EMC presentation, 14th January 2010

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Built on a solid technical heritage

- Over 85 years experience of delivering technology solutions to governments and blue chip companies

- World-class engineers:
  - 73% with university degrees
  - 53% with post-graduate qualifications

- Based across three UK locations
  - Leatherhead, Surrey
  - Kidlington, Oxfordshire
  - Abingdon, Oxfordshire

- Certified to BS EN ISO 9001: 2000, including TickIT (Leatherhead and Abingdon)
Cobham Organisational Structure

- Cobham Defence Electronic Systems
- Cobham Avionics & Surveillance
- Cobham Technical Services
  - ERA Technology
  - Vector Fields Software
  - Lightning Testing and Consultancy
- Cobham Mission Systems
- Cobham Aviation Services
<table>
<thead>
<tr>
<th>Cobham Technical Services</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Antenna and Electronic Systems</strong></td>
</tr>
<tr>
<td><strong>Vector Fields Software</strong></td>
</tr>
</tbody>
</table>
EMC Market Sectors
Electromagnetic Compatibility

- EM management plans provide risk assessment and best practice guidance for complex EM environments
- EM measurements, investigations and testing over the entire frequency range between 20 Hz and 40 GHz
- EM modelling to predict the risks to electronic equipment, human health and explosive environments, from a range of EM threats
- UK Government (BIS) accredited EMC Notified Body
- Ofcom outsourced research and measurement resource
EMC is a legal requirement

EMC Directive 2004/108/EC
UK Statutory Instrument 3418
Equipment compliance: (Regulation 15)

Equipment used in installations shall:

- Have information on how it is to be installed and maintained in the installation.
- Have information on how the equipment is to be operated in the installation.
- Have a Declaration of Conformity with the UK Regulations or how it meets the regulations if the equipment is specific to the installation.
Installation compliance: (Regulations 5 and 35)

that installation Designers and Operators:

• meet the protection requirements of the Directive by
  – the provision of EMC assurance evidence and that the installations EM characteristics have been identified
  – provide documentation for the precautions to be taken so the installations conformity is not compromised by future refurbishments.

• have a responsible person identified for the design and taking into service of the installation

• have applied and documented good engineering practices
Specify the EMC environment (Regulation 4)
Where you will come across EMC Regulations and Requirements
Railway Built Environment

- Network Rail and LU have EMI requirements that must be met.
- Emissions covered by RC1500 and LU standard I-222
- Compliance must be demonstrated through design and construction phases.
Airports

• Complex EMI environment

• Required to meet EMI industrial equipment requirements, Rail and LU requirements, non-ionizing radiation limits.

• Required to meet CAA compliance to ensure safe operation of the airport during construction.
• HTM 06-01 Electrical services supply and distribution includes need to meet EMC requirements.

• EMF Directive 2004/40/EC applies particularly in MRI suites and diathermy. Protection of the general public, i.e. patients, and workers

• Medical Research Centre specification for use of collocated NMR and Electron Microscopes
Data Centres

- Resilient operation required
- Density of cabling and systems
- Substation interference to main communication rooms
- Screening requirements between plant room and communication rooms
- System-to-system risk assessments
Client requirements

- A history of interference to sensitive systems
- Design and construction solutions required to meet tight limits
- Very cost conscious due to previous experience of blanket solutions
Planning Authorities

- Required to make an Environmental Impact Assessment statement for Tall buildings
- Will need statement regarding impact on TV reception on areas in TV and radio shadow.
Building Regulations, Wiring Regulations

Building Regulations SI 2531

Regulation 7

(Refers to)

Part P, Electrical Safety

(Refers to)

Electricity at Work Act 1989

BS7671 Wiring Regulations

Requires sign off by a Competent Person

(hence)

HD60364-4-444 EMC requirements

EMC compliance to be met as part of Building Regulations in addition to the EMC regulations SI 3418
Standards that contain EMC/EMF requirements

- HTM 06-01, section 11
- CIBSE Guide K, section 10
- IET 17th Edition wiring regulations, EMC addendum applicable from 2011
- HD60364-4-444 based on IEC60364-4-44-444. Applicable for electrical contractors
- EN50174-2. Applicable for telecommunication installation contractors
- EMF Directive 2004/40/EC
# Medical (MRI)

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Action value, magnetic flux density</th>
<th>Estimated exposure</th>
</tr>
</thead>
<tbody>
<tr>
<td>0Hz (static magnetic field)</td>
<td>0.2T</td>
<td>3T (clinical)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7T (research)</td>
</tr>
<tr>
<td>500Hz (magnetic field gradient)</td>
<td>50uT</td>
<td>2,000uT (to head)</td>
</tr>
<tr>
<td>10-400 MHz (radiofrequency)</td>
<td>SAR 0.4 Wkg(^{-1})</td>
<td>&lt; 0.4 Wkg(^{-1})</td>
</tr>
</tbody>
</table>
Project requirements - Summary

- Wide variety of different requirements – per sector
- Need to meet regulations
- Implement early in RIBA stages to prevent project delays
- Specific to meet Client’s Brief
Why meet EMC compliance in projects
Legal requirement - EMC Directive

- Installations are legally required to comply with UK law
- Must provide EMC conformance evidence for installations
- UK legislation (SI 3418) applied since 1996, and revised requirements applicable to installations from July 2007
Contractual project requirements

- Owner/Operator/Developer sets building brief
  - Sets the broad EMC requirements
  - Sets building performance criteria
- Design Consultant complies by:
  - Meets the project brief for EMC
  - Applies EMC engineering techniques
  - Performs risk assessments studies
  - Produces EMC Assurance Evidence File
  - Risk assessments for variations
  - System procurement & compliance review
  - Adds to EMC Assurance Evidence File stating the design has been met
- Constructor follows design
  - Holds EMC Assurance Evidence File
  - Manages EMC for the life of the building
- Owner/Operator takes into service
Controlling cost

- **Avoid project delays and re-works**
  - Penalties

- **Efficient planning for EMC**
  - Avoid post-construction fixes
  - Structured, integrated project EMC
  - Stage/Phase considerations

- **Maintain operational continuity**
  - Reduce the risk of malfunction
  - Reduce troubleshooting
Examples of poor EMC planning

<table>
<thead>
<tr>
<th>Cause</th>
<th>Cost to correct £k</th>
</tr>
</thead>
<tbody>
<tr>
<td>TV reflections from building cladding</td>
<td>400</td>
</tr>
<tr>
<td>Litigation from poor building attenuation advice</td>
<td>500</td>
</tr>
<tr>
<td>Litigation for poor design of systems in an automated building</td>
<td>15000</td>
</tr>
</tbody>
</table>
EMC aspect of a successful project

- Project complies:
  - Legally
  - Contractually
  - Operationally
  - Financially
EMC Effects
EMC Effects

Radio Tx

Stand-by generator

Air Handling Unit

Other systems

Data systems

HV + LV switch

UPS

Fire and Security

The neighbourhood

Radar

Railway
System Interaction with the EM Environment

- Sensor
- Microprocessor Controller
- Central Terminal
- Emissions
- Induced Currents
- Power
- Earth voltages
- Common impedance
- From Other Loads
- Transients Dips
- Radio Transmitter
- Relays
- Output
- Comms.
- ESD
- M
- C
- Id
- Ic
- Earth
- Cobham Technical Services – ERA Technology
EMC Effects: Interference from Environment

Radio Tx

Shielding

Stand-by generator
Air Handling Unit
Other systems
Data systems
HV + LV switch
UPS
Fire and Security
EMC Effects: Interference from Environment

Radio Tx

Cable coupling

Stand-by generator

Air Handling Unit

Other systems

Data systems

HV + LV switch

UPS

Fire and Security

Radar

Railway
EMC Effects: Interference from Environment

- Radio Tx
- Radar
- Railway

Direct radiation

- Stand-by generator
- Air Handling Unit
- Other systems
- Data systems
- HV + LV switch
- UPS
- Fire and Security
EMC Effects: Internal EMC Effects

Cable-to-cable coupling

Interference induced on cables

Stand-by generator

Air Handling Unit

Other systems

Data systems

HV + LV switch

UPS

Fire and Security
EMC Effects: Internal EMC Effects

Interference from cables

Equipment radiation

HV + LV switch

UPS

Fire and Security

Stand-by generator

Air Handling Unit

Other systems

Data systems
EMC Effects: Internal EMC Effects

Stand-by generator
Air Handling Unit
Internal radio transmitters
Other systems
Data systems
HV + LV switch
UPS
Fire and Security
EMC Effects: Effect on external environment

The neighbourhood

Stand-by generator

Air Handling Unit

Other systems

Data systems

HV + LV switch

UPS

Fire and Security

The neighbourhood
Techniques for managing EMC
EMC Management Planning

Management Plan
- Project scope, structure, roles & responsibilities
- EMC Requirements
- Environment
- Systems review
- Zoning
- Initial risk assessment

Control Plan
- Generic design guidance
- Detailed studies
- Updated risk assessment
- Specific design guidance and recommendations
- Procurement advice
- Audit declarations of conformity
- Audit subcontractor populated control plans

Assurance Evidence File
- Documentation of all evidence
EMC Management Planning

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Assurance Evidence File
- Documentation of all evidence

- Contractually agreed roles
- Just M&E/Other
- Systems (Comms, BME, etc)
- Boundaries/Interfaces
EMC Management Planning

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Environment: EMC Survey

- Greenfield site
- Brownfield site
- Pre- and post-construction
- Sources
  - Mobile phone base station
  - Communications
  - Power lines
  - RF heating devices
  - Broadcast transmitters
  - Airport radar

Broadband Field: Platform 4, Farringdon Station 3rd October 2002
(Measurement range 150kHz - 1GHz)
Environment: EMC Modelling

Mobile base stations

Low frequency magnetic fields from railway

Buildings

Radar

High frequency radar fields
EMC Management Planning

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Assurance Evidence File
- Documentation of all evidence

- Type of equipment
- Environments
- Standards
Zoning

- Zoned through usage
- Zoned through criticality
- Zoned through type of equipment
EMC Management Planning

Management Plan
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- **Initial risk assessment**

Control Plan
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Assurance Evidence File
- Documentation of all evidence
# Initial Risk Assessment

<table>
<thead>
<tr>
<th>Source : S</th>
<th>S1 : T1 132kV / 11kV Electrical Power Systems</th>
<th>S2 : CTRL TP &amp; OHL</th>
<th>S3 : Thameslink TP &amp; OHL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Receptor : R</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R1 : T1 LV power, data, control and telecommunication systems</td>
<td>Rad, Mut, Con</td>
<td>Rad, Mut</td>
<td>Rad, Mut</td>
</tr>
<tr>
<td>R2 : T1 residential and commercial broadcast receivers</td>
<td>Rad</td>
<td>Rad</td>
<td>Rad</td>
</tr>
<tr>
<td>R3 : T1 residential and commercial CRT type VDUs</td>
<td>Rad</td>
<td>Rad</td>
<td>Rad</td>
</tr>
<tr>
<td>R4 : CTRL signalling and telecommunication systems</td>
<td>Mut, Con</td>
<td>Responsibility of the Railway Authorities</td>
<td>Responsibility of the Railway Authorities</td>
</tr>
<tr>
<td>R5 : Thameslink signalling and telecommunication systems</td>
<td>Mut, Con</td>
<td>Responsibility of the Railway Authorities</td>
<td>Responsibility of the Railway Authorities</td>
</tr>
<tr>
<td>R6 : Human Beings (Radiation Hazards)</td>
<td>Rad</td>
<td>Rad</td>
<td>Rad</td>
</tr>
</tbody>
</table>
EMC Management Planning

Management Plan
- Project scope, structure, roles & responsibilities
- EMC Requirements
- Environment
- Systems review
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- Initial risk assessment

Control Plan
- **Generic design guidance**
- Detailed studies
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Assurance Evidence File
- Documentation of all evidence
Cable separation rules
### Minimum cable separation, no containment, maximum 100m runs

<table>
<thead>
<tr>
<th>Type of power cable</th>
<th>Type of sensitive cable</th>
<th>Distance (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HV 3- core cable</td>
<td>Control cable</td>
<td>0.9</td>
</tr>
<tr>
<td>LV 4- core cable</td>
<td>Control cable</td>
<td>1.6</td>
</tr>
<tr>
<td>LV busbar</td>
<td>Control cable</td>
<td>3.9</td>
</tr>
<tr>
<td>Modular wiring</td>
<td>Control cable</td>
<td>0.3</td>
</tr>
<tr>
<td>HV 3- core cable</td>
<td>Signal cable</td>
<td>0.03</td>
</tr>
<tr>
<td>LV 4- core cable</td>
<td>Signal cable</td>
<td>0.05</td>
</tr>
<tr>
<td>LV busbar</td>
<td>Signal cable</td>
<td>0.1</td>
</tr>
<tr>
<td>Modular wiring</td>
<td>Signal cable</td>
<td>0.006</td>
</tr>
</tbody>
</table>
# Cable and Containment selection

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Cable type</th>
<th>Containment</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>HV power</td>
<td>Armoured cable</td>
<td>Hangers</td>
<td>Acceptable</td>
</tr>
<tr>
<td>LV power (main distribution)</td>
<td>Steel enclosed busbar</td>
<td>Hangers</td>
<td>Acceptable</td>
</tr>
<tr>
<td></td>
<td>Armoured cables</td>
<td>Tray</td>
<td>Acceptable</td>
</tr>
<tr>
<td>LV power (final distribution)</td>
<td>Modular wiring</td>
<td>Flexible conduit</td>
<td>Potential interference issue to lighting control cables.</td>
</tr>
<tr>
<td>Comms backbone</td>
<td>Optical fibre</td>
<td>N/A</td>
<td>Acceptable</td>
</tr>
<tr>
<td>Comms distribution</td>
<td>UTP in Supertube</td>
<td>Basket</td>
<td>Acceptable</td>
</tr>
<tr>
<td>Comms final distribution</td>
<td>UTP in Supertube</td>
<td>Plastic conduit</td>
<td>Must use good termination practices</td>
</tr>
<tr>
<td>Analogue control</td>
<td>UTP</td>
<td>Basket</td>
<td>Not acceptable with low signal levels (100uV range)</td>
</tr>
</tbody>
</table>
Grounding Schemes

(a) Series
- Common-impedance coupling, generates unwanted voltages.
- Loops induce voltages

(b) Parallel or single point
- Same earth potential. Good at Power and Audio Frequencies. OK if loops are electrically small

(c) Multipoint
- Same earth potential. Theoretically best at HF (>10 MHz)
Panel installation

- Separate noisy and sensitive circuits
- Signal and power cables in separate trunking
- Keep earth wires short
- Screens bonded to the backplane at the point of entry
- Avoid pigtaills
- Trunking for different classifications of cable, power, signal etc
- Filters well bonded to backplane, 180 degree separation of input and output
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Assurance Evidence File
- Documentation of all evidence
Detailed Studies: Emissions from risers to equipment

- Eliminate interference to sensitive systems
- Model power source emissions
- Specify attenuation
Detailed Studies: Model, mitigate, shield emissions from risers

- Should screening be used?
- Specify level of screening to protect services
Electrical plant close to recording studios

- Multiple Busbars in adjacent corridors
- Risers
- 3-D model
- Studio Limit 0.8 A/m
- Re-locate busbars
- Exclusion Zones
- Shielding
Computer Simulation of Internal EM Fields

Simulation of field strengths from internal communications systems

Comparison of measured and simulated fields
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### Gap Analysis - Example

<table>
<thead>
<tr>
<th>EMC Test</th>
<th>Applicable Standard</th>
<th>Product Standard</th>
<th>Requirement Met</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>EN 50121 - 4 Signalling &amp; Telecoms</strong></td>
<td><strong>EN 50130-4 Fire Alarm Panel</strong></td>
<td></td>
</tr>
<tr>
<td>Conducted Emissions</td>
<td>0.15 - 0.5 MHz  79 dBµV</td>
<td>Product Dependent</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>0.50 - 30 MHz   73 dBµV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Radiated Emissions</td>
<td>30-230 MHz     40 dBµV/m</td>
<td>Product Dependent</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>230-1000 MHz    47dBµV/m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrostatic Discharge</td>
<td>6 kV contact</td>
<td>6 kV contact</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>8 kV air</td>
<td>8 kV air</td>
<td></td>
</tr>
<tr>
<td>Radiated Immunity</td>
<td>80 - 1000 MHz   10 V/m</td>
<td>80 - 1000 MHz  10 V/m</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>800 - 1000 MHz  20 V/m</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.4 - 2.1 GHz   10 V/m</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.1 - 2.5 GHz   5 V/m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>50 Hz Magnetic Field</td>
<td>100 A/m</td>
<td>None</td>
<td>No</td>
</tr>
<tr>
<td>Pulsed Magnetic Field</td>
<td>300 A/m</td>
<td>None</td>
<td>No</td>
</tr>
<tr>
<td>Fast Transient Immunity</td>
<td>2 kV Power</td>
<td>2 kV AC</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>2 kV I/O</td>
<td>1 kV I/O and DC</td>
<td></td>
</tr>
<tr>
<td>Surge Immunity</td>
<td>2 kV CM 1 kV DM  Power</td>
<td>2 kV CM 1 kV DM  AC</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>2 kV CM 1 kV DM I/O</td>
<td>0.5 kV CM I/O and DC</td>
<td></td>
</tr>
<tr>
<td>Conducted Immunity</td>
<td>0.15 - 80 MHz   10 V</td>
<td>0.15 - 100 MHz  10 V</td>
<td>Yes</td>
</tr>
</tbody>
</table>
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Assurance Evidence File
- Documentation of all evidence
Documentation: Assurance Evidence File

- **Introduction**
- **Scope of works**
- **EMC Organisation for scope of works**
- **Specific EMC Requirements**
- **Description of the system**
- **Description of the Local EM Environment (completed at design stage?)**
- **Review of Suppliers EMC Documentation (DoC vs Requirements)**
- **Test Evidence and/or DoCs**
- **EMC Installation Rules**
- **EMC Risk Analysis (completed at design stage or is design independent?)**
- **EMC activities required post commissioning**
- **O&M Manual Inputs**
  - EMC good practices related to the general infrastructure
  - EMC requirements specific to individual systems
  - Checks to be undertaken
Roles and Responsibilities
Roles and responsibilities

Owner/Operator/Developer sets building brief

Design Consultant complies by:

- EMC assessment
- Apply standards

Constructor follows design

Owner/Operator takes into service
EMC Roles and Responsibilities - Designer (1)

- Usually defined by contractual boundaries

- Designer can only demonstrate EMC good practices based on the detail of design they are employed to undertake

- Up to RIBA Stage C
  - Determine EMC Strategy (EMC Management Plan)
  - Understand the electromagnetic environment
  - Qualitative review of threats
  - Place basic requirements within outline design specifications
  - Define the necessity (or not) to zone the building
  - Highlight design conclusions which may impact on later design stages

- RIBA Stage D and Stage E
  - EMC Control Plan defining the design EMC good practices/ rules applied to the installation
  - Produce a fully detailed threat assessment - Quantitative
  - Produce more detailed EMC requirements within design specifications
  - Produce Earthing and Bonding Specifications
  - Define change control procedures
EMC Roles and Responsibilities - Designer (2)

- **Up to RIBA Stage F**
  - Determine EMC procurement specification
  - Compile EMC Evidence File
  - Highlight design conclusions which may impact on later design stages

- **Prepare EMC Evidence File to handover for Tender/Construction Phase**
EMC Roles and Responsibilities – Constructor

• Construction design review – demonstrates that the design brief has been met

• Risk assessment of construction phase variations

• Gap analysis of procured equipment versus specification
  – Suppliers and subcontractors will need to produce submissions for each significant system installed

• Update and maintain EMC Evidence File

• Provide completed EMC Evidence File to Client (Owner/Operator)
  – Maintained for the life of the installation
EMC – How much EMC effort?
T5 - EMC management of Contractors

- Over arching EMC strategy
- Audit Contractors EMC compliance plans
- Provide T5 EMC Compliance File

Best practice
Risk analysis
Control of suppliers
EM environment
Kings Cross development

- **EMC Management Plan**
  - Set strategy
  - Set actions
  - Set responsibilities

- **EMC Control Plan**
  - Analysis
  - Measurements
  - Modelling

- **Assurance Evidence File**
  - Compliance to EMC Directive
  - Satisfies Client brief
London Underground Substations

Rectifier Floor

Mezzanine level
Second floor gallery level
First floor gallery level
Rectifier floor level (Ground floor)
Basement level

SVC
SVC Control Cabin
500kVA aux transformer
LVAC board
## London Underground Substations

<table>
<thead>
<tr>
<th>Sources</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
<th>16</th>
</tr>
</thead>
<tbody>
<tr>
<td>HV Power cables &amp; distr.</td>
<td>N</td>
<td>Y</td>
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### Outside world

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The ERA EMC Group provide the following solutions
We provide an integrated service

**Qualitative assessments**
EM Management

**Standards and regulations**
Risk analysis

Recommendations, procedures, design guidelines

**EM Measurement**
**EM Modelling**

**Quantitative assessments**

**Control plan**
- shielding
- filtering / cabling
- earthing and bonding etc

Audit

Populate Assurance Evidence File

Implementation
EMC Management & Control Plans

Whole-life EMC Solution

- **EMC Management Plan**
  - Set strategy
  - Set actions
  - Set responsibilities

- **EMC Control Plan**
  - Analysis
  - Measurements
  - Modelling

- **Assurance Evidence File**
  - Compliance to EMC Directive
  - Satisfies Infrastructure Owners
Modelling Capability

**Power Group**
5 EM modelling engineers

**EMC Group**
4 EM modelling engineers (3 PhDs)

**Antenna Systems**
5 EM modelling engineers (3 PhDs)

**Commercial Tools**
- FEKO (3D MoM, PO, UTD)
- XFDTD - 3D FDTD
- NEC - MoM
- Quickfield (2D LF FEM)
- HFSS - HF FEM
- Pspice - circuit simulation

**ERA developed tools**
- EMC Exclusion Zones
- Cabling emission & coupling
- ERACS - power
Radio Frequency Assessments

GSM
3G
WiMAX
WiFi
UWB
DVB-T
DVB-H
DAB
Satellite
Fixed links
Radar
PMR
Tetra
Tetrapol
PMSE
GPR
WSD

Laboratory measurements

Field trials

Propagation modelling
Questions