DIGITAL BROADCASTING

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SOME ABBREVIATIONS

- DAB = Digital Audio Broadcasting
- DVB = Digital Video Broadcasting
  - DVB-S satellite
  - DVB-C cable
  - DVB-T terrestrial
  - DVB-H = DVB-T modified for handheld reception

- If I use terms or abbreviations that you do not understand, please INTERRUPT ME

THE FUTURE OF BROADCASTING . . .

Lord Kelvin, mathematician and physicist, 1897

– **“Radio has no future”**

Lord Kelvin, 1895

– **“Heavier-than-air flying machines are impossible”**

The future is DIGITAL

WHY DIGITAL ?

- Digital technology is rapidly replacing analogue technology in many areas
- Broadcasting is no exception
- All transmitted signals are affected by some amount of noise or interference
- In analogue systems, such noise or interference is part of the received signal and cannot be separated from the audio or video signal
- In digital systems, the receiver needs only to decide whether the received signal represents a “0” or a “1” – if the noise is small (< 0.5), the original signal can be decoded without error

SOMETHING FOR NOTHING ?

- Digital signals can provide “perfect reception”
- But *“you never get something for nothing”*
- Digital TV signals in studios have a bit rate of 216 Mbit/s
- As the most efficient schemes for digital modulation can deliver about 1 bit/s per Hertz, a digital TV signal would need more than 200 MHz of radio-frequency (RF) bandwidth
- But analogue TV services occupy only 8 MHz of RF bandwidth . . . .
- Digital broadcasting needs to combine digital compression and digital modulation

DIGITAL COMPRESSION

- How does digital compression work?
- Parts of many TV pictures are relatively static and may be unchanged for several seconds
- Other objects may move:
  - slowly or quickly
  - predictably or unpredictably

VIDEO COMPRESSION

- It is only necessary to transmit information about those parts of the picture that change
- Smooth predictable motion (such as the camera panning from left to right) can be signalled to the receiver using motion vectors describing the speed and direction of movement
- Scenes containing complex unpredictable motion are difficult to compress
- The transmitter sends only the most important information, throwing away the rest
- The receiver must try to reconstruct the original scene using only the transmitted information

AUDIO COMPRESSION

- Using knowledge about the performance of the human ear & brain, audio signals can be compressed so that even expert listeners can only just detect the difference between the original and compressed signals
- The fundamental principle is that of “masking”
- Loud sounds mask (or hide) quiet sounds
  - as thunder masks the sound of a pin dropping, there is no need to transmit the pin sound
  - the masking effect is greatest when the frequency of the loudest sound is similar to that of quieter sounds

EFFECTS OF COMPRESSION

- Digital compression can provide good quality TV pictures at 5 Mbit/s – which means that about 98% of the original 216 Mbit/s data has been discarded before transmission
- Digital compression can provide good quality audio at about 0.2 Mbit/s – which means that about 86% of the original 1.5 Mbit/s data has been discarded before transmission
- Digital compression of video is “easier” than digital compression of audio

DIGITAL MODULATION

THE KEY TECHNOLOGY

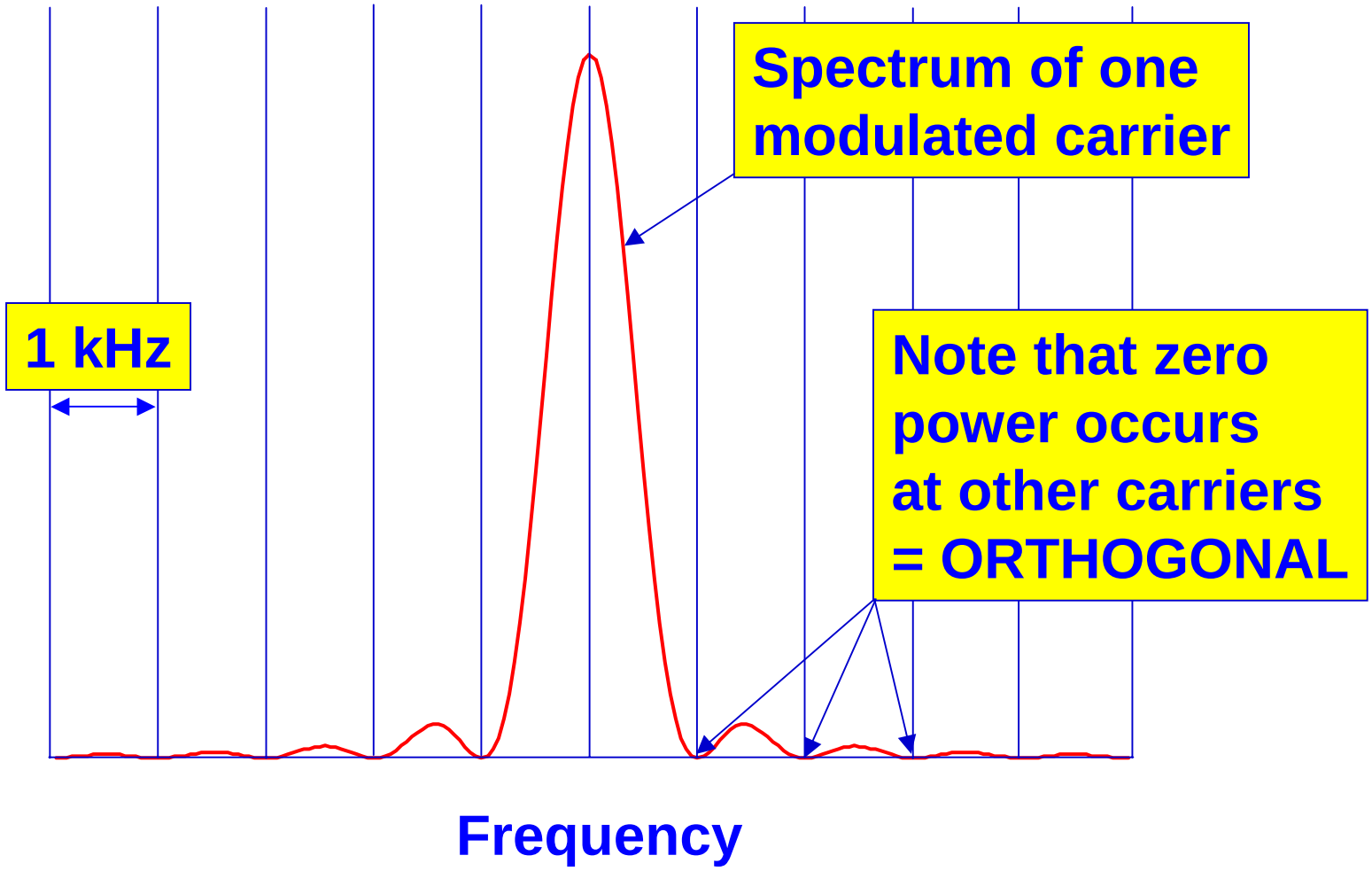
COFDM

=

Coded Orthogonal Frequency Division Multiplex

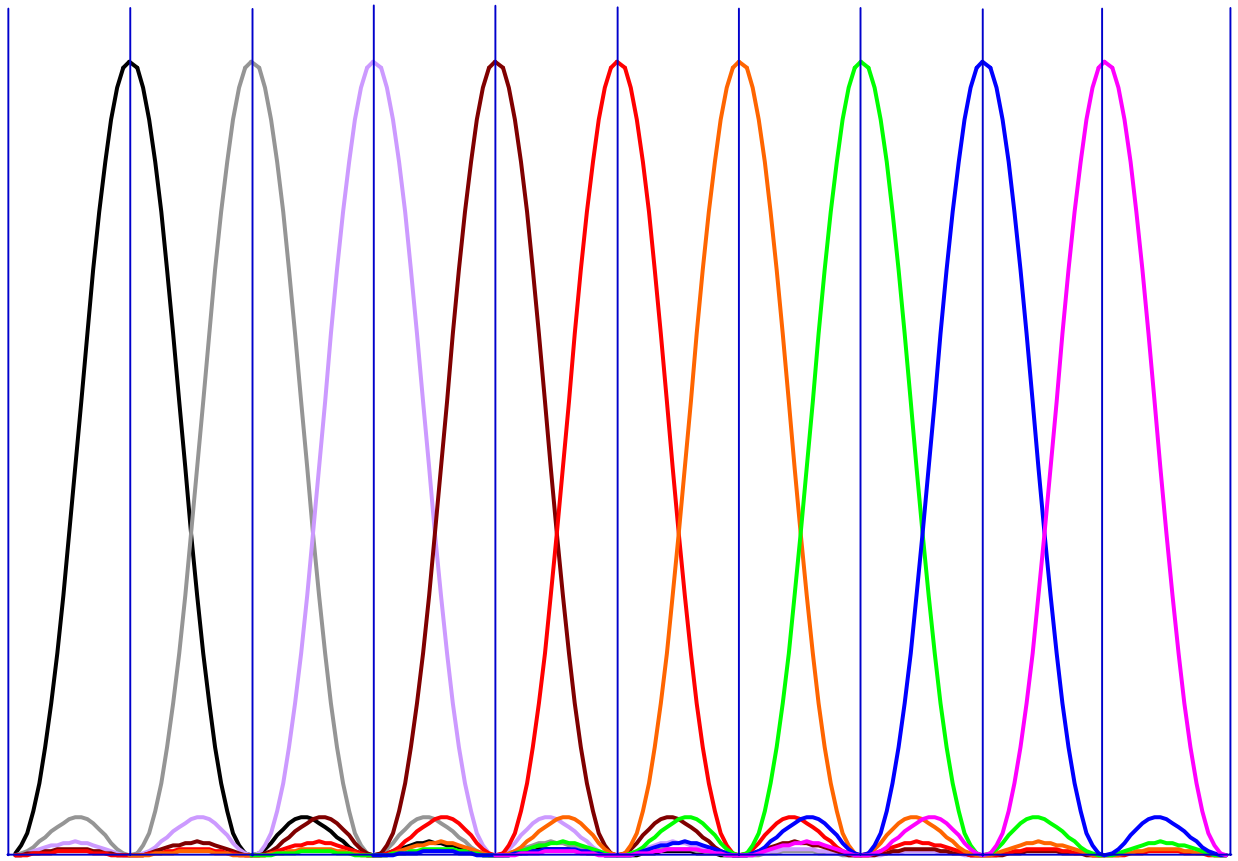
ORTHOGONAL

DAB: 1536 carriers spaced at 1 kHz intervals



MUTUALLY ORTHOGONAL

1536 carriers spaced at 1 kHz intervals



Frequency

CODED OFDM

- Channel state information:
  - if the amplitude of a particular carrier is lower than the amplitudes of the other carriers, the soft-decision decoder assigns less weight to the data from that carrier
- In practice, the performance of individual carriers is closely correlated with that of adjacent carriers, but uncorrelated with those 0.5 MHz away
- DAB uses time and frequency interleaving across the 1.5 MHz bandwidth, plus heavy error correction mechanisms (e.g. FEC = ½)

UNEQUAL ERROR PROTECTION

- The DAB system was the first system to use sophisticated audio compression schemes
- The designers of the DAB system realised that, in audio, “not all bits are created equal”
  - errors in some bits would produce no audible difference even in ideal listening conditions
  - errors in other bits would produce very audible degradation
- So they adopted a scheme called Unequal Error Protection in which the most sensitive bits are given much higher protection in the RF channel

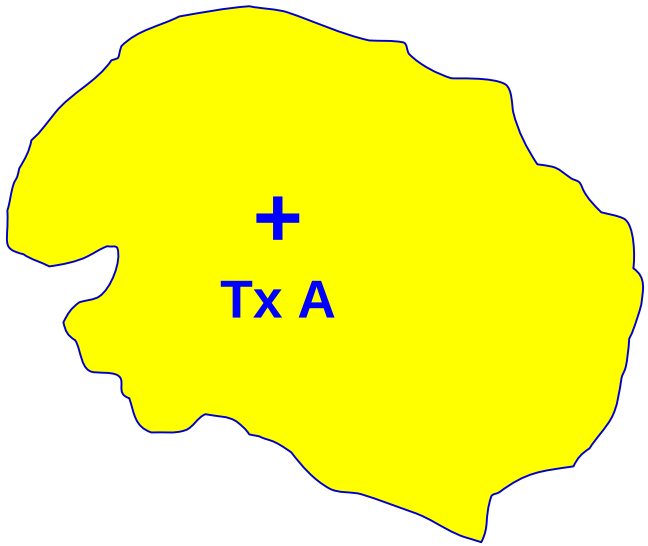
MULTIPATH

- Multipath produces ghost images on analogue TV and causes unreliable reception on FM, especially for portable and mobile reception
- COFDM is inherently tolerant of multipath due to the use of a guard interval
  - if the delayed signals arrive within the guard interval, they add constructively to the direct signal: the more signals, the better ….
  - if the delayed signals arrive outside the guard interval, reception is damaged by interference

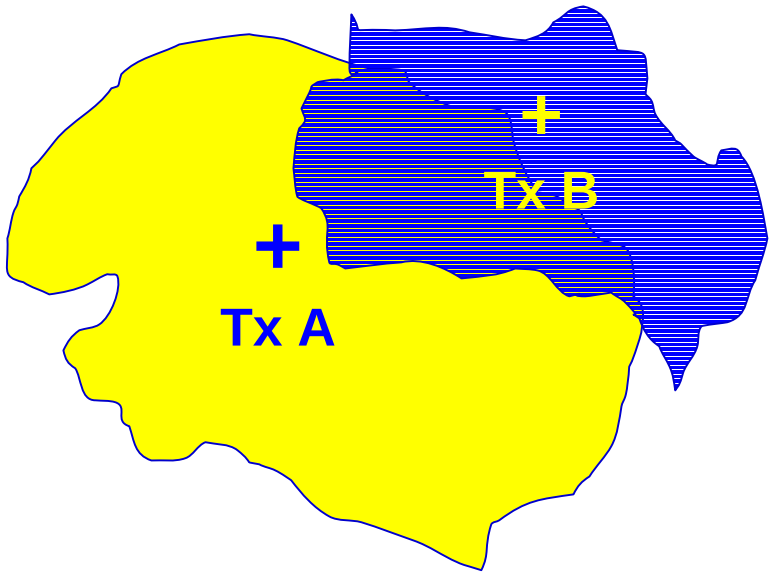
SINGLE-FREQUENCY NETWORKS

- Analogue transmitters on the same frequency cannot have overlapping service areas
- COFDM allows transmitters with overlapping coverage to operate on the same frequency without gaps in coverage
- DAB's guard interval of 256 µs permits national single frequency networks (SFNs)
- National SFNs cannot offer regional services because all transmitters must have identical modulation
- DVB-T has a much shorter guard interval, typically 28 µs or less, which does not permit SFNs over large areas

ONE TRANSMITTER



TWO TRANSMITTERS



- **In the overlap areas, coverage is improved by "network gain" because 2 signals are available**

MULTI-FREQUENCY NETWORK (MFN)

- MFNs are similar to the planning methods used in analogue broadcasting:
  - area coverage is achieved by a network of transmitters using several channels
  - service areas of co-channel transmitters cannot overlap
  - no restrictions on use of regional programmes
- MFNs are used for digital services in channels already used by analogue services
- As most countries have no unused VHF or UHF channels, MFNs will be widely used for DVB-T

CHOICE OF STANDARDS

- **The great thing about standards is that there are so many to choose from**

Mae West, film star:

- **“When choosing between two evils,**
  I always pick the one I never tried before”

DIGITAL RADIO

DAB SYSTEM

- DAB signal has a bandwidth of 1.5 MHz and can deliver a useful data rate of about 1.2 Mbit/s
- Most DAB services transmit 8 – 12 services at different bit rates, such as:
  - 192 kbit/s for high quality stereo
  - 64 kbit/s for low quality mono
- Dynamic re-configuration of the DAB multiplex permits “part-time” services, such as extended sports coverage on Saturday afternoons

DAB IMPLEMENTATION

- DAB system standardised in 1995 by ETSI
  - latest version (EN 300 401 v1.1.3) can be downloaded free of charge from www.etsi.org
- Following assurances from consumer electronics industry about mass manufacturing of DAB radios, the first DAB services were introduced in September 1995 (in UK and Sweden)
- Most countries in Europe now have substantial networks of DAB transmitters, but the consumer electronics industry did not deliver affordable DAB radios to the shops . . . . until 2003

HUGE SUCCESS IN THE UK

- The UK is the most developed market for DAB:
  - 2 national DAB networks (BBC & Digital One)
  - many regional and local DAB services
  - more than 400,000 DAB radios had been sold at the end of 2003, predicted to pass 1 million by the end of 2004
  - pre-Christmas 2003 sales of DAB accounted for 85% of value in the portable radio market
- This success has been achieved by several small "unknown" manufacturers who saw a market where demand exceeded supply
- Big manufacturers are now following . . . .

WHAT DO LISTENERS WANT ?

- Experience of DAB (e.g. in the UK and Germany) indicates that most consumers are unwilling to buy new radios simply to get higher quality versions of services already available on FM
- Technical quality is important, but CONTENT is much more important
  - UK broadcasters (public and commercial) are together offering a wide range of attractive content on DAB (simulcast and new services)
  - DR (Denmark) is now offering 8 new national radio services, all of which are ONLY on DAB

DIGITAL RADIO MONDIALE

- In Europe, initial interest in Digital Radio Mondiale (DRM) was focused on HF (short wave) broadcasting where DRM can deliver dramatic improvements in quality
- Now, broadcasters with AM transmitters in the MF band are interested in DRM because:
  - audiences for AM services are declining, partly because people now expect better quality
  - their existing AM transmitters can be modified relatively cheaply to transmit DRM
  - transmitter powers can be reduced

DRM and DAB

- DRM and DAB were designed for very different applications:
  - DRM is a narrowband system offering ~ 20 kbit/s in a 9 or 10 kHz AM channel below 30 MHz
  - DAB is a wideband system offering ~ 1.2 Mbit/s in a 1.5 MHz channel in VHF and UHF bands
- As the DRM and DAB systems are very similar, it is probable that future generations of DAB receivers will also receive DRM signals
- Some broadcasters in Europe will use DAB, others will use DRM and many will use both

DIGITAL TV

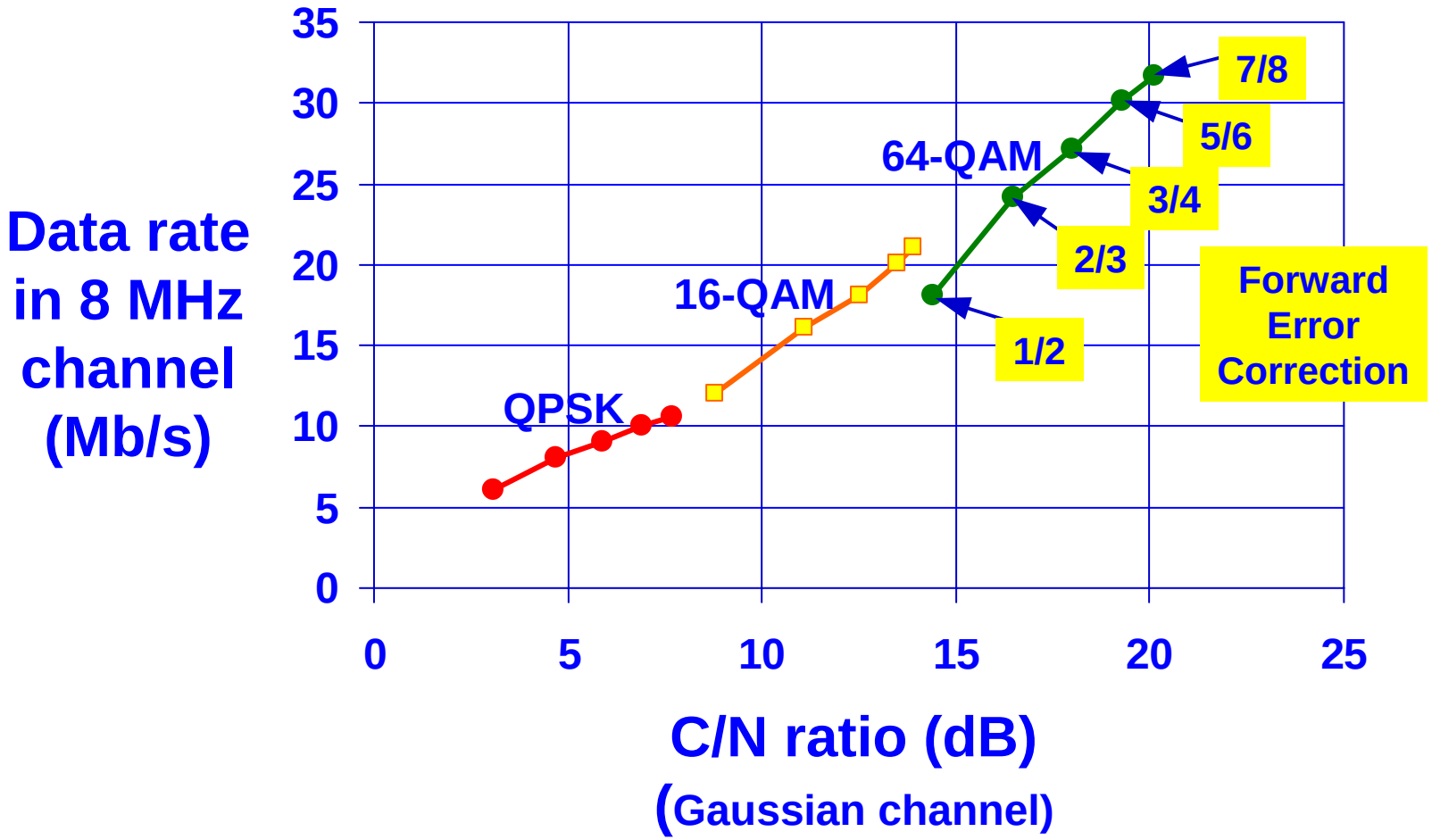
DVB-T IMPLEMENTATION

- DVB-T system standardised in 1997 by ETSI
  - latest version (EN 300 744) can be downloaded free of charge from www.etsi.org
- DVB-T offers a range of system variants
  - UK started DVB-T using 2k version (2,000 carriers) but other countries used 8k version (8,000 carriers)
  - broadcasters can select different parameters, trading data rate against C/N ratio
  - most have chosen data rates of 18-24 Mbit/s

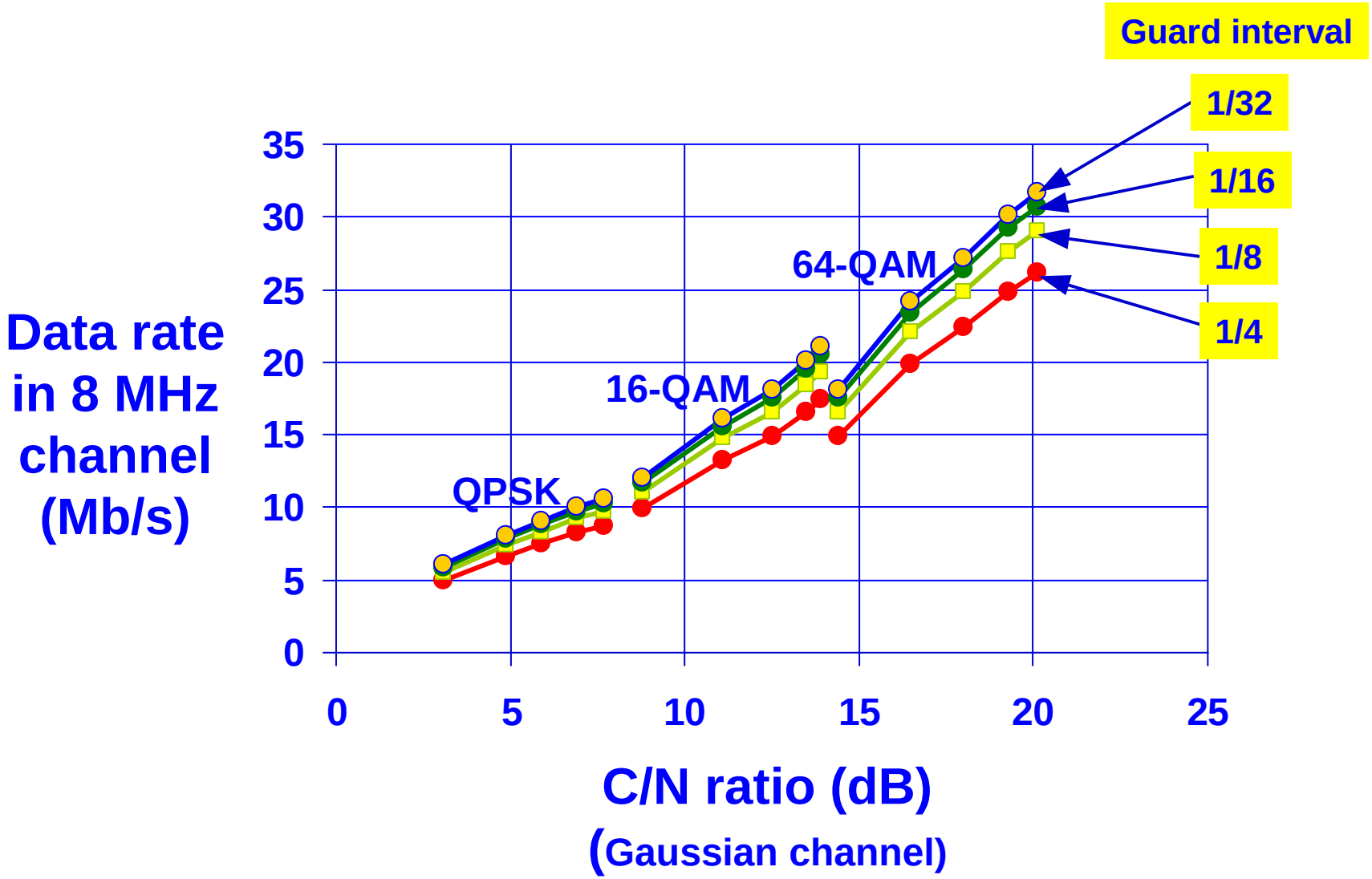
SOME ABBREVIATIONS ….

- **Modulation schemes:**
  - **QPSK Quaternary Phase-Shift Keying**
  - **QAM Quadrature Amplitude Modulation**
  - **QPSK uses 4 states**
  - **16-QAM uses 16 states**
  - **64-QAM uses 64 states**

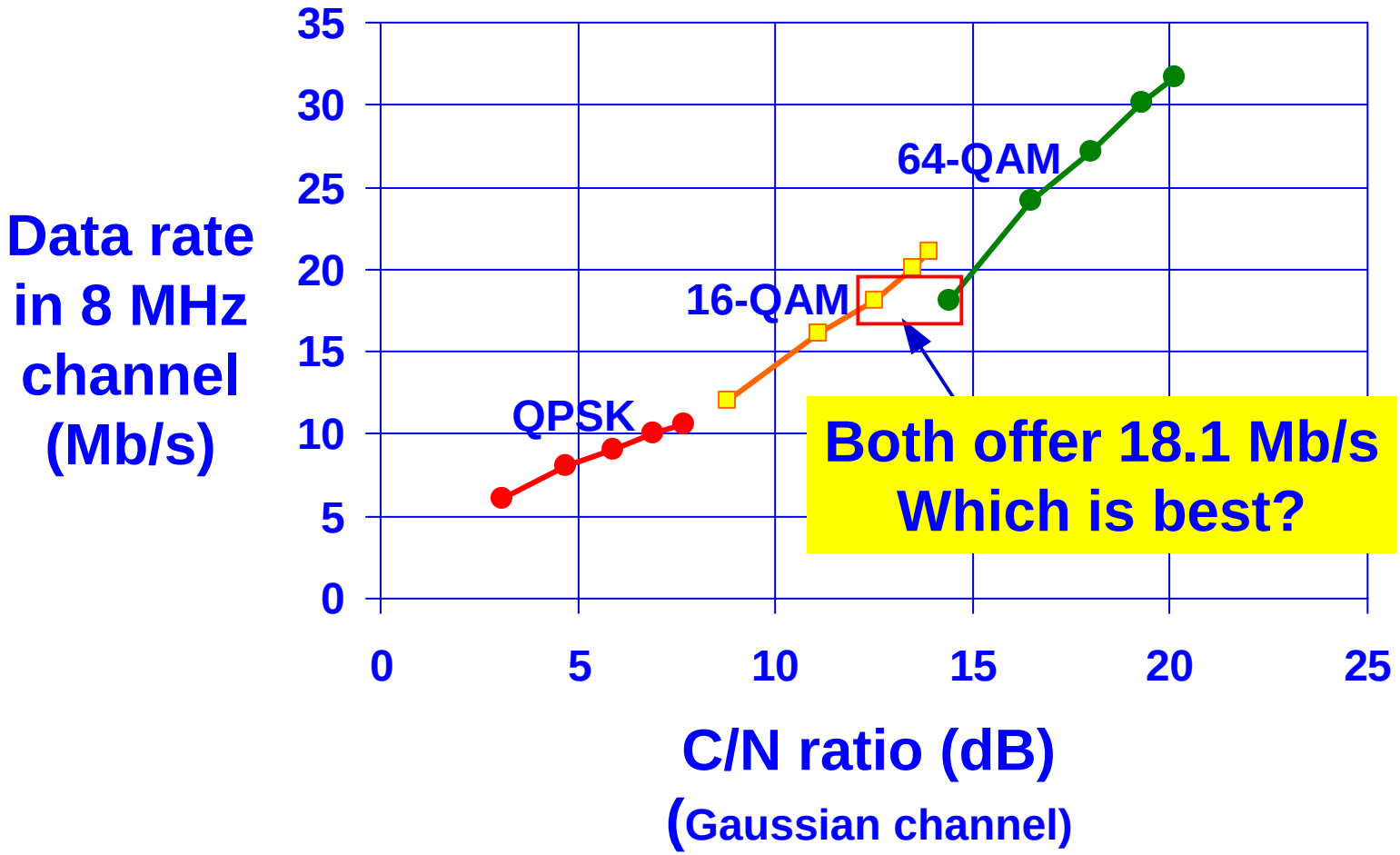
DVB-T OPTIONS



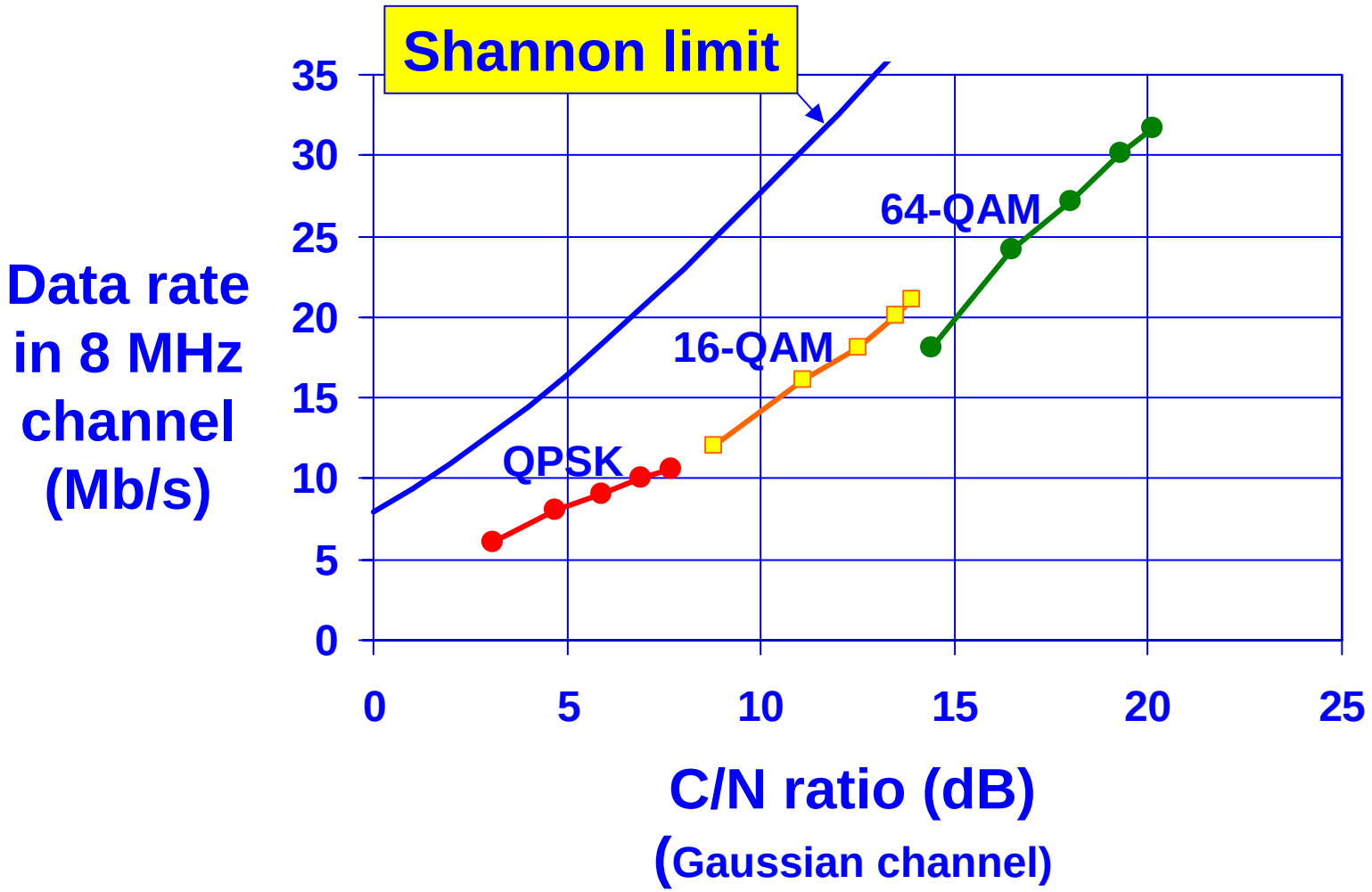
DVB-T OPTIONS



SYSTEM COMPARISONS



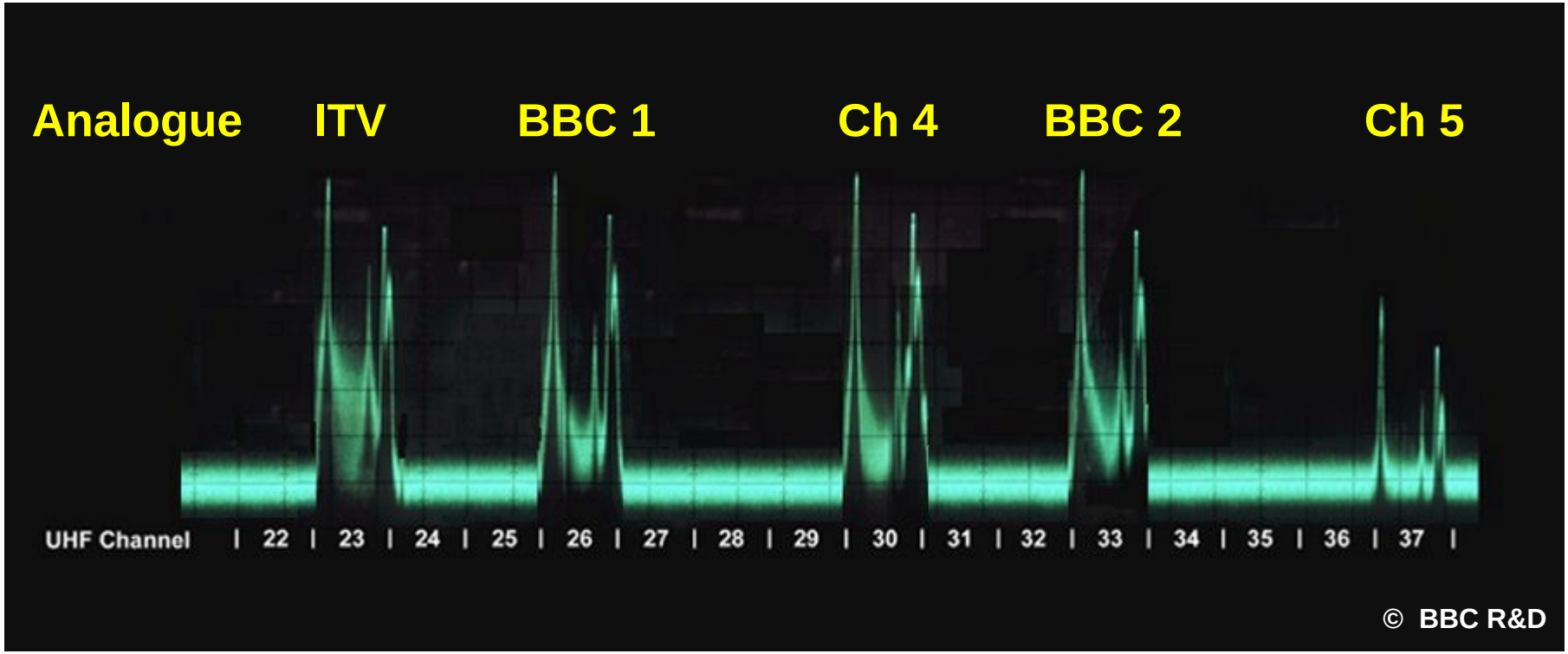
DVB-T OPTIONS



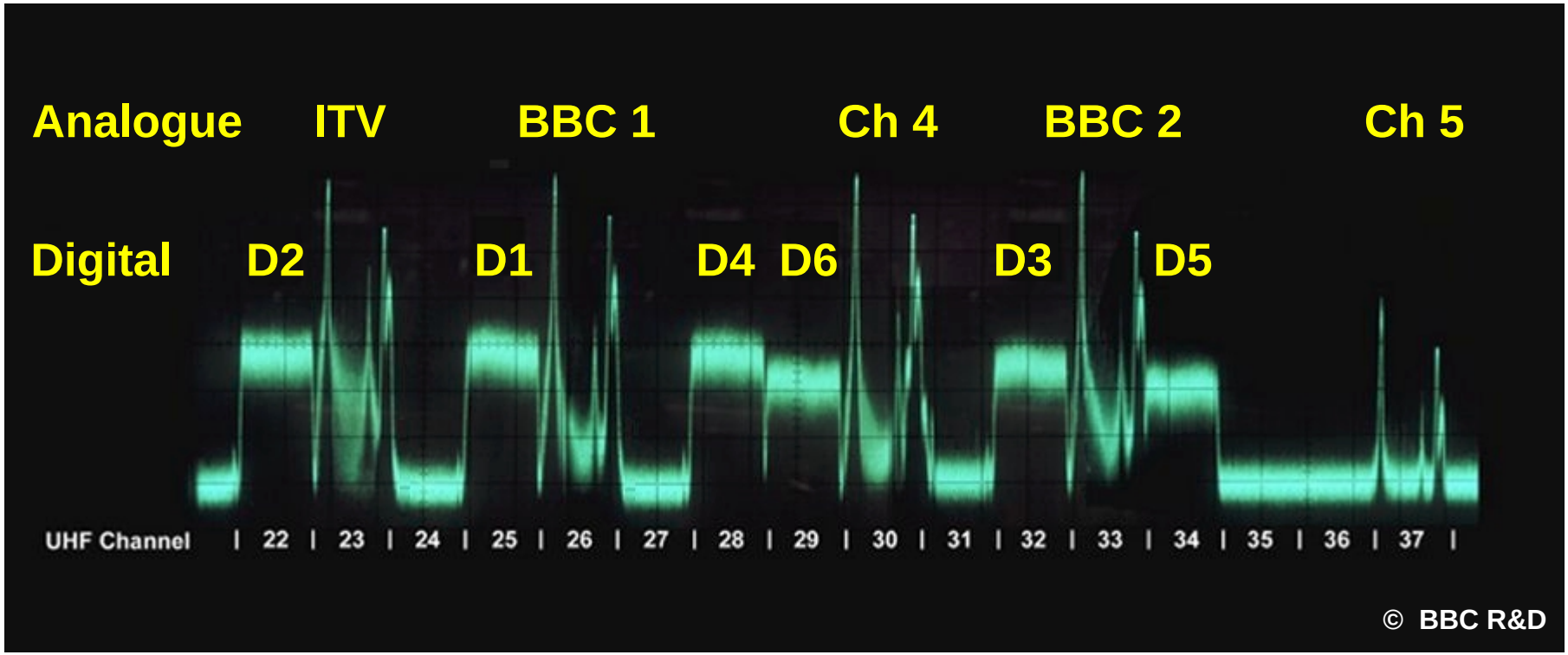
COFDM EVERYWHERE . . . . .

- COFDM seems to the preferred technology:
  - DAB
  - DVB-T: terrestrial digital TV
  - DVB-H: terrestrial digital TV for delivery to hand-held devices
  - DRM: digital radio below 30 MHz
  - HD-Radio: IBOC system for FM radio
  - ISDB-T: terrestrial digital broadcasting
- The only exception seems to be the ATSC system for digital terrestrial TV, which uses 8-VSB

UK: ANALOGUE TV



UK: ANALOGUE TV & DIGITAL TV



No new spectrum needed for digital TV
Each digital service carries 4-5 TV programmes

SPECTRUM EFFICIENCY

- Spectrum efficiency is the key benefit of digital broadcasting
- Digital broadcasting services can offer more services (e.g. multi-channel programming) or higher quality (e.g. HDTV)
- Initially, the DVB-T services will operate alongside existing analogue TV services
- When the analogue services are closed down, some spectrum can be released – either to allow additional DVB-T services or for other services
- This “digital dividend” is politically attractive

DIGITAL DIVIDEND

- The “digital dividend”: how many MHz?
- The size of the digital dividend depends on:
  - the number of digital TV services required
  - the type of digital service (reception on roof-top antennas, portable, mobile, handheld, etc.)
  - interference constraints due to other services and broadcasts in adjacent countries
- Countries on the edge of Europe will achieve a larger dividend than small countries surrounded by other countries
- RRC-06 will help countries to define the size of their digital dividend

WHICH DELIVERY SYSTEM?

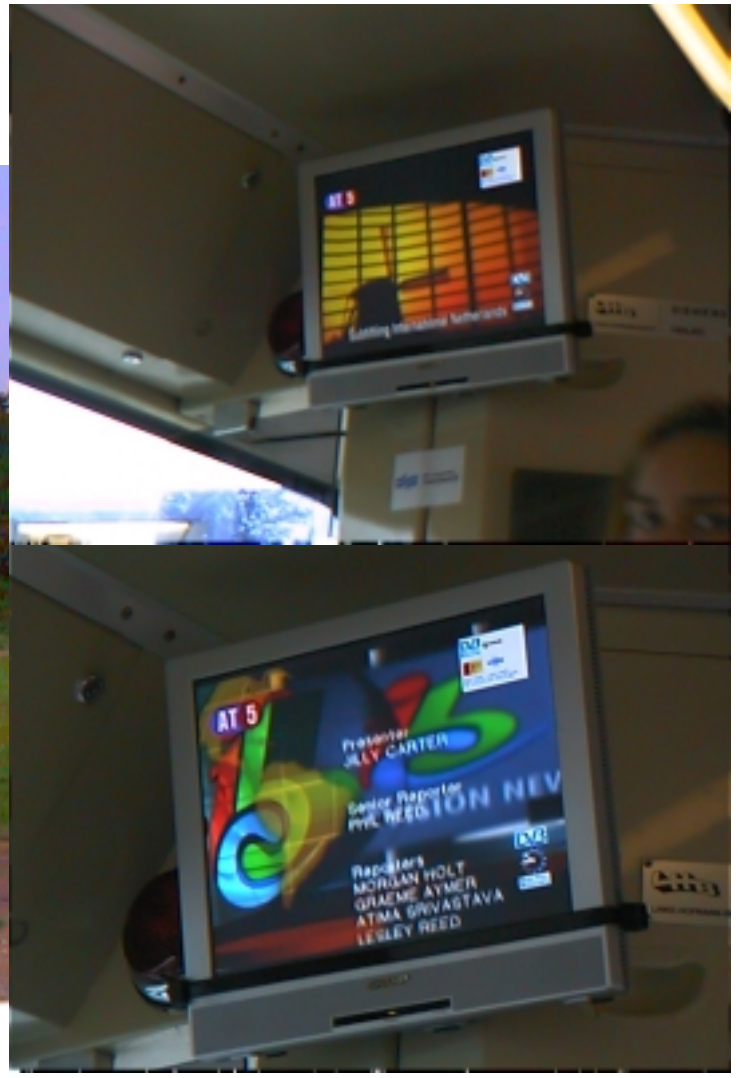
- The potential success of various delivery systems depends on many factors, such as:
  - geographical considerations (size of country, population density, terrain)
  - existing infrastructure (e.g. cable TV)
  - spectrum availability
  - economic considerations
  - regulatory environment
- No single solution can be applied across Europe

WHY DIGITAL TV?

- The impetus for digital TV varies from country to country
- In many countries (e.g. Spain and UK), digital TV simply increases the number of TV services
- In other countries (e.g. Netherlands or Germany) with high penetration of analogue cable and/or satellite TV, digital terrestrial TV offers some new features:
  - mobile TV reception
  - portable TV reception

DVB-T MOBILITY

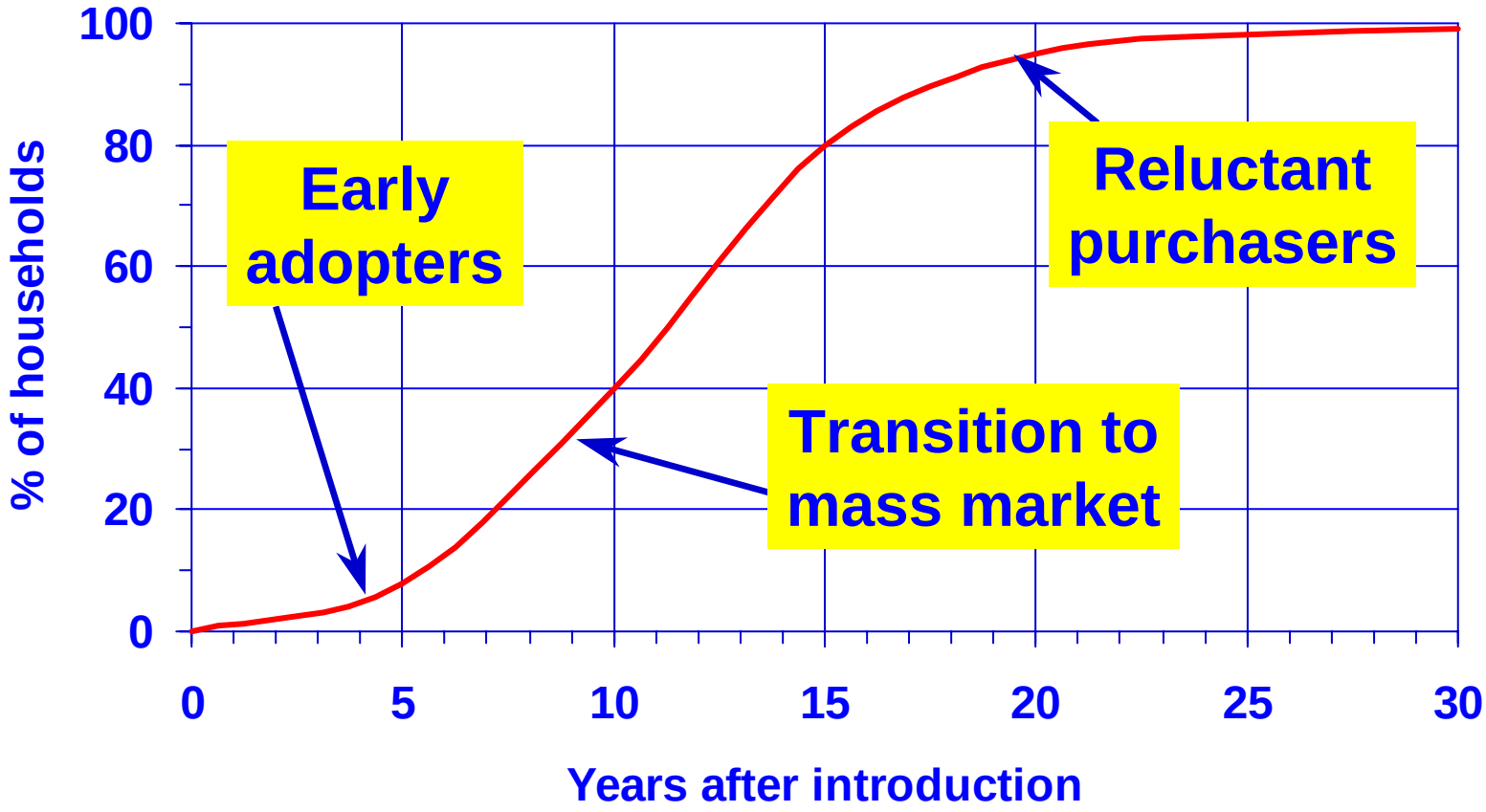
- **IBC 99 Amsterdam**



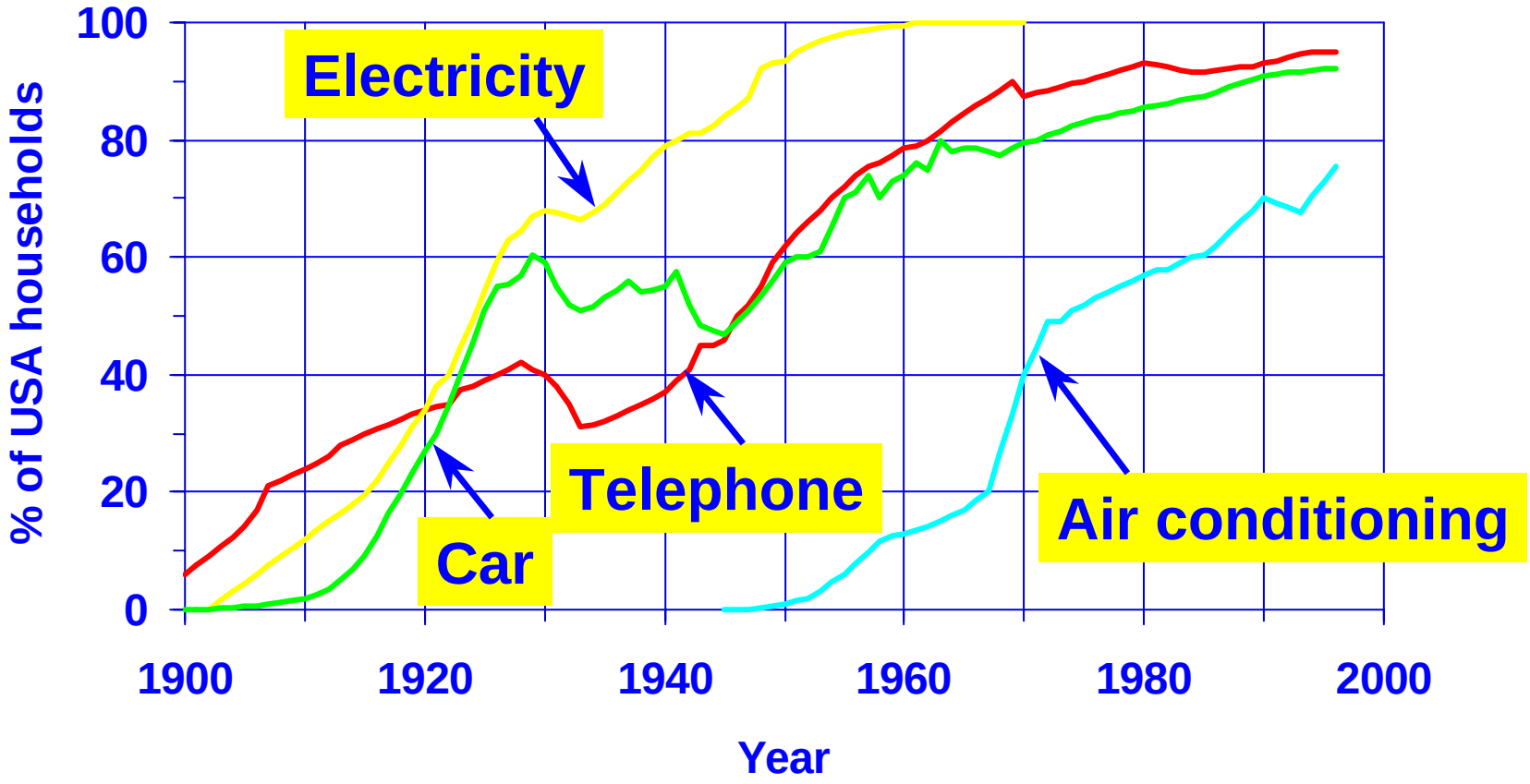
DVB-T PORTABILITY

Nokia Media Screen

AN IDEALISTIC “S-CURVE”

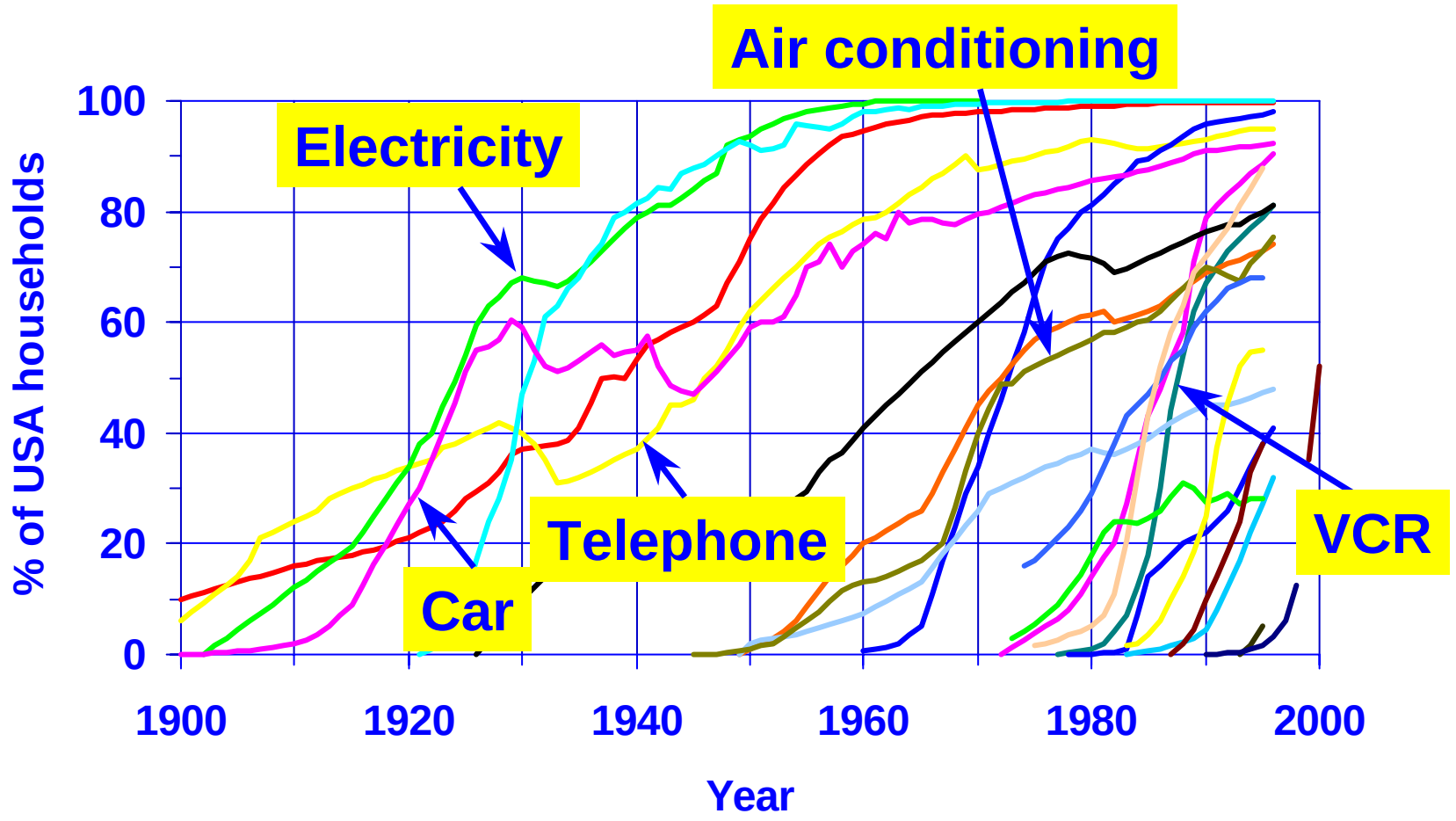


REAL S-CURVES



Source: Federal Reserve Bank of Dallas & Forbes magazine

SPEED OF PROGRESS



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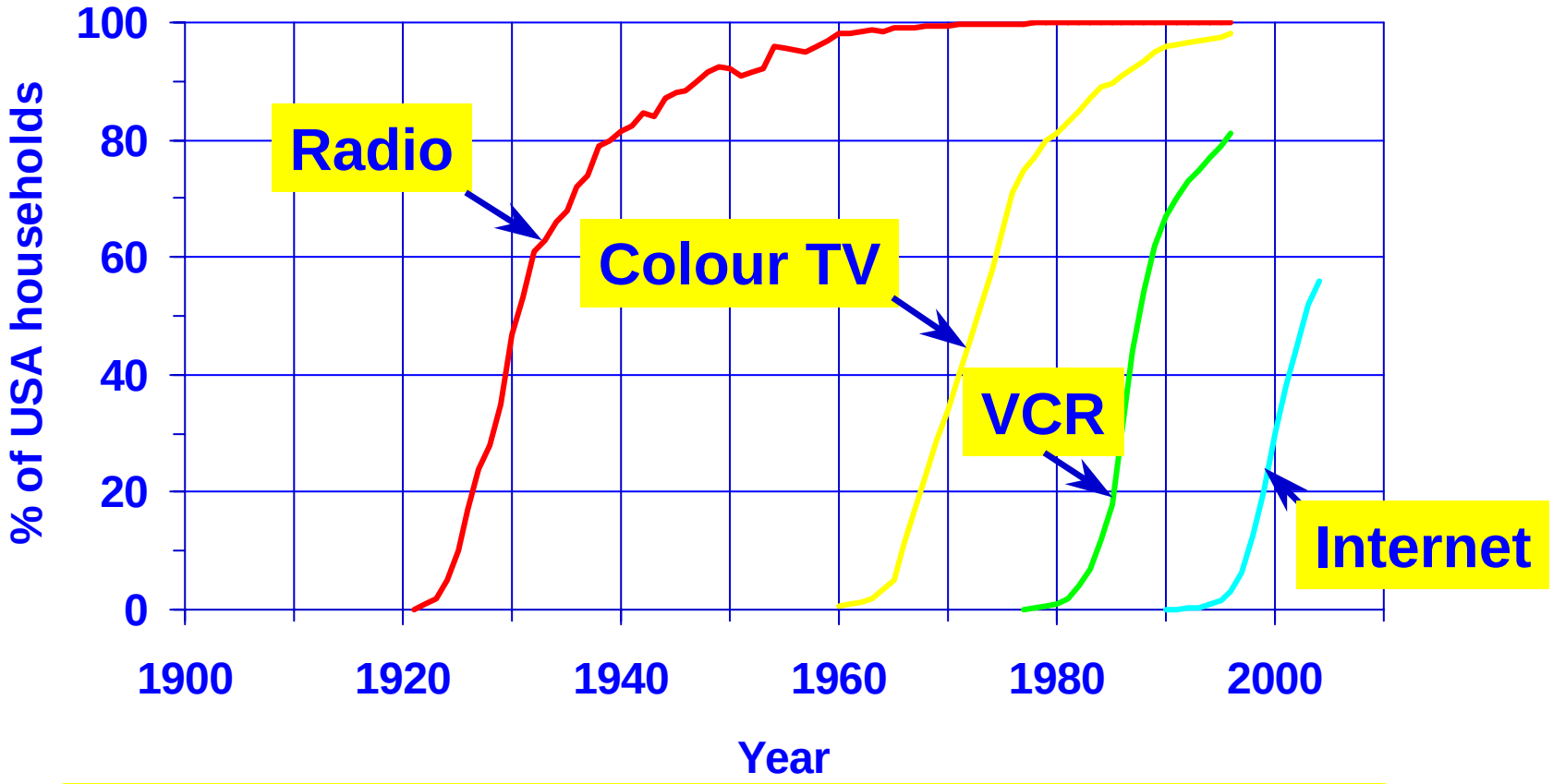
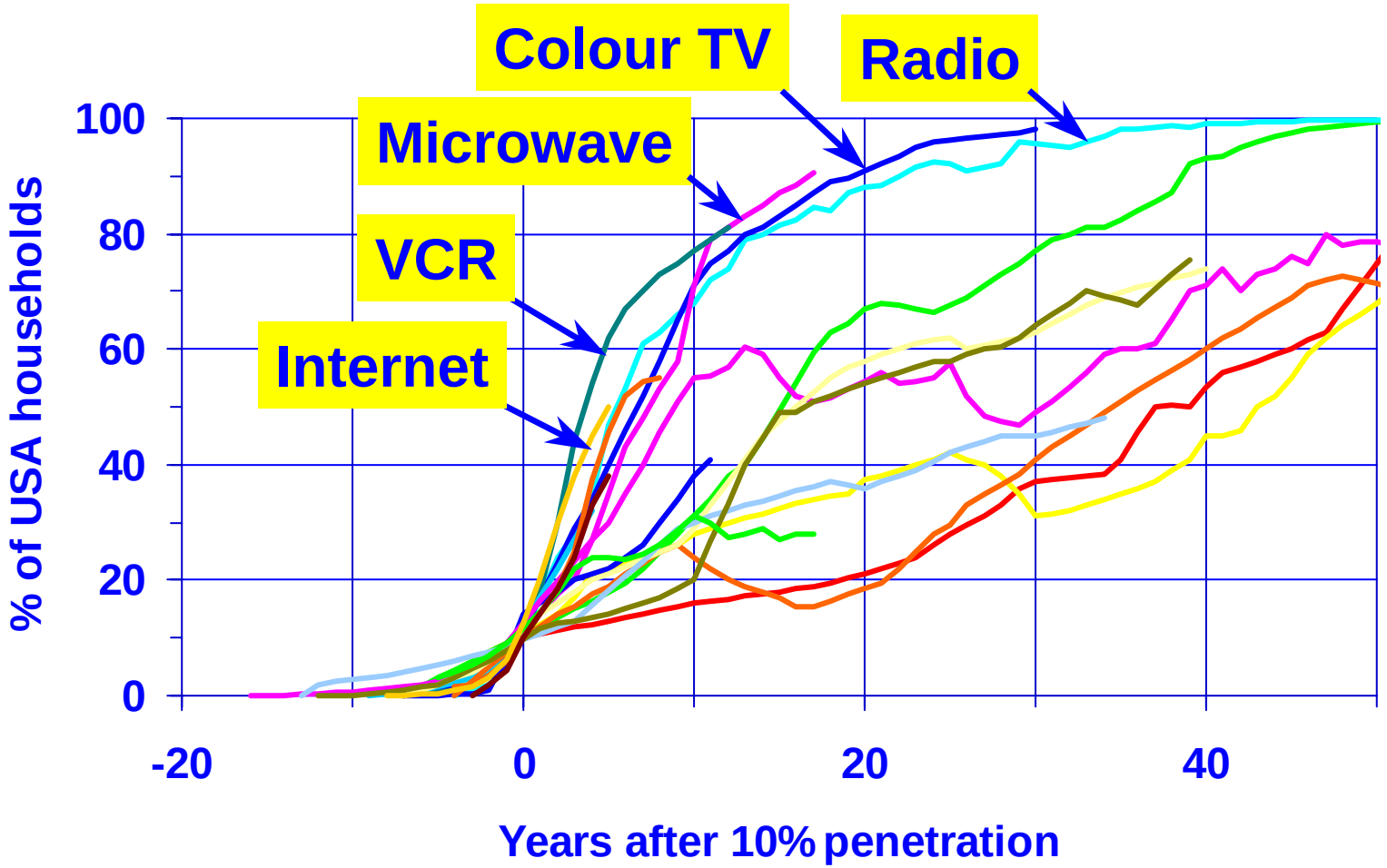
ALMOST IDENTICAL?

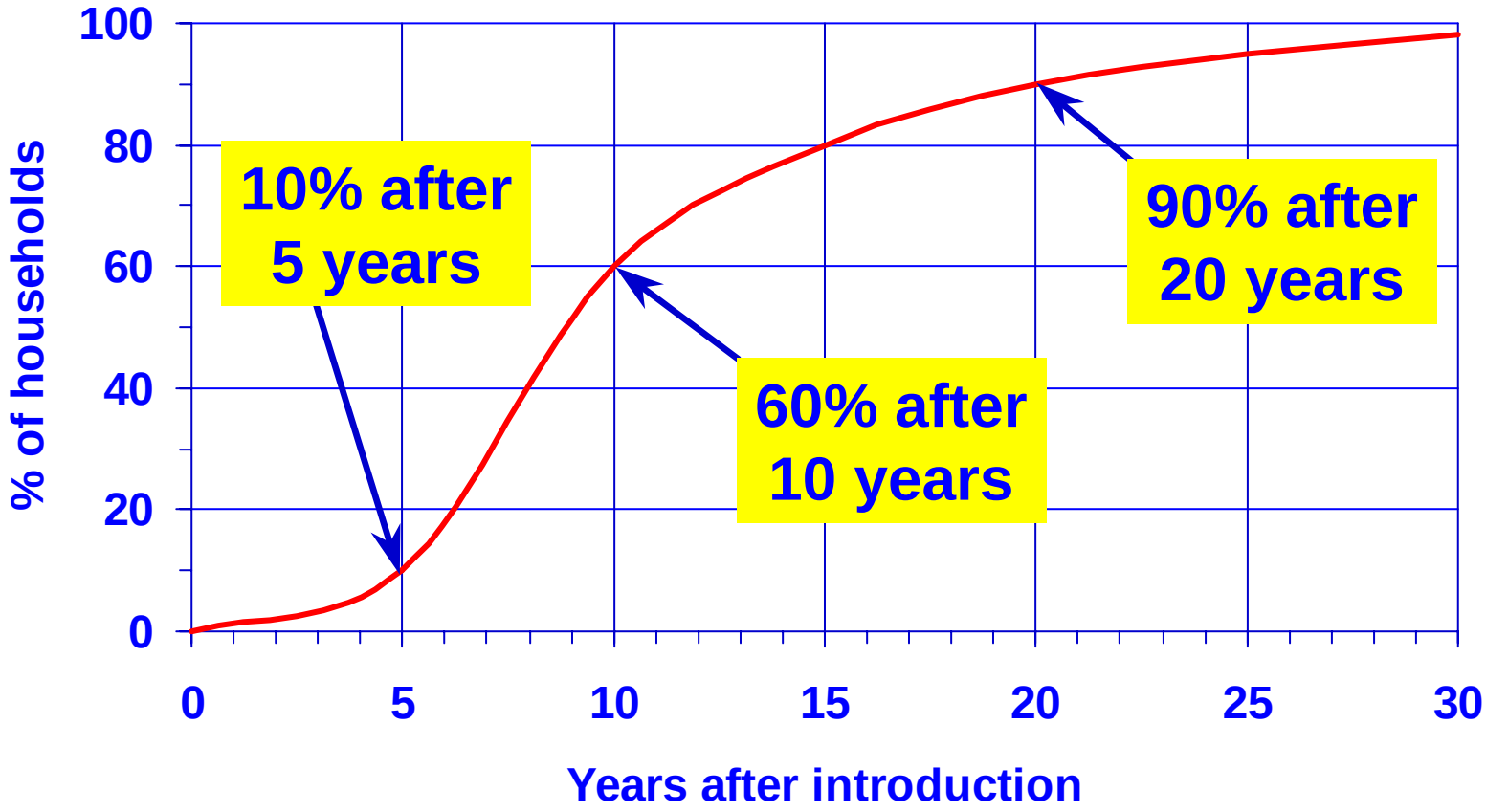


Despite the hype, the adoption of the Internet in the USA is no faster than that of VCRs!

FROM 10% TO 90%


Colour TV
Radio
Microwave
VCR
Internet
100
80
60
40
20
0
% of USA households
-20
0
20
40
Years after 10% penetration

IF YOU ARE VERY, VERY LUCKY ….



TRANSITION TO DIGITAL

- Some countries want a rapid transition from analogue to digital broadcasting
  - several have proposed dates around 2007
  - analogue TV services have already been switched off on Berlin – but is this possible in other countries?
- Some countries have NO plans for digital TV broadcasting – and have not even considered a date for closure of their analogue TV services
- Frequency plans must take full account of these different conditions (even in adjacent countries)

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