

**MEMORANDUM TO THE HOUSE OF
COMMONS SCIENCE AND TECHNOLOGY
SELECT COMMITTEE INQUIRY *SCIENTIFIC
ADVICE, RISK AND EVIDENCE: HOW
GOVERNMENT HANDLES THEM***

**Case study on the use of MRI equipment: the EU Physical
Agents (Electromagnetic Fields) Directive**

*A joint submission by the Royal College of Radiologists, the British
Institute of Radiology, the Institute of Physics, the Institute of Physics
and Engineering in Medicine and the British Chapter of the International
Society for Magnetic Resonance in Medicine*

1. EXECUTIVE SUMMARY

1.1 The Physical Agents (Electromagnetic Fields) Directive contains occupational exposure limits that would restrict the use of MRI equipment, with damaging consequences for medical treatment and research. In particular, it could prohibit interventional MRI, a new technique that may replace X-ray guided procedures, improving treatment and eliminating ionising radiation hazards to patients and staff.

1.2 The exposure limits, presented as thresholds for 'known short-term adverse effects', are based on extremely cautious, in effect precautionary, interpretation of limited scientific data. The same limit values were recommended for use in the UK by the Health Protection Agency (HPA) in 2004, but more accurately described by the Agency as 'a cautious approach... to indicate thresholds for adverse health effects that are scientifically plausible'.

1.3 Against this, around 400 million patients have been imaged using MRI, with no evidence of adverse effects at the EMF exposure levels indicated in the Directive.

1.4 Negotiation of the Directive on behalf of the UK was the responsibility of the Health and Safety Executive. The HSE relied excessively on a single source of advice – the HPA guidelines – ignoring the nuances in that advice and resisting input from the MRI community. The community repeatedly indicated shortcomings in the scientific evidence and the likely impact of the Directive, but it was necessary to go to the press and to ministers before our concerns were taken seriously. The HSE and government are now seeking a solution, but options are limited as the Directive has been adopted and the UK is obliged to implement it.

1.5 In this memorandum the MR community addresses the questions posed by the Committee by highlighting how failings in the treatment of advice, handling of evidence and understanding of risk have led to this situation. The memorandum also makes reference to the failings of the proposals themselves, to show that the case advanced by the community was well substantiated and strongly argued, which is relevant to consideration of whether external advice was sought or acknowledged.

2. INTRODUCTION

2.1 The Submitting Organisations

2.1.1 **The Royal College of Radiologists (RCR)** is the professional body for clinical radiologists and oncologists in the UK. It is established by Royal Charter as ‘an authoritative body for the purpose of consultation in matters of public and professional interest concerning clinical radiology and clinical oncology’.

2.1.2 **The British Institute of Radiology (BIR)** is a multidisciplinary learned society, bringing together the professions involved in radiology to share knowledge and improve the detection and treatment of disease.

2.1.3 **The Institute of Physics (IOP)** is a membership organisation devoted to increasing the understanding and application of physics. It has a worldwide membership of over 35,000, and is a leading communicator of physics with all audiences from specialists through government to the general public.

2.1.4 **The Institute of Physics and Engineering in Medicine (IPEM)** is a professional body dedicated to promoting the advancement of physics and engineering applied to medicine and biology and representing the interests of engineering and physical sciences in the provision and advancement of health care.

2.1.5 **The British Chapter of the International Society for Magnetic Resonance in Medicine (ISMRM)** is the UK branch of a multidisciplinary association devoted to the development and application of magnetic resonance in medicine. Its aims include provision of information and advice on aspects of public policy concerned with MRI.

2.1.6 Collectively, these organisations represent the united voice of the magnetic resonance community in the UK. Their members work in both clinical and research settings and include radiologists and other medical specialists, radiographers, medical physicists, industrial scientists and academics.

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3. BACKGROUND

3.1 Magnetic Resonance Imaging

3.1.1 Magnetic Resonance Imaging (MRI) is a medical imaging modality that uses magnetic fields and radio waves to produce detailed images of the body. Unlike X-ray and nuclear medicine, it does not use ionising radiation, and is thus safer for both patients and staff. It has widespread and growing applications.

3.1.2 There are almost 500 MRI scanners in UK hospitals, performing over one million examinations each year. The government has recently invested around £100 million in over 100 new scanners, which will play a crucial role in waiting time reduction for cancer patients. The UK is leading in MRI research, with considerable investment from the funding councils, research councils and medical charities. MRI is increasingly important in preclinical research, attracting significant funding from the pharmaceutical industry. The UK is also a major centre for manufacture of MRI magnets, with two of the world's largest manufacturers based here.

3.1.3 MRI is beginning to be used in interventional procedures that have traditionally been performed under X-ray guidance: improving image quality, providing additional information, and eliminating ionising radiation dose to patients and staff. There are interventional MRI facilities at several UK hospitals, responsible for a number of breakthroughs in the field, and further installations are planned as the technique matures.

3.2 The Physical Agents (Electromagnetic Fields) Directive

3.2.1 Directive 2004/40/EC¹ was adopted on 29 April 2004, and member states have four years to transpose it into national law. The Directive limits occupational exposure to electromagnetic fields (EMF) in the frequency range 0 – 300 GHz, claiming to protect workers from 'known short-term adverse effects in the human body'. It sets 'exposure limit values' that may not be exceeded, and subsidiary 'action values', expressed in more easily measurable terms, to ensure compliance with these limits. Limits are stated explicitly in the Directive, with no room for leeway in implementation or exceptions for specific occupational sectors.

¹ Official Journal of the European Union L 159 of 30 April 2004 (and corrigenda L 184 of 24 May 2004)

3.3 Impact of the Directive on MRI

3.3.1 MRI uses EMF in three frequency ranges, all within the scope of the Directive.

3.3.2 *A static magnetic field (0 Hz)*. Early drafts of the Directive contained a static magnetic field exposure limit of 2T (tesla). This was later removed, although an action value of 200mT remains. A review in 2009 may re-introduce a limit.

3.3.3 *A time-varying magnetic field, known as a 'switched gradient' (100s - 1000s Hz)*. Over this frequency range limits are set in terms of the electrical current induced in the body by the changing magnetic field, and are such that staff will not be permitted to stand close to the scanner while it is operating. This is the main source of concern to the MR community.

3.3.4 *A radiofrequency field (10s - 100s MHz)*. Here limits are set in terms of specific absorption rate (SAR) to limit heating. The limits are very low, and it is possible that some MR activities may be affected.

3.3.5 The impact of the Directive on MRI may be summarised as follows.

- 3.3.5.1 It will be difficult to monitor patients requiring close supervision during imaging – e.g. anaesthetised or sedated children, very sick patients and uncooperative psychiatric patients – since staff will not be able to stand close to the scanner.
- 3.3.5.2 Movement of staff near the scanner may be restricted even when it is not operating. The static magnetic field is present at all times, and movement through it will expose staff to a time-varying field that may breach the relevant limit. This will also affect testing of magnets during manufacture and maintenance of installed systems.
- 3.3.5.3 Most interventional MR procedures will become illegal, as clinicians will not be permitted to stand close enough to the scanner to perform them.
- 3.3.5.4 Some functional MRI studies will become impossible – e.g. studies on deaf-blind subjects, where staff 'sign' into the palm of the patient during imaging.
- 3.3.5.5 Additional problems will arise if a static field limit is introduced in 2009, the severity of which would depend on the limit adopted. A 2T limit would

make use, cleaning and maintenance of the latest generation of 3T scanners effectively impossible.

3.3.6 The extent of these problems will vary between scanners and with the type of imaging being performed. However, there are clearly substantial difficulties that cannot be eliminated by changing working practices or re-designing scanners. There is likely to be increased recourse to X-ray and CT imaging in place of MRI, resulting in unnecessary ionising radiation dose burden to patients and staff. X-ray guided interventional procedures can result in a significant risk of cancer for the patient, while a recent study found that almost 40% of interventional radiologists have signs of radiation damage to the eyes².

3.4 The Evidence Base

3.4.1 Exposure limits and action values in the Directive were adopted from guidelines issued by the International Commission on Non-ionising Radiation Protection (ICNIRP) in 1998³. These guidelines are based on cautious interpretation of sparse scientific evidence in order to exclude any possibility of adverse effects, rather than on established thresholds for actual effects. In the switched gradient frequency range, limits are inferred from biological effects (not adverse health effects) observed at 20-60 Hz, but assumed on an essentially precautionary basis to be relevant up to 100,000 Hz. Much of the original work dates from the 1980s, and some has never been replicated.

3.4.2 In 2004 the National Radiological Protection Board (NRPB – now part of the Health Protection Agency, HPA) recommended adoption of the ICNIRP guidance in the UK⁴. In the switched gradient frequency range, justification focuses on essentially precautionary assumptions about the electrical properties of the central nervous system, based on mainly theoretical arguments advanced by the *Ad Hoc* Weak Electric Fields Group⁵. It is described as ‘a cautious approach... to indicate thresholds for adverse health effects that are scientifically plausible’⁶. These are much weaker statements than those in the Directive. The HPA’s decision to adopt

² Junk A et al (2004) *Society of Interventional Radiology Annual Meeting*. Phoenix AZ.

³ International Commission on Non-Ionizing Radiation Protection (1998) *Health Physics* **74** 494-522.

⁴ NRPB (2004) *Documents of the NRPB* Vol 15 (2).

⁵ Weak Electric Fields Group position statement. Appendix A to *Documents of the NRPB* Vol 15 (3).

⁶ NRPB (2004) *Documents of the NRPB* Vol 15 (3) p137.

the ICNIRP limits in the face of considerable scientific uncertainty was based as much on a desire for international harmonisation as on science.

3.4.3 Neither ICNIRP nor HPA considered the fact that approximately 400 million patients have been imaged using MRI, involving exposure to switched gradient fields well above the occupational exposure limit, with no indication of adverse effects. Limitations on patient exposure are based on peripheral nerve stimulation, which occurs at a threshold about 100 times the occupational exposure limit contained in the Directive⁷.

4. CONSULTATION WITH THE MR COMMUNITY IN THE UK

4.1 Appendix A summarises action taken by the MR community to draw the attention of government agencies to the weak evidence base underlying the Directive and to its potential impact on MRI. A list of the scientists and clinicians involved in these activities appears in Appendix B. In addition, the stakeholder meeting in January 2006 was attended by 54 people from all sections of the MR community and relevant agencies.

4.2 During passage of the Directive, the MR community repeatedly raised concerns with the Health and Safety Executive (HSE), which conducted negotiations on behalf of the UK. Although the scientists involved were internationally acknowledged experts in MRI, they were unable to influence the HSE's position. A stakeholder meeting involving all affected sectors was held in July 2004, but this was concerned with implementation of a Directive that had by then been adopted, and was unable to address fundamental issues about the exposure limits themselves.

4.3 In September 2005 a group of scientists, including Nobel laureate Sir Peter Mansfield, issued a press release about the issue. The HPA responded⁸ by acknowledging that there is no evidence of deleterious effects, but recommended caution in case there are unknown long-term effects - an issue excluded from the ICNIRP guidelines because of lack of evidence and explicitly excluded from the Directive.

⁷ International Electrotechnical Commission (2001) IEC standard 60601-2-33.

⁸ <http://news.bbc.co.uk/1/hi/health/4264228.stm>

4.4 Events took a more encouraging turn once Lord Hunt of King's Heath and senior HSE policy staff became involved. All sections of the MR community were invited to a stakeholder meeting, concerned largely with how the problem that we now have is to be solved and the detrimental impact of the Directive on MRI alleviated. However, the situation is now very difficult because the Directive has been adopted and the UK is obliged to implement it.

5. RELEVANCE TO ISSUES BEING CONSIDERED BY THE COMMITTEE

5.1 Sources and Handling of Advice, and Relationship Between Scientific Advice and Policy Development

5.1.1 HSE has limited resources and expertise in medical applications of EMF: during meetings in August 2003, it emerged that HSE was unaware of the existence of interventional MRI or of high-field MR imaging.

5.1.2 The position taken by HSE in European negotiations therefore relied heavily on external advice. HSE turned primarily to the HPA guidelines, which they interpreted as providing support for the limits in the Directive. But the HPA's assessment of the scientific evidence (see paragraph 3.4.2) falls well short of asserting the existence of 'known short-term adverse effects in the human body' as is claimed in the Directive.

5.1.3 The HSE has stated that the Directive will have little impact on MRI, since it replicates existing HPA advice that we should already be following. This fails to recognise the distinction between cautious guidance, which can be considered alongside other factors as part of a wider risk assessment, and statutory exposure limits. It assumes that the limits should be applied rigidly in all situations, whereas HPA has stated that its recommendations 'do not address detailed aspects of applying the guidelines to specific exposure situations'⁹.

5.1.4 The HSE should have drawn on more diverse sources of advice, to both supplement and aid in interpretation of the HPA guidelines. The UK has extensive expertise in MRI, including safety aspects. Unfortunately the HSE declined to give due weight to this expertise until the matter was raised in the press and the responsible minister became involved personally.

⁹ NRPB (2004) *Documents of the NRPB* Vol 15 (3) pp 5, 10, 135

5.2 Treatment of Risk

5.2.1 In our opinion the derivation of exposure limits from sparse evidence in the ICNIRP guidelines is manifestly precautionary, in that ‘potentially dangerous effects... have been identified, and... scientific evaluation does not allow the risk to be determined with sufficient certainty’¹⁰. Therefore, application of these guidelines in the EU should be guided, *inter alia*, by proportionality and cost-benefit analysis. Both economic and non-economic aspects of cost-benefit assessment are necessarily specific to a given setting: the considerations appropriate to medical MRI are likely to differ from those relevant to, for example, the telecommunications industry. However, the limits are not presented in the Directive as precautionary values, but as established thresholds for onset of adverse effects.

5.2.2 The HPA advice uses the term ‘caution’ when assessing uncertain scientific data that inform the numerical limits, and ‘precaution’ only in respect of possible further measures related to long-term effects of exposure¹¹. However, we maintain that the HPA’s adoption of numerical limits is precautionary according to the EU definition. It is based on a key assumption about central nervous system function described in the literature as being appropriate if one wished to adopt ‘a precautionary principle.’¹²

5.2.3 These inconsistencies in terminology, and failure to understand the status of scientific evidence and of guidelines derived from it, led HSE to believe that exposure limits were necessary to protect the health of workers, whereas there is no positive evidence to this effect.

5.2.4 Given this belief, regulators were unwilling or unable to consider the fact that prohibiting some MRI practices would lead to increased radiation risk to staff.

5.2.5 Exclusion of patient risk from ionising radiation from consideration in the context of occupational exposure is of particular concern: medical staff routinely bear risk in order to provide healthcare. If this were not accepted, then X-ray imaging and certainly X-ray guided intervention would have to be prohibited.

¹⁰ Commission of the European Communities (2000) Communication from the Commission on the Precautionary Principle. http://europa.eu.int/comm/dgs/health_consumer/library/pub/pub07_en.pdf

¹¹ NRPB (2004) *Documents of the NRPB* Vol 15 (3) p 210

¹² Attwell D (2003) *Radiat Prot Dosim* 106 341-348.

5.3 Transparency, Communication and Public Engagement

5.3.1 Communication between the MR community and the HSE during passage of the Directive was poor, and there was no input to negotiations at European level. We were told that the HSE was bound by HPA and ICNIRP advice, and that scanner design and clinical practice would simply have to change to accommodate the Directive.

5.3.2 This is in marked contrast to the experience of the medical imaging community during negotiation of Directives relating to ionising radiation, where meaningful dialogue resulted in sensible legislation.

5.3.3 The MR community is now working with the HSE to try to solve the problems that have arisen. We are grateful to Lord Hunt and to senior HSE policy staff for their constructive and open approach. We believe that better consultation earlier in the process could have influenced the UK's position and hence the content of the Directive. It should not have been necessary for the community to go to the press and escalate matters to ministerial level in order to be taken seriously by the HSE.

5.4 Evaluation and Follow-up

5.4.1 Most of the scientific data that informed the ICNIRP guidelines had been peer reviewed. The HPA literature review in 2004 is widely regarded as a definitive summary of the state of the science. However, it is not clear that the process of sifting evidence and theoretical speculation in order to develop exposure limits has been subject to equally rigorous evaluation. The leap from cautious, guarded statements in the ICNIRP guidelines to 'known... adverse health effects' in the Directive would certainly not have survived objective scientific review.

6. RECOMMENDATIONS FOR THE COMMITTEE TO CONSIDER

- 6.1 The government should consider whether it is appropriate for the same agency, and indeed the same small group of individuals within it, to have responsibility for consultation, negotiation, implementation and enforcement of legislation. In this situation it is easy for views to become entrenched and for other interests to be excluded from meaningful participation.
- 6.2 Government agencies should draw more widely on the expertise of professional bodies and funding bodies (public, charitable and commercial) to develop a clearer understanding of the implications of legislative proposals. Meaningful consultation with these bodies should be a statutory requirement when UK representatives are formulating positions for negotiation at European level.
- 6.3 Development of science-based health and safety guidelines and legislation should be subject to a robust peer review process. It might be appropriate for the Royal Society to lead on this, drawing on the expertise of other learned and professional societies, as well as the HSE.
- 6.4 Greater consistency is needed in the use of terminology – particularly the definition of ‘precautionary’ - to ensure that the status of pieces of evidence is preserved throughout the process of policy development.
- 6.5 The government should seek amendment of the Directive, at least to exclude MRI from its scope, on the basis that it is disproportionate and that any benefits are hypothetical and heavily outweighed by the costs.
- 6.6. An essentially precautionary approach has been adopted because of the lack of relevant scientific evidence. Rather than curbing valuable activity on this basis, appropriate research should be commissioned to inform development of more credible guidelines. A steering group should be established to define research needs, drawing on recommendations from the recent HSE stakeholder meeting and other sources.

APPENDIX A

Activity by the MR community concerning the Directive

Date	Action	Outcome
July 2003	BIR writes to HSE expressing concerns.	HSE response <ul style="list-style-type: none"> • Issues about limits should be directed to NRPB.
August 2003	BIR writes to NRPB expressing concerns as part of consultation on new guidance.	No response – concerns not addressed in guidance.
August 2003	HSE inspector visits MRI research centres to discuss concerns.	Comments by inspector <ul style="list-style-type: none"> • HSE's hands tied by NRPB and ICNIRP limits. • Manufacturers and users must redesign scanners and practices to comply.
19 September 2003	Meeting of MR scientists with HSE.	<ul style="list-style-type: none"> • Static magnetic field limit dropped from Directive as ICNIRP have withdrawn that part of guidance. • HSE will still seek to enforce this limit in the UK because it is in the NRPB guidance.
26-27 April 2004	ICNIRP/NRPB meeting on static magnetic fields.	More research and data collection needed.
June 2004	IPEM writes to MHRA expressing concerns about consequences for ionising radiation protection.	Issues will be discussed at forthcoming HSE stakeholder meeting.
27 July 2004	HSE stakeholder meeting covering all affected employment sectors.	HSE position <ul style="list-style-type: none"> • Manufacturers and users must redesign scanners and practices to comply. • Static field limit should not have been removed - HSE will seek to enforce it in UK because it is in NRPB guidance. • Increased patient exposure to ionising radiation is not relevant, as Directive is about occupational exposure. • Concerns of the MR community are 'esoteric and of no interest to anyone else in this room'. Implementation group established with input from MR community.

October 2004	IPEM raises concerns about consequences for ionising radiation protection with HSE contacts.	HSE ionising radiation inspectors believe risk-benefit analysis is needed.
October 2004	Letter to MHRA raising concerns about conflict with IR(ME)R in intervention.	Reply from Department of Health <ul style="list-style-type: none"> • No conflict will exist, as MR technique will be illegal. • Subsequent apology from DH and offer to involve community in stakeholder group. • Stakeholder group subsequently abandoned – DH believes MHRA input sufficient; HSE says patient radiation protection not an issue as Directive is about occupational exposure.
October 2004	IPEM meeting on EMF attended by HSE.	HSE position <ul style="list-style-type: none"> • Manufacturers and users must redesign scanners and practices to comply.
6 June 2005	Debate with HSE at UKRC conference.	HSE position <ul style="list-style-type: none"> • Manufacturers and users must redesign scanners and practices to comply. • No case for medical staff to be treated differently from other groups. • HSE will seek to include 2T static field limit in UK legislation. 96% of audience support motion that Directive will be detrimental to clinical services and research.
20 September 2005	Group of eminent scientists write to Health Secretary raising concerns.	DH response (believed to have been prepared by HSE) <ul style="list-style-type: none"> • Directive not onerous, as limits follow existing guidance. • Health of workers 'of paramount importance'. • Data on acute effects 'well established'. • Stakeholder meeting will be held.
20 September 2005	MR scientists and clinicians hold press conference highlighting concerns.	European Commission response ¹³ <ul style="list-style-type: none"> • Experts agree excessive exposure to MRI dangerous to health. • Risk is to those exposed regularly, not patients. HPA response ¹⁴

¹³ <http://www.esmrm.org/index.php?pid=409&SID=cf56847d32bff904b5a31433eff64982>, with response from European Society for Magnetic Resonance in Medicine and Biology (ESMRMB).

¹⁴ <http://news.bbc.co.uk/1/hi/health/4264228.stm>

		<ul style="list-style-type: none"> • ‘...there is a lack of evidence for deleterious effects’. • But need to be cautious in case there are long-terms effects.
September-December 2005	Letters to HSE from scientists, funding bodies and charities expressing concerns	(Preparatory to stakeholder meeting in January)
20 October 2005	Meeting of RCR with Lord Hunt of King’s Heath and HSE	<p>Main points of agreement</p> <ul style="list-style-type: none"> • Further research needed on exposure limits. • HSE will explore options for renegotiation or amendment of Directive. • Need to establish exact extent of the problem for MRI. • Directive will be a low priority for enforcement. <p>On 25 October Lord Hunt confirmed in parliament that the static field limit has been removed¹⁵.</p>
25 November 2005	RCR writes to Lord Warner expressing concerns.	Lord Warner concerned about impact on clinical MRI.
5 January 2006	Stakeholder meeting at HSE.	<p>Agreement that work is needed on</p> <ul style="list-style-type: none"> • Quantifying extent of problem, • Defining research needed, • Updating ICNIRP guidance, • Decoupling MRI from rest of Directive.
24 January 2006	Meeting of RCR with Lord Hunt and HSE.	Forthcoming.

¹⁵ http://www.publications.parliament.uk/pa/ld199900/ldhansrd/pdvn/lds05/text/51025-02.htm#51025-02_spopq0

APPENDIX B

Individuals known to have made representations about the Directive

Name	Position	Actions
Professor Gareth Barker	Institute of Psychiatry, King's College London	(16)
Professor Colin Blakemore	Chief Executive, MRC	(16)
Professor Peter Dawson	Registrar, RCR	(15)
Dr Stuart Derbyshire	School of Psychology, University of Birmingham	(16)
Mr Günter Dombrowe	President, BIR	(13)
Professor Wladyslaw Gedroyc	Consultant Radiologist, St Mary's Hospital	(11)
Professor Penny Gowland	MR Centre, University of Nottingham	(3) (5)
Professor John Griffiths	Head of Basic Medical Sciences, St George's Hospital Medical School; past Chair, ISMRM British Chapter	(1) (2)
Professor Donald Hadley	Clinical Neurosciences, University of Glasgow	(1) (2)
Professor Jeff Hand	Radiological Sciences Unit, Hammersmith Hospitals NHS Trust; past Chair, IOP Medical Physics Group	(7)
Professor Janet Husband	President, RCR	(13) (17)
Dr Peter Jackson	President, IPEM	(13) (16)
Professor Peter Jezzard	Centre for Functional MRI of the Brain, University of Oxford	(13)
Dr Stephen Keevil	Consultant Physicist, Guy's and St Thomas'; Chair, IPEM SET Committee	(3) (7) (12) (14) (15)
Dr Robert Kirby-Harris	Chief Executive, IOP	(13)
Professor Sir Peter Lachmann	President Emeritus, Federation of the European Academies of Medicine	(16)
Professor Martin Leach	Co-director of MR group, Royal Marsden Hospital; Chair, ISMRM British Chapter	(1) (2) (7) (16)
Dr Robin Lovell-Badge	Head of Developmental Genetics, NIMR	(16)
Dr Catherine Ludman	Consultant Radiologist; Chair, BIR MR Committee	(1) (2)
Professor John Mallard	Professor Emeritus, University of Aberdeen	(13)
Professor Sir Peter Mansfield	Nobel Laureate; Emeritus Professor, University of Nottingham	(13) (14)
Dr Donald McRobbie	Consultant Physicist, Charing Cross Hospital; past Chair, IPEM MR SIG	(6) (10)
Dr Virginia Ng	Consultant Neuroradiologist, Maudsley Hospital	(16)
Professor Roger Ordidge	Deputy Head of Medical Physics and	(1) (3) (4)

	Bioengineering, University College London	
Professor Dudley Pennell	Director of Cardiovascular MRI, Royal Brompton; President, British Society of Cardiovascular MR	(13)
Professor Sir George Radda	Former Chief Executive, MRC; Emeritus Professor, University of Oxford	(16)
Professor Reza Razavi	Deputy Head of Imaging Sciences, King's College London	(9)
Professor Peter Styles	Former Director, MRC Biochemical and Clinical Magnetic Resonance Unit, University of Oxford	(13)
Dr Andrew Taylor	Consultant Radiologist, Great Ormond Street Hospital	(14) (15)
Mr James Thurston	Consultant Physicist, King's College Hospital; past Chair, IPEM Radiation Protection SIG	(7) (8)
Dr Janet de Wilde	Manager of MR National Evaluation Team	(4) (7)
Professor Steve Williams	Head of Imaging Sciences, King's College London	(16)
Sir Martin Wood	Honorary President, Oxford Instruments plc	(13)
Professor Ian Young	Emeritus Professor, Imperial College London	(1) (2) (13) (14)

- (1) Letter of July 2003 to HSE
- (2) Letter of August 2003 to NRPB
- (3) Meetings with HSE inspector, August 2003
- (4) Meeting with HSE inspector, September 2003
- (5) ICNIRP meeting in Oxford, April 2004
- (6) Letter of June 2004 to MHRA
- (7) HSE stakeholder meeting, July 2004
- (8) E-mails to HSE radiation inspectorate, October 2004
- (9) Letter to MHRA, October 2004
- (10) IPEM EMF meeting, October 2004
- (11) HSE implementation group since December 2004
- (12) UKRC debate, June 2005
- (13) Letter to Health Secretary, September 2005
- (14) Press conference, September 2005
- (15) Meeting with Lord Hunt, October 2005
- (16) Letters and e-mails to HSE September-December 2005 (those known to authors, excluding institutional responses)
- (17) Letter to Lord Warner, November 2005