PRESENT AND FUTURE OF BROADBAND AND UWB TECHNOLOGIES

BILL LUTHER
FEDERAL COMMUNICATIONS COMMISSION
WASHINGTON, D.C.

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TOPICS FOR DISCUSSION

- ULTRA-WIDEBAND (UWB) SYSTEMS
- FUTURE (SOFTWARE AND COGNITIVE) RADIOS
- ITU MULTIMEDIA STUDIES
- ADVANCED WIRELESS SYSTEMS
- DIGITAL RADIO BROADCAST
- DIGITAL TELEVISION BROADCAST
- 12 GHz TERRESTRIAL SHARING WITH GSO SATELLITE DBS
- BROADBAND SATELLITE
- ABOVE 50 GHz
- EXPECTED BROADBAND GROWTH TRENDS

UWB INTRODUCTION

- UWB TECHNOLOGY HAS BEEN IN LIMITED USE FOR YEARS BY PUBLIC SERVICE, RESEARCH, AND MILITARY AGENCIES, PRIMARILY FOR IMAGING AND RADAR
- CONSUMER UWB DEVICES ARE BEING DEVELOPED FOR WIRELESS COMMUNICATION AND OTHER APPLICATIONS

ULTRA-WIDEBAND (UWB)

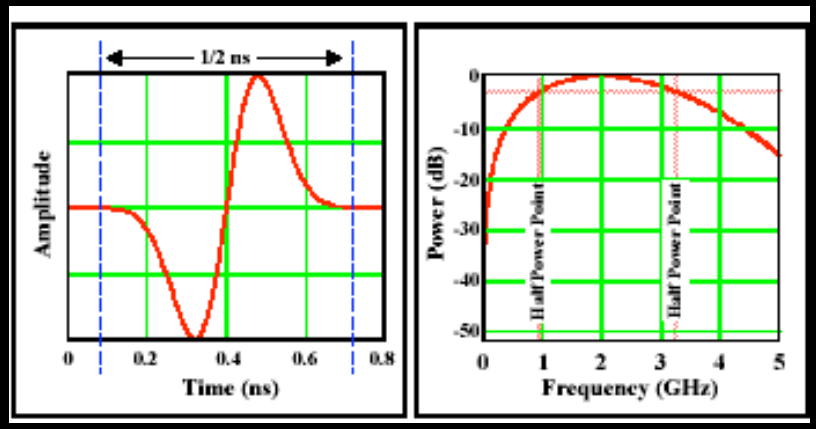
- TIMED, CODED PULSES OF EXTREMELY SHORT DURATION
- NOISE-LIKE EMISSION WHICH SPREADS ACROSS THE SPECTRUM
- EXCELLENT IMMUNITY TO MULTIPATH INTERFERENCE
- IDEAL FOR SHORT RANGE APPLICATIONS FOR HIGH BIT RATE COMMUNICATIONS
- IMPLEMENTED BY RELATIVELY LOW COST INTEGRATED CIRCUITS
- CHARACTERIZED BY
  - PULSE REPETITION FREQUENCY
  - RADIATED POWER DENSITY, AND
  - PEAK POWER IN A WIDE BANDWIDTH
- NECESSARY BANDWIDTH FOR COMMUNICATIONS CAN BE RESTRICTED BY FILTERS

UWB USES

- GROUND PENETRATING RADARS (PUBLIC SAFETY, ARCHEOLOGICAL, CIVIL ENGINEERING, EARTHQUAKE)
- THROUGH-WALL RADAR FOR PUBLIC SAFETY AND CONSTRUCTION
- EMERGENCY MOTION AND IMAGING
- HIGH PERFORMANCE MICROPHONES
- LOCAL AREA VOICE, DATA, AND VIDEO NETWORKS
- SECURITY DEVICES
- COLLISION AVOIDANCE AND AIRBAG SENSORS
- FLUID LEVEL DETECTION
- SHORT RANGE CLANDESTINE COMMUNICATION
- LONG RANGE MILITARY COMMUNICATIONS
- IDENTIFICATION AND LOCATION TAGS

UNLICENSED, UNCONTROLLED, UBIQUITOUS

UWB WAVEFORM CHARACTERISTICS



A Monocycle Pulse in Time and Frequency Domain

- UWB signal definition:
  - The fractional bandwidth is greater than 20% of the center frequency, or
  - The -10 dB bandwidth occupies ≥ 500 MHz or more of spectrum

UWB FRACTIONAL BANDWIDTH

FRACTIONAL BW = $2(F_h - F_l)/(F_h + F_l)$

WHERE

F_h = HIGHEST FREQUENCY LIMIT WITH SIGNAL 10 dB BELOW PEAK EMISSION

F_l = LOWEST FREQUENCY LIMIT WITH SIGNAL 10 dB BELOW PEAK EMISSION

F_c = CENTER FREQUENCY = $(F_h + F_l)/2$ = 1/(DURATION OF ONE CYCLE)

UWB EFFECTIVENESS

IMPROVED CHANNEL CAPACITY IS ONE MAJOR ADVANTAGE OF UWB. SHANNON'S CAPACITY LIMIT EQUATION SHOWS THAT INCREASING CHANNEL CAPACITY REQUIRES LINEAR INCREASES IN BANDWIDTH WHILE SIMILAR CHANNEL CAPACITY INCREASES WOULD REQUIRE EXPONENTIAL INCREASES IN POWER.

SHANNON'S CAPACITY LIMIT EQUATION

$$C = BW\,[\log_2(1+SNR)]$$

where:

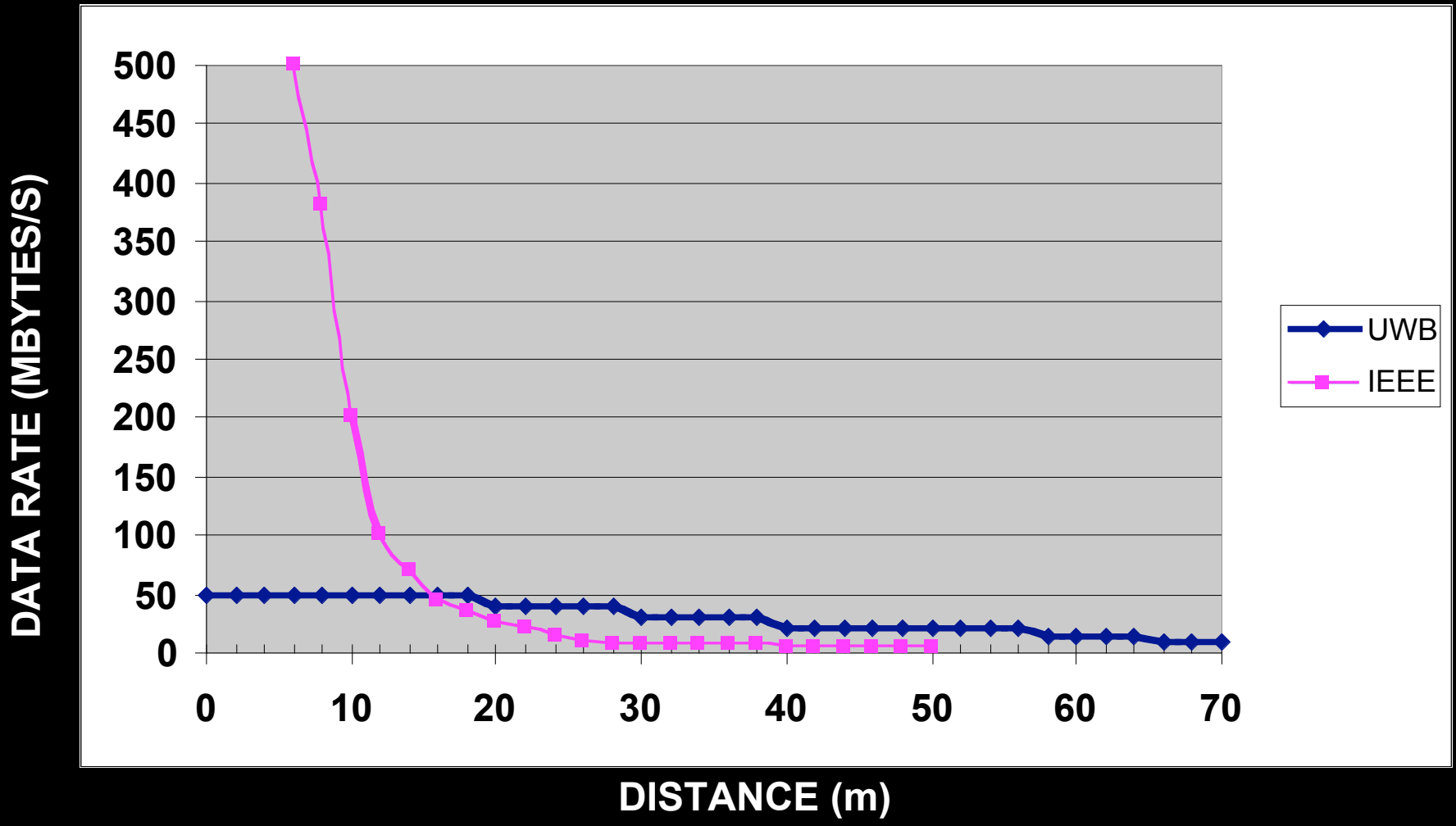
C = Channel Capacity (bits/sec)

BW = Channel Bandwidth (Hz)

SNR = Signal to Noise Ratio

$$= \frac{\text{Received Signal Power}}{(\text{Bandwidth})\,(\text{Noise Power Spectral Density})}$$

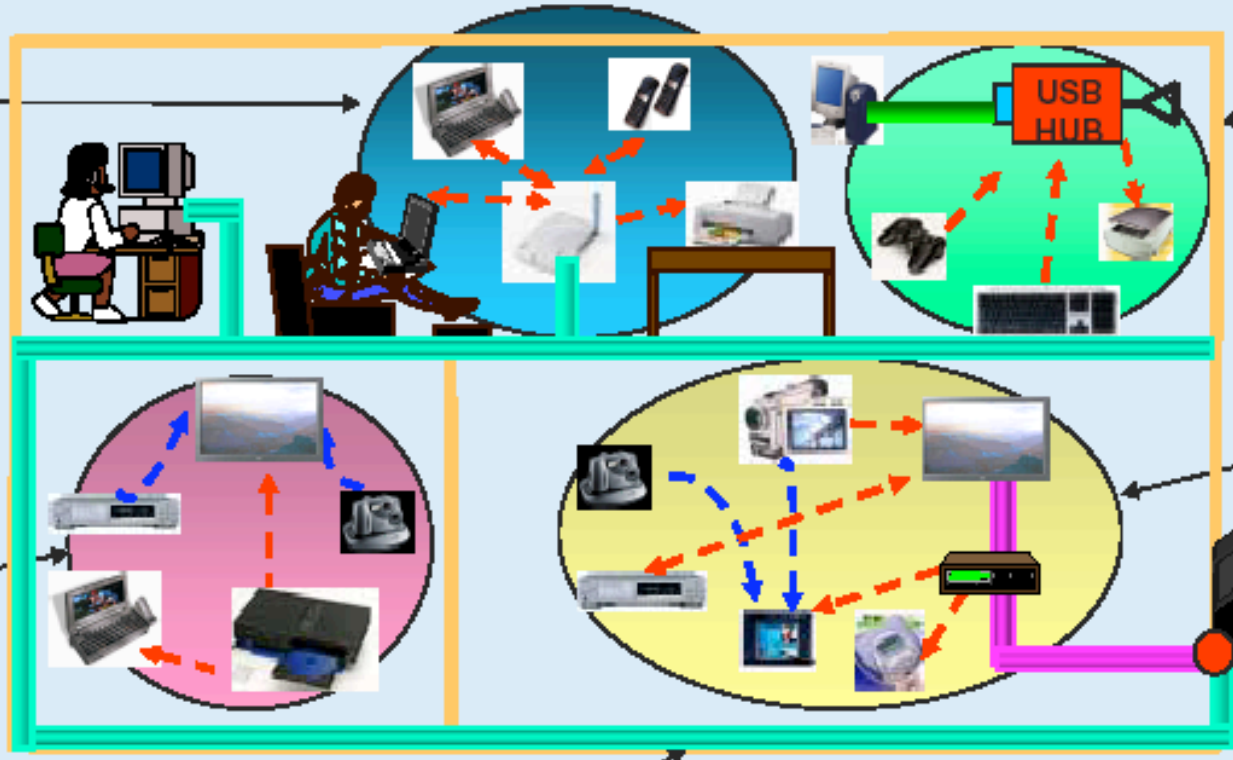
UWB DATA RATE VS. RANGE FOR DIFFERENT TECHNOLOGIES



SOURCE: INTEL

Ground Penetrating Radars

Wireless Offices & Homes



Office Cluster (infrastructure)

USB Cluster (ad-hoc) PC, printer, scanner, etc.

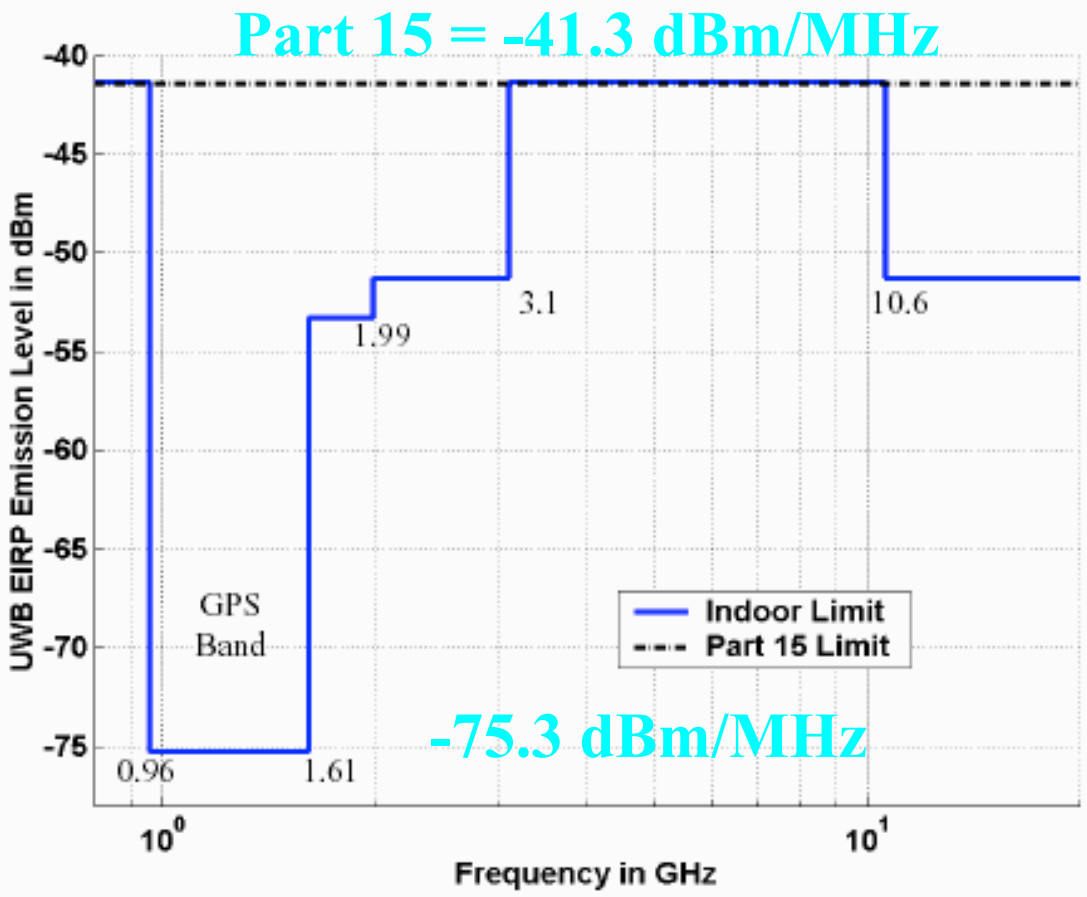
Office Multi-media Cluster (infrastructure-based)

Ad-hoc Video Conferencing Room

Network Gateway

Wired Backbone

UWB Emission Limits

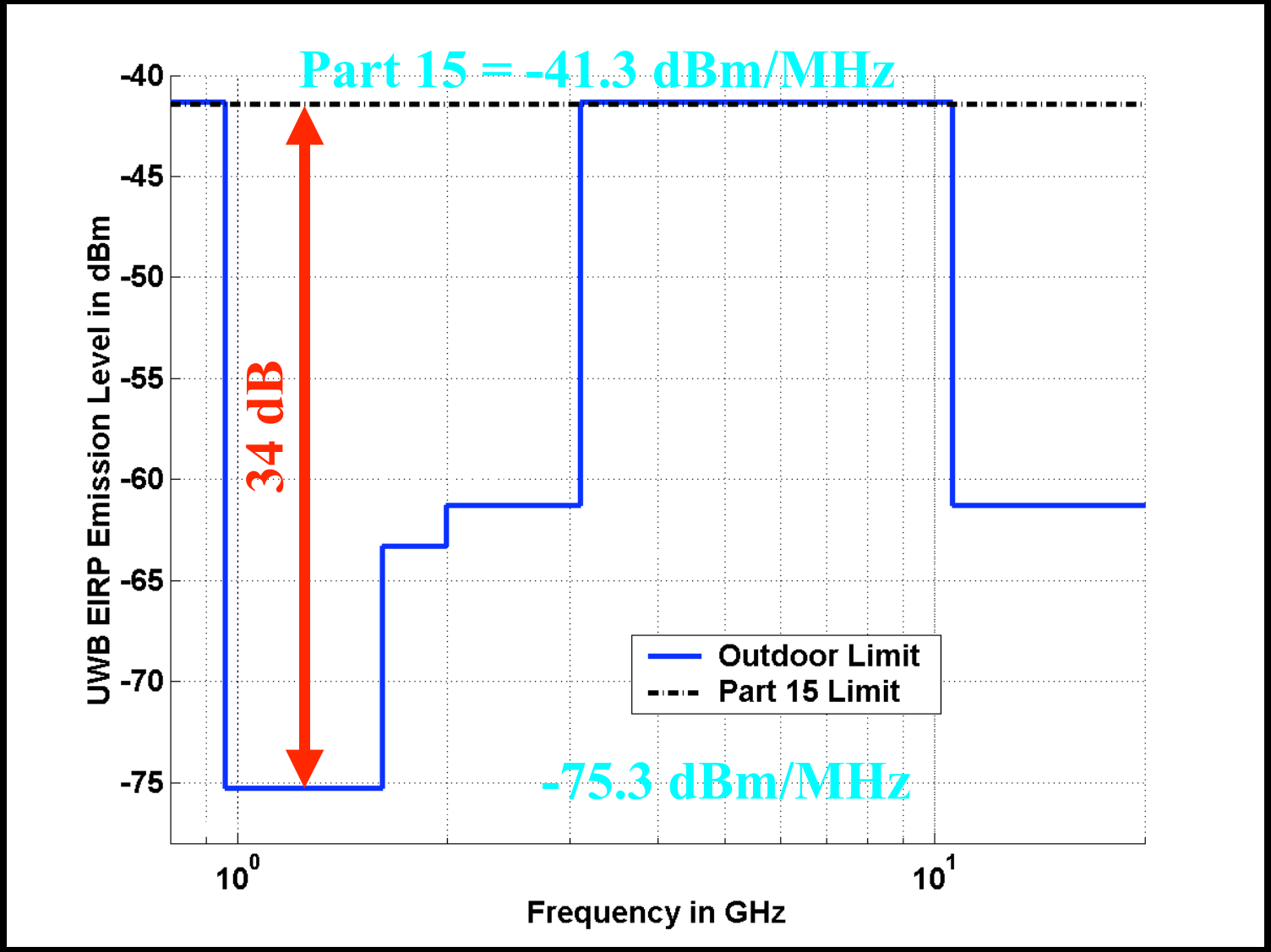


UWB Emission Limit for Indoor Systems

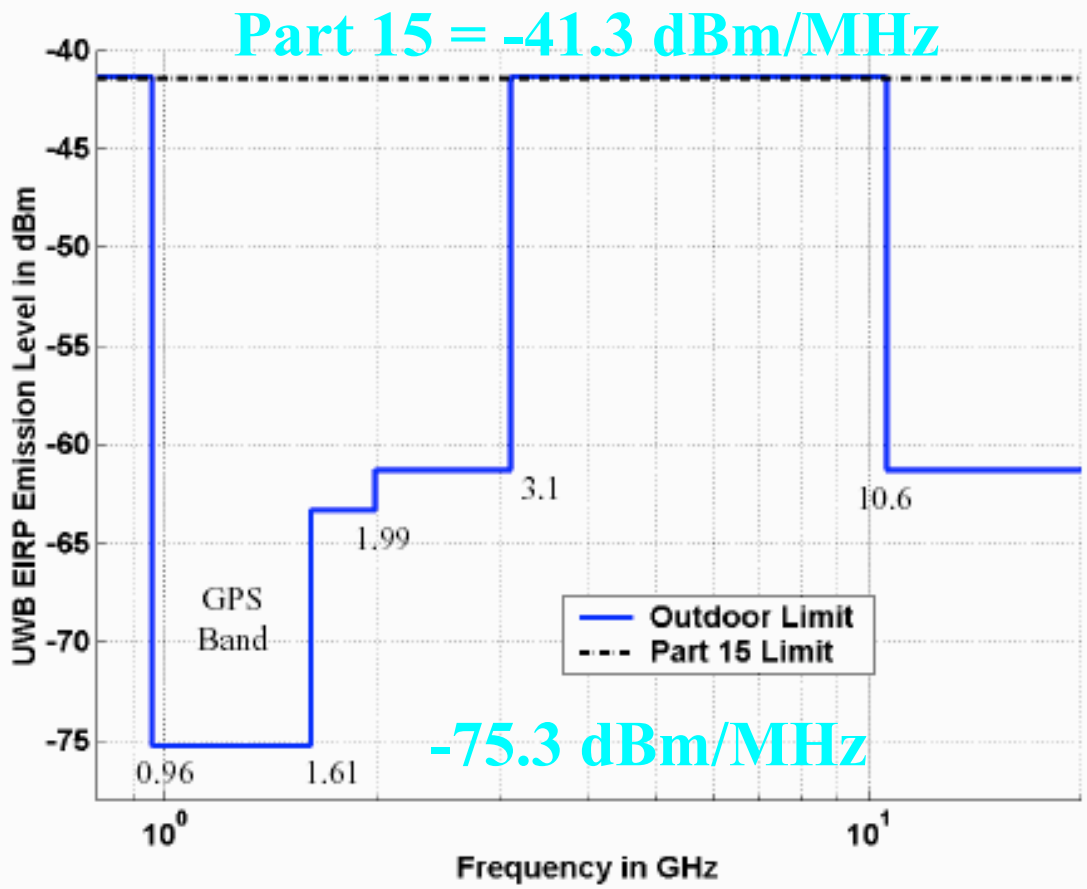
U.S. LIMITS

Equipment must be designed to ensure that operation can only occur indoors or it must consist of hand-held devices that may be employed for such activities as peer-to-peer operation.

DIFFERENCE IS 34 dB



UWB Emission Limits



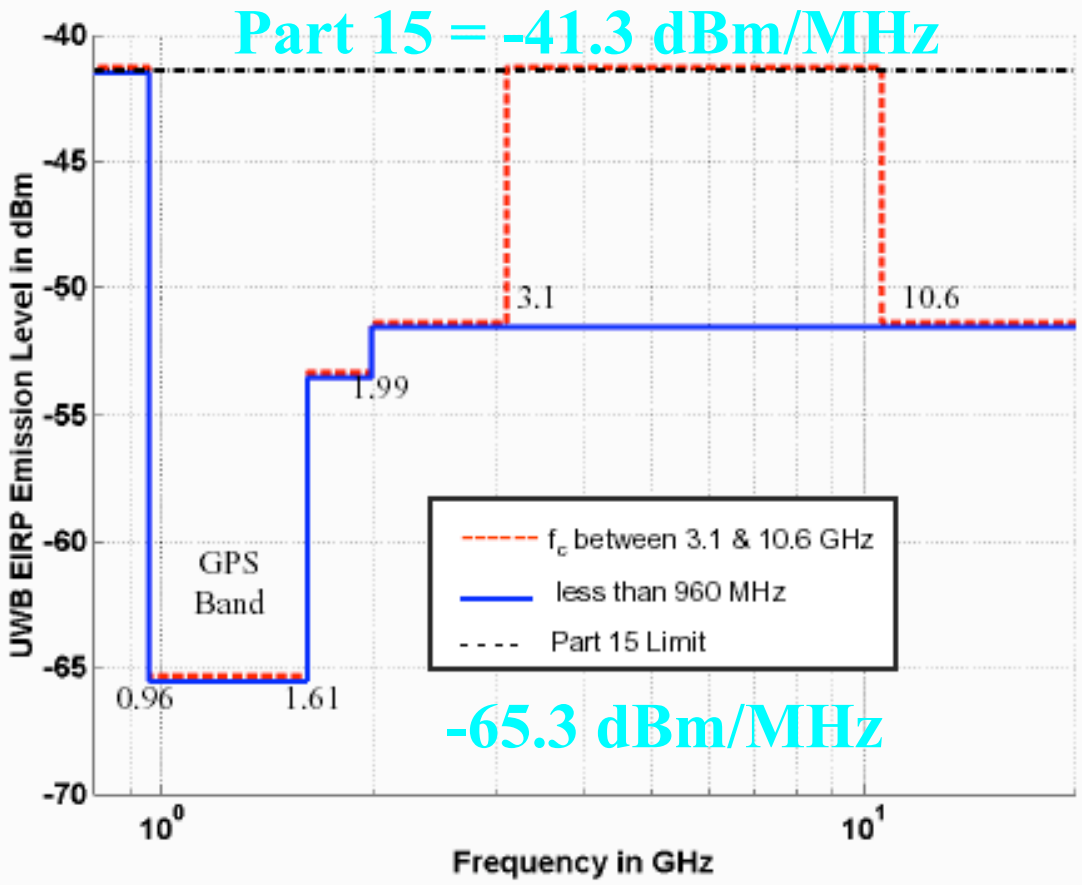
UWB Emission Limit for Outdoor Systems

U.S. LIMITS

Equipment must be hand-held.

Same GPS mask for vehicle radars

UWB Emission Limits



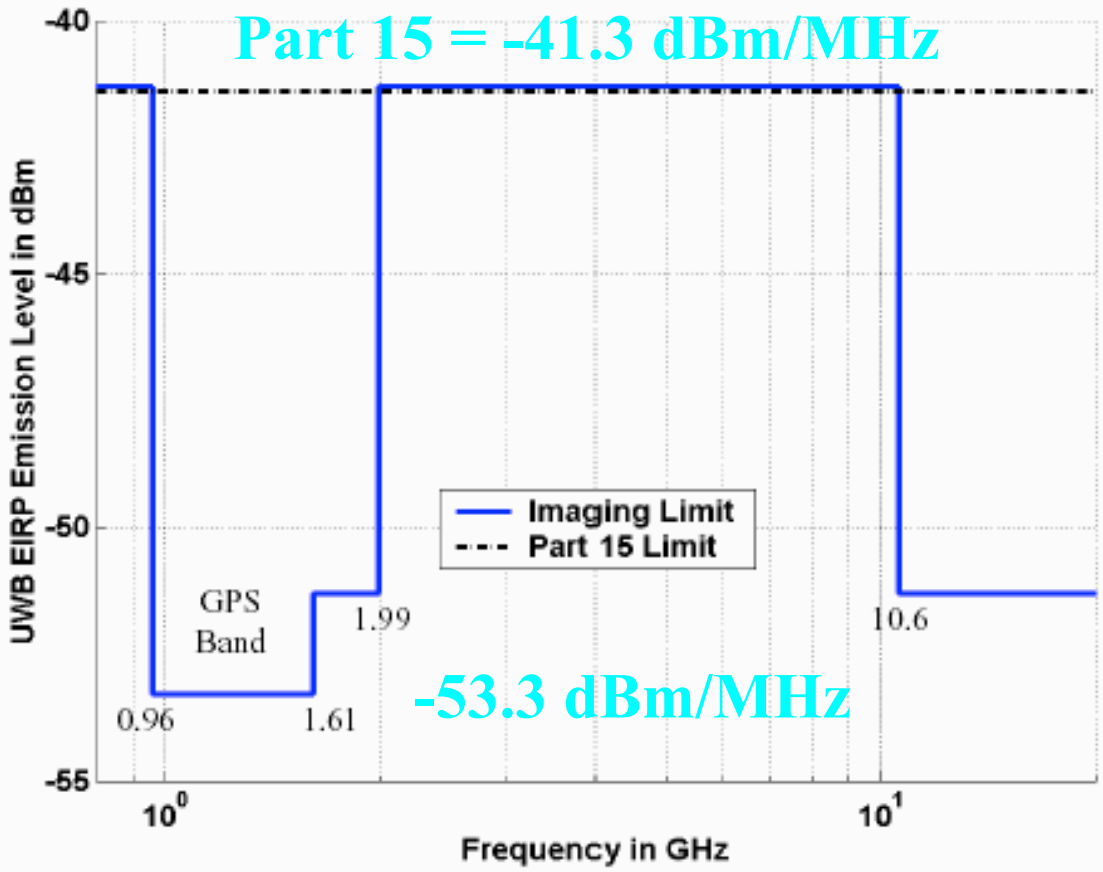
10 dB Stronger

GPRs, Wall Imaging, & Medical Imaging Systems

U.S. LIMITS

Operation is limited to law enforcement, fire and rescue organizations, scientific research institutions, commercial mining companies, and construction companies.

UWB Emission Limits



20 dB Stronger

UWB Emission Limits for Thru-wall Imaging & Surveillance Systems

U.S. LIMITS

Operation is limited to law enforcement, fire and rescue organizations. Surveillance systems may also be operated by public utilities and industrial entities.

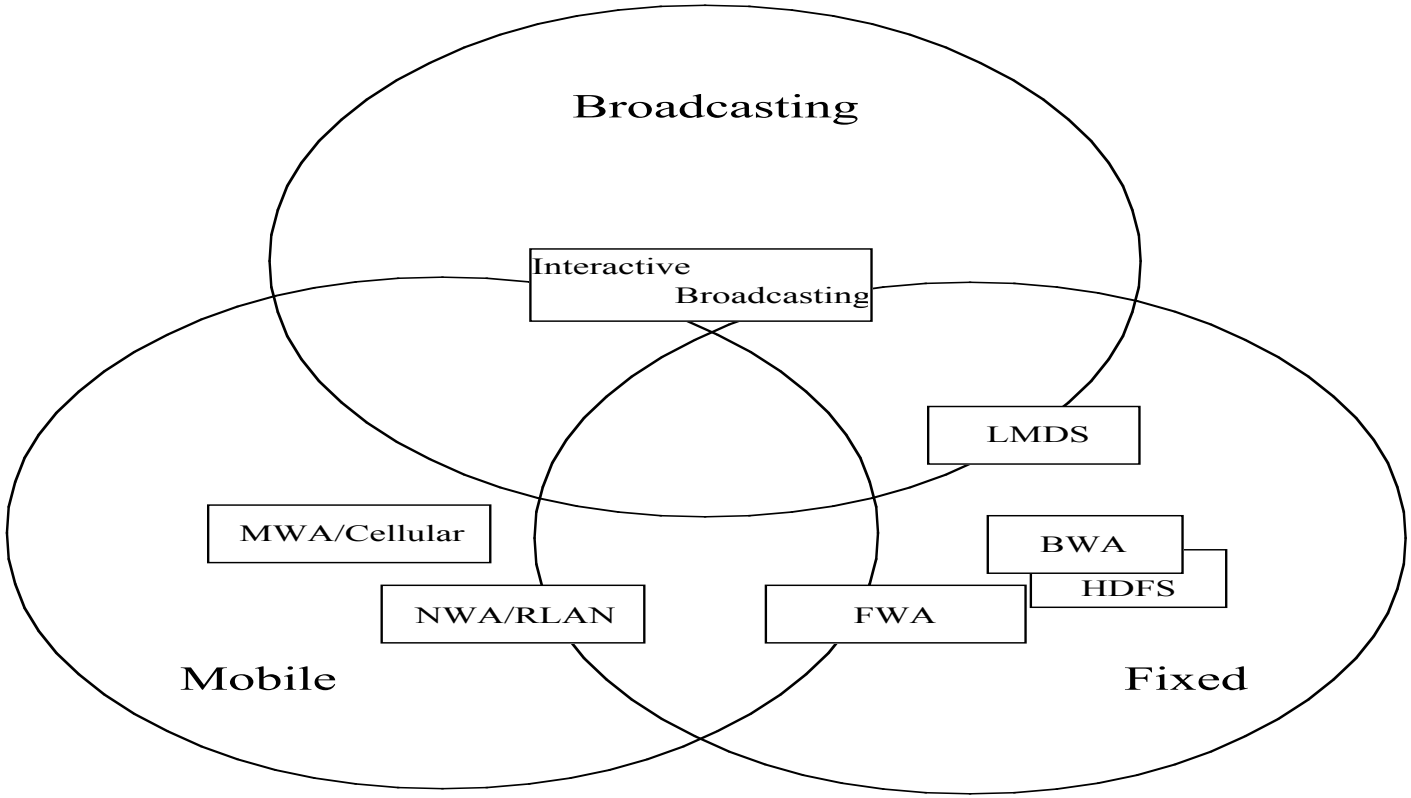
SOFTWARE DEFINED RADIO

- NEW TECHNOLOGY USING SOFTWARE (COMPUTERS), RATHER THAN HARDWARE FOR TRANSMITTERS AND RECEIVERS TO CHANGE OPERATING PARAMETERS, INCLUDING FREQUENCY, MODULATION, AND POWER
- RADIOS QUICKLY CHANGE TRANSMIT FREQUENCIES AND FORMAT
- DESIGNED TO ALLEVIATE POTENTIAL SPECTRUM SHORTAGE AND SPUR MORE EFFICIENT USE OF BANDWIDTH
- WILL ASSIST INTEROPERABILITY, PARTICULARLY FOR PUBLIC SAFETY AND BETWEEN FEDERAL AND LOCAL OFFICIALS
- ITU-R SG 8 STUDYING APPROPRIATE TECHNICAL CHARACTERISTICS, FREQUENCY BANDS, INTERFERENCE CONSIDERATIONS, OPERATIONAL ISSUES, AND DEFINITIONS

COGNITIVE RADIO

- NEW TECHNOLOGY USING SMART RADIOS TO ADAPT THEIR USE OF SPECTRUM IN RESPONSE TO INFORMATION EXTERNAL TO THE RADIO
- GEOLOCATION INFORMATION CAN BE USED TO DETERMINE IF TRANSMISSIONS ARE PERMISSIBLE
- SENSING OF THE RF ENVIRONMENT TO DETERMINE OPTIMAL FREQUENCIES AND TRANSMIT POWERS, WHILE AVOIDING HARMFUL INTERFERENCE TO OTHERS
- INTERPRET AND TRANSMIT SIGNALS IN DIFFERENT FORMATS OR MODULATION SCHEMES
- IDENTIFICATION OF VACANT SPECTRUM CHANNELS
- EXPLOITATION OF THE INTERFERENCE TEMPERATURE CONCEPT

TERRESTRIAL WIRELESS INTERACTIVE MULTIMEDIA



LMDS:	Local multipoint distribution system	RLAN:	Radio local area network
FWA:	Fixed wireless access	NWA:	Nomadic wireless access
BWA:	Broadband fixed wireless access	MWA:	Mobile wireless access
HDFS:	High density applications in the fixed service		

SPECTRUM MANAGEMENT (ITU-R SG 1) STUDIES

- HOW ARE INTERACTIVE MULTIMEDIA APPLICATIONS OF TERRESTRIAL FIXED, MOBILE, AND BROADCASTING SERVICES CONVERGING TECHNICALLY?
- HOW DOES TECHNICAL CONVERGENCE IMPACT ON THE NATIONAL AND INTERNATIONAL RADIO REGULATORY ENVIRONMENT?
- IF TECHNICAL CONVERGENCE IMPACTS THE SERVICE DEFINITIONS OF THE RADIO REGULATIONS, HOW SHOULD THE DEFINITIONS BE REVISED?

SPECTRUM MANAGEMENT (ITU-R SG 1) QUESTIONS

- WHAT CHARACTERISTICS DOES A TERRESTRIAL WIRELESS INTERACTIVE MULTIMEDIA SYSTEM HAVE?
- WHAT ARE THE APPLICATIONS AND TECHNOLOGIES THAT FALL INTO THIS CATEGORY?
- HOW DO THESE APPLICATIONS AND TECHNOLOGIES RELATE TO THE SPECTRUM?
- WHAT ARE THE SHARING SCENARIOS?
- WHAT ARE REGULATORY IMPEDIMENTS?
- WHAT ARE TRENDS (CURRENT AND FORESEEN) THAT WILL IMPACT THE RESPONSES TO THESE QUESTIONS?

BROADCAST (ITU-R SG 6) STUDIES

STUDY GROUP 6 STUDIES TERRESTRIAL AND SATELLITE BROADCASTING FROM END-TO-END, INCLUDING VISION, SOUND, MULTIMEDIA AND DATA SERVICES INTENDED FOR THE GENERAL PUBLIC. USE IS MADE OF POINT-TO-EVERYWHERE INFORMATION DELIVERY. WHEN RETURN CHANNELS ARE REQUIRED FOR ACCESS CONTROL, INTERACTIVITY, ETC., AN ASYMMETRICAL INFRASTRUCTURE IS USED.

MOBILE SERVICE STUDIES ITU-R WORKING PARTY 8F (IMT-2000 AND BEYOND)

- FUTURE SYSTEMS WITH DATA RATES > 2 Mbit/s
- INCLUDE FREQUENCY BANDS ABOVE 3 GHz
- SERVICE APPLICATIONS, OBJECTIVES AND USER NEEDS
- INCLUDE ENHANCED INTERNET PROTOCOL
- TECHNICAL AND OPERATIONAL ISSUES, AND CHARACTERISTICS
- HARMONIZE SPECTRUM
- MIGRATION STRATEGY
- GLOBAL CIRCULATION AND MUTUAL RECOGNITION AGREEMENTS

THIRD GENERATION (IMT-2000 AND BEYOND)

1710 - 1755 MHz - FIXED & MOBILE

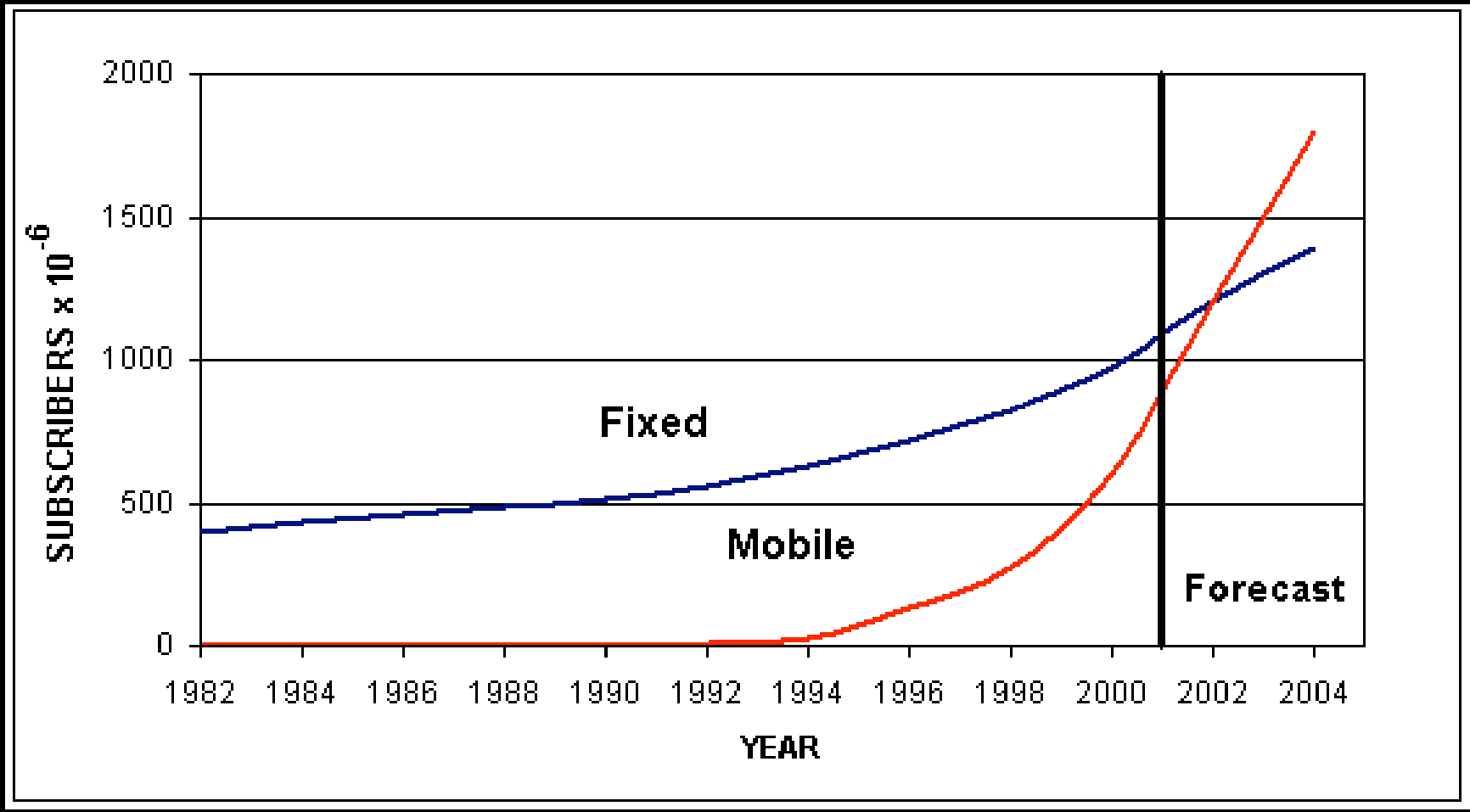
1755 - 1850 MHz - DEFENSE USES

2110 - 2150 MHz - FIXED & MOBILE

2160 - 2165 MHz - FIXED & MOBILE

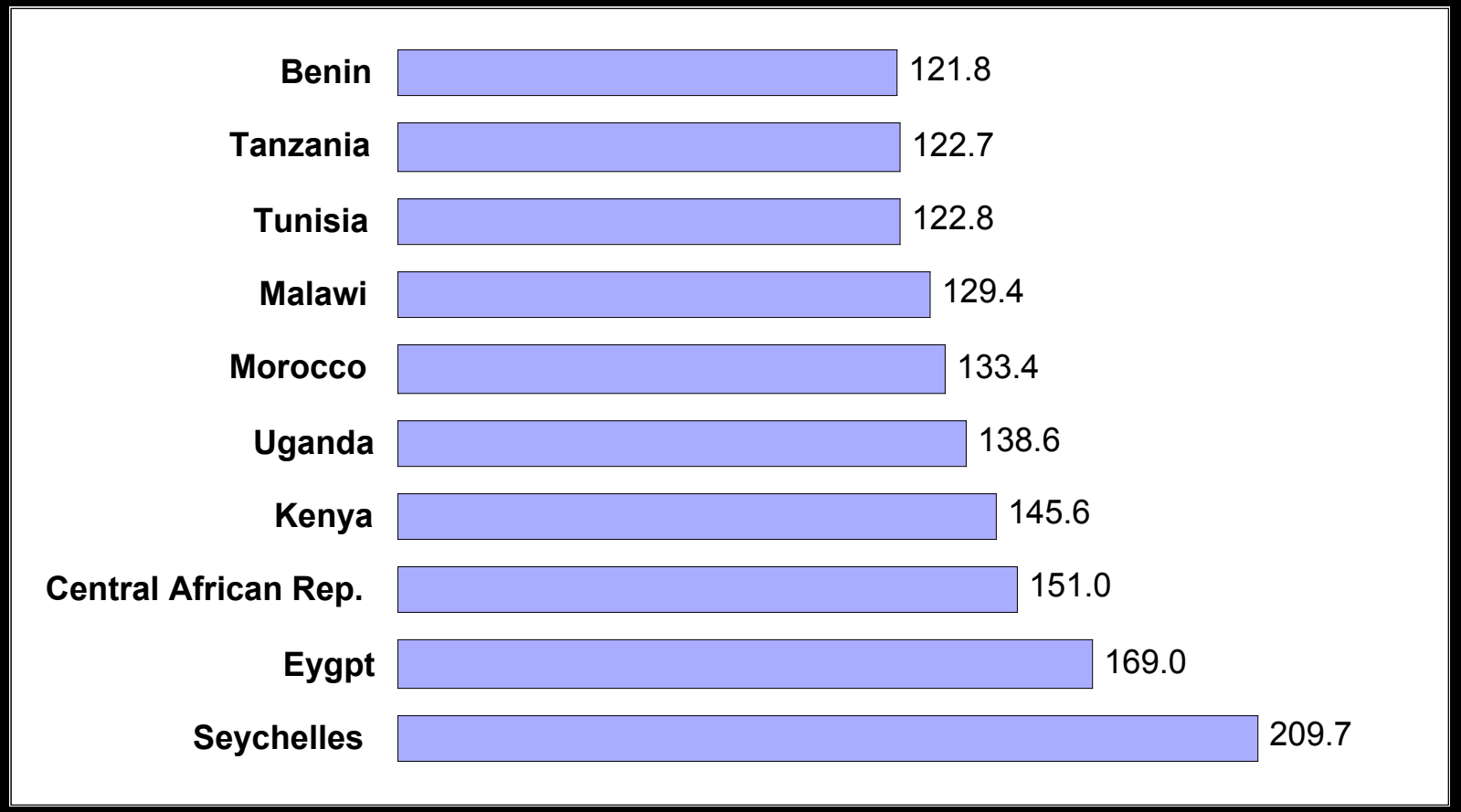
2500 - 2690 MHz - MMDS and ITFS

MOBILE AND FIXED TELEPHONE SUBSCRIBERS (WORLDWIDE) AS A FUNCTION OF YEARS



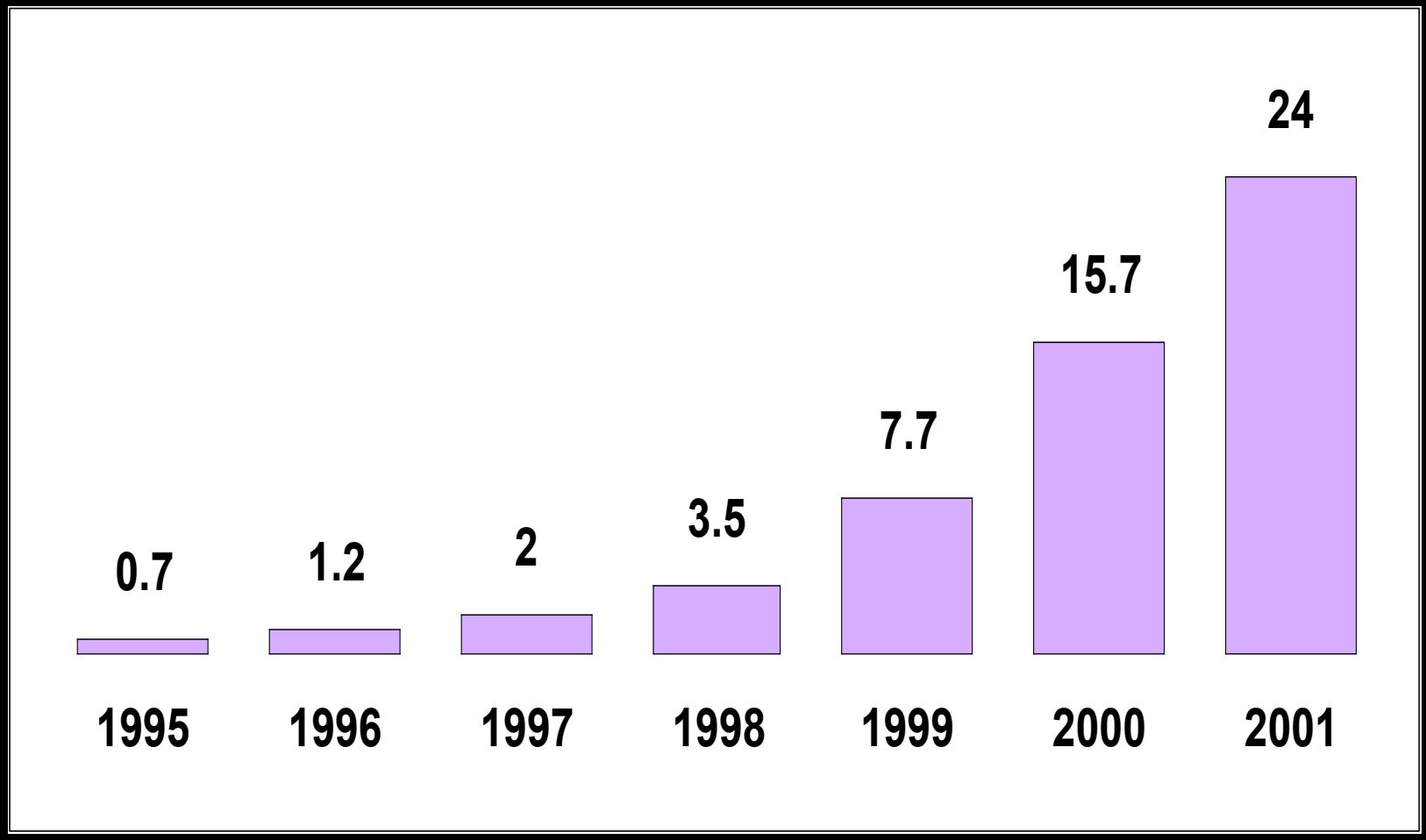
Source: ITU World Telecommunication Indicators Database and ITU projections.

MOBILE GROWTH IN AFRICA (1995-2001) TOP 10 ECONOMIES, COMPOUND ANNUAL GROWTH RATE (%)



Source: ITU Internet Reports 2002: Internet for a Mobile Generation.

MOBILE SUBSCRIBERS IN AFRICA IN 2001 (MILLIONS)



Source: ITU Internet Reports 2002: Internet for a Mobile Generation.

ASIA-PACIFIC AS OF SEPTEMBER 2003

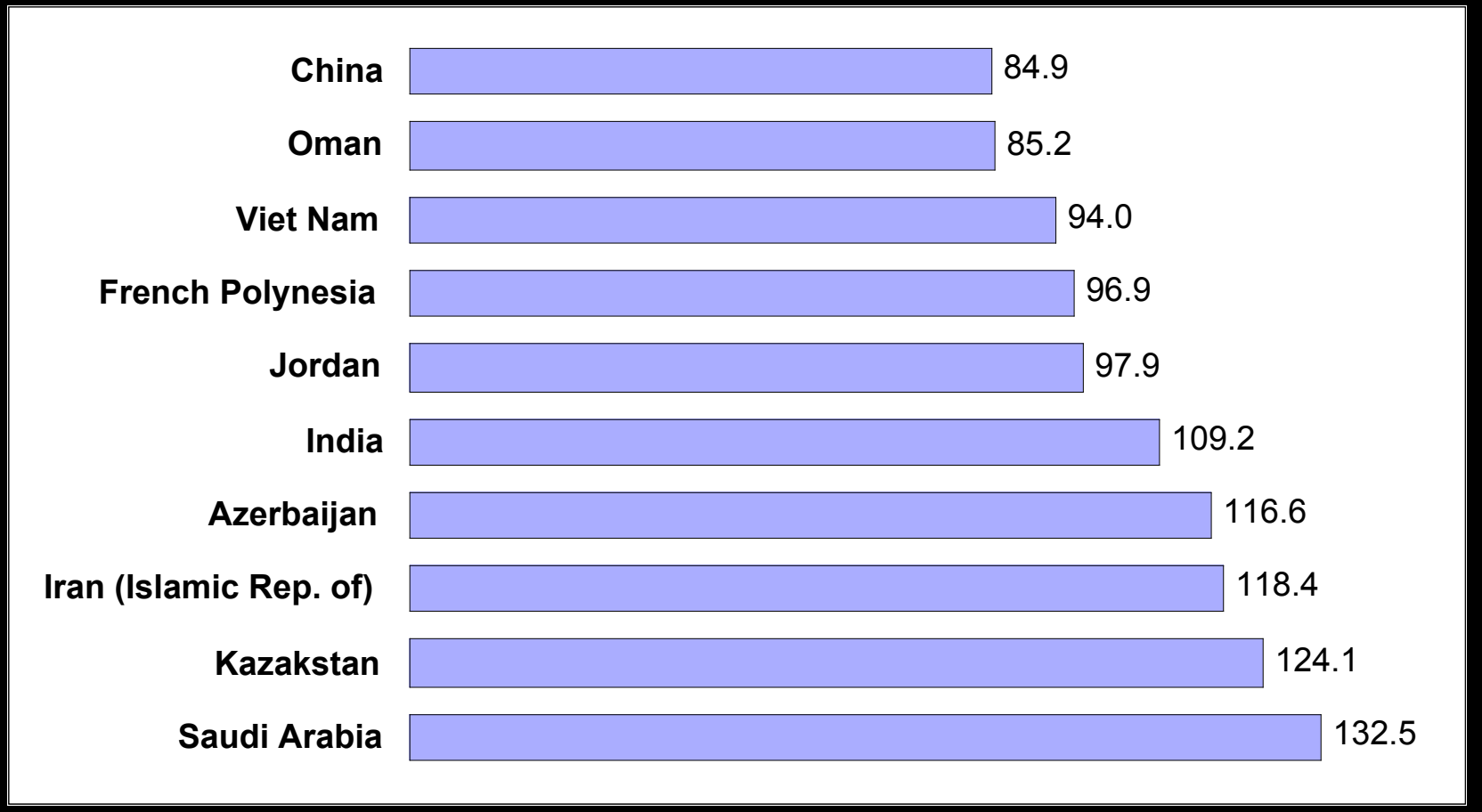
CELLULAR TELEPHONE SUBSCRIPTIONS BY SELECTED COUNTRY (TOTAL 511.64 MILLION)

COUNTRY	SUBSCRIBERS	NUMBER OF NETWORKS	POPULATION PENETRATION (%)
AUSTRALIA	14,554,840	6	73.76
BANGLADESH	1,222,800	4	0.88
CHINA	249,974,000	6	19.42
HONG KONG	6,754,217	9	91.35
INDIA	18,297,147	69	1.74
INDONESIA	16,480,174	9	7.02
JAPAN	78,594,300	8	61.78
KAZAKHSTAN	1,209,600	3	7.22
KYRGHYZ REPUBLIC	127,280	2	2.60
MALAYSIA	10,684,000	8	46.27
PAKISTAN	2,479,580	4	1.65
PHILIPPINES	20,168,981	8	23.83
SINGAPORE	3,402,200	3	73.82
SOUTH KOREA	33,273,788	8	68.91
UZBEKISTAN	288,280	8	1.11
VIETNAM	1,869,000	2	3.12

SOURCE: GLOBAL MOBILE SUBSCRIBER DATABASE

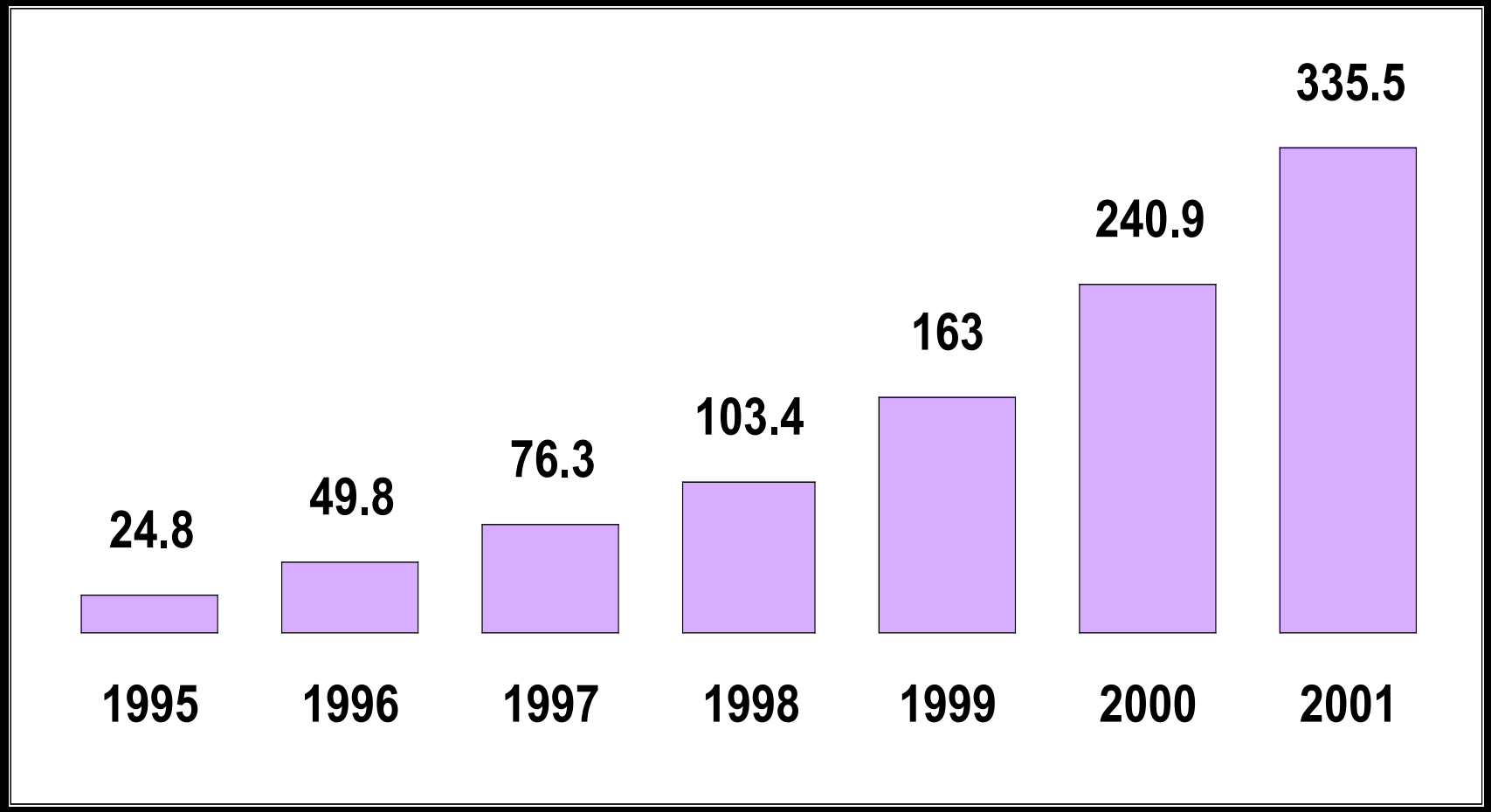
MOBILE GROWTH IN ASIA-PACIFIC (1995-2001)

TOP 10 ECONOMIES, COMPOUND ANNUAL GROWTH RATE (%)



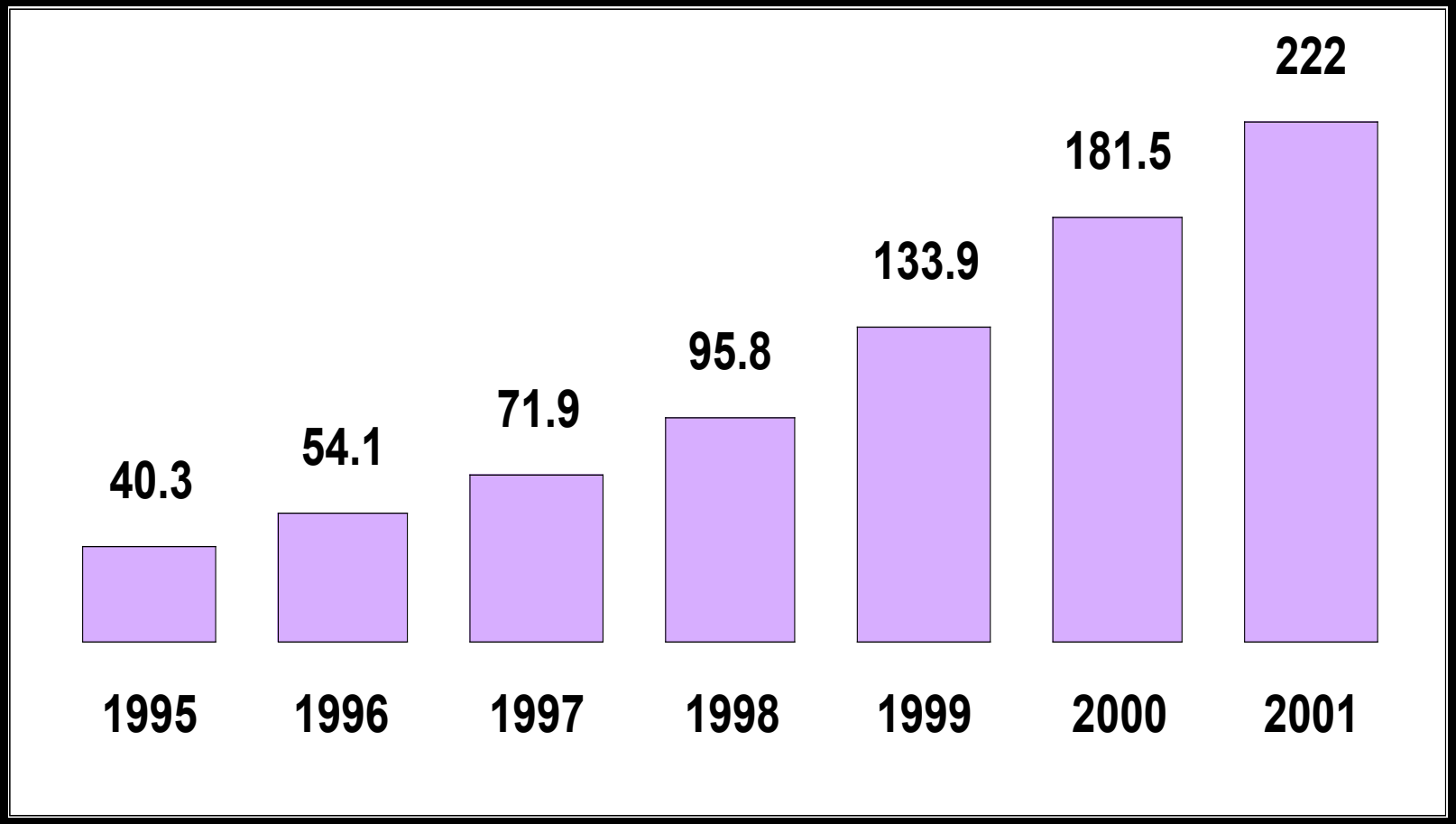
Source: ITU Internet Reports 2002: Internet for a Mobile Generation.

MOBILE SUBSCRIBERS IN ASIA AND THE PACIFIC IN 2001 (MILLIONS)



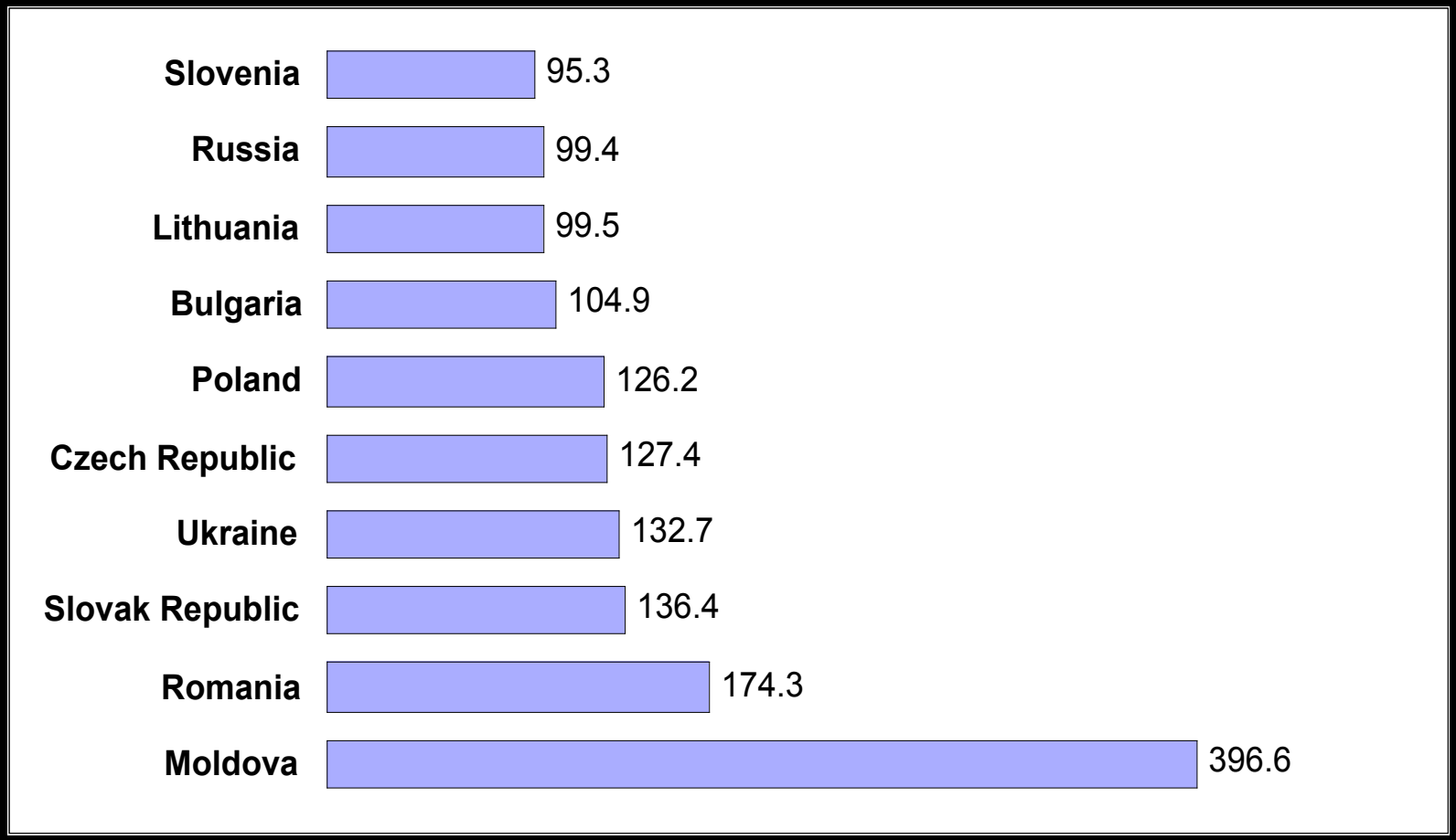
Source: ITU Internet Reports 2002: Internet for a Mobile Generation.

MOBILE SUBSCRIBERS IN THE AMERICAS IN 2001 (MILLIONS)



Source: ITU Internet Reports 2002: Internet for a Mobile Generation.

MOBILE GROWTH IN EUROPE (1995-2001) TOP 10 ECONOMIES, COMPOUND ANNUAL GROWTH RATE (%)



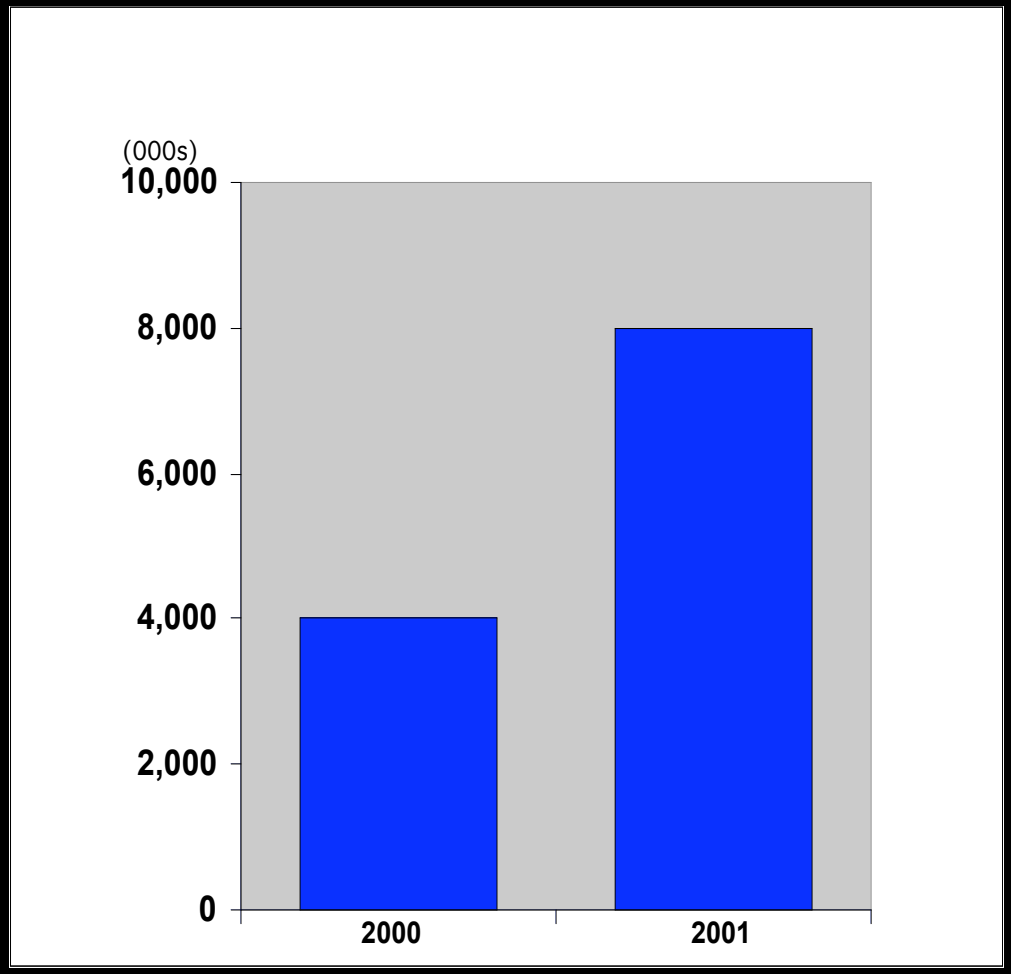
Source: ITU Internet Reports 2002: Internet for a Mobile Generation.

ADVANCED WIRELESS SERVICES

- STUDIES HAVE JUST BEGUN OF TYPES OF ADVANCED, FUTURE MOBILE AND FIXED COMMUNICATIONS SERVICES, INCLUDING 3G
- STUDIES
  - TECHNICAL CHARACTERISTICS
  - SPECTRUM REQUIREMENTS
    - AMOUNT OF SPECTRUM
    - FREQUENCY BANDS
- STUDIES INCLUDE OF BANDS CURRENTLY USED FOR ANALOG CELLULAR, PERSONAL COMMUNICATIONS SERVICE, SPECIALIZED MOBILE RADIO AND THE FIVE BANDS JUST ALLOCATED BY WRC-2000 (ISTANBUL)

Big Growth for WLANs

Worldwide Wireless LAN Shipments



Source: CDW-G Wireless Guide.

DIGITAL FM BROADCAST

- 88 - 108 MHz BAND
- EXISTING FM RADIO STATIONS USE EITHER +/- 75 kHz DEVIATION AT 200 kHz CHANNEL SEPARATION, OR +/- 50 kHz DEVIATION AT 100 kHz CHANNEL SEPARATION
- IN-BAND ON CHANNEL (IBOC) DIGITAL OVERLAY EXPERIMENTS
- IBOC DIGITAL SIGNAL INSERTED ~25 dB BELOW THE ANALOG FM SIGNAL
- OTHER STANDARDS BEING DISCUSSED INTERNATIONALLY WITH THE HOPE OF FINDING A COMMON GLOBAL STANDARD

DIGITAL SOUND BROADCASTING BELOW 30 MHz

THE WORLD BROADCASTING UNION AND THE ITU HAVE BEEN COOPERATING IN SUPPORT OF STUDIES LEADING TO THE ADOPTION OF SINGLE WORLDWIDE BROADCASTING STANDARDS, PARTICULARLY:

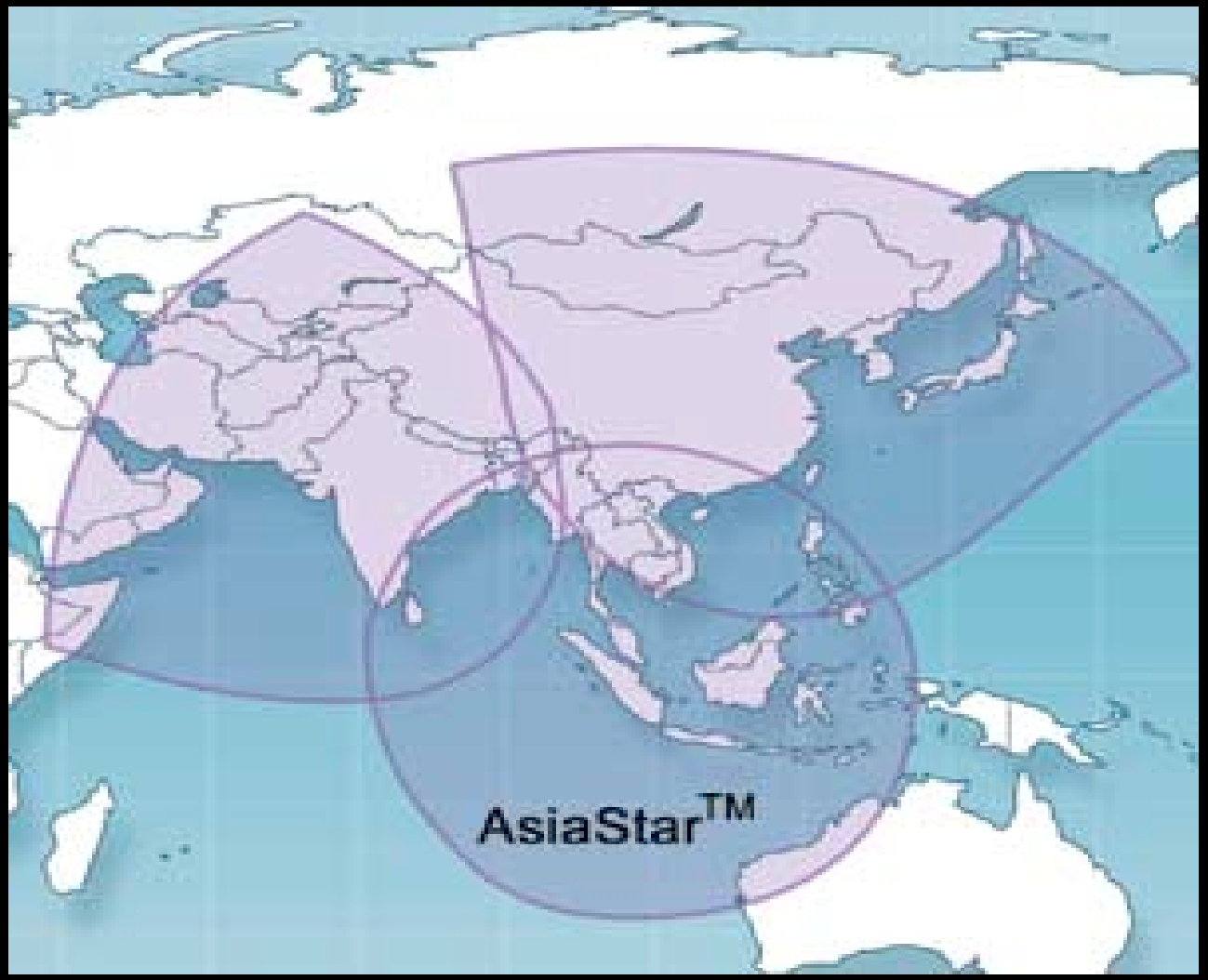
- SINGLE COMMON DIGITAL SOUND BROADCAST SYSTEM IN LF, MF, AND HF
- DIGITAL CODING AND MODULATION COMPATIBLE WITH EXISTING STATION PLANNING
- WHAT ARE ADVANTAGES OVER ANALOG
- WHAT ARE NEW SERVICES
- COMPLEXITY OF DUAL STANDARD (ANALOG AND DIGITAL) BROADCAST RECEIVERS

SATELLITE RADIO SYSTEMS

	U.S. Services		International
	Sirius	XM satellite radio	Worldspace
Market	auto	auto/home	home/portable
Orbit	inclined	GEO	GEO
Size	3 satellites	2 satellites	3 satellites
Manuf.	Loral	Hughes	Alcatel
Channels	100	100	NA
OEM	Ford	GM	NA

WORLDSPACE COVERAGE
AFRICA, MIDDLE EAST, AND EUROPE

WORLDSPACE COVERAGE
ASIA



DIGITAL TELEVISION

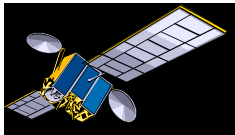
- **THERE ARE TWO COMMON GLOBAL STANDARD (ANALOG) TELEVISION BROADCAST CHANNEL BANDWIDTHS, 6 MHz AND 8 MHz**
- **THERE IS A COMMON DIGITAL TELEVISION DISPLAY FORMAT BUT DIFFERENT RF MODULATION SCHEMES, COFDM AND 8VSB**
- **VERY POLITICAL**
- **RECALL THE DIGITAL LAG IN TRANSITION FROM ANALOG TO DIGITAL (HIGH DEFINITION DEFINED AS EQUIVALENT TO A 35 mm CINEMA PICTURE)**

INTERACTIVE TELEVISION

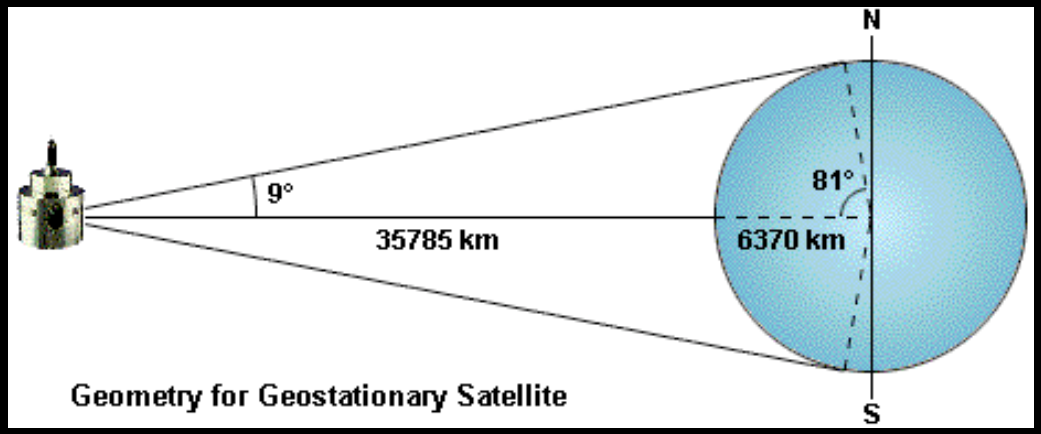
- **STUDIES HAVE BEGUN (JANUARY 2001) OF THE DEFINITION OF *INTERACTIVE TELEVISION SERVICES* SO AS TO FACILITATE APPROPRIATE LICENSING:**
  - **VIDEO PIPELINE (MPEG VIDEO)?**
  - **HIGH SPEED INTERNET PROTOCOL?**
  - **CUSTOMER PREMISES EQUIPMENT?**
  - **ANTI-COMPETITIVE BEHAVIOR?**

BSS-TERRESTRIAL SHARING

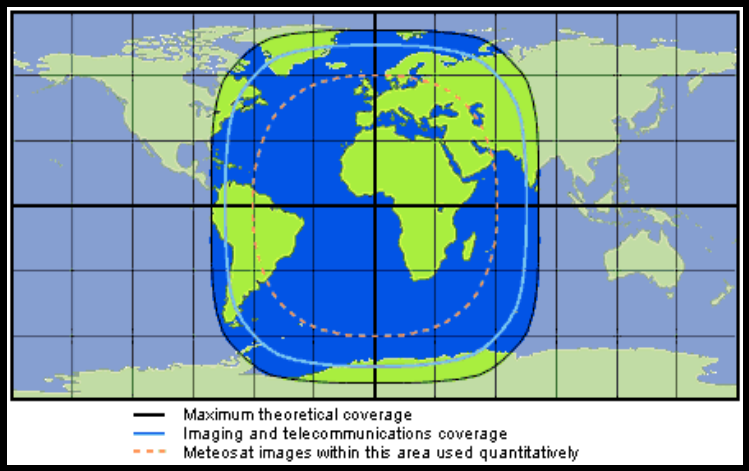
- SHARING WITH GEOSTATIONARY SATELLITE, BROADCAST SATELLITE SERVICE (BSS), IS FEASIBLE
- UNIQUE TECHNICAL PROPOSAL
- MANDATORY INTERFERENCE TESTING REQUIRED (BY U.S. CONGRESS)
- POLITICALLY SENSITIVE



GEOSTATIONARY ORBIT



Geometry for Geostationary Satellite



Ka/Ku-BAND BROADBAND SATELLITE SYSTEMS

- **Medsat** (Aerospatiale)
- **Videosat** (France Telecom)
- **WEST** (Matra Marconi Space)
- **Genesis** (Deutsche Telekom)
- **Euroskyway** (Alenia Spazio)
- **Astra** (Societe Europenne des Satellites)
- **Megasat** (Mexico)
- **Gelikon** (Informkosmos)
- **South Africa-sat** (South Africa)
- **Diamondsat** (South Africa)
- **PC DataStar** (PCG)
- **Afrisat** (United Kingdom)

BROADBAND CAPACITY ISSUES

- EXPECTED GROWTH IN SATELLITE AS DELIVERY MECHANISM FOR BROADBAND DATA COULD STRAIN SATELLITE CAPACITY
- MILLIONS OF PEOPLE IN RURAL AREAS WILL NEED BROADBAND VIA SATELLITE
- CURRENT ESTIMATE: 20,000 BROADBAND SUBSCRIBERS/TRANSPONDER OR 480,000 BROADBAND CONSUMERS/SATELLITE (24 TRANSPONDERS/SATELLITE)

PROMOTING COMMERCIAL MILLIMETER WAVE USE (ABOVE 50 GHz)

- 51.4 - 52.6 GHz AND 58.2 - 59 GHz BANDS ARE ALLOCATED TO FIXED AND MOBILE SERVICES (INTERCONNECT MOBILE SERVICE BASE STATIONS AND INTERCONNECT DIFFERENT SYSTEMS)
- 57 - 64 GHz ALLOCATED IN U.S. TO UNLICENSED USES SO AS TO PROVIDE 7 GHz (VERY HIGH SPEED AND/OR HIGH BANDWIDTH COMMUNICATION OVER SHORT DISTANCES AND FOR NETWORKING BACKBONE PURPOSES IN CONGESTED AREAS)

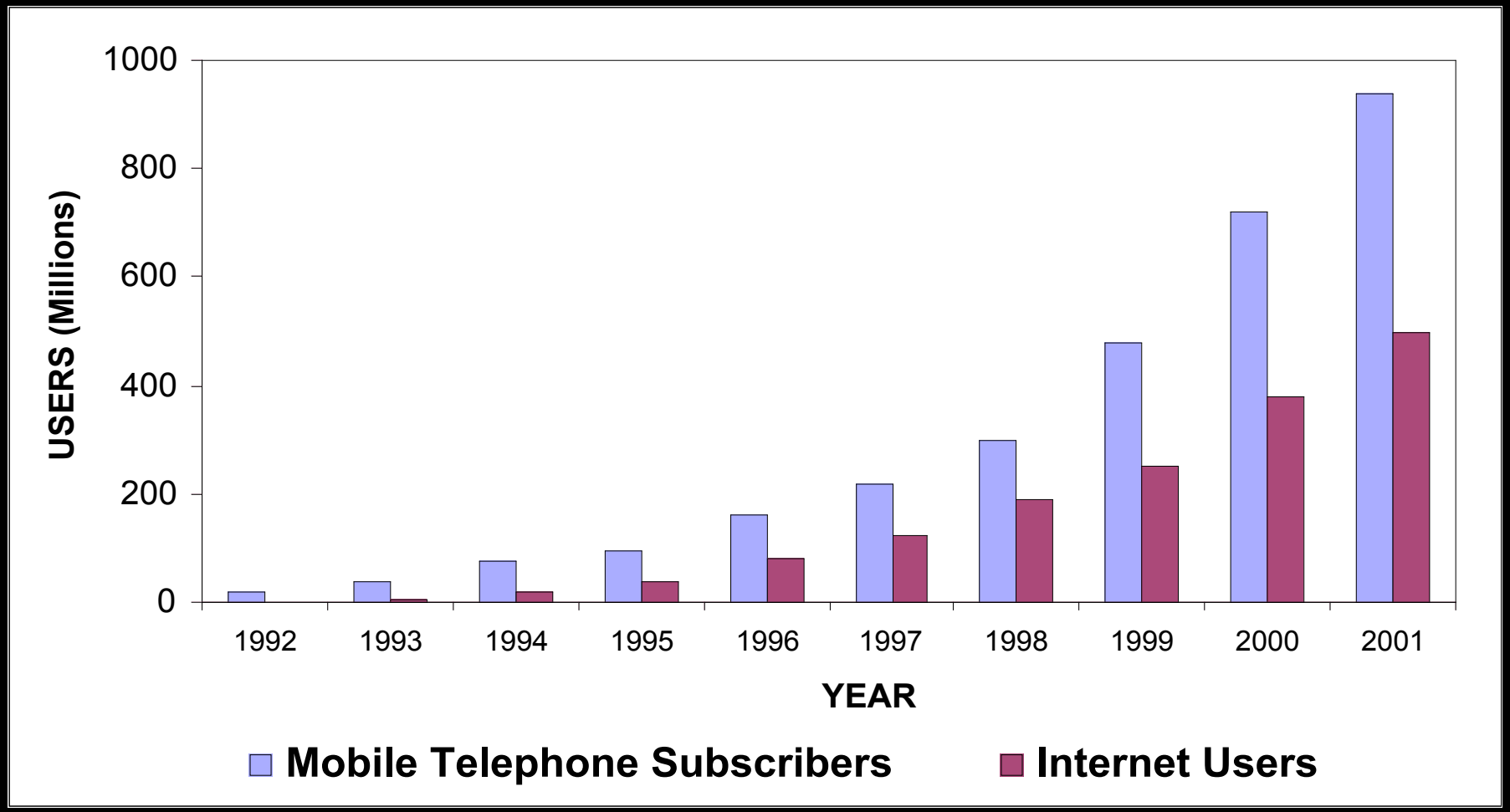
PROMOTING COMMERCIAL MILLIMETER WAVE USE (ABOVE 50 GHz)

- 64 - 66 GHz ALLOCATED TO FIXED AND MOBILE SERVICES, EXCEPT FOR AERONAUTICAL MOBILE SERVICE (AGAIN, INTERCONNECT MOBILE SERVICE BASE STATIONS AND INTERCONNECT DIFFERENT SYSTEMS)
- 65 - 71 GHz ALLOCATED TO INTERSATELLITE SERVICE (ISS) TO MAKE SATELLITE NETWORK INTERCONNECTIONS MORE EFFICIENT (WILL PROMOTE VIDEO TELEPHONY, MEDICAL AND TECHNICAL TELE-IMAGING, HIGH SPEED DATA NETWORKS, AND BANDWIDTH-ON-DEMAND FOR CONSUMERS)

UNLICENSED OPERATION
57 - 64 GHz

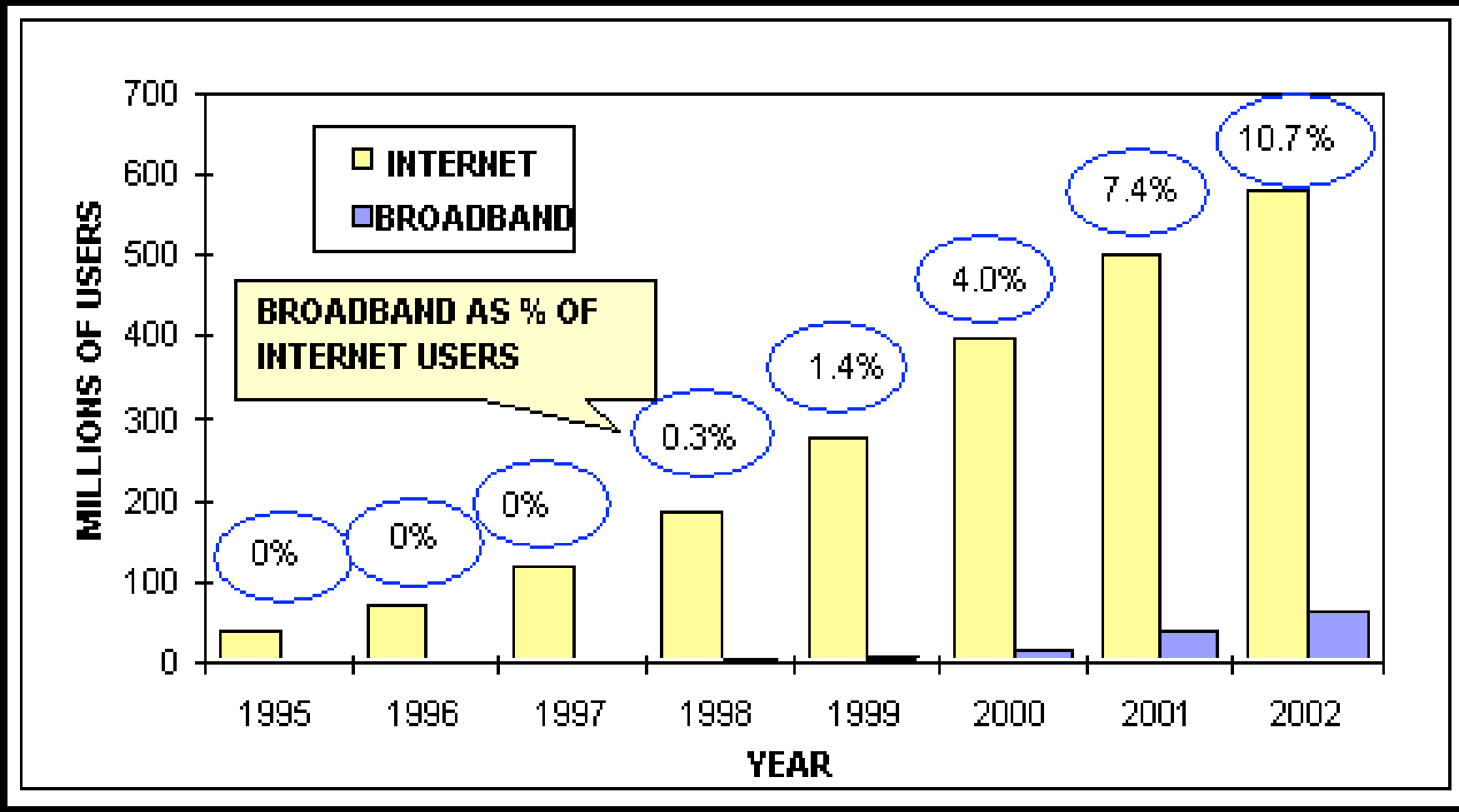
- LICENSING THIS BAND IS UNNECESSARY BECAUSE OF THE VERY LIMITED POTENTIAL FOR INTERFERENCE DUE TO THE LOW POWER LIMITS, THE DRAMATIC OXYGEN ABSORPTION OF RF ENERGY AT FREQUENCIES AROUND 60 GHz, AND THE NARROW BEAMWIDTH OF POINT-TO-POINT ANTENNAS USED OUTSIDE
- MAXIMUM PFD PERMITTED IN THIS 7 GHz BAND IS 9 uW/cm^2 AVERAGE, AND 18 uW/cm^2 PEAK AT 3 METERS
- NOKIA HAS ALREADY BEGUN DEPLOYING UNLICENSED MICRO-CELLULAR EQUIPMENT IN THE BAND 57 - 59 GHz IN EUROPE

WORLDWIDE DIGITAL MOBILE SUBSCRIBERS AND INTERNET USERS



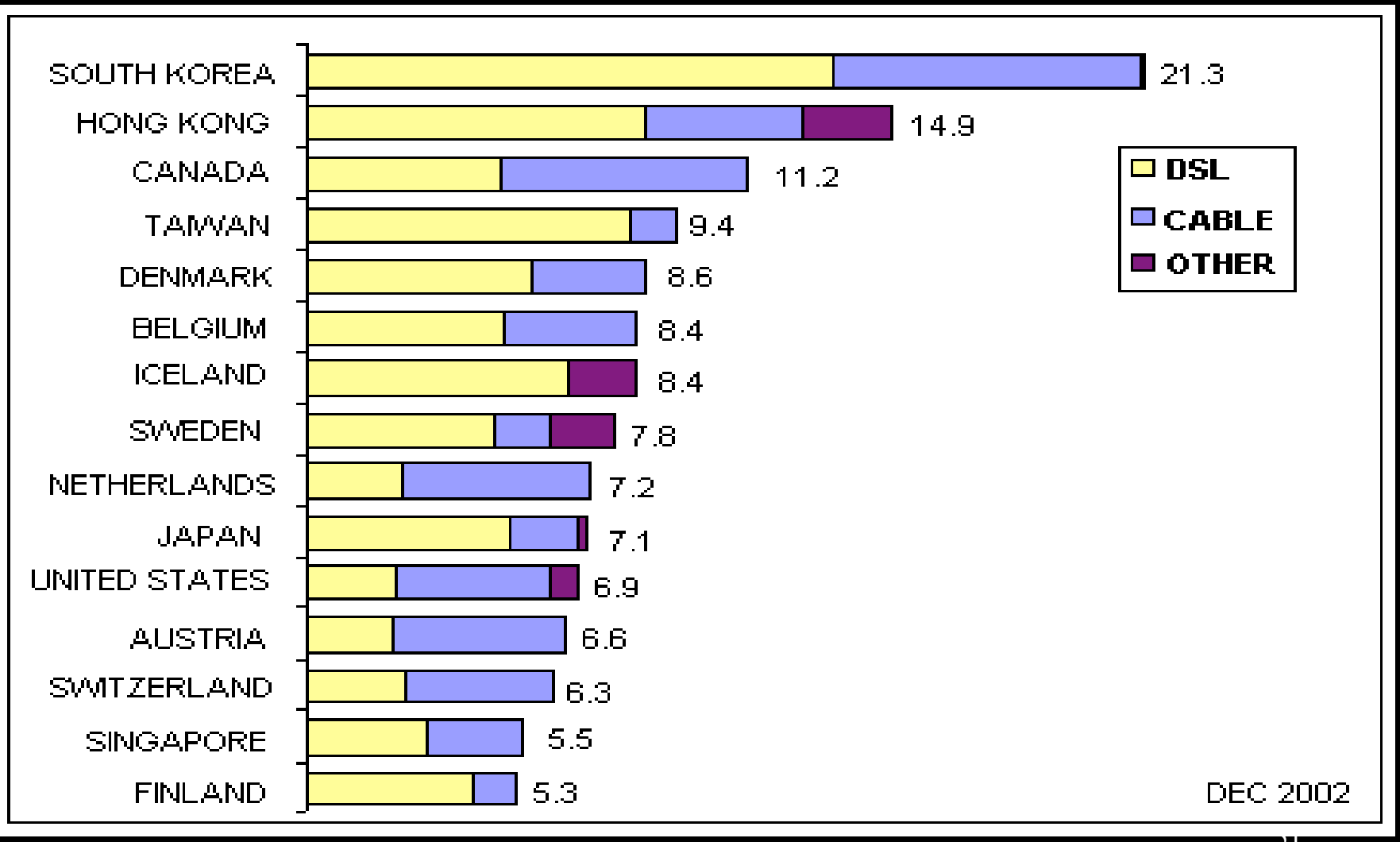
Source: ITU World Telecommunication Indicators Database.

WORLDWIDE BROADBAND AND INTERNET USE



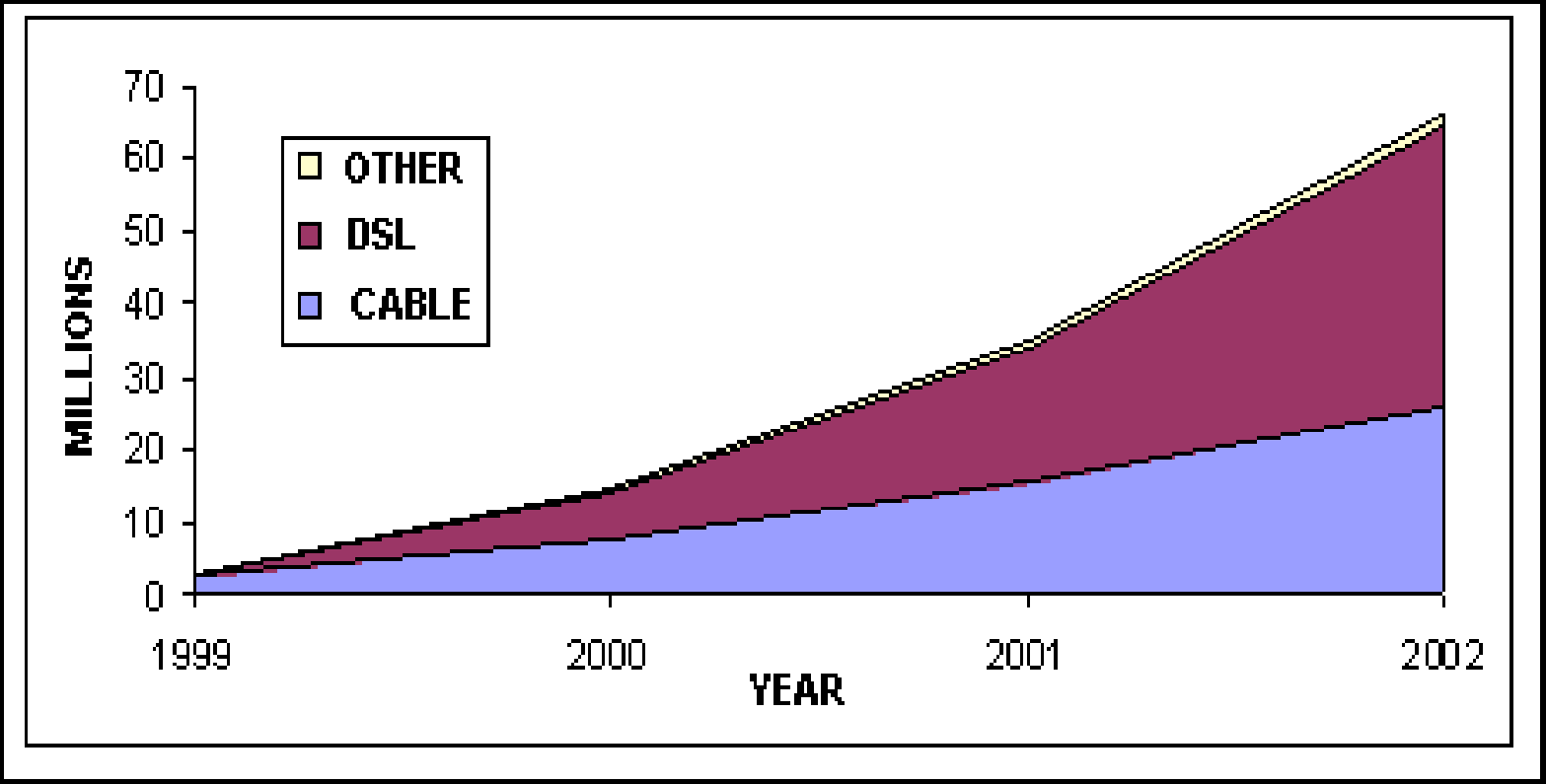
SOURCE: ITU WORLD TELECOMMUNICATION INDICATORS DATABASE

BROADBAND PENETRATION PER 100 INHABITANTS



SOURCE: ITU WORLD TELECOMMUNICATION INDICATORS DATABASE

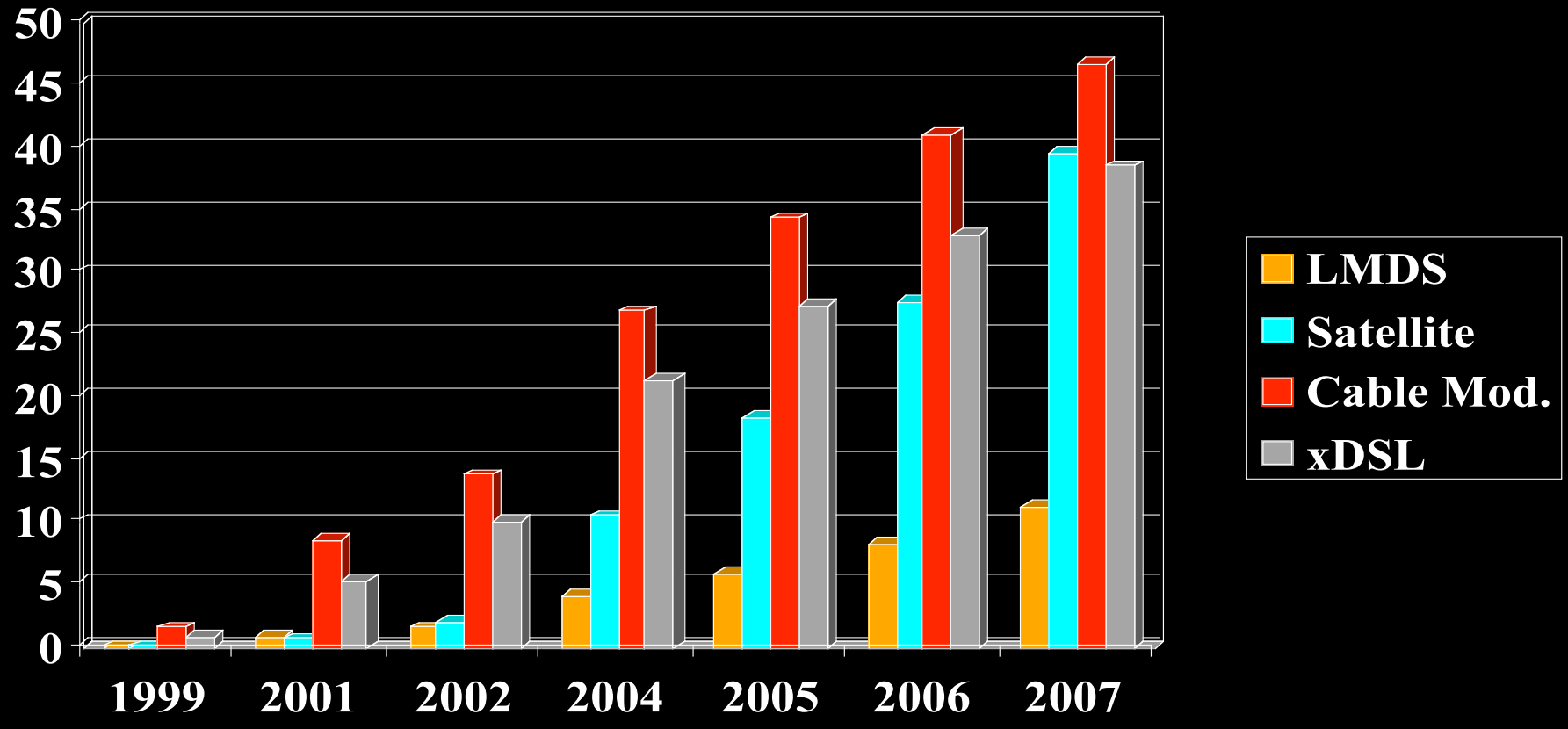
WORLDWIDE BROADBAND PENETRATION



SOURCE: ITU

GLOBAL BROADBAND MARKET

MILLIONS OF SUBSCRIBERS



Source: Publications Resource Group

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William.luther@fcc.gov