FRONTIERS OF RADIOCOMMUNICATIONS

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FEDERAL COMMUNICATIONS COMMISSION

WASHINGTON, D.C.

2005

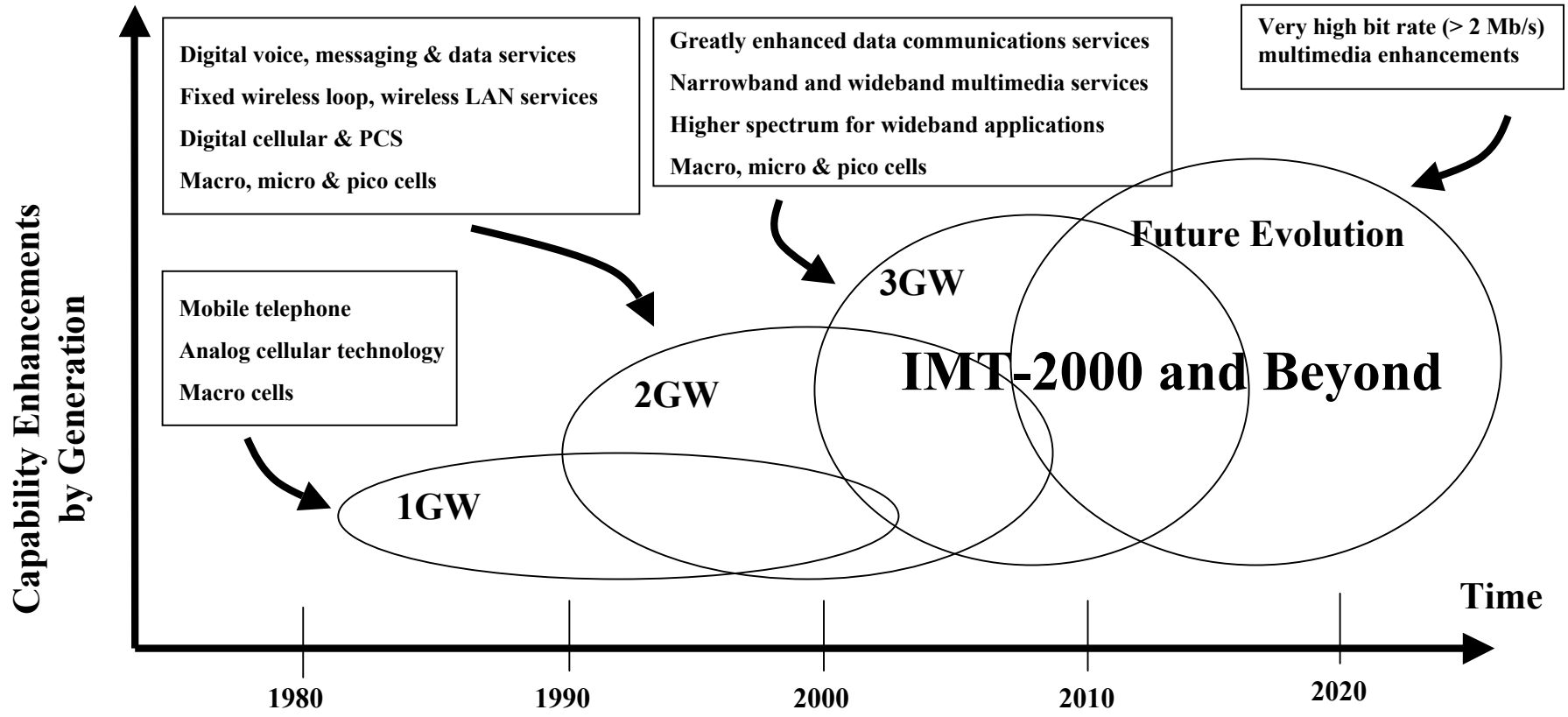
FRONTIER TOPICS FOR DISCUSSION

FORCES IMPACTING FRONTIERS
IMT-2000 AND BEYOND
IEEE STANDARDS DEVELOPMENT
UNDERLAYS AND INTERFERENCE
SOFTWARE AND COGNITIVE RADIOS
RADIONAVIGATION SATELITES
BSS / FSS SHARING
> 50 GHz
RF IDENTIFICATION TAGS
POWER LINE TELECOMMUNICATIONS
SPECTRUM MANAGEMENT STUDIES
BROADCAST STUDIES
FRONTIER TECHNOLOGY
S-CURVES

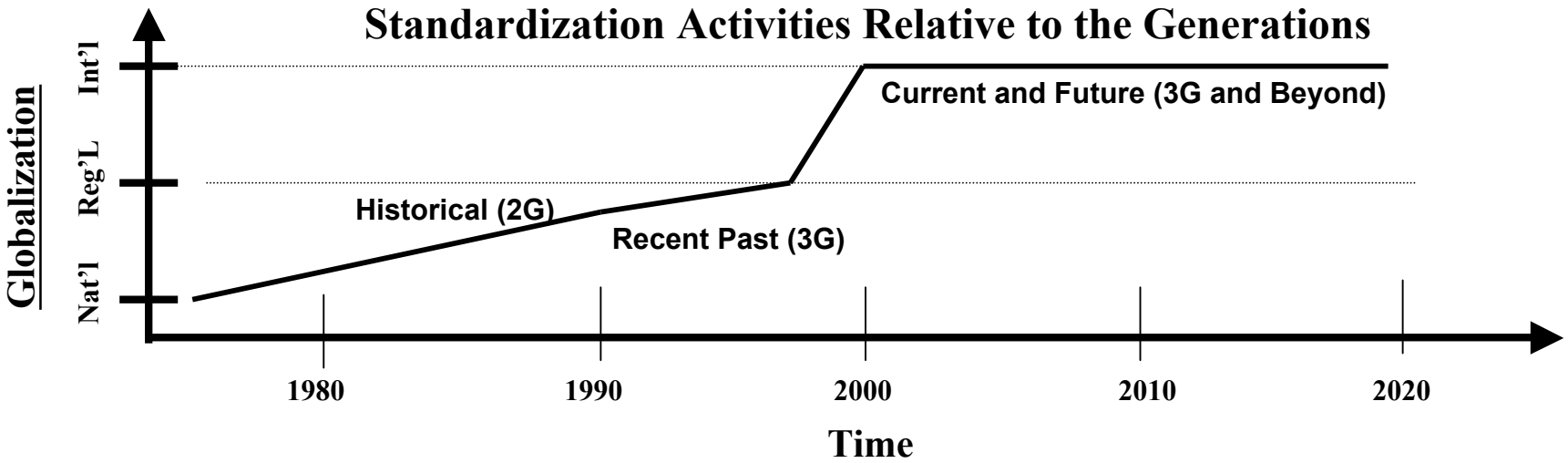
FORCES IMPACTING TELECOMMUNICATION FRONTIERS

- INTERNET
- GLOBALIZATION (UNIVERSAL SWITCHED NETWORK ACCESS) AND LIBRALIZATION
- NATIONAL PRIORITIES (REGULATIONS)
- PRIVATIZATION AND INVESTMENT OPPORTUNITIES
- COMPETITION AND ECONOMICS
- TECHNOLOGY AND MARKET INNOVATION
- PUBLIC AND SOCIAL INTEREST
- CONSUMERS' INTERESTS AND MOBILITY
- WORLD TRADE ORGANIZATION AND INTERNATIONAL TELECOMMUNICATION UNION AGREEMENTS (OPEN MARKETS)
- FOREIGN OWNERSHIP / ACCESS (INVESTMENT)
- EARTH ENVIRONMENT

Generations of Terrestrial Commercial Wireless Systems



Standardization Activities Relative to the Generations



ITU-R WORKING PARTY 8F

- WP8F IS THE GLOBAL FOCAL POINT FOR THE CONTINUING VISION OF NEXT GENERATION WIRELESS SERVICES AND SYSTEMS, ACTING AS A FORUM FOR USER REQUIREMENTS AND AS A CATALYST FOR TRANSLATING THOSE REQUIREMENTS INTO TECHNICAL REALITY

- WP8F HAS THE CHALLENGING TASK OF SUPPORTING THE NEAR TERM NEEDS OF THE IMT-2000 MARKETPLACE WHILE EXPLORING WHERE WE MIGHT GO IN THE WIRELESS WORLD OF THE FUTURE

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

- FUTURE SYSTEMS WITH DATA RATES > 2 Mbit/s
- SERVICE APPLICATIONS, OBJECTIVES AND USER NEEDS
- 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

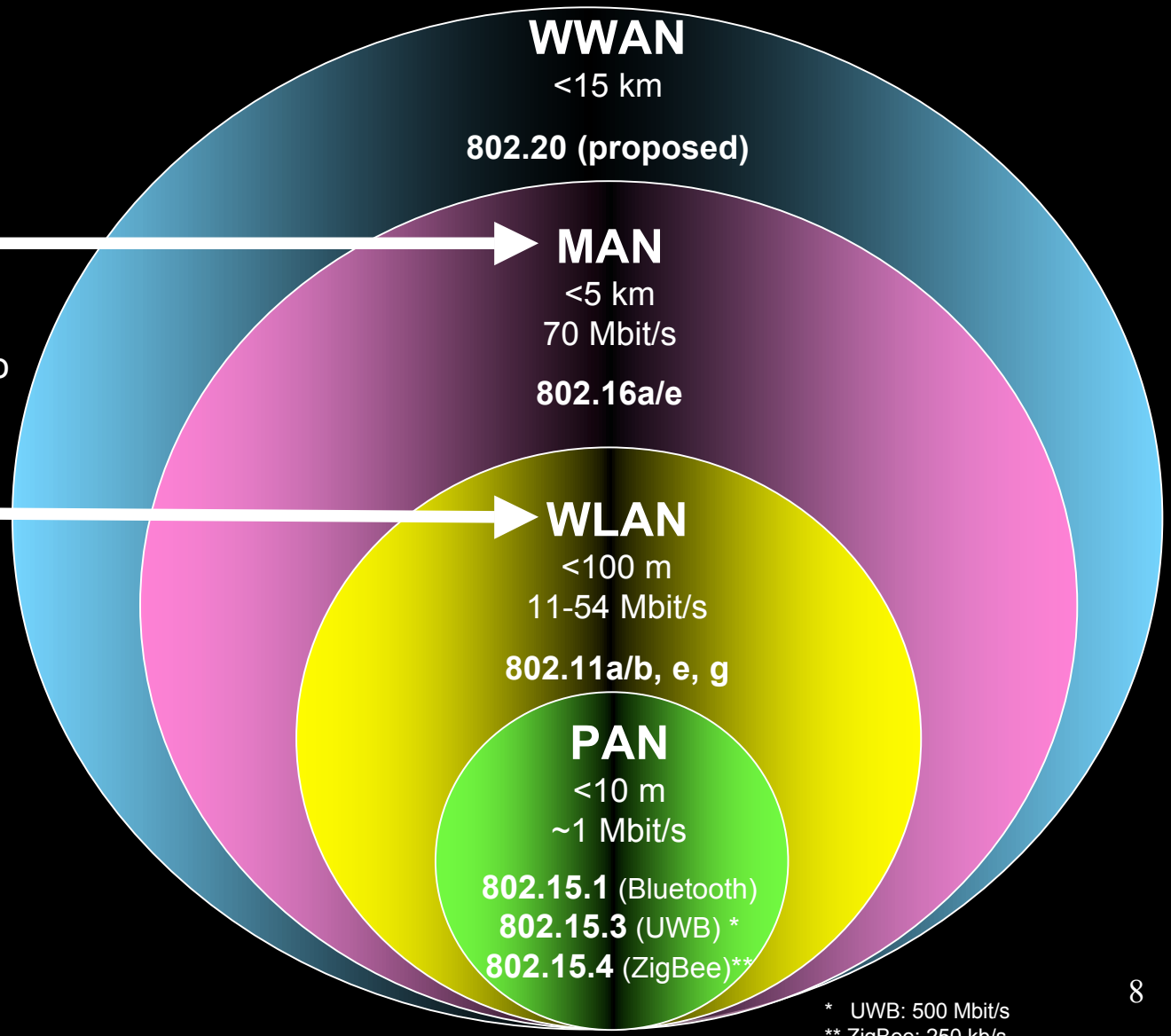
2160 - 2165 MHz - FIXED & MOBILE

2500 - 2690 MHz – MMDS, ITFS, BSS

IEEE STANDARDS VIEW OF WIRELESS NETWORK TECHNOLOGIES

WiMAX
New standard for Fixed broadband Wireless. Trying to do for MAN what Wi-Fi did for LAN.

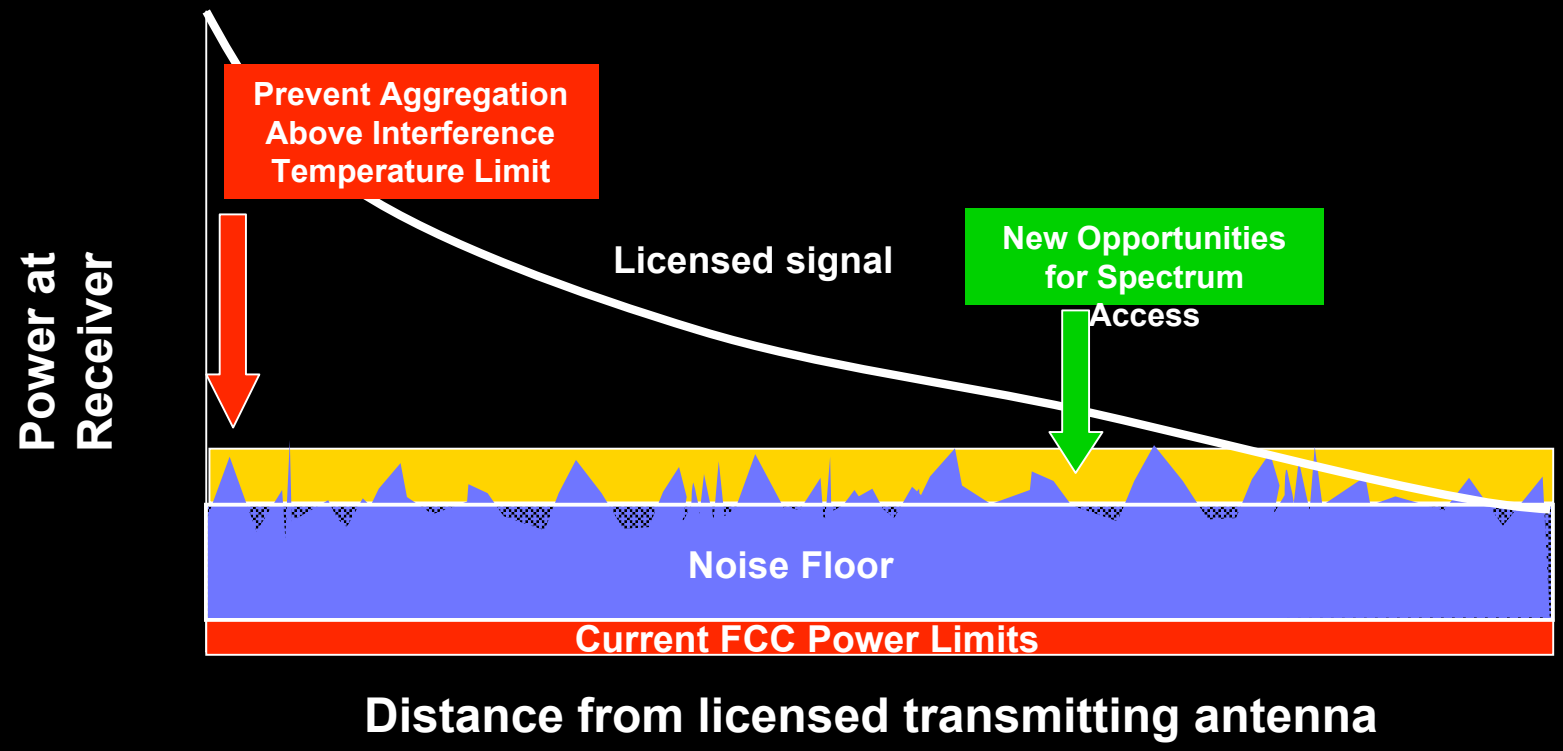
Wi-Fi®



* UWB: 500 Mbit/s
** ZigBee: 250 kb/s

Source: International Telecommunications Union, "Birth of Broadband", September 2003

UNDERLAYS AND INTERFERENCE AVOIDANCE



INTERFERENCE TEMPERATURE

WITH THIS CONCEPT, USING COGNITIVE RADIOS, OPERATION IS BEING CONSIDERED IN FIXED SERVICE, FIXED SATELLITE SERVICE, AND MOBILE SERVICE BANDS:

- 6525-6700 MHz
- 12.75-13.15 GHz
- 13.2125-13.25 GHz

SOFTWARE DEFINED RADIO

A RADIO THAT INCLUDES A TRANSMITTER IN WHICH THE OPERATING PARAMETERS OF FREQUENCY RANGE, MODULATION TYPE OR MAXIMUM OUTPUT POWER (EITHER RADIATED OR CONDUCTED) CAN BE ALTERED BY MAKING A CHANGE IN SOFTWARE WITHOUT MAKING ANY CHANGES TO HARDWARE COMPONENTS THAT AFFECT THE RADIO FREQUENCY EMISSIONS

COGNITIVE RADIO

A RADIO THAT SENSES ITS ENVIRONMENT AND LOCATION, AND AUTOMATICALLY ADAPTS TO THAT ENVIRONMENT MAKING USE OF AVAILABLE SPECTRUM AND TECHNOLOGY INCLUDING FOR OVERLAYS AND UNDERLAYS

SDR / COGNITIVE RADIO ABILITIES AND PROCESSES

1. USE "EMPTY" SPECTRUM
2. FILL EMPTY TIME SLOTS
3. VARY SIGNAL LEVELS
4. APPLY CODING
5. DIGITALLY PROCESS
6. VARY ROUTING
7. USE ADAPTIVE ANTENNAS
8. ENABLE BOTH NEGOTIATED AND NON-VOLUNTARY SHARING

(USED TODAY IN WIRELESS LANs AND MOBILE SERVICE NETWORKS BOTH ON A MULTIBAND AND MULTIFUNCTION BASIS)

GLOBAL POSITIONING (RADIONAVIGATION SATELLITE SERVICE)

GPS

GLONASS

GALILEO

NEW JAPANESE SYSTEM

BSS / FSS SHARING (SKYBRIDGE)

- BSS SHARING WITH NGSO FSS OPERATIONS IS FEASIBLE
- TERRESTRIAL MVDDS CAN OPERATE AT 12 GHz Ku BAND ON NON-HARMFUL INTERFERENCE BASIS
- GLOBAL TECHNICAL AND SERVICE RULES IN PLACE FOR AGGREGATION
- INTERFERENCE TESTING MANDATORY

MILLIMETER WAVES (ABOVE 50 GHz)

- 51.4 - 52.6 GHz AND 58.2 - 59 GHz ALLOCATED TO FIXED AND MOBILE SERVICES TO INTERCONNECT MOBILE SERVICE BASE STATIONS AND OTHER SYSTEMS

- 57 - 64 GHz UNLICENSED ALLOCATION (HIGH O_2 ABSORPTION) TO PROVIDE 7 GHz OF VERY HIGH SPEED AND/OR HIGH BANDWIDTH COMMUNICATION OVER SHORT DISTANCES, AND FOR NETWORKING BACKBONE PURPOSES IN CONGESTED AREAS

- 64 - 66 GHz ALLOCATED TO FIXED AND MOBILE SERVICES, EXCEPT AMS TO I NTERCONNECT MOBILE SERVICE BASE STATIONS AND OTHER SYSTEMS

- 65 - 71 GHz ALLOCATED TO INTERSATELLITE SERVICE FOR SATELLITE NETWORK INTERCONNECTIONS PROMOTING VIDEO TELEPHONY, MEDICAL AND TECHNICAL TELE-IMAGING, HIGH SPEED DATA NETWORKS, AND BANDWIDTH-ON-DEMAND FOR CONSUMERS

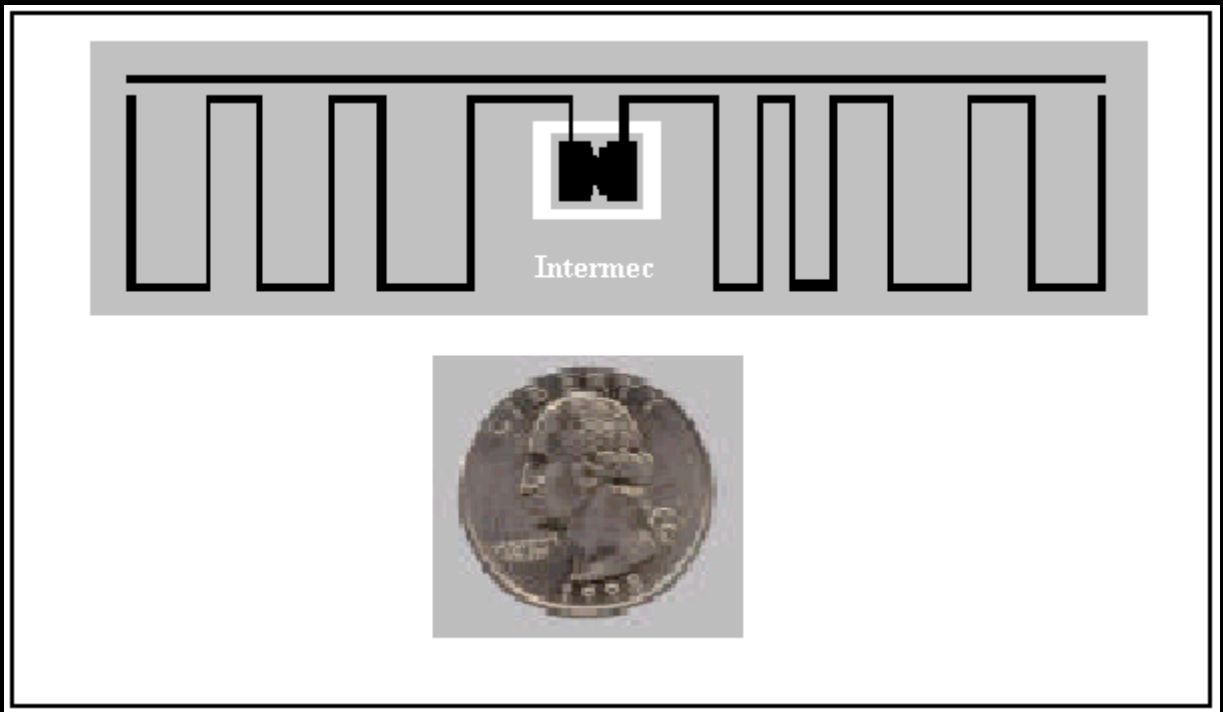
RF IDENTIFICATION (RFID) TAGS

READ AT ~ 3 OR 4 METER DISTANCE
PRIVACY IS A PARTICULAR ISSUE

RAPID TRANSPORTATION
RAIL CARS
TOLLBOOTH PASSES
PARKING GATES
PALLETS
PERSONNEL ENTRY
LIBRARY MANAGEMENT
FINANCIAL PROTECTION
"BEST CUSTOMER" CARDS

PRODUCT INVENTORY
PRODUCT DISTRIBUTION
AIRLINE LUGGAGE / SECURITY
SCHOOL ATTENDANCE
MEDICATION TRACKING
FOOD TRACEABILITY
ENVIRONMENTAL, ANIMAL, POULTRY, FISH, WILDLIFE MANAGEMENT

Source: TIA, "The Economic and Social Benefits of Broadband Deployment", October 2003



COURTESY OF INTERMEC TECHNOLOGIES

SOURCE: WASHINGTON POST

RFID TAG CONTAINING A MICROCHIP SURROUNDED BY COPPER STRANDS THAT ACT AS AN ANTENNA

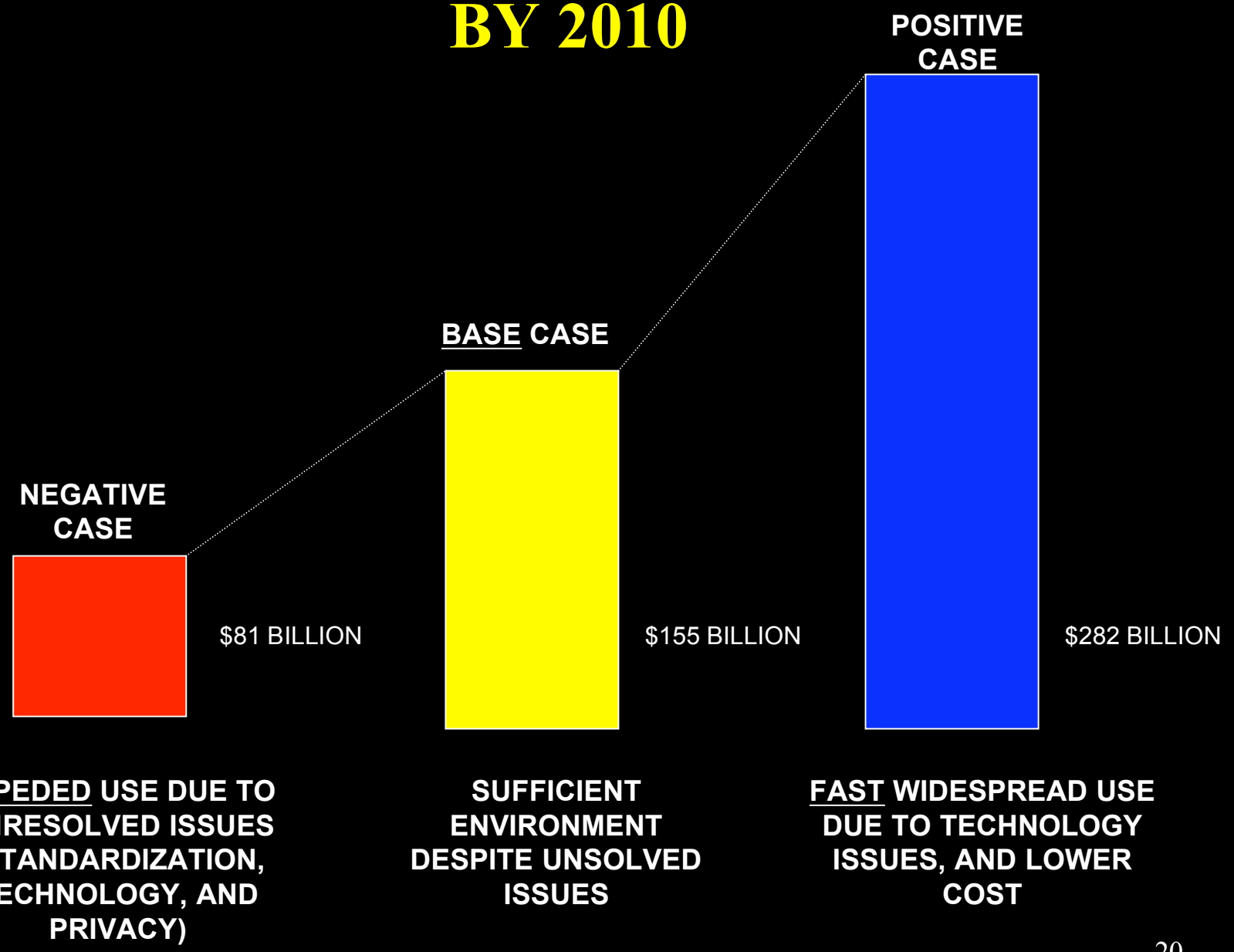
CURRENT RFID TAG TYPES BY FORM, DIMENSIONS, AND MAIN APPLICATION

TECHNOLOGY – UWB?

FORM	DIMENSIONS	MAIN APPLICATION
DISK	SEVERAL mm TO TENS OF mm	•CLOTHING MANAGEMENT •TAGS FOR EMBEDDING IN DEVICES
TUBE	SEVERAL mm TO TENS OF mm	•ANIMAL / AQUATIC MANAGEMENT •PALLET MANAGEMENT
LABEL	SEVERAL mm TO TENS OF mm	•TAGS FOR POINT-OF-SERVICE PAYMENT •DOCUMENT MANAGEMENT •FREIGHT MANAGEMENT
CARD	85 x 54 x SEVERAL mm	•PUBLIC TRANSPORTATION PASSES •TELEPHONE CARDS •ID CARDS FOR ENTRY / EXIT
BOX	50 x 50 x 10 mm ~	•VEHICLE MANAGEMENT •CONTAINER MANAGEMENT

SOURCE: NEW BREEZE, ITU ASSOCIATION OF JAPAN 2004

FORECAST OF RFID ECONOMIC IMPACT BY 2010



SOURCE: NEW BREEZE, ITU ASSOCIATION OF JAPAN 2004

POWER LINE TELECOMMUNICATIONS (PLT OR BPL)

- ADVANCED DIGITAL PROCESSING AND MODULATION
- MULTIPLE CARRIERS
- SERVICE OUT TO ≈ TWO KILOMETERS
- 2 to 80 MHz BANDWIDTHS - - UP to 80 MHz RF
- TELECOMMUNICATIONS ACCESS TO NEIGHBORHOODS OR TO BUILDINGS OR HOMES WHERE EXISTS POWER INFRASTRUCTURE

BPL BENEFITS

- COMPETITION TO DSL, CABLE, AND SATELLITE
- ACCESS TO WHEREVER THERE IS MAINS POWER
- REDUNDANCY AT LOW COST
- BETTER MANAGEMENT OF ELECTRIC GRIDS
- FOSTER SMART HOME APPLICANCES
- REMOTE NOTIFICATION (SECURITY, TRAFFIC, REMOTE METER READING, INTERNET CONNECTIVITY)

BPL RULES

- UNLICENSED
- NO HARMFUL INTERFERENCE
- MUST ACCEPT INTERFERENCE
- LIMITED RF EMISSION (TABLE)
- 12 AERONAUTICAL BANDS RESTRICTED (TABLE)
- REQUIRED CONSULTATION WITH PUBLIC SAFETY AND AERONAUTICAL SITES
- EXCLUSION ZONES
  - 2182 kHz WITHIN 1 km OF A MARITIME STATION
  - 73-74.6 MHz WITHIN 29 km (OVERHEAD) AND 11 km (UNDERGROUND) OF RADIOASTRONOMY
- ADAPTIVE IX MITIGATION TECHNIQUES
  - EXCLUDE OR NOTCH ANY SPECIFIC FREQUENCY
  - REMOTELY TURN OFF ANY BPL DEVICE

BPL EXCLUDED AERONAUTICAL FREQUENCIES

2850 – 3025 kHz	3400 – 3500 kHz	4650 – 4700 kHz
5450 – 5680 kHz	6525 – 6685 kHz	8815 – 8965 kHz
10005 – 10100 kHz	11275 – 11400 kHz	13260 – 13360 kHz
17900 – 17970 kHz	21924 – 22000 kHz	74.8 – 75.2 MHz

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?

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.

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 ~20 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

DIGITAL TELEVISION

- HIGH DEFINITION DEFINED AS EQUIVALENT TO A 35 mm CINEMA PICTURE
- 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)
- TRANSITION FROM ANALOG TO DIGITAL
- VERY POLITICAL

INTERACTIVE TELEVISION

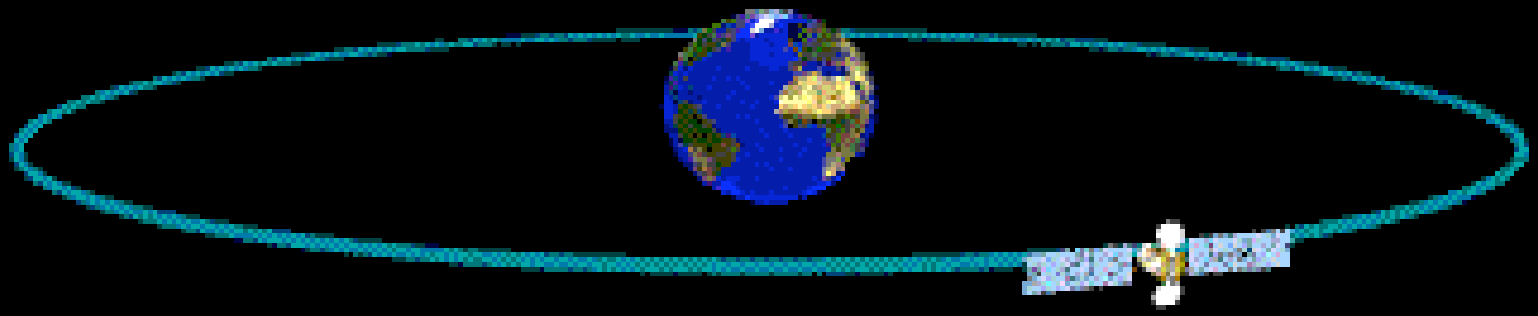
STUDIES ARE UNDERWAY OF *INTERACTIVE TELEVISION SERVICES* SO AS TO FACILITATE APPROPRIATE LICENSING:

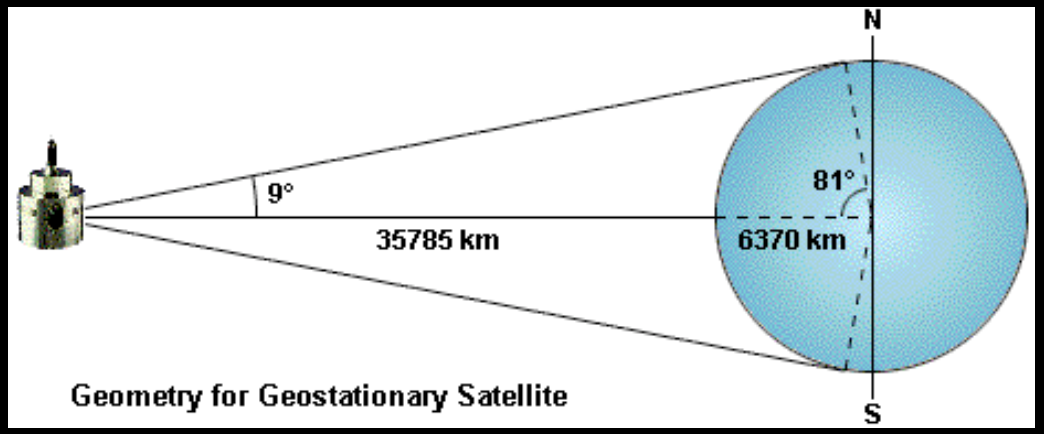
- **VIDEO PIPELINE (MPEG VIDEO)?**
- **HIGH SPEED INTERNET PROTOCOL?**
- **CUSTOMER PREMISES EQUIPMENT?**
- **ANTI-COMPETITIVE BEHAVIOR?**

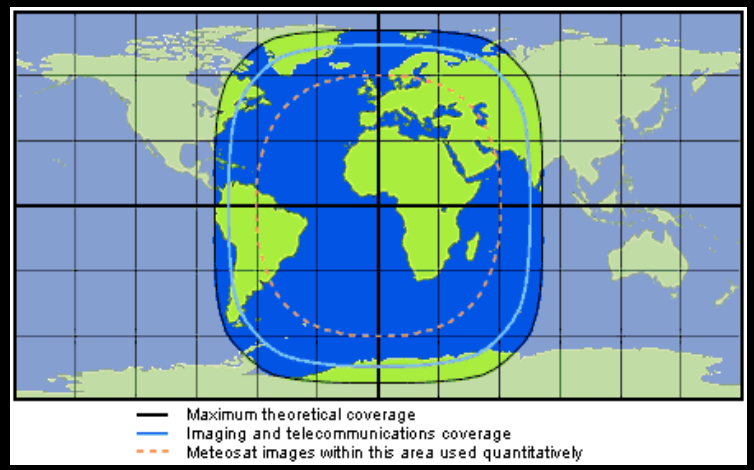
BSS-TERRESTRIAL SHARING

- SHARING WITH GEOSTATIONARY SATELLITE, BROADCAST SATELLITE SERVICE (BSS), IS FEASIBLE
- UNIQUE TECHNICAL PROPOSAL
- INTERFERENCE TESTING
- POLITICALLY SENSITIVE

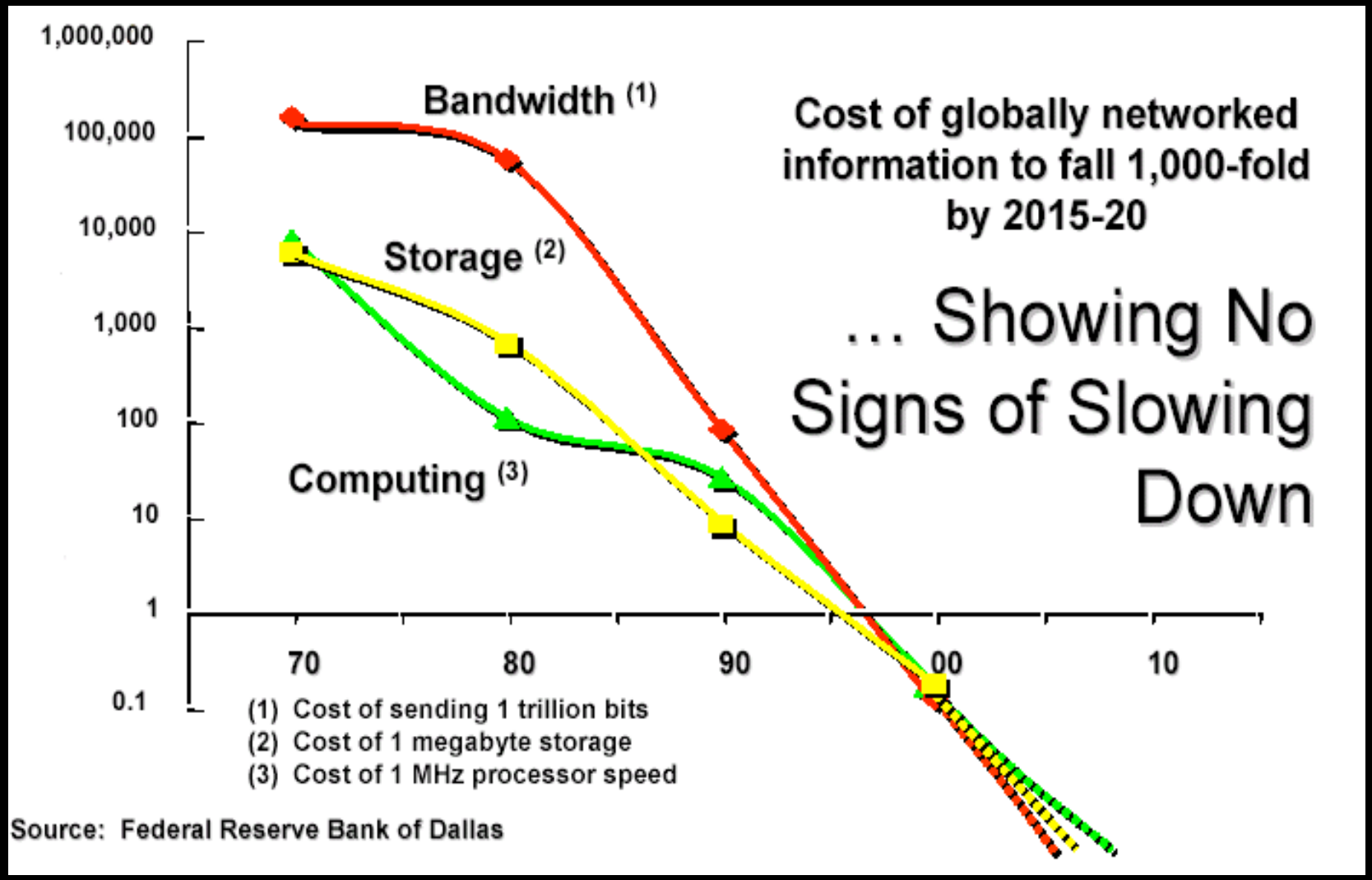
GEOSTATIONARY ORBIT





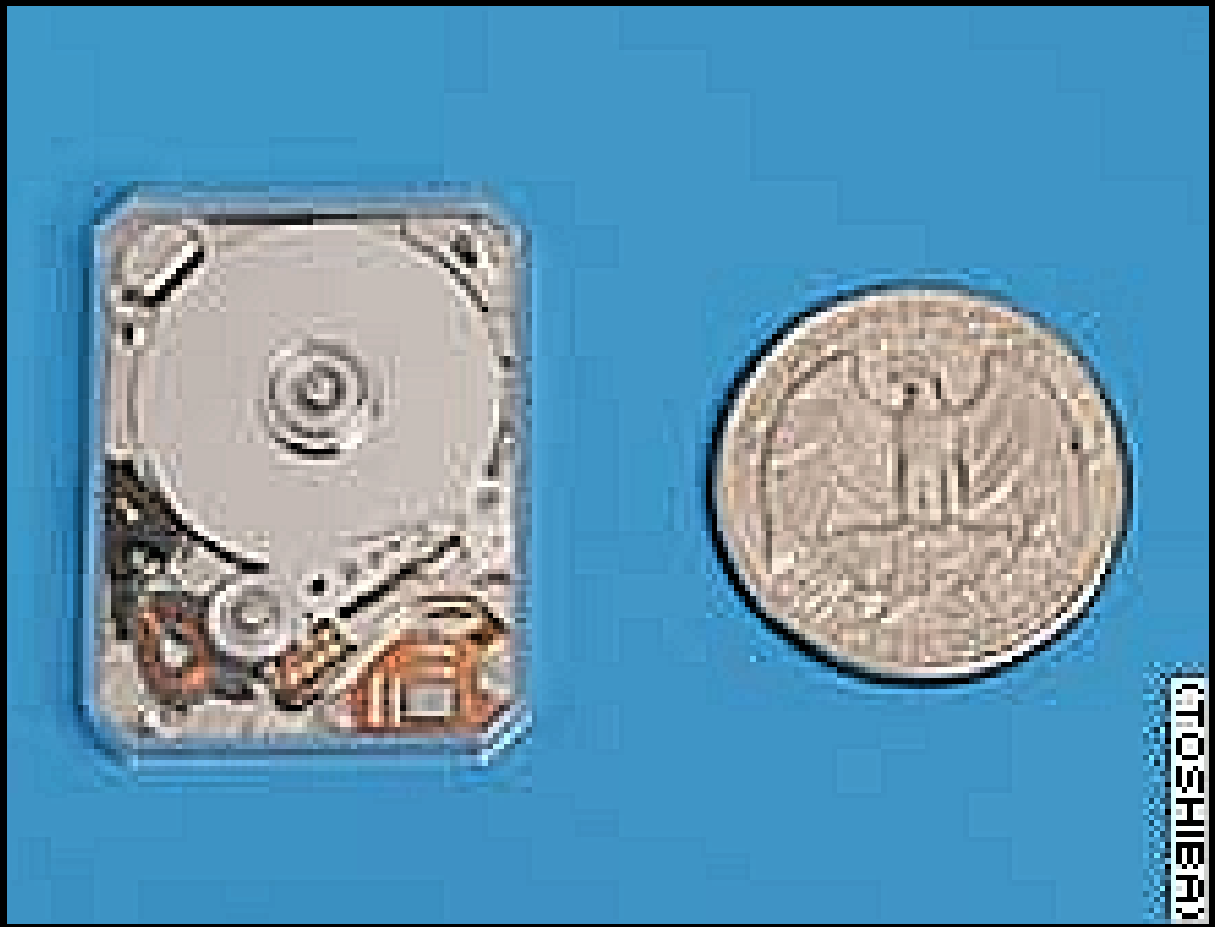


TECHNOLOGY CONTINUES TO EVOLVE



NEW COMPUTER TECHNOLOGY

4 GIGABYTES STORAGE IN A SMALL PACKAGE - 2004



SOURCE: TOSHIBA

MOORE'S LAW

FAMOUS FORECAST BY INTEL FOUNDER GORDON: MOORE PREDICTED THE NUMBER OF TRANSISTORS ON A CHIP WOULD ROUGHLY DOUBLE EVERY TWO YEARS

- INTEL HAS ACHIEVED A MILESTONE IN SHRINKING THE SIZE OF TRANSISTORS TO POWER ITS NEXT-GENERATION CHIPS TO 35 NANOMETERS
- EVEN CURRENT 90 NANOMETER TRANSISTORS HAVE PROBLEMS WITH HEAT AND POWER DISSIPATION
- 65 NANOMETER TRANSISTORS ARE ON TRACK FOR DELIVERY IN 2005
- 35 NANOMETER TRANSISTORS (30% SMALLER THAN TODAY'S STATE-OF-THE-ART CHIPS) ARE USED ON 70 MBIT MEMORY CHIPS
- POSSIBLE WITH NEW MATERIALS, PROCESSES, AND CHIP STRUCTURES
- SLEEP TRANSISTORS SHUT OFF ELECTRICAL CURRENT TO CHIP PARTS (NOT BEING USED) → DECREASING HEAT GENERATION AND HELPING BATTERY-POWERED DEVICES LAST LONGER
- MOORE'S LAW HOLDS

NEW COMPUTER CHIPS

MULTIPLE FUNCTIONS REPLACE SPEED AS MAIN FEATURE

NEW CHIPS IN 2005 WILL SIMULTANEOUSLY RUN MULTIPLE TASKS SUCH AS BURNING CDS AND WORD PROCESSING

WORLD'S BIGGEST SEMICONDUCTOR MAKER DESIGNING CHIPS WITH MORE THAN ONE PROCESSOR

"A SEA CHANGE IN COMPUTING" – MOVING FROM FASTER CHIPS TO MULTIPLE FUNCTION CHIPS

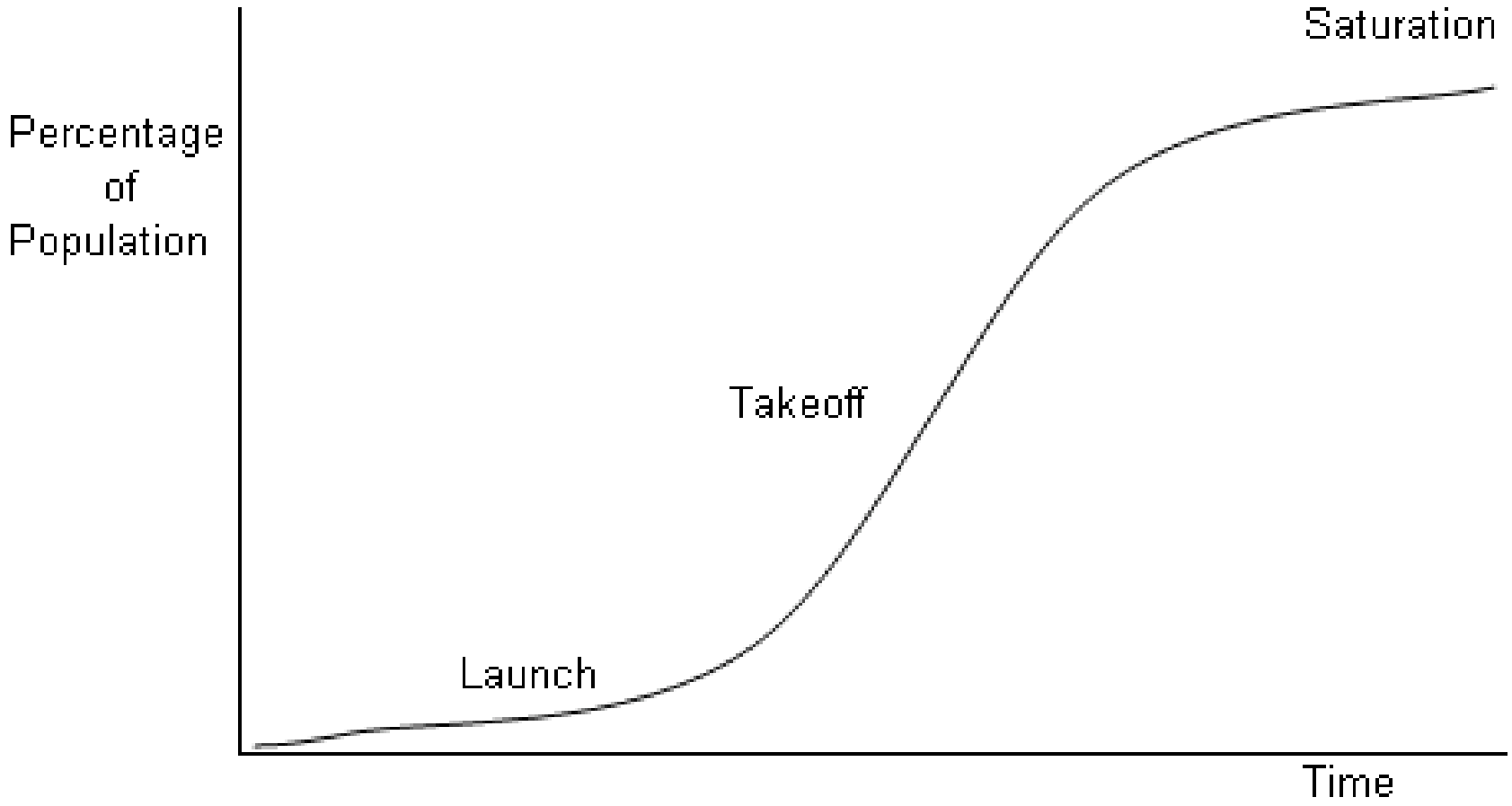
TRADITION HAS BEEN INCREASING CHIP "CLOCKSPEED" (NUMBER OF CALCULATIONS PER SECOND)

"CLOCKSPEED" TODAY IS 36 TIMES FASTER THAN IN 1995, BUT USERS WANT FEATURES SUCH AS A LONGER BATTERY LIFE, SURROUND SOUND, AND MULTIPLE FUNCTIONS

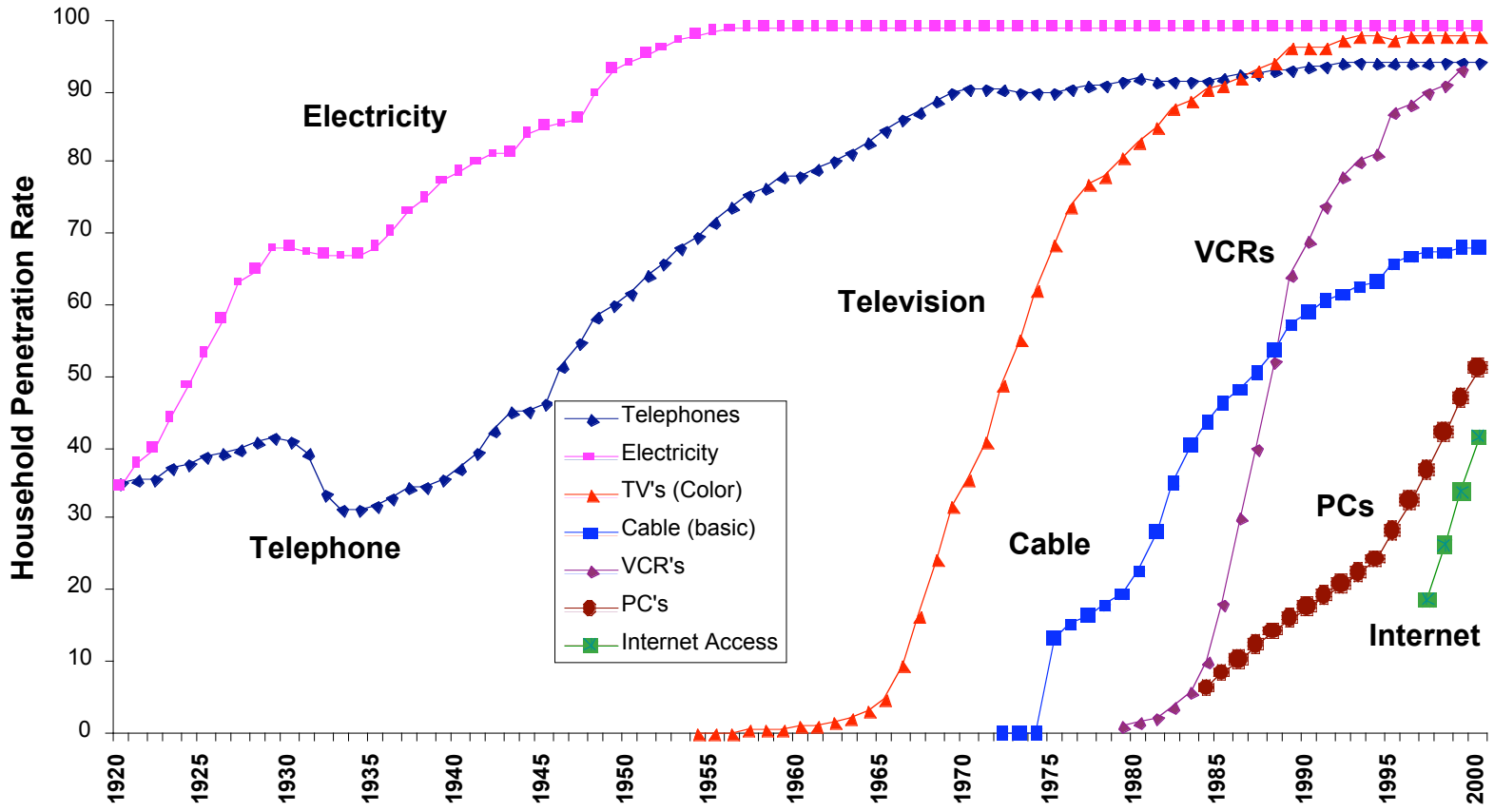
EACH NEW CHIP HAS ON THE ORDER OF 2 MILLION TRANSISTORS

SOURCE: WASHINGTON POST

GENERIC "S-CURVE"

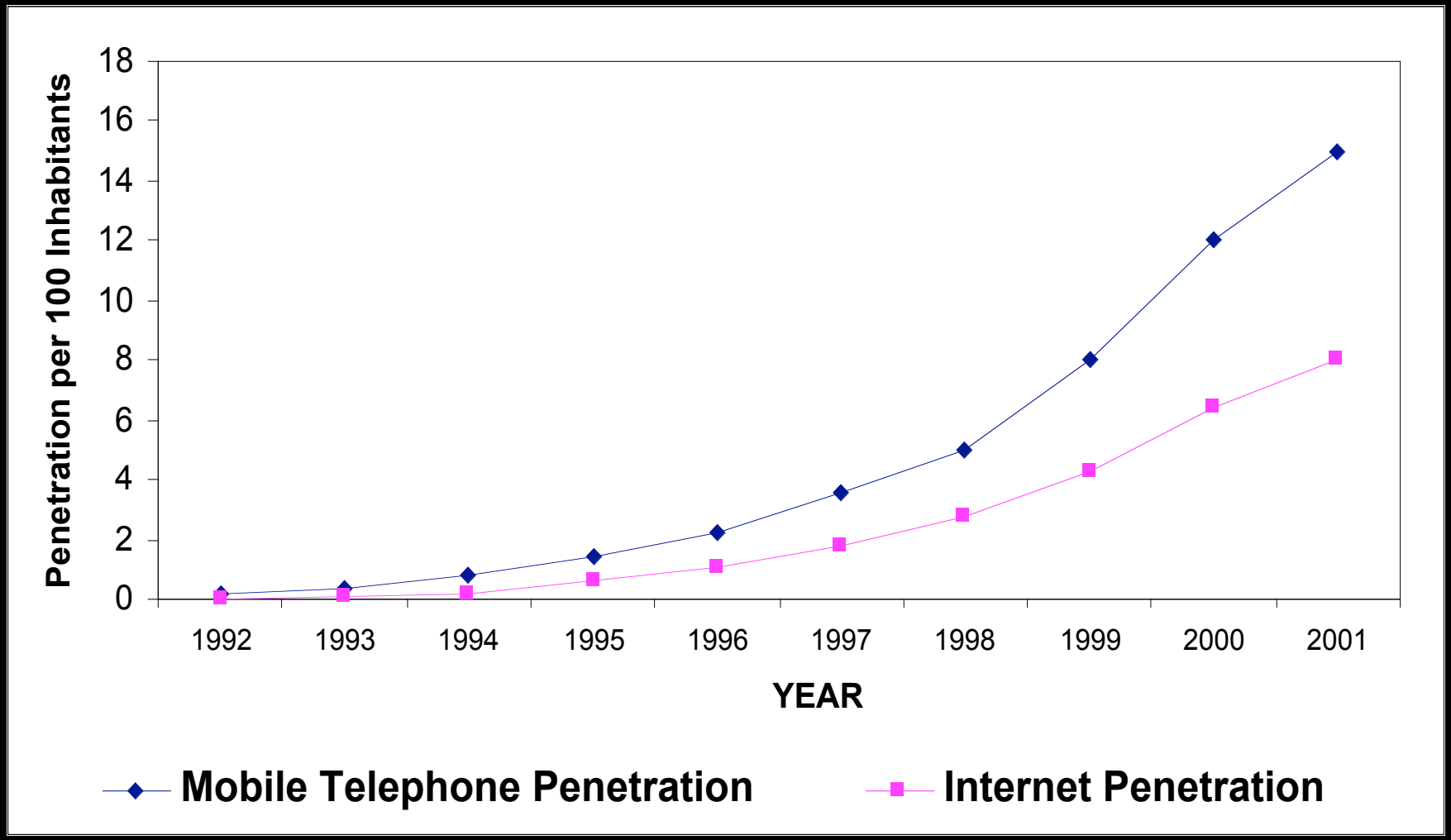


"S-CURVES" FOR VARIOUS TECHNOLOGIES



Sources: Telephone and electricity industry data from 1920-1970 from Historical Statistics of the United States: Colonial Times to 1970, Part 2, p. 783. 1970-present and from Statistical Abstract of the United States, various years. Cable data from A.C. Nielsen Co. data as reported by the National Cable Television Association (NCTA). VCR, PC, and TV data from Consumer Electronics Association, E-Brain (http://www.ebrain.org/). Internet data from U.S. Department of Commerce (http://www.ntia.doc.gov/ntiahome/fttn00/chartscontents.html).

GLOBAL DIGITAL MOBILE AND INTERNET S-CURVES



Source: ITU World Telecommunication Indicators Database.

http://www.fcc.gov

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