Optical-Fibre Telecommunication Systems

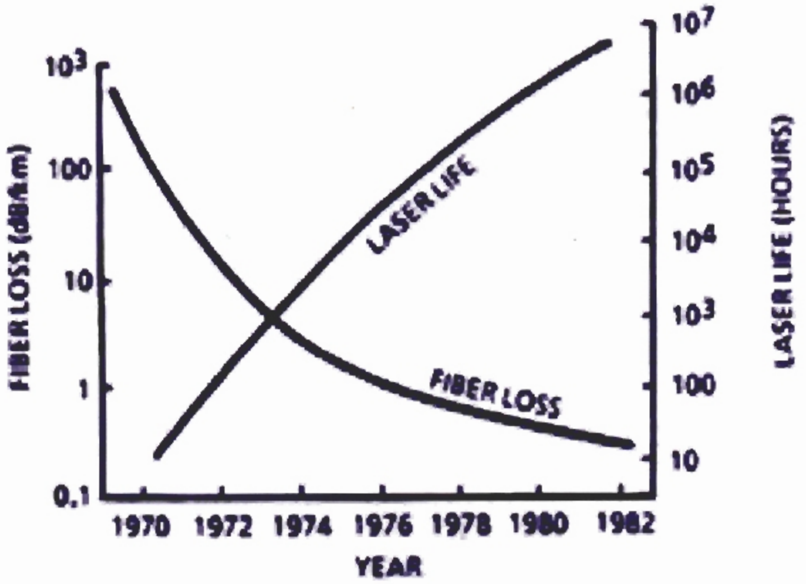
Optical communications has a long history – think of fire & smoke signals!
Heliograph used for signalling during military operations in 1800's.
The advent of electronic communications virtually eliminated interest in optical communications.

By the middle of the 20th Century, the electronic communication spectrum was becoming very crowded. It was difficult to get more telephone lines -especially in more urban areas.

When the semiconductor laser was invented in the 1960's interest in optical communication was revived due to its many advantages:

- *Very high concentration of optical power and very little spread in power with distance – i.e. low beam divergence*
- *Ability to carry huge amounts of information – i.e. large information bandwidth*
- *Narrow spectral linewidth allowing high rejection of light except at laser wavelength*
- *High coherence, allowing frequency modulation and superheterodyne detection*
- *Small detectors compared to large radio frequency antennas*

Light is scattered by atmospheric turbulence – haze and dust also a problem. Therefore optical fibres are the solution. *Significant* improvement in both lasers and fibres in the last few years.

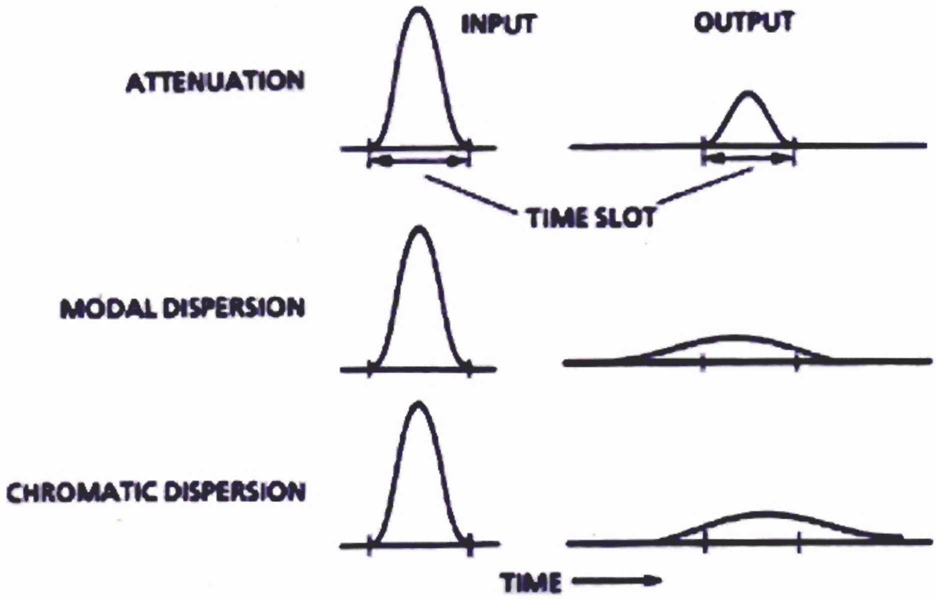


<u>Three main causes of signal degradation in optical fibres.</u>

1.) Attenuation: The intensity of the light decreases as it travels along the fibre – mainly due to impurities in silica based fibres. Currently we can get better than 0.2dB/km at 1.55μm.

2.) Modal dispersion: The light travels down the fibre taking different paths, such that some arrives earlier and some later. This results in a broadening of the pulse.

3.) Chromatic dispersion: The speed of light down the fibre varies as the refractive index varies with wavelength. This results in a spreading of the pulse as it travels down the fibre.



Three main minima in fibre loss characteristic – at 0.85μm, 1.3μm and 1.55μm referred to usually as the 1st, 2nd and 3rd windows respectively.

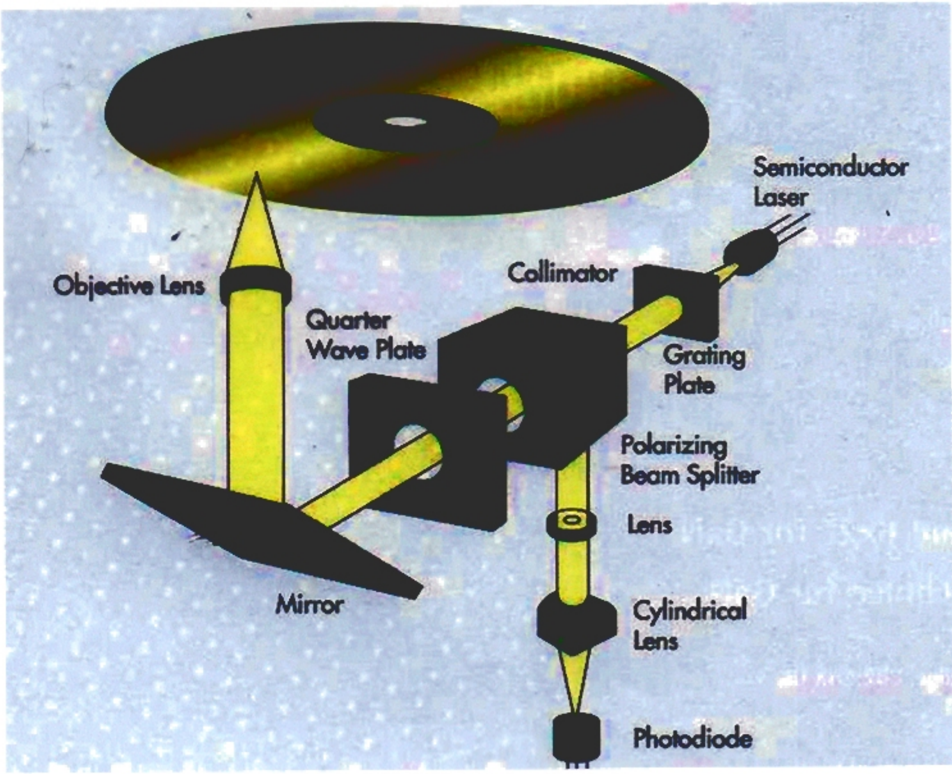
Window	Fibre Loss	Laser	Detector
1st/0.85μm	2dB/km	AlGaAs	Si
2nd/1.3μm	0.5dB/km	InGaAsP	Ge or InGaAs
3rd/1.55μm	0.2dB/km	InGaAsP	InGaAs

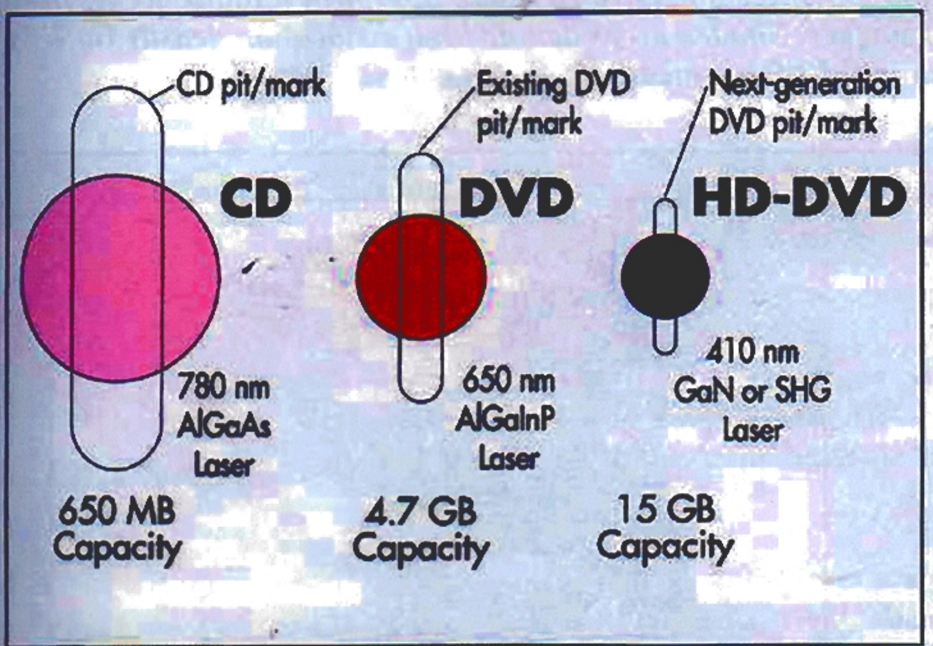
Example:

A 1.55μm laser couples 0.1mW power into a fibre that has a loss of 0.2dB/km. The optical receiver at the far end of the fibre can detect a signal of 40dBm. How long can the fibre be without an optical repeater or amplifier?

Solution: dBm = dB's below 1mW, i.e. 0dBm = 1mW
So 0.1mW = 10dBm
This means that the system has a margin of (40-10)dBm to cover losses. This works out to 30/0.2 = 150km of fibre.

Avalanche photodiodes (APDs) are optical detectors that amplify the optical signal, increasing the receiver sensitivity by about another 10dBm. This translates to another 50km of fibre (i.e. 200km) without need for a repeater.





Schematic representation of the relative sizes of laser spots and pit marks in CDs, current DVDs and the next generation of high density DVDs.