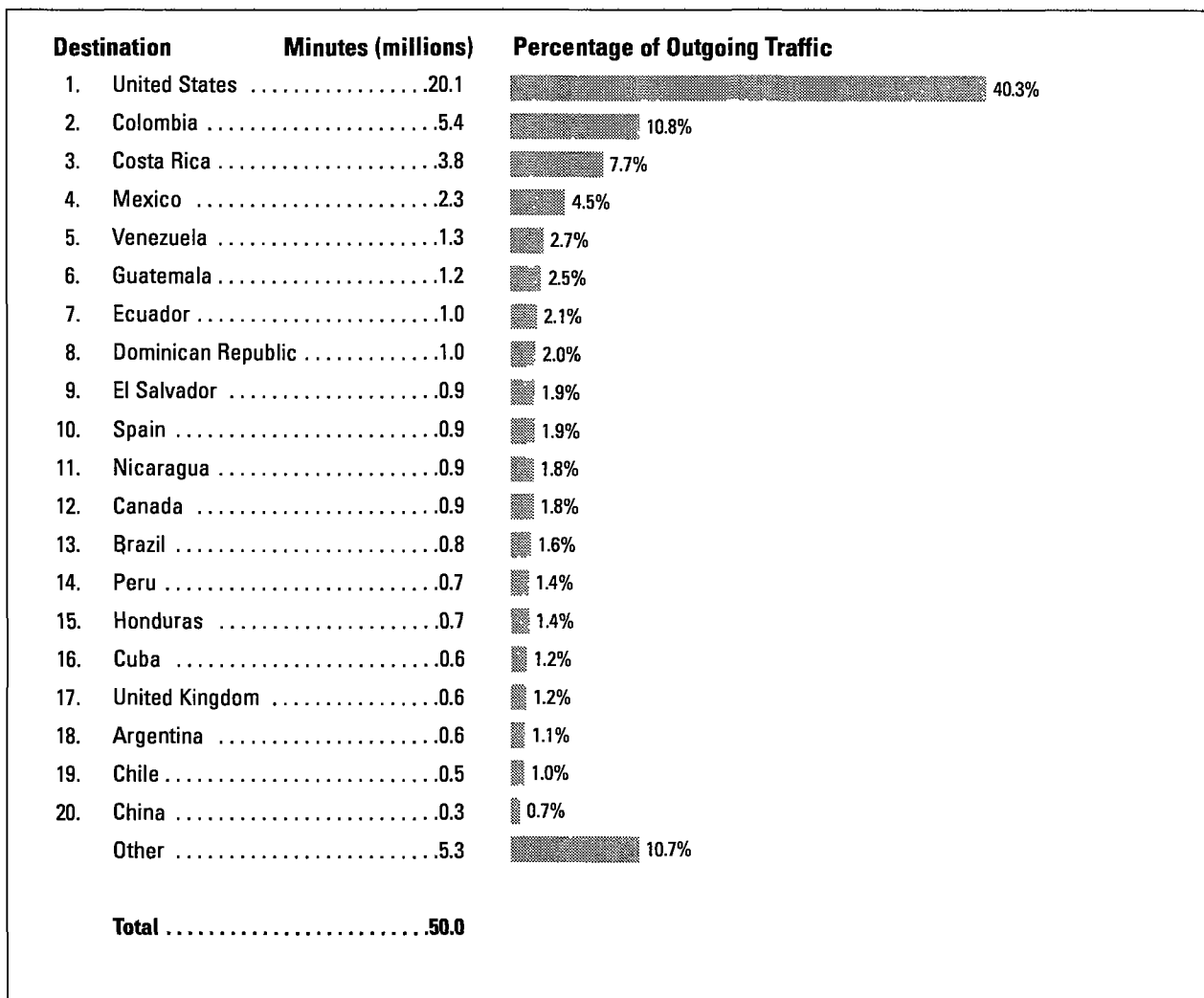
Minutes	1996	1997	1998
Incoming	n.a.	n.a.	16.6
Outgoing	n.a.	n.a.	27.6
Surplus (Deficit)	n.a.	n.a.	(11.0)
Total Volume	n.a.	n.a.	44.3

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic. Data exclude traffic with Israel.

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Largest Telecommunications Routes, 1998



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National Traffic Balance

Minutes	1996	1997	1998
Incoming	97.7	95.1	97.6
Outgoing	41.2	41.4	50.0
Surplus (Deficit)	56.5	53.7	47.6
Total Volume	138.9	136.5	147.6

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic. Data based on billing point of traffic.

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Paraguay

Largest Telecommunications Routes, 1998

Destination	Minutes (millions)	Percentage of Outgoing Traffic
1. Argentina	12.0	31.8%
2. Brazil	8.6	22.8%
3. United States	3.8	10.1%
4. Uruguay	1.5	3.9%
5. Chile	1.3	3.4%
6. Germany	0.6	1.5%
7. Bolivia	0.5	1.4%
8. Spain	0.5	1.3%
9. Lebanon	0.4	1.1%
10. Taiwan	0.4	1.1%
11. Korea, Rep.	0.4	1.0%
12. Peru	0.4	1.0%
13. France	0.3	0.8%
14. China	0.3	0.7%
15. Italy	0.3	0.7%
16. Mexico	0.3	0.7%
17. Japan	0.2	0.6%
18. Canada	0.2	0.6%
19. Switzerland	0.2	0.5%
20. United Kingdom	0.2	0.4%
Other	5.5	14.5%
Total	37.8	

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National Traffic Balance

Minutes	1996	1997	1998
Incoming	49.4	n.a.	57.4
Outgoing	24.9	26.1	37.8
Surplus (Deficit)	24.5	n.a.	19.6
Total Volume	74.3	n.a.	95.2

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic.

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Largest Telecommunications Routes, FY 1998/99

Destination	Minutes (millions)	Percentage of Outgoing Traffic
1. United States	30.3	33.6%
2. Chile	7.0	7.7%
3. Argentina	6.9	7.6%
4. Spain	5.5	6.1%
5. Colombia	3.8	4.2%
6. Italy	3.3	3.7%
7. Venezuela	2.9	3.2%
8. Bolivia	2.8	3.1%
9. Mexico	2.8	3.0%
10. Brazil	2.7	3.0%
11. Canada	2.5	2.8%
12. Japan	2.5	2.7%
13. Ecuador	2.0	2.2%
14. Germany	1.6	1.8%
15. United Kingdom	1.3	1.4%
16. France	1.1	1.2%
17. Switzerland	0.8	0.9%
18. Panama	0.7	0.8%
19. Costa Rica	0.6	0.6%
20. Korea, Rep.	0.4	0.5%
Other	8.8	9.8%
Total	90.4	

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National Traffic Balance

Minutes	FY 1996/97	FY 1997/98	FY 1998/99
Incoming	226.5	256.9	272.6
Outgoing	66.7	79.4	90.4
Surplus (Deficit)	159.8	177.5	182.3
Total Volume	293.2	336.3	363.0

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic. Data based on billing point of traffic. Fiscal year ends 31 March.

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Philippines

Largest Telecommunications Routes, FY 1998/99

Destination	Minutes (millions)	Percentage of Outgoing Traffic
1. United States	85.0	28.8%
2. Japan	45.0	15.3%
3. Hong Kong	38.0	12.9%
4. Canada	20.0	6.8%
5. Taiwan	18.0	6.1%
6. Singapore	15.0	5.1%
7. Australia	13.0	4.4%
8. Korea, Rep.	7.0	2.4%
9. Malaysia	7.0	2.4%
10. Saudi Arabia	7.0	2.4%
Other	40.0	13.6%
Total	295.0	

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National Traffic Balance

Minutes	FY 1996/97	FY 1997/98	FY 1998/99
Incoming	767.0	930.0	n.a.
Outgoing	240.0	295.0	295.0
Surplus (Deficit)	527.0	635.0	n.a.
Total Volume	1,007.0	1,225.0	n.a.

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic. Data based on billing point of traffic. Fiscal year ends 31 March.

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Poland

Largest Telecommunications Routes, 1998

Destination	Minutes (millions)	Percentage of Outgoing Traffic
1. Germany	233.8	38.8%
2. United Kingdom	35.9	6.0%
3. Italy	35.6	5.9%
4. France	33.0	5.5%
5. United States	26.3	4.4%
6. Austria	20.3	3.4%
7. Netherlands	20.1	3.3%
8. Ukraine	18.8	3.1%
9. Sweden	16.8	2.8%
10. Czech Republic	14.9	2.5%
11. Russia	14.5	2.4%
12. Belgium	13.5	2.2%
13. Vietnam	12.1	2.0%
14. Denmark	10.3	1.7%
15. Switzerland	8.2	1.4%
16. Belarus	7.5	1.3%
17. Spain	7.3	1.2%
18. Canada	7.0	1.2%
19. Hungary	5.8	1.0%
20. Norway	5.3	0.9%
Other	55.5	9.2%
Total	602.4	

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National Traffic Balance

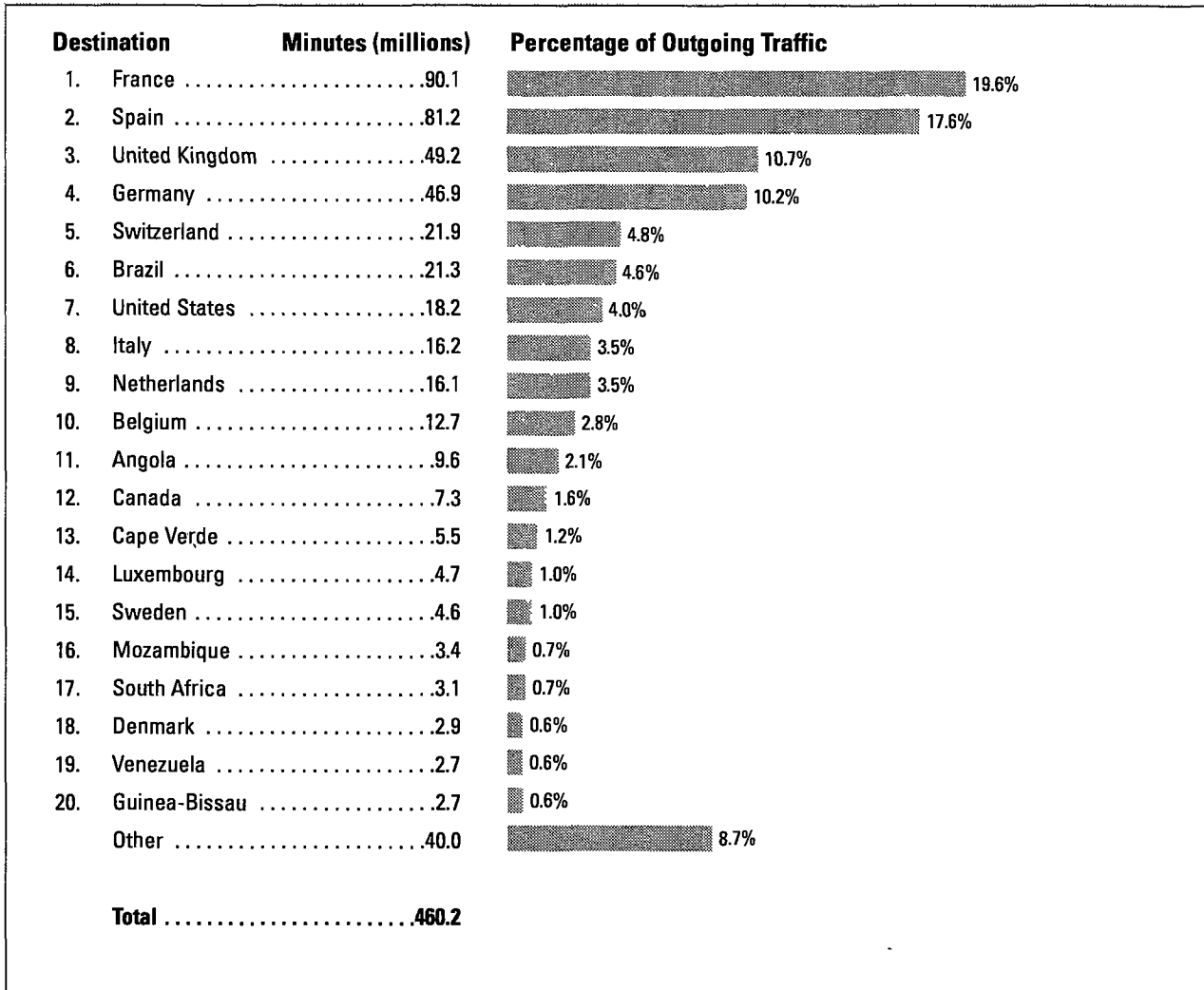
Minutes	1996	1997	1998
Incoming	725.5	800.2	1,144.2
Outgoing	437.2	529.0	602.4
Surplus (Deficit)	288.3	271.2	541.8
Total Volume	1,162.7	1,329.2	1,746.6

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic. Data based on billing point of traffic.

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Portugal

Largest Telecommunications Routes, 1998



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National Traffic Balance

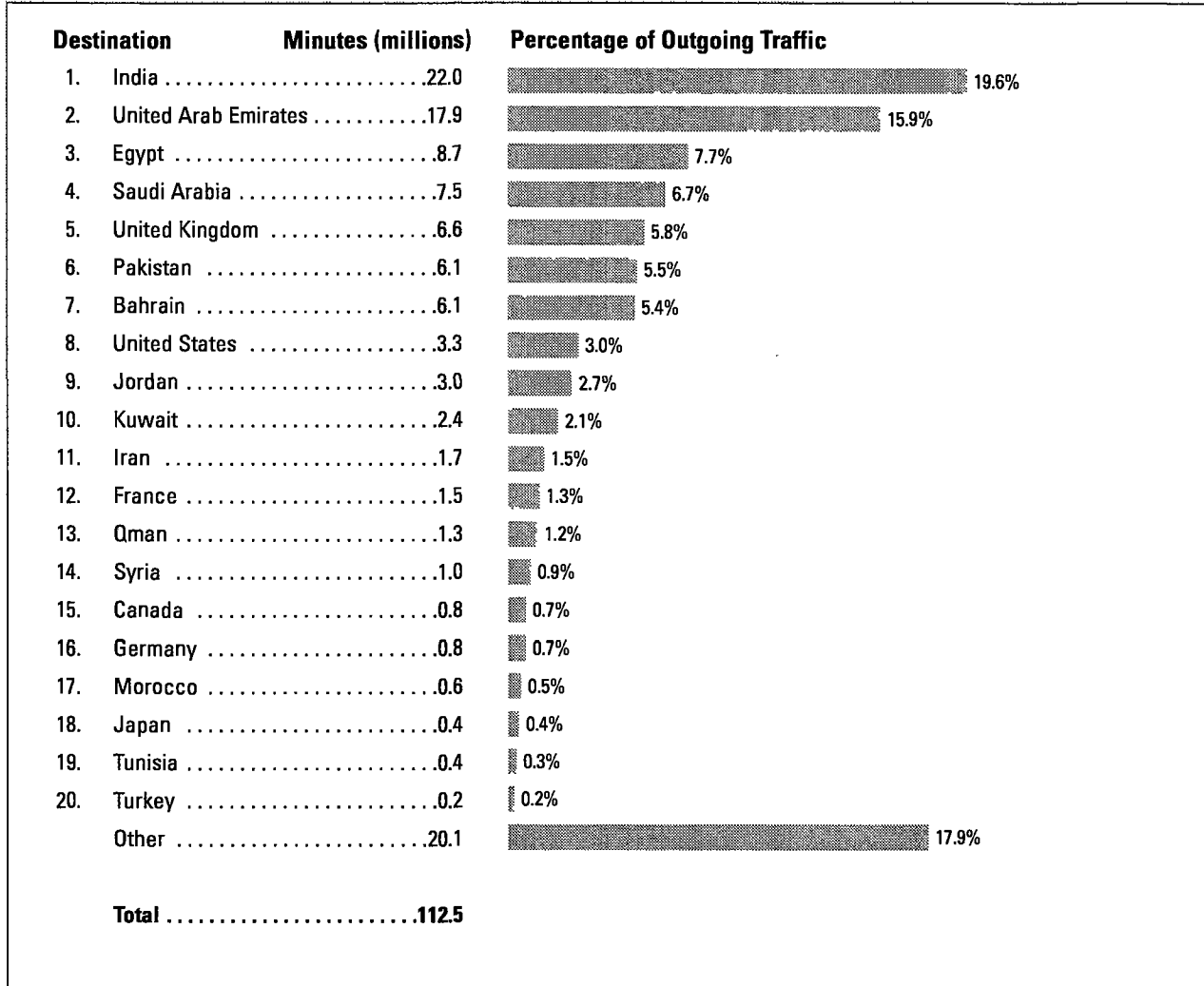
Minutes	1996	1997	1998
Incoming	571.4	628.8	711.5
Outgoing	340.0	393.3	460.2
Surplus (Deficit)	231.4	235.5	251.3
Total Volume	911.4	1,022.1	1,171.7

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic. Data based on billing point of traffic. Data may exclude some cross-border traffic to Spain.

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Largest Telecommunications Routes, 1998



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National Traffic Balance

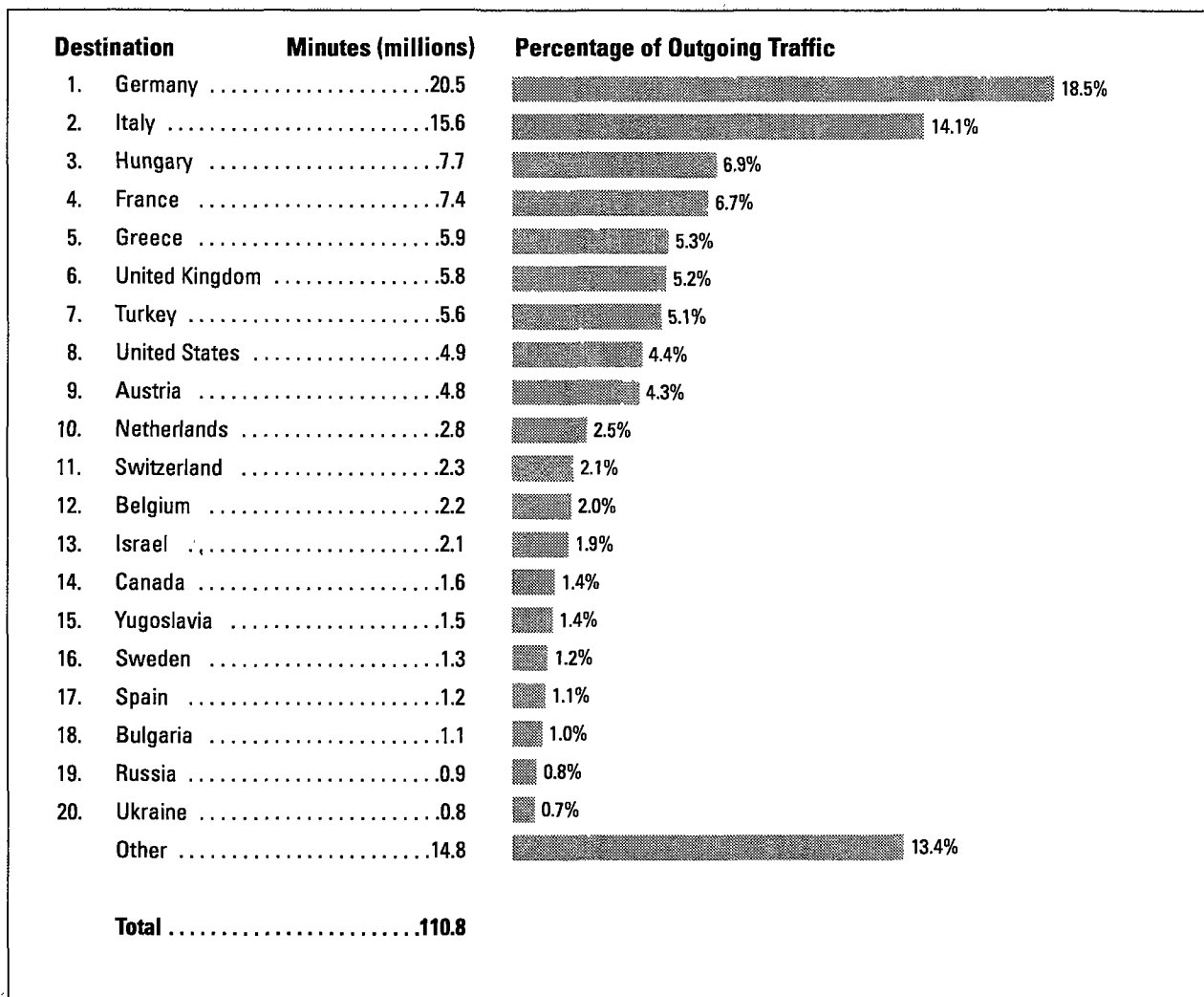
Minutes	1996	1997	1998
Incoming	66.0	59.5	70.0
Outgoing	84.3	99.9	112.5
Surplus (Deficit)	(18.3)	(40.4)	(42.5)
Total Volume	150.3	159.4	182.5

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic.

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Romania

Largest Telecommunications Routes, 1997



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National Traffic Balance

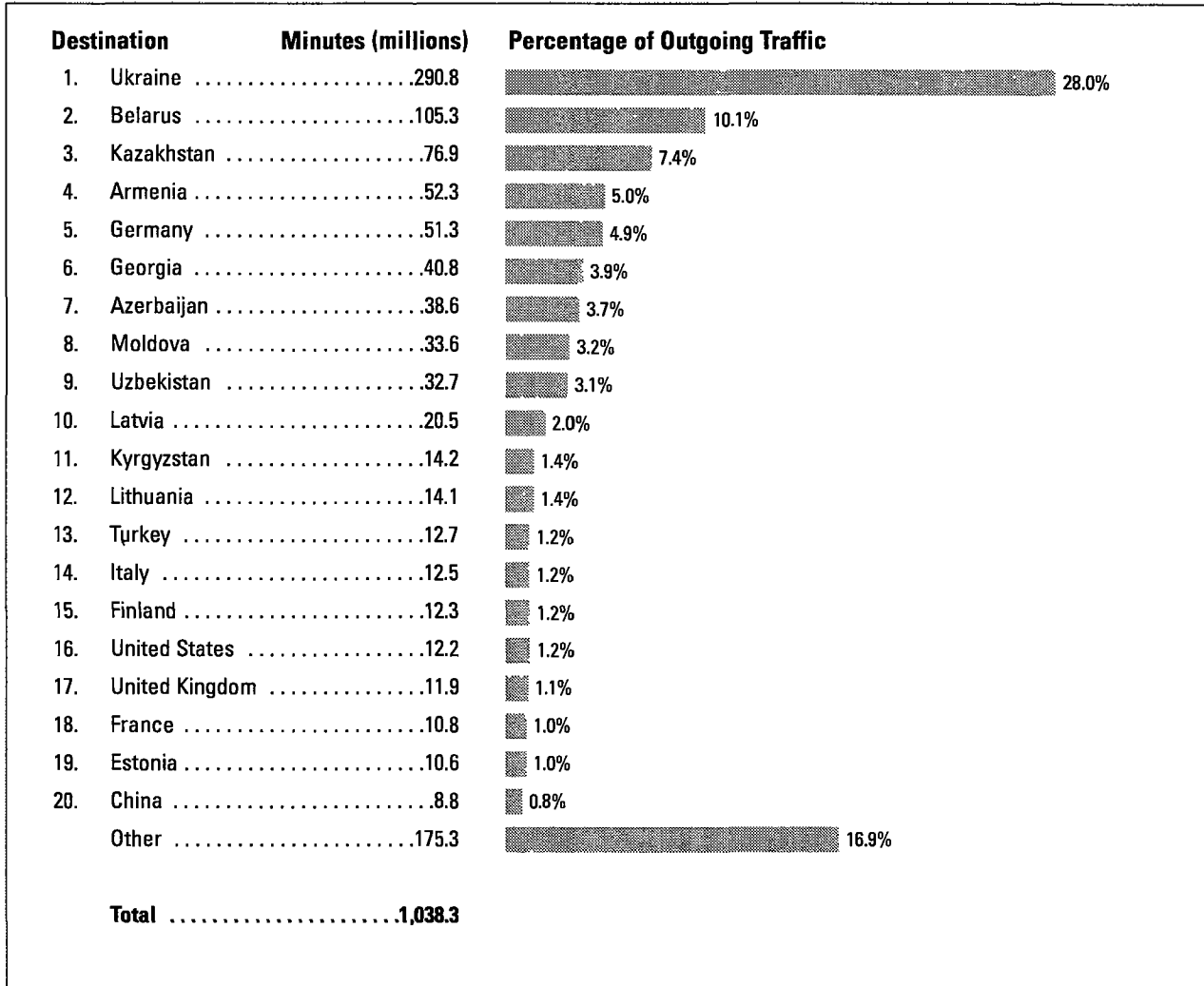
Minutes	1996	1997	1998
Incoming	237.5	278.6	n.a.
Outgoing	91.5	110.8	n.a.
Surplus (Deficit)	146.0	167.8	n.a.
Total Volume	329.0	389.4	n.a.

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic.

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Russia

Largest Telecommunications Routes, 1998



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National Traffic Balance

Minutes	1996	1997	1998
Incoming	1,037.6	1,035.6	1,029.8
Outgoing	851.3	969.6	1,038.3
Surplus (Deficit)	186.3	66.0	(8.5)
Total Volume	1,888.9	2,005.2	2,068.1

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic. Data are for Rostelecom only. Other operators sent an estimated 200 million minutes of additional traffic in 1998.

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Saudi Arabia

Largest Telecommunications Routes, 1998

Destination	Minutes (millions)	Percentage of Outgoing Traffic
1. Egypt	164.0	17.6%
2. India	114.0	12.2%
3. Pakistan	85.0	9.1%
4. United Arab Emirates	43.0	4.6%
5. Syria	42.0	4.5%
6. Bahrain	38.0	4.1%
7. United States	37.0	4.0%
8. United Kingdom	30.0	3.2%
9. Yemen	28.0	3.0%
10. Philippines	28.0	3.0%
11. Kuwait	27.0	2.9%
12. Canada	22.0	2.4%
13. Jordan	22.0	2.4%
14. Bangladesh	22.0	2.4%
15. Sudan	22.0	2.4%
Other	208.6	22.4%
Total	932.6	

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National Traffic Balance

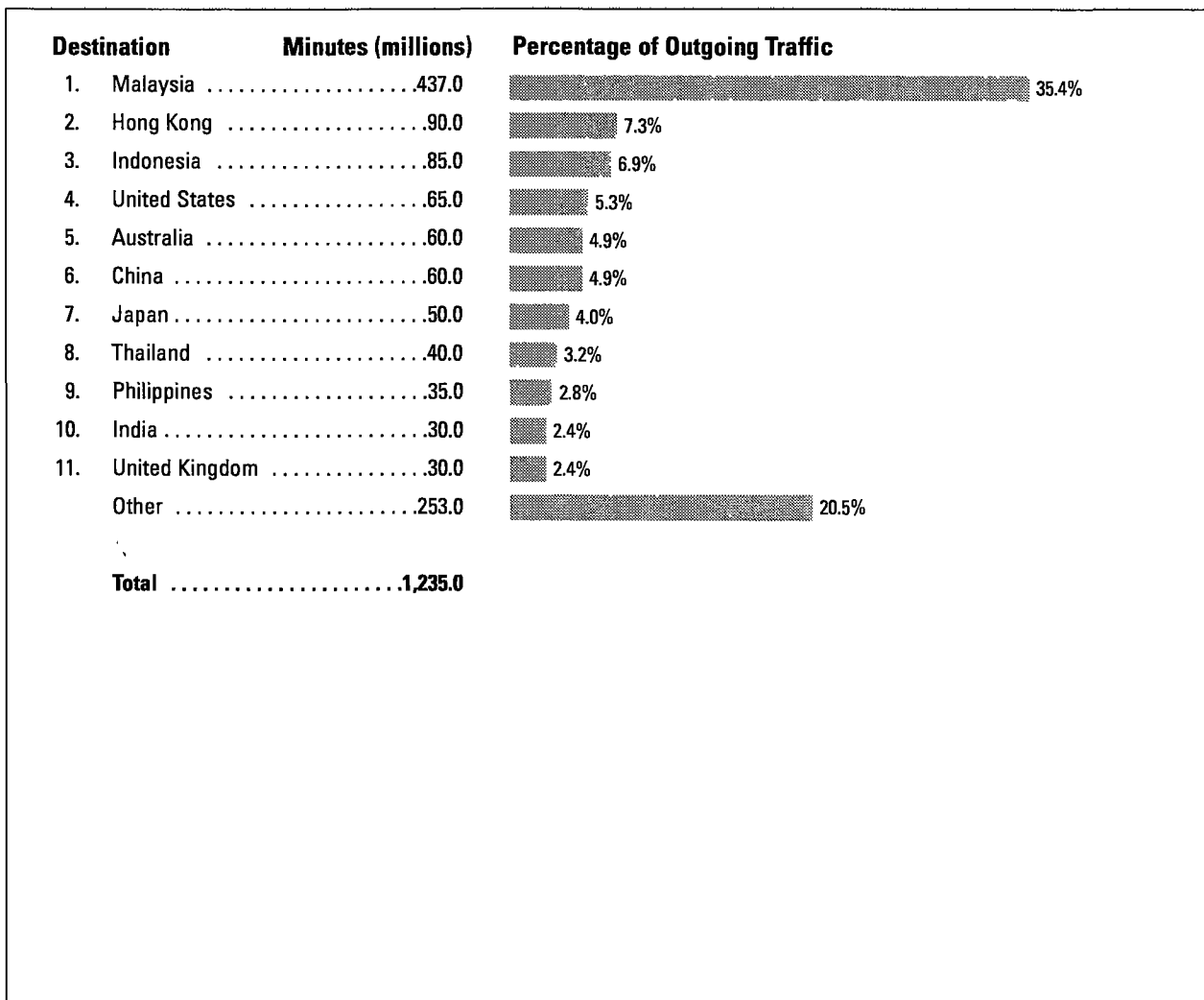
Minutes	1996	1997	1998
Incoming	n.a.	n.a.	n.a.
Outgoing	584.4	801.3	932.6
Surplus (Deficit)	n.a.	n.a.	n.a.
Total Volume	n.a.	n.a.	n.a.

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic.

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Singapore

Largest Telecommunications Routes, FY 1998/99



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National Traffic Balance

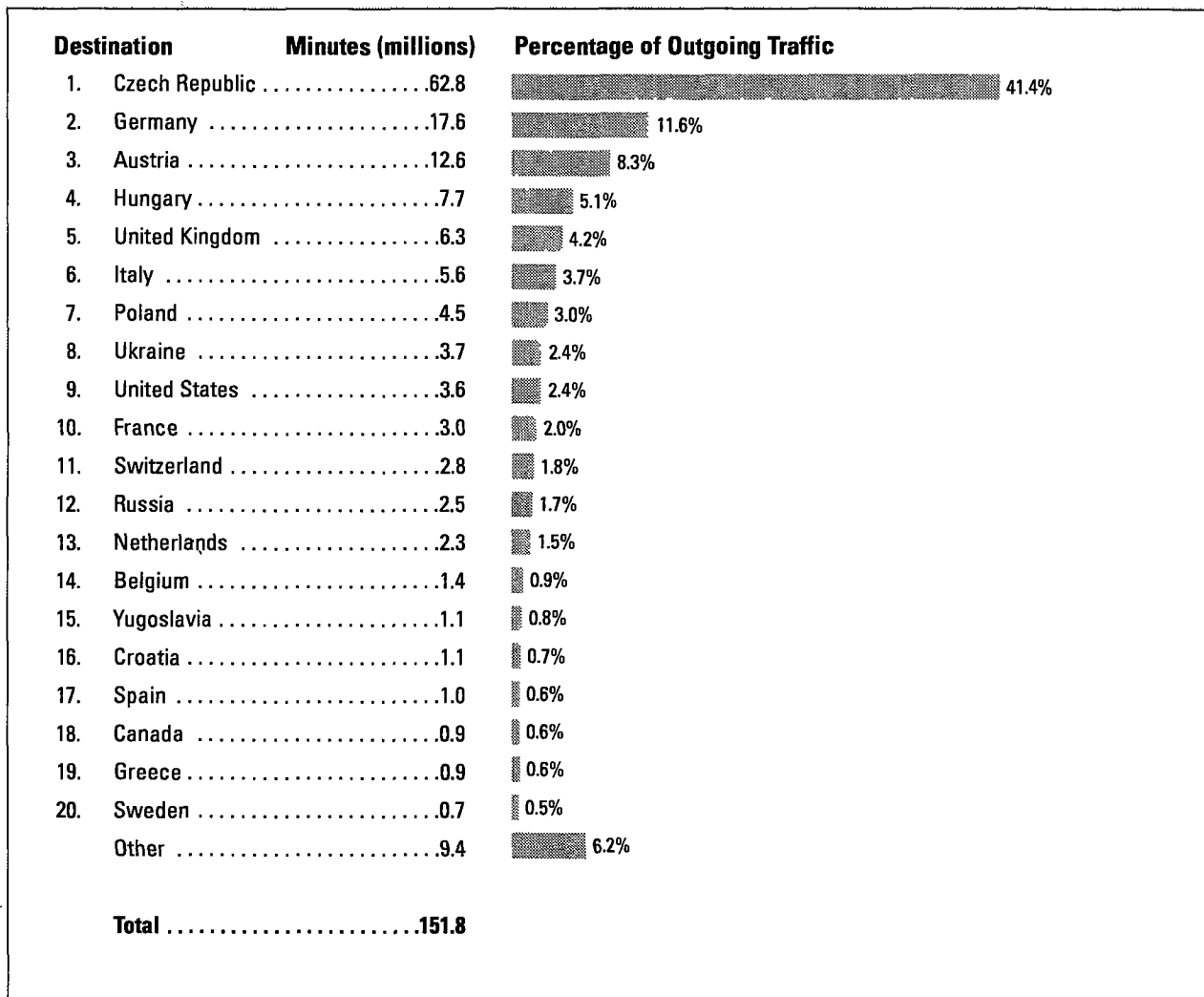
Minutes	FY 1996/97	FY 1997/98	FY 1998/99
Incoming	n.a.	n.a.	n.a.
Outgoing	942.0	1,161.0	1,235.0
Surplus (Deficit)	n.a.	n.a.	n.a.
Total Volume	n.a.	n.a.	n.a.

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic. Data based on billing point of traffic. Fiscal year ends 31 March.

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Slovak Republic

Largest Telecommunications Routes, 1998



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National Traffic Balance

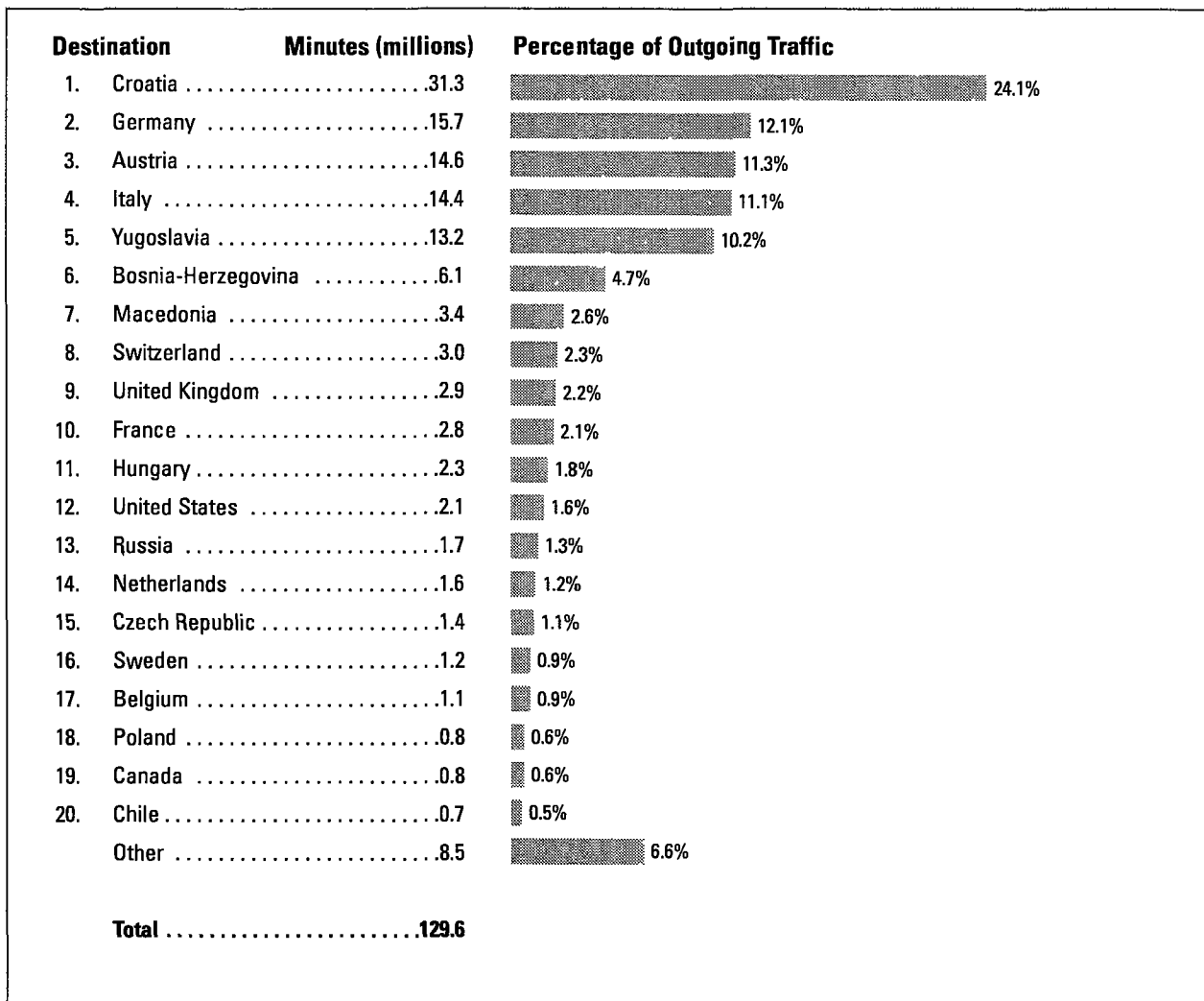
Minutes	1996	1997	1998
Incoming	159.0	174.4	186.4
Outgoing	134.1	144.7	151.8
Surplus (Deficit)	24.9	29.7	34.6
Total Volume	293.1	319.1	338.1

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic. Data based on billing point of traffic.

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Slovenia

Largest Telecommunications Routes, 1998



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National Traffic Balance

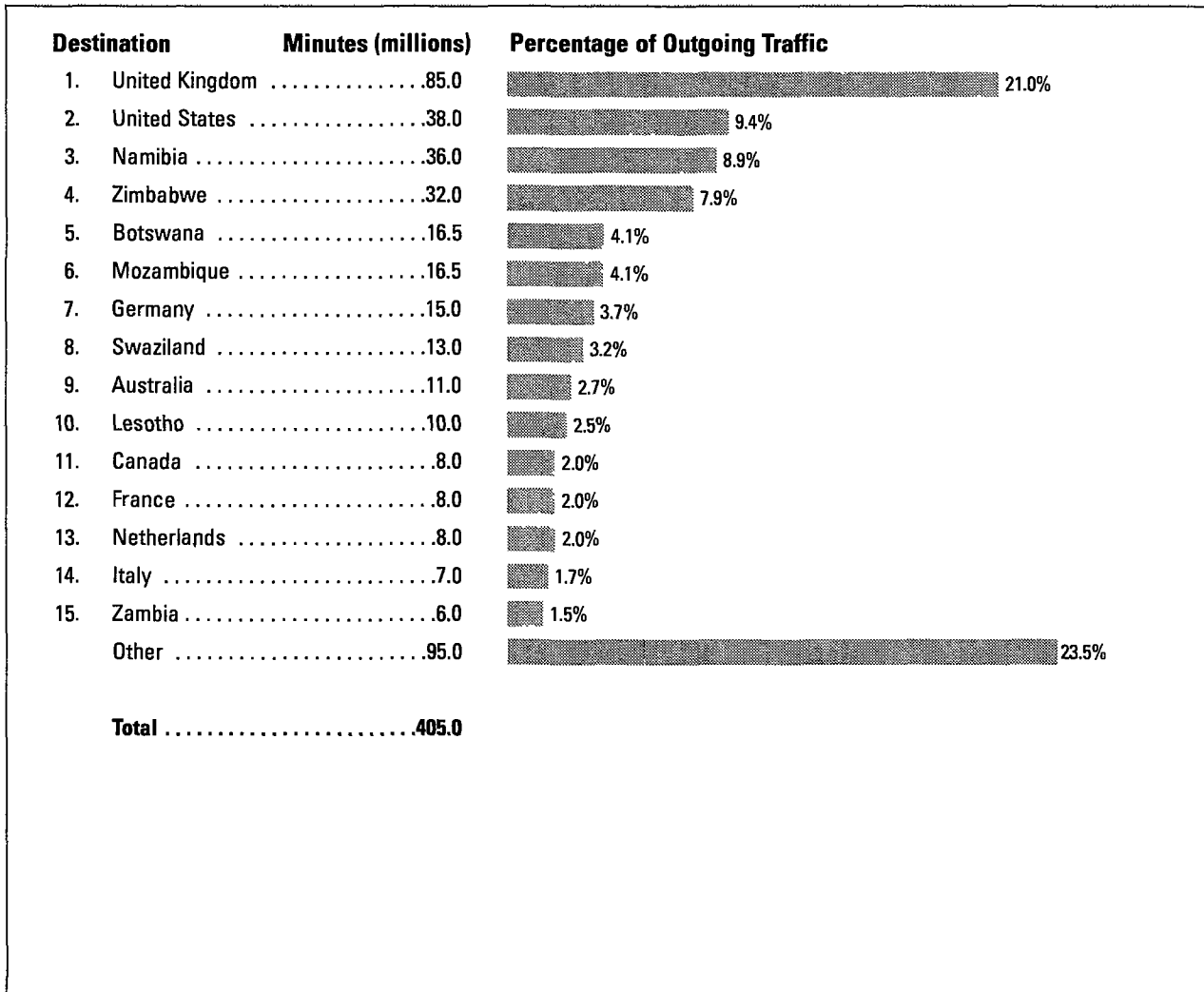
Minutes	1996	1997	1998
Incoming	113.9	118.9	137.0
Outgoing	105.3	113.5	129.6
Surplus (Deficit)	8.6	5.4	7.4
Total Volume	219.2	232.4	266.6

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic.

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South Africa

Largest Telecommunications Routes, 1998



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National Traffic Balance

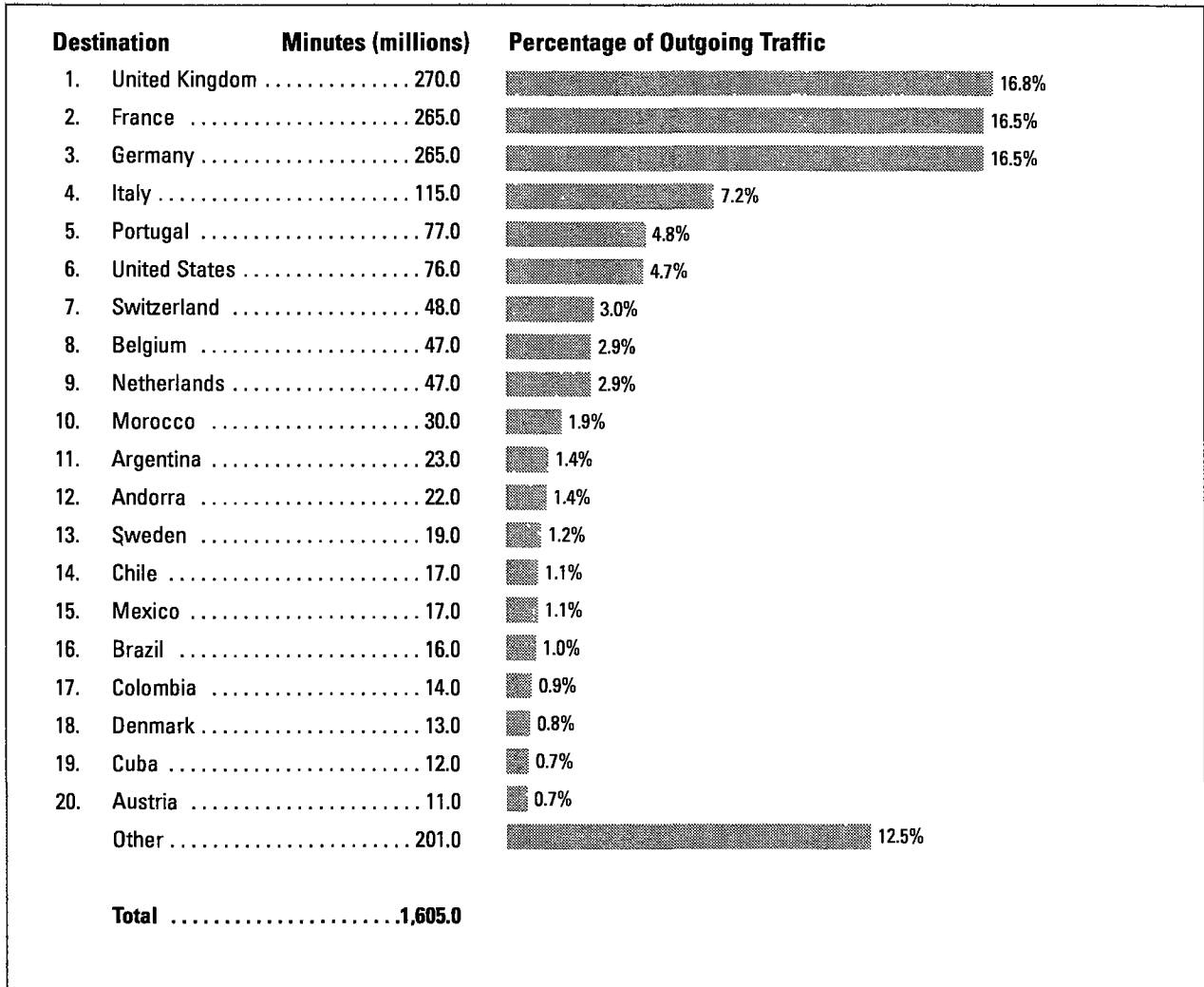
Minutes	1996	1997	1998
Incoming	n.a.	343.2	n.a.
Outgoing	353.0	368.8	405.0
Surplus (Deficit)	n.a.	(25.6)	n.a.
Total Volume	n.a.	712.0	n.a.

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic.

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Spain

Largest Telecommunications Routes, 1998



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National Traffic Balance

Minutes	1996	1997	1998
Incoming	n.a.	n.a.	n.a.
Outgoing	1,189.0	1,319.0	1,605.0
Surplus (Deficit)	n.a.	n.a.	n.a.
Total Volume	n.a.	n.a.	n.a.

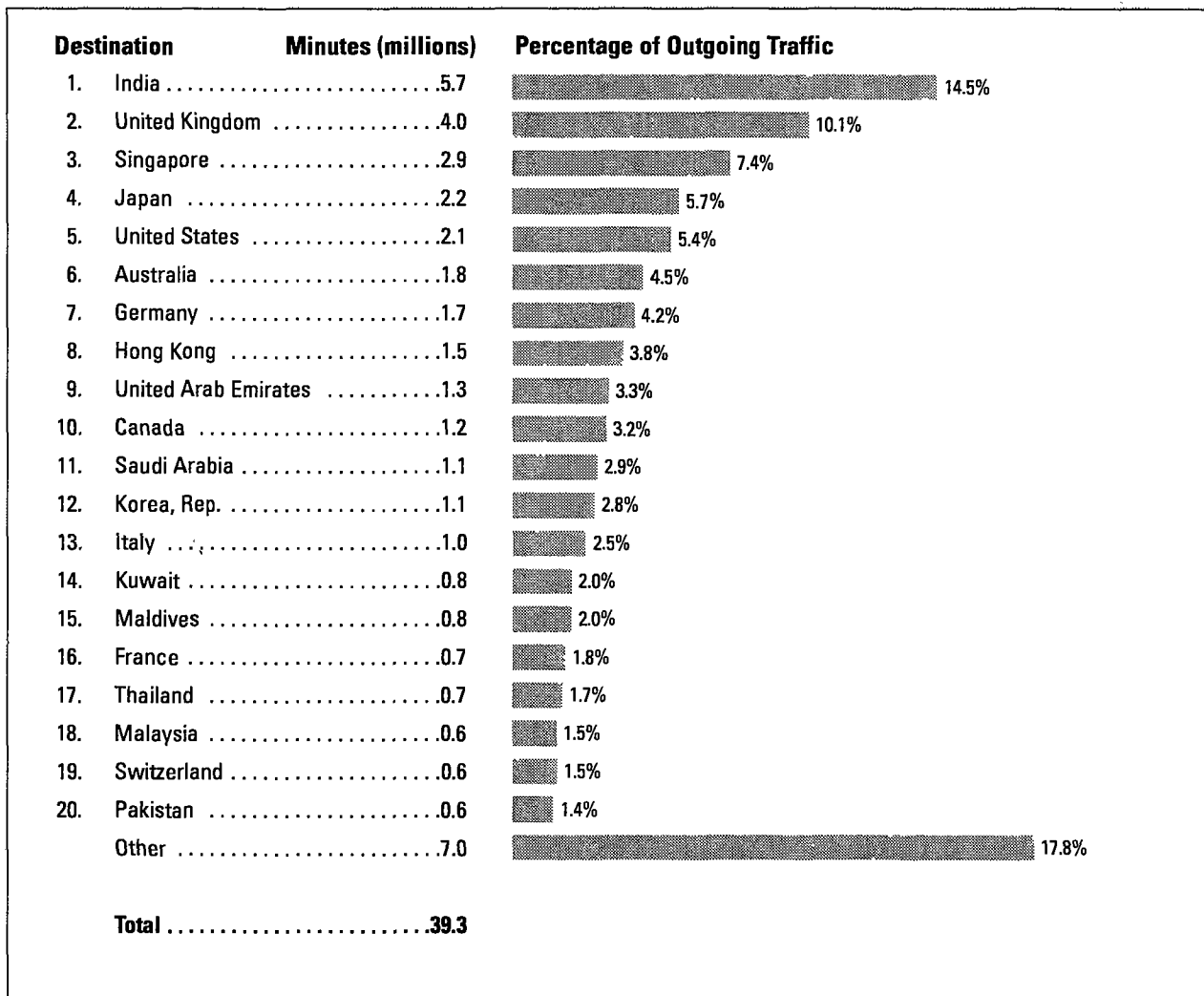
Note: Data are in millions of minutes of outgoing public switched telecommunications traffic. Data based on billing point of traffic.

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Sri Lanka

Largest Telecommunications Routes, 1998



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National Traffic Balance

Minutes	1996	1997	1998
Incoming	96.0	124.3	146.8
Outgoing	29.3	33.2	39.3
Surplus (Deficit)	66.7	91.1	107.5
Total Volume	125.3	157.5	186.1

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic.

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Sudan

Largest Telecommunications Routes, 1998

Destination	Minutes (millions)	Percentage of Outgoing Traffic
1. Saudi Arabia	6.6	35.9%
2. Egypt	1.9	10.1%
3. United Arab Emirates	1.9	10.1%
4. United Kingdom	1.2	6.3%
5. Qatar	0.6	3.5%
6. United States	0.5	2.9%
7. China	0.5	2.8%
8. Jordan	0.3	1.8%
9. Canada	0.3	1.7%
10. Germany	0.3	1.6%
11. Malaysia	0.2	1.3%
12. Netherlands	0.2	1.2%
13. Italy	0.2	1.2%
14. France	0.2	1.2%
15. India	0.2	1.2%
16. Oman	0.2	0.9%
17. Kenya	0.2	0.9%
18. Switzerland	0.2	0.9%
19. Yemen	0.1	0.8%
20. Libya	0.1	0.7%
Other	2.4	13.2%
Total	18.4	

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National Traffic Balance

Minutes	1996	1997	1998
Incoming	30.4	43.2	88.0
Outgoing	12.9	14.8	18.4
Surplus (Deficit)	17.5	28.4	69.6
Total Volume	43.3	58.0	106.4

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic. Data exclude some cross-border traffic to Chad.

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Sweden

Largest Telecommunications Routes, 1998

Destination	Minutes (millions)	Percentage of Outgoing Traffic
1. United Kingdom	185.0	15.4%
2. Finland	160.0	13.3%
3. Norway	150.0	12.4%
4. United States	125.0	10.4%
5. Denmark	120.0	10.0%
6. Germany	110.0	9.1%
7. Poland	65.0	5.4%
8. France	55.0	4.6%
9. Netherlands	40.0	3.3%
10. Switzerland	30.0	2.5%
Other	165.0	13.7%
Total	1,205.0	

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National Traffic Balance

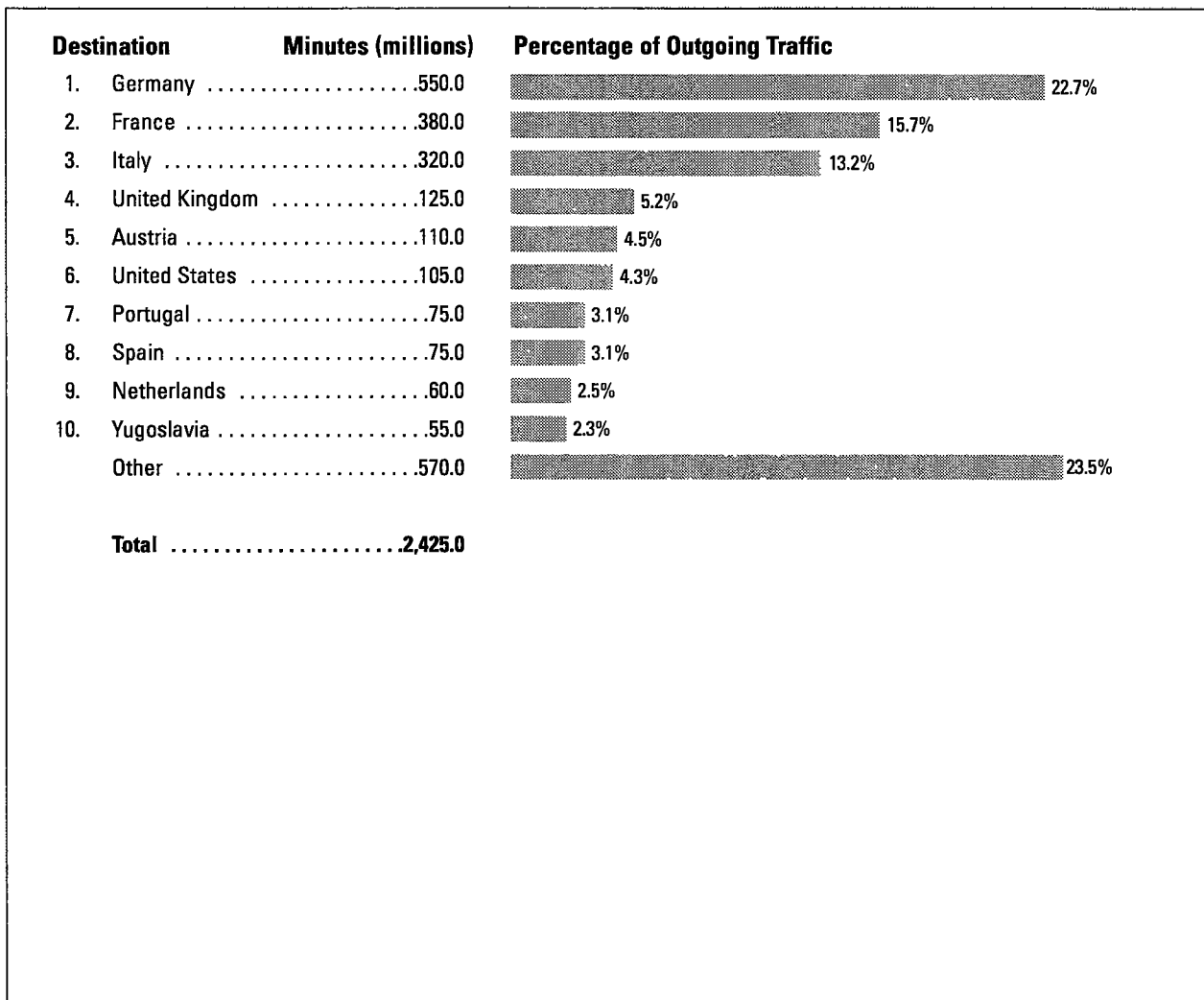
Minutes	1996	1997	1998
Incoming	n.a.	n.a.	n.a.
Outgoing	1,026.0	1,140.0	1,205.0
Surplus (Deficit)	n.a.	n.a.	n.a.
Total Volume	n.a.	n.a.	n.a.

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic. Data based on billing point of traffic.

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Switzerland

Largest Telecommunications Routes, 1998



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National Traffic Balance

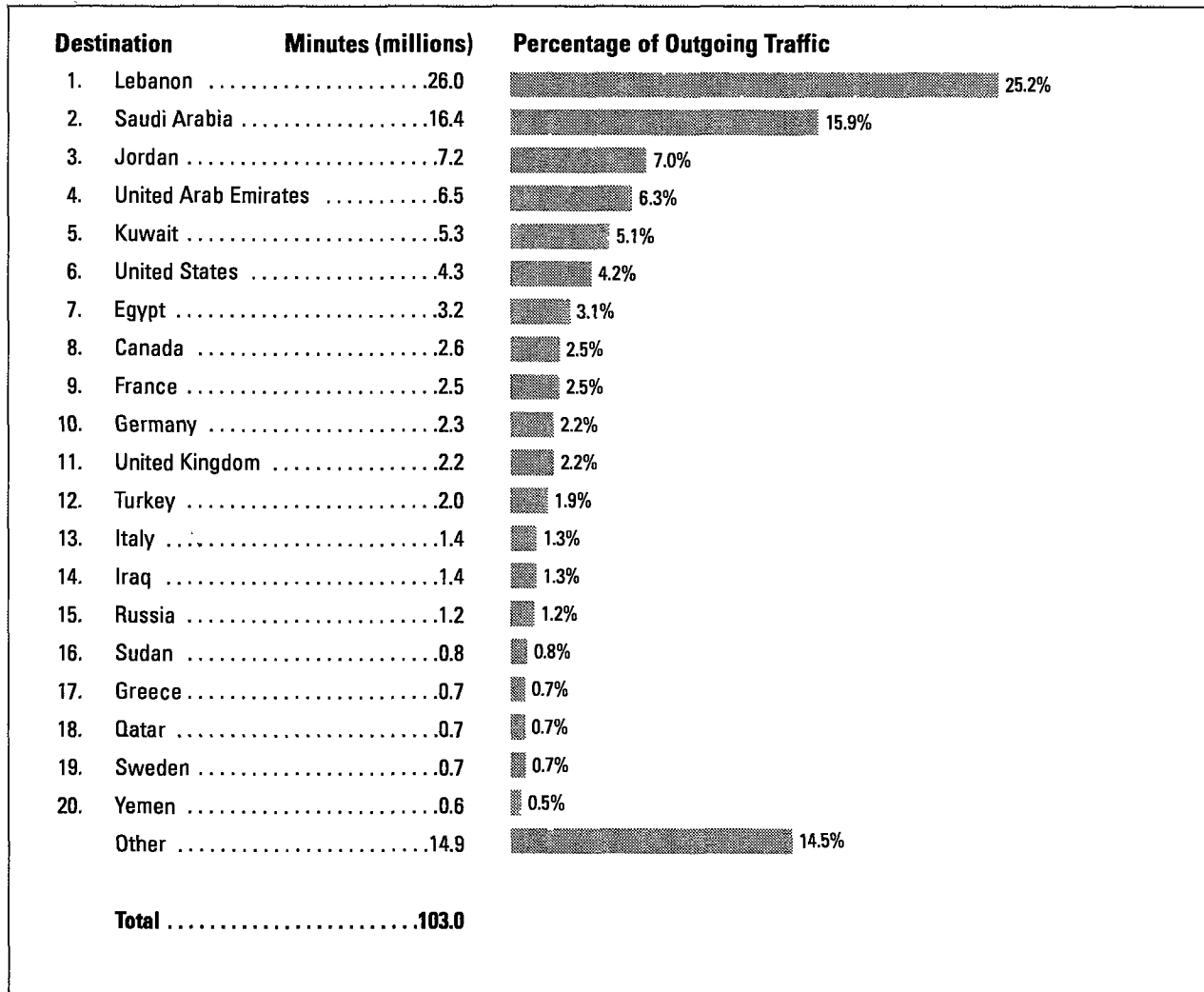
Minutes	1996	1997	1998
Incoming	1,562.8	1,723.0	n.a.
Outgoing	1,935.5	2,164.0	2,425.0
Surplus (Deficit)	(372.7)	(441.0)	n.a.
Total Volume	3,498.3	3,887.0	n.a.

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic.

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Largest Telecommunications Routes, 1998



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National Traffic Balance

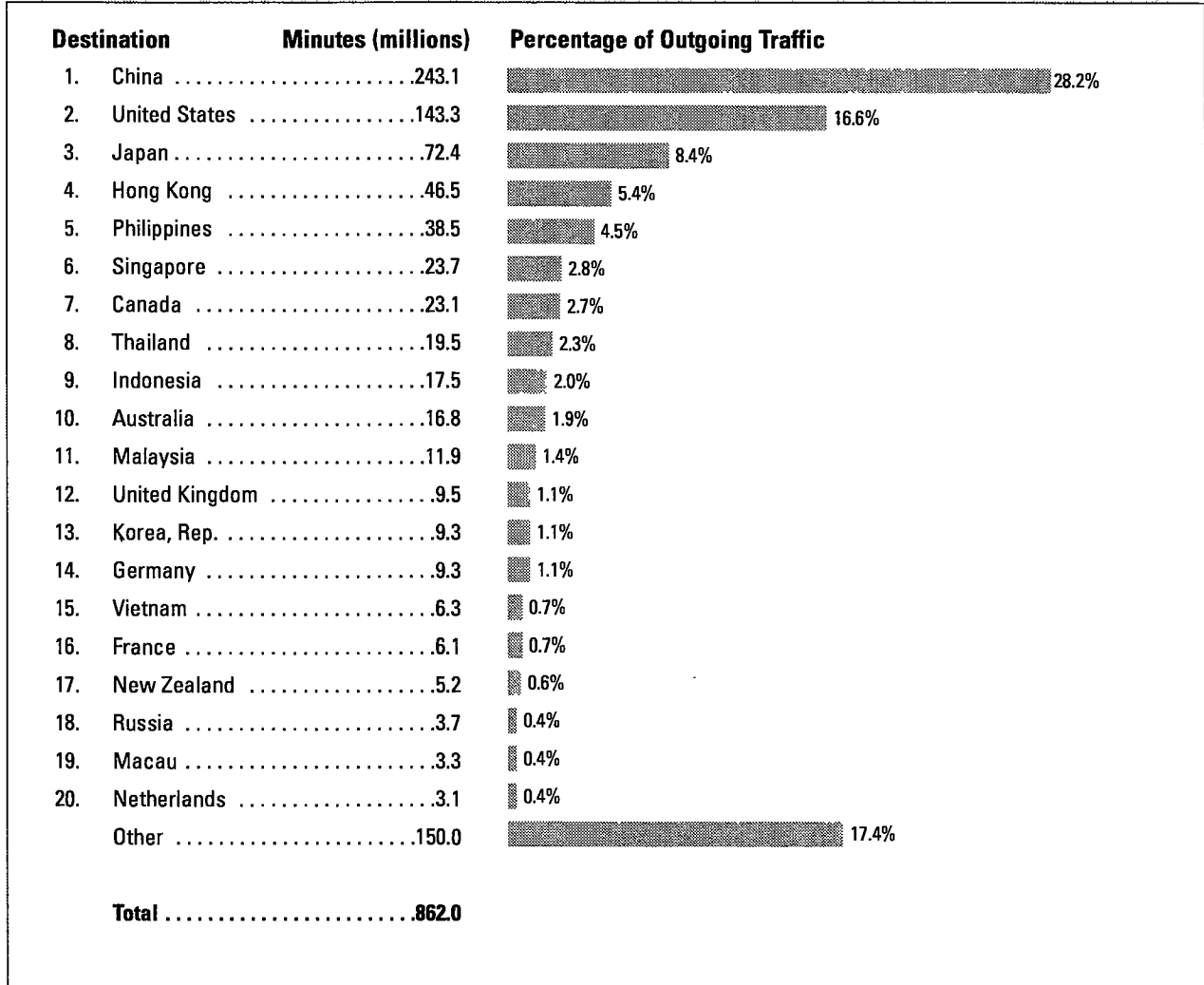
Minutes	1996	1997	1998
Incoming	156.0	173.2	n.a.
Outgoing	78.9	89.3	103.0
Surplus (Deficit)	77.1	83.9	n.a.
Total Volume	234.9	262.5	n.a.

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic. Data based on billing point of traffic.

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Taiwan

Largest Telecommunications Routes, 1998



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National Traffic Balance

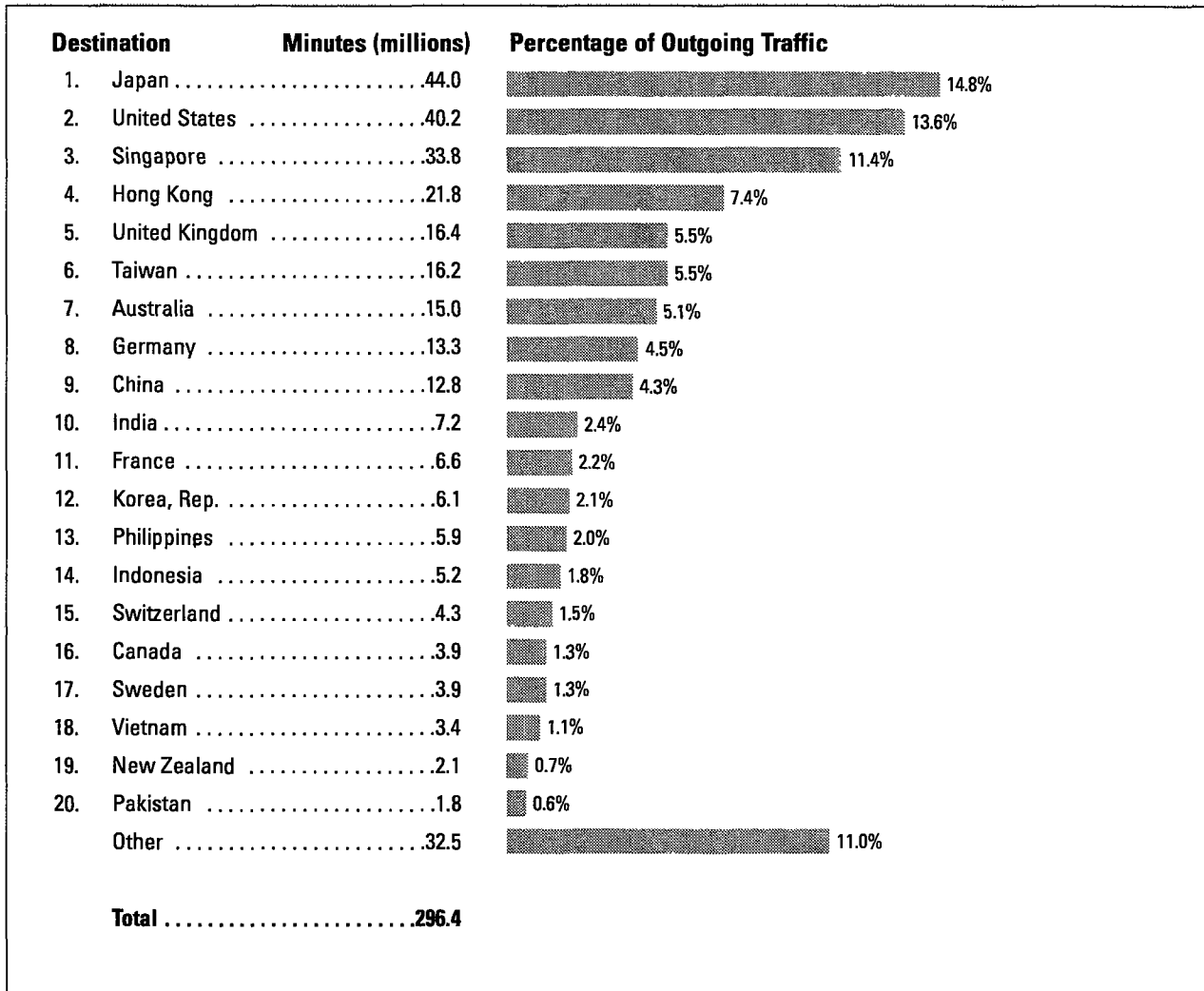
Minutes	FY 1996/97	1997	1998
Incoming	736.8	842.2	781.8
Outgoing	674.0	789.0	862.0
Surplus (Deficit)	62.8	53.2	(80.2)
Total Volume	1,410.8	1,631.2	1,643.9

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic. Data based on billing point of traffic. Data based on calendar year reporting for 1997 and 1998 and fiscal year reporting for FY 1996/97.

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Thailand

Largest Telecommunications Routes, 1998



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National Traffic Balance

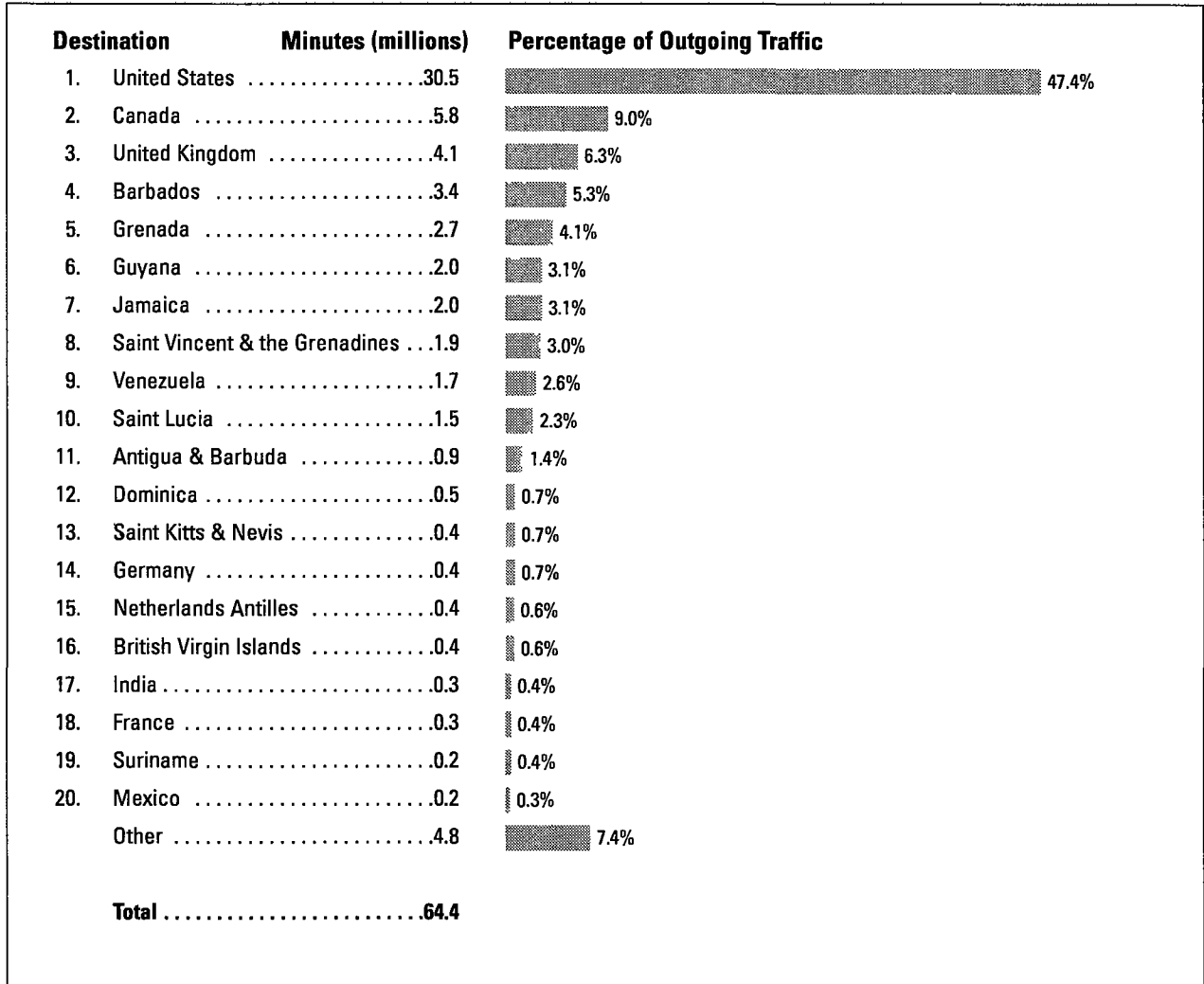
Minutes	1996	1997	1998
Incoming	376.2	408.5	358.6
Outgoing	247.4	278.4	296.4
Surplus (Deficit)	128.8	130.1	62.2
Total Volume	623.6	686.9	655.0

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic. Data based on billing point of traffic. Data exclude some cross-border traffic with Laos, Malaysia, and Myanmar.

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Trinidad & Tobago

Largest Telecommunications Routes, FY 1998/99



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National Traffic Balance

Minutes	FY 1996/97	FY 1997/98	FY 1998/99
Incoming	117.9	130.0	141.5
Outgoing	60.8	62.0	64.4
Surplus (Deficit)	57.1	68.0	77.1
Total Volume	178.7	192.0	206.0

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic. Data based on billing point of traffic. Fiscal year ends 31 March.

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Turkey

Largest Telecommunications Routes, 1998

Destination	Minutes (millions)	Percentage of Outgoing Traffic
1. Germany	186.4	28.9%
2. United Kingdom	48.5	7.5%
3. France	34.3	5.3%
4. Netherlands	28.4	4.4%
5. United States	24.6	3.8%
6. Russia	21.9	3.4%
7. Italy	20.1	3.1%
8. Romania	17.1	2.7%
9. Bulgaria	16.1	2.5%
10. Switzerland	15.4	2.4%
11. Austria	15.2	2.4%
12. Belgium	12.7	2.0%
13. Ukraine	10.1	1.6%
14. Azerbaijan	10.1	1.6%
15. Greece	9.3	1.4%
16. Iran	6.6	1.0%
17. Saudi Arabia	5.6	0.9%
18. Israel	5.6	0.9%
19. Sweden	4.9	0.8%
20. Denmark	4.9	0.8%
Other	146.3	22.7%
Total	644.1	

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National Traffic Balance

Minutes	1996	1997	1998
Incoming	755.0	836.0	955.9
Outgoing	473.4	557.5	644.1
Surplus (Deficit)	281.6	278.5	311.7
Total Volume	1,228.4	1,393.5	1,600.0

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic. Data exclude some cross-border traffic to Iran.

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Ukraine

Largest Telecommunications Routes, 1998

Destination	Minutes (millions)	Percentage of Outgoing Traffic
1. Russia	280.3	60.2%
2. Belarus	26.1	5.6%
3. Moldova	18.6	4.0%
4. Germany	17.0	3.7%
5. Poland	11.1	2.4%
6. Armenia	6.5	1.4%
7. United States	5.7	1.2%
8. Czech Republic	5.3	1.1%
9. Kazakhstan	5.1	1.1%
10. United Kingdom	4.6	1.0%
11. Latvia	4.5	1.0%
12. Azerbaijan	4.3	0.9%
13. Hungary	4.2	0.9%
14. Georgia	4.0	0.9%
15. Italy	4.0	0.9%
16. Uzbekistan	4.0	0.9%
17. Turkey	3.7	0.8%
18. Israel	3.5	0.8%
19. Lithuania	3.3	0.7%
20. Bulgaria	2.7	0.6%
Other	47.3	10.2%
Total	465.9	

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National Traffic Balance

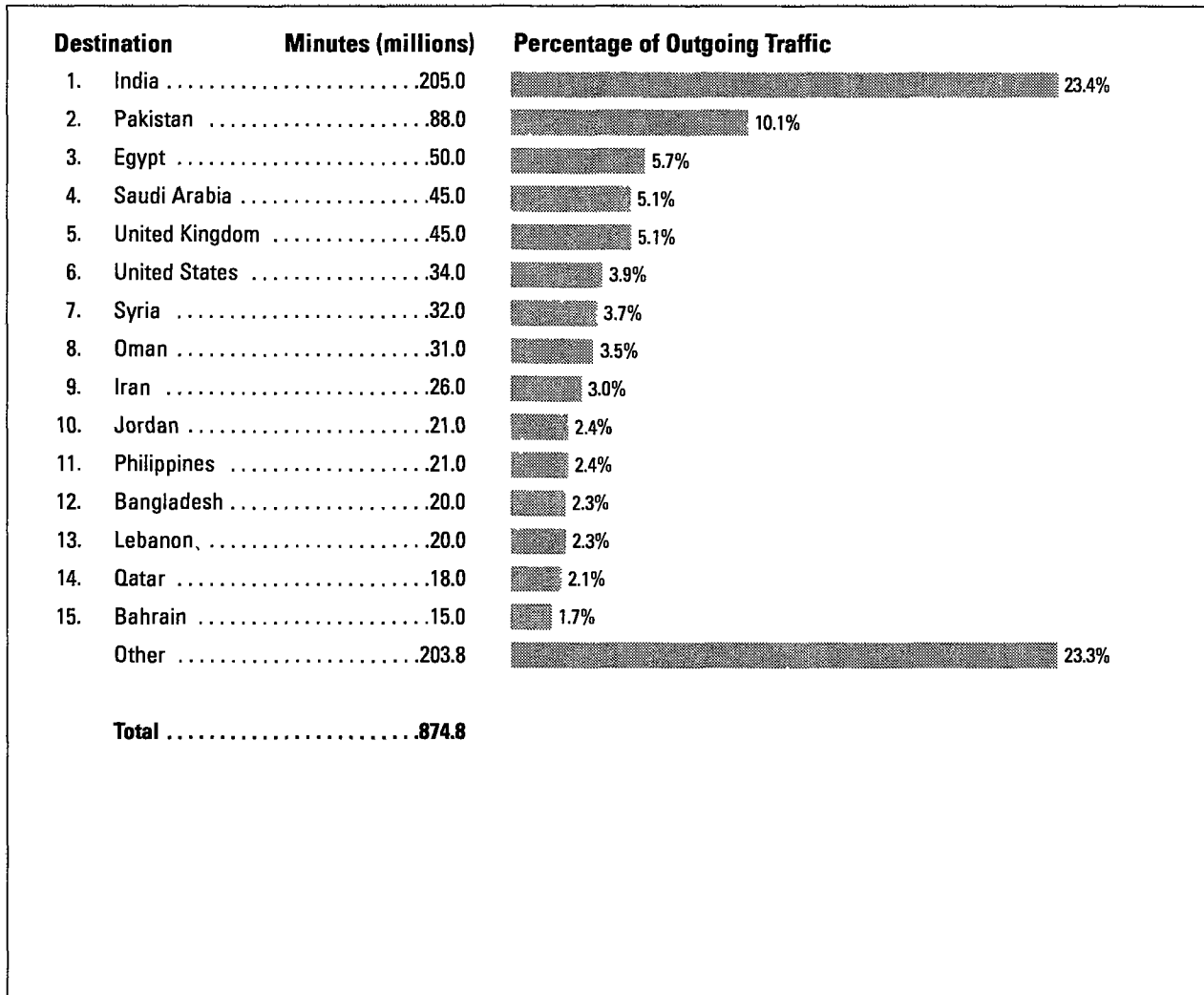
Minutes	1996	1997	1998
Incoming	175.0	n.a.	n.a.
Outgoing	340.8	486.8	465.9
Surplus (Deficit)	(165.8)	n.a.	n.a.
Total Volume	515.8	n.a.	n.a.

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic. Totals for 1996 include only traffic with other members of the Commonwealth of Independent States.

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United Arab Emirates

Largest Telecommunications Routes, 1998



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National Traffic Balance

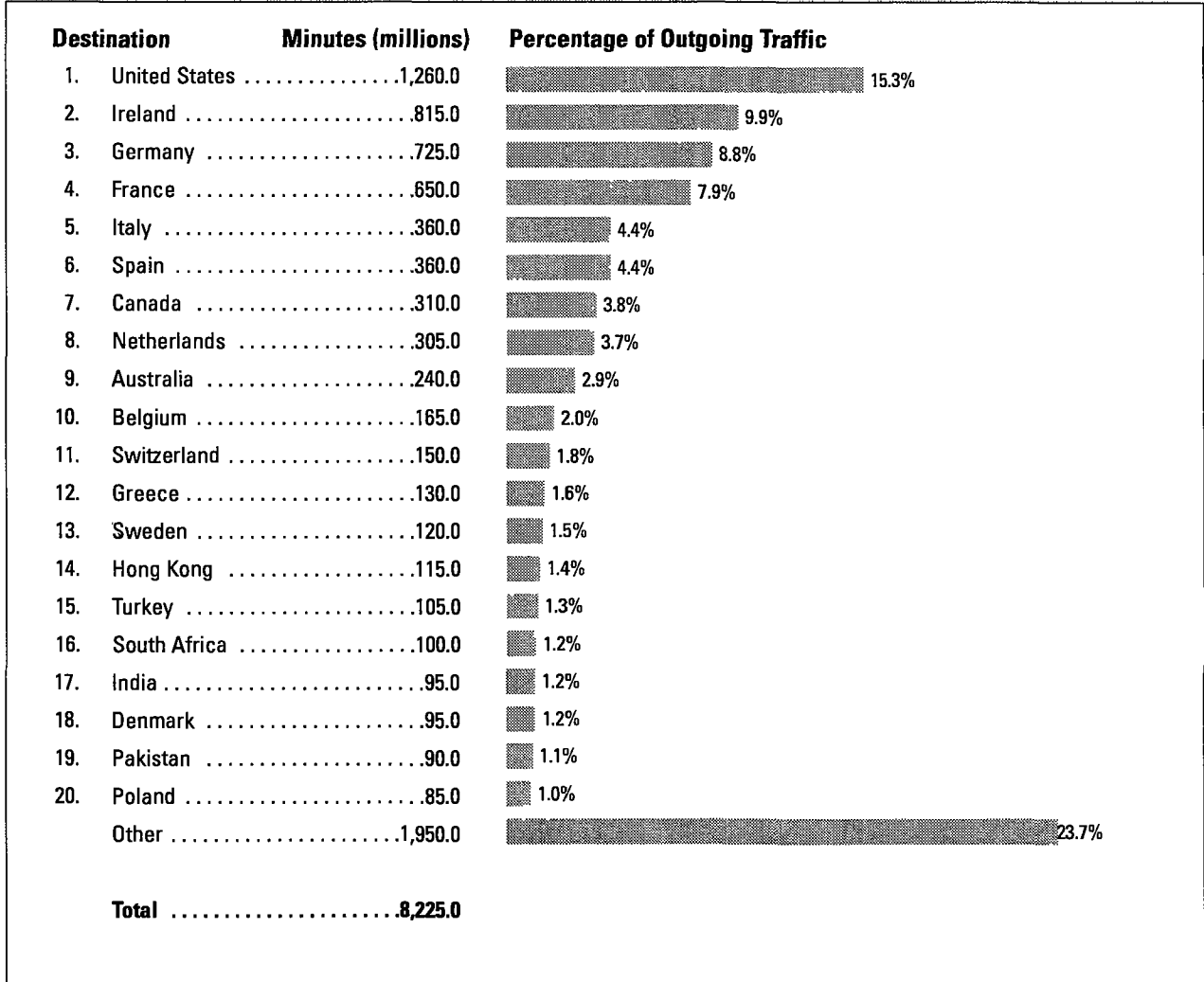
Minutes	1996	1997	1998
Incoming	n.a.	n.a.	n.a.
Outgoing	589.3	738.0	874.8
Surplus (Deficit)	n.a.	n.a.	n.a.
Total Volume	n.a.	n.a.	n.a.

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic.

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United Kingdom—Outgoing

Largest Telecommunications Routes, FY 1998/99



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National Traffic Balance

Minutes	FY 1996/97	FY 1997/98	FY 1998/99
Incoming	4,360.0	n.a.	6,400.0
Outgoing	4,569.2	6,800.0	8,225.0
Surplus (Deficit)	(209.2)	n.a.	(1,825.0)
Total Volume	8,929.2	n.a.	14,625.0

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic. Data based on billing point of traffic. Fiscal year ends 31 March. Data include approximately one billion minutes of traffic refiled via the U.K., thus overstating U.K.-originated volumes. FY 1996/97 totals are for BT and C&W Communications only.

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United Kingdom—Incoming

Largest Telecommunications Routes, FY 1998/99

Destination	Minutes (millions)	Percentage of Outgoing Traffic
1 United States	1,530.0	23.9%
2 Ireland	605.0	9.5%
3 France	485.0	7.6%
4 Germany	400.0	6.3%
5 Spain	270.0	4.2%
6 Australia	240.0	3.8%
7 Canada	230.0	3.6%
8 Netherlands	225.0	3.5%
9 Italy	220.0	3.4%
10 Sweden	185.0	2.9%
11 Belgium	140.0	2.2%
12 Switzerland	125.0	2.0%
13 Greece	100.0	1.6%
14 Denmark	90.0	1.4%
15 Norway	70.0	1.1%
16 South Africa	85.0	1.3%
17 Hong Kong	70.0	1.1%
18 Japan	50.0	0.8%
19 Portugal	50.0	0.8%
20 Turkey	50.0	0.8%
Other	1,180.0	18.4%
Total	6,400.0	

U.K. Top 100 Correspondents



Country	Outgoing		Incoming		Country	Outgoing		Incoming	
	Q3 96/97	Q3 97/98	Q3 96/97	Q3 97/98		Q3 96/97	Q3 97/98	Q3 96/97	Q3 97/98
Albania	n.a.	1.7	n.a.	0.2	Libya	1.6	1.5	1.2	1.4
Algeria	4.8	3.5	2.0	2.1	Lithuania	1.2	1.8	0.2	0.3
Argentina	2.2	2.7	1.2	1.1	Luxembourg	6.0	6.5	3.8	3.9
Australia	55.9	65.3	59.3	67.6	Macedonia	n.a.	1.6	n.a.	0.4
Austria	19.8	25.7	8.4	7.2	Malaysia	6.3	5.8	6.2	3.7
Bahrain	2.3	2.2	3.1	1.6	Mali	n.a.	2.6	n.a.	0.7
Bangladesh	5.6	5.8	0.9	2.3	Malta	3.6	4.0	2.8	3.1
Barbados	2.2	2.3	1.1	1.0	Mauritius	2.8	3.2	1.1	2.1
Belgium	43.8	37.2	32.5	33.3	Mexico	2.7	2.8	1.3	1.3
Brazil	5.8	6.7	4.1	4.1	Monaco	1.7	3.0	1.4	1.9
Bulgaria	2.2	3.8	0.9	0.9	Morocco	9.3	7.3	1.5	2.7
Cameroon	n.a.	1.5	n.a.	0.3	Netherlands	61.9	63.2	49.0	55.7
Canada	42.6	48.8	38.9	53.8	New Zealand	12.1	15.0	12.8	14.2
Chile	2.5	3.6	1.0	0.9	Nigeria	11.9	16.4	3.7	4.9
China	8.4	6.7	3.0	3.6	Norway	17.6	21.6	16.9	21.1
Colombia	2.8	7.0	1.0	1.2	Oman	2.1	1.9	1.5	1.5
Congo, Dem. Rep.	2.1	1.3	0.5	0.7	Pakistan	22.5	23.5	7.1	4.0
Croatia	3.6	3.3	1.5	1.7	Peru	n.a.	1.5	n.a.	0.4
Cuba	n.a.	1.7	n.a.	1.5	Philippines	4.0	5.3	1.6	1.3
Cyprus	9.3	10.9	7.8	7.6	Poland	20.2	28.0	8.0	9.4
Czech Republic	8.9	11.3	4.6	4.5	Portugal	19.4	19.8	11.0	13.1
Denmark	22.1	23.5	15.2	16.6	Qatar	2.2	1.6	1.6	1.7
Ecuador	1.1	1.7	0.2	0.2	Romania	2.9	5.8	1.7	1.8
Egypt	7.2	9.1	2.6	2.9	Russia	19.8	14.7	8.5	3.5
Ethiopia	2.2	1.4	0.4	0.3	Rwanda	n.a.	1.5	n.a.	0.0
Finland	9.2	11.1	7.4	5.4	Saudi Arabia	15.3	7.7	12.5	6.9
France	147.4	135.0	101.4	106.0	Senegal	2.9	1.3	0.2	0.2
Gambia	n.a.	1.7	n.a.	0.3	Singapore	13.0	8.8	6.1	5.2
Germany	151.3	177.9	98.6	81.6	Slovak Republic	3.9	4.9	15.0	2.0
Ghana	5.7	9.2	2.4	2.7	Slovenia	1.3	1.6	0.8	0.9
Gibraltar	2.1	2.4	1.5	1.7	South Africa	29.6	25.5	18.9	21.0
Greece	29.2	31.0	21.7	25.0	Spain	73.4	83.1	52.0	59.0
Hong Kong	25.1	22.4	12.9	7.6	Sri Lanka	4.3	6.5	1.0	1.2
Hungary	8.2	13.2	4.1	4.0	Sweden	26.8	37.2	41.2	38.3
Iceland	1.6	1.7	1.2	1.4	Switzerland	35.6	35.7	27.6	23.7
India	25.6	33.0	11.8	9.4	Syria	2.1	4.3	0.5	0.6
Indonesia	4.2	2.0	3.0	2.0	Taiwan	3.4	3.7	2.3	2.3
Iran	4.0	5.2	2.2	3.1	Tanzania	1.3	2.2	0.5	0.6
Ireland	190.3	197.4	128.5	149.2	Thailand	4.3	5.2	3.8	3.6
Israel	10.1	10.7	4.3	6.4	Trinidad & Tobago	3.7	2.0	1.6	1.2
Italy	81.4	90.7	46.7	43.8	Tunisia	3.9	3.9	0.7	0.9
Jamaica	6.7	6.5	1.3	1.3	Turkey	24.0	30.0	10.1	12.6
Japan	19.4	20.4	12.8	11.5	UAE	9.5	11.1	11.5	9.4
Jordan	3.4	3.9	1.0	1.5	Uganda	n.a.	1.8	n.a.	0.6
Kazakhstan	n.a.	1.8	n.a.	0.6	Ukraine	3.2	8.6	1.1	1.3
Kenya	3.7	4.4	1.6	1.8	United States	264.0	323.0	332.8	344.0
Korea, Rep.	4.8	2.5	3.7	2.7	Vietnam	7.5	5.0	0.9	4.3
Kuwait	4.1	4.4	2.0	2.1	Yemen	2.3	1.7	0.3	1.3
Latvia	2.0	4.0	0.8	0.5	Yugoslavia	2.8	4.9	1.3	1.3
Lebanon	4.4	4.4	0.6	1.6	Zimbabwe	2.4	1.9	2.2	2.6






















Note: Data are millions of minutes of public switched traffic for the largest U.K. international carriers during the third quarters (October-December) of FY 1997/98 and FY 1998/99. Route data may include some calls refiled via the U.K., thus overstating actual U.K.-originated traffic.

Source: Office of Telecommunications (OFTEL)

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United States—Outgoing

Largest Telecommunications Routes, 1998

Destination	Minutes (millions)	Percentage of Outgoing Traffic
1. Canada	3,988.0	 16.0%
2. Mexico	3,117.6	 12.5%
3. United Kingdom	1,531.4	 6.1%
4. Germany	1,194.2	 4.8%
5. Japan	833.3	 3.3%
6. India	772.9	 3.1%
7. Hong Kong	635.6	 2.5%
8. Brazil	592.3	 2.4%
9. France	580.2	 2.3%
10. Philippines	573.1	 2.3%
11. Italy	532.2	 2.1%
12. Australia	459.7	 1.8%
13. Dominican Republic	452.9	 1.8%
14. China	434.5	 1.7%
15. Korea, Rep.	397.3	 1.6%
16. Taiwan	327.9	 1.3%
17. Jamaica	282.1	 1.1%
18. Netherlands	273.2	 1.1%
19. Venezuela	231.1	 0.9%
20. Spain	230.9	 0.9%
Other	7,508.8	 30.1%
Total	24,949.3	

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National Traffic Balance

Minutes	1996	1997	1998
Incoming	8,194.9	9,213.3	10,598.8
Outgoing	19,119.1	23,001.7	24,949.3
Surplus (Deficit)	(10,924.2)	(13,788.4)	(14,350.5)
Total Volume	27,314.0	32,215.0	35,548.1

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic. Data based on billing point of traffic. Data include include one to two billion minutes of traffic refiled via the U.S., thus overstating traffic originating from the U.S. Carriers and traffic from points beyond the United States, Puerto Rico, and the U.S. Virgin Islands are excluded.


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United States—Incoming



Largest Telecommunications Routes, 1998

Destination	Minutes (millions)	Percentage of Outgoing Traffic
Canada	3,400.8	32.1%
United Kingdom	1,261.4	11.9%
Mexico	1,095.4	10.3%
Germany	394.7	3.7%
Japan	336.4	3.2%
France	289.1	2.7%
Australia	242.1	2.3%
Korea, Rep.	231.5	2.2%
Sweden	216.6	2.0%
Israel	180.3	1.7%
Italy	170.7	1.6%
Brazil	169.6	1.6%
Dominican Republic	154.2	1.5%
Taiwan	152.9	1.4%
Netherlands	122.2	1.2%
Switzerland	102.1	1.0%
Chile	81.1	0.8%
China	79.4	0.7%
Ireland	77.7	0.7%
Spain	76.0	0.7%
Other	1,764.5	16.6%
Total	10,598.8	



U.S. Top 100 Correspondents

Country	Outgoing Minutes		Incoming Minutes		Country	Outgoing Minutes		Incoming Minutes	
	1997	1998	1997	1998		1997	1998	1997	1998
Antigua & Barbuda	52.6	66.9	6.7	7.1	Jamaica	262.6	282.1	50.2	51.9
Argentina	228.1	220.8	38.8	46.1	Japan	830.5	833.3	339.4	336.4
Aruba	16.8	25.6	6.6	5.7	Jordan	57.1	51.0	5.4	6.8
Australia	383.5	459.7	123.5	242.1	Kenya	24.2	24.3	3.5	4.1
Austria	58.8	74.3	24.9	26.1	Korea, Rep.	421.9	397.3	203.5	231.5
Bahamas	66.4	81.6	46.5	49.7	Kuwait	48.3	46.3	8.8	8.8
Bangladesh	59.0	51.9	4.5	4.7	Lebanon	38.6	56.6	4.4	11.2
Barbados	38.4	46.2	12.8	12.6	Luxembourg	10.9	15.4	6.2	6.9
Belgium	120.7	116.1	49.7	49.7	Malaysia	83.4	101.5	26.4	25.2
Belize	14.5	15.3	4.2	5.0	Mexico	2,757.6	3,117.6	946.5	1,095.4
Bermuda	38.7	42.7	29.9	30.0	Morocco	13.8	57.2	5.8	6.4
Bolivia	34.5	49.3	3.6	5.8	Netherlands	222.3	273.2	105.8	122.2
Brazil	497.3	592.3	159.6	169.6	Netherlands Antilles	42.3	61.7	8.1	7.2
Bulgaria	12.2	14.5	1.3	1.6	New Zealand	107.8	84.8	40.6	64.8
Canada	3,926.6	3,988.0	3,173.3	3,400.8	Nicaragua	50.3	62.7	6.1	8.2
Cayman Islands	21.9	26.2	12.1	14.2	Nigeria	101.8	158.9	8.7	17.4
Chile	115.5	125.8	75.1	81.1	Norway	66.5	89.0	52.5	42.2
China	388.1	434.5	61.7	79.4	Pakistan	162.9	210.9	10.5	15.6
Colombia	260.5	218.0	68.7	51.2	Panama	68.2	68.5	19.3	18.9
Congo, Dem. Rep.	8.0	19.2	2.0	0.2	Paraguay	10.4	15.4	3.3	3.7
Costa Rica	75.3	73.2	26.4	26.6	Peru	164.9	182.9	24.5	31.4
Côte d'Ivoire	14.8	16.3	4.4	3.4	Philippines	417.2	573.1	32.2	50.8
Croatia	22.5	23.9	6.0	5.1	Poland	170.9	189.6	27.3	27.8
Cuba	118.9	143.4	1.2	1.2	Portugal	54.8	71.6	15.1	23.1
Czech Republic	26.9	30.3	9.2	9.9	Romania	28.9	74.9	5.2	31.5
Denmark	75.3	75.0	27.9	26.5	Russia	102.9	154.9	32.9	22.0
Dominica	16.4	29.1	1.9	2.1	Saint Lucia	14.7	19.5	3.2	3.5
Dominican Republic	392.1	452.9	95.6	154.2	Saint Vincent	16.7	14.9	1.7	2.0
Ecuador	156.7	112.2	17.8	13.6	Saudi Arabia	111.4	108.1	32.1	36.9
Egypt	111.2	111.5	10.7	11.7	Senegal	18.9	19.5	1.7	2.0
El Salvador	154.6	198.1	12.8	16.0	Sierra Leone	11.3	41.6	1.2	1.2
Ethiopia	18.0	21.4	1.6	1.8	Singapore	197.8	168.8	63.5	65.8
Finland	29.4	30.6	17.8	14.1	South Africa	110.6	129.8	31.2	36.5
France	500.0	580.2	216.6	289.1	Spain	190.8	230.9	88.1	76.0
Germany	994.3	1,194.2	324.6	394.7	Sri Lanka	16.2	20.0	2.0	3.1
Ghana	50.0	44.0	5.2	8.0	Sweden	140.0	149.1	100.6	216.6
Greece	97.4	115.7	35.0	42.8	Switzerland	225.8	196.4	108.1	102.1
Grenada	16.9	63.5	2.4	2.3	Syria	15.2	15.5	2.9	4.1
Guatemala	126.1	144.9	15.5	31.2	Taiwan	379.1	327.9	174.3	152.9
Guyana	59.7	46.6	12.5	7.8	Thailand	117.7	120.7	26.2	32.2
Haiti	92.2	99.7	5.1	7.1	Trinidad & Tobago	94.4	108.3	26.2	31.5
Honduras	111.1	149.1	11.5	13.4	Turkey	62.0	105.4	28.3	42.7
Hong Kong	673.2	635.6	82.4	68.2	Ukraine	44.4	43.5	6.9	6.3
Hungary	41.0	37.7	15.2	13.4	United Arab Emirates	52.3	59.7	28.4	32.2
India	579.4	772.9	49.7	58.5	United Kingdom	1,532.6	1,531.4	950.2	1,261.4
Indonesia	119.2	99.8	28.1	28.6	Uruguay	26.2	33.6	7.5	8.2
Iran	46.0	63.7	16.0	17.7	Venezuela	219.8	231.1	63.9	60.2
Ireland	134.8	163.8	49.0	77.7	Vietnam	157.0	190.4	4.0	4.5
Israel	216.5	223.2	161.7	180.3	Yemen	23.9	28.5	1.2	1.3
Italy	475.6	532.2	121.9	170.7	Yugoslavia	15.7	33.9	5.5	8.4

Note: All data are millions of minutes of public switched and International Simple Resale (ISR) traffic. Because data are based on the billing point of the traffic, route data may not exactly correspond with traffic volumes as measured by the originating point of traffic (see Methodology on page 271). Carriers and traffic from outside the U.S. states, Puerto Rico, and the U.S. Virgin Islands (e.g., Guam) are excluded.

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Uruguay

Largest Telecommunications Routes, 1998

Destination	Minutes (millions)	Percentage of Outgoing Traffic
1. Argentina	40.6	51.9%
2. Brazil	10.5	13.4%
3. United States	7.5	9.6%
4. Spain	3.2	4.1%
5. Chile	2.0	2.6%
6. Paraguay	1.7	2.2%
7. Italy	1.5	1.9%
8. France	0.9	1.1%
9. Germany	0.8	1.0%
10. Mexico	0.8	1.0%
11. Canada	0.7	0.9%
12. Venezuela	0.7	0.9%
13. United Kingdom	0.6	0.8%
14. Peru	0.5	0.6%
15. Australia	0.4	0.5%
16. Colombia	0.4	0.5%
17. Switzerland	0.4	0.5%
18. Bolivia	0.3	0.4%
19. Netherlands	0.3	0.4%
20. Sweden	0.2	0.3%
Other	4.3	5.5%
Total	78.3	

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National Traffic Balance

Minutes	1996	1997	1998
Incoming	80.1	93.7	97.0
Outgoing	54.5	68.4	78.3
Surplus (Deficit)	25.6	25.3	18.7
Total Volume	134.6	162.1	175.3

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic.

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Uzbekistan

Largest Telecommunications Routes, 1998

Destination	Minutes (millions)	Percentage of Outgoing Traffic
1. Russia	32.3	35.2%
2. Kazakhstan	18.5	20.1%
3. Kyrgyzstan	6.7	7.3%
4. Tajikistan	4.8	5.2%
5. Ukraine	4.0	4.4%
6. Turkmenistan	3.0	3.2%
7. Germany	1.6	1.7%
8. United States	1.5	1.6%
9. Belarus	1.2	1.3%
10. China	1.1	1.2%
11. Korea, Rep.	0.9	0.9%
12. United Kingdom	0.8	0.9%
13. Armenia	0.7	0.8%
14. Azerbaijan	0.7	0.8%
15. France	0.5	0.5%
16. Georgia	0.4	0.5%
17. Japan	0.4	0.4%
18. Italy	0.4	0.4%
19. Switzerland	0.3	0.3%
20. Moldova	0.2	0.3%
Other	11.9	13.0%
Total	91.7	

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National Traffic Balance

Minutes	1996	1997	1998
Incoming	n.a.	n.a.	74.7
Outgoing	54.2	63.1	91.7
Surplus (Deficit)	n.a.	n.a.	(17.0)
Total Volume	n.a.	n.a.	166.5

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic. Totals for 1996 include only traffic with other members of the Commonwealth of Independent States.

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Venezuela

Largest Telecommunications Routes, 1998

Destination	Minutes (millions)	Percentage of Outgoing Traffic
1. United States	74.5	45.3%
2. Colombia	15.8	9.6%
3. Canada	12.9	7.8%
4. Spain	9.4	5.7%
5. Italy	7.6	4.6%
6. United Kingdom	6.2	3.7%
7. Peru	4.1	2.5%
8. Mexico	3.4	2.0%
9. Trinidad & Tobago	3.0	1.8%
10. Argentina	3.0	1.8%
11. Ecuador	2.6	1.6%
12. Brazil	2.5	1.5%
13. Portugal	2.5	1.5%
14. France	2.4	1.5%
15. Dominican Republic	2.1	1.2%
16. Chile	1.8	1.1%
17. Germany	1.4	0.9%
18. Cuba	1.3	0.8%
19. Panama	1.1	0.7%
20. Sweden	0.2	0.1%
Other	6.9	4.2%
Total	164.5	

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National Traffic Balance

Minutes	1996	1997	1998
Incoming	228.8	286.9	298.1
Outgoing	139.0	159.2	164.5
Surplus (Deficit)	89.8	127.7	133.6
Total Volume	367.8	446.1	462.6

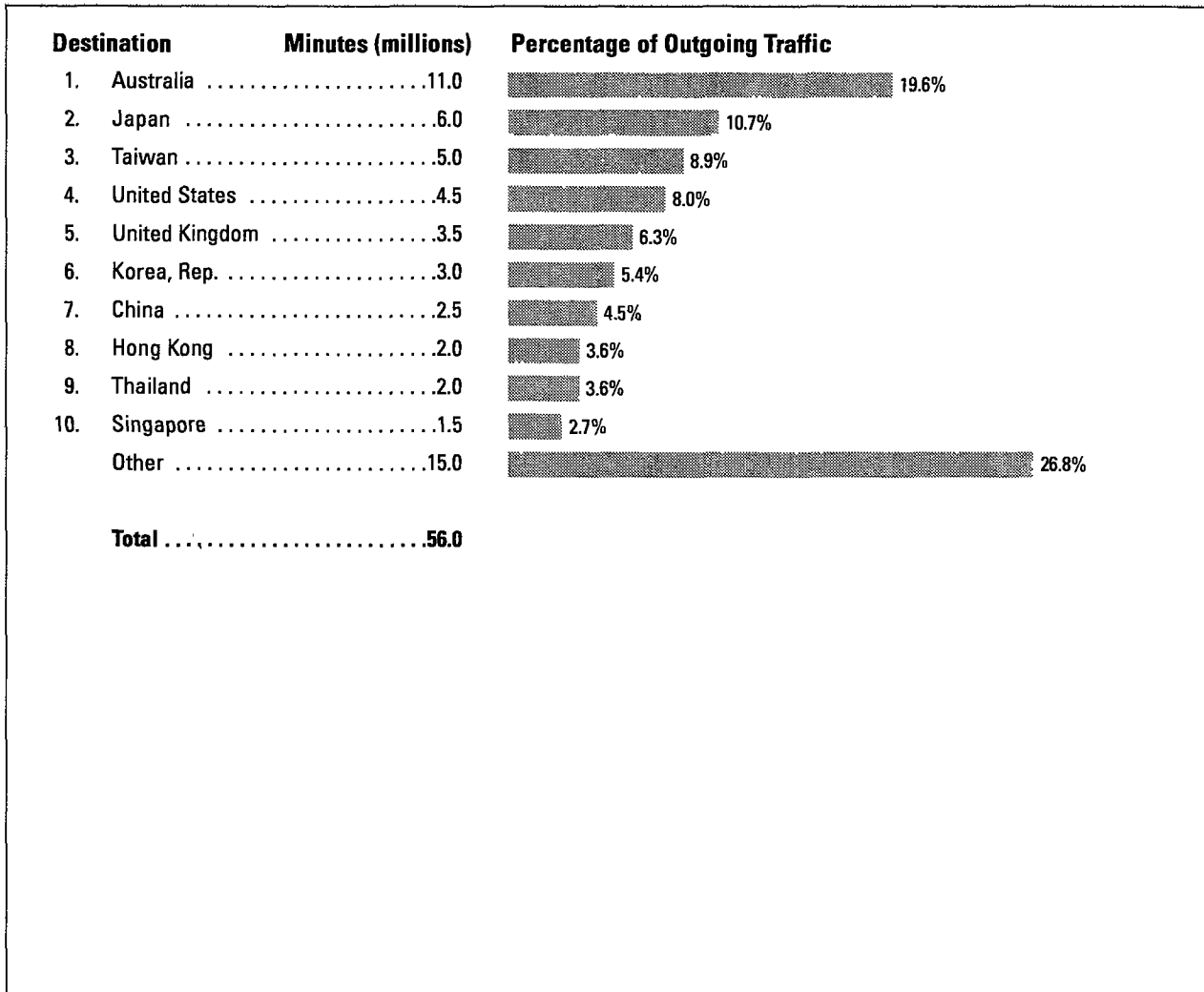
Note: Data are in millions of minutes of outgoing public switched telecommunications traffic. Data based on billing point of traffic.

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Vietnam

Largest Telecommunications Routes, 1998



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National Traffic Balance

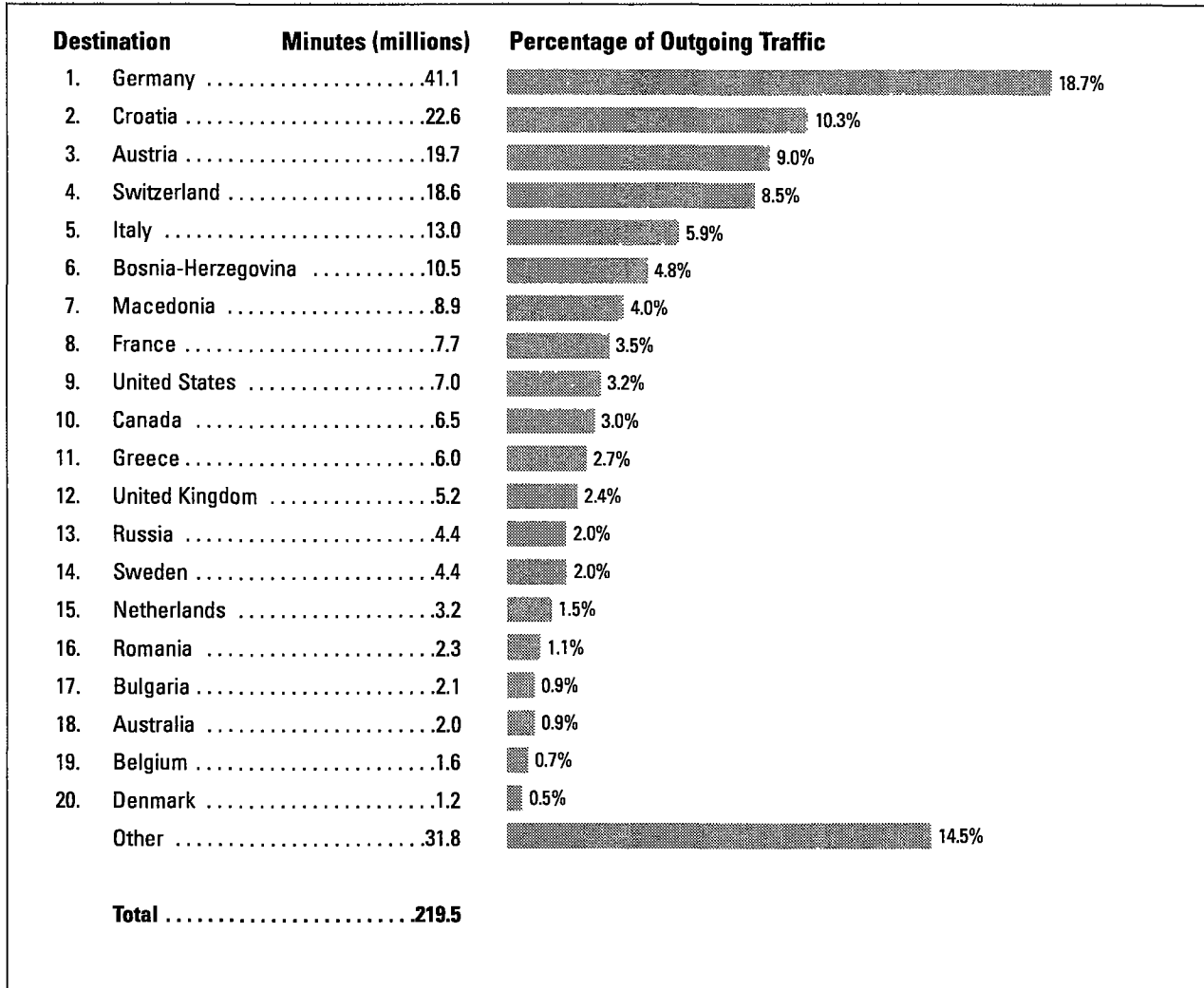
Minutes	1996	1997	1998
Incoming	n.a.	294.6	334.0
Outgoing	52.4	50.2	56.0
Surplus (Deficit)	n.a.	244.4	278.0
Total Volume	n.a.	344.8	390.0

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic.

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Yugoslavia

Largest Telecommunications Routes, 1998



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National Traffic Balance

Minutes	1996	1997	1998
Incoming	325.7	332.0	423.3
Outgoing	237.2	217.0	219.5
Surplus (Deficit)	88.5	115.0	203.8
Total Volume	562.9	549.0	642.9

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic. Data based on billing point of traffic.

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Zimbabwe

Largest Telecommunications Routes, 1998

Destination	Minutes (millions)	Percentage of Outgoing Traffic
1. South Africa	22.5	42.6%
2. United Kingdom	4.1	7.9%
3. United States	3.1	5.8%
4. Botswana	2.7	5.0%
5. Germany	0.8	1.5%
6. India	0.7	1.3%
7. Australia	0.7	1.2%
8. Kenya	0.7	1.2%
9. France	0.6	1.1%
10. Netherlands	0.5	1.0%
11. Namibia	0.4	0.8%
12. Switzerland	0.4	0.8%
13. Canada	0.4	0.8%
14. Belgium	0.4	0.7%
15. Italy	0.3	0.7%
16. Japan	0.3	0.7%
17. Mauritius	0.3	0.6%
18. Denmark	0.3	0.6%
19. Sweden	0.3	0.5%
20. Tanzania	0.3	0.5%
Other	13.0	24.7%
Total	52.8	

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National Traffic Balance

Minutes	1996	1997	1998
Incoming	n.a.	n.a.	53.2
Outgoing	48.9	n.a.	52.8
Surplus (Deficit)	n.a.	n.a.	0.4
Total Volume	n.a.	n.a.	106.0

Note: Data are in millions of minutes of outgoing public switched telecommunications traffic.

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Methodology

The traffic statistics in *TeleGeography 2000* were compiled primarily from an independent survey of telecommunications service providers by TeleGeography, Inc. (TGI). For some countries and carriers, traffic data have been estimated based upon annual reports, government publications, and industry interviews. See the footnotes to each table for further information. The *Direction of Traffic 1999* publication, jointly compiled by TGI and the International Telecommunication Union (ITU), was also consulted.

To enable comparisons of countries' international traffic statistics, TGI has endeavored to apply a consistent methodology. When reviewing the traffic statistics in *TeleGeography 2000*, however, readers should keep in mind the following issues:

Public Switched Network vs. Private Line Traffic

Traffic volumes in *TeleGeography 2000* are generally reported in minutes. In most cases, the statistics refer to paid minutes of traffic on public switched circuits and thus include voice as well as fax traffic.

Traffic carried by International Simple Resale (ISR) carriers is also included. ISR carriers resell the capacity of international private lines (IPLs) for switched services by interconnecting their IPLs to the public switched network at one or both ends.

Traffic carried by "pure" resellers of international switched voice services is included in this report. These resellers do not own or lease their own international transmission facilities. Instead, they resell the traffic of other carriers; thus, pure resale traffic is counted as part of the minutes for the facilities-based carrier whose services are resold.

Internet Traffic

Statistics do not include traffic carried on the public Internet. Traffic volumes also exclude minutes sent over private lines using Internet Protocol (IP). For an overview of Voice over IP traffic volumes, see "VoIP Traffic and Settlements."

Cross-Border Traffic

Neighboring countries may not classify local cross border traffic in the same way. That is, one country may treat some cross-border traffic as domestic, while its neighbor counts all such traffic as international.

Billing Point vs. Originating Point of Traffic

Unless otherwise stated in the notes to a table, the outbound minutes reported for countries in *TeleGeography 2000* refer to outbound traffic originated in the reporting country even if it is billed in another country.

In the past, most international calls were billed at the point of origination. The number of billed minutes thus coincided with the volume of outgoing traffic. Billed minutes also included collect or reverse charge calls because the calls were set up by an operator in the originating country. However, the recent use of calling card and call-back services has shifted the billing point for many international calls. For example, calls from Italy to the United States (or a third country, such as Argentina) may now be set up and billed in the U.S.

Some countries, including the U.S., report international traffic data based solely on the location where the traffic is billed. Consequently, "outbound" traffic data for these countries can include traffic actually originating in another. Thus, incoming minutes reported for one country may not match the outgoing traffic on the same route by the correspondent country. Some double counting may also occur. For example, a call from Thailand to the U.S. which is billed to a U.S. calling card is reported by the U.S. carrier as outbound U.S. traffic; the same call also is reported as outbound minutes by Thailand.

Accordingly, in countries where calling card and call-back services are widely used, a year-to-year comparison of national traffic also requires examining the statistics of countries, such as the U.S. and the U.K., where the calls are hubbed.

Transit Traffic

Unless otherwise stated, *TeleGeography 2000* excludes refile traffic from the totals of countries acting as transit hubs. Notable exceptions include the U.K. and U.S. statistics, which do include some traffic reoriginated from other countries.

Fixed vs. Mobile Traffic

Traffic volumes include international calls originated and terminated on both fixed and mobile networks.

Rounding

Rounding may cause the figures on total national incoming and outgoing traffic to appear inconsistent with other national data.

Revised Data

Some differences exist between the historical statistics (1997 or earlier) reported in *TeleGeography 2000* and data stated in prior TGI reports or *Direction of Traffic*. The variations reflect corrections and/or revised data subsequently provided to TGI.

Global Reference: Blue Pages

National Telecommunications Indicators (A-L)

Country	GDP 1998 (US\$ billions)	Population 1998 (millions)	Main Lines 1998 (thous.)	Lines Per 100 people	Cellular Users 1998 (thous.)	International Carriers 1999	Internet Hosts 1999 (thous.)
Albania (a, c)	3.0	3.1	116	3.7	6	1	n.a.
Algeria (c)	48.4	30.1	1,600	5.3	19	1	n.a.
Andorra	n.a.	0.1	33	44.1	14	1	n.a.
Angola	6.6	12.1	72	0.6	10	1	n.a.
Argentina	344.4	36.1	7,323	20.3	2,822	2	114
Armenia	1.9	3.5	556	15.7	7	1	n.a.
Aruba	n.a.	0.1	33	35.3	8	1	n.a.
Australia (b)	364.2	18.7	9,580	51.2	5,392	28	1,037
Austria (c)	212.1	8.1	3,999	49.1	2,030	17	229
Azerbaijan (a, c)	3.9	7.7	680	8.9	65	1	n.a.
Bahamas	n.a.	0.3	104	35.2	8	1	n.a.
Bahrain (a)	5.3	0.6	158	24.6	92	1	n.a.
Bangladesh	42.8	124.8	n.a.	n.a.	n.a.	1	n.a.
Belarus (a, c)	n.a.	10.3	2,490	24.1	12	1	n.a.
Belgium (a)	247.1	10.1	5,073	50.0	1,748	18	302
Bolivia	8.6	8.0	535	6.7	218	1	n.a.
Bosnia-Herzegovina (c)	n.a.	3.7	332	9.0	25	3	n.a.
Brazil (a)	778.3	165.9	19,987	12.0	7,761	2	302
Bulgaria	12.3	8.3	2,742	32.9	127	1	n.a.
Canada (a)	598.8	30.3	19,241	63.5	5,320	49	2,346
Chile	78.0	14.8	2,977	20.0	956	10	54
China	960.9	1255.7	87,421	7.0	23,863	1	43
Costa Rica (a)	91.1	3.8	660	17.2	109	1	n.a.
Côte d'Ivoire	11.0	14.3	170	1.2	91	1	n.a.
Cyprus (a, c)	n.a.	0.7	405	58.5	116	1	n.a.
Czech Republic (a)	56.4	10.3	3,741	36.4	965	1	108
Denmark (a)	15.5	5.3	3,496	66.0	1,931	18	317
Dominican Republic	56.4	8.2	764	9.3	256	3	n.a.
Egypt	174.3	66.0	3,972	6.0	91	1	n.a.
El Salvador	15.5	5.9	360	6.0	106	10	n.a.
Estonia (a)	5.5	1.5	499	34.3	247	1	26
Finland	n.a.	5.2	2,855	55.4	2,933	8	634
France	1,432.9	59.7	34,000	57.0	11,210	50	778
Germany (a)	2,142.0	82.1	46,500	56.6	13,925	40	1,676
Ghana	7.5	19.2	106	0.6	44	1	n.a.
Greece	120.3	10.6	5,536	52.2	2,057	1	70
Hong Kong (a, b)	166.6	6.7	3,729	55.8	3,174	80	208
Hungary (a)	47.8	10.2	3,423	33.6	1,073	1	116
India (a, b, c)	383.4	982.2	21,594	2.2	1,195	1	32
Indonesia (a)	96.3	206.3	5,572	2.7	1,066	2	20
Iran	100.3	65.8	7,355	11.2	390	1	n.a.
Ireland (b)	80.9	3.7	1,600	43.5	946	25	52
Israel (a)	100.0	6.0	2,800	46.8	2,500	3	235
Italy (c)	1,171.0	57.7	25,986	45.1	20,489	15	534
Jamaica (a)	6.3	2.5	419	16.5	74	2	n.a.
Japan (b)	3,783.1	126.2	60,381	47.8	47,308	50	2,373
Jordan (a)	7.4	6.0	403	6.7	70	1	n.a.
Kazakhstan	21.0	17.1	1,818	10.6	30	3	n.a.
Kenya	11.6	29.0	272	1.0	7	1	n.a.
Korea, Rep.	297.9	46.4	20,089	43.3	13,982	24	318
Kuwait	n.a.	1.8	412	22.7	250	1	n.a.
Latvia (a)	6.4	2.5	741	30.2	167	1	n.a.
Luxembourg	16.5	0.4	293	69.2	131	3	n.a.

Note: Figures reflect year end totals except International Carriers (Sept. 1999) and Internet Hosts (Sept. 1999)

Source: TeleGeography, Inc., International Telecommunication Union, World Bank, and Telcordia Technologies

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International Telephone Traffic (A-L)

Outgoing MiTT (millions)			Incoming MiTT (millions)			Traffic Balance		Country
1997	1998	% Change	1997	1998	% Change	1997	1998	
40.8	49.1	20.2%	n.a.	52.2	n.a.	n.a.	3.1	Albania (a, c)
n.a.	121.3	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	Algeria (c)
42.2	47.4	12.3%	30.1	32.2	7.0%	-12.1	-15.2	Andorra
21.9	27.3	24.7%	18.8	22.3	18.3%	-3.1	-5.0	Angola
223.4	358.7	60.6%	444.2	n.a.	n.a.	220.8	n.a.	Argentina
48.8	56.6	16.0%	n.a.	94.3	n.a.	n.a.	37.7	Armenia
20.3	21.1	3.9%	25.8	31.0	20.3%	5.5	9.9	Aruba
1,510.0	1,690.0	11.9%	1,250.0	n.a.	n.a.	-260.0	n.a.	Australia (b)
995.5	1,160.0	16.5%	957.7	n.a.	n.a.	-37.8	n.a.	Austria (c)
n.a.	42.9	n.a.	n.a.	46.0	n.a.	n.a.	3.2	Azerbaijan (a, c)
62.7	63.5	1.3%	n.a.	90.0	n.a.	n.a.	26.5	Bahamas
106.6	124.4	16.7%	85.4	102.1	19.6%	-21.2	-22.3	Bahrain (a)
46.9	41.8	-11.0%	187.0	196.2	4.9%	140.1	154.4	Bangladesh
148.6	176.1	18.5%	185.2	193.5	4.5%	36.6	17.3	Belarus (a, c)
1,340.0	1,460.0	9.0%	1,420.0	n.a.	n.a.	80.0	n.a.	Belgium (a)
22.7	31.6	39.2%	69.3	76.4	10.3%	46.6	44.8	Bolivia
66.2	94.9	43.3%	n.a.	159.2	n.a.	n.a.	64.3	Bosnia-Herzegovina (c)
459.1	545.8	18.9%	761.3	806.9	6.0%	302.2	261.1	Brazil (a)
76.0	96.0	26.4%	135.0	201.0	48.9%	59.0	105.0	Bulgaria
4,286.3	4,805.0	12.1%	4,635.1	n.a.	n.a.	348.8	n.a.	Canada (a)
242.0	259.4	7.2%	n.a.	n.a.	n.a.	n.a.	n.a.	Chile
1,631.8	1,711.5	4.9%	n.a.	n.a.	n.a.	n.a.	n.a.	China
66.9	82.7	23.6%	111.6	112.9	1.1%	44.7	30.2	Costa Rica (a)
40.1	57.3	42.9%	50.6	46.6	-7.9%	10.5	-10.7	Côte d'Ivoire
154.4	182.0	17.9%	115.2	120.6	4.7%	-39.2	-61.4	Cyprus (a, c)
306.1	317.4	3.7%	355.0	406.9	14.6%	48.9	89.5	Czech Republic (a)
607.5	710.0	16.9%	682.0	n.a.	n.a.	74.5	n.a.	Denmark (a)
142.0	157.5	10.9%	476.9	730.5	53.2%	334.9	573.0	Dominican Republic
119.3	127.3	6.7%	451.2	475.3	5.3%	332.0	348.0	Egypt
34.3	43.1	25.6%	168.2	149.2	-11.3%	133.9	106.1	El Salvador
66.3	75.1	13.3%	67.0	79.2	18.2%	0.7	4.1	Estonia (a)
371.1	410.8	10.7%	n.a.	n.a.	n.a.	n.a.	n.a.	Finland
3,545.0	4,115.0	16.1%	3,609.0	n.a.	n.a.	64.0	n.a.	France
4,813.0	5,495.0	14.2%	5,618.0	n.a.	n.a.	805.0	n.a.	Germany (a)
21.9	28.9	31.9%	n.a.	100.8	n.a.	n.a.	72.0	Ghana
593.7	681.3	14.8%	634.6	710.1	11.9%	40.9	28.8	Greece
1,718.0	1,879.8	9.4%	2,100.3	1,833.0	-12.7%	382.3	-46.8	Hong Kong (a, b)
287.1	296.3	3.2%	324.6	374.5	15.4%	37.5	78.2	Hungary (a)
420.5	436.2	3.7%	1,256.6	1,498.8	19.3%	836.1	1,062.6	India (a, b, c)
351.6	324.5	-7.7%	456.0	434.2	-4.8%	104.4	109.7	Indonesia (a)
160.7	177.0	10.1%	130.2	185.7	42.7%	-30.5	8.8	Iran
695.0	885.0	27.3%	n.a.	n.a.	n.a.	n.a.	n.a.	Ireland (b)
459.0	661.0	44.0%	425.0	424.0	-0.2%	-34.0	-237.0	Israel (a)
2,351.9	2,640.0	12.2%	2,475.1	n.a.	n.a.	123.2	n.a.	Italy (c)
n.a.	60.1	n.a.	n.a.	349.8	n.a.	n.a.	289.7	Jamaica (a)
1,771.7	1,895.0	7.0%	1,635.0	1,575.0	-3.7%	-136.7	-320.0	Japan (b)
91.9	122.6	33.4%	145.0	176.9	22.0%	53.1	54.4	Jordan (a)
114.7	118.9	3.7%	n.a.	137.5	n.a.	n.a.	18.6	Kazakhstan
29.0	29.2	0.6%	69.5	72.5	4.3%	40.5	43.3	Kenya
885.0	907.7	2.6%	782.0	719.4	-8.0%	-103.0	-188.3	Korea, Rep.
160.5	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	Kuwait
44.0	55.4	25.8%	81.8	87.2	6.5%	37.8	31.8	Latvia (a)
282.9	293.8	3.9%	208.0	242.6	16.6%	-74.9	-51.2	Luxembourg

Notes: Data are in millions of minutes of public switched traffic.

a. International minutes based on billing point of traffic.

b. International traffic for year ending 31 March. Australia and Pakistan ends 30 June.

c. Traffic data exclude some carriers or routes. (See country table for details.)

d. 1997 and 1998 traffic data not directly comparable. (See country table for details.)

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National Telecommunications Indicators (M-Z)

Country	GDP 1998 (US\$ billions)	Population 1998 (millions)	Main Lines 1998 (thous.)	Lines Per 100 people	Cellular Users 1998 (thous.)	International Carriers 1999	Internet Hosts 1999 (thous.)
Macau (a)	n.a.	0.4	174	40.9	65	1	n.a.
Macedonia (c, d)	2.2	2.0	408	20.4	31	1	n.a.
Malaysia (a, b, d)	71.3	22.2	4,384	19.8	2,200	5	59
Malta	3.7	0.4	192	49.9	23	1	n.a.
Mauritius (b)	4.2	1.1	245	21.4	60	1	n.a.
Mexico (a)	393.2	95.8	9,927	10.4	3,302	16	200
Moldova (a)	1.6	4.4	657	15.0	9	1	n.a.
Monaco	n.a.	n.a.	n.a.	n.a.	n.a.	2	n.a.
Morocco	35.1	27.9	1,515	5.4	116	1	n.a.
Namibia	3.1	1.7	101	6.1	20	1	n.a.
Netherlands	382.5	15.7	9,337	59.3	3,351	30	817
Netherlands Antilles	n.a.	0.2	n.a.	n.a.	n.a.	1	n.a.
New Zealand (b)	54.1	3.9	1,868	47.9	790	19	241
Nicaragua (a)	2.1	4.4	128	2.9	20	1	n.a.
Norway (a)	145.9	4.4	2,935	66.0	2,107	14	391
Oman (a)	15.0	2.4	220	9.2	103	1	n.a.
Pakistan (b, c)	63.9	142.3	2,557	1.8	110	1	n.a.
Palestinian Authority	n.a.	n.a.	n.a.	n.a.	n.a.	1	n.a.
Panama (a)	9.2	2.8	104	n.a.	n.a.	1	n.a.
Paraguay	8.8	5.2	289	5.5	215	1	n.a.
Peru (a, b)	64.1	24.8	1,655	6.7	743	18	n.a.
Philippines (a, b)	65.1	72.9	2,700	3.7	1,595	12	n.a.
Poland (a)	148.9	38.7	8,812	22.8	1,928	1	155
Portugal (a)	106.7	10.0	4,117	41.4	3,075	1	65
Qatar	n.a.	0.6	151	26.0	66	1	n.a.
Romania	38.2	22.6	3,777	16.8	643	1	17
Russia (c)	276.6	147.7	26,875	18.2	800	35	197
Saudi Arabia	125.8	20.2	2,878	14.3	627	1	n.a.
Singapore (a, b)	85.4	3.2	1,778	56.2	1,095	1	109
Slovak Republic (a)	20.4	5.4	1,539	28.6	465	1	20
Slovenia	18.2	2.0	722	36.3	196	1	22
South Africa	116.7	44.3	5,075	11.5	2,500	1	207
Spain (a)	551.9	39.4	16,289	41.4	7,051	16	382
Sri Lanka	15.1	18.5	524	2.8	174	1	n.a.
Sudan (c)	n.a.	28.3	162	0.6	9	1	n.a.
Sweden (a)	225.0	8.9	5,965	67.4	4,109	16	615
Switzerland	264.4	7.1	4,803	67.5	1,672	40	315
Syria (a)	16.3	15.3	1,530	10.0	n.a.	1	n.a.
Taiwan (a)	n.a.	21.9	11,500	52.5	4,727	1	842
Thailand (a, c)	111.3	60.3	4,827	8.0	1,957	2	34
Trinidad & Tobago (a, b)	5.8	1.3	266	20.7	24	1	n.a.
Turkey (c)	198.8	66.7	16,960	25.4	3,506	1	79
Ukraine	49.7	50.9	9,410	18.5	143	2	32
United Arab Emirates	47.2	2.4	915	38.9	493	1	n.a.
United Kingdom (a, b)	1,357.4	58.9	32,072	54.4	14,874	215	2,073
United States (a)	8,210.6	270.5	172,452	63.8	69,209	679	44,230
Uruguay	20.2	3.3	824	25.0	196	1	14
Uzbekistan	14.2	23.8	1,490	6.2	25	1	n.a.
Venezuela (a)	105.8	23.2	2,712	11.6	2,015	1	n.a.
Vietnam	25.9	77.6	2,000	2.6	187	1	n.a.
Yugoslavia (a)	n.a.	10.6	2,319	21.8	240	2	n.a.
Zimbabwe	6.5	12.7	212	1.7	15	1	n.a.

Note: Figures reflect year end totals except International Carriers (Sept. 1999) and Internet Hosts (Sept. 1999)

Source: TeleGeography, Inc., International Telecommunication Union, World Bank, and Telcordia Technologies

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International Telephone Traffic (M-Z)

Outgoing MiTT (millions)			Incoming MiTT (millions)			Traffic Balance		Country
1997	1998	% Change	1997	1998	% Change	1997	1998	
119.0	125.2	5.2%	92.2	95.8	3.9%	-26.8	-29.4	Macau (a)
51.7	37.1	n.a.	85.0	91.7	n.a.	33.3	54.6	Macedonia (c, d)
588.5	685.0	n.a.	592.0	n.a.	n.a.	3.5	n.a.	Malaysia (a, b, d)
34.4	37.3	8.4%	37.0	n.a.	n.a.	2.6	n.a.	Malta
24.6	29.7	20.8%	35.0	38.5	10.0%	10.4	8.8	Mauritius (b)
1,213.6	1,310.0	7.9%	2,819.3	3,060.0	8.5%	1,605.7	1,750.0	Mexico (a)
55.6	55.8	0.4%	80.2	90.3	12.6%	24.6	34.4	Moldova (a)
n.a.	234.0	n.a.	n.a.	140.0	n.a.	n.a.	-94.0	Monaco
149.9	158.0	5.4%	364.0	460.0	26.4%	214.1	302.0	Morocco
49.7	61.9	24.5%	42.3	45.3	7.1%	-7.4	-16.6	Namibia
1,615.0	1,805.0	11.8%	n.a.	n.a.	n.a.	n.a.	n.a.	Netherlands
n.a.	43.0	n.a.	n.a.	113.8	n.a.	n.a.	70.9	Netherlands Antilles
407.0	580.0	42.5%	430.0	n.a.	n.a.	23.0	n.a.	New Zealand (b)
40.4	n.a.	n.a.	52.5	n.a.	n.a.	12.1	n.a.	Nicaragua (a)
481.0	540.0	12.3%	515.0	n.a.	n.a.	34.0	n.a.	Norway (a)
74.3	92.9	25.1%	70.4	74.2	5.4%	-3.9	-18.7	Oman (a)
84.1	87.5	4.0%	557.8	640.4	14.8%	473.7	552.9	Pakistan (b, c)
n.a.	27.6	n.a.	n.a.	16.6	n.a.	n.a.	-11.0	Palestinian Authority
41.4	50.0	20.8%	95.1	97.6	2.7%	53.7	47.6	Panama (a)
26.1	37.8	44.8%	n.a.	57.4	n.a.	n.a.	19.6	Paraguay
79.4	90.4	13.8%	256.9	272.6	6.1%	177.5	182.3	Peru (a, b)
295.0	295.0	0.0%	930.0	n.a.	n.a.	635.0	n.a.	Philippines (a, b)
529.0	602.4	13.9%	800.2	1,144.2	43.0%	271.2	541.8	Poland (a)
393.3	460.2	17.0%	628.8	711.5	13.1%	235.5	251.3	Portugal (a)
99.9	112.5	12.6%	59.5	70.0	17.8%	-40.4	-42.5	Qatar
110.8	n.a.	n.a.	278.6	n.a.	n.a.	167.8	n.a.	Romania
969.6	1,038.3	7.1%	1,035.6	1,029.8	-0.6%	66.0	-8.5	Russia (c)
801.3	932.6	16.4%	n.a.	n.a.	n.a.	n.a.	n.a.	Saudi Arabia
1,161.0	1,235.0	6.4%	n.a.	n.a.	n.a.	n.a.	n.a.	Singapore (a, b)
144.7	151.8	4.9%	174.4	186.4	6.9%	29.7	34.6	Slovak Republic (a)
113.5	129.6	14.2%	118.9	137.0	15.2%	5.4	7.4	Slovenia
368.8	405.0	9.8%	343.2	n.a.	n.a.	-25.6	n.a.	South Africa
1,319.0	1,605.0	21.7%	n.a.	n.a.	n.a.	n.a.	n.a.	Spain (a)
33.2	39.3	18.4%	124.3	146.8	18.1%	91.1	107.5	Sri Lanka
14.8	18.4	24.5%	43.2	88.0	103.7%	28.4	69.6	Sudan (c)
1,140.0	1,205.0	5.7%	n.a.	n.a.	n.a.	n.a.	n.a.	Sweden (a)
2,164.0	2,425.0	12.1%	1,723.0	n.a.	n.a.	-441.0	n.a.	Switzerland
89.3	103.0	15.3%	173.2	n.a.	n.a.	83.9	n.a.	Syria (a)
789.0	862.0	9.3%	842.2	781.8	-7.2%	53.2	-80.2	Taiwan (a)
278.4	296.4	6.5%	408.5	358.6	-12.2%	130.1	62.2	Thailand (a, c)
62.0	64.4	3.9%	130.0	141.5	8.9%	68.0	77.1	Trinidad & Tobago (a, b)
557.5	644.1	15.5%	836.0	955.9	14.3%	278.5	311.7	Turkey (c)
486.8	465.9	-4.3%	n.a.	n.a.	n.a.	n.a.	n.a.	Ukraine
738.0	874.8	18.5%	n.a.	n.a.	n.a.	n.a.	n.a.	United Arab Emirates
6,800.0	8,225.0	21.0%	n.a.	6,400.0	n.a.	n.a.	-1,825.0	United Kingdom (a, b)
23,001.7	24,949.3	8.5%	9,213.3	10,598.8	15.0%	-13,788.4	-14,350.5	United States (a)
68.4	78.3	14.5%	93.7	97.0	3.5%	25.3	18.7	Uruguay
63.1	91.7	45.4%	n.a.	74.7	n.a.	n.a.	-17.0	Uzbekistan
159.2	164.5	3.3%	286.9	298.1	3.9%	127.7	133.6	Venezuela (a)
50.2	56.0	11.6%	294.6	334.0	13.4%	244.4	278.0	Vietnam
217.0	219.5	1.2%	332.0	423.3	27.5%	115.0	203.8	Yugoslavia (a)
n.a.	52.8	n.a.	n.a.	53.2	n.a.	n.a.	0.4	Zimbabwe

Notes:

- a. International MiTT based on billing point of traffic.
- b. International traffic for year ending 31 March (30 June for Australia, Pakistan)
- c. Traffic data exclude some carriers or routes. (See country table for details.)
- d. 1997 and 1998 traffic data are not directly comparable. (See country table for details.)

International Dialing Codes, by Number

1 Canada	266 Lesotho	500 Falkland Islands	692 Marshall Islands
Guam	267 Botswana	501 Belize	7 Kazakhstan
Northern Marianas	268 Swaziland	502 Guatemala	Russia
United States	269 Comoros & Mayotte	503 El Salvador	800 International Freephone
Caribbean	27 South Africa	504 Honduras	81 Japan
20 Egypt	290 St. Helena	505 Nicaragua	82 South Korea
212 Morocco	291 Eritrea	506 Costa Rica	84 Vietnam
213 Algeria	297 Aruba	507 Panama	850 North Korea
216 Tunisia	298 Faroe Islands	508 St. Pierre & Miquelon	852 Hong Kong
218 Libya	299 Greenland	509 Haiti	853 Macau
220 Gambia	30 Greece	51 Peru	855 Cambodia
221 Senegal	31 Netherlands	52 Mexico	856 Laos
222 Mauritania	32 Belgium	53 Cuba	86 China
223 Mali	33 France	54 Argentina	870 Inmarsat Special
224 Guinea	34 Spain	55 Brazil	871 Inmarsat East Atlantic
225 Ivory Coast	350 Gibraltar	56 Chile	872 Inmarsat Pacific
226 Burkina Faso	351 Portugal; Azores	57 Colombia	873 Inmarsat Indian
227 Niger	352 Luxembourg	58 Venezuela	874 Inmarsat West Atlantic
228 Togo	353 Ireland	590 Guadeloupe	880 Bangladesh
229 Benin	354 Iceland	591 Bolivia	881x Global Mobile Satellite
230 Mauritius	355 Albania	592 Guyana	Systems
231 Liberia	356 Malta	593 Ecuador	886 Taiwan
232 Sierra Leone	357 Cyprus	594 French Guiana	90 Turkey
233 Ghana	358 Finland	595 Paraguay	91 India
234 Nigeria	359 Bulgaria	596 Martinique	92 Pakistan
235 Chad	36 Hungary	597 Suriname	93 Afghanistan
236 Central African Republic	370 Lithuania	598 Uruguay	94 Sri Lanka
237 Cameroon	371 Latvia	599 Netherlands Antilles	95 Myanmar
238 Cape Verde Islands	372 Estonia	60 Malaysia	960 Maldives
239 Sao Tome and Principe	373 Moldova	61 Australia	961 Lebanon
240 Equatorial Guinea	374 Armenia	62 Indonesia	962 Jordan
241 Gabon	375 Belarus	63 Philippines	963 Syria
242 Congo (Brazzaville)	376 Andorra	64 New Zealand	964 Iraq
243 Congo (Kinshasa)	377 Monaco	65 Singapore	965 Kuwait
244 Angola	378 San Marino	66 Thailand	966 Saudi Arabia
245 Guinea-Bissau	379 Vatican City	672 Australian Territories	967 Yemen
246 Diego Garcia	380 Ukraine	673 Brunei	968 Oman
247 Ascension Island	381 Yugoslavia	674 Nauru	971 United Arab Emirates
248 Seychelles	385 Croatia	675 Papua New Guinea	972 Israel
249 Sudan	386 Slovenia	676 Tonga Islands	973 Bahrain
250 Rwanda	387 Bosnia-Herzegovina	677 Solomon Islands	974 Qatar
251 Ethiopia	389 Macedonia	678 Vanuatu	975 Bhutan
252 Somalia	39 Italy	679 Fiji	976 Mongolia
253 Djibouti	40 Romania	680 Palau	977 Nepal
254 Kenya	41 Switzerland	681 Wallis & Futuna	98 Iran
255 Tanzania	41-75 Liechtenstein	682 Cook Islands	992 Tajikistan
256 Uganda	420 Czech Republic	683 Niue	993 Turkmenistan
257 Burundi	421 Slovak Republic	684 American Samoa	994 Azerbaijan
258 Mozambique	43 Austria	685 Western Samoa	995 Georgia
260 Zambia	44 United Kingdom	686 Kiribati	996 Kyrgyzstan
261 Madagascar	45 Denmark	687 New Caledonia	998 Uzbekistan
262 Reunion Island	46 Sweden	688 Tuvalu	
263 Zimbabwe	47 Norway	689 French Polynesia	
264 Namibia	48 Poland	690 Tokelau	
265 Malawi	49 Germany	691 Micronesia	

International Dialing Codes, by Country

Afghanistan .....93	Bulgaria .....359	Eritrea .....291	India .....91
Albania .....355	Sofia .....2	Estonia .....372	Mumbai .....22
Tirana .....42	Burkina Faso .....226	Tallinn .....2	Calcutta .....33
Algeria .....213	Burundi .....257	Ethiopia .....251	New Delhi .....11
Algiers .....2	Cambodia .....855	Addis Ababa .....1	Indonesia .....62
American Samoa .....684	Cameroon .....237	Falkland Islands .....500	Jakarta .....21
Andorra .....376	Canada .....1	Faroe Islands .....298	Inmarsat
Angola .....244	Montreal .....514/450	Fiji .....679	Special .....870
Luanda .....2	Ottawa .....613	Finland .....358	East Atlantic .....871
Anguilla .....1-264	Toronto .....416	Helsinki .....9	Pacific .....872
Antigua & Barbuda .....1-268	Vancouver .....604	France .....33	Indian .....873
Argentina .....54	Cape Verde .....238	Paris .....1	West Atlantic .....874
Buenos Aires .....1	Cayman Islands .....1-345	Marseille .....4	International Freephone .....800
Armenia .....374	Central African Republic .....236	French Antilles .....596	Iran .....98
Yerevan .....2	Bangui .....61	French Guiana .....594	Tehran .....21
Aruba .....297	Chad .....235	French Polynesia .....689	Iraq .....964
Ascension Island .....247	Chile .....56	Gabon .....241	Baghdad .....1
Australia .....61	Santiago .....2	Gambia .....220	Ireland .....353
Melbourne .....3	China, People's Republic of .....86	Georgia .....995	Dublin .....1
Sydney .....2	Beijing .....10	Tbilisi .....32	Israel .....972
Australian Territories .....672	Guangzhou .....20	Germany .....49	Jerusalem .....2
Austria .....43	Shanghai .....21	Berlin .....30	Tel Aviv .....3
Vienna .....1	Colombia .....57	Bonn .....228	Italy .....39
Azerbaijan .....994	Bogota .....1	Frankfurt .....69	Rome .....06
Baku .....12	Cocos Islands; Norfolk &	Munich .....89	Milan .....02
Bahamas .....1-242	Christmas Islands .....672	Ghana .....233	Ivory Coast .....225
Bahrain .....973	Comoros .....269	Accra .....21	Jamaica .....1-876
Bangladesh .....880	Congo .....242	Gibraltar .....350	Japan .....81
Dhaka .....2	Brazzaville .....81/82/83	Global Mobile Satellite	Osaka .....6
Barbados .....1-246	Congo .....243	Systems	Tokyo .....3
Belarus .....375	Kinshasa .....12	Globalstar .....8818/8819	Jordan .....962
Minsk .....172	Costa Rica .....506	ICO Global Comm. ....8810/8811	Amman .....6
Belgium .....32	Croatia .....385	Iridium .....8816/8817	Kazakhstan .....7
Brussels .....2	Zagreb .....1	Greece .....30	Almaty .....3272
Belize .....501	Cuba .....53	Athens .....1	Kenya .....254
Belmopan .....8	Havana .....7	Greenland .....299	Nairobi .....2
Benin .....229	Cyprus .....357	Grenada .....1-473	Kiribati .....686
Bermuda .....1-441	Nicosia .....2	Guadeloupe .....590	Kuwait .....965
Bhutan .....975	Czech Republic .....420	Guam .....1-671	Kyrgyzstan .....996
Bolivia .....591	Prague .....2	Guatemala .....502	Bishkek .....3312
La Paz .....2	Denmark .....45	Guinea .....224	Laos .....856
Bosnia .....387	Diego Garcia .....246	Guinea-Bissau .....245	Latvia .....371
Sarajevo .....71	Djibouti .....253	Guyana .....592	Riga .....2
Botswana .....267	Dominica .....1-767	Georgetown .....2	Lebanon .....961
Brazil .....55	Dominican Republic .....1-809	Haiti .....509	Beirut .....1
Brasilia .....61	Ecuador .....593	Honduras .....504	Lesotho .....266
Rio de Janeiro .....21	Quito .....2	Hong Kong .....852	Liberia .....231
São Paulo .....11	Egypt .....20	Hungary .....36	Libya .....218
British Virgin Islands .....1-284	Cairo .....2	Budapest .....1	Tripoli .....21
Brunei .....673	El Salvador .....503	Iceland .....354	Liechtenstein .....41-75
Bandar Seri Begawan .....2	Equatorial Guinea .....240		Lithuania .....370
			Vilnius .....2

Luxembourg	352	Niger	227	Singapore	65	Tuvalu	688
Macau	853	Nigeria	234	Slovak Republic	421	Uganda	256
Macedonia	389	Lagos	1	Bratislava	7	Kampala	41
Skopje	91	Niue	683	Slovenia	386	Ukraine	380
Madagascar	261	North Korea	850	Ljubljana	61	Kiev	44
Malawi	265	Pyongyang	2	Solomon Islands	677	United Arab Emirates	971
Malaysia	60	Northern Marianas	670	Somalia	252	Abu Dhabi	2
Kuala Lumpur	3	Saipan	322	Mogadishu	1	Dubai	4
Maldives	960	Norway	47	South Africa	27	United Kingdom	44
Mali	223	Oslo	22	Johannesburg	11	Cardiff	1222
Malta	356	Oman	968	Pretoria	12	Glasgow	141
Marshall Islands	692	Pakistan	92	South Korea	82	London	171/181
Martinique	596	Islamabad	51	Seoul	2	Manchester	161
Mauritania	222	Palau	680	Spain	34	United States	1
Mauritius	230	Panama	507	Madrid	91	Chicago	312/773
Mayotte	269	Papua New Guinea	675	Barcelona	93	Houston	713/281
Mexico	52	Paraguay	595	Sri Lanka	94	Los Angeles	213/323
Guadalajara	36	Asuncion	21	Colombo	1	Miami	305/786
Mexico City	5	Peru	51	Sudan	249	New York	212/917
Monterrey	83	Lima	14	Khartoum	11	Washington	202
Micronesia	691	Philippines	63	Suriname	597	U.S. Virgin Islands	1-340
Moldova	373	Manila	2	Swaziland	268	Uruguay	598
Chisinau	41	Poland	48	Stockholm	8	Montevideo	2
Monaco	377	Warsaw	22	Sweden	46	Uzbekistan	998
Mongolia	976	Portugal	351	Switzerland	41	Tashkent	3712
Ulaanbaatar	1	Lisbon	2	Berne	31	Vanuatu	678
Montserrat	1-664	Puerto Rico	1-787	Zurich	1	Vatican City	379
Morocco	212	Qatar	974	Syria	963	Venezuela	58
Casablanca	2	Reunion Island	262	Damascus	11	Caracas	2
Rabat	7	Romania	40	Tahiti	689	Vietnam	84
Mozambique	258	Bucharest	1	Taiwan	886	Wallis & Futuna	681
Maputo	1	Russia	7	Taipei	2	Western Samoa	685
Myanmar	95	Moscow	095	Tajikistan	992	Yemen	967
Namibia	264	St. Petersburg	812	Dushanbe	3772	Sanaa	1
Windhoek	61	Rwanda	250	Tanzania	255	Yugoslavia	381
Nauru	674	St. Helena	290	Dar Es Salaam	51	Belgrade	11
Nepal	977	St. Kitts & Nevis	1-869	Thailand	66	Zambia	260
Kathmandu	1	St. Lucia	1-758	Bangkok	2	Lusaka	1
Netherlands	31	St. Pierre & Miquelon	508	Togo	228	Zanzibar (Tanzania)	255
Amsterdam	20	St. Vincent & the Grenadines	1-809	Tokelau	690	Zimbabwe	263
Netherlands Antilles	599	San Marino	378	Tonga	676	Harare	4
New Caledonia	687	São Tome and Principe	239	Trinidad & Tobago	1-868		
New Zealand	64	Saudi Arabia	966	Tunisia	216		
Auckland	9	Riyadh	1	Tunis	1		
Wellington	4	Senegal	221	Turkey	90		
Nicaragua	505	Seychelles	248	Ankara	312		
Managua	2	Sierra Leone	232	Istanbul	212		
		Freetown	22	Turkmenistan	993		
				Ashkhabad	12		
				Turks & Caicos	1-649		



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North American Area Codes, by Jurisdiction

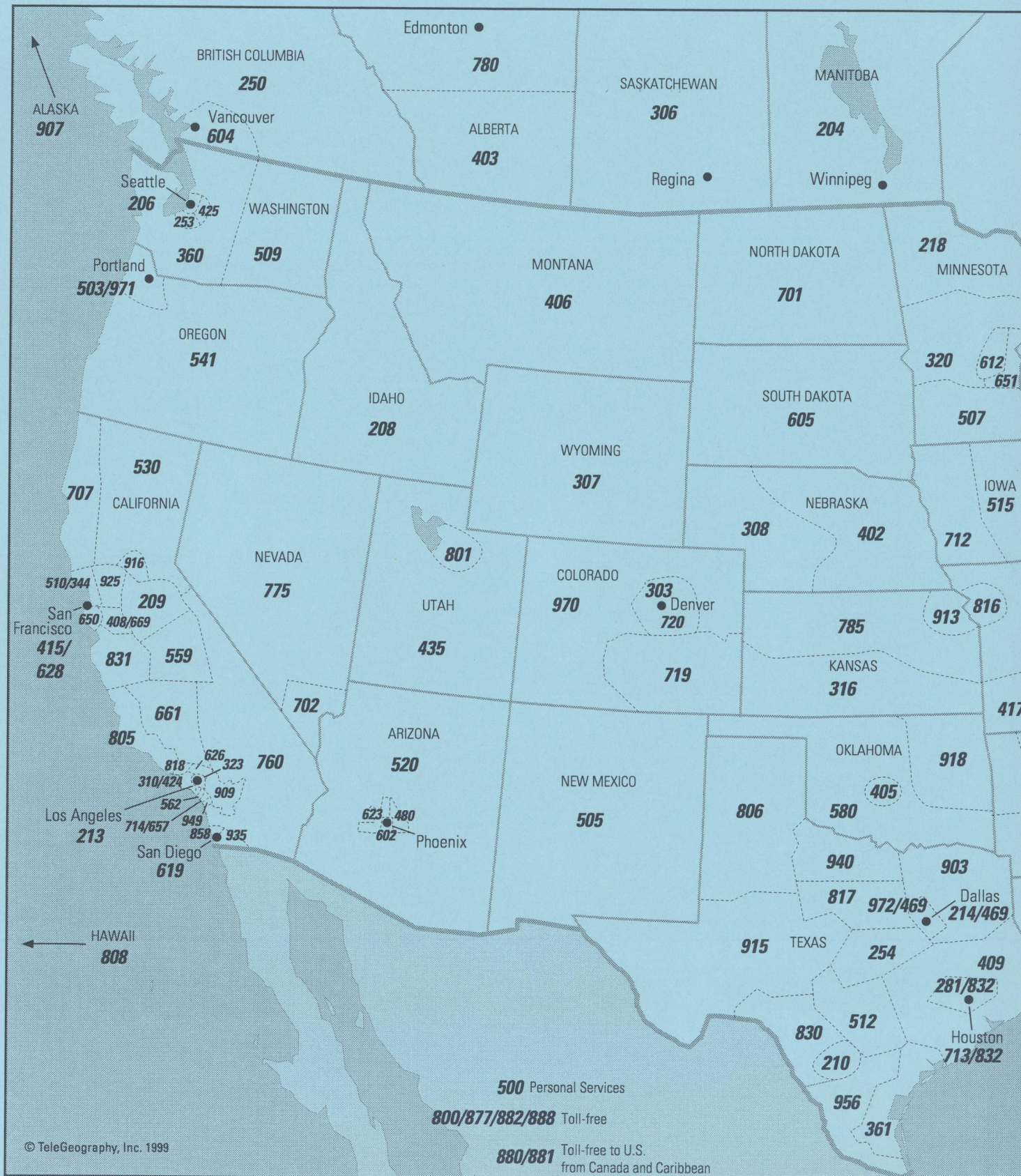
Alabama		Georgia		Missouri		Pennsylvania	
Birmingham	205	Athens	706	Jefferson City	573	Allentown	484/610
Huntsville	256	Atlanta	404/678	Kansas City	816	Altoona	814
Montgomery	334	Marietta	770/678	St. Joseph	660	Harrisburg	717
Alaska	907	Savannah	912	St. Louis	314	New Castle	724
Alberta				Springfield	417	Philadelphia	215/267
Calgary	403	Grenada	473	Montserrat	664	Pittsburgh	412
Edmonton	780	Guam	671	Montana	406	Puerto Rico	787
Anguilla	264	Hawaii	808	Nebraska		Quebec	
Antigua & Barbuda	268	Idaho	208	North Platte	308	Montreal	514
Arizona		Illinois		Omaha	402	Quebec	418
Buckeye	623	Aurora	630/331	Nevada		Sherbrooke	819
Phoenix	602	Cairo	618	Las Vegas	702	Trois Rivières	450
Tempe	480	Chicago	312/773/872	Reno	775	Rhode Island	401
Tucson	520	Evanston	847/224	New Brunswick	506	St. Kitts & Nevis	869
Arkansas		Oak Brook	708/464	New Hampshire	603	St. Lucia	758
Jonesboro	870	Peoria	309	New Jersey		St. Vincent/Grenadines	809
Little Rock	501	Rockford	815	Elizabeth	908	Saskatchewan	306
Bahamas	242	Springfield	217	Jersey City	201	South Carolina	
Barbados	246	Indiana		Newark	973	Charleston	843
Bermuda	441	Evansville	812	New Brunswick	732	Columbia	803
British Columbia		Gary	219	Trenton	609	Greenville	864
Victoria	250	Indianapolis	317	New Mexico	505	South Dakota	605
Vancouver	604	Lafayette	765	New York		Tennessee	
British Virgin Islands	284	Iowa		Albany	518	Columbia	931
California		Council Bluffs	712	Queens	347/718	Memphis	901
Anaheim	714	Des Moines	515	Buffalo	716	Nashville	615
Bakersfield	805	Dubuque	319	Long Island	516	Knoxville	423
Burbank	626	Jamaica	876	Ithaca	607	Texas	
Concord	925	Kansas City	913	Manhattan	212/646/917	Amarillo	806
Fresno	209	Topeka	785	Syracuse	315	Austin	512
Irvine	949	Wichita	316	White Plains	914	Brownsville	956
Long Beach	562	Kentucky		Newfoundland	709	Dallas	469/214
Los Angeles	213/323	Dade Park	270	North Carolina		Deer Park	832/281
Monterey	831	Lexington	606	Asheville	828	Del Rio	830
Oakland	344/510	Louisville	502	Charlotte	704	El Paso	915
Palm Springs	760	Louisiana		Fayetteville	910	Fort Worth	817
Redding	530	Baton Rouge	225	Greensboro	336	Galveston	409
Riverside	909	New Orleans	504	Raleigh	919	Houston	713/281/832
Sacramento	916	Shreveport	318	Rocky Mountain	252	Irving	469/972
Palo Alto	650	Maine	207	North Dakota	701	San Antonio	210
San Diego	619	Manitoba	204	Northern Marianas	670	Tyler	903
San Fernando	818	Maryland		NW Territories/Yukon	867	Waco	254
San Francisco	415/628	Baltimore	410/443	Nova Scotia & Prince Edward Island	902	Wichita Falls	940
San Jose	669/408	Rockville	301/240	Ohio		Trinidad & Tobago	868
Santa Ana	657/714	Massachusetts		Canton	330	Turks & Caicos	649
Santa Monica	424/310	Boston	617	Cincinnati	513	U.S. Virgin Islands	340
Santa Rosa	707	Cambridge	781	Cleveland	216	Utah	
Visalia	559	Lowell	978	Columbus	614	Salt Lake City	801
Cayman Islands	345	New Bedford	508	Dayton	937	Provo	435
Colorado		Springfield	413	Marietta	740	Vermont	802
Colorado Springs	719	Michigan		Oberlin	440	Virginia	
Denver	303/720	Ann Arbor	734	Toledo	419	Alexandria	703
Ft. Collins	970	Detroit	313	Oklahoma		Richmond	804
Connecticut		Flint	586/810	Enid	580	Roanoke	540
Bridgeport	203	Grand Rapids	616	Oklahoma City	405	Norfolk	757
Hartford	860	Lansing	517	Tulsa	918	Washington	
Delaware	302	Pontiac	248	Ontario		Belleuve	425
District of Columbia		Sault Ste. Marie	906	Hamilton	905	Olympia	360
Washington	202	Minnesota		London	519	Seattle	206
Dominica	767	Duluth	218	North Bay	705	Spokane	509
Dominican Republic	809	Minneapolis	612	Ottawa	613	Tacoma	253
Florida		Rochester	507	Thunder Bay	807	West Virginia	304
Ft. Lauderdale	954	St. Cloud	320	Toronto	416/647	Wisconsin	
Ft. Myers	941	St. Paul	651	Oregon		Green Bay	920
Gainesville	352	Mississippi		Eugene	541	Madison	608
Jacksonville	904	Biloxi	228	Portland	503/971	Milwaukee	414
Miami	305/786	Jackson	601	Wyoming		Eau Claire	715
Orlando	321/407						307
Tallahassee	850						
Tampa	813/727						
W. Palm Beach	561						

Note: Two codes separated by a slash (e.g., in Houston, Texas) indicate an overlay; multiple codes are used for the same geographic area.

North American Area Codes, by Number

201	New Jersey	407	Florida	618	Illinois	816	Missouri
202	District of Columbia	408	California	619	California	817	Texas
203	Connecticut	409	Texas	623	Arizona	818	California
204	Manitoba	410	Maryland	626	California	819	Quebec
205	Alabama	411	Directory Assistance	628	California	828	North Carolina
206	Washington	412	Pennsylvania	630	Illinois	830	Texas
207	Maine	413	Massachusetts	646	New York	831	California
208	Idaho	414	Wisconsin	647	Ontario	832	Texas
209	California	415	California	649	Turks & Caicos	843	South Carolina
210	Texas	416	Ontario	650	California	847	Illinois
212	New York	417	Missouri	651	Minnesota	850	Florida
213	California	418	Quebec	657	California	858	California
214	Texas	419	Ohio	660	Missouri	860	Connecticut
215	Pennsylvania	423	Tennessee	661	California	864	South Carolina
216	Ohio	424	California	664	Montserrat	867	NW Territories
217	Illinois	425	Washington	669	California	868	Trinidad & Tobago
218	Minnesota	435	Utah	670	Northern Marianas	869	St. Kitts/Nevis
219	Indiana	440	Ohio	671	Guam	870	Arkansas
224	Illinois	441	Bermuda	678	Georgia	847	Illinois
225	Louisiana	443	Maryland	701	North Dakota	876	Jamaica
228	Mississippi	450	Quebec	702	Nevada	877	Toll-free services
240	Maryland	464	Illinois	703	Virginia	880	Toll-free services
242	Bahamas	469	Texas	704	North Carolina	881	Toll-free services
246	Barbados	473	Grenada	705	Ontario	882	Toll-free services
248	Michigan	480	Arizona	706	Georgia	888	Toll-free services
250	British Columbia	484	Pennsylvania	707	California	900	Information Services
252	North Carolina	500	Personal Comm.Serv. (PCS)	708	Illinois	901	Tennessee
253	Washington	501	Arkansas	709	Newfoundland	902	Nova Scotia & PEI
254	Texas	502	Kentucky	710	U.S. Government Emergency	903	Texas
256	Alabama	503	Oregon	712	Iowa	904	Florida
264	Anguilla	504	Louisiana	713	Texas	905	Ontario
267	Pennsylvania	505	New Mexico	714	California	906	Michigan
268	Antigua & Barbuda	506	New Brunswick	715	Wisconsin	907	Alaska
270	Kentucky	507	Minnesota	716	New York	908	New Jersey
281	Texas	508	Massachusetts	717	Pennsylvania	909	California
284	British Virgin Islands	509	Washington	718	New York	910	North Carolina
301	Maryland	510	California	719	Colorado	911	Emergency Services
302	Delaware	512	Texas	720	Colorado	912	Georgia
303	Colorado	513	Ohio	724	Pennsylvania	913	Kansas
304	West Virginia	514	Quebec	727	Florida	914	New York
305	Florida	515	Iowa	732	New Jersey	915	Texas
306	Saskatchewan	516	New York	734	Michigan	916	California
307	Wyoming	517	Michigan	740	Ohio	917	New York
308	Nebraska	518	New York	757	Virginia	918	Oklahoma
309	Illinois	519	Ontario	758	St. Lucia	919	North Carolina
310	California	520	Arizona	760	California	920	Wisconsin
312	Illinois	530	California	765	Indiana	925	California
313	Michigan	540	Virginia	767	Dominica	931	Tennessee
314	Missouri	541	Oregon	770	Georgia	935	California
315	New York	559	California	773	Illinois	937	Ohio
316	Kansas	561	Florida	775	Nevada	940	Texas
317	Indiana	562	California	780	Alberta	941	Florida
318	Louisiana	570	Pennsylvania	781	Massachusetts	949	California
319	Iowa	573	Missouri	784	St. Vincent/Grenadines	954	Florida
320	Minnesota	580	Oklahoma	785	Kansas	956	Texas
321	Florida	586	Michigan	786	Florida	970	Colorado
323	California	601	Mississippi	787	Puerto Rico	971	Oregon
330	Ohio	602	Arizona	800	Toll-free services	972	Texas
331	Illinois	603	New Hampshire	801	Utah	973	New Jersey
334	Alabama	604	British Columbia	802	Vermont	978	Massachusetts
336	North Carolina	605	South Dakota	803	South Carolina		
340	U.S. Virgin Islands	606	Kentucky	804	Virginia		
344	California	607	New York	805	California		
345	Cayman Islands	608	Wisconsin	806	Texas		
347	New York	609	New Jersey	807	Ontario		
352	Florida	610	Pennsylvania	808	Hawaii		
360	Washington	611	Repair Service	809	Dominican Republic		
401	Rhode Island	612	Minnesota	809	St. Vincent & Grenadines		
402	Nebraska	613	Ontario	810	Michigan		
403	Alberta	614	Ohio	812	Indiana		
404	Georgia	615	Tennessee	813	Florida		
405	Oklahoma	616	Michigan	814	Pennsylvania		
406	Montana	617	Massachusetts	815	Illinois		

North American Area Codes



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A Primer on Bits

Measuring Bytes Bit by Bit

Below are the standard metric prefixes used in the SI (Système International) conventions for scientific measurement. With units of time (e.g., gigabits per second) or things that come in powers of 10, they retain their usual meanings of multiplication by powers of 1,000 = 10^3 . When used with bytes (e.g., gigabytes of data storage) or other things that naturally come in powers of 2, they usually denote multiplication by powers of 1,024 = 2^{10} .

Base 10		Base 2	
1 Kilobit/s	= $1,000^1 = 10^3$	1,000	1 Kilobyte = $1,024^1 = 2^{10}$
1 Megabit/s	= $1,000^2 = 10^6$	1,000,000	1 Megabyte = $1,024^2 = 2^{20}$
1 Gigabit/s	= $1,000^3 = 10^9$	1,000,000,000	1 Gigabyte = $1,024^3 = 2^{30}$
1 Terabit/s	= $1,000^4 = 10^{12}$	1,000,000,000,000	1 Terabyte = $1,024^4 = 2^{40}$
1 Petabit/s	= $1,000^5 = 10^{15}$	1,000,000,000,000,000	1 Petabyte = $1,024^5 = 2^{50}$
1 Exabit/s	= $1,000^6 = 10^{18}$	1,000,000,000,000,000,000	1 Exabyte = $1,024^6 = 2^{60}$
1 Zettabit/s	= $1,000^7 = 10^{21}$	1,000,000,000,000,000,000,000	1 Zettabyte = $1,024^7 = 2^{70}$
1 Yottabit/s	= $1,000^8 = 10^{24}$	1,000,000,000,000,000,000,000,000	1 Yottabyte = $1,024^8 = 2^{80}$

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Measuring Telecommunications Bandwidth—DS-0 to OC-192

Carrier Technology	Data Rate(Mbps)	Description	64 Kbps Circuits*
DS-0	0.064	Base rate in the Digital Signal (DS) level hierarchy	1
T-1 (DS-1)	1.544	Primary level of the American T-carrier multiplexing system; capacity is the same as a DS 1 carrier	24
T-2 (DS-2)	6.312	Four times the capacity of T-1	96
T-3 (DS-3)	44.736	28 times the capacity of T-1	672
T-4 (DS-4)	274.176	168 times the capacity of T-1	4,032
E-1	2.048	Primary level of the European E-carrier multiplexing system	30
E-2	8.448	Carries four multiplexed E-1 signals	120
E-3	34.368	Carries four E-2 signals	480
E-4	139.264	Carries four E-3 signals	1,920
E-5	565.148	Carries four E-4 signals	7,680
OC-1/STS-1	51.840	Basic signaling rate of SONET hierarchy	810
OC-3/STM-1	155.520	Exactly three times the capacity of OC-1**	2,430
OC-12/STM-4	622.080	12 times the capacity of OC-1	9,720
OC-24	1,244.160	24 times the capacity of OC-1	19,440
OC-48/STM-16	2,488.320	48 times the capacity of OC-1	38,880
OC-192/STM-64	9,953.280	192 times the capacity of OC-1	155,520

Key

"T" T-carrier system in U.S., Canada, and Japan with 1.544 Mbps as the primary level (24 voice channels x 64 Kbps per channel).

"DS" Digital Signal that travels on the T-carrier or E-carrier.

"E" Used in countries other than U.S., Canada, and Japan. The hierarchy was established by the CEPT (Conférence Européenne des Postes et Télécommunications) with 2.048 Mbps as the primary level ([30 voice channels + 2 channels for overhead] x 64 Kbps per channel).

"OC" Optical Carrier interface designed to work with STS-*n* (Synchronous Transport Signal) signaling rate in a SONET (Synchronous Optical Network).

"STM" Synchronous Transport Module refers to a large carrier (base signal 155.52 Mbps) in a SONET.

"STS" Synchronous Transport Signal is the electrical counterpart to the Optical Carrier (OC).

* Voice traffic on digital networks is commonly encoded at 64 Kbps, but the actual number of simultaneous conversations possible over a given carrier may vary depending on the encoding scheme used.

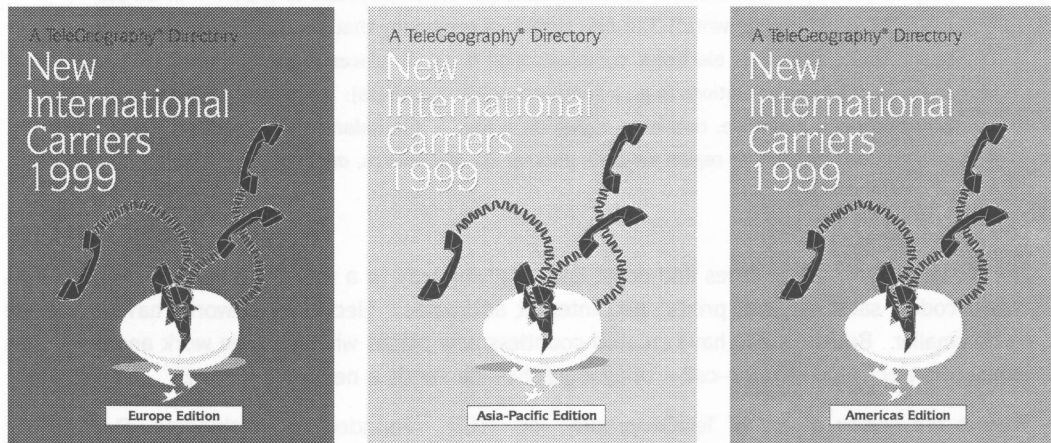
** In the "E" and "T" hierarchies, each higher level is set to be "almost but not exactly" a multiple of the bit rate for the previous order (plesiochronous). To eliminate problems associated with plesiochronous multiplexing, SONET, a synchronous hierarchy, was defined in the United States in 1986. As a result, the "OC" and "STM" carriers are exact bit-rate multiples of their primary levels, OC-1 and STM-1, respectively.

Source: TeleGeography, Inc.; Alcatel; *Newton's Telecom Dictionary*

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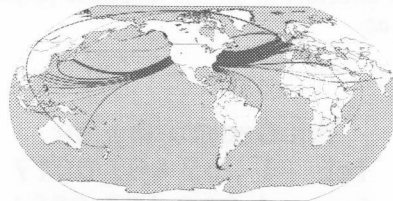
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The old geography of countries and coast lines is giving way to a new geography marked by telephone codes, satellite "foot prints" and Internet addresses. Electronic networks have made the world smaller. But they also have created countless new places where people work and play. This expanding electronic terrain—call it telegeography—demands a new cartography.

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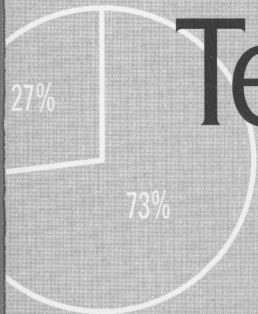
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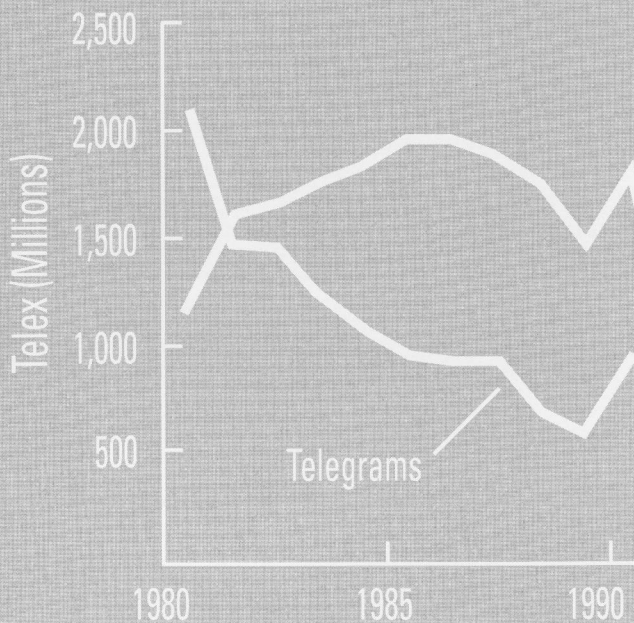
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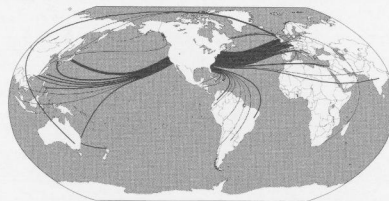
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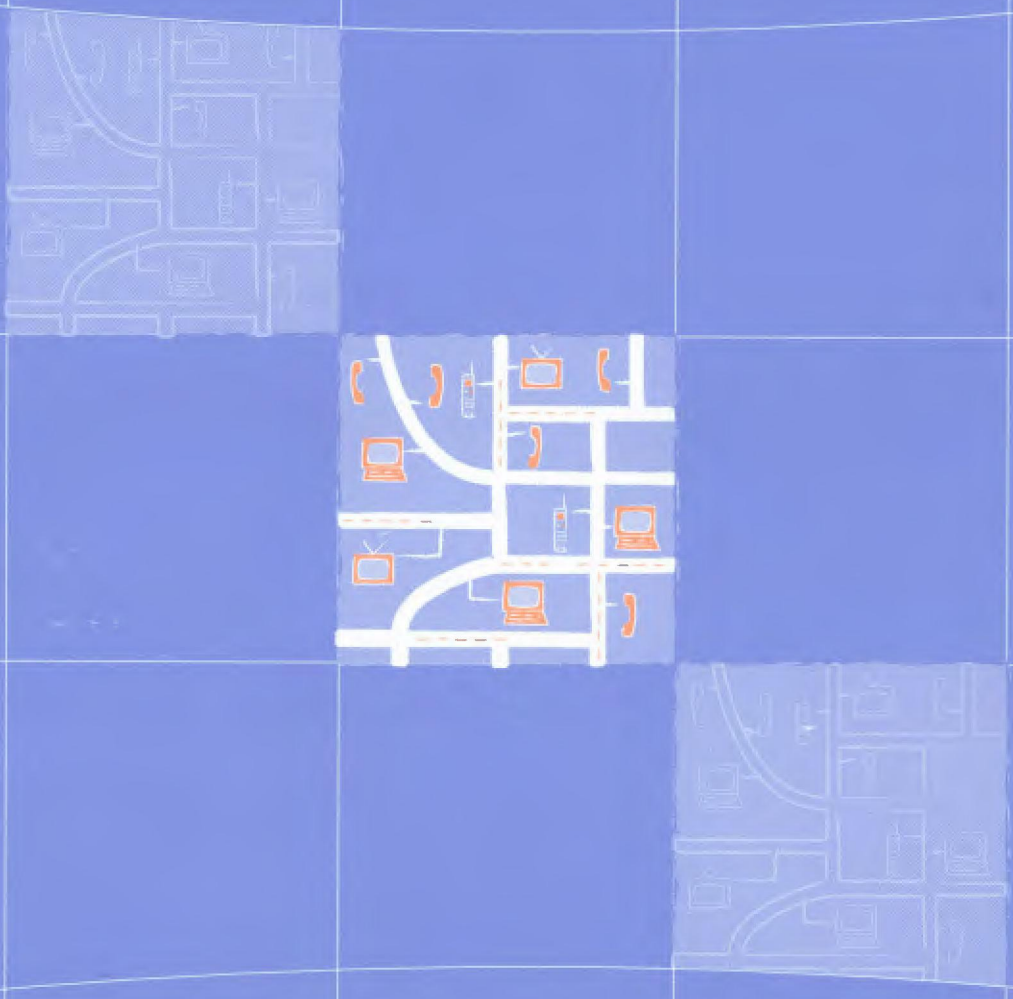
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