

ME1400 EMI AND EMC

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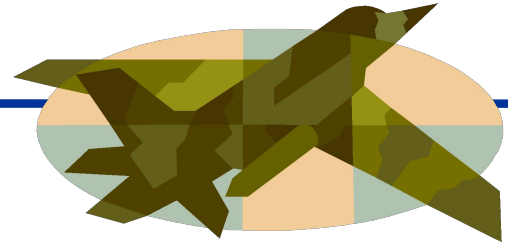
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<http://dreamcatcher.asia/cw>

1. Introduction to EMI/EMC

EMI in the Sky



On a flight from New York City's La Guardia airport to Chicago's O'Hare airport, the captain observed **an interference on the navigational equipment** during take-off. They found a passenger using a laptop computer, and asked him to turn it off.

Sometime later, the same navigational problems recurred; the same man had again turned on his laptop.

As the plane was descending, the VORs again had problems. Once more the passenger had turned his computer on. He refused repeatedly to turn it off.

The passenger was arrested for disorderly conduct.

EMI = Electromagnetic Interference

ANATOMY OF AN INCIDENT



① A passenger sitting in seat 3D of a Boeing 737 descending into Melbourne on autopilot uses an IBM ThinkPad laptop computer, despite the pilot's instructions that electronic equipment be switched off.

② The plane suddenly banked left at a 30° angle.

③ Investigators suspected electronic emissions from the laptop affected the aircraft's systems. Seat 3D was directly above the plane's electronics bays which extend about 15m from the plane's nose cone.

Tuned in to terror

By PETER LALOR and ADAM HARVEY

THE Boeing 737 was making a normal descent into Melbourne. The plane was on autopilot and the lateral navigation system was working.

In seat 3D, a passenger was hard at work on an IBM Thinkpad laptop computer.

About 60km north of Melbourne the big plane lurched to the left, banking about 30deg.

But no one had touched any of the plane's controls and the movement certainly wasn't part of the autopilot program.

The passenger in 3D may have noticed the movement but remained blissfully unaware of the crisis happening on the other side of the cabin door and equally unaware of what is believed to be his role in it.

"It is suspected that electronic emission from the laptop impinged on the aircraft systems," an air safety report into the incident concluded.

Experts believe that one

day a small personal electronic device (PED) such as a laptop, mobile phone, CD player or games computer is going to cause as much carnage on an aircraft as a terrorist's bomb.

Tiny electronic signals from these devices can be picked up by a plane's automatic navigation systems, sending them haywire.

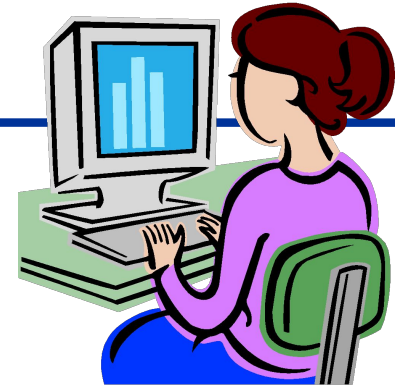
The personal devices, like most modern electrical equipment, operate on a binary system which sees small electric currents switching at incredibly fast rates through the system.

The switch goes on if it receives a message of between two to five volts or stops if it gets nothing.

In modern computers this switching process occurs at a rate of hundreds of millions a second and creates electro-magnetic radiation in its immediate area.

A mobile phone communicates by electro-

ESD on a PC



A Workstation Support person was attending to a call regarding **a PC which was continually freezing up**. ... air-conditioner ... very dry atmosphere. The staff noticed a lot of static charge on his clothes and the client's.

The client did have a static discharge pad under her keyboard but had not been touching it prior to using the keyboard. Support person instructed her to do so and ... no more freezing problem ...!

ESD = Electrostatic Discharge

ESD on a Motor Vehicle



A “**Vehicle Safety Recall**” was issued by a well-known motor vehicle manufacturer for six vehicle models manufactured between 1995 and 1996.

“There exists a remote possibility that the driver air bag may inadvertently deploy in certain atmospheric conditions (high **static electricity charges**). This may only occur when the driver is entering or exiting the vehicle and touches the centre (air bag area) of the steering wheel.”

... The recall service will be carried out free of charge...



In 1982 Britain and Argentina fought a war over the Falkland Islands. British HMS Sheffield was destroyed by an Exocet missile as it switched off its missile defence system that was causing interference to its satellite communications.





What is EMC?

EMC = Electromagnetic compatibility

Definition [IEC 61000-1-1]

The ability of a device, unit of equipment, or system to **function satisfactorily** in its electromagnetic environment **without introducing intolerable electromagnetic disturbances** to anything in that environment.

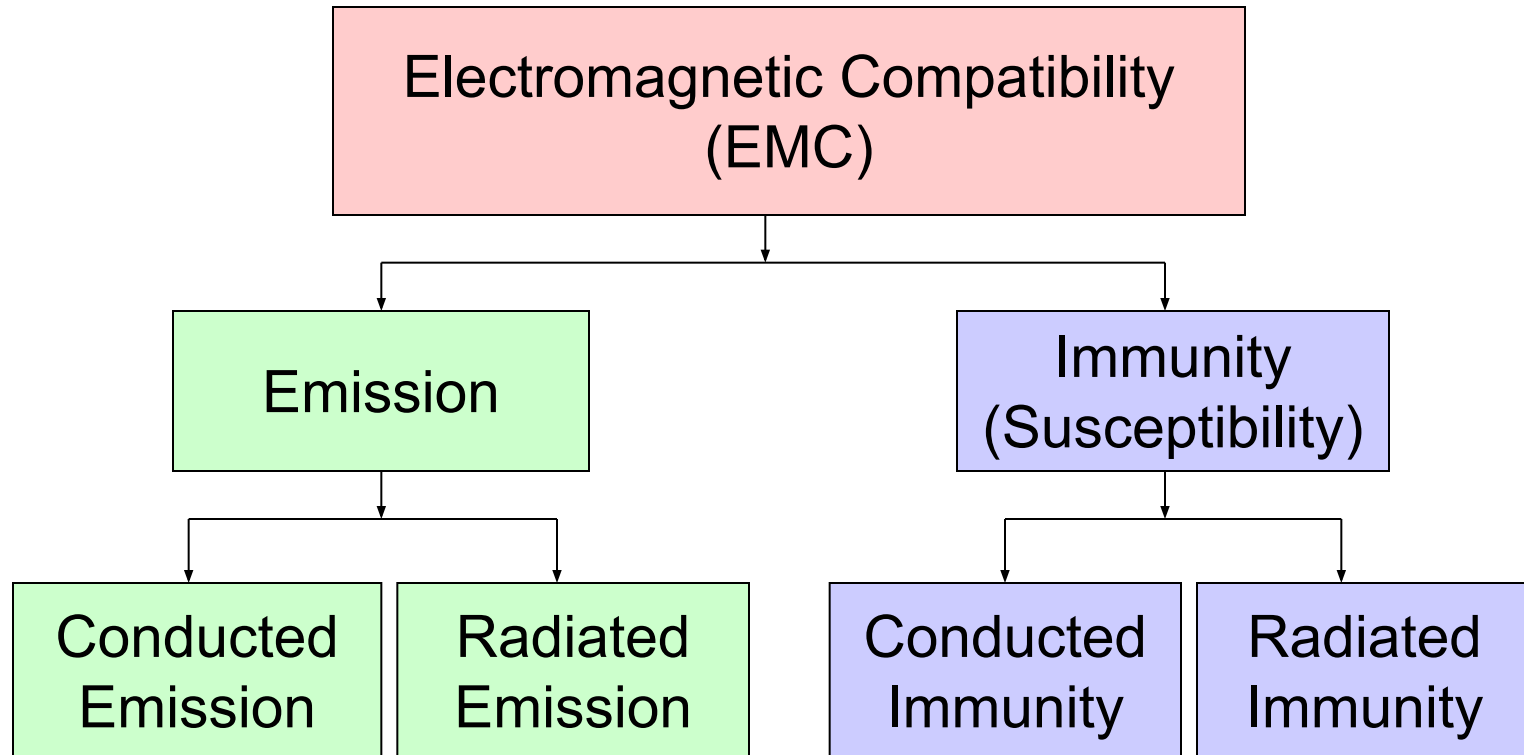
European EMC Directive 89/336/EEC, ... 92/31/EEC, ... 2004/108/EC*

- The **electromagnetic disturbance** generated by an apparatus does not exceed a level allowing the radio and telecommunications equipment and other apparatus to operate as intended.
- The apparatus has an adequate level of intrinsic **immunity** to the electromagnetic disturbance to enable it to operate as intended.
- *EMC Directive 2004/108/EC was published in the Office Journal (OJ) on 31 December 2004.
- 89/336/EEC to be repealed as from 20 July 2007.

Two Aspects to Consider

- Emission
the ability to operate without interfering with others
- Immunity
the ability to operate within a specified electromagnetic environment

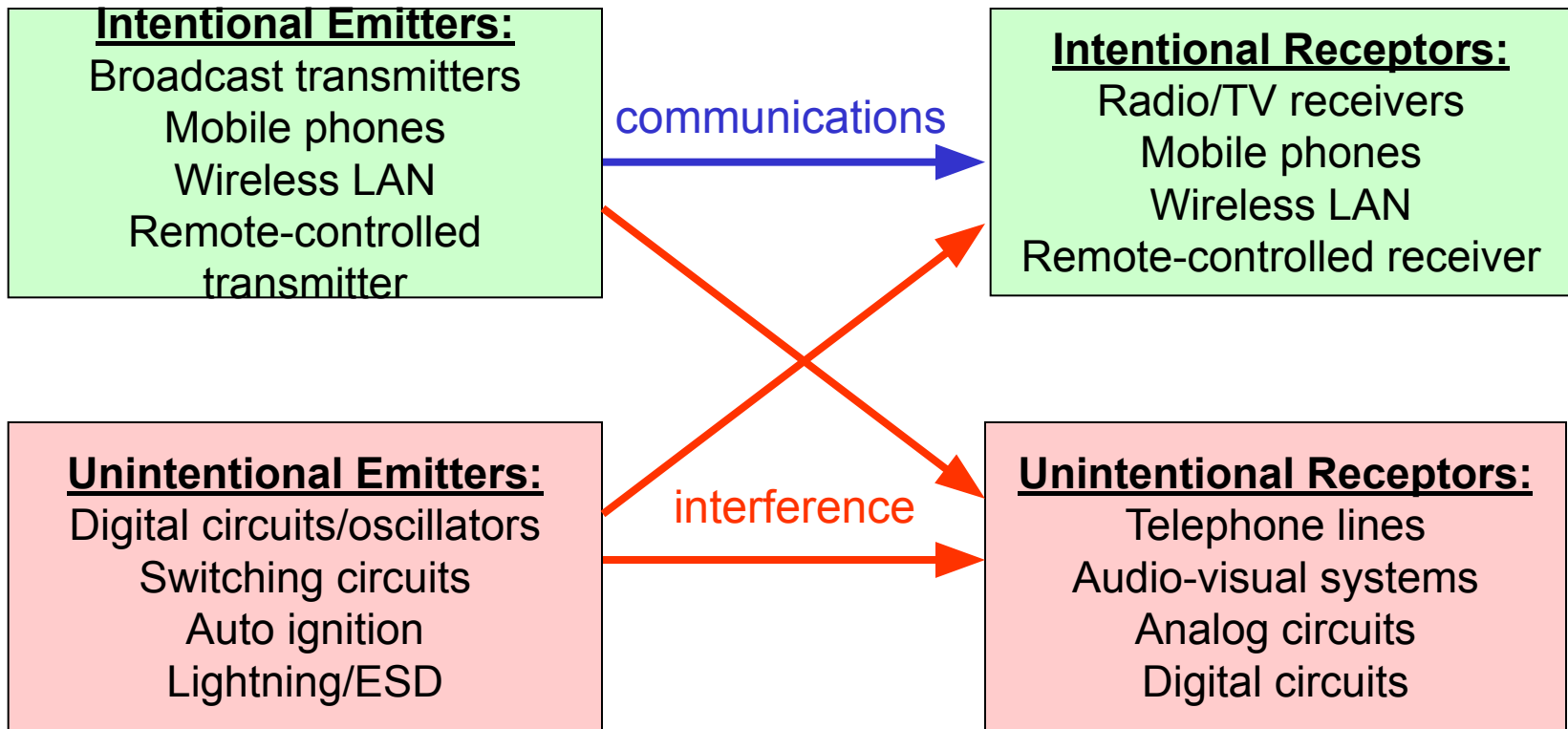
What is EMC?



“Ingredients” for Electromagnetic Interference (EMI)



Intentional and Unintentional Emitters and Receptors





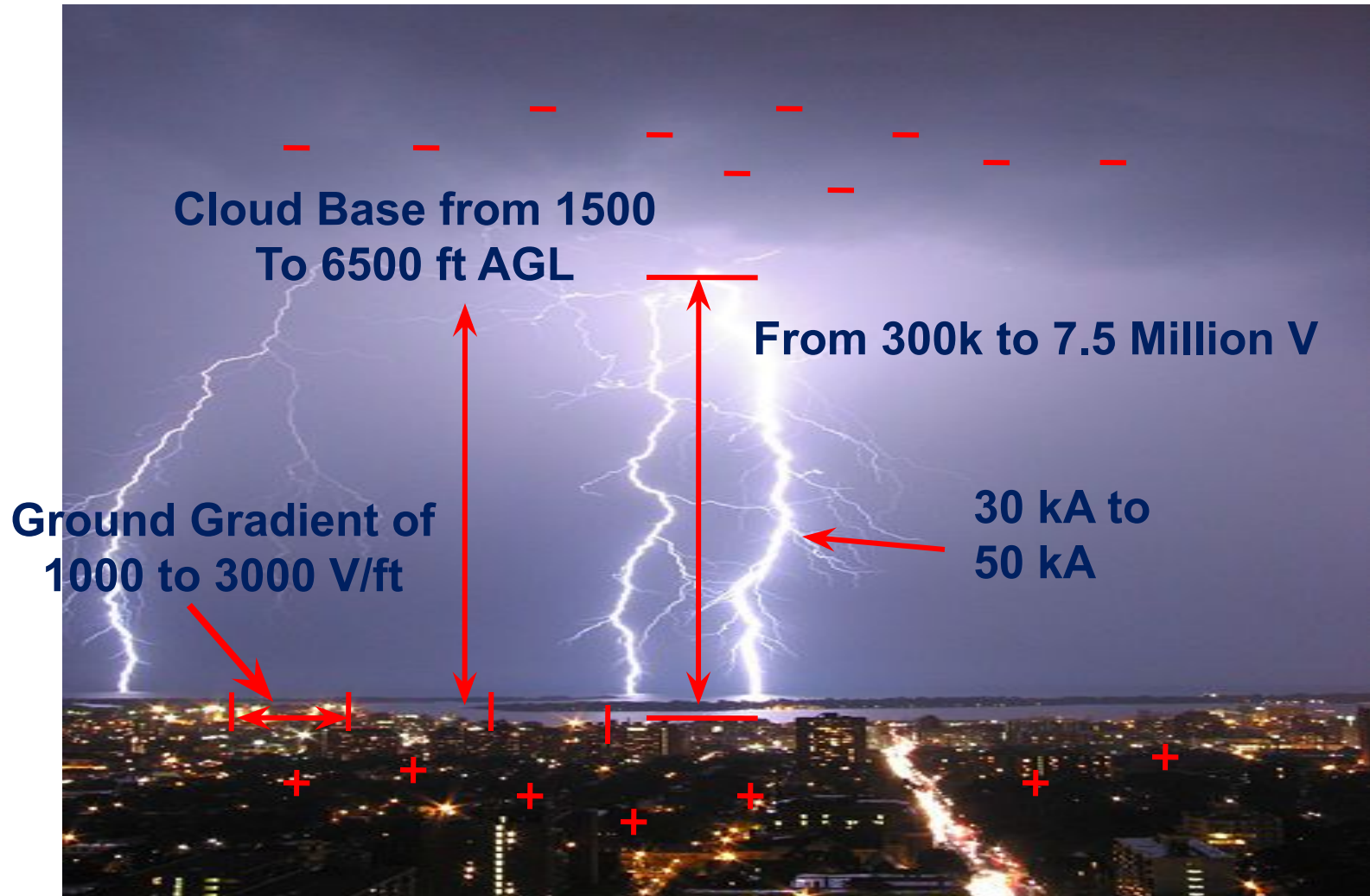
Lightning

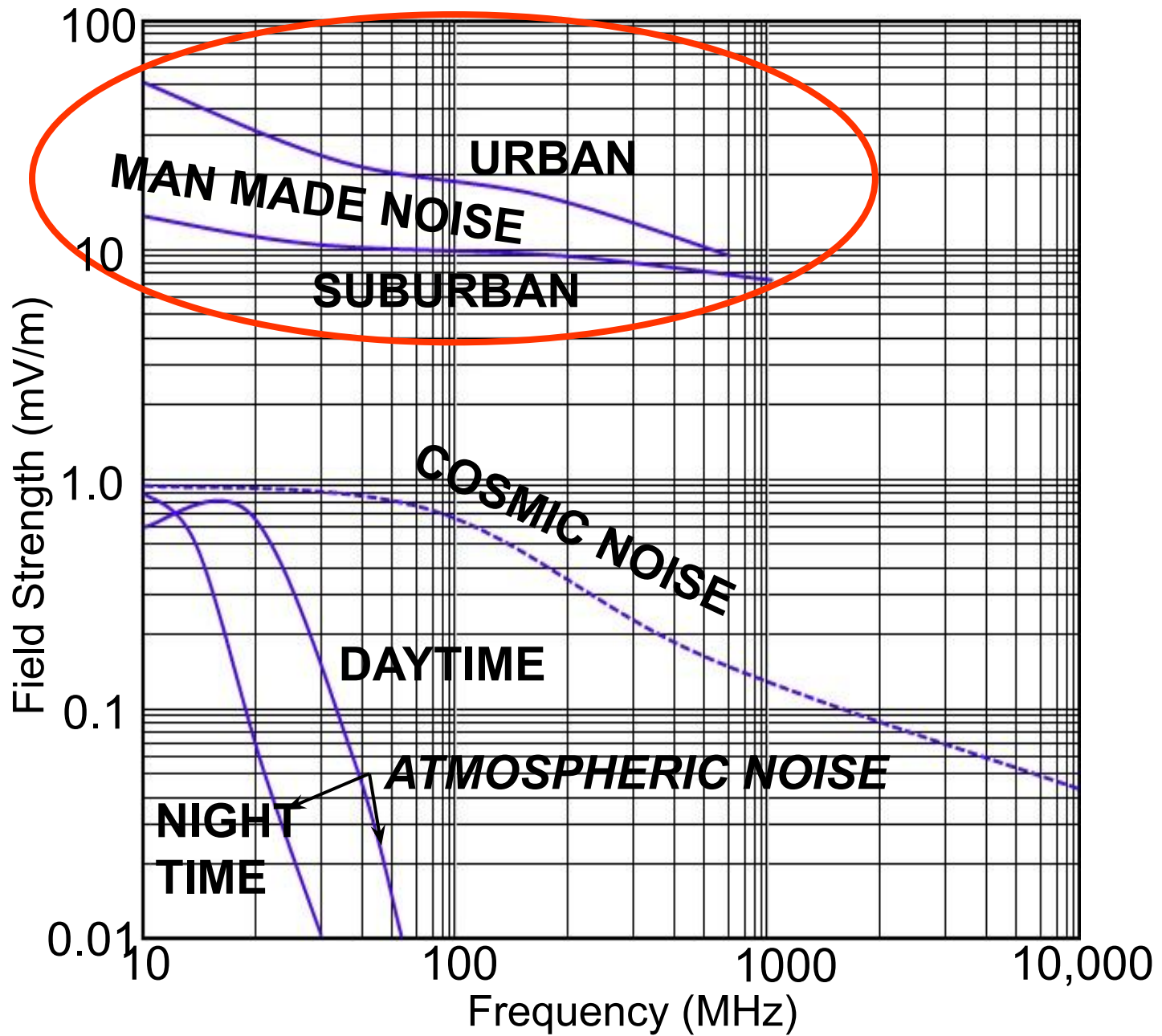
*an example of a
naturally occurring
noise source*

Brisbane 19 May 2005

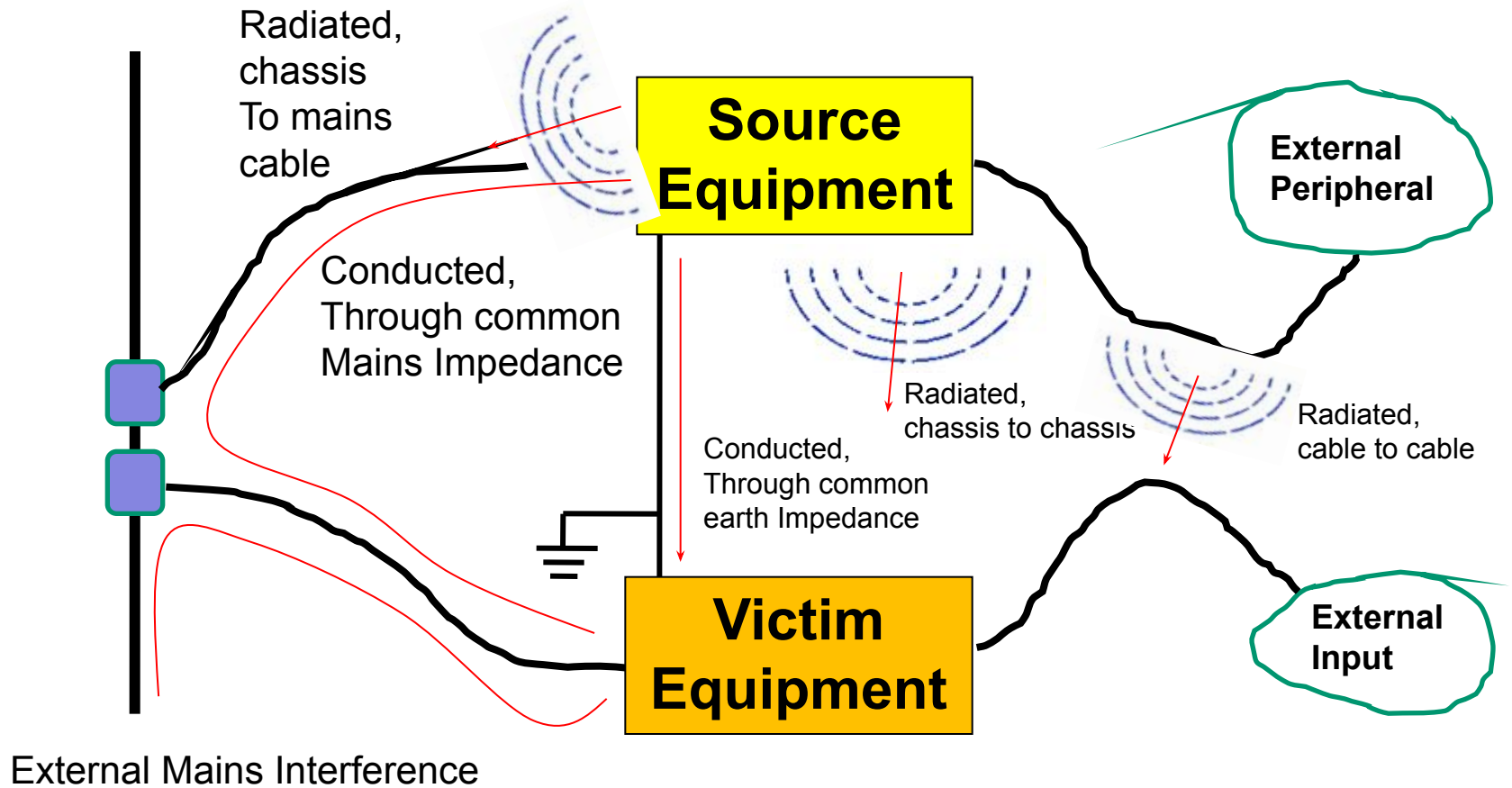
[Image Source: Wikipedia, <http://en.wikipedia.org/wiki/Lightning>]

Lightning: Ground Voltage Gradient





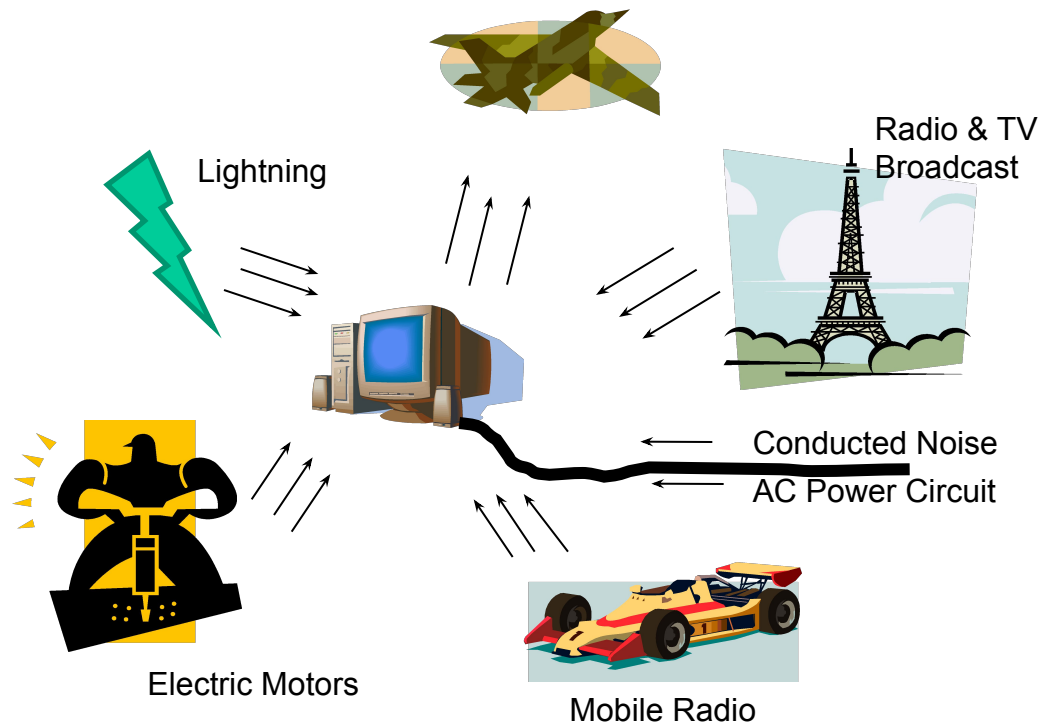
Coupling Paths: Conducted and Radiated



Intersystem and Intrasystem EMC

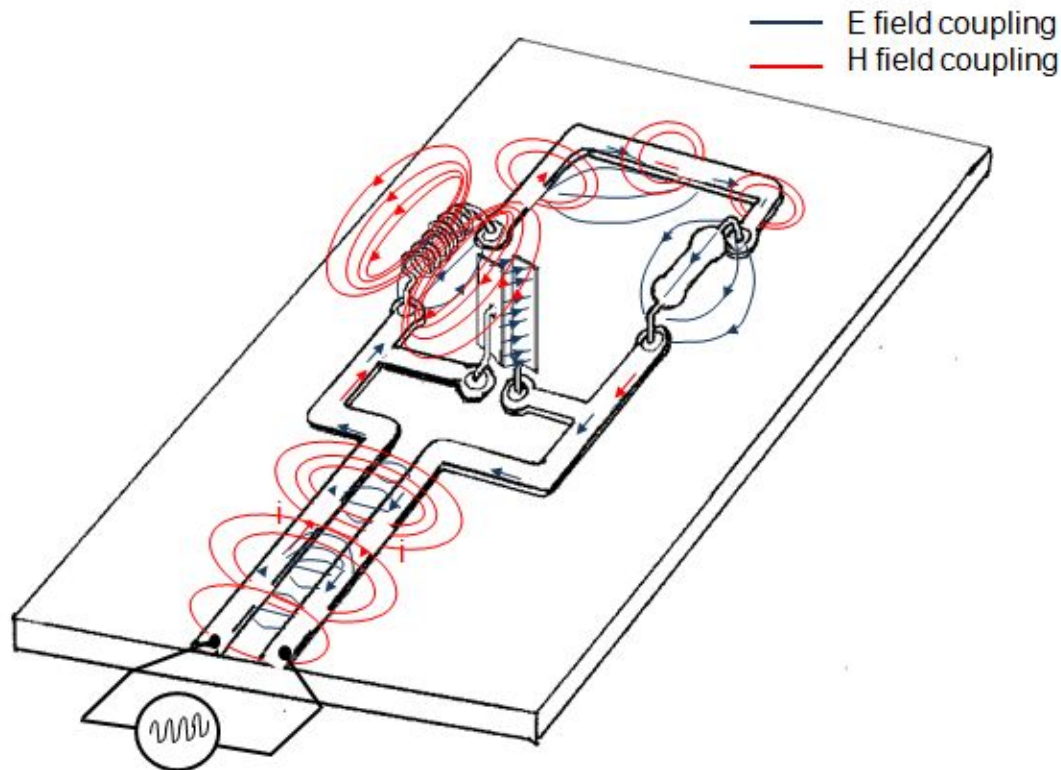
- Intersystem EMC

- Source and victim are in two different pieces of an equipment
- A victim may also be a source
- Need to comply with the EMC regulations



Intersystem and Intrasystem EMC (cont'd)

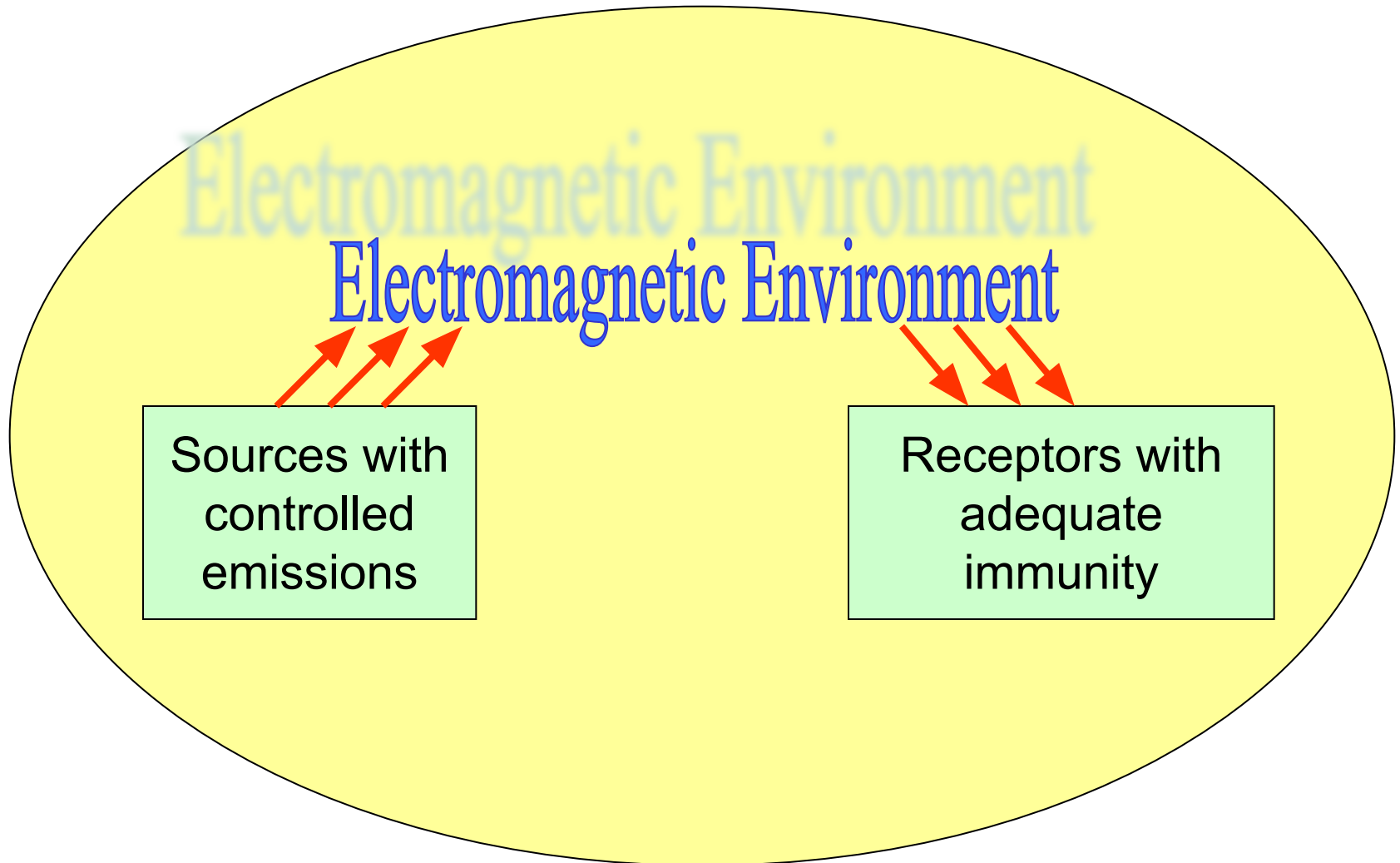
- Intrasystem EMC
 - Source and victim are in the same piece of an equipment
 - Usually an in-house problem



EMI Mitigation Methods

- Separation in **SPACE**
- Separation in **TIME**
- Separation in **FREQUENCY**
- Application of the **Design Techniques** to:
 - minimise source emissions
 - minimise path couplings
 - minimise victim susceptibility

Compatibility



Levels of Compliance

Special/Contractual
Requirements

- harsh environment
- security, ... etc
- military standards + ...



Regulatory
Requirements

- sales, trade
- legal obligation
- commercial standards



In-house
Requirements

- functionality
- reliability
- self-imposed design rules

Why Do We Need EMC Regulations?

- Safeguard the consumers
- Protect the environment
- Market forces
- International trade – import and export (free trade)
- Prevent dumping
- Legal responsibility

EMC Regulations

- Europe ("International")
 - EMC Directive (CE label)
- United States
 - Federal Communications Commission (FCC) Rules
- Australia/New Zealand
 - Australian EMC Framework (C-tick label)
- Other nations
 - implementing...
- Most EMC regulations (except USA) are based on the established international EMC standards which prescribe the test methods and limits.



Example of an EMC Compliance Labelling of a Product

Agilent
E4980A Precision
LCR Meter
20 Hz to 2 MHz





EUROPE

Emission

Immunity

CANADA

AUSTRALIA & NEW ZEALAND

EMC	
 ISM 1-A	European Council Directive 89/336/EEC, 92/31/EEC, 93/68/EEC IEC 61326-1:1997 +A1:1998 +A2:2000 EN 61326-1:1997 +A1:1998 +A2:2001 CISPR 11:1997 +A1:1999 +A2:2002 EN 55011:1998 +A1:1999 +A2:2002 Group 1, Class A IEC 61000-4-2:1995 +A1:1998 +A2:2001 EN 61000-4-2:1995 +A1:1998 +A2:2001 4 kV CD/8 kV AD IEC 61000-4-3:1995 +A1:1998 +A2:2001 EN 61000-4-3:1996 +A1:1998 +A2:2001 3 V/m, 80-1000 MHz, 80% AM IEC 61000-4-4:1995 +A1:2001 +A2:2001 EN 61000-4-4:1995 +A1:2001 +A2:2001 1 kV power /0.5 kV Signal IEC 61000-4-5:1995 +A1:2001 EN 61000-4-5:1995 +A1:2001 0.5 kV Normal/1 kV Common IEC 61000-4-6:1996 +A1:2001 EN 61000-4-6:1996 +A1:2001 3 V, 0.15-80 MHz, 80% AM IEC 61000-4-11:1994 +A1:2001 EN 61000-4-11:1994 +A1:2001 100% 1 cycle
	ICES/NMB-001 This ISM device complies with Canadian ICES-001:1998. Cet appareil ISM est conforme a la norme NMB-001 du Canada.
	 N10149 AS/NZS 2064.1 Group 1, Class A

[Source: Keysight Technologies, E4980A brochure and data sheet]

International (CE) EMC Emission Standards

- CISPR 11 (IEC 61000-3-11): ISM equipment
- CISPR 12 (IEC 61000-3-12): Spark ignition engines
- CISPR 13 (IEC 61000-3-13): TV receivers and audio equipment
- CISPR 14 (IEC 61000-3-14): Electrical motor operated and thermal appliances, electric tools and similar apparatus
- CISPR 15 (IEC 61000-3-15): Electrical lighting and similar equipment
- CISPR 16 (IEC 61000-3-16): CISPR measurement methods and apparatus
- CISPR 19 (IEC 61000-3-19): Microwave ovens
- CISPR 22 (IEC 61000-3-22): Information technology

Class A and Class B Devices in EMC Emission Standards

- **Class A** Nondomestic establishment
- **Class B** Domestic establishments

Other establishments using the LV supply connected to the domestic establishments

- **Warning notice for Class A products:**

WARNING

This is a Class A product. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

IEC Immunity Standards

- IEC 61000-4-2 Electrostatic discharge (ESD)
- IEC 61000-4-3 Radiated EM Field
- IEC 61000-4-4 Fast transient/burst
- IEC 61000-4-5 Surge
- IEC 61000-4-6 Conducted disturbance
- IEC 61000-4-11 Supply dips and variations

*These are **basic** standards.*

They are referred to by generic and product standards.

EMC Terms and Acronyms

- EMC = Electromagnetic compatibility
- EMI = Electromagnetic interference
- EM Disturbance = “RF noise”
- EM Environment = “Where the RF noise exists”
- Immunity = Ability to reject EM disturbances
- Susceptibility = Tendency to be interfered by EM disturbances
- The following terms are the safety limits for a human (not EMC):
 - EMR = Electromagnetic radiation (RF emissions)
 - EMF = Electromagnetic field (AC mains E and H fields)