Opportunities for a Sustainable Communications Technology

Stefan Spaarmann

Presentation given at the Conference of the *Compentence Initiative for the Protection of Humanity, Environment and Democracy*
at Chateau Klingenthal in 2009.

From 2008 to 2009, the project received guidance from the BUND Saxony, Working Group Electrosmog and Radiation Protection - Citizen Project "The Electromagnetic Eye".

Valuable suggestions were received from Claus Scheingraber / Working Group Electrobiology Munich, Ingrid Dickenson / Bio-Electromagnetic Research Initiative (BEMRI) , Birgit Stöcker / Federal Association for Electrosensitive, and Karl Richter / Competence Initiative.

Summary

- The historical development and trends in optical communications engineering are outlined.
- Problems with light and electromagnetic pollution, information clutter, off-limits frequencies, sensory overload are discussed, showing that, for environmental reasons, currents of communication (incl. light) must run inside cables as much as possible.
- Photon-based networks are already worldwide the backbone of communications. The further extension of fiber-optic cables to the end user is indispensable. RF radiation is not sustainable as a basis for mass communication.
- It will be shown that--just like in nature--light or optical communication is possible without pollution.
- A concept for an optical cell phone is introduced.

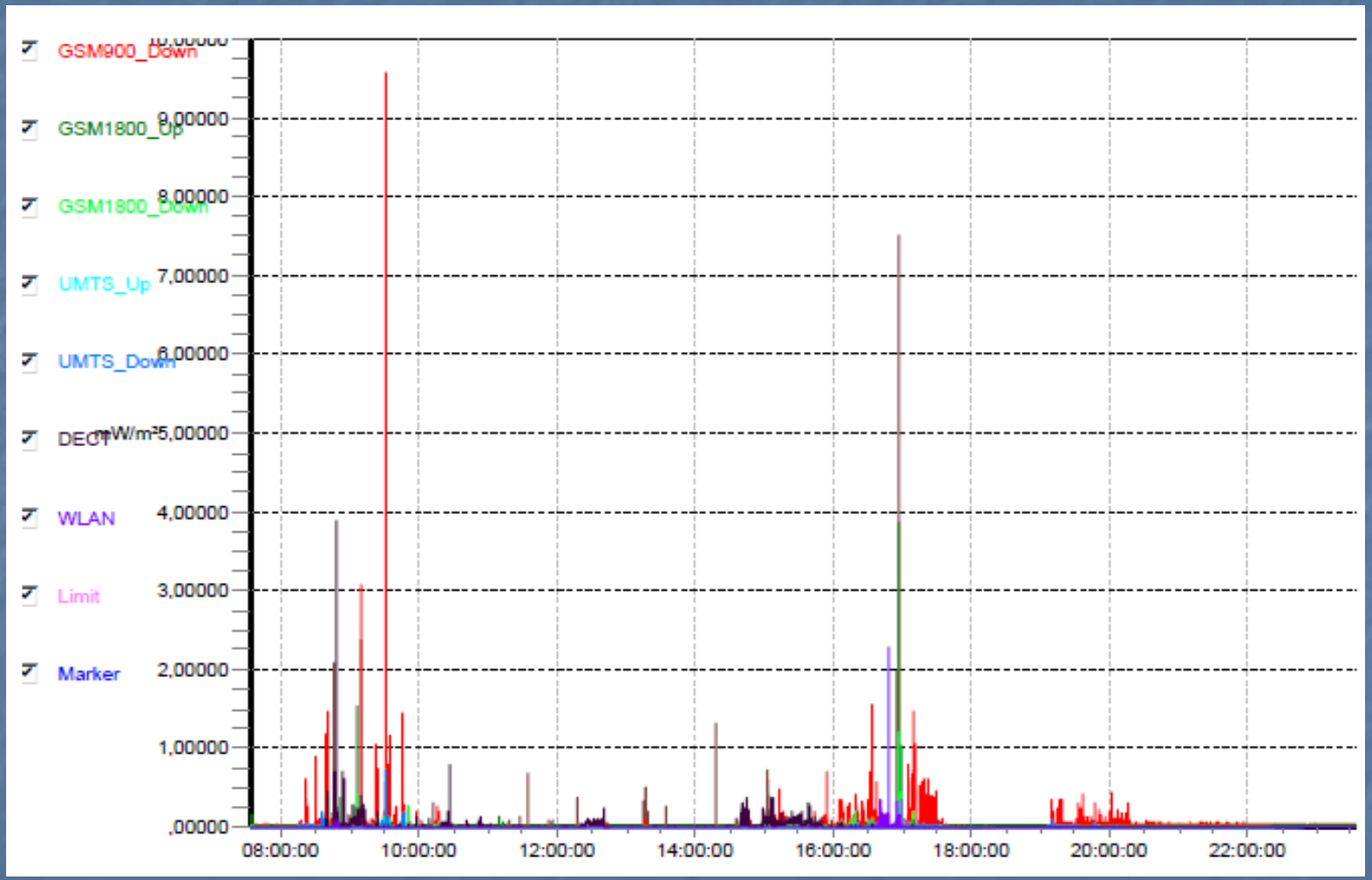
TODAY

Environmental Pollution through Microwaves and a Blatant Waste of Energy



www.strahlengefahr.de

Under Constant Fire from Microwave Pulses



Personal Dosimeter Monitoring in Northern Saxony, Germany

The Basics

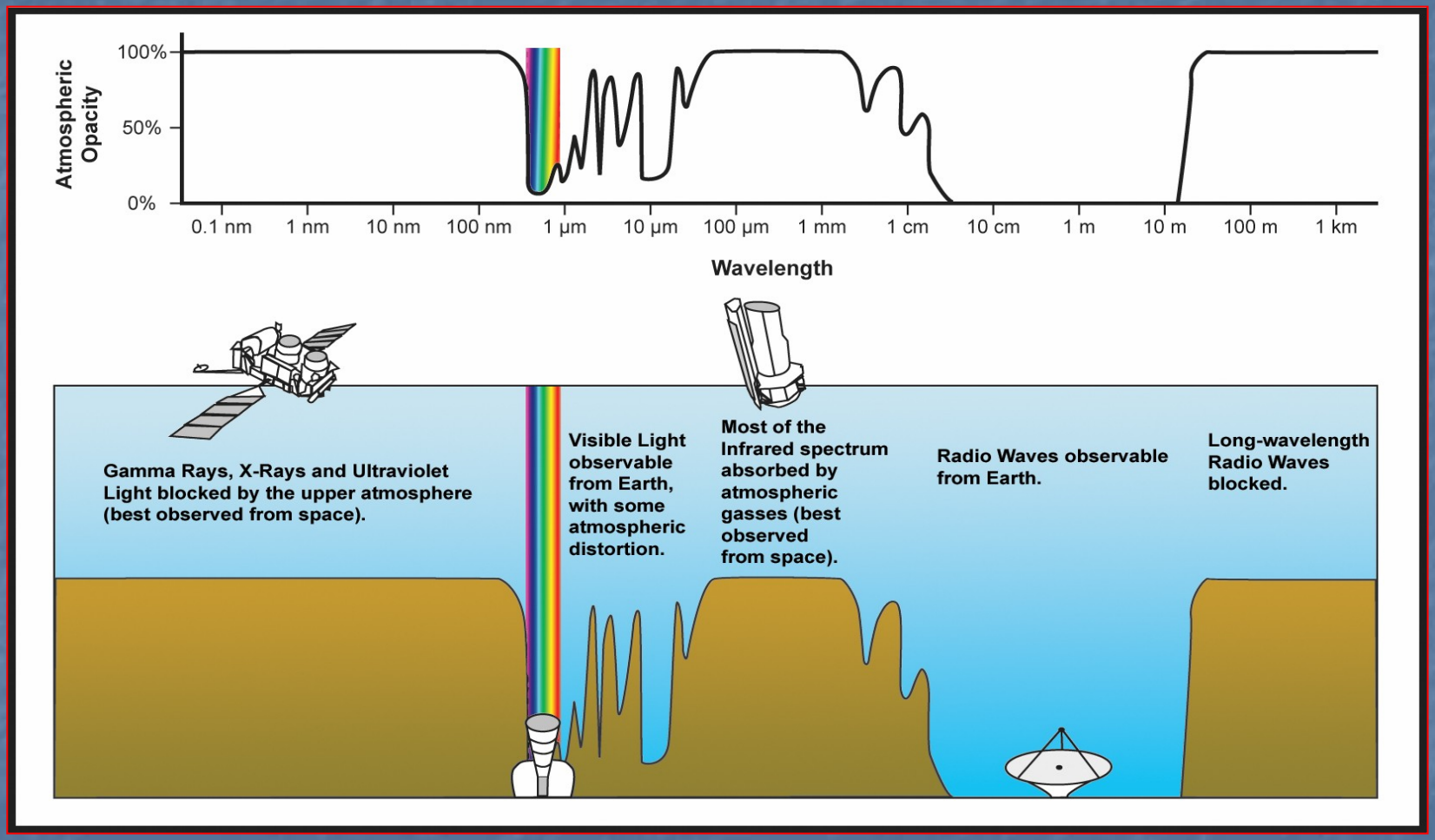
What does "sustainable" mean?

Communications technologies must meet the needs of data transmission without polluting the environment. RF radiation goes up to about 300 GHz or millimeter waves. In fact, there is no sustainable RF technology because it is always associated with electromagnetic pollution.

Our Proposition: Light can be the way out.

In contrast, RF radiation for mass communication must gradually be removed from the airwaves because it is suspected of jeopardizing the gene pool on Earth.

EMF



http://en.wikipedia.org/wiki/Image:Atmospheric_electromagnetic_transmittance_or_opacity.jpg

Principles of Communications with EMF

A transmitter emits the carrier frequency modulated by the encoded information signals; a receiver demodulates or decodes it.

Medium: Wave Guide (zero exposure) / Airwaves (radiation, exposure)
Airwaves: RF Radiation / Light (FSO)

Bit/s: Proportional Frequency Bandwidth

The Special Properties of Light

- The physical properties of light differ from those of radio and microwaves (change of thinking).
- Line-of-Sight (LOS) Transmitter – Receiver: Size of a cell determined by existing wall structures (femtocell where required), connection via cables
- In case of high bundling rates, mobile receiver and transmitter must track each other → tracking problem → optical cell phone

Photonic Networks

- Without limitation of data transfer rates (bandwidth)
- Cost savings over RF radiation technologies
- No license fees, secure data transfer, eavesdropping-proof
- Basic network structure already worldwide in place (fiber-optic networks)
- Fiber-optic networks and wireless ones supplement each other
- Environmentally friendly (space-specific and free of wireless pollution)
- Light does not go through walls, protection of humans and nature protection of residences/property possible (Constitution)
- Connection with existing technology (electronics, optics)
- Optimal transmission efficiency
- Transmission power savings on the order of magnitudes
- Prime example of the unity between economy and ecology

"Ecological Turning Point of the Communications Technology"

Even with Light: Caution and Precaution

- Glare (high intensity lamps, sun, laser)
- Flicker frequencies (compare ELF and structure-borne noise)
- Abnormal biorhythm due to artificial lighting (night work)
- Blue light portion of artificial lighting, sufficient daylight and incandescent light (continuum)
- Solar UV due to ozone hole, halogen lamp only with UV filter, sunglasses without UV protection hazardous
- Overstimulation through visual impressions (too much illuminated advertising, TV, computer work, games, Internet)

E-smog - Lightsmog, Off-limits Frequencies

- In a physics sense, light is also EMF even though it features totally different properties. In fact, lightsmog is also electrosmog. Just like with RF radiation, quantitative exposure levels must stay within the framework of nature (otherwise glare)
- Natural frequencies essential to life must also remain off-limits for light modulations (brain waves, Schumann resonances, fair weather frequencies, etc.), qualitative components of smog
- Information clutter is a basic problem with any mass communication (unnatural and constant overstimulation) ->

Away with the Information Clutter

- Without information no life, but too much means overstimulation, overstimulation makes sick
- Information clutter may, but does not have to be directly accessible to our sensory organs, can be visible or invisible, audible or inaudible, detectable or not--whether it penetrates the body or not is what counts
- Information clutter caused by EMF
  - Electrosmog is especially well known as ELF and microwave radiation
  - Light pollution is known as advertising, sea of lights, ...
  - Artificial lighting with too high a portion of blue light or glare is common today

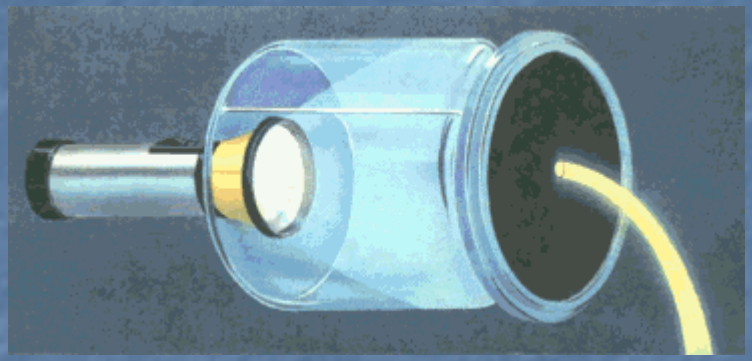
Transition from RF Radiation to Photonics

If you believe you could simply replace RF frequencies with light frequencies and everything would be alright, you are mistaken!

The infrastructure of light communication has to be switched to fiber-optic cables and must not be based on airwave transmission because potentially dangerous currents of substances or information overload the environment.

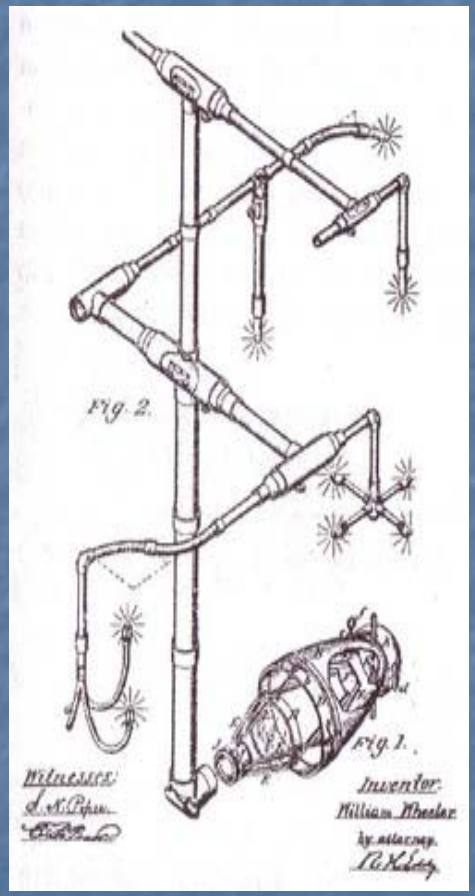
Fiber-optic Cable

1970 Fiber-optic Bundle



1870 John Tyndall: Light can be guided by total internal reflection in a jet of water

1881 William Wheeler: hollow glass pipes with silver coating for the lighting of a home



(From 1970 optical fibers. 1976 first fiber-optic cable with 144 fibers for 50,000 phone calls in the USA)

Today Worldwide Fiber-optic Backbone

Fiber-optic cable (FOC) made from optical fibers for IR is standard today, fiber-optic bundles connect continents and the megacities of the world. IR attenuation developed from 1000 dB/km to 0.4 dB/km at optimal wavelengths.
In a building (vehicle, etc.), polymer fibers and visible light are preferable, attenuation plays only a minor role because of the short distances

USB- Adapter Ethernet -Optical fiber for 10 Gb/s at 1310 nm or 1550 nm.
Maximum distance with 10µm - Monomode fibers are 10 km or 40 km long without an amplifier !



"The entire population of the Earth could be on the phone on a single fiber at the same time!"

Hierarchy of Networks

- Wide-area network (WAN)
- Metropolitan area network (MAN)
- Local area network (LAN) and gigabit Ethernet port (GEP)
- Mobile end user in communications network cell (femtocell)

Optical technologies have not yet reached the lower levels of this hierarchy in 2009. As a result, we suffer from chaotic wireless pollution. In truly advanced industrial countries, FOC is already supplied to the end user.

Electrical Installations and Telecommunications

Broadband over Power Line (BPL) technologies must be refused because they pollute an entire building across the home wiring with their communications electrosmog.

In contrast, light offers a pollution-free solution. Optical fibers can easily be integrated into electrical wiring. They do not interfere with each other!

Combination cables for electricity and telecommunications are already available, but not yet common.

Later, after reintroduction of DC electricity for home wiring (in order to avoid the 50/60-Hz magnetic-field pollution), these cables won‘t have to be replaced.

Volkrodt's Dream

Dr.-Ing. W. Volkrodt, former R&D engineer at Siemens, put his hope in the common sense of decision makers.

He wrote in 1987:

„Future historians will refer to the wireless plight during the time period between around 1975 and 1990 as a minor "technical incident" of limited duration. Thanks to the introduction of fiber-optic technology, it could quickly and permanently be remedied."

Free Space Optics

Terms

- Free Space Optics (FSO)
- Free Space Photonics (FSP)
- Optical Wireless Communications (OWC)
- Visible Light Communications (VLC)
- Optical Wireless LAN (OWLAN)
- Ham radio operators use: “Optical Radiation,” “Optical Phone,” “Optical Talk”

The beginnings

- Using light for the dissemination of news is the natural form of visual communication.
- In the past, humans could communicate across great distances virtually at light speed via beacon fires, smoke signals, signal markers and light houses. It brings the signal flag alphabet to mind.
- Optical communications engineering has a long history, longer than RF engineering. Even though the e-smog problem was known, RF technologies were ruthlessly applied and through misuse have turned into a threat to life. Optical communications engineering is only at its beginnings and its possibilities are not really explored yet.
- As will be shown later: Back to the roots will lead to pollution-free communication with high tech.

1813 Chappe's Telegraph

(Optical Telegraph Connection Metz–Mainz)



French Military: Chappe's telegraph system (semaphore) consisted of wooden structures mounted five meters high every 11 km, each featuring three movable arms to create 196 different signs with word and sentence meanings as well as telescopes to observe the signs from neighboring stations in both directions. In one minute a single sign crossed a distance of 135 km. Lamps attached to the movable arms allowed nighttime signaling.

1880 Photophone by Graham Bell

3 . History of Visible Light Communications

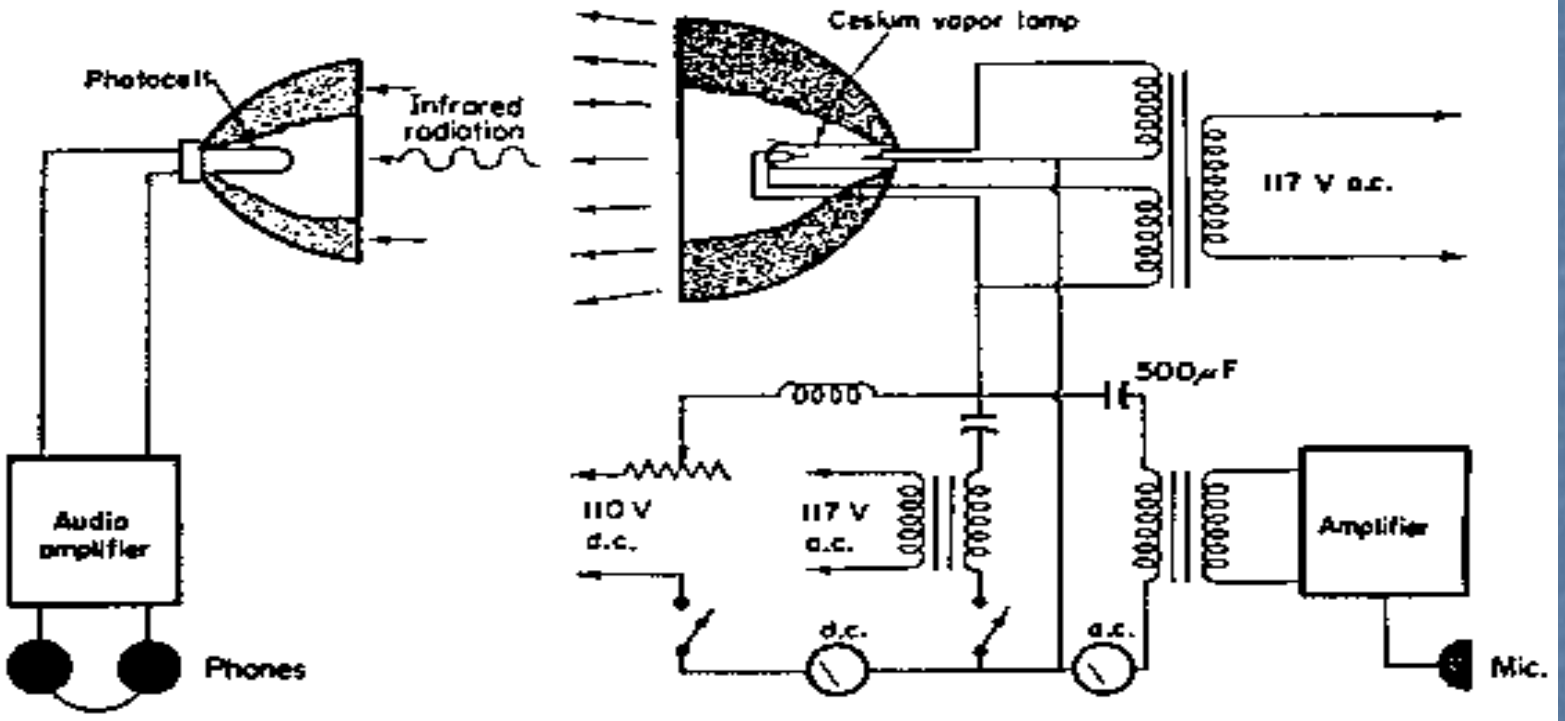
Photophone by Graham Bell in 1880



The first experiment of Visible Light Communications was done by Graham Bell whose system was called Photophone. He loved the idea.

This picture is from the website of Bell Laboratories whose experiment showed 200m distance voice communication.

1944 Military Infrared Telephony



Cesium vapour infra-red lamp (852 and 894 nm) used for covert audio communications. by the US Navy in 1944. The discharge ran at 17 volts, 6 amps quiescent.

www.modulatedlight.org/Modulated_Light_DX/OpticalComms4Amateur79.html

1955 First Wireless Remote Control
(Visible Light)



Zenith with Flash-Matic Remote Control

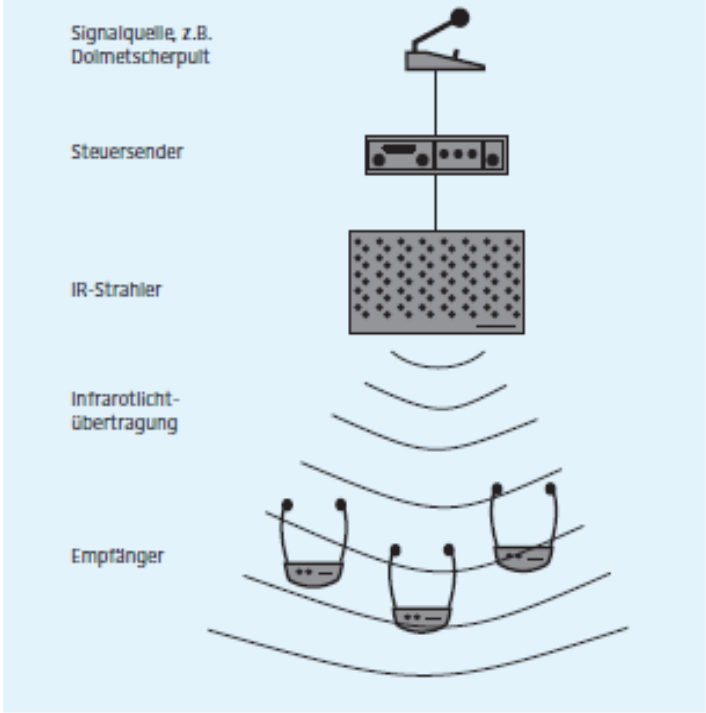
This system uses photoelectric cells in the four corners of the screen to control on/off, mute and channel selection. One year later, ultrasound technology replaced the light system.

Today infrared remote control is common.

www.vintagetvsets.com/fm1.htm

1976 IR Translation Systems

The Sennheiser IR technology combines amplitude with frequency modulation. It also adds another intermediate step: The ELF signal is shifted to frequency bands (channels) in the RF range. Different ELF signals are modulated onto various channels. These signals are mixed and control the intensity of the IR diodes. A receiver tuned to a given channel demodulates the signal then.



Signalweg einer Infrarotlicht-Übertragungsanlage

www.sennheiser.com/sennheiser/icm.nsf/...D.../Einleitung_D.pdf

LED Communication with RONJA

Prague: **R**easonable **O**ptical **N**ear **J**oint **A**ccess is a user controlled technology project (like free software) of an optical point-to-point data link. The device has a 1.4 km range and a stable 10 Mbps full duplex data rate. You can mount RONJA on your house and connect your PC or any other networking device to it. All documents for a do-it-yourself project are available for free under the GNU license.



Single high-output LED with a 13-cm glass lens. At 1 km, the beam is about 4 meters wide.

Past and Future Next to Each Other



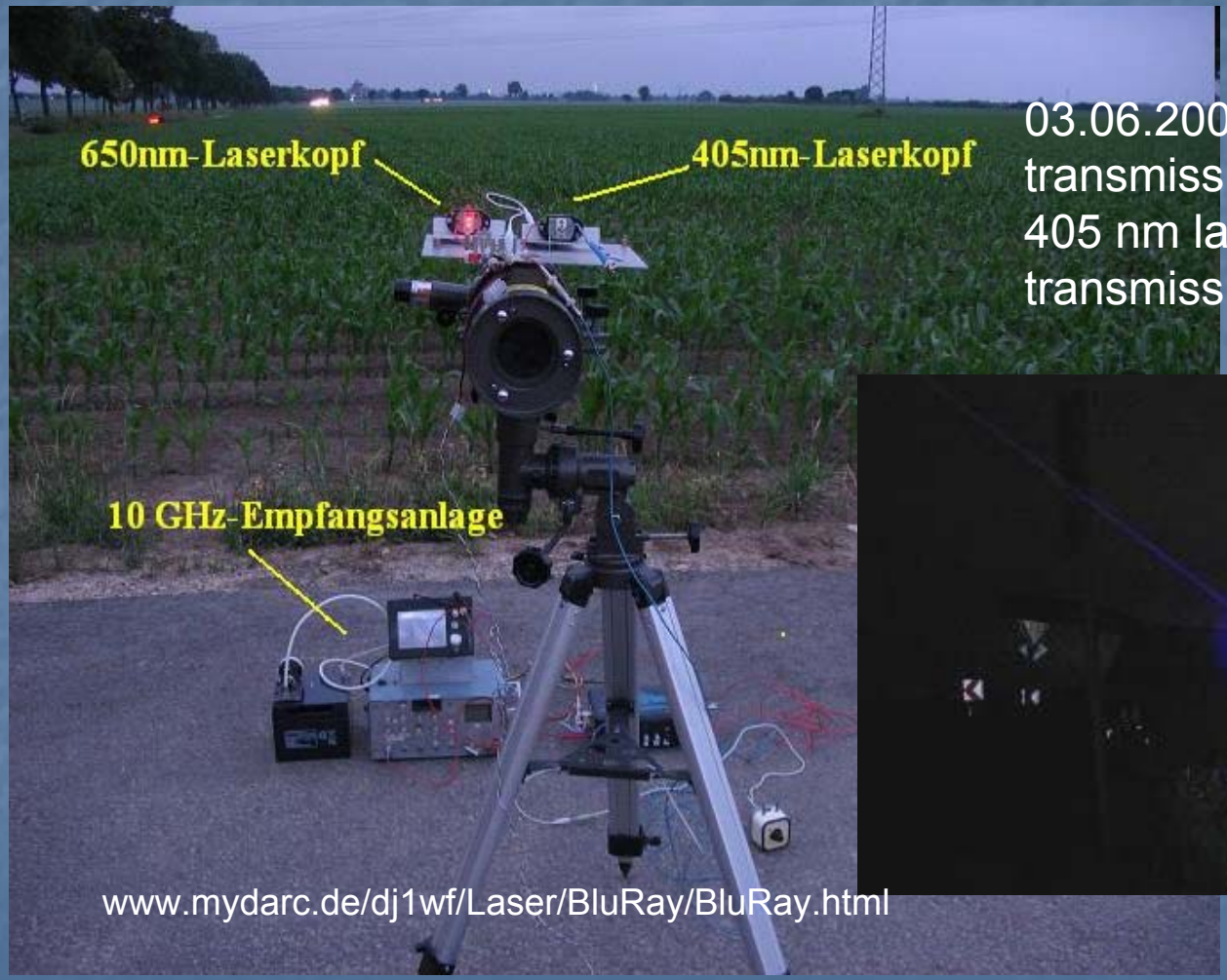
http://ronja.twibright.com/models.php

LED or Laser

Today data transfer rates from 2 to 32 Mbit/s are common. The data transfer rate for LED transceivers is limited to 622 Mbit/s. Due to the characteristic switch hysteresis, the emitter LED has this inertia. In a 10-Gigabit Ethernet, an LED transceiver does not do. A Laser is used instead so that 100 Gbit/s can be realized.

Laser radiation is coherent. Upon penetration of a body, its coherence length becomes increasingly shorter. The development of optical emitters and receivers is only in its infancy (nanotech).

2007 Ham Radio Operators: Blu Ray Light



03.06.2007 , DJ1WF, TV transmission across 112 km with 405 nm laser beam, only 5 mW transmission power



www.mydarc.de/dj1wf/Laser/BluRay/BluRay.html

Commercially available IR FSO Device

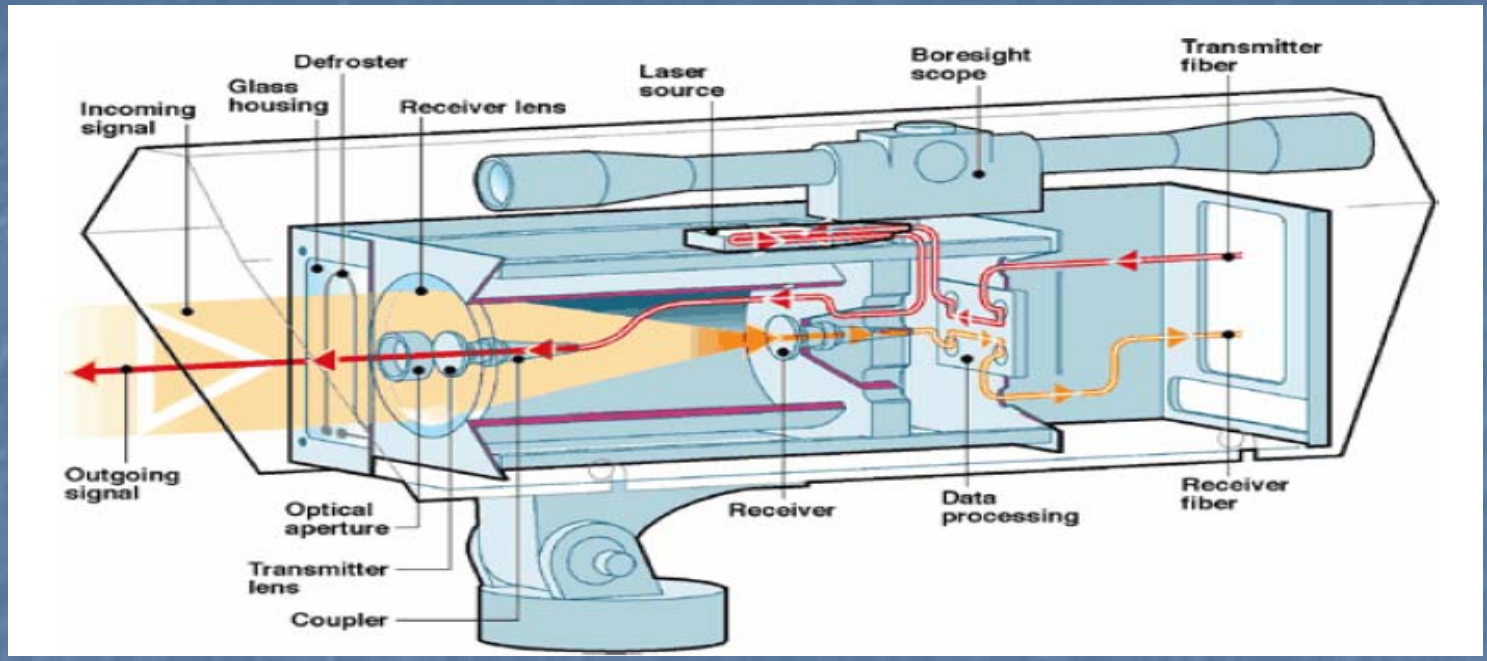
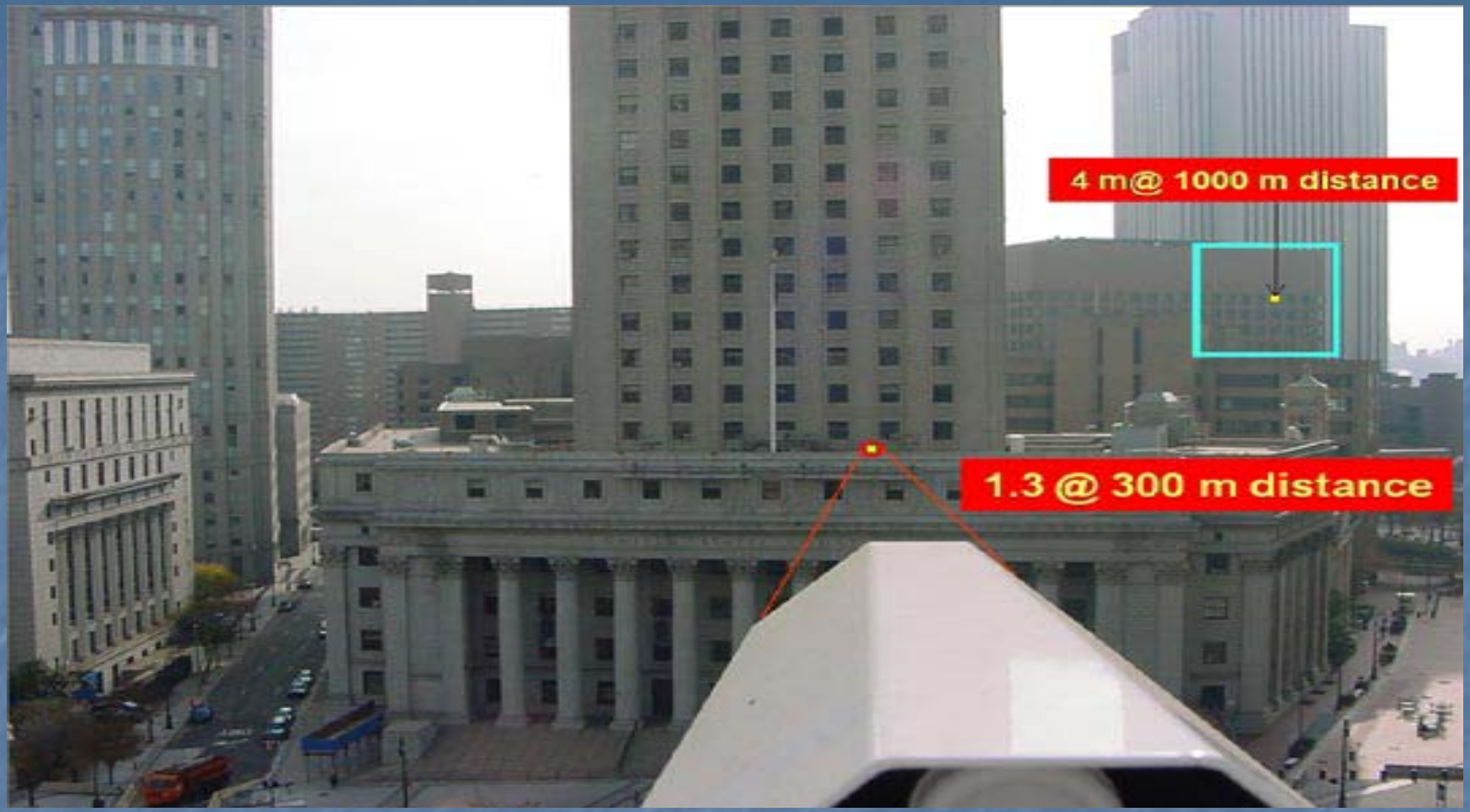


Figure 1.1.3: This is a schematic cross section of an FSO system. To the right: network system connections, to the left of it the controls. At the top: "pointing telescope" for alignment of device during installation, below which the laser diode is located. To the left: single or emitter beam as well as the lens system. In the center: receiver, photodiode. In front of the lens system is a glass pane with integrated heating to prevent the freezing of water or the fogging up of the glass pane.

www.blue-neutrino.com/download/Optischer%20Richtfunk.pdf



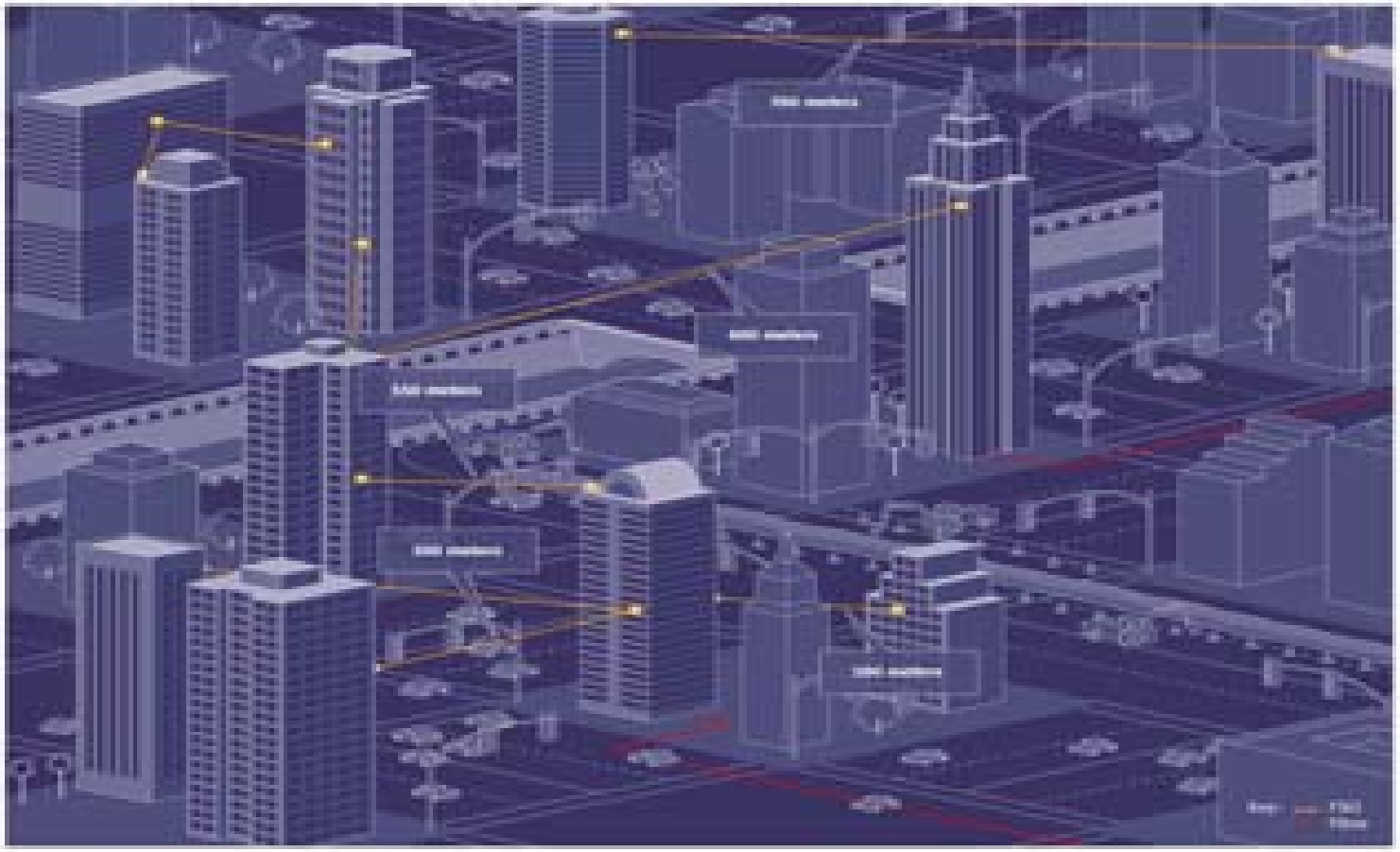
Due to the fact that the beam divergence angles in optical wireless systems are very narrow, the FSO community typically uses milliradiant as measure for beam divergence. 1 radiant (rad)=57.3 degrees or 1 milliradiant (mrad)=0.0573 degrees. In other words, the divergence angle in mrad roughly corresponds to the beam diameter at a distance of 1 kilometer from the originating source.

http://www.lightpointe.com/whitepapers/LPC_FSO_OpticalWirelessSecurity.pdf

2001 Quick Disaster Help

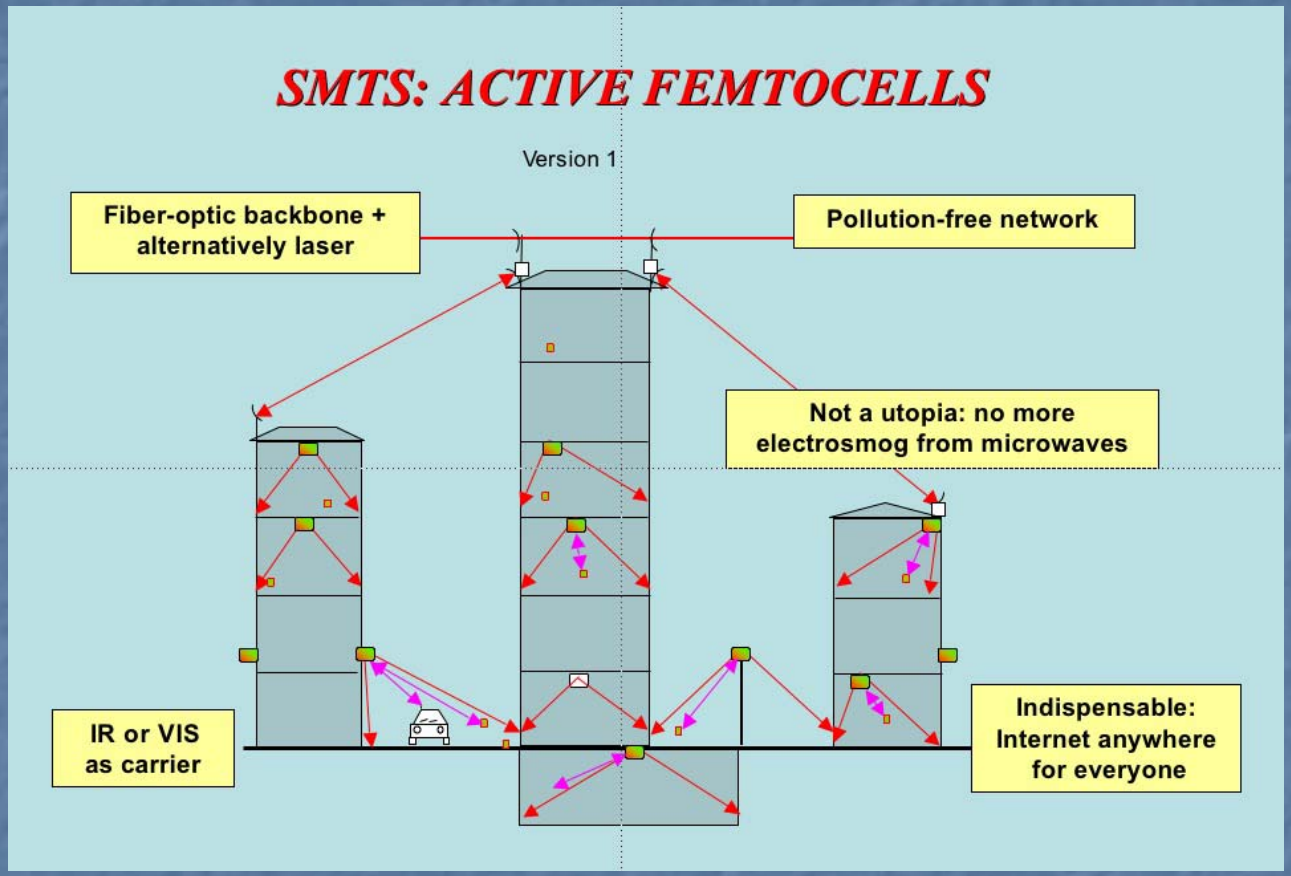
- After the destruction of the World Trade Center on September 9, 2001, free space optics was in the limelight for the first time. Many newspapers reported about the amazing possibilities of this technology. Due to the collapse of the WTC, fiber-optic cables at the lower floors had been destroyed. Several companies in the surrounding buildings were completely cut off from the Internet.
- After it was clear that the repair of the fiber-optic cables would take some time, a few companies decided on a somewhat unconventional solution: They had FSO systems installed on their buildings, which could establish a connection with other offices of their company that were further away.
- The entire installation was completed within a few days, downtime was reduced significantly.

LIGHTPOINTE™



METRO BASE

2002, 2007 FSO Femtocell Concept



ALARA

could be put into action like this.

SMTS: A Concept for Sustainable Wireless Communication, HESE Project 2003 and
Is there a way out of the EMF crisis? Frankfurt Envrionmental Conference 2007, Spaarmann

Global IR Satellite Downlink

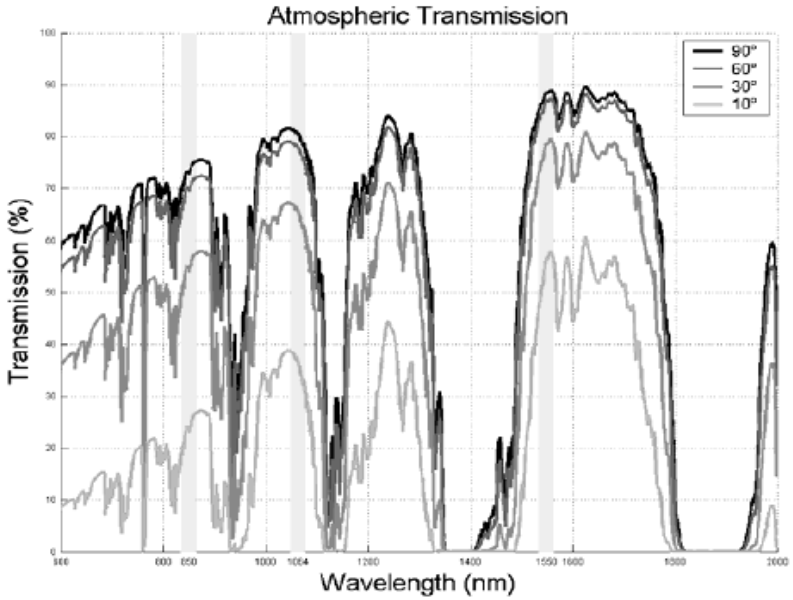


Fig. 7. Atmospheric transmission for LEO downlinks to Neustrelitz at selected elevation angles. Clear-sky atmospheric transmission windows that determine the wavelength selection for FSO and at which suitable components are available are marked by grey background coloring. The used atmosphere model is the Midlatitude Summer model combined with a rural aerosol model for the last 2km and a moderate volcanic activity model for the rest of the atmosphere.

Plan for **L**ow **E**arth **O**rbit LEO: Orbit at 700 -1500 km. Wavelength regions for IR-FSO are 850 nm, 1064 nm, 1550 nm

http://elib.dlr.de/55548/

2003 IrDA and VLCC Join Forces

- Infrared: IrDA (www.irda.org) is an international organization formed in 1993 and is dedicated to creating global, interoperable, low-cost infrared technology specification standards.

- Visible Light Communications Consortium (VLCC) was founded in 2003 to research, develop, plan, standardize the visible light communication system in Japan. **25 companies including Tokyo Electric Power Company Inc, KDDI Corp, Panasonic Corp, Sharp Corp and Fuji Television Network Inc.** VLCC's standardization activities resulted in the JEITA standards (Japan Electronics and Information Technology Industries Association) as "visible light ID system" in 2007, and has been preparing to propose visible light communication standards for various applications.

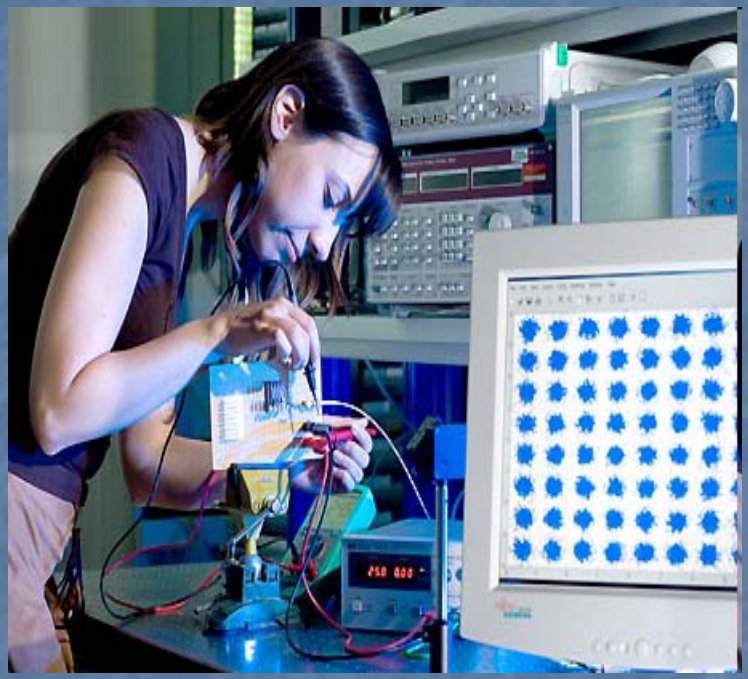
  www.vlcc.net/

- Chairman of VLCC, Professor Masao Nakagawa of Keio University

VLC Project of the EU: OMEGA

- Development of a global standard for ultra-broadband home networks (operating at 1 Gbit/s) LED-powered VLC is the key technology. (project error: power line!)
- An OMEGA showroom 2010 at the offices of France Telecom in Paris, where the ceiling lighting will be broadcasting data at 100 Mbit/s. LED lighting and communications with street lamps.

http://kn.theiet.org/magazine/issues/0819/see-send-0819.cfm



http://w1.siemens.com/innovation/en/about_fande/corp_technology/research_technologies/info_comm.htm

2010 VLC and LED Lighting

(Office, Road, Vehicle, ... Femtocells)

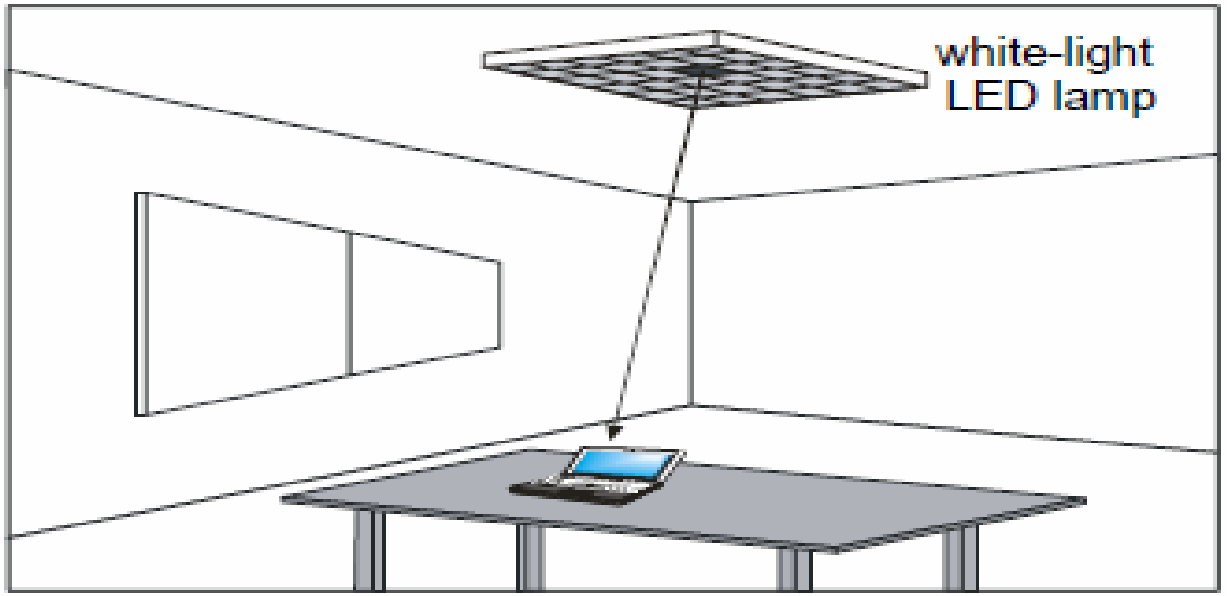


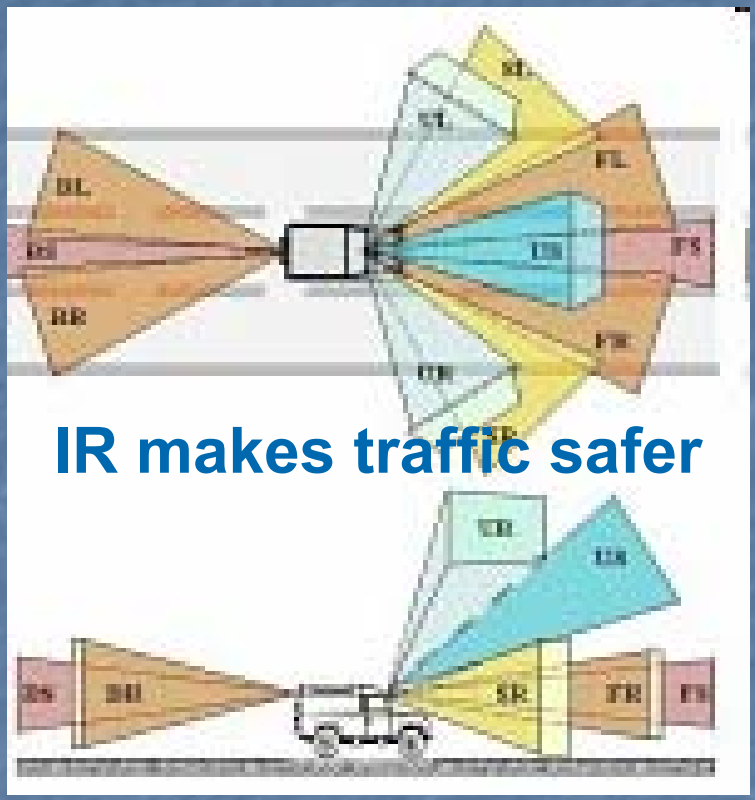
Fig. 1. Data transmission and illumination scenario from a white-light LED lamp to a laptop.

Wireless High-Speed with White-Light LEDs, Grubor, Lee, Walewsky.

Modulation bandwidth increased from 3 to 20 MHz, used only blue

2006 – 2010 EU Traffic Safety

- CVIS (Cooperative Vehicle-Infrastructure System). Budget € 40 million, consortium of over 60 industrial, public and academic organizations, complete its 4-year programme in early 2010.
- Hardware filter against ambient light, since 2005 new international standard.
- ISO CALM active bi-directional high speed IR communication
- www.efkon.com



www.innovations-report.de/html/berichte/automotive/unfallverhuetung_per_infrarot_56421.html

2003 – 2010 Japan Traffic Management

First signs of a new direction: Design of image-sensor-based photo receiver and transmitter optics for inter-mobile-appliance free-space optical communications

„We are developing a fast and compact free-space optical communication system based on a special CMOS-image-sensor photo receiver for mobile appliances. We have designed and fabricated an image-sensor-based photo receiver with 50*50 pixels and four concurrent output channels by use of a 0.35-.MU.m CMOS technology. We have also developed a two-dimensional scanning lens for a MEMS (Micro-Electro Mechanical Systems) mirror to realize a compact optical transmitter.“

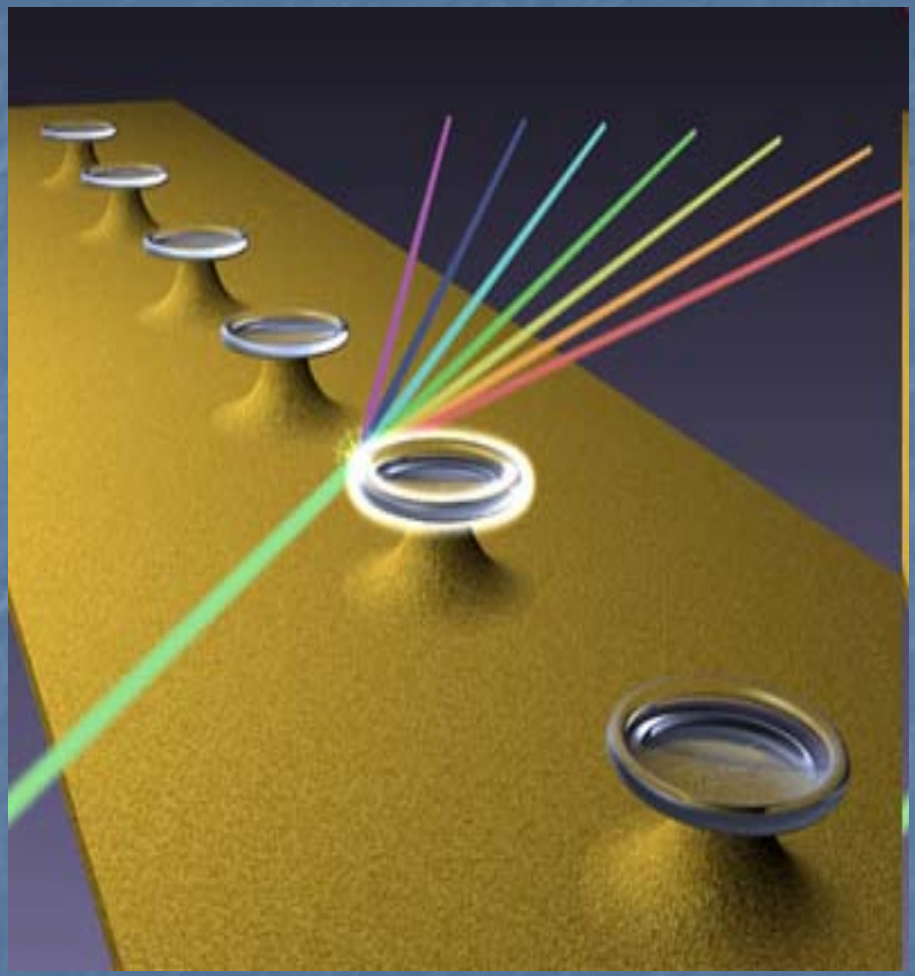
KAGAWA KEIICHIRO (Advanced Inst. Sci. and Technol., Nara) et al. , Eizo Joho Media Gakkai Gijutsu Hokoku, VOL.27;NO.39(IST2003 21-30/ME2003 117-126);PAGE.1-4(**2003**)

Business Information 2009

- Two new visible light communication technologies (VLC)
  - Long-distance Photodiode Communication
  - Image Sensor Communication (ISC)
- The experiments were performed in October 2008 in collaboration with the Japan Coast Guard and in February 2009 with the Japan Traffic Management Technology Association
- A receiver equipped with an "image sensor" used for **cameras** was set up at the receiving end of the visible light communication. Reception of communication signals from a distance of about 260 m was also successful.
- www.businesswire.com/portal/site/google/?ndmViewId=news_view&newsId=20090327005161&newsLang=en

Outlook

Research: Frequency Combs



Ring-like glass resonator 75 µm on a silicon chip. While the lines of a traditional frequency comb are extremely close to each other and rather dim, monlithic frequency combs (Kerr effect) only have a distance of about 400 gigahertz and power outputs in the mW range. This meets the requirements for the carriers of fiber-optic data channels. Until now each single frequency channel requires a separate generator with its own laser. In contrast, a frequency comb on a microchip would make it possible to define a large number of data channels on a single element.

MPI for Quantum Optics, Press Release 20/12/2007, Nature, 20. December 2007

Possible Codings

Intensity modulation	Today
Multiplex (time/frequency)	Today
Point-to-point reception	Today
Reception with superimposition	Future
All modulation technologies	Future
Image sensor technology	Laboratory
Optical frame communications	Future, see below
Broadband, ultra wideband	Laboratory
Entangled photons	Laboratory

By and Large Light Replaces Microwaves

- Cordless phone and indoor communications (also in car, airplane, train)
- Router and PC networks
- Light points as successor of phone booths
- LED lamps with wireless Internet connection
- Government and military networks
- Free "Citizen Band" (point-to-point connection)
- Last mile by Ethernet und ADSL networks
- Optical cell phones require a tightly woven network of nodes ("light points," "info points," "telepoints")
- Ultrafast nano computer technology

Advances in Optical Modules

- Color selective heterodyne reception (idea)
- Atomic spectral lines as frequency normal (atomic clocks)
- Hyperfine structure – Connection to microwave technology
- Frequency combs (available)
- Fiber amplifier, optical switch (available)
- Laser, maser, mixer (available)
- Ultrafast photo detectors (available)
- 3 D (HDTV 2010) and holography (in laboratory)
- Photonic crystals (in laboratory)
- Nanoantennae structures (in laboratory)
- OLED walls (communicator on the wall)

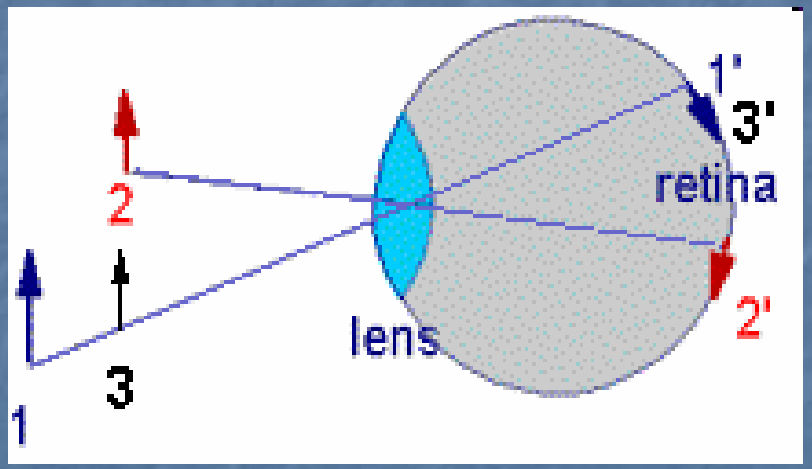
Pollution-free and Energy Efficient Communications

Learning from Nature

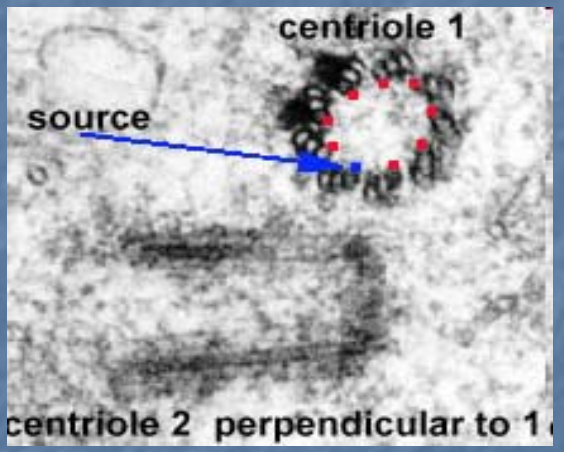
(Optical Communications in Living Organisms)

The mobile mammalian cell uses eyes and (-> centrioles) + „data processing“ (-> nucleus) for orienteering purposes. Communications engineering can explain the functioning of cell mobility (wavelength, angle resolution, absorption, signal-noise ratio, pulse frequency).

Cellint.htm. G.Albrecht-Buehler 2008



Eye, 380 -780 nm, < 25 Hz image sequence



Cellular eye for NIR , 800 nm, 1-Hz modulation

Comparison: Cell - Cell Phone Base Station

- With their cellular IR emitters, cells maintain the body's homeostasis and necessary body heat

  (-> G. Pikora, Quantum Thermodynamics, U. Warnke: 75 % of the energy emitted by the body is derived from its environment).

- Comparison: The base stations of the current cell phone networks require a kW power input. The efficiency of these wireless communications technologies is minimal, they generate predominantly electromagnetic pollution. RF radiation is not suitable for sustainable mass communication. Microwave cell phone networks are a model soon to be phased out.

Our Natural Environment Does Not Emit RF Radiation but Light!

In contrast to RF radiation, light opens possibilities for a completely different type of communications, which we know as „seeing" in nature. It is no technical emission (with resulting exposures) required, but only the superimposition of the information onto a localized portion of the environment (frame) in the form of an image (display), which can be read with the appropriate optics and then can be processed electronically. Technically speaking, this kind of approach results in an environmentally friendly, pollution-free communications technology. The fate of the currently forced exposures to cell phone radiation and other microwave services is sealed--without having to create a new technology from scratch.

RF Radiation -> Photonics

- RF Radiation – Radiation chaos and all-encompassing electromagnetic pollution
- Free Space Optics FSO
  - Infrared IRC (invisible)
  - Visible VLC (eye detects "smog")
    - Light Emitter Communications LEC – No wireless pollution, locally limited lightsmog
    - Light Receiver Communications LRC – No wireless pollution, no lightsmog

From Transmitting to Seeing

(LEC -> LRC)

Depending on the greater bundling at emitter/receiver side

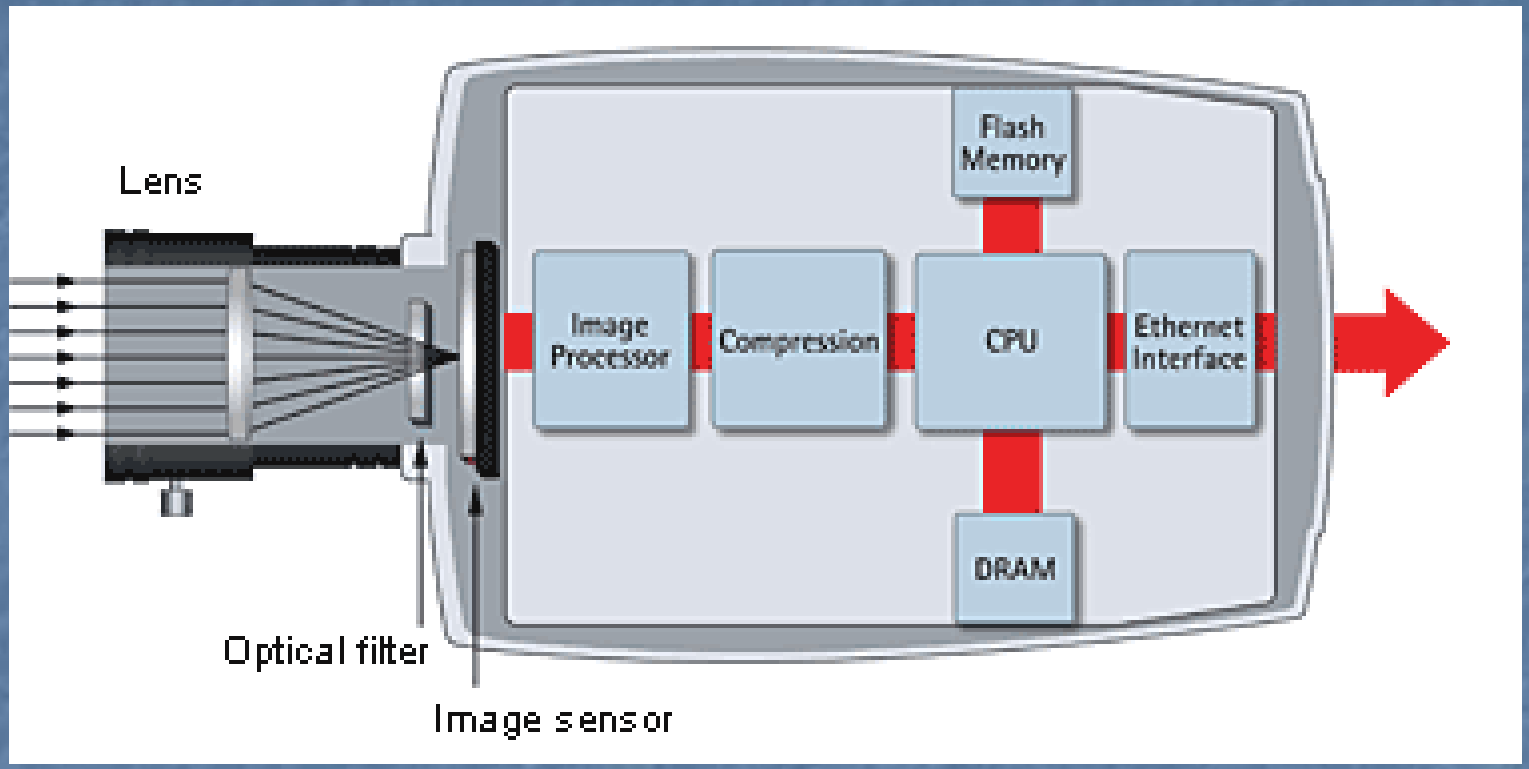
- Light Emitter Communications LEC (local lightsmog)
  - One-channel (Ronja, Lightpointe, …)
  - Multi-channel (Light panel like Sennheiser, Siemens)
- Light Receiver Communications LRC (no lightsmog)
  - Image Sensor Communications ISC
    Serial reading of image points (color, brightness) ->
    Video, TV , one channel per image point, optimum at 50*50
  - Optical Frame Communications OFC
    Entire sensor/emitter surface area, multi-user panels
    Identification (user ID, Galileoposit., N_{max}) for tracking

Lower Emission – Lower Smog

(Greater Effort at Receiving -> Less at Emitting)

	Emitter	Receiver
• LEC	**Bundling**	
▪	Excessive	Unavoidable
▪	Emission	Exposure
	Transmitting technology	
• LRC		**Bundling**
▪	Embedded	Avoidable
▪	Emission	Exposure
		camera/display technology

Display/Camera Technology Applied



Network Camera, Autozoom, Gyroscope-Stabilized Image

www.axis.com/products/video/camera/ccd_cmos.htm
www.golem.de/0909/69783.html

Practical Applications of Emitter Technology

- Active Emitter
- - LED panel, traffic lights
- - Projector
- - IR FSO
- - Optical coupler
- Passive Emitter with Additional Light
- Reflection
- - Wrist watch, normal traffic sign
- - Barcode of labels
- - CD/DVD/Blu-ray Disc
- Transmission
- - LCD screen
- - Illuminated traffic sign
- - Polarization or shutter emitter for 3D-TV

Interaction between Emitter - Receiver

- The contrast required for the reading of information from the frame determines the necessary emission of the emitter:
- With daylight or artificial lighting, the emission has not to be quantitatively different from the ambient environment, only the detail/image frame is crucial → Optical Frame Communications
- Transmitter and receiver must be tuned to each other for their optical and electronic characteristics. The contrast of both needs to change sufficiently quick and synchronous.
- When the human eye/brain is the receiver ->
  Today TV LCD screen e.g. 2 ms response time, contrast 10,000:1,
  400 Hz scan frequency

Zero Pollution Is Not Science Fiction

- Community and home infrastructure: combination cables for electricity, lighting, and telecommunications
- Fixed optical communications devices (screen with camera) on walls (display, OLED wallpaper) / LED rods (one unit per channel, street lamps also act as Internet access points)
- Mobile optical communications devices worn close to the body (optical terrestrial or satellite cell phones)

Concept of an Optical Cell Phone

- Design similar to the current ones, optics modules
- Point towards a telepoint like a camera (line-of-sight), fine-tuning with navigational/tracking automatic/image stabilization.
- Dial number, participant or Web appears on display screen
- Alternative cell phone glasses with 3-D shutter/ cell phone headband/cell phone cap
- Development of optical and electronic modules needed



Considering ecology for technical developments is a must today.