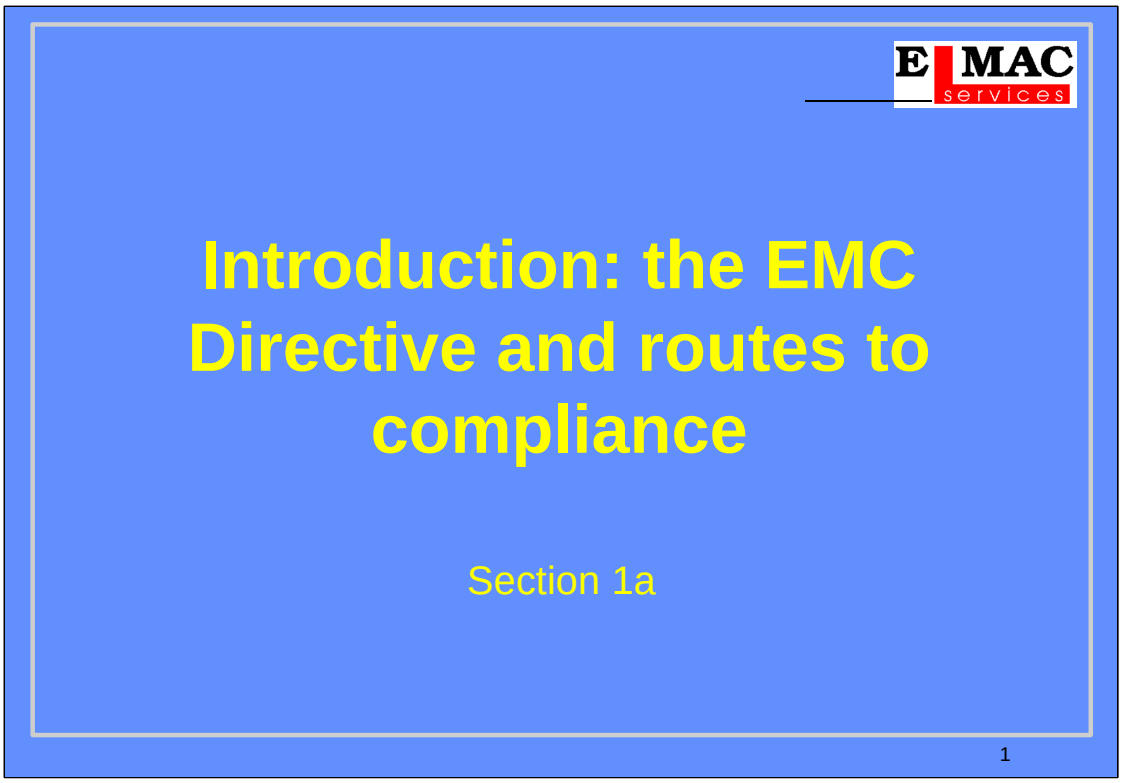
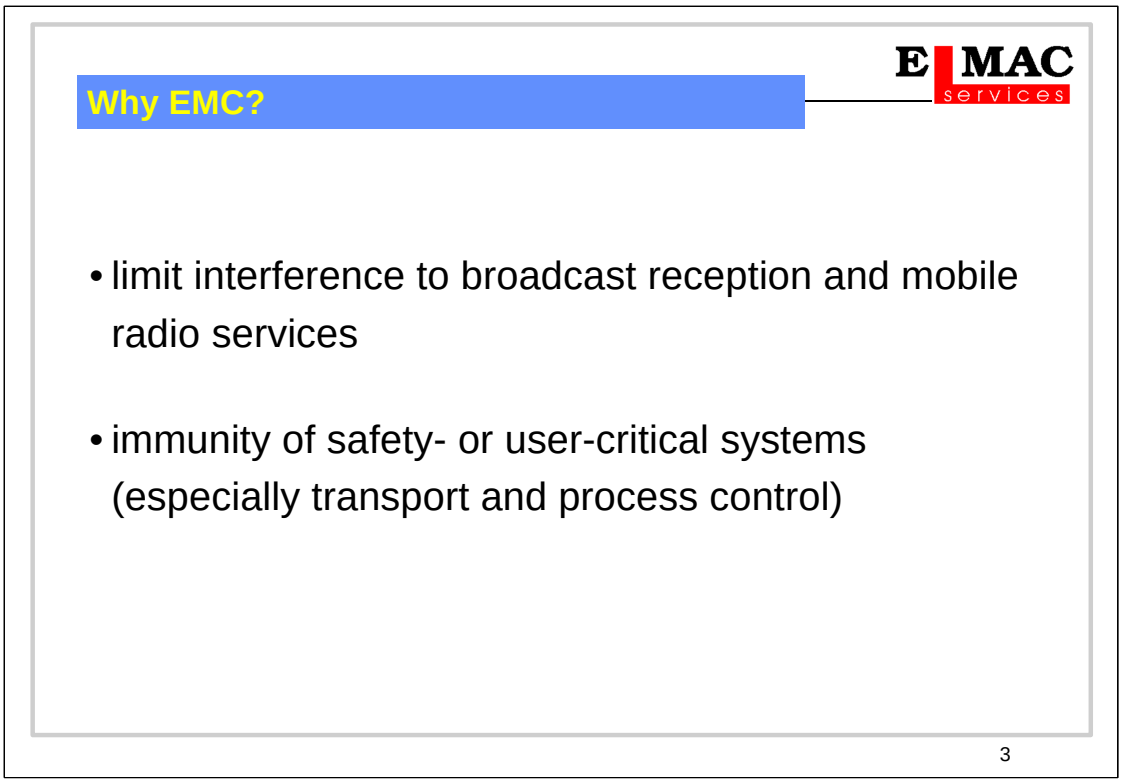

EMAC
services
Introduction: the EMC Directive and routes to compliance
Section 1a
1

Outline

- Why EMC?
- Definition of EMC and EMC phenomena
- Commercial and management aspects
- European legislation: the EMC Directive
- Routes to compliance

2



All electrical and electronic devices generate electromagnetic interference, and are susceptible to it. It is the job of the product designer to reduce this generation and susceptibility to acceptable levels. With the increasing penetration of solid-state electronics into all areas of activity, acceptable levels of interference have become progressively tighter as physical separation between devices has reduced and reliance on their operation has increased. Solid-state, particularly integrated circuit technology, is more susceptible than the vacuum-tube devices of years ago, and the popularity of plastic cases with their lack of screening is a further factor. The ability of a device to operate within the limits of interference immunity and suppression is known as electromagnetic compatibility (EMC).

EMC is concerned both with ensuring that bona fide users of the radio spectrum are not inconvenienced by operation of another piece of equipment, and that the operation of that equipment itself is not affected by external interference.

The definition of EMC

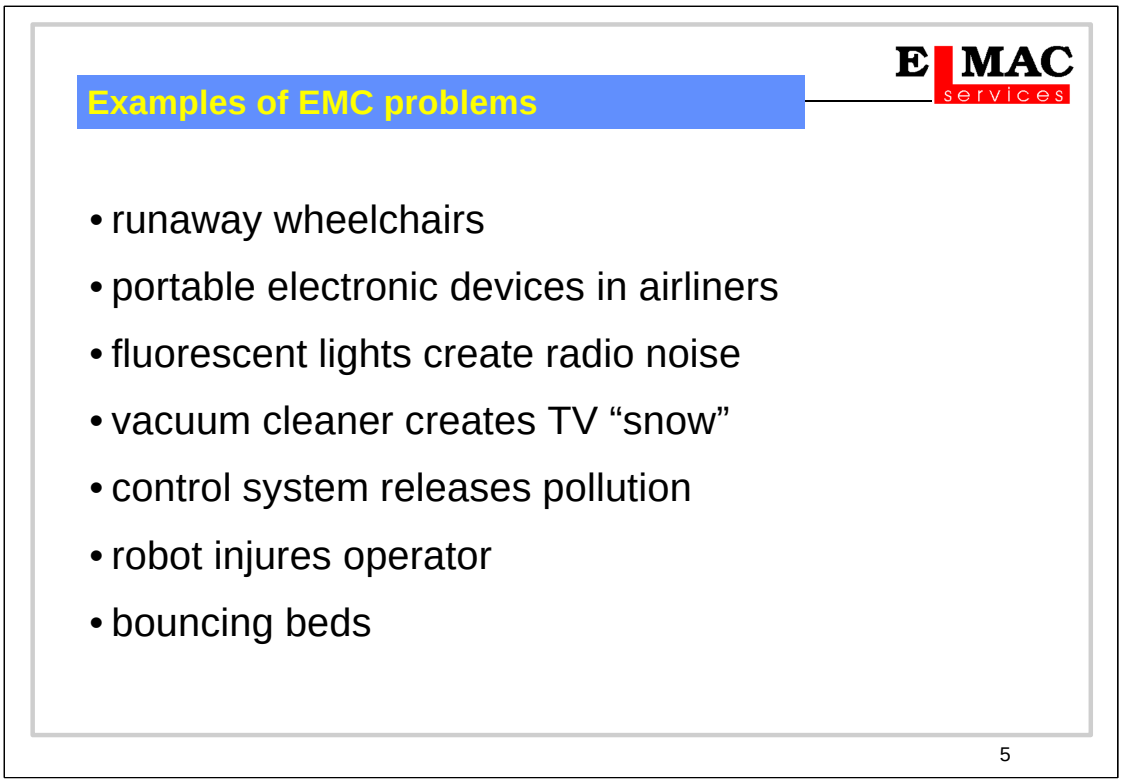
"The ability of a device, equipment or system to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbance to anything in that environment"

– International Electrotechnical Vocabulary, Chapter 161

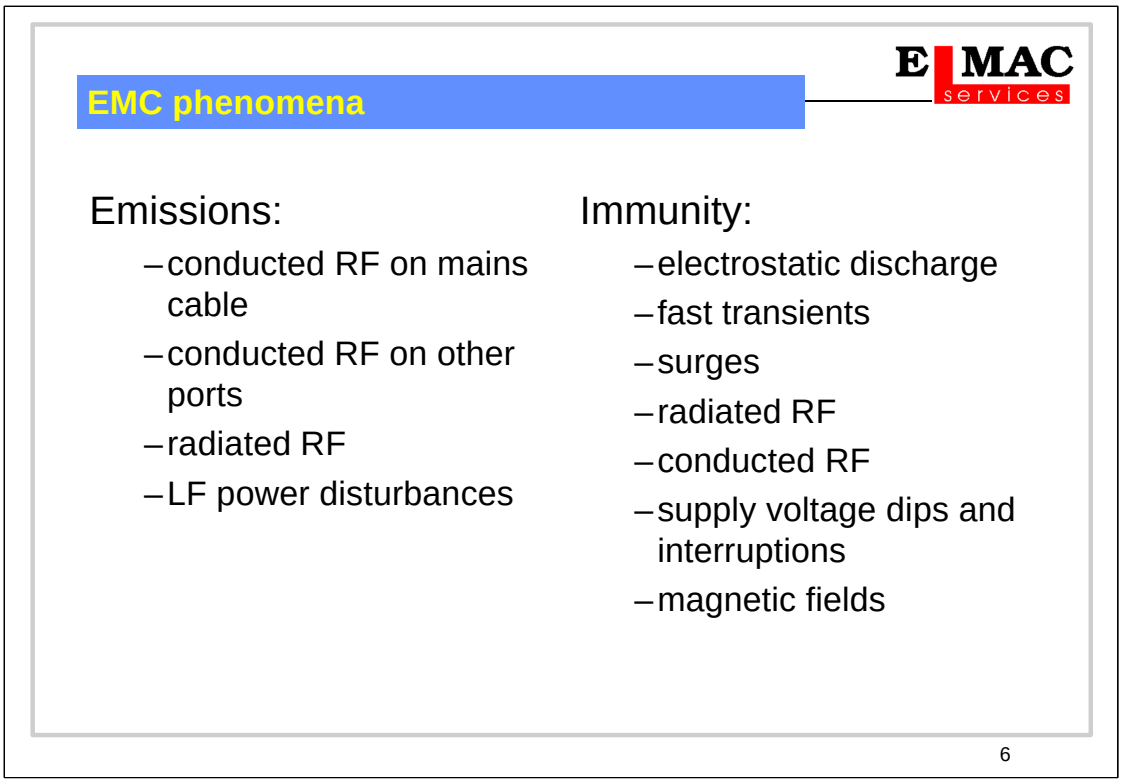
4

The formal definition of EMC emphasizes the two complementary aspects of immunity from interference – to ensure the correct operation of the equipment – and the control of interference emissions, to protect users of the radio spectrum and the public power supply.

The electromagnetic environment as referenced in the above definition is itself defined as "the totality of electromagnetic phenomena existing at a given location". A wide variety of such phenomena are encountered which are complex and time-varying, such that it is only really possible to obtain a description of the environment by the use of statistical methods. No frequency limits are specified, nor are the routes by which the disturbances may be propagated.



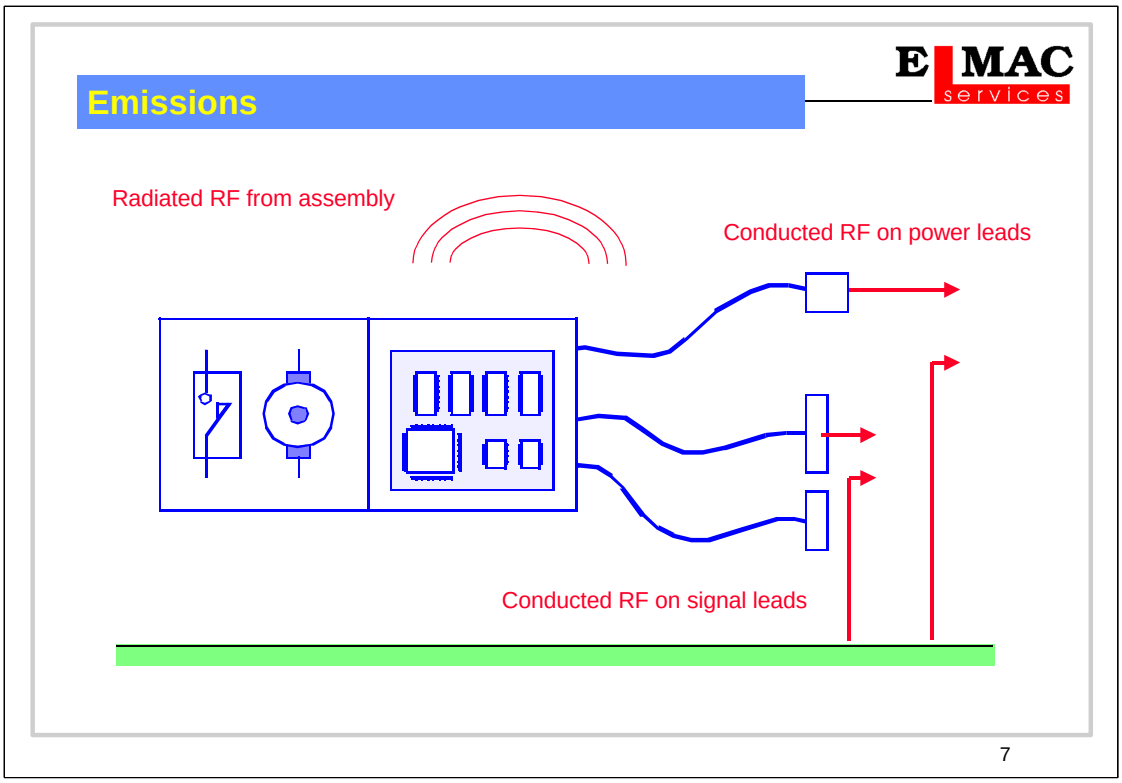
There are many ways in which EMC manifests in daily life. A few examples of the myriad case histories accumulated over the years are suggested here.



This list summarizes the range of phenomena that fall under the heading of electromagnetic compatibility for commercial equipment. It corresponds to the various phenomena that are covered by the European EMC Directive. These phenomena are already the subject of product-specific or generic standards. Any electronic product will, either now or in the near future, have to consider all the items on this list as part of its performance specification.

Other applications (for instance aerospace and transport) cover a similar range of phenomena, but may include a further range of induced low frequency requirements.

Although RF signals are present in the environment or generated by the product at many frequencies, the coupling routes into or out of the equipment vary and therefore the phenomena are treated separately over different frequency bands for the purposes of testing and regulation.

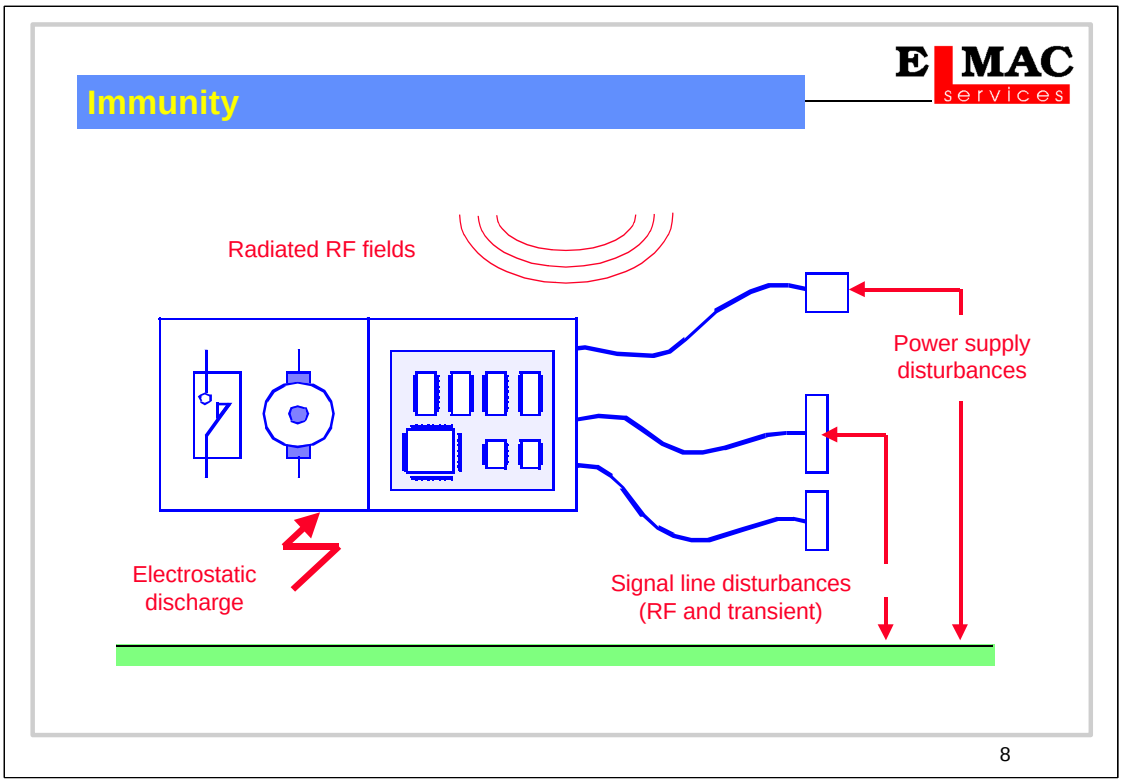


With the exception of mains harmonics, practical EMC concerns emission of interference in the radio frequency part of the spectrum, i.e. from 150kHz up to 1GHz. These emissions are classified into conducted and radiated, and for ease of measurement and analysis, radiated emissions from the equipment or its cables are assumed to predominate above 30MHz and conducted emissions along the cables are assumed to predominate below 30MHz.

Major sources of emissions are:

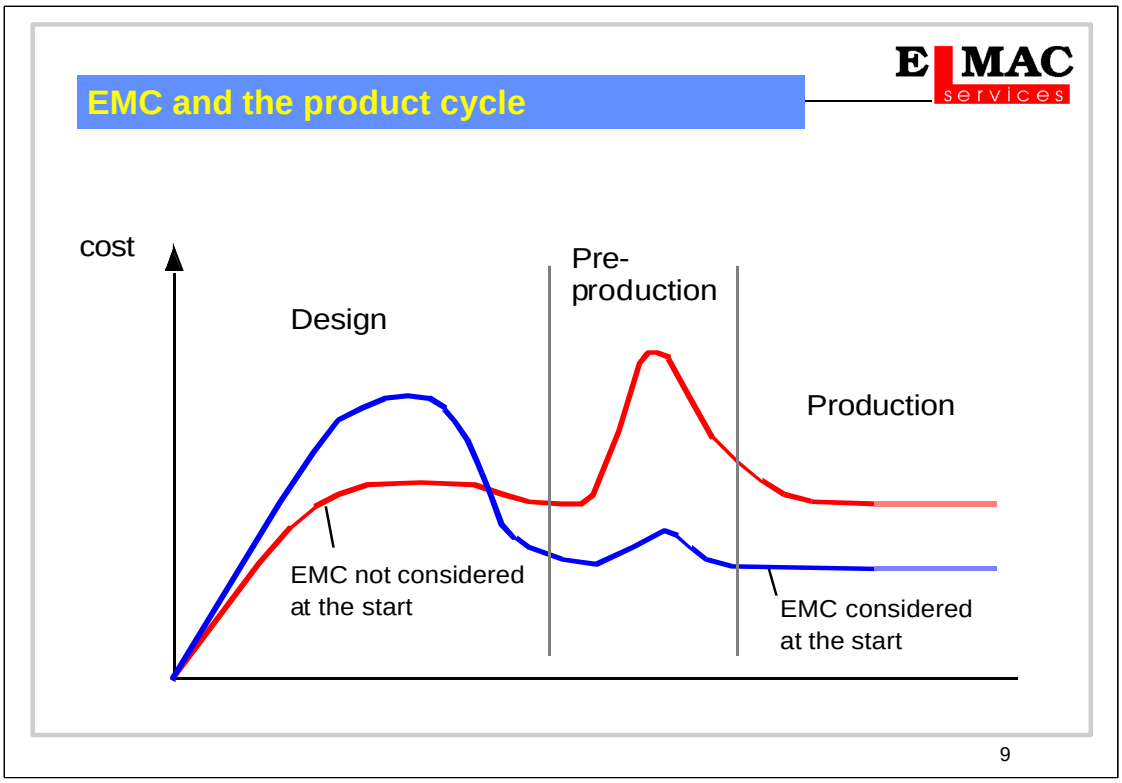
- narrowband: high frequency oscillator signals, digital clock harmonics, generated by electronic circuit functions
- broadband: switching operations (including commutator motors), repetitive arcing, data transfer

Strictly speaking the narrowband/broadband distinction is made on the basis of the test receiver bandwidth, which depends on the test specification.



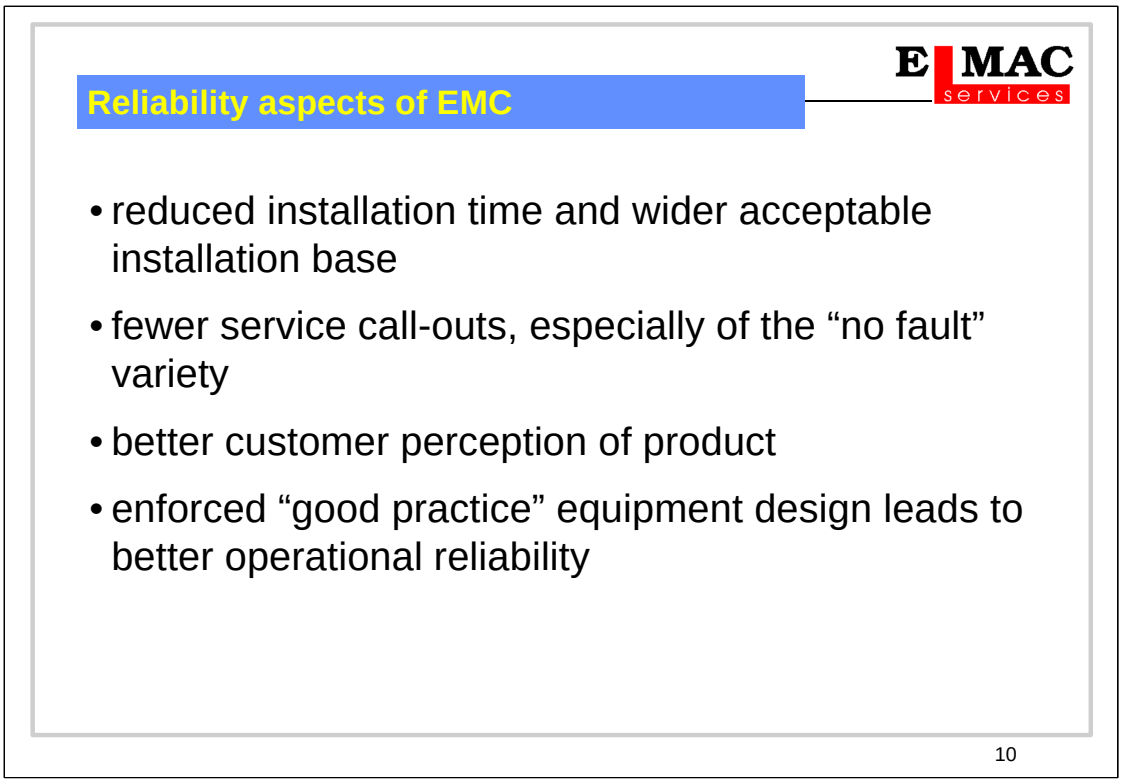
Any or all of the effects shown may cause a malfunction in the victim. Coupling for RF and transients is mainly through connected cables; at the higher frequencies when board dimensions become comparable to a quarter or half wavelength the circuits themselves become efficient at coupling RF energy. ESD can be coupled directly to the case or cables or indirectly through a discharge to a nearby object, which then produces an intense transient field.

Malfunctions can range from a slight variation in analogue operating conditions to complete corruption of digital operation. The actual definition of a malfunction must be provided by the equipment manufacturer, although guidelines for definition of performance criteria are offered in the generic immunity standards. Susceptibility may vary for different operating configurations, e.g. with different peripheral cables connected, or for different operating modes, e.g. when a car trip computer is displaying miles per gallon or distance.



Meeting EMC requirements is not difficult and brings many advantages in its wake, especially with regard to product quality. Historically, experience with EMC has been on military projects and for many reasons military EMC is expensive and time-consuming.

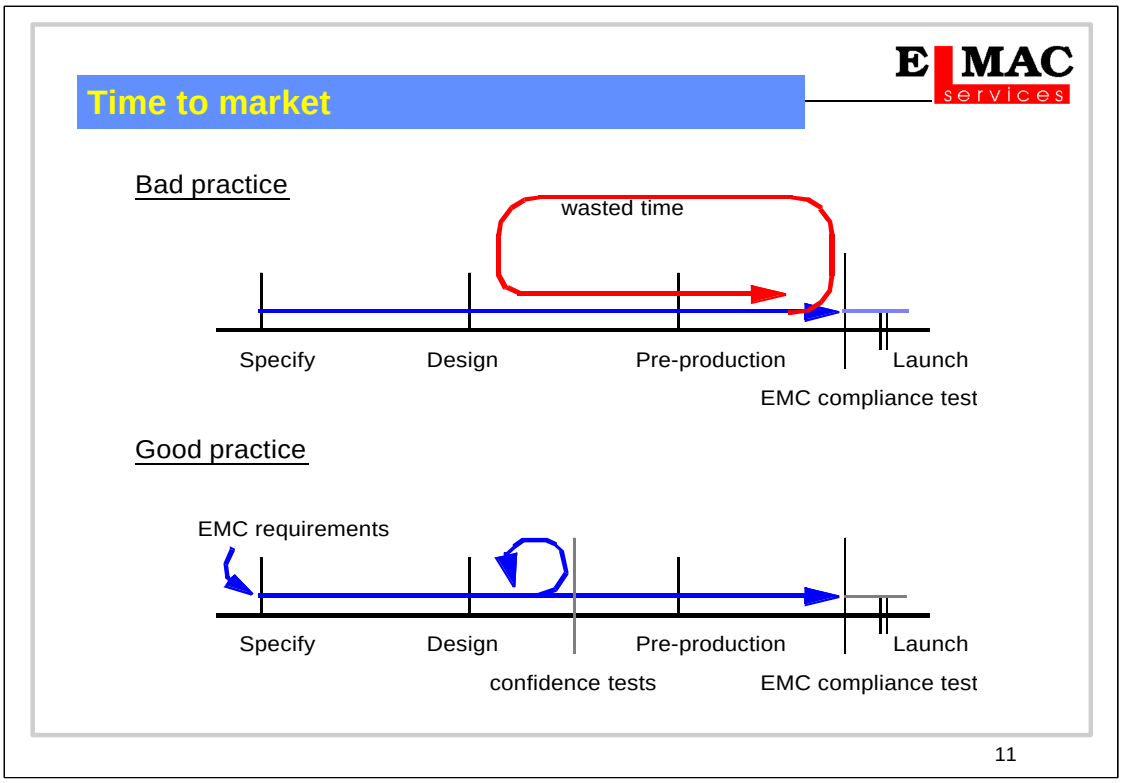
The need for remedial EMC work is normally due to poor design which could have been overcome in the early design stages. Good EMC design is no more than proper design practice, awareness and attention to detail. It adds tasks at the front end of the design but brings overall benefits by minimizing the risk of later re-work. Development time is saved overall because of fewer iterations, production costs will be lower because good EMC design tends to encourage more integration and a better appreciation of production constraints, and expensive EMC compliance testing is minimized because of the greater chance of meeting performance requirements first time.



The EC’s immunity standards represent typical, not worst case, operating environments, derived on a statistical basis. Meeting them should be regarded as a minimum requirement for the continued reliable operation of equipment in the real world, as electromagnetic pollution increases.

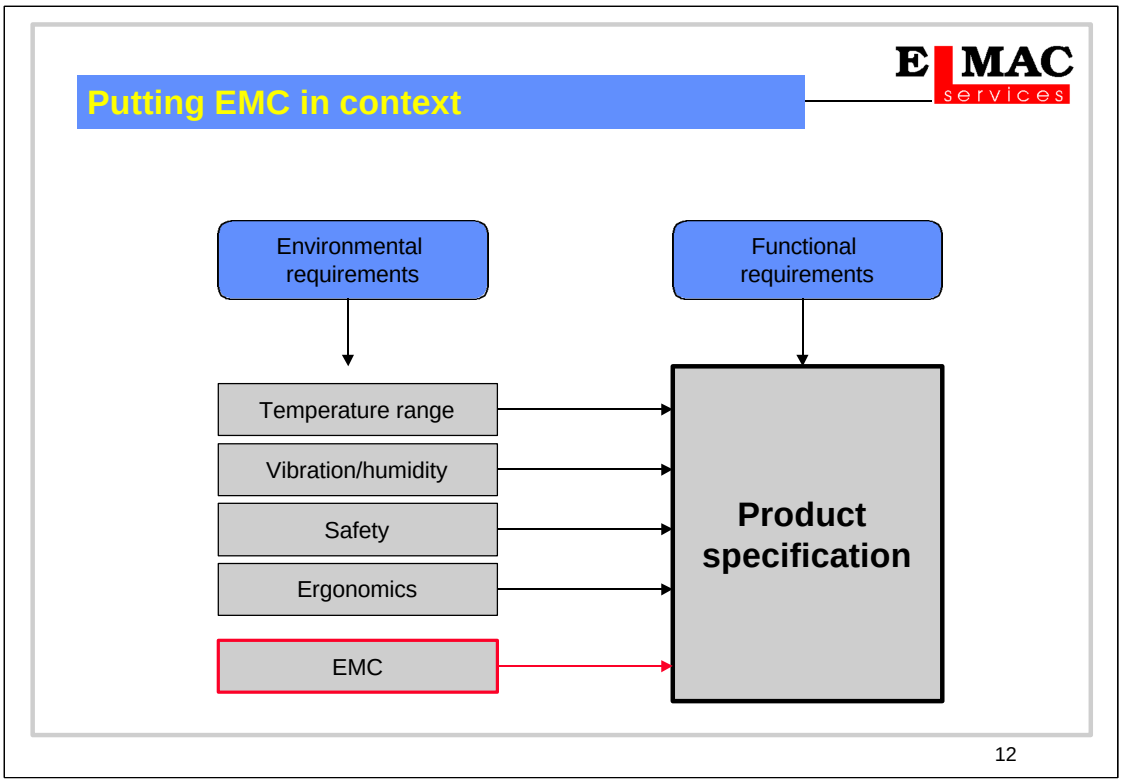
A product which has had EMC designed-in at the beginning may or may not have better performance, but because of its good immunity to interference it will have better reliability in the field and will be easier to install. Service calls will be fewer, especially the troublesome “no fault found” category which are so time consuming. Warranty costs will reduce and customer perception of the product will be good, resulting in a higher level of repeat business.

For all these reasons EMC is not just a technical issue, but has major marketing and sales implications.



A critical factor in product development is not just the overall development cost but also the timescale. In many product sectors the marketing window of opportunity is of short duration, so lost time in bringing the product out translates to lost sales and poor profits. If ignored for long, EMC requirements will undoubtedly impact time to market. Every EMC test house has a long, sad list of companies which have optimistically brought their product along the day before launch only to find they were non-compliant.

The two ways to prevent this happening are to ensure that EMC is treated as part of the overall specification, so that its dictates are adhered to right from the start of the project; and to continually monitor the EMC profile throughout the development stage so that late surprises are eliminated. It is also wise to assume that one re-test will be needed – even when all the design principles are adhered to, the probability of initial compliance is only about 80% – and to factor this in to the development schedule.

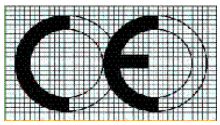


Most products are already subject to a range of other environmental or safety specifications. These requirements are partly fixed by legislation and partly to ensure “fitness for use” of the product, and they include factors such as temperature and relative humidity ranges over which the equipment must operate, together with ergonomic aspects and control of hazards (such as heat or electric shock) associated with the unit. EMC is best regarded as simply another of these specifications.

Immunity to external EM disturbances is clearly an environmental requirement. A product must function reliably in its intended environment, and if this environment includes EM disturbances then these should be incorporated in the environmental specification. Control of emissions is more properly a regulatory requirement unless such emissions have an intra-system aspect – that is, if they affect the proper functioning of the overall system or its installation.

The EC and the New Approach

- European Directives:
  - must be implemented by EC member states in their own laws
  - are concerned with free movement of goods and eliminating technical barriers to trade
- The New Approach:
  - gives only “essential requirements”
  - employs harmonized European standards
  - compliance is signified by the CE Mark

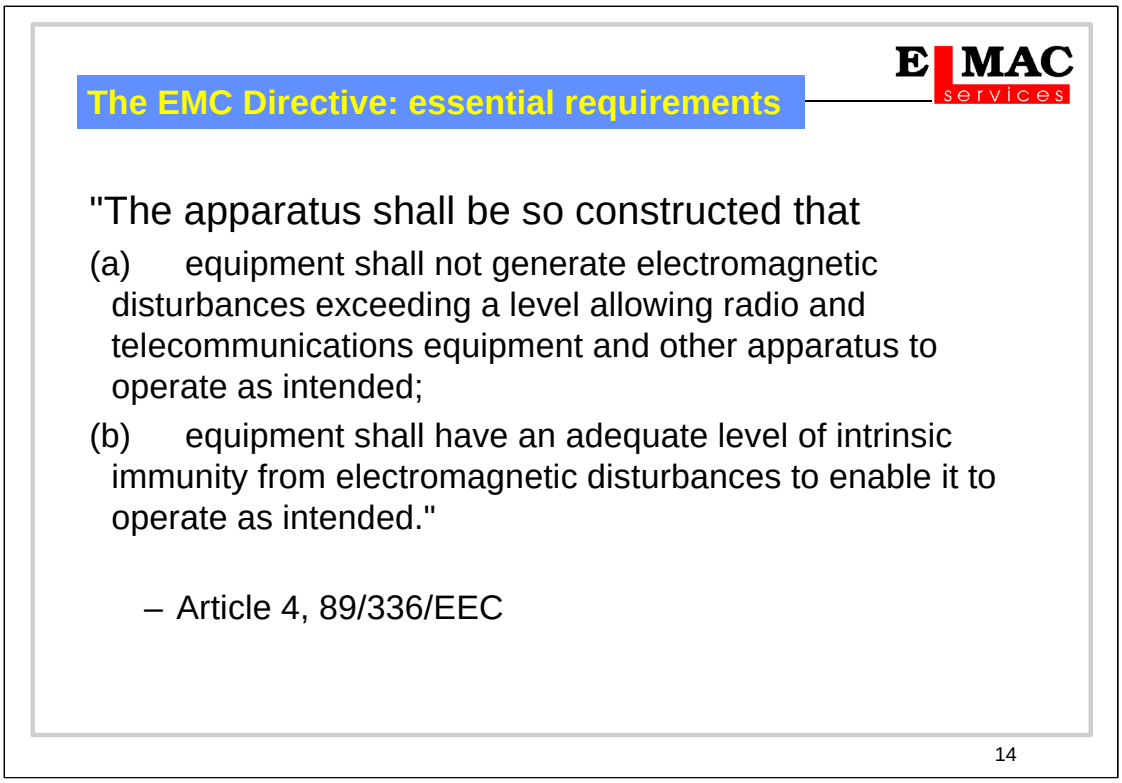


13

The regulatory regime for electronic products in Europe is now dominated by a clutch of EC Directives, of which the most important and general are the Low Voltage Directive (for electrical safety), the EMC Directive and the R&TTE Directive. Each of these Directives is an instruction by the European Council to each member state to embody the requirements of the Directive into its own laws. The principal purpose of each Directive is to try to ensure that technical requirements (for safety, EMC and telecom/radio issues) imposed by individual countries do not result in a barrier to trade within the EC. They do, of course, appear as a barrier to other countries that wish to trade with the EC. The Directives are also recognised by countries outside the European Union but within the European Economic Area (EEA), that is, Norway, Iceland and Liechtenstein.

In the mid-1980s the European Commission gave up trying to set detailed technical requirements itself and instead mandated the task to the European standards bodies, specifically CEN, CENELEC and ETSI. This was known as the “New Approach”. The published Directives now give only general essential requirements, and state that conformity to these requirements can be demonstrated by compliance with “harmonized” standards. The process of harmonizing a standard means that the Commission is advised by the standards body that the standard is suitable for embodying the essential requirements of a Directive, and the Commission then publish the reference of the standard in a list in the Official Journal of the EC.

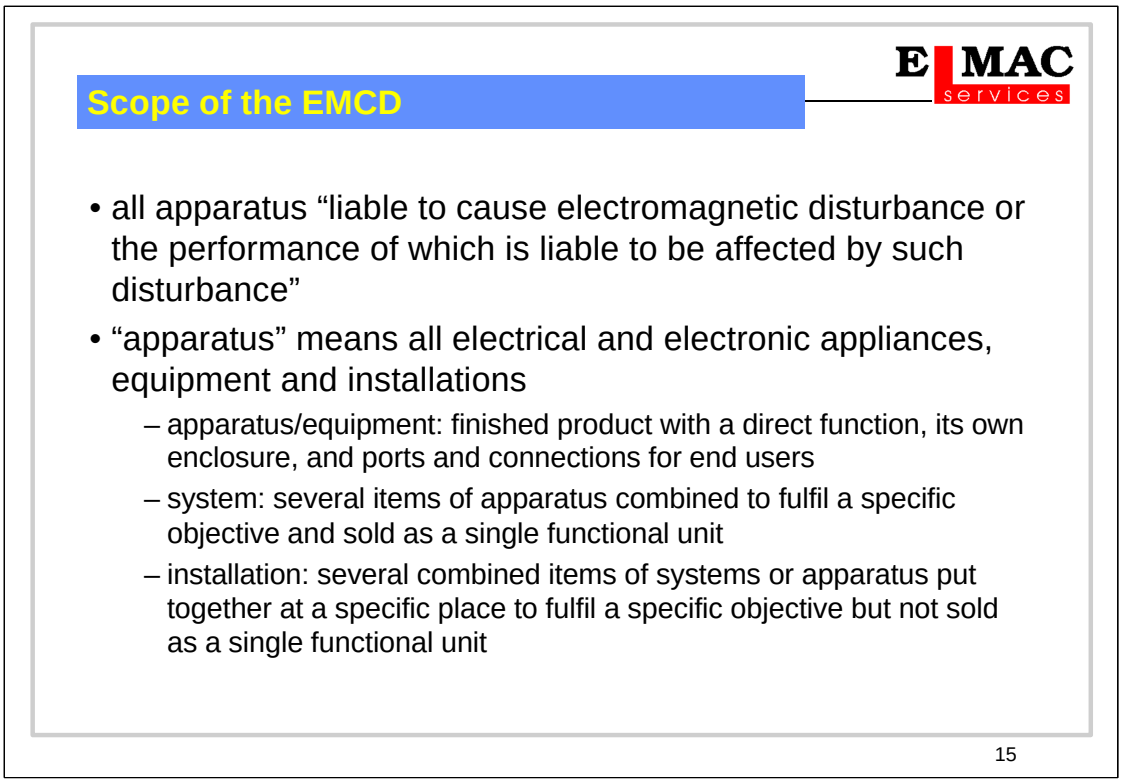
Compliance with all applicable New Approach Directives for a given product is signified by the manufacturer affixing the CE Mark to the product, or its packaging or instructions. The CE Mark is not in any sense a guarantee or a mark of quality: it is more akin to a passport. It merely states that the manufacturer (or importer) believes that his product complies with the Directives. Manufacturers are likely to apply different levels of diligence to their CE Marking.



The relaxed EMC regime that used to exist throughout Europe, with the exception of Germany, changed dramatically in 1996. In accord with the general objective of the single European market, the European Commission put forward an EMC directive whose purpose is to remove any barriers to trade on technical grounds relating to EMC.

The directive applies to all equipment placed on the market or taken into service, so that it includes systems as well as individual products. It operates as follows: it sets out the essential requirements (quoted above); it requires a statement to the effect that the equipment complies with these requirements; and it provides alternative means of determining whether the essential requirements have been satisfied. Thus protection is extended not only to radio and telecoms but also to other equipment such as information technology and medical equipment - in fact any equipment which is susceptible to electromagnetic (EM) disturbances.

The Directive has been fully operational since the beginning of 1996 and as experience has been gained with it, so the official guidance on how to apply it has proliferated. The most recent guidance document was published in mid-97. There is now a second version of the EMC Directive being drafted, which is likely to be published some time in 2001 or 2002.



The Directive applies to a vast range of equipment encompassing virtually anything electrical, including vehicles, power distribution and supply grids, transport and telecom networks as well as equipment on its own, with a few specific exceptions. A special case is made in the UK regulations for educational electronic equipment and electromagnetic test apparatus, which although remaining within the scope may be exempted from meeting some of the essential requirements.

Apparatus which is wholly electromagnetically benign is inherently excluded from the scope. “Benign” in this case means that the inherent qualities of the apparatus are such that neither is it liable to cause, nor is its performance liable to be degraded by, electromagnetic disturbance.

The application of the Directive depends to a large degree on how the product which is placed on the market is defined. It is clear that a single item of apparatus must be tested and certified as compliant. However when a collection of equipment is put together as a system then it may not be possible to test or certify it, either because the system is too large or distributed to test properly, or because its configuration may be varied with each time it is placed on the market.

The EC’s explanatory document makes the definitions of a system and an installation as shown above. If the product is a system, then it must be tested and certified as a unit, i.e. with all the constituent apparatus connected and functioning together. If it is an installation, i.e. a more or less random combination of apparatus and systems that cannot “enjoy” free movement within the EC/EEA market, then the constituent parts must themselves be tested and certified in accordance with the Directive but the overall installation need not be, provided that manufacturers’ installation instructions are followed to ensure proper operation.

Components

Type of component	Description	Application of EMC Directive
Components not intended to be placed on the market to the final end user	Designed, manufactured and intended for incorporation into other apparatus which will itself be certified	No
Components placed on the market but having no direct function	Available to the end user but not offering a direct function, e.g. resistors, capacitors, transistors, relays, etc	No
Components placed on the market and offering a direct function	E.g. PC plug-in cards, lift controllers, motors, electronic temperature controls	Yes

16

The EMC Directive applies to apparatus, which by implication contains components. Components themselves therefore are excluded from the scope of the Directive provided they are not themselves apparatus with a direct function, and their only purpose is to be incorporated within an apparatus. Therefore electronic sub-assemblies which are not intended to stand alone may be regarded as components, although an exception is made for third-party plug-in PC cards, which if they are available on the market must be certified compliant.

The definition of “direct function” is

> *any function of a component or a finished product which fulfils the intended use specified by the manufacturer in the instructions for use for an end-user. This function can be available without further adjustment or connections other than simple ones which can be performed by any person not fully aware of the EMC implications..*

Placing on the market

- placing on the market: the first making available of every individual, physically existing finished product in the EC by the manufacturer, importer or his authorized representative
- taking into service: the first use in the EC of a product by its final user

17

A product is placed on the market at the time at which it passes for the first time from the manufacturing stage (within the EC) or the importing stage (when it is imported) into the distribution chain or direct to the customer. Every individual new product is covered, regardless of the time and place of its manufacture, and such a product must declare (by means of the CE mark and the declaration of conformity) that it meets the Directive's essential requirements, but sales of second-hand products are not covered.

A product is taken into service when it is used for the first time by its final user. Apparatus which is taken into service but not placed on the market – for example, apparatus intended for the manufacturer's own use – must meet the essential requirements, but does not have to go through the conformity assessment and certification procedures.

The declaration of conformity

- a description of the apparatus to which it refers;
- a reference to the specifications under which conformity is declared;
- an identification of the signatory empowered to bind the manufacturer or his authorized representative;
- a declaration that the apparatus conforms to the essential protection requirements.

18

The EC declaration of conformity is required whether the manufacturer self-certifies to harmonized standards or follows the technical file route. It must include the components as shown above, and it is typical (though not mandatory) to refer to EN45014 for the format.

The description of the apparatus should take into account the possibility of future product variants and the implications of design changes for the product's EMC profile.

The empowered signatory will not necessarily be competent to judge the technicalities of what is being declared. Normally this will be one of the directors of the manufacturing or importing company. In small companies the technical director will probably be close enough to the product in question to understand the detail of its EMC performance, but in medium or large-scale enterprises the directors will have to rely on the technical advice of their product development and manufacturing engineers. Likewise if the authorized representative signs the certificate, he must rely on information provided to him by the manufacturer.

As is discussed later, the compliance via standards route only gives a presumption of conformity with the essential requirements. The declaration is a statement that the product is believed to meet the essential requirements, using the harmonised standard as an indication of this.

The R&TTE Directive: scope

The Radio and Telecommunications Terminal Equipment Directive 99/5/EC

- implemented 8th April 2000
- an extension of the TTE-SES Directive 98/13/EC

• Scope:

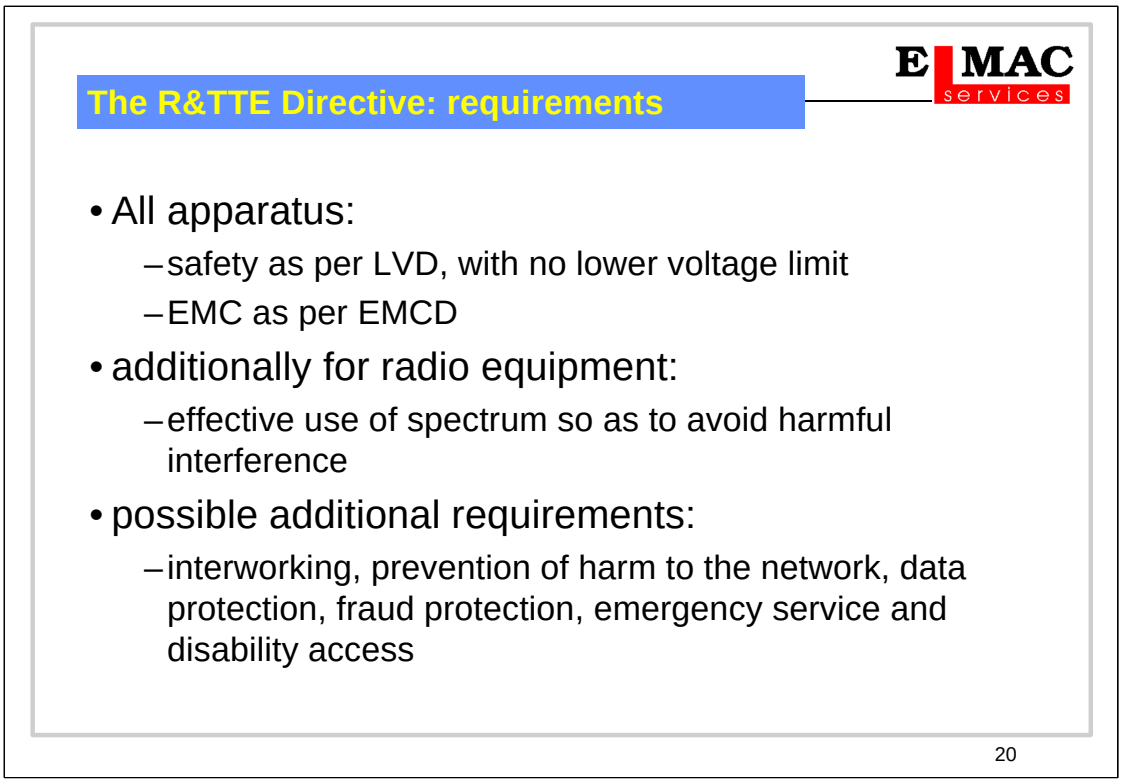
- Telecommunications terminal equipment
- Radio equipment
- such apparatus even if it incorporates medical devices or vehicle components
- some exceptions

19

The Radio & TTE Directive went into effect on April 8th 2000, with a transition period to April 7th 2001; after this date all equipment within the scope must comply with its provisions. Exceptions to the scope are:

- •apparatus exclusively used for public security, defence, state security, and state activities in the area of criminal law;
- •marine equipment, civil aviation equipment and air traffic management equipment (all covered by their own regulations);
- •amateur radio equipment, broadcast radio receivers, and cabling and wiring.

It represents a fairly fundamental shift in the way that radio and telecom equipment, previously subject to national and pan-European type approval regimes, are regulated. The goals which the R&TTE Directive addresses were, basically, simplified and relaxed procedures, minimum essential requirements, consistency with the EC's approaches and a responsiveness to market needs.



The R & TTE requirements incorporate the requirements of the LVD and EMCD and allow a continuation of the conformity assessment regime already in place for those Directives. An important extension is the removal of the lower voltage limit (50V AC or 75V DC) for application of the LVD. This means that safety requirements apply even to handheld, battery powered apparatus, meaning, for example, mandatory application of safe radiation limits, so that mobile handheld transmitters should be subject to SAR assessment.

Type approval of radio transmitters has been abolished, with the additional requirement for effective use of the spectrum so as to avoid harmful interference. This does not preclude national authorities from applying restrictions on the grounds of local spectrum management through the licensing process, but they must not attempt to enforce a type-approval regime in this context. There is a requirement to inform the relevant national authorities whenever it is intended to place on the market equipment that uses non-harmonized spectrum allocations. The authorities then have a four week period within which to raise objections.

The Directive also allows the Commission to impose extra requirements for certain classes of equipment, but to date this has not been applied. A particular requirement for terminal equipment is the prevention of harm to the network or its functioning which causes an unacceptable degradation of service to persons other than the use of the apparatus. This aspect was traditionally handled by the type approval process. There are concerns that leaving the network requirement specifications hanging, as it were, in mid-air will damage the pan-European harmonization of the wired sector of the telecomms industry.

The R&TTE Directive: compliance

- Conformity assessment annexes
  - ii: Internal Production Control with technical documentation
  - iii: Annex ii plus specific tests
  - iv: Annex iii plus Technical Construction File submitted to a notified body
  - v: Full Quality Assurance assessed by a notified body
- Annexes applicable:
  - Telecomms equipment: **ii**, iv or v
  - Radio equipment with harmonized standards: **iii**, iv or v
  - Radio equipment without harmonized standards: iv or v

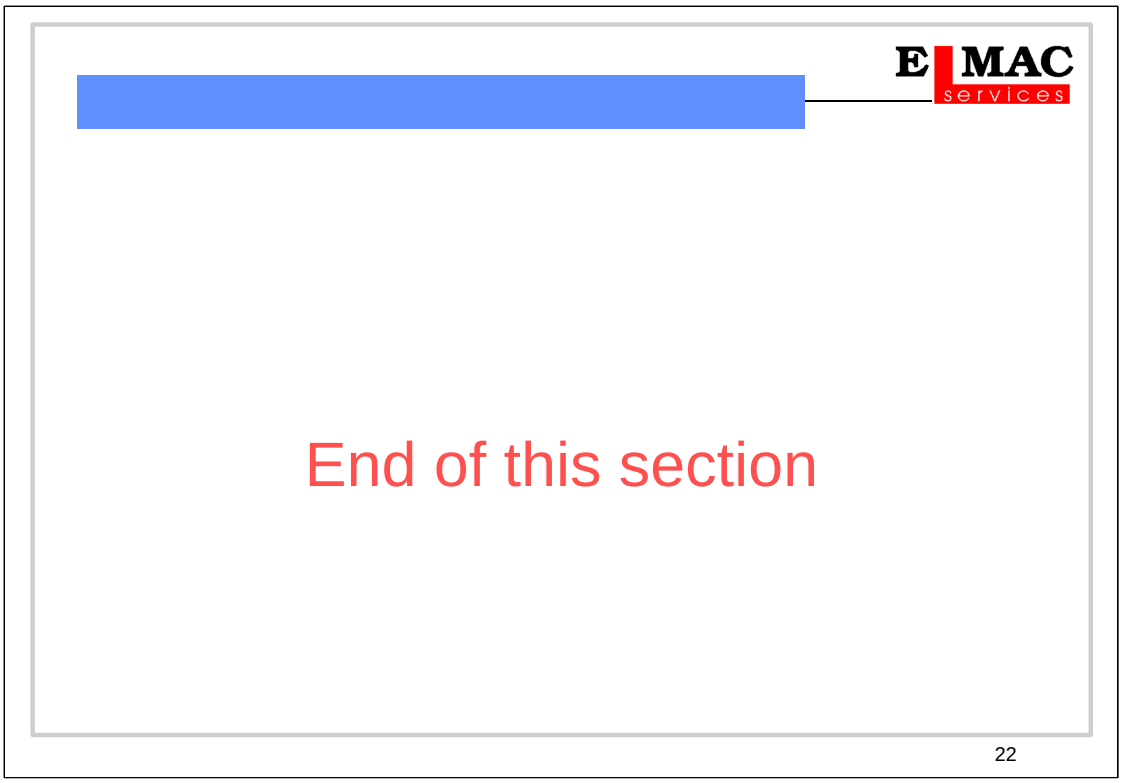
21

The conformity assessment procedures allowed under the R&TTE Directive are outlined above. Their applicability varies depending on whether the equipment is telecoms terminal, or radio equipment; the receiving part of radio equipment is treated as telecoms equipment. In either of the cases of annexes ii or iii, there is no absolute requirement for the involvement of a notified body. The specific tests in annex iii must be identified by a notified body unless they are already defined in the harmonized standard(s). Otherwise, these annexes represent pure self-certification on the part of the manufacturer.

The Full Quality Assurance method of Annex V may be an attractive route for a large manufacturer of radio equipment, since it is the only option that avoids the case-by-case involvement of a notified body for radio terminals whose tests are not defined in harmonized standards.

Transitional activities for existing products will include:

- reviewing the marking of the product: marking requirements other than the CE Mark include, a new Notified Body number, if applicable, information on the class identifier and areas of use, and full type/batch/serial number/manufacturer information
- a new declaration of conformity, referencing safety and LVD requirements as well as any specific radio or telecomms standards
- making sure that the declaration of conformity and information for the user on the intended use of the apparatus are supplied with each item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