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Mobile Phones and Health 2004

Report by the Board of NRPB

National Radiological Protection Board

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Working in partnership with the Health Protection Agency

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ABSTRACT

In May 2000 the Independent Expert Group on Mobile Phones (IEGMP), chaired by Sir William Stewart, issued its report on mobile phones and health. The report reviewed epidemiological and experimental studies relevant to an assessment of health effects from exposure to radiofrequency (RF) radiation from the use of mobile phones. It also made a number of recommendations that were designed to address public health concerns and related issues.

This 2004 report, by the Board of NRPB, provides further advice to address remaining public concerns about mobile phone technology as well as related technological developments. It also reviews progress on implementing the recommendations in the Stewart Report.

This report from the Board of NRPB reflects understanding and evaluation of the current scientific evidence as presented and referenced in this document.

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Executive Summary

BACKGROUND

1 There are currently about 50 million mobile phones in use in the UK compared with around 25 million in 2000 and 4.5 million in 1995. These are supported by about 40 000 base stations in the UK network. The majority of these base stations operate under the Global System for Mobile Communications (GSM).

2 In less than ten years since the first GSM network was commercially launched as the second generation of mobile phones, it has become the world's leading and fastest growing telecommunications system. It is in use by more than one-sixth of the world's population and it has been estimated that at the end of January 2004 there were 1 billion GSM subscribers across more than 200 countries. The growth of GSM continues unabated with more than 160 million new customers in the last 12 months.

3 The revolution in communications continues world-wide. The third generation of mobile phones, 3G, is now being marketed in the UK and in many other countries and it is to be expected that further developments will become available in due course. In addition, there are many other telecommunications and related systems in use, all of which result in exposure of the population to radiofrequency (RF) fields.

4 The UK government has given strong encouragement to the development of mobile phone technology. Operators have been given support for the installation of the cellular networks and government has seen this as an important area for UK based firms to establish themselves as world leaders. There have also been extensive developments in security-related equipment that utilise radiocommunications systems.

PUBLIC HEALTH CONCERNS

5 The extensive use of mobile phones suggests that users do not in general judge them to present a significant health hazard. Rather they have welcomed the technology and brought it into use in their everyday lives. Nevertheless, since their introduction, there have been persisting concerns about the possible impact of mobile phone technologies on health.

6 This was appreciated by the UK government, which in 1999 took the early initiative of setting up the Independent Expert Group on Mobile Phones (IEGMP) to review the situation. Its report, *Mobile Phones and Health* (the Stewart Report), was published in May 2000. It stated:

> "The balance of evidence to date suggests that exposures to RF radiation below NRPB and ICNIRP* guidelines do not cause adverse health effects to the general population.
>
> "There is now scientific evidence, however, which suggests that there may be biological effects occurring at exposures below these guidelines.

* The International Commission on Non-Ionizing Radiation Protection.

> "We conclude therefore that it is not possible at present to say that exposure to RF radiation, even at levels below national guidelines, is totally without potential adverse health effects, and that the gaps in knowledge are sufficient to justify a precautionary approach.
>
> "We recommend that a precautionary approach to the use of mobile phone technologies be adopted until much more detailed and scientifically robust information on any health effects becomes available."

7 **The Board notes that a central recommendation in the Stewart Report was that a precautionary approach to the use of mobile phone technologies be adopted until much more detailed and scientifically robust information on any health effects becomes available.**

8 The Stewart Report was welcomed by government, the general public and by industry. Various subsequent reports from across the world have supported the main thrust of its general conclusions.

9 Since then, the widespread development in the use of mobile phones world-wide has not been accompanied by associated, clearly established increases in adverse health effects. Within the UK, there is a lack of hard information showing that the mobile phone systems in use are damaging to health. It is important to emphasise this crucial point.

10 Nevertheless, the following issues have to be taken into consideration.

11 First, the widespread use of mobile phone technologies is still fairly recent and technologies are continuing to develop at a pace which is outstripping analyses of any potential impact on health (see paragraphs 55–57, 84 and 85).

12 Second, there are data which suggest that RF fields can interfere with biological systems (AGNIR, 2003; IEGMP, 2000).

13 Third, because the use of mobile phone technologies is a fairly recent phenomenon, it has not yet been possible to carry out necessary long-term epidemiological studies and evaluate the findings. However, an increase in the risk of acoustic neuromas has recently been reported in people in Sweden with more than ten years' use of mobile phones. This study has been able to obtain long-term follow-up data and highlights the need for extended follow-up studies on phone users, as has been noted in a number of reviews (see AGNIR, 2003). Epidemiological studies, because of a lack of sensitivity, may miss any effects in small subsets of the general populations studied. This is a reason why the Board welcomes the large international cohort study proposed for support by the Mobile Telecommunications and Health Research (MTHR) programme (see paragraph 89). A recent German study has also suggested concerns.

14 Fourth, a recent paper has suggested possible effects on brain function resulting from the use of 3G phones, although the study has some limitations and needs replication. The Stewart Report had previously identified the need for research on brain function.

15 Fifth, populations are not homogeneous and people can vary in their susceptibility to environmental and other challenges. There are well-established examples in the literature of the genetic predisposition of some groups that could influence sensitivity to disease. This remains an outstanding issue in relation to RF exposure and one on which more information is needed. A number of people also report symptoms they

ascribe to electromagnetic hypersensitivity arising from exposure to a range of electromagnetic fields (EMFs) encountered in everyday life. There is concern by an increasing number of individuals, although relatively small in relation to the total UK population, that they are adversely affected by exposure to RF fields from mobile phones (see also paragraphs 58–64).

16 Sixth, IEGMP considered that children might be more vulnerable to any effects arising from the use of mobile phones because of their developing nervous system, the greater absorption of energy in the tissues of the head and a longer lifetime of exposure. Data on the impact on children have not yet been forthcoming. The potential for undertaking studies to examine any possible effects on children, however, are limited for ethical reasons.

17 Seventh, there are ongoing concerns in the UK about the use of Terrestrial Trunked Radio (TETRA) by the police and the nature of the signals emitted as well as about exposures to RF from other telecommunications technologies.

18 Eighth, there remain particular concerns in the UK about the impact of base stations on health, including well-being. Despite current evidence which shows that exposures of individuals are likely to be only a small fraction of those from phones, they may impact adversely on well-being. The large numbers of additional base stations which will be necessary to effectively roll out the 3G and other new networks are likely to exacerbate the potential impact. People can also be concerned about effects on property values when base stations are built near their homes.

19 **The Board believes that the main conclusions reached in the Stewart Report in 2000 still apply today and that a precautionary approach to the use of mobile phone technologies should continue to be adopted.**

PROGRESS MADE IN ADDRESSING PUBLIC HEALTH CONCERNS

20 The recommendation in the Stewart Report to adopt a precautionary approach was immediately accepted by government. It also endorsed many of the other recommendations in the Report.

21 The Stewart Report made a number of other recommendations that were designed to provide more information about the operation of mobile phones and base stations and to address public concerns about this technology. This sought to allow individuals, local communities and local authorities to make informed choices about how the technology should be developed.

22 The responses to the recommendations in the Stewart Report are reviewed in the report by the Board and issues where further progress is needed have been identified (NRPB, 2004a). The key findings are summarised below.

Tightening of exposure guidelines

23 A recommendation in the Stewart Report was that, as a precautionary approach, the ICNIRP (1998) guidelines for public exposure be adopted for use in the UK for mobile phone frequencies. It was felt that this would bring the UK into line with other countries in the European Union. These guidelines have now been adopted by government for application across the UK and provide for a five-fold reduction in exposure guidelines

for members of the public compared with the recommended values for people whose work brings them into contact with sources of RF fields (NRPB, 2004b,c).

24 **The Board welcomes the introduction by government of tighter exposure guidelines for the general public.**

Base stations

25 A wide variety of types of base stations make up the UK network. Macrocells provide the main framework of the system. Where there are areas of high demand, as in busy streets and shopping areas, microcells are used to infill the network and help to prevent 'lost' calls. Picocells may be installed in buildings or other enclosed areas to improve signal strength and to infill the network in areas of high demand for calls.

26 To allay public concerns about levels of exposure, the Stewart Report recommended that there should be an independent, random, ongoing audit of base stations and this has been carried out by the Office of Communications (Ofcom, previously the Radiocommunications Agency). Audits began in 2001 and the website 'Sitefinder', provided by Ofcom, which was launched in October 2001, gives information on the location and operating characteristics of mobile phone base stations throughout the UK. It is expected that by the end of 2004 nearly 450 sites will have been surveyed; progress in general has, however, been disappointingly slow. The Ofcom measurements indicate that exposures of the public from macrocell base stations are small fractions of exposure guidelines, although the information on its website is difficult to find. Similar conclusions on exposure levels have been reached by NRPB from surveys of around 60 base station sites. Exposures in proximity to picocells have been found to be no more than a few per cent of guidelines for the public.

27 **The Board supports the ongoing audit of base stations and sees this as providing reassurance to the public that exposure guidelines are not being exceeded.**

28 **The Board recommends that the audit should continue, to include 3G base stations and address a wide cross-section of sites reflecting public concerns.**

29 **The Board also recommends that Ofcom ensures that the information on the surveys posted on its website is much more readily accessible, easily interpretable by members of the public, and kept up-to-date.**

30 **The Board notes that whilst the planning process applies to macrocells it does not obviously apply to microcells and picocells. It is important that as the networks develop there is a need for clarity in terms of legal responsibilities and regulations in relation to the installation of microcells and picocells and the availability of information about their deployment.**

31 **The Board recommends that monitoring of potential exposures from 3G base stations should be concomitant with the rollout of the network.**

Mobile phones and SAR values

32 In September 2001 the European Committee for Electrical Standardisation (CENELEC) published a standard testing procedure for the measurement of specific energy absorption rate (SAR) from mobile phones. Information on all phones marketed in the UK, using this standard testing procedure, is now available.

33 However, it is still difficult for people to readily and easily acquire the necessary information so that comparisons of different phones can be made.

34 **The Board welcomes the provision of information on the SAR from phones by all manufacturers using a standard testing procedure. This is an important contribution to providing information to the public about the potential for exposure and informs consumer choice. It recommends that comparative information on the SAR from phones is readily available to the consumer. The inclusion of comparative data on the SAR from phones in its promotional literature by at least one retailer is a welcome development. The public also need to be able to understand the merits and limitations of published SAR values.**

Planning guidance on base station locations

35 IEGMP was concerned that anxiety about the presence of local base stations and resulting exposure to RF fields could affect peoples' health, including well-being. IEGMP also heard at open meetings that information about base station developments was frequently not provided to the local community.

36 A number of recommendations were made in the Stewart Report to improve the transparency of the local planning process and to improve the planning procedure. A specific recommendation was that permitted development rights for the erection of masts under 15 m should be revoked and that the siting of all new base stations should be subject to the normal planning process.

37 Following publication of the Stewart Report reviews of the planning process were put in place throughout the UK. Revised guidance that was issued aimed to provide for more discussions between operators and local authorities on the development of all proposals for telecommunications equipment and to minimise visual intrusion.

38 In Scotland and Northern Ireland the recommendation to require full planning approval for all base station sites has been essentially implemented, but this is not the case in England and Wales. In 2002 the Office of the Deputy Prime Minister (ODPM) also issued a *Code of Best Practice on Mobile Phone Network Development*. This was produced jointly by representatives of central and local government and the mobile phone industry. Its aim was to provide practical advice to ensure the delivery of significantly better and more effective communication and consultation between operators, local authorities and local people. A similar document was issued by the Welsh Assembly Government in 2003.

39 The Mobile Operators Association (MOA, 2004) has published 'ten commitments to best siting practice' and a report entitled *Working with the Community* to assist mobile telecommunications site acquisition staff in their interactions with local communities when seeking to site local base stations.

40 **The Board notes that whilst there has been a plethora of documents about planning issues for base stations, public concerns have not abated.**

41 **The Board supports the government view that whilst planning is necessarily a local issue, the assessment of evidence related to possible health concerns associated with exposures to RF fields from base stations is best dealt with nationally.**

42 **Accepting that, the Board believes that it is timely for there to be set in place a much clearer and more readily understandable template of protocols and procedures to be followed by local authorities and phone operators across the UK. It is clear that at present the application of guidance is very variable and that the extent to which the underpinning facts are presented can also be variable. It recommends that there should be an independent review of the extent to which implementation of good practice guidelines by operators and local authorities is being carried out.**

43 **The Board considers that it is important that 'best practice' in relation to network development operates consistently across the country and that how planning applications are dealt with should be an open and transparent process.**

44 **The Board welcomes the ODPM *Code of Best Practice on Mobile Phone Network Development*, that incorporates the 'ten commitments on best siting practice'.**

Terrestrial Trunked Radio (TETRA)

45 This emergency service radio system presently being deployed for use by the police in the UK uses a network of base stations to serve terminals that are either vehicle mounted (repeaters) or in the form of separate handsets (mobile terminals). This is a digitally based system and its operation results in power modulation of some of the RF signal at a pulse frequency of 17.6 Hz.

46 At the request of the Home Office, and following publication of the Stewart Report when concerns about the signals from TETRA were raised, AGNIR reported on the possible health effects of TETRA signals (AGNIR, 2001). The report described the operating characteristics of TETRA systems, the physical dosimetry related to signals from the handsets and base stations, and studies relevant to consideration of biological effects.

47 It was found by AGNIR that the signals from fixed TETRA base stations were not pulsed, whereas those from associated mobile terminals and repeaters were. It concluded that, "although areas of uncertainty remain about the biological effects of low level RF radiation in general, including modulated signals, current evidence suggests that it is unlikely that the special features of the signals from TETRA mobile terminals and repeaters pose a hazard to health". Nevertheless it recommended that further research was required.

48 The Board is aware that the Ofcom base station audit has included some measurements at TETRA base station sites and understands that these have demonstrated that exposures are low compared with guidelines. However, surprisingly, this information is not presently available on the Ofcom audit website.

49 For people who are occupationally exposed to RF signals from TETRA handsets the AGNIR (2001) report concluded that it is possible that exposure levels from some handsets can approach guideline levels for the public. The Board understands from the Home Office that these handsets are not in use in the UK.

50 **The Board places high importance on accumulating knowledge of exposure levels and possible biological effects as the use of TETRA based technology develops and is implemented.**

51 **The Board welcomes the research programme that the Home Office has established. This includes an epidemiological study on police officers who are occupationally exposed to TETRA signals.**

52 **The Board also considers that information on the location and specification of installed TETRA base stations be included in the Ofcom Sitefinder website.**

53 **The Board recommends that TETRA base stations are audited in the same way as GSM base stations.**

54 **Until much more information becomes available the Board considers that it would be premature to rule out the possibility of health effects on users of TETRA based equipment and believes that a precautionary approach should be adopted.**

Developing technologies

55 A variety of additional technologies are now being progressively developed and implemented in the field of telecommunications. New technologies include third-generation (3G) mobile telephony, wireless local area networks (WLANs), Bluetooth and ultra-wideband (UWB) technology, and radiofrequency identification (RFID) devices.

56 **The Board considers that it is important to understand the signal characteristics and field strengths arising from new telecommunications systems and related technologies, to assess the RF exposure of people, and to understand the potential biological effects on the human body.**

57 **The Board also believes it important to ensure that the exposure of people from all new and existing systems complies with ICNIRP guidelines.**

Sensitive groups

58 Populations as a whole are not genetically homogeneous and people can vary in their susceptibility to environmental hazards. There could also be a dependency on age. The issue of individual sensitivity remains an outstanding one in relation to RF exposure and one on which more information is needed.

59 IEGMP considered that children might be more vulnerable to any effects arising from the use of mobile phones. The potential for undertaking studies to examine any possible effects on children are, however, limited for ethical reasons. It was recommended in the Stewart Report that the use of mobile phones by children should be minimised and this was supported by the Departments of Health. Text messaging has considerable advantages as the phone is in use for only a short time, when the phone transmits the message, compared with voice communication.

60 **The Board concludes that, in the absence of new scientific evidence, the recommendation in the Stewart Report on limiting the use of mobile phones by children remains appropriate as a precautionary measure.**

61 **The Board also welcomes an initiative by the World Health Organization in its EMF programme to focus attention on research relevant to the potential sensitivity of children.**

62 Additionally, there is concern by an increasing number of individuals, although relatively small in relation to the total UK population, that they are adversely affected by

exposure either to EMFs in general or specifically to RF fields from mobile phones. A European Commission group of experts termed the syndrome 'electromagnetic hypersensitivity'. Similar concerns have been raised in the past in relation to exposure to agricultural chemicals and other materials.

63 Members of the public who have written to the Department of Health in England in relation to RF exposure have reported a variety of distressing symptoms including dizziness, fatigue, chronic headache, irregular heart beat, nausea and vertigo, and loss of memory and concentration. These and other symptoms are reported to result from exposure to a range of EMFs, including RF fields, encountered in everyday life. Similar symptoms were reported to IEGMP at open meetings. Many people also consider that there are serious long-term risks associated with such exposures. In Sweden electromagnetic hypersensitivity has been addressed nationally, accepted as a physical impairment, and a scheme is in place to improve home and working conditions for people who consider themselves to be sufferers.

64 **The Board considers that the issue of electromagnetic hypersensitivity needs to be carefully examined in the UK. It supports the strengthening of work designed to understand the reasons for the reported electromagnetic hypersensitivity of some members of the public.**

Occupational exposure

65 Levels of exposure to RF fields can be higher through occupational exposure than for members of the public and sometimes approach guideline levels.

66 **The Board welcomes the establishment of a register of occupationally exposed people at the Institute of Occupational Health, Birmingham. This should facilitate the determination of whether, occupationally, there are health effects from exposure to RF fields not observed in the general public.**

Exclusion zones

67 A recommendation in the Stewart Report was that clear, well-defined exclusion zones should be delineated around base station installations within which exposure guidelines might be exceeded. Some improvements in signage are being made to provide for more consistency but the Board is aware that there is no automatic procedure to monitor the appropriate identification of exclusion zones.

68 **The Board recommends that a formal inspection procedure should be put in place to ensure that exclusion zones are clearly identified.**

Mobile phones and driving

69 The Stewart Report demonstrated that there is good experimental evidence that the use of mobile phones whilst driving has a detrimental effect on drivers' responsiveness. This translates into a substantial increased risk of an accident. The evidence suggested that the negative effects of phone use while driving were similar whether the phone was hand-held or hands-free.

70 The Board welcomes the intention of government to increase the penalty for the offence of using a hand-held mobile phone while driving by making it endorsable with three penalty points and an increased fine of £60.

71 **The Board notes that the UK legislation on the use of phones in motor vehicles, making it illegal to use any hand-held phone, is tailored to the practicality of enforcement. The evidence remains, however, that the use of mobile phones in moving vehicles, both hand-held and hands-free, can significantly increase the risk of an accident.**

Hands-free kits

72 There has been considerable interest in the extent to which hands-free kits could reduce the exposure of phone users. The Stewart Report contained a recommendation that independent testing should be available which would allow the effectiveness of such devices to be demonstrated and information provided at the point of sale. The Department of Trade and Industry has commissioned independent testing of various devices and this has shown their use results in a reduction in the exposure of the head by about 50%. However, a standard testing procedure is not yet available.

73 **The Board recommends the development of standard testing procedures for measuring the effectiveness of hands-free kits for reducing exposure to RF fields.**

74 **The Board further recommends that test data should be available with such equipment at the point of sale.**

Ombudsman

75 The Board notes that government has not seen it necessary to appoint an ombudsman with responsibilities relating to concerns about RF exposure.

76 **The Board is aware of the significant role of ombudsmen in other service industries, such as water, electricity and gas, and considers that there is a useful place for such a role in the mobile telecommunications industry.**

Communication, public information and consumer choice

77 The Stewart Report made a number of recommendations in relation to providing information to the public about mobile phone technology, including circulating leaflets to every household.

78 The Departments of Health, instead, have issued two information leaflets: one on mobile phones and one on base stations. Around nine million leaflets have been distributed through shops selling mobile phones, doctors surgeries, post offices and libraries, as well as being distributed to local authorities. These leaflets have also been published in Welsh by the Welsh Assembly Government and widely distributed throughout Wales.

79 The extent to which this information helps to inform public health concerns is not clear and the Board therefore welcomes the intention by MTHR to support a review of the effectiveness of information related to public concerns about mobile phone technologies.

80 The provision of information needs to use all the media with emphasis on ensuring that information on such issues as SAR and exposure guidelines are presented in a straightforward way. Whilst websites are valuable for providing information to the public, great care is needed in presenting the information and ensuring that it is readily accessible.

81 **The Board welcomes the MTHR-sponsored initiative to review the effectiveness of information related to public concerns about mobile phone technologies.**

NRPB

82 NRPB has put considerable effort into providing information that is available to the public on mobile phones and base stations. It has done this through improvements to its website, provision of leaflets, production of a video/CD that has been distributed to all local authorities, and presentations at public meetings throughout the UK. It has also extended its research programme on health-related studies and on dosimetry as well as base station surveys. It is encouraged to continue to develop and improve the approaches it uses to address issues of public concern.

83 **The Board considers that both now and when NRPB becomes part of the Health Protection Agency, it must have a key role in communicating information on health issues related to emissions from mobile phone and related technology, based on sound scientific evidence.**

Health-related research

84 Outstanding health-related concerns can be addressed by epidemiological (human health) studies, experimental investigations with animals, and the use of cell-based techniques. Dosimetric studies are important for understanding the exposure of people from various sources and human volunteer studies can investigate short-term interactions of RF fields, for example, with brain function. In the area of telecommunications, however, technological change is rapid and it is a challenge to carry out comprehensive research and to determine the possibility of any health effects.

85 Research into any health effects of exposure to RF fields is still in a developmental phase. There are analogies with work on the consequences of exposure to EMFs from power lines. In the early 1980s, the epidemiological studies on exposure to extremely low frequency (ELF) EMFs lacked methods to directly assess exposure of individuals and instead surrogates for exposure were frequently used. Subsequently portable measurement equipment became available in the late 1980s/early 1990s and the quality of studies providing exposure–response information, for both occupational and domestic exposures, rapidly improved. Studies on RF exposure were in a similar position in the 1990s to those on ELF EMFs in the early 1980s. In recent years, however, considerable effort has gone into developing RF-related studies that combine high quality dosimetry with well-designed studies in experimental biology and epidemiology. Inevitably it will be some time before the present generation of studies come to fruition. The MTHR programme in the UK has been at the forefront of this advance in RF-related research.

86 The MTHR programme was launched in February 2001 with an initial budget of £7.36 million funded by government and industry on a 50:50 basis. To date around 30 projects have been funded through MTHR with additional support from the Home Office, the Department of Trade and Industry, and industry. It presently has a budget of £8.8 million, all of which has now been allocated to the ongoing research programme. The RF-related research in the UK is complementary to further research being carried out world-wide, much of it co-ordinated through the WHO EMF programme.

87 The Board considers that the MTHR programme, which was first announced in December 2000, has set the standard for independent, high quality, health-related research on RF exposure.

88 The Board further recommends that government and industry should provide support for a continuation of the programme.

89 The Board particularly supports the need for further research, in the following areas:

(a) an international cohort study of mobile phone users aimed at pooling and sharing experimental design, findings and expertise internationally,
(b) an expanded programme of research on TETRA signals and biological effects,
(c) effects of RF exposure on children,
(d) investigation of public concerns about mobile phone technology,
(e) electromagnetic hypersensitivity and its possible impact on health, including well-being, associated with mobile phone technology,
(f) studies of RF effects on direct and established measures of human brain function and investigations of possible mechanisms involved,
(g) complementary dosimetry studies focused on ascertaining the exposure of people to RF fields.

In developing the MTHR and other research programmes, care needs to be taken to prevent unnecessary duplication of studies whilst at the same time seeking to replicate significant findings.

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INTRODUCTION

1 In 1999 the UK government asked the Board of NRPB to establish an independent expert group to examine any possible health effects resulting from exposure to radiofrequency (RF) fields from mobile phones, base stations and transmitters. The Chairman of the Independent Expert Group on Mobile Phones (IEGMP) was Sir William Stewart and the group published its report, *Mobile Phones and Health,* in May 2000. The Stewart Report comprised a comprehensive review of the scientific information available related to exposure to radiofrequency (RF) fields and made a number of recommendations (IEGMP, 2000).

2 The Stewart Report stated that:

> "The balance of evidence to date suggests that exposures to RF radiation below NRPB and ICNIRP* guidelines do not cause adverse health effects to the general population.
>
> "There is now scientific evidence, however, which suggests that there may be biological effects occurring at exposures below these guidelines.
>
> "We conclude therefore that it is not possible at present to say that exposure to RF radiation, even at levels below national guidelines, is totally without potential adverse health effects, and that the gaps in knowledge are sufficient to justify a precautionary approach.
>
> "We recommend that a precautionary approach to the use of mobile phone technologies be adopted until much more detailed and scientifically robust information on any health effects becomes available."

3 The Board notes that a central recommendation in the Stewart Report was that a precautionary approach to the use of mobile phone technologies be adopted until much more detailed and scientifically robust information on any health effects becomes available.

4 From the evidence heard by IEGMP at open meetings it was clear there was considerable public concern about the possible health implications of the use of this rapidly developing technology. A total of 34 recommendations were made in the Stewart Report, many of which were designed to provide more information about the operation of mobile phones and base stations and to address public health concerns. A summary of the conclusions and recommendations of the Stewart Report is given in Appendix A.

5 The UK government immediately accepted the central recommendation to adopt a precautionary approach for mobile phone frequencies. It also endorsed many of the other specific recommendations, including topic areas for further research. The government response is reproduced in Appendix B.

6 The mobile phone industry also welcomed the report and subsequently issued 'ten commitments on best siting practice' intended to provide information to local communities on network development. The industry response to the Stewart Report and the ten commitments are reproduced in Appendix C.

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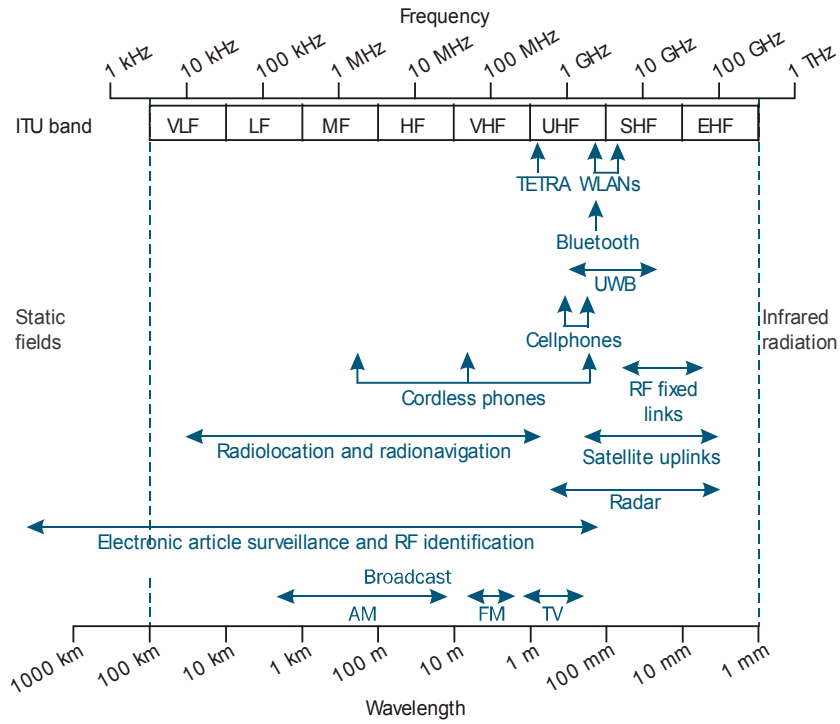
* The International Commission on Non-Ionizing Radiation Protection.

7 A recommendation in the Stewart Report was that "the issue of possible health effects of mobile phone technology should be the subject of a further review in three years time, or earlier if circumstances demand it". The government asked NRPB to undertake this further review and the Board of NRPB requested the independent Advisory Group on Non-ionising Radiation (AGNIR) to carry it out. The review, within the broader context of a consideration of health effects from exposure to RF fields (see Figure 1), was published in the *Documents of the NRPB* (AGNIR, 2003).

FIGURE 1
RF spectrum and sources



8 It was concluded in 2003 by AGNIR that:

> "In aggregate the research published since the IEGMP Report does not give cause for concern. The weight of evidence now available does not suggest that there are adverse health effects from exposures to RF fields below guideline levels, but the published research on RF exposures and health has limitations, and mobile phones have only been in widespread use for a relatively short time. The possibility therefore remains open that there could be health effects from exposure to RF fields below guideline levels; hence continued research is needed."

9 The Board concluded that a precautionary approach to the development of mobile phone technology remained a justifiable approach. There is an ongoing research programme in the UK and in other countries. Some of the issues being addressed include the consequences of exposure to pulsed signals, the potential for greater

sensitivity of children and other groups in the population to RF fields, and long-term epidemiological studies on mobile phone users.

10 In addition to the AGNIR review a number of other reviews of the possible effects of exposure to RF fields from mobile phones and base stations have been published. These include reports from the Netherlands, France, USA, Canada, Sweden and the World Health Organization (WHO). The main conclusions reached in the reviews published since May 2000 are summarised in the table in Appendix D and the reports published since 2003 are summarised in that appendix. Summaries of the additional reports given in the table can be found on the NRPB website (www.nrpb.org). The conclusions in these and other reports are very similar to those in the Stewart Report (see paragraph 2 above). Nevertheless, a number of outstanding issues remain.

11 First, the widespread use of mobile phone technologies is still fairly recent and technologies are continuing to develop at a pace which is outstripping analyses of any potential impact on health (see paragraphs 21–24 and 102–104 and Appendix E).

12 Second, there are data which suggest that RF fields can interfere with biological systems (AGNIR, 2003; IEGMP, 2000).

13 Third, because the use of mobile phone technologies is a fairly recent phenomenon, it has not yet been possible to carry out necessary long-term epidemiological studies and evaluate the findings. However, an increase in the risk of acoustic neuromas has recently been reported in people in Sweden with more than ten years' use of mobile phones (Lönn et al, 2004). This study has been able to obtain long-term follow-up data and highlights the need for extended follow-up studies on phone users, as has been noted in a number of reviews (see AGNIR, 2003, and Appendix D). Epidemiological studies, because of a lack of sensitivity, may miss any effects in small subsets of the general populations studied. This is a reason why the Board welcomes the large international cohort study proposed for support by the Mobile Telecommunications Health Research (MTHR) programme (see paragraph 172). A recent German study has also suggested concerns (Eger et al, 2004).

14 Fourth, a recent paper has suggested possible effects on brain function resulting from the use of third-generation, 3G, phones (Zwamborn et al, 2003), although the study has some limitations and needs replication. The Stewart Report had previously identified the need for research on brain function.

15 Fifth, populations are not homogeneous and people can vary in their susceptibility to environmental and other challenges. There are well-established examples in the literature of the genetic predisposition of some groups that could influence sensitivity to disease. This remains an outstanding issue in relation to RF exposure and one on which more information is needed. A number of people also report symptoms they ascribe to electromagnetic hypersensitivity arising from exposure to a range of electromagnetic fields (EMFs) encountered in everyday life. There is concern by an increasing number of individuals, although relatively small in relation to the total UK population, that they are adversely affected by exposure to RF fields from mobile phones (see also paragraphs 105–122).

16 Sixth, IEGMP considered that children might be more vulnerable to any effects arising from the use of mobile phones because of their developing nervous system, the greater absorption of energy in the tissues of the head, and a longer lifetime of exposure. Data on the impact on children have not yet been forthcoming. The potential

for undertaking studies to examine any possible effects on children, however, are limited for ethical reasons.

17 Seventh, there are ongoing concerns in the UK about the use of Terrestrial Trunked Radio (TETRA) by the police and the nature of the signals emitted as well as about exposures to RF fields from other telecommunications technologies.

18 Eighth, there remain particular concerns in the UK about the impact of base stations on health, including well-being. Despite current evidence which shows that exposures of individuals are likely to be only a small fraction of those from phones, they may impact adversely on well-being. The large numbers of additional base stations that will be necessary to effectively roll out the 3G and other new networks are likely to exacerbate the potential impact. People can also be concerned about effects on property values when base stations are built near their homes.

19 **The NRPB Board believes that the main conclusions reached in the Stewart Report in 2000 still apply today and that a precautionary approach to the use of mobile phone technologies should continue to be adopted.**

20 Against this backcloth the Board is now providing further advice based on the overall evidence available, as of December 2004. The responses by government and others to the recommendations in the Stewart Report are also examined and issues where the Board considers further action continues to be needed are addressed. First though, recent developments in telecommunications technologies are considered.

INCREASING DEMAND FOR THE USE OF MOBILE PHONES AND RELATED TECHNOLOGY

21 There are currently about 50 million mobile phones in use in the UK compared with around 25 million in 2000 and 4.5 million in 1995. These are supported by about 40 000 base stations which provide the UK network. The majority of these base stations operate under the Global System for Mobile Communications (GSM). The details of GSM networks are described in the Stewart Report (IEGMP, 2000)The GSM platform is a hugely successful wireless technology. In less than ten years since the first GSM network was commercially launched, as the second generation of mobile phones, it has become the world's leading and fastest growing mobile standard. It is in use by more than one-sixth of the world's population and it has been estimated that, by the end of January 2004, there were 1 billion GSM subscribers across more than 200 countries. The growth of GSM continues unabated with more than 160 million new customers in the last 12 months.

22 In the UK, in addition to GSM base stations there are a few thousand third-generation, 3G, base stations. The first 3G mobile phone network in the UK was launched in 2003. A further four 3G networks are under construction by the other UK operators and are beginning to provide 3G services for domestic and business applications. The growth of the networks will depend upon the extent to which the new system is adopted but it is predicted by the operators that the number of base stations is likely to increase to around 48 000 by 2007 with the rollout of the 3G network. It is likely that a significant amount of the operators' new 3G networks will be built on existing sites and masts (Mobile Operators Association, MOA, 2004a).

23 There are a range of other technological developments that result in exposure of the population to RF fields. These include:

(a) Terrestrial Trunked Radio (TETRA) being developed for use by the police and which could be used by other emergency services,
(b) wireless local area networks (WLANs) which are increasingly used in offices, schools and homes,
(c) Bluetooth wireless technology used in mobile phone handsets and other portable devices,
(d) ultra-wideband (UWB) used in radar, imaging and wireless communications, particularly for high speed data transmission,
(e) radiofrequency identification (RFID) devices.

24 The proliferation of these technologies has raised concerns about the consequences of exposure to RF fields. These technologies are summarised below. More details are given in Appendix E.

3G mobile telephony

25 The development of the 3G network represents the next stage in mobile communications. The broadband communications that 3G provides enables access to sophisticated technology for the business and home user. Examples are high speed access to services including video conferencing and improvements in email. The function of 3G mobile phone networks in Europe is based on the Universal Mobile Telecommunications System (UMTS) standard. It operates at frequencies between 1900 and 2200 MHz.

26 The first 3G mobile phone network in the UK was launched in 2003 by Hutchison 3G. Five-thousand base stations had been built and integrated into the network by December 2003, and over a third of a million customers were attracted in the first year of operation (MOA, 2004a). A further four 3G networks are under construction by the other UK operators (O_2, Orange, T-Mobile and Vodafone).

27 The research and technology agenda in mobile and wireless communications does not end with 3G mobile and there is a substantial global research effort underway. The broad technology development agenda is usually referred to as Beyond 3G (B3G) or 4G, although there are as yet no formal standards.

Terrestrial Trunked Radio (TETRA)

28 Since 1997, many countries, including the UK, have been introducing an emergency service radio standard known as Terrestrial Trunked Radio (TETRA, see Figure 2). The digitally based system was trialled by the Lancashire constabulary in 2000/01 and is now being rolled out across the UK police forces by O_2 Airwave. It will also be used by the Serious Organised Crime Agency and it has the potential for use by all the emergency services and other users. The TETRA system uses frequencies around 400 MHz which have improved data transmission capabilities.

29 TETRA is not simply a replacement for the large number of old, out-of-date and incompatible analogue radio systems that the police have been using. There are operational advantages in the use of TETRA technology. It provides clearer and more secure and extensive coverage than the existing analogue systems. The technology

also has additional features. For example, TETRA allows for group calls to be set up quickly, and it can cope with very high peak demand, meaning that police operations will not be hindered at major incidents when many officers need to communicate at the same time. TETRA technology provides a high standard of encryption, preventing eavesdropping on police communications. In terms of data transmission, TETRA technology will allow police officers to use their radios to connect to facilities such as the Police National Computer or the Scottish Criminal Record Office without needing to return to their station. Photographs for identification of people can be transmitted, as can maps and instructions. The TETRA network can also be used to transmit data from satellite tracking systems on the location of both people and vehicles.

FIGURE 2 *Typical TETRA masthead showing three stacks of four folded dipole antennas*

Wireless local area networks (WLANs)

30 Wireless computer networking is becoming increasingly widespread in offices, schools and homes. It is also possible to access Internet services via radio from a personal computer (PC) at locations remote from the home or workplace, known as wireless hotspots. Wireless connectivity is provided by wireless local area networks (WLANs). Computer terminals in WLANs are known as clients and have antennas either mounted outside their body-shell or integrated internally. The antennas may be removable if they are attached to or installed within PC cards or Personal Computer Memory Card International Association (PCMCIA) cards. Clients communicate with

fixed access points that provide an interface with conventional wired networks. WLANs operate in various frequency bands between 2.4 and 5.85 GHz.

Bluetooth

31 Short-range connectivity can be achieved using Bluetooth wireless technology. Devices incorporating Bluetooth include mobile phone headsets and computer accessories such as printers, keyboards, mice, mobile phones and personal digital assistants. This technology is being increasingly used in business and in the home. It operates at a frequency of 2.45 GHz. The technology can support small networks, known as piconets, and these have a point-to-multipoint configuration.

Ultra-wideband (UWB)

32 Ultra-wideband (UWB) uses spreading techniques such as Orthogonal Frequency Division Multiplexing (OFDM) or impulse modulation that result in a broad emission spectrum, usually centred at frequencies of a few gigahertz or tens of gigahertz. UWB has applications in radar, imaging and wireless communications, particularly short-range, high speed data transmissions suitable for broadband access to the Internet. The attractions of the technology are high data rates, low power, security and immunity from interference effects. Furthermore, the low power spectral density of UWB ensures that interference with other users of the radio spectrum is minimised.

Radiofrequency identification (RFID) devices

33 Another area where low power wireless communication is widely used is in radiofrequency identification (RFID). Devices continue to be introduced utilising the benefits of modern digital signal processing for transmitting data from transponders or tags placed on a variety of goods for purposes of asset tracking and security. The radio communications system enables the tag devices to be interrogated and read (and in some cases programmed) remotely for purposes of identifying goods vehicles or animals. The readers and tags both have radio antennas as required for wireless communication using propagating electromagnetic waves. Frequencies up to about 2.5 GHz are used for current applications, often using bands assigned for industrial, scientific and medical (ISM) use. Higher frequency bands up to 6.8 GHz have been allocated for possible use in the future.

34 The rapid growth of such devices results in the widespread exposure of people to RF fields, arising in most cases from the inductive fields close to the various sources such as anti-theft equipment but also from propagated fields used by some RFID devices. The International Commission on Non-Ionizing Radiation Protection estimated that in 2002 there were well over one million systems installed world-wide (ICNIRP, 2002) and future trends appear positive.

Conclusion

35 The introduction of new technologies that result in exposure of the population to RF signals, particularly for communications, superimposes novel signal characteristics on an existing complex RF background. The issue of signal characteristics, in particular the nature and extent to which they exhibit pulsing, remains a subject of public concern.

PUBLIC HEALTH CONCERNS

36 The Stewart Report (IEGMP, 2000) was a comprehensive review of the scientific information available related to possible effects of RF fields on health. It also made a number of recommendations that were designed to provide more information about the operation of mobile phones and base stations and to address public health concerns about this technology. The recommendations covered government, industry, the need for public information and consumer choice, and the role of NRPB. Recommendations for further research were also made. Many of the recommendations have now been implemented, as described below.

37 The Board notes that the Stewart Report was the first to have both comprehensively reviewed the scientific evidence and addressed public health concerns. Its recommendations followed an informative consultation exercise involving submissions of written evidence, the presentation of views by scientists and others to IEGMP and the holding of open meetings in Belfast, Cardiff, Edinburgh, Liverpool and London at which the public were invited to express their views.

38 The Board welcomes the extent to which most of the recommendations in the Stewart Report have now been implemented. As a fuller understanding of the technology becomes available, significant progress has been made in addressing some of the concerns raised in the Stewart Report. There remain, however, a number of outstanding issues that still need to be addressed and the development of additional technologies involving RF fields presents new challenges, as considered below.

Tightening of exposure guidelines since 2000

39 A recommendation in the Stewart Report was that, as a precautionary approach, the guidelines for public exposure to mobile phone frequencies recommended by ICNIRP (1998) be adopted for use in the UK. It was felt that this would bring the UK into line with other countries in the European Union and accord with the recommendations in the report on mobile phones and health of the House of Commons Select Committee on Science and Technology (SCST, 1999). The ICNIRP guidelines are a two-tier standard that makes a distinction between occupational and general public exposure. Reductions in basic restrictions, by a factor of five, are recommended for members of the public, compared with the recommended values for people whose work brings them into contact with sources of RF fields, on the assumption that their health status may be different from that of workers. The guidelines for EMFs are set to prevent adverse health effects, which for RF exposure relate to whole or partial body heating. Members of the public include the frail, infants and young children and people with disease, or taking medicine, that may compromise thermal tolerance.

40 The government agreed, in line with the recommended precautionary approach, that exposures of people from mobile phones and base stations should meet the ICNIRP guidelines, as expressed in the EU Council recommendation of 12 July 1999 on the limitation of exposure of the public to EMFs in the frequency range 0–300 GHz) (EC, 1999; see Appendix B). The Board of NRPB also accepted the recommendation to adopt the ICNIRP guidelines for mobile phone frequencies.

41 NRPB has now comprehensively reviewed its advice on exposure guidelines for EMFs. This followed an extensive consultation exercise involving input from national and international experts and publication of a consultation draft on the NRPB website in May 2003. New advice was issued in March 2004 (NRPB, 2004a). This advice

recommended adoption in the UK of the exposure guidelines published by ICNIRP (1998) for EMFs in the frequency range 0–300 GHz. It covers static fields and extremely low frequency (ELF) fields, as from power lines, in addition to RF fields.

42 The advice by NRPB is underpinned by a report that comprehensively reviews the scientific evidence for health effects (NRPB, 2004b) and draws on advice from the independent Advisory Group on Non-ionising Radiation on the potential health effects of exposure to ELF EMFs (AGNIR, 2001a) and RF fields (AGNIR, 2003). The potential for greater sensitivity to EMFs of individual members of the public than workers has been demonstrated in a number of recent studies and is described in the review (NRPB, 2004b). A response to issues raised in the consultation has also been published (McKinlay et al, 2004). This advice to adopt the ICNIRP guidelines for the UK was welcomed by the Parliamentary Under Secretary of State for Public Health, Melanie Johnson MP, in July 2004 (see Appendix F).

43 **The Board welcomes the introduction by government of tighter exposure guidelines for the general public.**

Exposures from base stations

44 IEGMP examined likely exposures of people to emissions from base stations. It concluded that:

> "the balance of evidence indicates that there is no general risk to the health of people living near to base stations on the basis that exposures are expected to be small fractions of guidelines"

45 NRPB had made measurements at 118 locations around 17 base station sites and these are referred to in the Stewart Report (Mann et al, 2000). Many more measurements have now been made by the Office of Communications (Ofcom, previously the Radiocommunications Agency) and NRPB. Public concerns about the possible effects of exposure to RF fields from base stations remain.

46 IEGMP was also concerned that there could be indirect effects on people's well-being in some cases, particularly if individuals were concerned about their exposures. It was considered that there was a need for more information to be made available to both local authorities and members of the public about the siting of base stations and their associated emissions. A recommendation in the Stewart Report was that an independent, random, ongoing, audit of all base stations be carried out to ensure that exposure guidelines were not exceeded outside the marked exclusion zone and that the base stations complied with their agreed specifications.

47 It was also recommended that a national database of base stations be set up by government giving details of all base stations and their emissions.

48 The UK government accepted this recommendation and the Radiocommunications Agency (now Ofcom) was asked to take this recommendation forward. By the end of 2003 it had measured exposures of the public to RF fields from around 300 base stations, with emphasis on sites near schools and hospitals. Information on the measurements can be found, with some difficulty, on the Ofcom website. NRPB has also undertaken measurements on about 60 macrocell base stations (major transmitters mounted on masts and building roofs) and has to date published results for 20 of these on its website (www.nrpb.org). The results of the more recent measurements by Ofcom and NRPB are consistent with the findings in the Stewart Report and support the conclusion that

exposures of the public are small fractions of guidelines. In excess of 100 sites are being surveyed by Ofcom in 2004 and by the end of the year it is expected that about 450 sites will have been audited, which amounts to about 1% of the total number of UK base stations.

49 The geographical area around a GSM base station for which it provides coverage is known as a cell. Cells may be divided into sectors, in which case the base station transmits different frequencies into the different sectors. Cells vary in size depending on the number of mobile phone users and the topography of the surrounding area. The largest cells are known by the industry as macrocells; smaller cells, particularly those in urban areas, can be classified as microcells or picocells (see Figure 3).

(a) A *macrocell* provides the main coverage in a mobile network. The antennas for macrocells are mounted on ground-based masts, rooftops and other existing structures. They must be positioned at a height that is not obstructed by surrounding buildings and terrain. Macrocells have a typical power output of tens of watts.

(b) A *microcell* provides infill radio coverage and additional capacity where there are high numbers of users within a macrocell. The antennas for microcells are mounted at street level, typically on the external walls of existing structures, lamp posts and other street furniture. The antennas are smaller than macrocell antennas and, when mounted on existing structures, can often be disguised as building features. Typically, microcells provide radio coverage across smaller distances and are placed 300–1000 m apart. They have lower outputs than macrocells, usually a few watts.

(c) A *picocell* provides more localised coverage than a microcell. They are normally found inside buildings where coverage is poor or where there are high numbers of users, such as airport terminals, train stations or shopping centres. They also have lower outputs than macrocells and occupancy is generally low, although close approach to the antennas may occur.

50 In addition to the macrocell base station assessments, NRPB has carried out measurements on a sample of low power, low antenna height, microcell and picocell base stations (Cooper et al, 2004a). The results show that power density levels are generally between 0.002% and 2% of the ICNIRP guideline reference values for the public at accessible locations within a few tens of metres of the antennas.

51 Owing to the relatively close distances of approach to these low power systems there is a tendency for power densities to be higher than those generally encountered by the public from the higher power macrocell base stations. Nonetheless, the measurements illustrate public exposures to be small fractions of the guidelines, the highest measured levels not exceeding 10% of the guideline reference values.

52 The NRPB measurements provide information on the various sources of RF exposure of the population where they were made (see paragraph 48). They demonstrate that RF exposures arise not only from the local base stations but also from a wide variety of other sources including other base stations, radio and TV transmitters, professional radio communication systems, pagers and radar. Often signals from a distant base station can give a higher exposure than those from a local base station as the antennas tend to be directed towards the horizon. Total exposures, however, need to comply with ICNIRP guidelines and not just exposures arising from a particular source. Detailed measurements made near one base station site are available on the NRPB website (Fuller et al, 2002).

(a)

(b)

(c)

(d)

FIGURE 3
(a) macrocell – an older style lattice mast supporting the antennas
(b) macrocell – a newer style monopole mast supporting the antennas
(c) street-level microcell in a town centre with the antenna mounted on a wall
(d) typical picocell antenna on the ceiling in an indoor public space

53 The measurements also demonstrate that there is no scientific basis for establishing minimal distances between base stations and areas of public occupancy, as has been suggested in some countries. There are many sources of exposure to RF fields, and it would in practice have little impact on people's overall exposure.

54 A database of mobile phone base stations ('Sitefinder', www.sitefinder.radio.gov.uk) is available from Ofcom, and provides information on the location of existing base stations throughout the UK with details of their radio power, type of transmission, height and the operator. More information on a particular site can be obtained from Ofcom on request.

55 With the rollout of 3G networks there is an increasing number of base stations and antennas that support this service. On the assumption that the powers of 3G sites are no more than those of 2G (GSM) sites and that mast configurations, eg antenna heights, antenna beam configurations and the tendency for shielding at public exposure locations due to intervening buildings etc, are also similar, exposures would be expected to be very much below guideline levels, as with 2G sites. NRPB measurements at a small number of 3G sites are consistent with this expectation.

56 **The Board supports the ongoing audit of base stations and sees this as providing reassurance to the public that exposure guidelines are not being exceeded.**

57 **The Board recommends that the audit should continue, to include 3G base stations and address a wide cross-section of sites reflecting public concerns.**

58 **The Board also recommends that Ofcom ensures that the information on the surveys posted on its website is much more readily accessible, easily interpretable by members of the public, and kept up-to-date.**

59 **The Board notes that whilst the planning process applies to macrocells it does not obviously apply to microcells and picocells. It is important that as the networks develop there is a need for clarity in terms of legal responsibilities and regulations in relation to the installation of microcells and picocells and the availability of information about their deployment.**

60 **The Board recommends that monitoring of potential exposures from 3G base stations should be concomitant with the rollout of the network.**

Exposures from mobile phones

61 In terms of making it possible for individuals to choose to use a mobile phone with a potentially low exposure to RF fields if they so wished, the Stewart Report recommended that the industry should make available to consumers information on the specific energy absorption rate (SAR) from phones once a scientifically sound assessment procedure had been established.

62 Information on the SAR values for new phones is now available for all phones manufactured and supplied by members of the Mobile Manufacturers Forum (MMF, www.mmfai.org/public). An index to the information given by manufacturers has been provided by MMF, which has links to the information for particular handset models.

63 The SAR information provided by the manufacturers of mobile phones is measured to assess compliance with a standard developed by the European Committee for Electrical Standardisation (CENELEC). This standard requires considerable effort to implement but provides the only available exposure data attributable to particular

handset models on an agreed basis (BSI, 2001). It provides a basis for assessing whether or not phones produce SARs less than the 2 W kg^{-1} (averaged over 10 g) basic restriction on localised SAR in the head, as recommended by ICNIRP (1998) and NRPB (2004a) for members of the public. The standard defines a range of conditions under which phones are to be tested and the value quoted after testing is the maximum SAR that occurs with any combination of these conditions.

64 Information about the SAR from phones can be found on websites apart from those provided by the industry. The information on such sites can be collected from various sources and it may not be clear that the data are comparable or based on a formally agreed testing procedure.

65 The CENELEC approach is likely to yield SAR values that are conservative with respect to normal use. This is because mobile phones have adaptive power control which limits output to that needed to communicate with the local base station. However, it does represent a practical solution to the provision of comparative SAR data for consumers.

66 In practice, text messaging has become a very popular means of communication among children and young people. This use of the phone does not bring it into close contact with the head, although the phone may be in contact with other parts of the body. The phone is also in use for only a short time (when it transmits the message) compared with voice communication.

67 The use of hands-free kits can also reduce exposure, although there is no standard testing procedure to demonstrate their effectiveness (see paragraphs 139–143).

68 **The Board welcomes the provision of information on the SAR from phones by all manufacturers using a standard testing procedure. This is an important contribution to providing information to the public about the potential for exposure and informs consumer choice. It recommends that comparative information on the SAR from phones is readily available to the consumer. The inclusion of comparative data on SARs from phones in its promotional literature by at least one retailer is a welcome development. The public also needs to be able to understand the merits and limitations of published SAR values.**

Planning guidance on base station locations

69 IEGMP was concerned that anxiety about the presence of local base stations and resulting exposure to RF fields could affect peoples' health, including well-being. IEGMP also heard at open meetings that information about base station development was frequently not provided to the local community.

70 To address concerns about the siting of base stations the Stewart Report recommended changes to planning guidance so that, for all base station sites, permitted development rights for their erection be revoked, including those with masts under 15 m, and that the siting of all new base stations should be subject to the normal planning process. Following publication of the Stewart Report reviews of the planning process were put in place throughout the UK. Revised guidance that was issued aimed to provide for more discussions between operators and local authorities on the development of all proposals for telecommunications equipment and to minimise visual intrusion.

71 In Northern Ireland, all new base stations now require full planning permission, except in emergency situations. In Scotland planning permission is required for all ground-based antennas and the more obtrusive of those on buildings (Appendix G). The recommendation in the Stewart Report has therefore been essentially implemented.

72 In England and Wales the proposal to revoke permitted development rights was not accepted by government. Instead guidance (PPG8: Office of the Deputy Prime Minister, ODPM, 2001) has been issued which seeks to provide for more discussions between operators and local authorities on the development of all proposals for telecommunications equipment and to minimise visual intrusion. New measures include lengthening the time limit for local planning authorities to consider the requests for prior approval to 56 days, and the requirement for them to carry out public consultations in the same way as would be done for full planning permission. The government's view is that the concerns expressed in the Stewart Report have been satisfied in England and Wales and that the only difference between the prior approval and the new planning permission procedures is the deemed consent after 56 days.

73 The guidance for England (PPG8) further indicates that health effects of exposure to RF fields should not be dealt with locally and should not be a reason for withholding planning permission. However, concerns about health could be a material consideration and the new planning guidance requires local consultation about the appropriate siting of base stations and the provision of site-specific information.

74 In 2002 the Office of the Deputy Prime Minister issued a *Code of Best Practice on Mobile Phone Network Development* (ODPM, 2002), produced jointly by representatives of the mobile phone industry and central and local government. This aims to provide practical advice to ensure the delivery of significantly better and more effective communication and consultation between operators, local authorities and local people. A similar document was issued by the Welsh Assembly Government (WAG, 2003).

75 Whilst these documents give valuable advice, they are not straightforward and do not provide a clear template for local authorities to readily follow. The application of this guidance is very variable.

76 In July 2004 a report by the All-Party Parliamentary Mobile Group (APPMG, 2004) on mobile phone base stations recommended that the proposal in the Stewart Report, that permitted development rights be revoked for all base stations, should be implemented by government.

77 The Board notes that a review of the implementation of the ODPM *Code of Best Practice* is underway and it is expected that this will be completed by March 2005. It supports, however, the recommendation in the Stewart Report that local planning for the installation of base stations requires a set of clear protocols for local authorities to prevent wide variability in their interpretation and implementation. This should be appropriately informed by the operators with clear, concise, site-specific information on proposed new base stations sites.

78 The Board also notes the recommendation given in the report by the All-Party Parliamentary Mobile Group (APPMG, 2004) that any revision of PPG8 should more clearly specify arrangements for public consultation during annual pre-rollout discussions to encourage local planning authorities, in conjunction with operators, to publicise the strategic plans for mobile phone networks.

79 To address concerns about the siting of base stations near schools the Department for Education and Employment (DfEE, 2000) issued information about the conclusions and recommendations of the Stewart Report to local authorities and schools. The network operators also agreed to provide schools, on request, information on the level of intensity of RF fields from a base station on or near a school premises. Where a base station is to be installed near to a school or college, local consultation is also required prior to the submission of an application for planning permission.

80 In relation to this issue, the mobile phone companies, through the Mobile Operators Association, have published 'ten commitments to best siting practice' which indicate that they are working to involve the local population much more in decisions about the planning and siting of base stations (Appendix C). The network operators also provide schools with information about emissions from local base stations on request. The Mobile Operators Association has issued a report entitled *Working with the Community* (MOA, 2004b) to assist mobile telecommunications site acquisition staff in their interactions with local communities when seeking to site local base stations. The ten commitments are an important contribution by the mobile phone operators to providing information on network development to local communities.

81 There is some information that suggests a variable approach to implementation of the ten commitments and that best practice is not necessarily followed, as it should be, by all operators and local authorities. An implementation review prepared by Deloite and Touche (2003) for the Mobile Operators Association found evidence that the operators had made demonstrable progress in their implementation of the ten commitments, although areas for improvement had been identified.

82 **The Board notes that whilst there has been a plethora of documents about planning issues for base stations, public concerns have not abated.**

83 **The Board supports the government view that whilst planning is necessarily a local issue, the assessment of evidence related to possible health concerns associated with exposures to RF fields from base stations is best dealt with nationally.**

84 **Accepting that, the Board believes that it is timely for there to be set in place a much clearer and more readily understandable template of protocols and procedures to be followed by local authorities and phone operators across the UK. It is clear that at present the application of guidance is very variable and that the extent to which the underpinning facts are presented can also be variable. It recommends that there should be an independent review of the extent to which implementation of good practice guidelines by operators and local authorities is being carried out.**

85 **The Board considers that it is important that 'best practice' in relation to network development operates consistently across the country and that how planning applications are dealt with should be an open and transparent process.**

86 **The Board welcomes the ODPM *Code of Best Practice on Mobile Phone Network Development*, that incorporates the 'ten commitments on best siting practice'.**

Terrestrial Trunked Radio (TETRA)

87 Since 1997, an emergency service radio standard known as Terrestrial Trunked Radio (TETRA), which operates using frequencies around 400 MHz, has been introduced in many countries. The system being used in the UK uses a network of base stations to serve terminals that are either vehicle mounted (repeaters) or in the form of separate handsets (mobile terminals). Its operation results in power modulation of some of the RF signal at a pulse frequency of 17.6 Hz (Appendix E).

88 In the Stewart Report, a number of studies on the effects of RF fields on the rate of loss of radioactive calcium from brain and other tissues, were examined. These studies, most of which were carried out in the late 1970s and early 1980s on isolated tissues, had suggested that when the RF signal was modulated at around 16 Hz the rate of calcium efflux was increased. It was concluded in the Stewart Report that, although no obvious health risk was suggested, as a precautionary measure, amplitude modulation around 16 Hz should be avoided, if possible.

89 At the request of the Home Office, and following publication of the Stewart Report, the independent Advisory Group on Non-ionising Radiation (AGNIR, 2001b) prepared a report on the possible health effects of TETRA signals. The report described the operating characteristics of the system, the physical dosimetry related to signals from the handsets and base stations and studies relevant to consideration of any biological effect. The report was published in the *Documents of the NRPB*. It included a detailed annex describing the signal characteristics of TETRA.

90 It was recognised by AGNIR that calcium plays an important role in many biological processes, especially in the function of nerve cells. There is some evidence that RF fields, amplitude modulated at about 16 Hz, may influence the leakage of calcium ions from tissues. However, findings have been contradictory; they are more uncertain for living than for non-living tissue, and no associated health risk has been identified. AGNIR concluded:

> "It is notable that the signals from TETRA base stations are not pulsed, whereas those from mobile terminals and repeaters are. Although areas of uncertainty remain about the biological effects of low level RF radiation in general, including modulated signals, current evidence suggests that it is unlikely that the special features of the signals from TETRA mobile terminals and repeaters pose a hazard to health."

91 In addition, Ofcom has made some measurements of TETRA base stations and these have shown that exposures are small fractions of guidelines. Consequently, there is no reason for the signals from TETRA base stations to be treated differently to signals from GSM base stations in relation to their potential for biological effects.

92 For people who are occupationally exposed to RF signals from TETRA handsets the AGNIR (2001) report concluded that it is possible that exposure levels from some handsets can approach guideline levels for the public (Appendix E). The Board understands from the Home Office that these handsets are not in use in the UK.

93 Eight specific recommendations for further research were made by AGNIR (2003) (see Appendix H). These included proposals for experimental investigations of the possible biological effects of specific TETRA signals or RF fields amplitude modulated at about 16 Hz, as well as other frequencies, using human volunteers, animals and cellular systems. Also recommended were physical and theoretical dosimetry studies to

improve the assessment of the amount and pattern of absorbed energy from the use of hand portables or any other transmitting equipment deployed for use.

94 Research on all these topics is being supported by the Home Office or through the MTHR programme (Appendix H). Details can be found on the respective websites (www.homeoffice.gov.uk and www.mthr.org.uk).

95 The Board is aware that there has been particular public concern about the development of TETRA and the issue of pulsed signals and their possible adverse biological effects. The Board notes that, although the recent AGNIR (2003) report does not specifically consider TETRA signals, it did refer to two recent well-designed studies which showed no change in the cellular concentration of calcium ions in response to RF exposure, even when using pulse modulation. AGNIR concluded that these studies add further doubt about the existence of a specific pulse modulation effect on calcium ions. The Board is aware that laboratory research using TETRA-like signals, supported by the Home Office, has not found an effect of the signals on intracellular calcium exchanges. This research urgently needs publication in a peer-reviewed scientific journal.

96 Although the Ofcom base station audit has included some measurements at TETRA base station sites and these have demonstrated that exposures are low compared with guidelines (paragraph 91), surprisingly, this information is not presently available on the Ofcom audit website.

97 **The Board places high importance on accumulating knowledge of exposure levels and possible biological effects as the use of TETRA based technology develops and is implemented.**

98 **The Board welcomes the research programme that the Home Office has established. This includes an epidemiological study on members of the emergency services who are occupationally exposed to TETRA signals (Appendix H).**

99 **The Board also considers that information on the location and specification of installed TETRA base stations be included in the Ofcom Sitefinder website.**

100 **The Board recommends that TETRA base stations are audited in the same way as GSM base stations.**

101 **Until much more information becomes available the Board considers that it would be premature to rule out the possibility of health effects on users of TETRA based equipment and believes that a precautionary approach should be adopted.**

Developing technologies

102 A variety of additional technologies are now being progressively developed and implemented in the field of telecommunications as described in Appendix E. New technologies include third-generation (3G) mobile telephony, wireless local area networks (WLANs), Bluetooth and ultra-wideband (UWB) technology, and radio-frequency identification (RFID) devices.

103 **The Board considers that it is important to understand the signal characteristics and field strengths arising from new telecommunications systems and related technologies, to assess the RF exposure of people, and to understand the potential biological effects on the human body.**

104 **The Board also believes it is important to ensure that the exposure of people from all new and existing systems complies with ICNIRP guidelines.**

Sensitive groups in the population

105 IEGMP was concerned that there may be sensitive groups in the population. In particular, it was concerned about the exposure of children and considered that, if there were currently unrecognised adverse health effects from the use of mobile phones, children may be more vulnerable because of their developing nervous system, the greater absorption of energy in the tissues of the head, and a longer lifetime of exposure.

106 It, therefore, recommended in line with its precautionary approach that the widespread use of phones by children for non-essential calls should be discouraged, and this was supported by the Department of Health.

107 It also recommended that the mobile phone industry should refrain from promoting the use of mobile phones by children.

108 Text messaging has considerable advantages in reducing exposure as the phone is in use for only a short time (when it transmits the message) compared with voice communication.

109 AGNIR in its 2003 report concluded that little has been published specifically on childhood exposures to RF fields, and no new substantial studies on this have been published since the Stewart Report. The Board therefore concludes that, in the absence of new scientific evidence, the recommendation in the Stewart Report on limiting the use of mobile phones by children remains appropriate as a precautionary measure. An initiative by the World Health Organization in its EMF programme is designed to focus attention on research relevant to the potential sensitivity of children (Appendix D).

110 **The Board concludes that, in the absence of new scientific evidence, the recommendation in the Stewart Report on limiting the use of mobile phones by children remains appropriate as a precautionary measure.**

111 **The Board also welcomes an initiative by the World Health Organization in its EMF programme to focus attention on research relevant to the potential sensitivity of children.**

112 In addition to these concerns about children, a number of people report symptoms attributed to 'electromagnetic hypersensitivity'. There is concern by an increasing number of individuals, although relatively small in relation to the total UK population, that they are adversely affected by exposure either to EMFs in general or specifically to RF fields from mobile phones. A European Commission group of experts termed the syndrome 'electromagnetic hypersensitivity' (Bergqvist and Vogel, 1997). Similar concerns have been raised in the past in relation to exposure to agricultural chemicals and other materials.

113 Members of the public who have written to the Department of Health in England in relation to RF exposure have reported a wide variety of distressing symptoms including dizziness, chronic headache, fatigue, clicking in the ears, hearing loss, tinnitus, sore eyes, nosebleeds, insomnia, stroke, heart attack, irregular heart beat, nausea and vertigo, loss of memory and concentration, skin rashes and diabetes.

114 These and other symptoms are reported to result from exposure to a range of EMFs, including RF fields, encountered in everyday life. Similar symptoms were

reported to IEGMP at open meetings and this was also raised with NRPB during the open consultation during 2003 on its advice on exposure guidelines for EMFs.

115 In Sweden the issue of electromagnetic hypersensitivity has been addressed nationally, accepted as a physical impairment, and a scheme is in place to improve both home and working conditions for people who consider themselves to be sufferers. Municipalities have to follow the *UN22 Standard Rules on the Equalization of Opportunities for Persons with Disabilities* (United Nations, 1993). There is also a scheme in place that allows people to register themselves as hypersensitive and many thousands of people have done so.

116 NRPB has commissioned a public health review of electromagnetic hypersensitivity in order to inform its advice.

117 The aims of the project are:

(a) to describe and define electromagnetic hypersensitivity using sources such as the scientific literature, grey literature (Internet and support groups), and personal anecdotes and correspondence,
(b) to examine its overlap with other conditions such as multiple chemical sensitivity,
(c) to review the information, the course of the condition, its prognosis and approaches to prevention and treatment,
(d) to explore whether there is a role for NRPB in terms of prevention, management and public information, in reflecting electromagnetic hypersensitivity in exposure guidelines and in understanding the scientific basis,
(e) to produce a report of the work for publication.

118 The review is being conducted by a consultant in public health.

119 The MTHR programme is supporting three studies on the issue. A team at King's College, London, is examining the effect of mobile phone use on symptoms and neuroendocrine function in normal and hypersensitive users. This is a volunteer study that will examine responses to mobile phones in a blind study. During the study blood samples will be taken for testing and the volunteers will be asked to report their symptoms.

120 A second study is being carried out by a team at the University of Essex. This aims to clarify the nature of electromagnetic hypersensitivity in more detail. It is a large-scale survey of 20 000 people using a questionnaire that aims to identify clear inclusion and exclusion criteria for electromagnetic hypersensitivity. Volunteer studies will also be carried out to determine whether electromagnetic hypersensitivity symptoms relate to exposure to RF fields as produced by GSM and UMTS (3G) signals and whether RF fields affect people who do not report sensitivity to EMFs. Previous studies in this area have suffered from a number of shortcomings such as too few participants and confounding variables. Considerable effort is going into the design of the exposure systems and protocols so that accurately controlled exposures can be carried out in properly blinded studies.

121 A third study is being undertaken at the National Hospital for Neurology and Neurosurgery, which is based on the observation that many of the self-reported symptoms associated with RF exposure are similar to those reported for inner ear dysfunction. The project will explore whether mobile phone exposure can affect inner ear function and whether this may explain the symptoms reported by some people.

122 **The Board considers that the issue of electromagnetic hypersensitivity needs to be carefully examined in the UK. It supports the strengthening of work designed to understand the reasons for the reported electromagnetic hypersensitivity of some members of the public.**

Occupational exposure

123 Levels of exposure to RF fields can be higher through occupational exposure than for members of the public and sometimes approach guideline levels. It was proposed in the Stewart Report that a register of occupationally exposed workers who are exposed to RF fields at relatively high levels should be established. This would facilitate future studies into possible effects on cancer incidence, mortality and other harmful effects. The Health and Safety Executive (HSE) has discussed with industry the setting up of such a register.

124 HSE commissioned the Institute of Occupational Health (IOH), University of Birmingham, to establish a register that would be confined to people whose work brings them into close proximity to transmitting antennas on telecommunications and broadcasting masts and other similar structures and that the information would be retained and maintained on a central database. The register now contains data on several hundred workers and financial support for its continued development and maintenance has come from the mobile telecommunications and broadcast infrastructure providers.

125 Additionally, NRPB and IOH have carried out a study to determine the feasibility of undertaking an industry-wide epidemiological investigation to examine any relationship between exposure to RF fields in the workplace and the risk of damage to health. Key features of the study have been the development of a method for exposure assessment, an examination of the availability of worker records, and assessments of job categories. The assessment of RF exposure was achieved using personal monitors recording electric and magnetic field strength over time. It was possible to investigate a variety of exposure metrics and to discriminate between types of work. The study concluded that there is a need for well-characterised exposure in epidemiological studies. Consideration of the use of personal dosemeters is warranted in categorising exposure for future studies (Cooper et al, 2004b).

126 **The Board welcomes the establishment of the register of occupationally exposed people at the Institute of Occupational Health, Birmingham. This should facilitate the determination of whether, occupationally, there are health effects from exposure to RF fields not observed in the general public.**

Exclusion zones

127 It was recommended in the Stewart Report that clear, well-defined physical exclusion zones should be established around base station installations within which exposure guidelines might be exceeded. In practice, exclusion zones should be in place around all base station antennas where guidelines could be exceeded. Some improvements in signage are being made to provide for more consistency but the Board is aware there is no automatic procedure to monitor the appropriate identification of exclusion zones.

128 The Health and Safety Executive (HSE) expects the network operator or landlord, as appropriate, to physically prevent any access to areas where people, who have no reason to be there, might exceed the basic restrictions for occupational exposure. HSE

considers that the type of barrier should be proportionate to the degree of access that is available to the public, ie in an open area a tall, stout barrier or anti-climb measures on a mast may be appropriate, but if access to the area is well controlled by locked doors, eg a rooftop, then a simpler signed barrier may be appropriate.

129 If workers need to be in proximity to the installation then HSE would only be concerned if they worked in RF fields or were in contact with RF sources that could potentially result in them exceeding the higher reference levels for people at work (ICNIRP, 1998). In such a case the employer, in conjunction with the operator, would need to assess the working conditions and then take appropriate measures to prevent them exceeding the higher basic restrictions for whole- or partial-body exposure. The employer would also need to provide information and training.

130 If the general area around an antenna is open to the public, then the lower, public exposure reference level for whole-body exposure applies (ICNIRP, 1998).

131 The Board notes that the EU EMF Physical Agents Directive (EU, 2004) was adopted in April 2004 and is expected to be brought into UK legislation in April 2008. In the Directive the term action level is used in place of reference level and the term exposure limit value in place of basic restriction.

132 **The Board recommends that a formal inspection procedure should be put in place to ensure that exclusion zones are clearly identified.**

Mobile phones and driving

133 The review in the Stewart Report demonstrated that there is experimental evidence showing that the use of mobile phones whilst driving has a detrimental effect on drivers' responsiveness. This translates into a substantial increased risk of an accident. The evidence suggested that the negative effects of phone use while driving were similar whether the phone was hand-held or hands-free. It was, therefore, recommended that drivers should be dissuaded from using either hand-held or hands-free phones whilst on the move.

134 Comparison can usefully be made with the aviation industry, where considerable experience has been gathered of pilots using the radio while flying. In aircraft the radio 'press to talk' switch is usually mounted on the control yoke on which pilots will always have their hands. A pilot's use of the radio is therefore hands-free.

135 Experience has shown that the unregulated use of the radio has the potential to compromise flight safety and a set of practices has been developed to reduce the potential detrimental effects of using the aircraft radio while flying. Student pilots are instructed to prioritise their tasks in the order 'aviate, navigate, communicate'. In contrast to the conversations that drivers may have on their mobile phones, where the subject matter may be novel, free ranging and thought provoking, communications by pilots, navigators and air traffic controllers are highly formalised. Standard phrases are used which are brief, accurate and, in nearly all cases, immediately pertinent to the safety of the flight. In multicrew operations, the pilot who is not flying the aircraft may manage the radio communications.

136 In contrast, drivers of motor vehicles do not need to use mobile phones for the safe conduct of their driving and neither are they trained to use them, nor are the people who may be speaking to them. The Department for Transport's leaflet *Switch it off! Missing a call won't kill you* gives guidance on using mobile phones in a car and advises drivers to switch off, or to switch to voicemail while driving (DoT, 2003).

137 Following public consultation in 2002, a new prohibition on the use of hand-held mobile phones when driving came into force in England, Scotland and Wales on 1 December 2003 (GB Parliament, 2003a). Similar regulations came into force in Northern Ireland on 1 January 2004 (GB Parliament, 2003b). The government has said that it intends to increase the penalty for the offence by making it endorsable with three penalty points and with an automatic fine increased to £60 when it has the legislative opportunity.

138 **The Board notes that the UK legislation on the use of phones in motor vehicles, making it illegal to use any hand-held phone, is tailored to the practicality of enforcement. The evidence remains, however, that the use of mobile phones in moving vehicles, both hand-held and hands-free, can significantly increase the risk of an accident.**

Shields and hands-free kits

139 There has been considerable interest in the extent to which shielding devices and hands-free kits could reduce the exposure of phone users. The Stewart Report contained a recommendation that independent testing should be available which would allow the effectiveness of such devices to be demonstrated and information provided at the point of sale. The Department of Trade and Industry commissioned independent testing for these two categories of add-on device.

140 A report on hands-free kits in November 2004 (Porter et al, 2004) indicated that their use can result in around a 50% reduction in exposure of the head compared to the normal use of the phone next to the head.

141 A report on shielding devices (Manning and Densley, June 2001) found that devices such as buttons placed on the phone casing had no effect on the exposure of users, but that many of the shielding devices gave appreciable reductions in the maximum SAR. Generally this was attained by causing a similar reduction in the efficiency of the phone. The phone may also boost power to improve the signal and overcome the shielding from the device. For such devices to be effective they needed to be designed in such a way that they increase the distance between the phone antenna and the head. When combined with the application of large-dimension screening components between the head and phone, SAR could be reduced without impairing the efficiency of the phone. It should therefore be possible to develop devices that would reduce exposure without impacting on the efficiency of the phone and network.

142 **The Board recommends the development of standard testing procedures for measuring the effectiveness of hands-free kits for reducing exposure to RF fields.**

143 **The Board further recommends that test data should be available with such equipment at the point of sale.**

Ombudsman

144 The Stewart Report recommended that an ombudsman should be appointed to provide a focus for decisions on the siting of base stations when agreement could not be reached locally, and on other relevant issues.

145 The government's view was that it was sympathetic to the objectives of the proposal but it felt there were better ways of achieving them. It considered that the role of an ombudsman would not sit comfortably with the existing appeal process within the planning system (Appendix B).

146 **The Board is aware of the significant role of ombudsmen in other service industries, such as water, electricity and gas, and considers that there is a useful place for such a role in the mobile telecommunications industry.**

Communication, public information and consumer choice

147 The Stewart Report included a recommendation that government should circulate a leaflet to every household in the UK providing clearly understandable information on mobile phone technology and related health aspects, including the use of mobile phones whilst driving. IEGMP considered that this leaflet should also be available at the point of sale for mobile phones.

148 The Departments of Health have issued two information leaflets: one on mobile phones and one on base stations. These leaflets summarise some of the main conclusions in the Stewart Report. In relation to the exposures of children, it is stressed that the use of phones by children should be kept to a minimum and limited to essential calls only. Although they were not circulated to all homes, around nine million leaflets have been widely distributed through shops selling mobile phones, doctors surgeries, post offices and libraries, as well as being distributed to local authorities. These leaflets have also been published in Welsh by the Welsh Assembly Government and widely distributed throughout Wales.

149 The extent to which the leaflets have helped to inform public health concerns is not clear. The MTHR programme has funded a project to examine the effectiveness of information available to the public about mobile phones, base stations and related technologies.

150 A further recommendation in the Stewart Report was that comparative information on the SAR from mobile phones should be readily available to consumers. While such information is available on manufacturers' websites and mobile phones on the market have been tabulated on the MMF website (www.mmfai.org/public), specific information on SAR values for phones is not provided in a format that allows for easy comparison (see paragraphs 61–68).

151 **The Board welcomes the MTHR-sponsored initiative to review the effectiveness of information related to public concerns about mobile phone technologies.**

NRPB

152 While commenting favourably on the national and international reputation of NRPB for scientific excellence, it was felt by IEGMP that the organisation should be more open about issues of public concern, especially those related to mobile telephony. NRPB was urged to be more proactive and more sensitive in its approach and to make more use of external experts.

153 NRPB has put considerable effort into improving its website, to facilitate its accessibility and has developed content for the site directed at providing information for the general public. The NRPB website was accredited in the National Grid for Learning (NGfL) scheme in 2003.

154 The NRPB system for dealing with public enquiries has been re-arranged to ensure a speedy and informative response. At present, the number of public enquiries concerning EMFs requiring a detailed written or verbal response, is about 10 000 per year.

155 More effort has been put into giving advice to the public on concerns about exposure to EMFs. NRPB has carried out further base station surveys and has extended its research programme relevant to health concerns related to exposures to EMFs. Information on many of the base station surveys is posted on the NRPB website.

156 In the last three years NRPB staff have attended many public meetings on the issue of mobile phones, base stations and TETRA, including those organised by MPs, local councils, civic groups, pressure groups and other concerned individuals. NRPB regularly provides scientists to speak on the matter to TV, radio and newspaper journalists.

157 NRPB has prepared a video and CD entitled *Mobile Telephony and Health,* which addresses the health issues of mobile telephony, describes the technology of mobile phones and base stations, and shows how measurements of exposure can be made. It features interviews with experts including some members of IEGMP. This has been distributed to local authorities. Details are available on the NRPB website.

158 The Stewart Report proposed that NRPB should better prioritise its work in relation to public concerns about exposure to EMFs. Since publication of the Report, the Board of NRPB has set up an independent Advisory Group on Radiation, Risk and Society which is examining how NRPB tackles issues of public concern, including exposures to EMFs. NRPB organised an open meeting in Birmingham chaired by Lord Robert Winston to address public concerns about exposure to EMFs from power lines as part of the consultation process on its new guidelines for EMFs. The panel included members of NRPB staff and other experts.

159 NRPB has increased its scientific effort on EMF-related work, which now accounts for around 18% of its total budget, covering advice, research and the provision of technical services.

160 The Stewart Report recommended that NRPB consider "non-peer reviewed data and anecdotal evidence" when giving advice on issues where there is little peer reviewed data. In developing advice to adopt the EMF guidelines recommended by ICNIRP, NRPB followed an open process of professional and public consultation to allow consideration of a wide range of views on the scientific and other evidence for effects. It has published on its website (McKinlay et al, 2004) a commentary on its response to the scientific and anecdotal issues raised in response to a consultation document posted on its website in May 2003.

161 **The Board considers that both now and when NRPB becomes part of the Health Protection Agency, it must have a key role in communicating information on health issues related to emissions from mobile phone and related technology, based on sound scientific evidence.**

Health-related research

162 The Stewart Report identified a number of areas where more research was considered to be desirable. This related particularly to exposures from handsets, although research on the consequence of such exposures would also be applicable to base station exposures. The areas identified were brain function, exposure to pulsed signals, dosimetry, subcellular and cellular changes, physiological and sociological studies, and epidemiological and human volunteer studies. It was also recommended that this should "operate under the aegis of a demonstrably independent panel" and be financed jointly by the mobile phone companies and the public sector.

163 The Mobile Telecommunications Health Research (MTHR) programme was first announced in December 2000 and launched in February 2001 with an initial budget of £7.36 million funded by government and industry on a 50 : 50 basis and overseen by an independent programme management committee (PMC), originally chaired by Sir William Stewart and now by Professor Lawrie Challis. There was a second call for further research proposals in February 2002 and a third call to complete the portfolio of studies needed was announced in December 2002. To date around 30 projects have been funded by MTHR with additional support from the Home Office, the Department of Trade and Industry, and UK industry. All the projects are managed by MTHR. It presently has a budget of £8.8 million, all of which has now been allocated to the ongoing research programme. Details of the research being funded can be found on the MTHR website (www.mthr.org.uk) and are summarised in the table in Appendix H. Further details are given by AGNIR (2003). This programme should be seen as part of the world-wide research effort, much of which is co-ordinated by WHO.

164 In selecting projects the PMC was aware of research initiatives elsewhere in the world. It includes a number of experts from other countries and maintains strong links with WHO, and the European co-ordination actions COST 281 and EMF-NET (see Appendix D).

165 An emphasis in the MTHR programme has been on epidemiological and volunteer projects to examine the risk of effects of RF fields on people. Support has been given to teams involved in a multinational epidemiology project (INTERPHONE) co-ordinated by the International Agency for Research on Cancer (IARC) to examine the risk of head and neck tumours from mobile phone use. Other epidemiological studies are examining possible links between phone use and leukaemia, and whether base station exposure is associated with the incidence of childhood cancer. MTHR also supported a pilot study that demonstrated the feasibility of a large cohort study of mobile phone users. Volunteer studies are examining possible effects on brain function and blood pressure. A particular feature of the programme has been funding for work to investigate whether exposure to either mobile phones or their base stations can be linked to the hypersensitive symptoms reported by some people. These studies have been designed to have greater power to detect effects than previous work in this area (see paragraphs 119–121). Another study has compared the use of mobile phones whilst driving with other distractions such as tuning a radio, and focus groups are being used to evaluate how best to communicate the results of research to the public.

166 There is a mechanistic component to the MTHR programme with work to examine possible effects on brain function by simultaneously looking for changes in gene expression, electrophysiology, and behaviour. Other studies are investigating possible changes in heat shock protein expression and cellular calcium ion concentrations. Work is also underway to investigate whether biological systems can demodulate pulsed fields. The programme includes a large dosimetry component to refine knowledge of the deposition of energy in the body and help resolve current uncertainties about absorption in the brains of young children. One completed project (Cooper, 2004a) has assessed exposures from microcell and picocell base stations (paragraph 51).

167 Research into any health effects of exposure to RF fields is still in a developmental phase. There are analogies with work on the consequences of exposure to EMFs from power lines. In the early 1980s, the epidemiological studies on exposure to extremely

low frequency (ELF) EMFs lacked methods to directly assess exposure of individuals and instead surrogates for exposure were frequently used. Subsequently portable measurement equipment became available in the late 1980s/early 1990s and the quality of studies providing exposure–response information, for both occupational and domestic exposures, rapidly improved. Studies on RF exposure were in a similar position in the 1990s to those on ELF EMFs in the early 1980s. In recent years, however, considerable effort has gone into developing RF-related studies that combine high quality dosimetry with well-designed studies in experimental biology and epidemiology. Inevitably it will be some time before the present generation of studies come to fruition.

168 Considerable effort has been put into ensuring that the work in the MTHR programme is carried out by strong teams and that the research undertaken provides a balanced portfolio of projects that target research needs. The PMC has aimed for independent, high quality experimental biology and epidemiology supported by the use of standardised exposure systems and sound dosimetry.

169 It seems unlikely that the present research programme will be sufficient to address all the outstanding public health concerns. Further high quality research relevant to exposures to RF fields is needed, particularly in relation to exposures to low level RF fields from the wide range of devices now available with a variety of signal characteristics. The potential sensitivity of children and other individuals in the population demands further attention and research is urgently needed to understand any mechanisms of interaction of RF fields with the organs and tissues of the body.

170 The Board considers that the MTHR programme, which was first announced in December 2000, has set the standard for independent, high quality, health-related research on RF exposure.

171 The Board further recommends that government and industry should continue to provide support for a continuation of the programme.

172 The Board particularly supports the need for further research, in the following areas:

(a) an international cohort study of mobile phone users aimed at pooling and sharing experimental design, findings and expertise internationally,
(b)an expanded programme of research on TETRA signals and biological effects,
(c) effects of RF exposure on children,
(d) investigation of public concerns about mobile phone technology,
(e) electromagnetic hypersensitivity and its possible impact on health, including well-being, associated with mobile phone technology,
(f) studies of RF effects on direct and established measures of human brain function and investigations of possible mechanisms involved,
(g) complementary dosimetry studies focused on ascertaining the exposure of people to RF.

In developing the MTHR and other research programmes, care needs to be taken to prevent unnecessary duplication of studies whilst at the same time seeking to replicate significant findings.

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Appendix A

THE STEWART REPORT – SUMMARY AND RECOMMENDATIONS

Reproduced from the Report of the Independent Expert Group on Mobile Phones, published 11 May 2000

BACKGROUND

1.1 The widespread use of mobile phones is a recent phenomenon. Their use has escalated over the past decade and to many they are now an essential part of business, commerce and society. Over the Christmas 1999 period alone approximately 4 million phones were sold in the UK and at present (April 2000) there are about 25 million mobile phones in circulation. This is equivalent to nearly one phone for every two people (see paragraph 2.16)

1.2 The fact that so many people own mobile phones attests to their perceived importance to the general public. The advent of third generation systems will extend the use of most forms of communications technologies, including fax, e-mail and Internet access. **The use of mobile phones and related technologies will continue to increase for the foreseeable future.**

1.3 The extensive use of mobile phones has been accompanied by public debate about possible adverse effects on human health. The concerns relate to the emissions of radiofrequency (RF) radiation from the phones (the handsets) and from the base stations that receive and transmit the signals (paragraphs 3.3–3.7). For the general population, the levels of exposure arising from phones held near to the head or other parts of the body are substantially greater than whole-body exposures arising from base stations (paragraphs 4.28–4.36).

1.4 There are two direct ways by which health could be affected as a result of exposure to RF radiation. These are by thermal (heating) effects caused mainly by holding mobile phones close to the body, and as a result of possible non-thermal effects from both phones and base stations (paragraphs 5.5–5.26).

1.5 There can also be indirect effects. There is evidence that using a mobile phone whilst driving can increase the risk of accidents. Also some people's well-being may be adversely affected by the environmental impact of mobile phone base stations sited near their homes, schools or other buildings, as well as by their fear of perceived direct effects (paragraphs 5.264, 6.44 and 6.45).

SOURCES OF EXPOSURE

1.6 Mobile phones and base stations emit RF radiation. In both cases levels of exposure generally reduce with increasing distance from the source. For mobile phones, exposures will be principally to the side of the head for hand-held use, or to the parts of the body closest to the phone during hands-free use.

1.7 For base station emissions, exposures of the general population will be to the whole body but normally at levels of intensity many times less than those from handsets (paragraphs 4.28–4.36). Base stations communicate with mobile phones within a defined area or 'cell'. These can be of three types: macrocells, microcells and picocells depending upon their size and the power output of the antenna (paragraph 4.9).

1.8 Macrocells provide the main structure for the base station network. The base stations for macrocells have power outputs of tens of watts and communicate with phones up to about 35 kilometres (22 miles) distant. There are at present about 20 000 macrocells covering the country (paragraph 4.9). We believe that this number will continue to increase. Measurements that have been made (see paragraphs 4.30–4.36) indicate that exposures of the general population from these sites are typically many hundreds, or thousands of times lower than existing exposure guidelines. There are concerns, nevertheless, about whether the emissions from all base stations are uniformly low, about whether the emissions could cause unknown health effects, and whether, with the increased use of mobile telecommunications, their output will have to rise.

1.9 Microcells are used to infill and improve the main network, especially where the volume of calls is high. They are sited in places such as airports, railway stations and shopping malls. Their number is rapidly increasing in line with the growth in demand for mobile phones. The microcell base stations emit less power than those for macrocells and their range is a few hundred metres. We understand that exposures above guidelines do not occur, provided the case surrounding the antenna is kept in place. However, as with some other items of electrical equipment – for example, lasers in CD equipment – there is a possibility of overexposure if the case is removed.

1.10 Picocell base stations have a lower power output than those of microcells (a few watts) and are generally sited inside buildings. It is likely that the number of picocells within buildings will substantially increase. Although we are satisfied that their emissions should not exceed the guidelines, the system of audits that we propose (paragraph 1.40) will provide an independent check on the output not only from picocell antennas but from all base station types.

1.11 As well as mobile phone base stations, there are a large number of other RF emitting sources in our environment, including antennas for radio, television and paging (paragraphs 4.20–4.22). Exposures of individuals to RF radiation from these sources will depend upon their proximity and may be above those from mobile phone base stations, although still well below guidelines.

CURRENT GUIDELINES ON ACCEPTABLE LEVELS OF EXPOSURE TO RADIOFREQUENCY RADIATION

1.12 Government has in place national guidelines (paragraphs 6.19–6.26, 6.32) established by the National Radiological Protection Board (NRPB) on the maximum levels of exposure to RF radiation emitted from mobile phones, base stations and other sources ('the NRPB guidelines'). These guidelines were established in 1993

when mobile phone technology was in its infancy. The guidelines were based on a comprehensive review of the scientific literature carried out by NRPB, a statutory body, which advises government on radiological issues related to health.

1.13 In 1998 the International Commission on Non-Ionizing Radiation Protection (ICNIRP) published its own guidelines (paragraphs 6.27–6.31) covering exposure to RF radiation. These were based on essentially the same evidence as that used by NRPB, and for workers the limits on exposure are similar. However, under the ICNIRP guidelines, the maximum levels of exposure of the public are about five times less than those recommended for workers. The reason for this approach was the possibility that some members of the general public might be particularly sensitive to RF radiation. However, no detailed scientific evidence to justify this additional safety factor was provided.

1.14 The ICNIRP guidelines for the public have been incorporated in a European Council Recommendation (1999), which has been agreed in principle by all countries in the European Union (EU), including the UK. In Germany the ICNIRP guidelines have been incorporated into statute (paragraph 6.33).

1.15 Both the NRPB and ICNIRP guidelines are based on the need to avoid known adverse health effects. At the time these guidelines were drawn up, the only established adverse effects were those caused by the heating of tissues.

MAIN CONCLUSIONS ON THE POSSIBLE EFFECTS OF MOBILE PHONE TECHNOLOGY ON HUMAN HEALTH

1.16 Despite public concern about the safety of mobile phones and base stations, rather little research specifically relevant to these emissions has been published in the peer-reviewed scientific literature. This presumably reflects the fact that it is only recently that mobile phones have been widely used by the public (paragraphs 2.1–2.12) and as yet there has been little opportunity for any health effects to become manifest. There is, however, some peer-reviewed literature from human and animal studies, and an extensive non-peer-reviewed information base, relating to potential health effects caused by exposure to RF radiation from mobile phone technology.

1.17 **The balance of evidence to date suggests that exposures to RF radiation below NRPB and ICNIRP guidelines do not cause adverse health effects to the general population** (Chapter 5, paragraphs 6.33–6.42).

1.18 **There is now scientific evidence, however, which suggests that there may be biological effects occurring at exposures below these guidelines** (paragraphs 5.176–5.194, 6.38). This does not necessarily mean that these effects lead to disease or injury, but it is potentially important information and we consider the implications below.

1.19 There are additional factors that need to be taken into account in assessing any possible health effects. Populations as a whole are not genetically homogeneous

and people can vary in their susceptibility to environmental hazards. There are well-established examples in the literature of the genetic predisposition of some groups, which could influence sensitivity to disease. There could also be a dependence on age. **We conclude therefore that it is not possible at present to say that exposure to RF radiation, even at levels below national guidelines, is totally without potential adverse health effects, and that the gaps in knowledge are sufficient to justify a precautionary approach** (Chapter 5, paragraphs 6.35–6.42).

1.20 In the light of the above considerations **we recommend that a precautionary approach to the use of mobile phone technologies be adopted until much more detailed and scientifically robust information on any health effects becomes available** (Chapter 5, paragraphs 6.35–6.42).

1.21 We note that a precautionary approach, in itself, is not without cost (paragraph 6.16) but we consider it to be an essential approach at this early stage in our understanding of mobile phone technology and its potential to impact on biological systems and on human health.

1.22 In addition to these general considerations, there are concerns about the use of mobile phones in vehicles. Their use may offer significant advantages – for example, following accidents when they allow emergency assistance to be rapidly summoned. Nevertheless, the use of mobile phones whilst driving is a major issue of concern and experimental evidence demonstrates that it has a detrimental effect on drivers' responsiveness. Epidemiological evidence indicates that this effect translates into a substantially increased risk of an accident. Perhaps surprisingly, current evidence suggests that the negative effects of phone use while driving are similar whether the phone is hand-held or hands-free (paragraph 5.213). **Overall we conclude that the detrimental effects of hands-free operation are sufficiently large that drivers should be dissuaded from using either hand-held or hands-free phones whilst on the move** (paragraphs 5.201–5.214, 5.262–5.263 and 6.93–6.95).

1.23 We consider below ways in which a precautionary approach to the use of mobile phone technology might be adopted.

A PRECAUTIONARY APPROACH AND RELATED ISSUES

1.24 **We recommend that national and local government, industry and the consumer should all become actively involved in addressing concerns about possible health effects of mobile phones** (paragraph 6.40).

1.25 Our recommendations focus on five areas:

- advice to government,
- advice to industry,
- research requirements,
- the need for better public information and consumer choice,
- the role of NRPB.

ADVICE TO GOVERNMENT

1.26 We recognise that the mobile phone industry impacts on people and business around the world and that the UK is a global leader in telecommunications technology. There are benefits that the development of mobile telecommunications can bring, provided there is no adverse impact on health. It is against this general backcloth that we make our recommendations.

Standards

1.27 **We recommend that, as a precautionary approach, the ICNIRP guidelines for public exposure be adopted for use in the UK rather than the NRPB guidelines.** This would bring the UK into line with other countries in the European Union and accord with the Recommendations of the House of Commons Select Committee on Science and Technology Report on Mobile Phones and Health (1999) (paragraphs 6.19–6.42).

1.28 **We are not convinced of the need to incorporate the ICNIRP guidelines in statutes.** We believe that they are liable to change as more scientific information on possible health effects becomes available (paragraph 6.36).

1.29 It would be sensible, in line with the precautionary approach, to set in place a long-term follow-up of workers who are occupationally exposed to RF radiation at relatively high levels. **We recommend that a register of occupationally exposed workers be established and that cancer risks and mortality be examined to determine whether there are any harmful effects. If any adverse effects of exposure to RF radiation are identified then the Health and Safety Executive should establish a system of health surveillance** (paragraph 5.240).

Planning issues

1.30 The siting of base stations in residential areas can cause considerable concern and distress. At all our open meetings and in written evidence we heard concerns about the location of base stations in sensitive sites. These include schools, residential areas and hospitals. This concern relates, in part, to the fact that base stations up to 15 m (48 ft) in height can be installed in residential areas without the need for a full planning application. We consider this to be unacceptable.

1.31 We are concerned at the indirect adverse impact which current planning procedures are having on those who have been, or are, subjected to the often insensitive siting of base stations. Adverse impacts on the local environment may adversely impact on the public's well-being as much as any direct health effects.

1.32 We recognise that exposures of people in the vicinity of base stations are expected to be well within guidelines yet there is no independent audit to ensure that this is the case (paragraphs 4.30–4.35).

1.33 **We conclude that the balance of evidence indicates that there is no general risk to the health of people living near to base stations on the basis that exposures are expected to be small fractions of guidelines.**

However, there can be indirect adverse effects on their well-being in some cases (paragraphs 5.264, 6.44 and 6.45).

1.34 We perceive a lack of clear protocols to be followed in the public interest prior to base stations being built and operated and note that there is significant variability in the extent to which mobile phone operators consult the public on the siting of base stations. We have heard little specific criticism of most of the network operators, apart from Orange. The Department of the Environment, Transport and the Regions and the National Assembly for Wales (DETR, 1998) produced a *Code of Best Practice: Telecommunications Prior Approval Procedures* as applied to mast/tower development. We understand that consideration is being given to extending this to include health concerns (paragraphs 6.104–6.109). We support this development.

1.35 Overall we consider that public concerns about the siting of base stations demand changes in the planning process. Thus:

1.36 **We recommend that for all base stations, including those with masts under 15 m, permitted development rights for their erection be revoked and that the siting of all new base stations should be subject to the normal planning process** (paragraphs 6.43–6.46 and 6.55–6.62).

1.37 **We recommend that, at national government level, a template of protocols be developed, in concert with industry and consumers, which can be used to inform the planning process and which must be assiduously and openly followed before permission is given for the siting of a new base station** (paragraphs 6.58–6.62). We consider the protocol should cover the following issues.

- All telecommunications network operators must notify the local authority of the proposed installation of base stations. This should cover installations for macrocells, microcells and picocells.
- The local authority should maintain an up-to-date list of all such notifications, which should be readily available for public consultation.
- The operator should provide to the local authority a statement for each site indicating its location, the height of the antenna, the frequency and modulation characteristics, and details of power output.
- Any change to an existing base station which increases its size, or the overall power radiated, should be subject to the normal planning process as if it were a new development.

1.38 **We recommend that a robust planning template be set in place within 12 months of the publication of this report. It should incorporate a requirement for public involvement, an input by health authorities/ health boards and a clear and open system of documentation which can be readily inspected by the general public** (paragraphs 6.55–6.62).

1.39 **We recommend that a national database be set up by government giving details of all base stations and their emissions. This should include the**

characteristics of the base stations as described in paragraphs 6.47 and 6.48 **and should be an essential part of the licence application for the site.**

1.40 **We recommend that an independent random, ongoing, audit of all base stations be carried out to ensure that exposure guidelines are not exceeded outside the marked exclusion zone and that the base stations comply with their agreed specifications. If base station emissions are found to exceed guideline levels, or if there is significant departure from the stated characteristics, then the base station should be decommissioned until compliance is demonstrated** (paragraphs 6.53 and 6.54).

1.41 **We recommend that particular attention should be paid initially to the auditing of base stations near to schools and other sensitive sites** (paragraphs 6.54 and 6.63–6.68).

1.42 **We recommend, in relation to macrocell base stations sited within school grounds, that the beam of greatest intensity** (paragraphs 4.32–4.35 and 6.63–6.68) **should not fall on any part of the school grounds or buildings without agreement from the school and parents. Similar considerations should apply to macrocell base stations sited near to school grounds.**

1.43 **We recommend that in making decisions about the siting of base stations, planning authorities should have the power to ensure that the RF fields to which the public will be exposed will be kept to the lowest practical levels that will be commensurate with the telecommunications system operating effectively** (paragraphs 6.55–6.62).

Exclusion zones

1.44 **We recommend the establishment of clearly defined physical exclusion zones around base station antennas, which delineate areas within which exposure guidelines may be exceeded** (paragraphs 6.49–6.52). **The incorporation of exclusion zones should be part of the template of planning protocols that we advocate.**

1.45 Each exclusion zone should be defined by a physical barrier and a readily identifiable nationally agreed sign with a logo. This should inform the public and workers that inside the exclusion zone there might be RF emissions which exceed national guidelines. **We recommend that the design of the logo should be taken forward by the British Standards Institute and implemented within 12 months** (paragraphs 6.49–6.52).

1.46 **We recommend that warning signs should be incorporated into micro-cell and picocell transmitters to indicate they should not be opened when in use** (paragraph 6.52).

Use of mobile phones near hospitals

1.47 We are concerned about the indiscriminate use of mobile phones in hospitals and other sites where the RF radiation could possibly interfere with sensitive equipment. **We understand that health authorities/health boards issue guidance on**

the use of mobile phones. They should ensure that all hospitals comply. This guidance should include the placing of visible warning signs at entrances to buildings to indicate that mobile phones should be switched off (paragraphs 4.6, 6.91 and 6.92).

Devolution in Scotland, Wales and Northern Ireland

1.48 Where recommendations (paragraphs 1.30–1.46) impact on the devolved responsibilities of the Scottish Parliament, the Welsh National Assembly and the Northern Ireland Assembly then they should be considered by their appropriate authorities or bodies. We have noted with interest the recent report on planning procedures for telecommunications developments produced by the Transport and the Environment Committee of the Scottish Parliament (2000) (paragraphs 6.112–6.117).

ADVICE TO INDUSTRY

1.49 We believe that in the global economy of the 21st Century a competitive edge will be generated by developing innovative, technologically advanced and safe products, which can lead the field and win competitive advantage.

1.50 We understand from the Mobile Manufacturers Forum that all mobile phones presently marketed in the UK comply with both NRPB and ICNIRP guidelines. A crucial issue in relation to the exposure of people using mobile phones is the specific energy absorption rate (SAR). This determines the amount of energy absorbed in the body of the user. In most circumstances of use this will be the head. The SAR depends upon the power output of the phone and its design (paragraph 4.37). We understand that an internationally agreed standard testing procedure that will allow the SAR from mobile phones to be compared is being developed and will be finalised this year (2000). Such a procedure should benefit consumers and should also be welcomed by industry. We note that in the case of cars, standard testing procedures for fuel consumption have been developed to inform consumer choice, and have resulted in the development of more efficient engines. We see no reason why, in the case of mobile phones, standard testing procedures should not lead to a progressive reduction in exposures from the equipment.

1.51 **We recommend that an international standard for the assessment of SAR values from mobile phones should be adopted for use in the UK once it has been demonstrated to be scientifically sound** (paragraphs 6.74–6.79)**.**

1.52 **We recommend that information on the SAR values for mobile phones must be readily accessible to consumers** (paragraph 6.77)**:**

- **at the point of sale with information on the box,**
- **on leaflets available in stores giving comparative information on different phones and with explanatory information,**
- **as a menu option on the screen of the phone and as a label on the phone,**
- **on a national web site, which lists the SAR values of different phone types.**

1.53 **If there are currently unrecognised adverse health effects from the use of mobile phones, children may be more vulnerable because of their developing nervous system, the greater absorption of energy in the tissues of the head** (paragraph 4.37)**, and a longer lifetime of exposure. In line with our precautionary approach, at this time, we believe that the widespread use of mobile phones by children for non-essential calls should be discouraged. We also recommend that the mobile phone industry should refrain from promoting the use of mobile phones by children** (paragraphs 6.89 and 6.90).

1.54 We have examined the value of mast sharing and roaming agreements. These can offer advantages in terms of providing a better service in rural areas and limiting environmental intrusion. **We recommend that operators actively pursue a policy of mast sharing and roaming where practicable** (paragraphs 6.69 and 6.70).

HEALTH-RELATED RESEARCH

1.55 The mobile phone industry has supported a substantial and ongoing programme of research internationally. The recent upsurge in the use of mobile phone technology in the UK has not been matched, in general, by the output of good quality relevant research supported by the public sector. Too many studies have been carried out at exposure levels and frequencies not directly related to the use of mobile phones or base stations.

1.56 In relation to present research findings, the following three areas deserve particular comment.

- First, the balance of the evidence available does not suggest that RF radiation from mobile phones or base stations causes cancer or other disease. However, there is now evidence that effects on biological functions, including those of the brain, may be induced by RF radiation at levels comparable to those associated with the use of mobile phones. There is, as yet, no evidence that these biological effects constitute a health hazard but at present only limited data are available. This is one reason why we recommend a precautionary approach.
- Second, concerns have been expressed that the pulsed nature of the signals from mobile phones and masts may have an impact on brain function. This is an intriguing possibility, which deserves further research, particularly if pulsed signals continue to be used in the third generation of phones and related technologies. Research should concentrate on signal modulations representative of present and future phone technology (paragraphs 5.4, 5.12–5.26 and 5.270).
- Third, we commend the World Health Organization (WHO) for encouraging the use of standard experimental protocols under realistic exposure conditions relevant to mobile phone technology (paragraph 5.284). This should allow experiments from different laboratories to be readily compared.

1.57 On the basis of the current state of knowledge **we recommend that priority be given to a number of areas of research related particularly to signals from handsets** (paragraph 5.270). These should include the following:

- effects on brain function,
- consequences of exposures to pulsed signals,
- improvements in dosimetry,
- the possible impact on health of sub-cellular and cellular changes induced by RF radiation,
- psychological and sociological studies related to the use of mobile phones,
- epidemiological and human volunteer studies (paragraphs 5.249–5.264), including the study of children, and individuals who might be more susceptible to RF radiation (paragraphs 4.37, 6.29 and 6.30).

1.58 **We recommend that a substantial research programme should operate under the aegis of a demonstrably independent panel.** The aim should be to develop a programme of research related to health aspects of mobile phones and associated technologies. This should complement work sponsored by the EU and in other countries. In developing a research agenda the peer-reviewed scientific literature, non-peer reviewed papers and anecdotal evidence should be taken into account (paragraphs 5.270–5.272).

1.59 **We further recommend that this programme be financed by the mobile phone companies and the public sector (industry departments, health departments and the research councils), possibly on a 50 : 50 basis.** The contribution from industry could be made on a voluntary basis or by a continuing levy reviewable every five years (paragraph 5.272).

1.60 It will be essential for further research in this area to be kept under review. **We recommend that the issue of possible health effects of mobile phone technology should be the subject of a further review in three years' time, or earlier if circumstances demand it** (paragraph 5.273).

PUBLIC INFORMATION AND CONSUMER CHOICE

1.61 We are concerned at the variability and the limited extent of the information made available to consumers on mobile phone products. **We recommend that government circulates a leaflet to every household in the UK providing clearly understandable information on mobile phone technology and on related health aspects, including the use of mobile phones while driving** (paragraphs 5.201–5.208). **This leaflet should additionally be available at the point of sale. The leaflet should be developed in concert with industry, which has already produced some good leaflets** (paragraphs 3.48 and 3.49).

1.62 **We recommend that an ombudsman be appointed to provide a focus for decisions on the siting of base stations when agreement cannot be reached locally, and on other relevant issues** (paragraphs 3.50 and 3.51).

1.63 There are various devices that seek to reduce exposure to RF radiation from mobile phones. These include shields and devices that attach to phones. We remain to be convinced of their effectiveness in reducing personal exposure in normal conditions of use of mobile phones.

1.64 Hands-free extensions, which allow the phone to be held away from the body, have the potential for reducing exposure, but some recent tests have cast doubt on their general level of effectiveness. For users wishing to reduce their exposure, we advocate the use of hands-free kits of proven effectiveness. A satisfactory design may involve the use of chokes or filters in the connecting lead. A standard testing procedure should be established.

1.65 The regulatory position on the use of shielding devices and hands-free kits, which may affect the phone's performance, is unclear. In addition, information available for the public on the use of such devices is limited to that provided by the suppliers of the devices and the mobile phone industry. **We recommend that government sets in place a national system which enables independent testing of shielding devices and hands-free kits to be carried out, and which enables clear information to be given about the effectiveness of such devices. A kite mark or equivalent should be introduced to demonstrate conformity with the testing standard** (paragraphs 6.86–6.88).

NATIONAL RADIOLOGICAL PROTECTION BOARD (NRPB)

1.66 We believe that NRPB is a valuable UK asset which should be built upon, and that it carries out scientific work which is well-regarded nationally and internationally.

1.67 Whilst there is no criticism of its science, **we recommend that NRPB gives greater priority to the execution of a more open approach to issues of public concern such as mobile phone technology and that it is proactive rather than reactive in its approach** (paragraph 3.44).

1.68 **We recommend that public concerns about risk be addressed by NRPB in a more sensitive and informative manner** (paragraph 3.45).

1.69 **We recommend that NRPB makes more use of specialist time-limited *ad-hoc* committees of experts and lay representatives to bring forward broadly based, well-considered advice** (paragraph 3.42).

1.70 **We recommend that in a rapidly emerging field such as mobile phone technology where there is little peer-reviewed evidence on which to base advice, the totality of the information available, including non-peer-reviewed data and anecdotal evidence, be taken into account when advice is proffered** (paragraph 3.46).

1.71 We note the paucity of resources available at NRPB for work on non-ionising radiation, including work on mobile phones, and related research on life sciences. **We recommend that work on non-ionising radiation and related life sciences work be strengthened at NRPB** (paragraph 3.47).

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Appendix B

THE STEWART REPORT – RESPONSE BY GOVERNMENT

Reproduced from the Department of Health website, www.dh.gov.uk, published 11 May 2000

1 STEWART REPORT – THE GOVERNMENT'S RESPONSE

1.1 The government welcomes the Stewart Group Report and its comprehensive and thorough review of the issues.

1.2 The report makes helpful recommendations on measures to reduce public concern about the health impacts of mobile telecommunications technologies. Importantly, it provides information for the consumer to help them to make informed choices about their own and their families' use of these technologies.

1.3 We are acting immediately on the findings of the report. Some of its conclusions and recommendations can be actioned straight away. Other issues will require more time for consideration and consultation and we will be issuing further information in due course.

2 THE CONTEXT

2.1 With over 27 million subscribers in the UK, it is clear that mobile phones are a popular and important means of modern communication. The technology has, and will continue, to revolutionise the way people live their lives and companies do business. The UK is the world leader in mobile telecommunications, with successful mobile network operators offering innovative and competitive services.

2.2 The government believes that people should be able to make the most of new technology without concerns that it may impact on their health. For this reason, the Minister for Public Health called for an independent expert group to be set up to undertake the world's most comprehensive review of the possible health effects of mobile telecommunications technologies.

2.3 The Independent Expert Group was set up under the chairmanship of Sir William Stewart and has published its report today.

2.4 In his foreword to the Report, Sir William Stewart states that **"the balance of evidence does not suggest that mobile phone technologies put the health of the general population of the UK at risk. There is some preliminary evidence that outputs from mobile phone technologies may cause, in some cases, subtle biological effects although, importantly, these do not necessarily mean that health is affected".** Stewart proposes that a precautionary approach be adopted until more robust scientific information becomes available.

3 ASSESSMENT OF HEALTH RISKS

Mobile phone technology

3.1 The Stewart Group has concluded that the balance of evidence suggests that for mobile phone users:

Exposure to radiofrequency radiation below guideline levels does not cause adverse health effects to the general population.

3.2 However, the Stewart Group has also concluded that there is now scientific evidence that:

there may be biological effects occurring at exposures below these guidelines. This does not necessarily mean that these effects lead to disease or injury but this is important information.

3.3 The Stewart Group concluded that:

It is not possible at present say that exposure to RF radiation, even at levels below national guidelines, is totally without potential adverse health effects, and that the gaps in knowledge are sufficient to justify a precautionary approach.

Specific issues

Drivers

3.4 The Stewart Group further concluded in relation to the risks of mobile phones:

that their use in cars can increase the chance of accidents and that drivers should be dissuaded from using phones on the move.

Children

3.5 The Stewart Group stated that it believes that the widespread use of mobile phones by children for non-essential calls should be discouraged because:

If there are currently unrecognised adverse health effects from the use of mobile phones, children may be more vulnerable because of their developing nervous system, the greater absorption of energy in the tissues of the head and a longer lifetime of exposure.

Base stations

3.6 The Stewart Group has made a separate assessment of the potential health risks of base stations and concluded that:

the balance of evidence indicates that there is no general risk to the health of people living near to base stations on the basis that exposures are expected to be small fractions of guidelines. However, there can be indirect adverse effects on their well-being in some cases.

The government accepts the conclusions of the risk assessment of mobile phone technology set out in the Stewart Group's report.

4 PUBLIC HEALTH ACTION

4.1 The Stewart Group has identified on the basis of its risk assessment the need to take a precautionary approach to the use of mobile phone technologies until we have more detailed and scientifically robust information on any health effects.

The government accepts the recommended precautionary approach advised by the Stewart Group and will, of course, wish to hold further discussion and consultation on specific elements. The government will be, therefore, taking forward the actions that follow in response to the report's specific recommendations.

Standards for mobile phones and base stations

4.2 The Stewart Group recommended that, as a precautionary approach, the ICNIRP guidelines for public exposure be adopted for use in the UK rather than the NRPB guidelines (paragraph 1.27 of the report).

We are not convinced of the need to incorporate the ICNIRP guidelines in statutes (paragraph 1.28).

The government agrees, in line with the recommended precautionary approach, that the emissions from mobile phones and base stations should meet the ICNIRP guidelines for public exposure as expressed in the EU Council Recommendation of 12 July 1999 on the limitation of exposure of the general public to electromagnetic fields (0 Hz to 300 GHz). The government further agrees that the guidelines do not need to be incorporated into statutes.

Mobile phones

Standards and public information

4.3 The Stewart Group recommended that an international standard for the assessment of SAR values from mobile phones should be adopted for use in the UK once it has been demonstrated to be scientifically sound (paragraph 1.51).

The Group recommended that information on the SAR values for mobile phones must be readily accessible to consumers

- at the point of sale with information on the box,
- on leaflets available in stores giving comparative information on different phones and with explanatory information,
- as a menu option on the screen of the phone and as a label on the phone,
- on a national web site, which lists the SAR values of different phone types. (paragraph 1.52).

Government is aware that all mobile phone handsets on sale in the UK already meet the ICNIRP guidelines. We are supporting CENELEC in developing a European standard for measuring the Specific Absorption Rate (SAR) values of mobile phones. The standard will be adopted in the UK once it has been finally approved. The government agrees that the consumer should have access to the SAR values when considering purchasing a mobile phone. The government will expect SAR measurements to be displayed at all points of sale and with each mobile phone and on the world wide web. The government considers that the SAR value should be

viewed in context, for example, by comparing the SAR value against the recommended exposure limits. We will work with industry to implement the recommendations.

The use of mobile phones whilst driving

4.4 Drivers should be dissuaded from using either hand-held or hands-free phones whilst on the move (paragraph 1.22).

Government agrees with the Stewart Group's view that the use of mobile phones whilst driving can substantially increase the risk of an accident and that drivers should be dissuaded from using either hand-held or hands-free phones whilst on the move. Government launched a publicity campaign in 1998 to warn of the dangers of using a mobile phone while driving and reinforced that campaign at the beginning of this year. There will be further campaigns. The police are content to rely on existing legislation for the powers of prosecution, and they use it. However, if drivers continue to use mobile phones while on the move, the government will review whether specific legislation is required.

Mobile phone use by children

4.5 The widespread use of mobile phones by children for non-essential calls should be discouraged. The Stewart Group also recommended that the mobile phone industry should refrain from promoting the use of mobile phones by children (paragraph 1.53).

Government accepts the Stewart Group's recommendation. The Chief Medical Officer will be discussing with the Stewart Group how best to ensure that parents are aware of these recommendations and the information contained in the report so that they are able to make informed choices about the use of mobile phones.

Mobile phone use near essential hospital equipment

4.6 The Stewart Group understood that health authorities/health boards issue guidance on the use of mobile phones. They should ensure that all hospitals comply. This guidance should include the placing of visible warning signs at entrances to buildings to indicate that mobile phones should be switched off (paragraph 1.47).

Government is aware that the use of mobile phones in hospitals and other sites where the RF radiation could possibly interfere with sensitive equipment and the Medical Devices Agency has already issued relevant guidance. This includes policy advice to hospitals covering restricted areas where mobile phones should not be used and the placing of visible warning signs at the entrances to these areas to indicate that mobile phones should be switched off.

Shielding devices and hands-free kits

4.7 The Stewart Group recommended that government sets in place a national system which enables independent testing of shielding devices and hands-free kits to be carried out, and which enables clear information to be given about the effectiveness of such devices. A kite mark or equivalent should be introduced to demonstrate conformity with the testing standard (paragraph 1.65).

The government agrees that shielding devices and hands-free kits should be independently tested and that there should be clear information about the effectiveness of such devices. The DTI have already commissioned independent SAR measurement of hands free kits; the results will be published shortly.

Base stations

Exclusion zones

4.8 The Stewart Group recommended the establishment of clearly defined physical exclusion zones around base station antennas, which delineate areas within which exposure guidelines may be exceeded. The incorporation of exclusion zones should be part of the template of planning protocols that we advocate (paragraph 1.44).

The Stewart Group recommended that the design of the logo should be taken forward by the British Standards Institute and implemented within 12 months (paragraph 1.45).

The Stewart Group recommended that warning signs should be incorporated into microcell and picocell transmitters to indicate they should not be opened when in use (paragraph 1.46).

Clear exclusion zones should already be in place around all base station antennas to prevent the public from exposure to radiofrequency radiation above ICNIRP guidelines. Different operators currently use different signs which may cause confusion. The government supports the recommendation for clearer signs around base stations. Government agrees that microcell and picocell transmitters should have warning signs to minimise the risk of undue exposure to RF radiation from being opened during use.

Planning issues

Siting – a more consultative process

4.9 The Stewart Group recommended that for all base stations, including those with masts under 15 m, permitted development rights for their erection be revoked and that the siting of all new base stations should be subject to the normal planning process (paragraph 1.36).

The Stewart Group recommended that, at national government level, a template of protocols be developed, in concert with industry and consumers, which can be used to inform the planning process and which must be assiduously and openly followed before permission is given for the siting of a new base station (paragraph 1.37).

The Stewart Group recommended that a robust planning template be set in place within 12 months of the publication of this report. It should incorporate a requirement for public involvement, an input by health authorities/health boards and a clear and open system of documentation which can be readily inspected by the general public (paragraph 1.38).

The Stewart Group recommended that an ombudsman be appointed to provide a focus for decisions on the siting of base stations when agreement cannot be reached locally, and on other relevant issues (paragraph 1.62).

The government is minded to introduce a requirement for full planning permission for all new telecommunication masts, as public consultation is an integral part of the planning process. We will need to consult widely before doing so including the principle and precise scope of any new arrangements. We shall issue a consultation paper on this and related guidance which will include consideration of health concerns.

The Group suggested that the appointment of an ombudsman would help with planning decisions on siting of base stations, for example, where agreement could not be reached locally. The government is sympathetic to the objectives of the proposal and feels there are better ways of achieving them, bearing in mind that there is no comparable arrangement in relation to other kinds of development. The role of an ombudsman would not sit comfortably with the existing appeal process within the planning system.

As regards siting, the government's view is that the objectives are met by the planning process. When considering applications for new development local planning authorities consult local people and take their views into account in making decisions. Where an authority refuses an application the developer can appeal to the Secretary of State. Pre-applications discussions with authorities and with local people also have an important part to play, providing opportunities to explore alternative approaches to the siting and appearance of masts.

Emissions from base stations – measurements and audit

4.10 The Stewart Group recommended that a national database be set up by government giving details of all base stations and their emissions. This should include the characteristics of the base stations as described in paragraphs 6.47 and 6.48 and should be an essential part of the licence for the site (paragraph 1.39).

The Stewart Group recommended that an independent random, ongoing, audit of all base stations be carried out to ensure that exposure guidelines are not exceeded outside the marked exclusion zone and that the base stations comply with their agreed specifications. If base station emissions are found to exceed guideline levels, or if there is significant departure from the stated characteristics, then the base station should be decommissioned until compliance is demonstrated (paragraph 1.40).

The Stewart Group recommended that particular attention should be paid initially to the auditing of base stations near to schools and other sensitive sites (paragraph 1.41).

The industry already maintains a national database of all base stations and emission levels. Government will explore further with industry the development of the database. The government also agrees that there is a need to establish an independent audit of emissions to give the public confidence that base stations do not exceed approved guidelines. We will seek to implement a national measurement programme and will be discussing this further with the Radiocommunications Agency. Auditing of base stations near to schools and other sensitive sites will receive priority and this will include measurements of the beam intensity. We will consider how best to make this information publicly available and relevant to siting of base stations.

Base stations – keep exposure low

4.11 The Stewart Group recommend that in making decisions about the siting of base stations, planning authorities should have the power to ensure that the RF fields to which the public will be exposed will be kept to the lowest practical levels that will be commensurate with the telecommunications system operating effectively (paragraph 1.43).

The Stewart Group recommended that operators actively pursue a policy of mast sharing and roaming where practical (paragraph 1.54).

The government would expect an efficient mobile network operator to ensure that this recommendation is met already. However, it will be exploring with the industry ways to ensure this recommendation is met.

The Stewart Group also examined the value of mast sharing and roaming agreements which can offer advantages in terms of providing a better service in rural areas and limiting environmental intrusion. We already require a network operator to examine the possibility of using an existing mast or structure before seeking to put up any new mast. We expect that any operator should be able to verify that this has been considered. We shall also pursue with the industry the report's recommendation that operators pursue a policy of roaming where practical to obviate the need for excessive build-out of networks in rural areas.

Base stations near or in school grounds

4.12 The Stewart Group recommended that particular attention should be paid initially to the auditing of base stations near to schools and other sensitive sites (paragraph 1.41).

The Stewart Group recommended, in relation to macrocell base stations sited within school grounds, that the beam of greatest intensity should not fall on any part of the school grounds or buildings without agreement from the school and parents. Similar considerations should apply to macrocell base stations sited near to school grounds (paragraph 1.42).

Government agrees that schools and parents should be reassured that the base stations near schools and other places where children spend considerable time operate within guidelines. We will be working with the Stewart Group on the further issues regarding measurements of emissions from base stations on or near schools and how to take forward the recommendation on the 'beam of greatest intensity'.

We will also be writing to local education authorities in the next few days regarding the Stewart report and will be issuing further guidance to schools and local education authorities in light of the action we have set out in paragraphs 4.5, 4.10 and 4.11.

Health-related research – filling in the gaps in knowledge

4.13 The Stewart Group recommended that priority be given to a number of areas of research related particularly to signals from handsets (paragraph 1.57).

The Stewart Group recommended that a substantial research programme should operate under the aegis of a demonstrably independent panel (paragraph 1.58).

The Stewart Group further recommended that this programme be financed by the mobile phone companies and the public sector (industry departments, health departments and the research councils), possibly on a 50 : 50 basis (paragraph 1.59).

The Stewart Group recommended that a register of occupationally exposed workers be established and that cancer risks and mortality be examined to determine whether there are any harmful effects. If any adverse effects of exposure to RF radiation are identified then the Health and Safety Executive should establish a system of health surveillance (paragraph 1.29).

The government agrees with the Stewart Group that there is an urgent need for further research into the potential health effects of mobile communications equipment. The government is commissioning a comprehensive programme of research costing several millions of pounds, which will result in further research findings emerging over the next few years. This work should also encompass emerging radio-based technologies.

Discussions have taken place with the industry about funding a UK based research programme and they have given their agreement in principle to support such a programme. It has been agreed that any research undertaken must be independent and scientifically rigorous. It should meet the research requirements suggested by the World Health Organization and follow their criteria for good laboratory practice. It should also fit with similar work done in other countries and with the EU Framework projects in this area. An appropriate mechanisms for channelling industry support for research, so that it does not prejudice the independence of the work, will need to be determined. It is planned to launch this programme by September 2000.

The Stewart Group proposed that a register of occupationally exposed workers should be established. A three year study is currently being undertaken to assess the feasibility of conducting an industry-wide epidemiological study to investigate any relationship between RF and the risk of damage to human health.

One aim is to develop a protocol to estimate total RF exposure during employment. The government will consult with the Health and Safety Commission and others on how the Stewart's Group recommendation might best be taken forward in the light of the outcome of this study.

Further review

4.14 The Stewart Group recommended that the issue of possible health effects of mobile phone technology should be the subject of a further review in three years' time, or earlier if circumstances demand it (paragraph 1.60).

The government is keen to maintain the momentum of reviewing the health effects of mobile phone technologies and recognises that the IEGMP recommends a further review in three years' time. We will be asking the NRPB to keep further research in this area under continual review and to report to us on progress with both national and international research activities in three years' time or when significant information becomes available.

Public information

4.15 The Stewart Group recommended that national and local government, industry and the consumer should all become actively involved in addressing concerns about possible health effects of mobile phones (paragraph 1.24).

The Stewart Group recommended that government circulates a leaflet to every household in the UK providing clearly understandable information on mobile phone technology and on related health aspects, including the use of mobile phones while driving. This leaflet should additionally be available at the point of sale. The leaflet should be developed in concert with industry, which has already produced some good leaflets (paragraph 1.61).

The government agrees that more information about mobile phone technology should be available. We will be working with the Stewart Group on circulating its recommendations and information to the public and we have already started discussions on the production and availability of information on health aspects of mobile phone technology. We will ensure that a leaflet will be issued shortly and be distributed widely as well as available where mobile phones are sold and elsewhere.

Appendix C

THE STEWART REPORT – RESPONSE BY INDUSTRY

Reproduced from the Mobile Operators Association website, www.mobilemastinfo.com (originally published in May 2000 on the Federation for the Electronics Industry website)

A REPORT WELCOMED BY INDUSTRY

The Independent Expert Group on Mobile Phones (IEGMP) was set up last year by the Minister for Public Health to assess the current state of research into possible health risks from mobile phones and to make recommendations on further work that should be carried out to improve the basis for sound advice.

Under the chairmanship of former chief science advisor to the government Professor Sir William Stewart, the IEGMP has consulted widely with members of the public, scientific experts, the mobile phone industry and others in preparing its report, which is published today.

The health and safety of the public, our customers, and employees is and always will be of prime importance to the industry. We believe the report is comprehensive and balanced, and we welcome it. The IEGMP was set up to address public concern and, in our view, it has done that very effectively. As such, we believe its report stands as a significant document.

The report contains many important recommendations for us, government, and local government and we will play our part in addressing them, continuing to take policy forward in response to public concern. Set out below are some of the ways in which we will support this process.

Supportive of science

The industry recognises that the massive growth in the use of mobile phones and the associated increase in the number of base stations has been accompanied by public concern about their possible effect on human health. The industry will continue to address this public concern in a transparent and factual way.

The IEGMP has agreed with many expert bodies around the world in concluding that, "the balance of evidence to date suggests that exposures to RF radiation below NRPB and ICNIRP [International Commission on Non-Ionizing Radiation Protection] guidelines do not cause adverse health effects to the general population".

The Group has proposed that "a precautionary approach be adopted until more robust scientific information becomes available and that the subject be reviewed again in three years' time, or before if circumstances demand it." We will play our part in developing and actioning recommendations based on a precautionary approach.

The industry will continue to support scientific research internationally, monitor developments in research around the world to ensure its activities take account of the latest scientific findings, and continue to test its products for compliance with relevant standards and guidelines.

Specifically, the industry, in consultation with government, will financially support the research programme recommended by the report.

Sympathetic siting

The UK's network operators will locate, as far as possible, new base stations on sites that minimise their social impact on the local community whilst ensuring the public's expectation of good quality of service is met. They will also support the development of new technology to help improve base station design, and continue to share sites and masts where practicable.

Better communication, more consultation

The industry recognises that local planning authorities are a key participant in the network development process and that improved communication with them is a vital element in addressing the issue. To this end, the operators will increase the provision of information to planners on network design strategies and give them access to the Radio Sites Databank*. The industry is also in the process of setting up appropriate training packages on working with the community in network roll out.

The industry recognises that the location of some base stations can generate more public concern in the local community than alternative locations might. To address this, operators will help ensure that local communities are better informed about applications made for new base station sites and have appropriate opportunity to make their views known.

The industry is committed to reviewing, with government, planning regulations relating to telecommunications development to ensure planning policy is balanced between community concerns and the need for the UK to have world-leading telecommunications networks.

The operators will allocate specific staff resources to respond to public enquiries and, where appropriate, meet with the local community to discuss their concerns. They will also ensure customers receive clear factual information on the health and safety issue to assist their understanding.

Public exposure to base station radio waves

The IEGMP's report recommends that "as a precautionary approach, the ICNIRP guidelines for public exposure be adopted for use in the UK rather than the NRPB guidelines." This is the approach recommended by the EU Council of Health Ministers on 12 July 1999. The majority of existing base stations already meet these

* The Radio Sites Databank outlines the location of many UK radio communications structures, and can be used to locate existing structures appropriate for base station sites.

guidelines and all new base stations will be built to this standard. All existing sites will be checked and modified, if necessary, as soon as is practicable.

More help with handsets

The industry agrees that better provision of accurate information on the subject of mobile phone handset safety is very important in communicating with consumers. To this end, we will continue to provide information to the public and will co-operate with government to develop appropriate materials for use at point of sale.

We support the report's recommendation that "an international standard for the assessment of SAR values for mobile phones be adopted for use in the UK once it has been demonstrated to be scientifically sound". We also accept the report's recommendation that "information on SAR (specific absorption rate) values must be readily accessible to consumers". We look forward to working with government on identifying the most effective way to present this highly technical information.

Children

The health and safety of children is of paramount importance. In the spirit of a precautionary approach we will review the implications of the report in respect of our marketing strategies and information literature. We recognise the need to find a balance between appropriate precautionary measures and the personal safety benefits for children, referred to in the report, which many parents find reassuring.

Driving

The industry has already recommended that handheld mobile phones should never be used whilst driving, and that hands-free kits should only be used when it is safe to do so.

Working with government

Health and safety is and always will be of prime importance to the industry. We are very conscious of the health and safety concerns of customers, employees and others. The industry's response to these concerns will continue to sit at the heart of the industry ethos.

We take seriously any potential health concern, irrespective of current substantiated scientific opinion on the issue. We recognise that quoting recognised scientific authority, whilst very important, is not necessarily the complete answer to the question of enhancing public trust in products and services.

Transparent and impartial decision-making, following wide consultation with relevant interest groups, is recognised as an important part of gaining trust and demonstrating integrity. This philosophy will continue to underpin our approach to this issue and any other issue with potential or perceived health and safety implications.

To this end, we are committed to working closely with government and others to take policy forward in this area and successfully address public concerns.

THE TEN COMMITMENTS

In 2001, the UK mobile phone network operators announced their voluntary decision to implement the ten commitments to best siting practice.

The ten commitments are aimed to ensure transparency in building mobile phone networks, to provide more information to the public and local planners, and to boost local communities' role in the siting of radio base stations.

The ten commitments

1. Develop, with other stakeholders, clear standards and procedures to deliver significantly improved consultation with local communities.
2. Participate in obligatory pre-rollout and pre-application consultation with local planning authorities.
3. Publish clear, transparent and accountable criteria and cross-industry agreement on site sharing, against which progress will be published regularly.
4. Establish professional development workshops on technological developments within telecommunications for local authority officers and elected members.
5. Deliver, with the government, a database of information available to the public on radio base stations.
6. Assess all radio base stations for international (ICNIRP*) compliance for public exposure, and produce a programme for ICNIRP compliance for all radio base stations as recommended by the Independent Expert Group on Mobile Phones.
7. Provide, as part of planning applications for radio base stations, a certification of compliance with ICNIRP public exposure guidelines.
8. Provide specific staff resources to respond to complaints and enquiries about radio base stations, within ten working days.
9. Begin financially supporting the government's independent scientific research programme on mobile communications health issues.
10. Develop standard supporting documentation for all planning submissions whether full planning or prior approval.

* International Commission on Non-Ionizing Radiation Protection.

Appendix D

SUMMARY OF RECENT REPORTS ON MOBILE PHONES AND HEALTH

INTRODUCTION

Since publication of the Stewart Report in May 2000 (IEGMP, 2000), a substantial number of reviews from national and international committees, expert groups, and agencies have been published that are concerned with the effects of RF fields from mobile phones and base stations on health. As in the Stewart Report, these have reviewed the epidemiological and biological effects literature, formed conclusions on the likelihood of adverse health effects, and made recommendations for additional research and, in some cases, made proposals for revisions to policy.

A large number of other papers have also been published that deal with the results of specific health studies or single laboratory experiments. These have been considered elsewhere in recent reports by the independent Advisory Group on Non-ionising Radiation (2003) and NRPB (2004). Similarly, most reports originating from colloquia, seminars or workshops have not been included*. Lastly, reports are not included that consider technical or sociological impacts from the use of mobile phones, such as planning procedures or codes of practice.

The various reports published since 2000 are listed in the table, along with their main conclusions and recommendations. In addition, reports issued from 2003 are summarised here.

Overall, the reports acknowledge that exposure to low level RF fields may cause a variety of subtle biological effects on cells, animals or humans, particularly on brain activity, but the possibility of exposure causing adverse health effects remains unproven. Nevertheless, these reports suggest additional well-targeted, high quality research would be valuable to explore remaining uncertainties further. Such studies also provide reassurance to the public and help to address concerns about health. Further, these reports stress that very low level exposures, typical of base stations, are very unlikely to engender any effects on biophysical grounds, whereas localised exposures, typical of those from mobile phones, may induce effects as a result of mild heating of superficial tissues close to the handset. It is of interest to note that a recently published, well-conducted, case–control study from Sweden (which has not been included any in of the reports considered here) identified an increased risk of acoustic neuroma among people using a mobile phone for ten or more years (Lönn et al, 2004).

* COST 281 and EMF-NET are very active in this regard. A number of international workshops have been held on topics such as the influence of RF fields on the expression of stress protein, sleep and cognitive functions, and the blood–brain barrier (available at www.cost281.org). COST is the acronym for European Co-operation in the Field of Scientific and Technical Research. It is a framework for international research and development co-operation, allowing co-ordination of national research at European level. COST 281 is concerned with potential health implications from mobile communications systems. EMF-NET is a EU-funded project under the Sixth Framework Programme to provide a means to co-ordinate research, and to aid in the dissemination of results from national and international research programmes.

Summary of major reports on mobile phones and health published since 2000

Reference	Frequency range	Summary of conclusions	Summary of recommendations
HCN (2000)	900 and 1800 MHz (base stations)	No good evidence of health risks from base stations Field strength near base stations very small Possible interference with implanted medical devices No change to existing guidelines	Restrict access to base stations Resident participation in base station siting decisions Possibility of noise/vibrations to be considered
AGNIR (2001)	400 MHz (TETRA)	Hazard to health from TETRA signals is unlikely Studies on calcium efflux contradictory Further research necessary	Keep TETRA usage records Include TETRA base stations in the ongoing base station audit Carry out exposure assessments for hand portables
BMA (2001, 2004)	450 MHz – 2 GHz	No adverse health effects Supports precautionary approach Further research necessary	Research on 3G and any risks of texting Use of 'quiet zones' BSI kitemark for HFKs and shields Information on power outputs of phones Signs in hospitals to switch off phones Avoid all phone use while driving
CSTEE (2001)	1 kHz – 300 GHz	No evidence that RF fields are carcinogenic Possibility of effects on blood pressure and on subjective symptoms	Further epidemiology studies necessary Investigation of synergistic effects of RF fields with carcinogens
GAO (2001)	Mobile phones	No adverse health effects observed Findings of some studies suggest further research needed Clear, accurate and timely public information necessary	Adopt standard SAR testing methods Publish SAR data on internet Improve public information on health issues
Krewski (2001a,b)	RF fields	Non-thermal levels may produce biological effects, but not suggestive of causing adverse health effects Limitations with epidemiology studies Existing exposure guidelines in Canada adequate to provide protection but ▪ exposure guideline for the head/neck to be reviewed for workers ▪ exposure guideline for the eyes of workers should be reduced to that of the public	Further experimental studies, including ▪ melatonin physiology ▪ neurotransmitters ▪ transmembrane ion transport ▪ blood–brain barrier function ▪ different signal modulations Epidemiological studies of highly exposed workers Clinical studies investigating increased sensitivity
Zmirou (2001)	400 MHz – 2.2 GHz	Possibility of non-thermal biological effects; relevance to health uncertain Adopt precautionary approach, especially for children Need to regularly review literature	Research on a wide range of endpoints, including ▪ benign effects in workers, children and patients ▪ hypersensitivity ▪ cancer risks from base stations, if possible ▪ brain function in healthy adults and children, and in patients ▪ cellular responses

Summary of major reports on mobile phones and health published since 2000 – continued

Reference	Frequency range	Summary of conclusions	Summary of recommendations
Boice and McLaughlin (2002)	450 MHz – 2.2 GHz	No increased risk of brain tumours Increases in cancer risk are not biologically plausible	Further research on long-term exposure and cancer
HCN (2002)	400 MHz – 2.4 GHz	No adverse health effects Possible subtle biological effects Detrimental effects on driving with hands-free kits Possible interference with common medical devices	Further research on brain function and cancer Model temperature rises in head Children need not restrict use of mobile phones Discourage prolonged use of phones while driving
Lorraine and Raoul (2002)	Mobile phone frequencies	Biological effects possible, but implications for health unknown No effects from fields associated with base stations	Improved public information and communication More research necessary, especially epidemiology of phone uses New foundation to consolidate study of RF effects in France
AGNIR (2003)	3 kHz – 300 GHz	Recent published research does not give cause for concern Cognitive effects inconsistent No suggestion of carcinogenic effects Exposure from base stations unlikely to pose a risk to health Paucity of studies with children	Research on ▪ heat shock proteins in cells ▪ brain tumours in animals ▪ heating on CNS development ▪ cognitive effects in humans ▪ longer term studies on cancer risks, with improved dosimetry No further research on non-cancer endpoints or on cancer risks from base stations
BUWAL (2003)	100 kHz – 300 GHz	Conclusive health assessment not possible Probable increase in symptoms, and effects on the brain from phones Possible increased risks of brain cancer from phones, and of leukaemia or lymphoma from transmitters; hypersensitivity and insomnia possible	Continued need for precautionary approach More research on human health effects
NCRP (2003)	3 kHz – 300 GHz	Existence of modulation-dependent effects not clearly defined RF effects mediated by heating No change to existing standards necessary	Further research useful, especially on the effects of high intensity RF pulses
SS1 (2003)	Mobile phones	No increased risk of cancer from mobile phones, no firm conclusions with regard to base stations Experimental studies do not suggest RF is carcinogenic Relevance of possible effects on blood–brain barrier and heat shock proteins unclear	Recent studies do not alter conclusions of IEGMP Personal RF exposure meter needed to further long-term epidemiological studies Replication of all studies essential Endorse precautionary approach

Summary of major reports on mobile phones and health published since 2000 – continued

Reference	Frequency range	Summary of conclusions	Summary of recommendations
HCN (2004b)	900 and 1800 MHz GSM, 2100 MHz UMTS	TNO study of good quality Relevance of effects on well being questioned Only one significant cognitive change Inherent differences between experimental groups	Independent replication essential with improvements to design Other follow-up studies advisable
ICNIRP (2004)	100 kHz – 300 GHz	No consistent or convincing evidence for adverse health effect or symptoms But existing (mobile phone) studies have many deficiencies, including uncertain exposure assessment and short lag times No research on children	Better exposure assessment essential - meter needed to monitor personal exposure Future research should include long-term exposure (15 years) and effects on children Wide range of health effects should be considered, including eye diseases, neurodegenerative diseases and cognitive effects
IEE (2004)	< 1 – 300 GHz	No adverse health effects; biological effects not consistently demonstrated No plausible mechanism for low level effects	Further research to address public concerns Replication of effects essential
MHRA (2004)	Mobile RF communication systems	Some restrictions on use of mobile phones are necessary near critical care or life-support equipment Total ban in hospitals not necessary	Manage the use of mobile devices in hospitals Report interference problems to MHRA
NRPB (2004)	0 – 300 GHz	No cause for concern No adverse health effects below guideline values, but subtle biological effects possible Further research necessary to address uncertainties	Adopt ICNIRP guidelines in UK Monitor results of ongoing research
WHO (2004)	EMFs	No good evidence that children are susceptible to RF fields below guideline values Little research done on vulnerability of children Precautionary approaches could be adopted	Further epidemiological and experimental work necessary but ethical concerns acknowledged Work with animals *in vitro* models recommended Relevant dosimetric and thermoregulatory models need to be developed

* A few reports on mobile phones and health have also been published since 2000 which have not been included. For example, a review was commissioned by the French Environmental Health and Safety Agency (l'Agence Française de Sécurité Sanitaire Environnementale, AFSSE, 2003a) to update the Zmirou report (2001). Subsequently, an opinion statement on mobile phones and health was issued (AFSEE, 2003b). Also, L'Institut National de l'Environnement Industriel et des Risques (INERIS) published a report on telecommunications and health for l'Autorité Régulation des Télécommunications (ART, 2002).

However, no association was seen with less than ten years' use (which is consistent with the results of previous studies). Epidemiological studies in progress should provide more information on this topic.

Hardell et al (2004) have recently produced another analysis of data from their case–control study of brain tumours and use of cellular and cordless phones in central Sweden (Hardell et al, 2002a,b, 2003). The earlier analyses were considered by AGNIR (2003). The new analysis looked particularly at whether any raised risk might vary by age. It was reported that the odds ratio (relative risk) of brain tumour associated with ipsilateral use of analogue cellular or cordless phones was highest among those aged 20–29 years at diagnosis. However, because the number of study subjects in this age group was small, the confidence intervals for the corresponding odds ratios were wide and generally inconclusive.

Regarding the potential increased sensitivity of children to RF fields, many reports suggest precautionary approaches may be appropriate in the absence of explicit scientific data. However, several reports also note that ethical or practical concerns may limit or prevent experimental studies with children. In contrast, the Health Council of the Netherlands did not consider that there was sufficient evidence to suggest that use of mobile phones by children should be limited (arguing that it was unlikely that major changes in sensitivity of the brain to EMFs still occur after the second year of life). A recent World Health Organization (WHO) symposium on this issue concluded that the question remained largely unanswerable at present due to the paucity of relevant research (WHO, 2004). The Chairman of the International Commission on Non-Ionizing Radiation Protection (ICNIRP), Dr Paulo Vecchia, made the point that, without recognised health effects, it was not possible to produce science-based standards. In its research agenda, WHO has decided to focus attention on the potential effects of RF fields on children (see WHO, 2004).

Although of particular interest in the UK, the effects of exposure to pulsed fields have received limited international attention. The main problem is the lack of an accepted biological model that shows consistent sensitivity to low level RF fields: without this model, it is not possible to examine and compare the effects of different signal modalities. Overall the evidence that modulated fields preferentially affect biological processes is fairly inconsistent and no expert groups appear to have identified any mechanism whereby modulation could cause increased effects. NCRP (2003) noted that some, but not all, studies suggest modulation-specific effects may occur, with pulsed fields generally more effective than unmodulated fields, but many of these require exposures well above guideline values. Krewski et al (2001a,b) reached broadly similar conclusions but recommended that differing frequencies and signal modulation should be investigated.

Many recent reports also offer guidance on public policy to decision makers and legislators, and generally favour some form of precautionary or prudent approach to reducing personal exposures from mobile phones. A proven and important effect of mobile phone use on driving exists. Many reports acknowledge that the distracting effects of holding a conversation on a mobile phone, even when using a hands-free kit, represent a serious threat to the public from mobile telephony. However, there has been insufficient applied research to see how these dangers might be mitigated, or what factors make them particularly severe. Similar dangers may also exist in relation to using phones while operating machinery and heavy plant equipment.

The outstanding health-related concerns are being addressed by epidemiological (human health) studies and experimental investigations with volunteers, animals, and the use of *in vitro*, cell-based, techniques. In addition, dosimetric studies are necessary in understanding the exposure of people from various sources. However, technological change is rapid and it is a challenge to carry out necessary research to analyse the possibility of any effects.

Epidemiological studies provide the most direct information on long-term health effects of any potential harmful agent. To assess any damage to health generally requires long follow-up, frequently for many years. If the specific concern is with cancer then this can frequently arise many years after exposure, and may also require many more years before it fully manifests itself in an exposed population. Thus for the atomic-bomb survivors in Japan the follow-up still continues more than 60 years after the bombings. A period of ten years may be regarded a minimum period of follow-up for the identification of any long-term health effects in exposed groups. In addition, epidemiological studies do not have a high sensitivity for detecting subtle effects. In respect of exposures to emissions from mobile phones, the present period of follow-up is relatively short. The international pooling of 13 national studies on the possible effects of using mobile phones in the INTERPHONE study, that is being co-ordinated by the International Agency for Research on Cancer (IARC) at Lyon, should provide the best way of obtaining information on any cancer-related health effects.

Volunteer studies are also very important in enabling transient physiological phenomena, such as effects on sleep patterns or on particular aspects of cognitive function to be studied. While these studies are important for indicating the likely response of people exposed under similar conditions, for ethical reasons they are usually restricted to the use of healthy adults and to investigating effects that are considered to be harmless.

Animal studies are frequently used to complement epidemiological studies. They are generally of shorter duration and have the advantage that they can use a homogeneous population exposed under well-controlled conditions. A range of exposure conditions can be used, and exposures are well quantified, allowing studies to be replicated. The disadvantage is that the results obtained cannot necessarily be extrapolated readily to human populations. Even in the case of studies of cancer incidence in animals, there can be very substantial differences in sensitivity between different species or strains of animals, making application to man difficult.

Cellular studies are valuable for examining the mechanisms involved in any interactions with body tissues. They are most usefully employed to understand demonstrated effects and have been particularly valuable through modern genetic analysis in understanding factors influencing the sensitivity of tissues to chemical or biological hazards. Applications involving the use of stem cells are of increasing importance in medical research and could well have an important place in understanding any effects of RF fields on body tissues.

In 2003 AGNIR issued a report on health effects from electromagnetic fields which was published in the *Documents of the NRPB* (AGNIR, 2003). Preparation of this report followed from a recommendation in the Stewart Report that there should be a further review of research in three years' time, or earlier if circumstances demand it (IEGMP, 2000). The main conclusions of the AGNIR report are summarised below and in the table. The main findings of other reports published in 2003 and 2004 are also given below.

REPORTS PUBLISHED IN 2003 AND 2004

Advisory Group on Non-ionising Radiation (AGNIR, 2003)

177 pages; 367 references

This report is comprehensive and thorough. Following a detailed review of the sources and exposures from RF fields, the experimental evidence for biological effects on cells, animals and humans is critically reviewed, with emphasis on carcinogenic and neurocognitive endpoints. Finally, the results of studies investigating cancer and non-cancer epidemiology and relevant clinical research are summarised and reviewed.

The report concludes that the overall evidence for RF fields on cognitive effects in humans is inconsistent and remains inconclusive, while the suggestions of effects on calcium efflux have not been supported by more recent, better-conducted studies. The biological evidence suggests that RF fields do not cause mutation or initiate or promote tumour formation, and the epidemiological data overall do not suggest causal associations between exposures to RF fields, in particular from mobile phone use, and the risk of cancer. It further concludes that exposure levels for those living near to mobile phone base stations are extremely low and the evidence indicates that they are unlikely to pose a risk to health. The paucity of RF studies with children was noted. The report concluded "in aggregate the research published since the IEGMP report does not give cause for concern". However, limitations in the existing database suggest continued research is needed.

Detailed recommendations for further research were made for each area covered by the review. For cellular studies, the lack of a model that demonstrated a robust response to RF exposure was an impediment to progress as was a lack of independent replication of reported positive effects. However, RF-induced changes in heat shock protein in cells were considered promising for further research.

For animal studies, models with targeted gene mutations that predispose the animals to brain tumours were thought potentially useful to explore carcinogenic effects. Uncertainties regarding the time course of the increased susceptibility of the central nervous system to the effects of heat during postnatal development should be addressed. In addition, it was recommended that potential RF effects on neurotransmitter function should be investigated further and changes in excitability of hippocampal slices *in vitro* require independent verification.

For human experimental studies, more research was recommended to investigate what impact, if any, the reported changes in brain activity after RF field exposure have on cognitive performance, and the health outcomes should be identified that may be associated with these changes. International co-operation to allow a multicentre approach was also encouraged. Trials on individuals who claim to be sensitive to RF fields and suffer acute symptoms would be helpful.

Regarding cancer epidemiology, national and international studies already in progress mean that there is no need to inaugurate further general population case–control studies in relation to mobile phone use. Future studies were recommended to avoid shortcomings of studies published to date, to lengthen the study period, and to make more precise estimates of exposure. Consideration was given as to how best to undertake further occupational and residential studies.

Bundesamt für Unwelt, Wald und Landschaft (Switzerland) (BUWAL, 2003)

167 pages, 207 references

This report from Switzerland was written by M Röösli and R Rapp of the Institut für Sozial- und Präventivmedizin der Universität Basel. It assessed the risk to health from exposure to RF fields at environmental levels. Only a summary is available in English.

Over 200 scientific papers dealing with the effects of RF fields were surveyed, and reported RF effects were assessed according to a five point scale (established, probable, possible, improbable, or not assessable) and their relevance to health classified into three groups (serious, reduced well-being, or not assessable). Where possible, the thresholds for effects were determined.

Interference effects on implanted medical devices, and the microwave hearing phenomenon in pulsed fields were identified as being established (highly replicable, plausible biological mechanism). Unspecific symptoms, changes in sleep and subtle effects on brain function were considered probable (repeatedly found, no plausible mechanism). The risks of leukaemia and lymphoma from TV and radio transmitters, brain tumours from mobile phone use, and hypersensitivity and insomnia from RF fields were considered possible (occur sporadically, but could result from study weaknesses). Total mortality and the risks of other cancers were classified as being improbable (multiple indications of absence, no plausible mechanism). Finally, other effects were considered not assessable (scant or contradictory evidence, study methods insufficient). Modulation-specific effects were considered few and contradictory.

The report concluded that there were insufficient data at present to assess the risk to health from low level exposure to RF fields. Some studies suggested the existence of non-thermal effects but their relevance was unclear. Nevertheless, it was concluded that no new health effects had been established below ICNIRP guideline values (ICNIRP, 1998), but the effects classified as being probable or possible may occur with exposures to mobile phones (with rates of energy absorption between 20 mW kg^{-1} and 2 W kg^{-1}) and effects classified as possible may occur with broadcast transmitters. Overall, a continued precautionary approach to RF fields was recommended, with intensified research on human health effects.

Health Council of the Netherlands (HCN, 2003)

3 pages, 0 references

The Electromagnetic Fields Committee of the Health Council of the Netherlands, a group of Dutch scientists and physicians chaired by E W Roubos (Nijmegen University) has issued a set of recommendations for further research into the health effects of RF fields (HCN, 2003). Only an executive summary is available in English.

A range of studies was proposed. For example, it was suggested that *in vitro* studies were necessary to investigate the interaction of RF fields with chemical and physical agents, although studies with animals were not recommended (since it was considered that sufficient research was being carried out elsewhere). Laboratory and epidemiology studies investigating subjective complaints were recommended, as was a large-scale cohort study investigating field exposure and a variety of health effects, including cancer. Doubts were expressed about the usefulness of investigating the incidence of cancer or other diseases in people living near base stations (but not about radio and TV

transmitters). Additional modelling and computational dosimetry studies were proposed to better characterise local exposure in the head from the use of mobile phones.

Finally, it was suggested that a centre of expertise should be established in the Netherlands to consolidate and co-ordinate research concerning the health effects of EMFs.

National Council on Radiation Protection and Measurements (USA) (NCRP, 2003)

52 pages; 152 references

This commentary was prepared for the US National Council on Radiation Protection and Measurements (NCRP) by Scientific Committee 89-4. This committee comprised seven scientists from the USA chaired by O P Gandhi (University of Utah). The report reviews the scientific literature on the biological interactions and human health effects of pulsed and amplitude-modulated RF fields in the frequency range 3 kHz to 300 GHz. Its objective was to determine whether existing exposure standards and guidelines need to be modified to take modulation into account. Much emphasis is placed on the older literature, and relatively few studies are included which use the fields associated with mobile phones.

Following a discussion of exposure standards, and definitions of the types of modulated signals, the report considers the effects of RF fields on a wide variety of *in vitro* studies (including effects on cell physiology, genotoxicity and DNA damage), behavioural and nervous system studies in animals, volunteer studies, and epidemiological studies. Lastly, biophysical mechanisms through which modulation-dependent effects might arise were considered.

The report concludes that apart from studies that allow a comparison of effects of continuous wave versus pulsed wave exposure, the literature relevant to modulation is very scattered. Several, but not all, studies suggest some modulation-specific effects may occur, with pulsed fields generally more effective than continuous wave fields, but none of these studies provided evidence of sufficient quality to recommend modifications to existing standards. In addition, most of the studies that report modulation-specific effects involve very high exposure levels, well above guideline values. Foster and Repacholi (2004) reached similar conclusions regarding the ability of different signal modulations to cause specific biological effects.

Overall, the report concluded that heating remains the only mechanism whereby low level RF fields, modulated or not, could produce observable effects, although intense RF pulses may produce biological effects through a mechanism related to the rate of heating. These particular effects were considered to warrant closer examination, although they may only occur under unrealistic exposure conditions from specialised military equipment.

Swedish Radiation Protection Authority (SSI, 2003)

28 pages; 66 references

This is the first annual report from the SSI Independent Expert Group on Electromagnetic Fields. It considers research available in 2000 and onwards on mobile telephony and cancer. It was written by an team of eight European scientists chaired by A Ahlbom (Karolinska Institutet, Stockholm).

The report describes epidemiological studies on cancer and exposure from mobile phones and base stations (and radio and TV transmitters), as well as experimental cancer research. In addition, laboratory studies investigating specific effects on heat shock proteins (HSP) and the blood–brain barrier (BBB) are considered. Finally, a brief treatment of a precautionary framework for dealing with the uncertainty in the scientific evidence is included.

It was reported that the majority of studies have found no indication of increased risk of cancer with phone use, although some positive findings have been reported in two studies. But since limitations were considered to exist in all studies because of small numbers of cases or very short follow-up periods, the current evidence was considered to be inconclusive regarding mobile phone use. Research into exposures from base stations and cancer was also considered to be at a very early stage of development, and the existing data concerning radio and TV transmitters are subject to many limitations (especially regarding personal exposure assessment) to draw any conclusions.

Results of recent animal studies did not suggest that exposure to RF fields could induce cancer or enhance the effects of known carcinogens. It was concluded that there was no consistent evidence for effects relevant to non-genotoxic mechanisms of carcinogenesis such as cell proliferation or apoptosis, or for the induction or enhancement of neoplastic transformation *in vitro*. Regarding possible RF effects on the expression of HSPs, it was concluded that it was not possible to make conclusions about the existence and the mechanism for such effects at present. Similarly, regarding RF effects on the BBB, it was concluded that the available data did not indicate the existence of a health risk. The precautionary framework being developed by WHO was endorsed as it would allow the development of reasonable policies when taking uncertainties into account.

The report concluded that, despite much research effort, no breakthrough results had emerged in recent years that allowed firm conclusions to be drawn about the carcinogenic potential of RF fields and possible effects on HSPs and the BBB. The overall scientific assessment had not changed markedly since the Stewart Report was published and the conclusions that were formulated at that time were considered to remain valid.

The report made a strong recommendation for the development of a personal RF meter that can be used in large-scale epidemiological research. With such a meter available, it was considered that studies of exposures from base stations and transmitters might become a high priority research area. In addition, epidemiological research on the effects of long-term exposure as well as investigation of diseases other than cancer were recommended. Since it was considered that expression of HSP might be used a marker of RF exposure, further studies on HSPs were recommended, as was work on the RF effects on the BBB. It was suggested that, given the complexity of the research area, replication of both negative and positive data was recommended before results should be accepted as part of a health risk assessment.

Health Council of the Netherlands (HCN, 2004a)

57 pages, 76 references

In addition to issuing advisory reports on possible health effects associated with EMFs, the Electromagnetic Fields Committee of the HCN also publishes annual updates

on EMF health effects to enable topical issues to be considered and recent reports from HCN to be highlighted.

The second update (HCN, 2004a) covered the period from May 2001 until May 2003. This summarised the mobile phone report (HCN, 2002, see the table) and considered developments in the area of (low frequency and) RF fields. It was concluded that no potential adverse effects could be identified from the introduction of new telecommunications systems, such as UMTS (3G) and TETRA. The results of recent animal carcinogenesis studies and human epidemiological studies did not give cause for concern. Similarly, it was also concluded that effects of RF fields on the BBB have not been established, nor has an association between mobile phone use and the incidence of melanoma of the eye been shown to exist. The report also discusses non-specific symptoms arising from EMFs, concluding that no causal relationship has been shown to exist.

Health Council of the Netherlands (HCN, 2004b)

55 pages, 24 references

This report comes from the Electromagnetic Fields Committee of the HCN. It considers the scientific quality, design and execution of a study from the Netherlands Organisation for Applied Scientific Research (TNO) on the effects of GSM and UMTS signals on well-being and cognition.

The original TNO report (Zwamborn et al, 2003) described a double-blind study which explored the effects of exposure to GSM and UMTS signals on self-reported well-being and cognitive function. Using a questionnaire to measure well-being, small, but significant, field-dependent effects with UMTS signals were seen in a group of subjects who had previously reported complaints attributed to GSM fields and in a control group who had not reported any complaints. No effects were seen using GSM signals at either 900 or 1800 MHz. At the same time, a rather diffuse and inconsistent pattern of field-dependent effects on a range of different cognitive tasks was observed following exposure to GSM and UMTS fields. Explanations based on heating effects seem unlikely, due to the small amounts of power absorbed by the tissues in the head.

The HCN report found the TNO study to be of good quality but the interpretation of some of the results was questioned. In particular, the validity of the questionnaire used to measure well-being was unclear, such that it could not be concluded that a change in score reflected an actual change in well-being. The effects on well-being were also found after about a 30-minute exposure period to UMTS signals at levels that would not normally be experienced by members of the public. Moreover, the results of the cognitive tests only produced a single significance difference when corrected for multiple comparisons, and the implications of this result are unclear. There were also differences between the groups of subjects, which makes comparison between them inadvisable. Nevertheless, the study was considered sufficiently important that it was recommended for independent replication using improved designs, including larger numbers of well-matched groups of subjects.

Overall, it was concluded that it was not possible, on the basis of the results of this study, to determine the existence of a causal relationship between exposure to EMFs and decreased well-being. A similar interpretation of the study was reached by AGNIR (2003).

International Commission on Non-Ionizing Radiation Protection (ICNIRP, 2004)

62 pages, 92 references

This report comes from the ICNIRP Standing Committee on Epidemiology. It was written by an international group of six epidemiologists chaired by A Ahlbom (Karolinska Institutet, Stockholm). The reports covers the epidemiological evidence relating to possible adverse health effects from long-term exposure to RF fields between 100 kHz and 300 GHz.

First, the report briefly describes the sources and distribution of exposure in the population, as well as outlining problems associated with exposure assessment in epidemiological studies. The report reviews the risks of cancer, cardiovascular disease, adverse outcomes of pregnancy, and cataract formation associated with RF field exposure at work. It then reviews the risk of leukaemia to populations who live close to RF transmitters used in broadcasting and telecommunications, and the risks of brain cancer and acoustic neuromas from mobile phone use. Indirect effects of RF fields – for example, on pacemaker function or on driving performance – are not considered.

The report concludes that the research performed to date, including studies of mobile phone users, give no consistent or convincing evidence of a causal relationship between RF field exposure and any adverse health effect. However, it was further concluded that these studies have too many deficiencies to rule out an association. The quality of RF field assessment was considered to be a key concern. Another general concern in mobile phone studies was that the lag periods that have been examined to date are necessarily short, and no data are available on childhood exposure. The report also concluded that little was known about population exposure from RF sources and less was known about the relative importance of different sources.

Overall, further epidemiological research with mobile phones was recommended to address the potential effects of long-term exposure, including that of children, and to examine health effects not currently under investigation, such as neurodegenerative diseases and cognitive function. The need for a personal field meter to monitor individual exposure in these studies was highlighted.

Institution of Electrical Engineers (IEE, 2004)

8 pages, 6 references

This report is from the Institution of Electrical Engineers (IEE) Biological Effects Policy Advisory Group. It considers the biological effects and health risks associated with exposure to low frequency fields and RF fields. It was written by a group of six UK scientists chaired by A T Barker (University of Sheffield). Similar reports have been published every two years since 1994.

The report broadly summarises the findings of the epidemiology and laboratory studies that have been published in the peer-reviewed literature during the previous two years (amounting to 121 papers for RF fields). It also considers the conclusions of recent reviews by scientific bodies on this literature.

The 2004 report concludes that the research published during the previous two years does not suggest harmful effects exist from exposure to low level RF fields. In particular, the report notes that results from seven epidemiological studies fail to provide convincing evidence to suggest that the use of mobile phones increases the

risk of brain cancer and acoustic neuromas in adults. More generally, none of the epidemiological studies of occupational exposure to RF fields from various sources that has been published over a span of many years has been able to satisfactorily deal with dosimetry issues. It was concluded that none of these studies was readily interpretable and, although some suggest risks, they were low and generally not repeatable. Studies on residential proximity to radio antennas and the risk of cancer were considered generally weak and to have methodological deficiencies. Results of recent laboratory studies also made the possibility of adverse health effects following acute exposure seem less likely. For example, it was considered that studies with volunteers or animals failed to demonstrate any clear pattern of field-induced biological responses, and inconsistencies existed within the studies reporting positive results. In addition, doubts remained about the validity of most claimed effects of EMF exposure at the cellular level as there was a poor record of reproducibility of findings; the results did not appear to form part of any pattern in terms of exposure or biological response; and there was no known mechanism of action. Finally, it was concluded that no plausible mechanism had emerged by which RF fields could have biological effects at levels below those that cause heating. It was noted that free-radical reactions continue to be investigated, but experimental evidence to support this mechanism in biological systems has yet to be found.

The IEE report recommends that further epidemiological and experimental research should be supported, if only to address public concern rather than a likelihood that harmful effects exist. It notes that the projects funded by the UK MTHR programme go some way to addressing this need. The report suggests that the continuing absence of any new and robust evidence of harmful effects in the past two years should be reassuring, and this fact should be taken into account by policy makers both when considering the implementation of a precautionary approach to public exposure and also during the development of exposure standards.

Medicines and Healthcare products Regulatory Agency (MHRA, 2004)

3 pages, 4 references/links

This report from the UK Medicines and Healthcare products Regulatory Agency (MHRA) is concerned only with the use of mobile communications systems, including mobile phones, in hospitals. It proposes that some restrictions are necessary to minimise the risk of electromagnetic interference with critical medial equipment, and reinforces existing MHRA guidance that a total ban on mobile phones in hospitals is not necessary. Indeed, it concludes that overly restrictive polices may act as obstacles to beneficial technology, although unmanaged use of mobile phones could place patients at risk.

The report lists analogue emergency service radios and private business radios as having a high risk of causing interference, and these should only be used in an emergency and never for routine communication in a hospital. Mobile phones, TETRA handsets, laptop computers, palmtops and gaming devices fitted with data transfer radio systems, as well as high performance radio local area networks (HIPERLANs), were assessed to have a medium risk of causing interference, and these should be only used in designated areas and be switched off near critical care or life-support equipment. Cordless phones, wireless local area networks (WLANs) and Bluetooth were considered very unlikely to cause interference and need not be restricted.

The report recommends measures that hospitals should introduce to balance the risks of mobile phones interfering with critical devices and the desire for better communication. For example, a hospital should identify staff to manage how mobile communications are used within the hospital and to identify interference risks. Hospitals should also consider designating areas where staff and visitors can use mobile phones safely. Particular mobile wireless systems that have a low interference risk with medical equipment could be issued to doctors and other hospital staff and comprehensively managed. Lastly, the report recommends that any interference problems should be reported to MHRA.

National Radiological Protection Board (NRPB, 2004)

215 pages, 1002 references

This report from NRPB reviews the scientific evidence for limiting human exposure to EMFs, covering static electric and magnetic fields, low frequency fields and RF fields (from 0 to 300 GHz). It was prepared by a committee of nine UK scientists chaired by A F McKinlay, at the request of the UK Department of Health. Its primary purpose was to provide the scientific basis of NRPB advice on quantitative restrictions on exposure. It also examined the issues of uncertainty in the science, aspects of precaution, and explored recent evidence on the possibility of variations in sensitivity between different groups in the population.

To formulate this advice, the views were taken of individuals in the UK, international scientific experts, and from published material including comprehensive reviews by expert groups. Advice was also was taken from an *ad hoc* expert group, chaired by C Blakemore (University of Oxford), on the effects of weak ELF electric fields in the body. In addition, consideration was given to the views expressed in response to a draft version of the report (issued for consultation in May 2003) and to the concerns of the public about health raised at an open meeting on power lines (held in December 2002) and at the meetings held around the country by IEGMP.

The epidemiological evidence that exposure to RF fields might have an adverse effect on the health of people was examined in the report, with emphasis on the risk of brain cancer from the use of mobile phone handsets. Next, the effects of whole-body and localised heating on people and the physiological responses to thermal stress were reviewed, and possible biological effects of RF fields in the absence of overt heating were considered for humans, animals and cells. Finally, methods used in computational dosimetry were described and results of such techniques reviewed. Limitations and uncertainties in the literature were highlighted for each of these topics.

The report concluded that, for RF fields, the most plausible and coherent set of data from which guidance can be developed concerned raised temperatures and the physiological stress induced by increased heat loads. All other studies that were reviewed were considered to lack plausibility, coherence and consistency. However, the need was identified for key uncertainties in these data to be addressed through further research. In particular, the distribution of increased sensitivity to the effects of heat in members of the population was not considered to be well defined at present.

In line with the AGNIR (2003) report, it was concluded that, overall, the recent research does not give cause for concern, and that the weight of evidence does not suggest that there are adverse health effects from exposures to RF fields below

guideline levels. Limitations with the published research were noted, however, as was the fact that mobile phones had only been in widespread use for a relatively short time. Therefore it was considered that the possibility remained open that there could be health effects from exposure to RF fields below guideline levels, and hence continued research was needed. The report noted that there was a great deal of ongoing scientific research on mobile phones and health, and indicated the need to monitor the results of this research and to keep the guidelines under review.

Overall, the major recommendation of the NRPB report was the adoption of the ICNIRP exposure guidelines for occupational and general public exposure between 0 and 300 GHz (ICNIRP, 1998). Exposure to fields below these guidelines was not considered to be harmful.

Nordic Authorities (2004)

2 pages, 0 references

This was a statement expressing a common view on mobile phones and health from six intuitions with responsibility for radiological protection in the Nordic countries. The institutions were the Danish National Board of Health (Sundhedsstyrelsen), the Radiation and Nuclear Safety Authority of Finland (Säteilyturvakeskus), the Icelandic Radiation Protection Institute (Geislavarnir Ríkisins), the Norwegian Radiation Protection Authority (Sataens strålevern), and the Swedish Radiation Protection Authority (Statens strålskyddsinstitut).

It was concluded that there was no scientific evidence for any adverse health effects from mobile telecommunications systems, either from mobile phones or their base stations, below the basic restrictions and reference values recommended by ICNIRP (1998). However, more research was justified since some gaps in knowledge were considered to exist and some published studies suggested biological effects may occur at levels below guidelines values. The paucity of data precluded any judgement regarding the comparative sensitivity of children to RF fields.

Overall, the gaps in knowledge and prevailing scientific uncertainty were considered sufficient to justify a precautionary attitude regarding the use of mobile phones, and the use of hands-free kits that reduced exposure to the head was considered prudent for adults, young people and children. It was also considered important that parents should inform their children about the different ways to reduce exposure from mobile phones.

World Health Organization (WHO, 2004)

A two-day international workshop was held in Istanbul in June 2004 to address the potentially greater sensitivity of children to EMF exposure. Co-sponsors included ICNIRP and the European Commission (through EMF-NET and COST 281).

In summary, there were clear biological and dosimetric differences between children and adults, but no good evidence indicating that children were susceptible to levels of RF fields below ICNIRP guidance values. However, it was appreciated that little research had specifically addressed the potential vulnerability of children to RF fields, and that individual countries might wish to address this resulting uncertainty through policy options incorporating some degree of precaution.

A set of research proposals was drafted aimed at overcoming this lack of knowledge. The epidemiological proposals given high priority included a prospective cohort study

of childhood mobile phone users and cognitive and general health effects, and an exploration of the feasibility of a case–control study of brain cancers amongst children who use mobile phones. Research of cognitive effects and other endpoints in volunteer studies were addressed, although it was acknowledged that there would be clear ethical problems using children as experimental subjects.

Research with appropriate animal models would be able to address some of these issues, although interpretation of the health consequences is less straightforward. One proposal was a study of the impact of RF field exposure on nervous system development of immature animals using behavioural, morphological and molecular techniques. *In vitro* studies of effects on nerve cell growth, along with further exploration of possible non-thermal interaction mechanisms, were also recommended. Finally, recommendations concerning further dosimetric studies included the development of dosimetric models of RF energy deposition in children and fetuses, combined with appropriate models of thermoregulatory responses in children.

Publication of the workshop proceedings and separate papers summarising the presentations and discussions at the workshop is underway.

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Appendix E

DEVELOPMENTS IN TELECOMMUNICATIONS TECHNOLOGIES

Most of the mobile phones presently in use in the UK operate using the Global System for Mobile Communications (GSM) which is a digital system, the second generation (2G) of mobile phones. This system was being rolled out by four operators – Cellnet (now O_2), One-2-One (now T-mobile), Orange and Vodafone – at the time of publication of the Stewart Report in 2000 (IEGMP, 2000). The description of the GSM system relevant to potential exposure is contained in that report and in NRPB reports on exposure of the public to radio waves from macrocell, microcell and picocell base stations (Mann et al, 2000; Cooper et al, 2004).

A variety of new technologies are, however, being progressively developed and implemented in the field of telecommunications. New technologies include third-generation (3G) mobile telephony, Terrestrial Trunked Radio (TETRA), wireless local area networks (WLANs), Bluetooth, ultra-wideband (UWB) technology and radiofrequency identification (RFID) systems. These technologies and their implications for human exposure to electromagnetic fields (EMFs) are summarised below. In this appendix, reference is made to guidelines for limiting occupational and general public exposure to EMFs recommended by ICNIRP (1998) and NRPB (2004). Figure 2 of the main text shows a TETRA mast and Figure 3 typical macrocell, microcell and picocell base stations.

3G MOBILE TELEPHONY

The first 3G mobile phone network in the UK was launched in 2003 by the operator, Hutchison 3G. Five-thousand base stations had been built and integrated into the network by December 2003, and over a third of a million customers were attracted in the first year of operation. A further four 3G networks are under construction by the existing GSM network operators and these are beginning to provide 3G services for domestic and business applications. The function of 3G mobile phone networks in Europe is based on the Universal Mobile Telecommunications System (UMTS) standards. The growth of the networks will depend upon the extent to which the new system is adopted but it is predicted by the operators that the total number of base stations is likely to increase from the present 40 000 to around 48 000 by 2007 (MOA, 2004).

The UMTS standard specifies two modes, known as frequency division duplex (FDD) and time division duplex (TDD). In FDD mode, two separate radiofrequency channels are allocated: one for the uplink (mobile to base station) transmission and one for the downlink (base station to mobile) transmission, similarly to the second-generation GSM standard. In TDD mode, the uplink and downlink transmissions are carried over the same frequency channel but at different times. TDD mode is not currently implemented in the UK. Some of the differences between the radio signals in GSM and UMTS networks are summarised in Table E1.

TABLE E1
Some operating characteristics of GSM and UMTS signals

Item	GSM	UMTS (FDD)
Access scheme	Time division multiple access (TDMA)	Direct-sequence code division multiple access (DS-CDMA)
Modulation scheme	Gaussian minimum shift keying (GMSK)*	Quadrature (quaternary) phase shift keying (QPSK)
Frequency band for uplink	890–915 MHz (GSM 900) 1710–1785 MHz (GSM 1800)	1920–1980 MHz
Frequency band for downlink	935–960 MHz (GSM 900) 1805–1880 MHz (GSM 1800)	2110–2170 MHz
Maximum peak power of handset	2 W (GSM900) 1 W (GSM1800)	0.125 W
Maximum time-averaged power of handset	0.25 W (GSM900) 0.125 W (GSM1800)	0.125 W

*The most recent editions of the GSM standard allow additionally for the use of octernary phase shift keying (8-PSK) in providing the 2½G service known as EDGE (Enhanced Data rate for GSM Evolution).

The peak output powers of UMTS handsets are lower than those of GSM handsets; however, the transmissions of GSM handsets are pulsed whereas UMTS handsets transmit continuously (in FDD mode, which is used). Consequently, the maximum time-averaged power is the same for UMTS handsets as for GSM handsets operating in the 1800 MHz frequency band. Both GSM and UMTS technologies support adaptive power control, therefore time-averaged powers under typical conditions of usage may be much lower than the maximum value specified.

The peak and spatial distribution of specific energy absorption rate (SAR) in the head under standard test conditions might be expected to be similar for UMTS and GSM1800 handsets. In practice, the SAR will depend on the characteristics of individual handsets, in particular the design and location of the antennas.

It is expected that the radiated power of 3G base stations will generally be less than that of 2G (GSM) base stations because 3G cell sizes are generally smaller. Nevertheless, as with 2G base stations, powers will be allocated to individual base stations based on their particular site circumstances and a range of powers up to the maximum licensed power may be used. Exposures at particular locations will be largely determined by the local power density, which can be measured, as has been done with 2G base stations.

On the assumption that the powers of 3G sites are generally no more than those of 2G sites and that mast configurations, eg antenna heights, antenna beam configurations and the tendency for shielding at public exposure locations due to intervening buildings etc are similar, exposures would be expected to be very much below guideline levels, as with 2G sites. NRPB measurements at a small number of 3G sites are consistent with this expectation.

The maximum licensed powers and the actual powers of individual 3G sites can be obtained from the Sitefinder online database provided by the Office of Communications (Ofcom, www.sitefinder.radio.gov.uk). The maximum licensed power is specified in terms of the equivalent isotropically radiated power (EIRP), which is the product of the radiated power and the antenna gain. A figure of 32 dB W (decibels relative to 1 W) was quoted on Sitefinder for all of the base station sites investigated by NRPB and this is

around 1600 W EIRP, and the same as that of 2G sites. Given a typical sector antenna with a gain of 18 dB, the maximum radiated power would be around 25 W.

The research and technology agenda in mobile and wireless communications does not end with 3G mobile and there is a substantial global research effort underway. The broad technology development agenda is usually referred to as Beyond 3G (B3G) or 4G, although there are as yet no formal standards.

TERRESTRIAL TRUNKED RADIO (TETRA)

Since 1997, many countries, including the UK, have been introducing an emergency service radio system known as Terrestrial Trunked Radio (TETRA). The system was used in a trial undertaken by the Lancashire constabulary in 2000/01 and is now being rolled out across the UK police forces by O_2 Airwave. It has the potential for use by all the emergency services and other users.

The TETRA system operates using frequencies around 400 MHz and the digitally based features provide improved data transmission capabilities and added security over existing analogue systems.

TETRA networks have similar architectures to mobile phone networks (AGNIR, 2001). In trunked mode operation (TMO) mobile terminals, ie hand portables or vehicle-mounted terminals, communicate with each other through fixed base stations with antennas mounted above ground level on masts or buildings. TETRA also supports direct mode operation (DMO) whereby a mobile terminal communicates directly with another mobile terminal so that the radio signals do not pass through the infrastructure of base stations.

AGNIR (2001) described the maximum power radiated from TETRA base station transmitters as similar to that from mobile phone base station transmitters, ie a few tens of watts. NRPB had made measurements of the power density of radio signals at publicly accessible locations in the vicinity of several TETRA base stations. The results indicated that the exposure values from base stations should be less than the ICNIRP guidelines for the general public if the exclusion zones are correctly set by the operators. The waveforms of the EMFs from base stations are continuous and not pulsed as they are from mobile terminals.

Hand portable equipment transmits at a peak power of 1 W or 3 W, depending on the class of radio; however, a time division multiple access (TDMA) scheme is used that reduces the average power output during speech transmission to 0.25 W or 0.75 W for the two classes, respectively. For speech transmission, the signal emitted by a TETRA hand portable is pulsed with a power modulation frequency of 17.6 Hz. AGNIR (2001) reported that very little information existed on the SARs produced by TETRA hand portables and that no numerical modelling had been carried out.

Since a base station could be in any direction with respect to the user, the hand portable antennas are designed to radiate equally in all directions. This means that a proportion of the radiated power is directed towards and absorbed by the part of the user's body next to the hand portable, normally the head or waist. Measurements of SAR in a phantom head at various positions of likely use for two commercially hand portables (1 W and 3 W) were reported to comply with the NRPB and ICNIRP

occupational guidelines. Whilst the 1 W hand portable complied with the ICNIRP public exposure restriction, the 3 W hand portable could exceed the guidelines under maximum power conditions. Later measurements under a variety of exposure conditions, including both head and body and use of hands-free kits or lapel-mounted radios, found that all measured SARs met the ICNIRP public exposure restrictions when a duty factor of 0.25 was assumed (Chadwick, 2003).

As part of the MTHR programme of work, the first peer-reviewed paper of the programme was a numerical assessment of exposure to a TETRA handset (Dimbylow et al, 2003) The representative handset studied showed that the SAR in the head depended on the type of antenna used and, whilst all 1 W versions complied with the ICNIRP public exposure restriction, the 3 W version using a helical antenna could exceed the restriction by up to about 50% if it were to transmit continuously for six minutes; occupational exposure guidelines were complied with.

WIRELESS LOCAL AREA NETWORKS (WLANs)

Wireless computer networking is becoming increasingly widespread in offices, schools and in homes. It is also possible to access Internet services via radio from a PC at locations remote from the home or workplace, known as wireless hotspots. Connectivity is provided by wireless local area networks (WLANs) and the operation of many WLAN products (sometimes known as Wi-Fi products) is based on the family of 802.11 standards published by the Institute of Electrical and Electronics Engineers (IEEE, see http://standards.ieee.org). The specified frequency bands and powers are shown in Table E2. Standards 802.11b and 802.11g apply to the operation of products in the 2.4 GHz band, with the latter allowing higher data rates. Standards 802.11a and 802.11h apply to the operation of products in the three 5 GHz bands, the latter being a development intended to achieve harmonisation with European standards. The modulation schemes employed by WLANs include frequency hopping and direct sequence spread spectrum in the 2.4 GHz band and orthogonal frequency division multiplexing (OFDM) in the 5 GHz bands.

Computer terminals in WLANs are known as clients and have antennas either mounted outside their body-shell or integrated internally. The antennas may be removable if they are attached to or installed within PC cards or PCMCIA cards. Clients communicate with fixed access points that provide an interface with conventional wired networks.

The operation of WLAN equipment is governed by European standards, and by UK Radio Interface Requirements published by Ofcom. The maximum permitted mean EIRP during a transmission burst is given in Table E2 for devices operating in different

TABLE E2 *IEEE 802.11 standards for frequency bands and powers for wireless networking*

Frequency band (GHz)	Maximum EIRP (W)
2.400–2.4835	0.1
5.150–5.350	0.2
5.470–5.725	1
5.725–5.850	2

frequency bands. WLAN transmissions are intermittent, therefore time-averaged powers will be lower and depend on the quantity of data being transmitted.

WLAN products transmitting in the 5 GHz bands in Europe should have dynamic frequency selection (DFS) and transmit power control (TPC) implemented. However, products without DFS have been permitted to transmit frequencies in the range 5.15–5.35 GHz in the UK under an interim arrangement that restricts the EIRP to either 0.12 W or 0.06 W depending on whether or not TPC is implemented.

Exposures to WLAN equipment will depend on how the transmitting antennas are located with respect to the body, the duration of any transmissions and the peak output power. NRPB has made measurements of power density generally in and about offices where WLANs are deployed and these have always been found to be very much below the reference levels for exposure recommended by ICNIRP and NRPB. The situation is rather more complicated for exposure within the first few centimetres of the antennas, eg for the situation where a laptop computer is placed on someone's lap. This is the situation where exposure would be highest and a detailed assessment of compliance with exposure guidelines would require the measurement or computation of SAR in the body.

BLUETOOTH

Short-range connectivity can be achieved using Bluetooth wireless technology. Devices incorporating Bluetooth technology include mobile phone headsets and computer accessories such as printers, keyboards, mice and personal digital assistants. This technology is being increasingly used in business and in the home.

The technology can support small networks, known as piconets, and these have a point-to-multipoint configuration. As for some WLANs, Bluetooth devices operate in the unlicensed industrial, scientific and medical (ISM) band around 2.45 GHz. The modulation scheme is gaussian frequency shift keying (GFSK) and frequency hopping is implemented at rates of up to 1600 s^{-1} in normal operation. The frequency hopping occurs over 79 channels spaced at 1 MHz intervals from 2.402 to 2.480 GHz.

Bluetooth devices are classified into three power classes. The maximum output power of devices in classes 1, 2 and 3 is about 100, 2.5 and 1 mW, respectively, although reduction of power is possible through optional adaptive power control. Devices in classes 2 and 3 are intended to communicate over short ranges and the low power outputs will give rise to correspondingly low exposures, well below guideline levels. Assessments would be necessary for any class 1 device used near to the body, as with mobile phones operating at similar power levels, to ensure guidelines are not exceeded.

ULTRA-WIDEBAND (UWB)

UWB uses spreading techniques such as orthogonal frequency division multiplexing (OFDM) or impulse modulation that result in a broad emission spectrum, usually centred at frequencies of a few gigahertz or tens of gigahertz. The occupied bandwidth is around 1 GHz or more, or is a large fraction (typically at least a quarter) of the centre frequency. UWB has applications in radar, imaging and wireless communications,

particularly short-range, high speed data transmissions suitable for broadband access to the Internet. The attractions of the technology are high data rates, low power, security and immunity from interference effects. Furthermore, the low power spectral density of UWB ensures that interference to other users of the radio spectrum is minimised.

The very wide bandwidths and frequency hopping of UWB devices pose significant challenges to exposure assessment – particularly through measurement – because of the low spectral density of the energy in the signal. It is likely that new measurement techniques will have to be developed and theoretical modelling may also play an important role. Careful consideration should be given to exposures from these devices to ensure they both are, and can be shown to be, within guidelines.

RADIOFREQUENCY IDENTIFICATION (RFID) SYSTEMS

Low power wireless communication is widely used in radiofrequency identification (RFID). Devices continue to be introduced utilising the benefits of modern digital signal processing for transmitting data from transponders or tags placed on a variety of goods for purposes of asset tracking. The radiocommunications system enables the tag devices to be interrogated and read (and in some cases programmed) remotely in order to identify goods, vehicles or animals. The readers and tags both have radio antennas as required for wireless communication using propagating electromagnetic waves. However, in some cases the data transfer process occurs under close-coupled (inductive) conditions close to the devices.

Frequencies up to about 2.5 GHz are used for current applications, often in bands assigned for ISM use. Higher frequency bands up to 6.8 GHz have been allocated for possible use in the future. The power required depends upon the range under given conditions for the tag to respond. It will also depend on the system and whether fixed position or hand-held equipment is used to interrogate the tag and read the data. The application of RFID technology is likely to increase with the development of automated systems for a wide variety of purposes.

The characteristics, use and possible health consequences of RFID equipment have been reviewed by ICNIRP (2002) as part of a study that covered electronic article surveillance (EAS) devices and metal detectors used for security and access control. In exposure situations where the fields are complex it may be necessary to carry out detailed exposure assessments using realistic computational models of people to assess compliance with guidelines. Given the possible variations in exposure conditions and the people exposed, models that address differences in body size, anatomy and age will need to be further developed.

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Appendix F

LETTER FROM THE PARLIAMENTARY UNDER SECRETARY OF STATE FOR PUBLIC HEALTH

From the Parliamentary Under Secretary of State for Public Health
Melanie Johnson MP

Department of Health

Richmond House
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Sir William Stewart
Chairman
National Radiological Protection Board
Chilton
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22 July 2004
recd 3/8.

Dear Sir William,

NRPB EMF Guidelines

I am writing today to welcome the publication of NRPB's new advice on limiting exposure to electromagnetic fields (EMF) that was published on 31 March 2004 *(Docs of NRPB Volume 15 No 2 2004)* updating their previous 1993 guidelines. I understand that NRPB will now follow the 1998 guidelines of the International Commission on Non-Ionizing Radiation Protection and I welcome the move towards a harmonised approach to limiting public exposure to EMF.

You have supported your new advice with a comprehensive review of recent scientific work and I note that the NRPB has drawn on advice from individual UK and international experts and from published comprehensive reviews by expert groups. I welcome the fact that your review has been informed by an awareness of the issues raised at open meetings organised by the Independent Expert Group on Mobile Phones and Health and that NRPB has also organised an open meeting to listen to public concerns about power lines. Government acknowledges that there is often a need to delineate the boundaries of scientific advice but it is fully supportive of the consultative approach to resolving issues that have wider societal impacts.

The main advance on the 1993 guidelines is the introduction of lower exposure restrictions for the public than for workers. You have explained that the reasons behind this change include the scientific uncertainties in the data and the wider variability in health status in the public compared with the working population. I believe this is a sensible approach. I am aware that the main industrial sectors implicated are mobile telecommunications and electricity transmission. The mobile phone industry already complies; it was content to adopt ICNIRP guidelines after the Stewart Report in 2000 as compliance did not incur significant additional cost. As you will be aware, central government, the local authorities and the industry have drawn up a *Code of Best Practice on Mobile Phone Network Development.* I believe this has been of considerable practical benefit to local decision makers.

DH Department of Health

A similar approach could be adopted for power frequencies (power lines being one example), where the detailed costs and practicalities of implementation of the guidelines are arguably more complex. Officials from Government departments concerned are currently discussing pragmatic approaches to implementation with the main electricity transmission company.

The NRPB has also, at the request of the Department, looked carefully at the specific scientific question and the concern in the public mind about power frequency magnetic fields and childhood leukaemia. This is one of the current issues that has led the World Health Organization to formulate a draft precautionary framework on health protection. I am pleased to note that the NRPB has developed similar ideas in recommending that government should consider the need for further precautionary measures.

You will be aware that stakeholder meetings have already been piloted on the issues associated with power lines near buildings and NRPB has participated. These discussions have generated the proposal that the Department of Health lead this process forward through wider stakeholder discussions. In this way, it is hoped that collective approach can be owned by a range of participants including EMF public concern groups and industrial interests on the need for a precautionary policy and what that might entail. Other government departments would also be involved in this process particularly in view of the stated policy of developing 'brownfield' sites which may already be crossed by overhead power lines.

For your information our response to the guidelines is attached in an Annex below.

Best wishes,

Melanie Johnson

MELANIE JOHNSON

Interdepartmental response to NRPB Advice in March 2004

1 Government welcomes the publication of new EMF guidelines from the National Radiological Protection Board (NRPB). Previous NRPB guidelines were issued in 1993 and we note NRPB's acknowledgement of the continuing development of the scientific understanding of EMF effects. The Guidelines apply to the EMF (electromagnetic fields) associated with power lines, mobile phones and a vast array of electrical and electronic equipment used in everyday life.

2 The NRPB draft guidelines were placed on its web site last year. This provided an opportunity for interested individuals and groups to submit comments. These responses included Government Departments, public concern groups and industrial interests. The NRPB has given consideration to these responses and we welcome this approach.

3 The new NRPB guidelines are more restrictive for public exposure than for occupational exposure because of the wider range of susceptibilities of the general public and their less controlled environment. This two-tier approach is similar to that of the International Commission on Non-ionising Radiation Protection (ICNIRP) Guidelines published in 1998. NRPB recommend using the ICNIRP levels in the interests of international harmonisation. The NRPB recognise that further reviews (eg WHO) and research programme results are expected over the next few years.

4 The NRPB guidelines incorporate a significant cautionary element but specifically do not take into account social or economic factors or the risks or disbenefits that may occur from action to limit exposure.

5 In 1999, Government agreed an EU Recommendation on public exposure (EC/519/1999) which advocated the use of ICNIRP levels but accepts the need for consideration of risks and benefits when implementing the guidelines.

6 Following publication of the Stewart Report on *Mobile Phones and Health* (2000), the mobile phone industry voluntarily adopted ICNIRP guidelines for public exposure to radio frequency fields. All cellular radio base stations comply with ICNIRP public exposure guidelines.

7 For all other sources the Government expects the NRPB guidelines to be implemented in line with the terms of the EU Recommendation, that is, taking account of the risks and benefits of action. Preliminary discussions have already taken place to identify what reasonable actions might be taken.

8 The occupational exposure guidelines have recently been incorporated in an EU Directive that will have to be transposed into UK law in 2008. The Government recommends that industry prepare for these new Regulations by adopting procedures to comply with the guidelines over the intervening period.

The Health and Safety Commission expects to undertake a consultative exercise on new Regulations in 2005/06.

9 At the start of the review process Government had asked the NRPB to consider where the scientific uncertainty might invoke the need for precautionary options appropriate for EMF protection. A precautionary approach has already been adopted for mobile phones technology (radiofrequency) following the Stewart Report. Government has recently engaged in preliminary stakeholder discussions to consider power lines and NRPB advice suggests that this process should be continued, focussing on the possible health effects of continuous low level exposure to power frequency electromagnetic fields.

10 The Government will be exploring further the practical applications of precautionary measures within a stakeholder engagement process. This will be the subject of wide consultation and will explore any risks and benefits arising in the same manner as a Regulatory Impact Assessment.

Appendix G

PLANNING ADVICE AND REGULATIONS IN NORTHERN IRELAND, WALES AND SCOTLAND SINCE PUBLICATION OF THE STEWART REPORT

NORTHERN IRELAND

Provided by the Department of the Environment

In relation to planning controls, the Stewart Report recommended the abolition of the prior approval system in England, Wales and Northern Ireland. Following a decision by the devolved administration, Mr Dermot Nesbitt, the then Minister of the Environment, placed legislation giving effect to the recommendation before the Northern Ireland Assembly and it came into operation on 21 June 2002. The effect of the new legislation is that all new masts or extensions or alterations to masts in Northern Ireland now require full planning permission, except in an emergency.

To accompany the new legislation the Department also published its new policy for telecommunications development – Planning Policy Statement 10 'Telecommunications' (April 2002). The aim of the PPS is to ensure that new telecommunications infrastructure can be developed in a way that continues to provide Northern Ireland with world class telecommunications services, while at the same time minimising the environmental impact of new or replacement equipment.

The PPS addresses health issues associated with telecommunications development in response to the Stewart Report and takes full account of the precautionary approach advocated by the Stewart Group. All planning proposals for mobile phone base stations are now required to be accompanied by a declaration confirming that the apparatus when operational will meet the ICNIRP guidelines.

The Department's press release issued to accompany the new legislation and publication of PPS 10 can be accessed at www.planningni.gov.uk.

WALES

Provided by the Welsh Assembly Government

'Planning Policy Wales', published in March 2002, sets out the land use planning policies of the Welsh Assembly Government and is supplemented by a series of Technical Advice Notes (TANs). These national planning policy documents include guidance/ advice on telecommunications development to take account of the Stewart Report.

In particular, TAN(W)19 'Telecommunications' advises that operators should discuss proposals for proposed mobile base stations on or near a school or college with the relevant governing body. Also, that the local planning authority, when it receives such applications, should consult the school or college's governing body.

In light of the precautionary approach recommended by the Stewart Report, the Welsh Assembly Government introduced statutory changes in 2002 designed primarily to improve planning procedures for prior approval applications. In the main, the legislation:

(a) increased the time (from 28/42 days to 56 days) for local planning authorities to deal with prior approval applications,
(b) required prior approval applications, and applications for planning permission, for telecommunications apparatus to be accompanied by a declaration that the apparatus will be operated in compliance with ICNIRP guidelines, and
(c) revised procedures for prior approval applications so that public consultation requirements are the same as applications for planning permission.

Bilingual information leaflets on mobile phones and health have been widely distributed in Wales to raise public awareness concerning mobile phone technology and related health aspects. Also a children's poster competition to be used as part of a wider education campaign on mobile phones was organised. The competition attracted 2500 entries and the winning poster has been circulated to all schools in the principality.

SCOTLAND

Provided by the Scottish Executive

In Scotland, an amendment was made to the General Permitted Development Order in 2001, to the effect that planning permission is now required for all ground-based antennae and the more obtrusive of those on buildings.

The recommendations in the Stewart Report on how the planning process should deal with the siting of mobile phone base stations are addressed in National Planning Policy Guidance (NPPG) 19 Radio Telecommunications and in Planning Advice Note (PAN) 62: Radio Telecommunications. The former sets out national policy in Scotland and the latter advises on how that policy should be implemented.

NPPG 19 addresses the issue of health risks from base station emissions in accordance with the general principle that the planning system should not be used to secure objectives that are more properly achieved under other legislation. In this case, the appropriate 'other legislation' would be that made under Section 3 of the Health and Safety at Work Act 1974, which places a legal duty on operators to properly control any health risks for members of the public.

NPPG 19 outlines the measures adopted in response to the recommendations of the Stewart Report, including the adoption of ICNIRP public exposure guidelines. Provided the guidance in NPPG 19 is followed, the Scottish Executive considers it is unlikely that planning authorities could find justification for applying extended or alternative requirements either in development plans or development control decisions. The guidance recognises that, notwithstanding central government advice on health risks, genuine concerns will persist to different degrees in different areas. Operators are therefore expected to make all reasonable efforts to select sites which minimise public concerns and failure to do so might properly be regarded by a planning authority as a material consideration that results in an application being refused.

Applicants who believe that planning permission has been unreasonably withheld by a planning authority can appeal for a determination by the Scottish Executive Inquiry Reporters Unit, a decision from which takes precedence over local decisions. The approach and policy set out in NPPG 19 will also be applied in the determination of appeals. Currently in Scotland, there is no complementary right of third-party appeal for objectors.

Appendix H

UK RESEARCH PROGRAMMES ON MOBILE TELECOMMUNICATIONS

MOBILE TELECOMMUNICATIONS AND HEALTH RESEARCH PROGRAMME

Background

The Stewart Report (IEGMP, 2000) included a recommendation that "a substantial research programme should operate under the aegis of a demonstrably independent panel". The stated aim of this research was to investigate health aspects of mobile phones and related technologies. It was envisaged that the UK research would complement work sponsored by the European Union and other national programmes, and that in developing a research agenda, account would be taken not only of peer-reviewed papers, but also of non-peer-reviewed and anecdotal evidence. It was also recommended that the research should be financed by the mobile phone companies and the public sector (industry departments, health departments and the research councils), possibly on a 50 : 50 basis.

On the basis of its review of the evidence then available, the Stewart Report recommended that priority be given to a number of areas of research related particularly to signals from handsets:

(a) effects on brain function,
(b) consequences of exposures to pulsed signals,
(c) improvements in dosimetry,
(d) possible impact on health of subcellular and cellular changes induced by exposure to RF fields,
(e) psychological and sociological studies related to the use of mobile phones,
(f) epidemiological and human volunteer studies including the study of children and individuals who might be more susceptible to exposure to RF fields.

These recommendations were supported by government and industry and led to the establishment of the LINK Mobile Telecommunications and Health Research (MTHR) programme, with initial funding of £7.36 million. Funding by government and industry was initially on a 50 : 50 basis.

An independent programme management committee (PMC) was set up to decide on research priorities, select projects and manage the research. Sir William Stewart originally chaired the PMC, which included some members of IEGMP and additional experts to provide a broad range of expertise. There was also strong international representation with overseas members and a representative of the World Health Organization. In November 2002 Sir William was succeeded by Professor Lawrie Challis as Chairman. In addition, some new members have been appointed to maintain the level of experience needed for effective management of the programme.

Selection of projects

In February 2001, the PMC issued its first call for proposals, which was based on the priorities given above. As for all subsequent calls this was published in the national press, major scientific journals and on the Internet. The selection process was rigorous with only 16 of the 82 proposals initially received actually funded. In most cases initial proposals were tailored to ensure that they addressed the research priorities of the programme and there was ongoing review of the work by the PMC. This selection and review process is a key element in ensuring the quality of the research undertaken.

In December 2001, the PMC issued a second, more specific, call for proposals and a third call was issued in November 2002. The resulting research projects were selected to provide a balanced portfolio of research that met the original objectives identified in the Stewart Report.

The research that has been funded under the programme has now gone further than the original objectives by addressing public concerns in relation to mobile phone base stations and about TETRA emergency services radio. Some additional projects have been supported using new funds provided by the Department of Trade and Industry, the Home Office, the Department of Health, and the private sector. This has increased the total funding available to approximately £8.8 million.

Status of projects at August 2004

Of the twenty-eight projects managed by the MTHR programme, there are five dealing with epidemiology, seven employing human volunteers (including three exploring reported hypersensitivity to mobile phones or base stations), one study examining risk perception and communication, three mechanistic studies, and twelve studies on exposure or dosimetry. The first projects were underway by the end of 2001, and approximately two-thirds of the projects are scheduled for completion by the end of 2005. Most of the remaining projects should be completed in 2006. The status of projects is summarised in the table. Further details are given on the MTHR website (www.mthr.org.uk).

The PMC actively monitors the progress of funded projects, continuing the interactive approach adopted during project selection. In addition, the PMC has organised annual two-day research seminars where all researchers supported by the programme get together to report on progress and exchange ideas. It is expected that the output from the programme will make a major contribution to the knowledge base in this area. It is also notable that the programme and the way that it is managed are internationally respected.

The PMC has decided that the main route for publication of the results of the research programme should be in peer-reviewed scientific journals. The PMC is committed to disseminating information from the programme as widely as possible and will publish full final reports for all projects on its website as soon as this can be done without jeopardising scientific publication.

In addition to the MTHR programme, the PMC has been very active in encouraging support for an international cohort study of mobile phone users that builds on the results of the pilot cohort study supported by MTHR (see the table). While there is no convincing evidence of health effects, most mobile phone users will have had their phones for appreciably less than ten years, which is less than the latency period of

many diseases, including many cancers. So the question of whether there is an association between the incidence of such diseases and RF exposure cannot be answered satisfactorily by the studies presently underway, which in any case are only looking at a limited range of cancers. There is therefore a clear need for a cohort study that will follow subjects into the future and be capable of identifying effects on a range of head and neck diseases. The pilot study funded by MTHR suggests that the most fruitful approach will employ sampling based on operator records of contract phone users. This will effectively set a lower age limit of 18 years. The large sample size required (preferably 250 000) will necessitate a major international collaboration. It is currently proposed that WHO will co-ordinate a study that involves a UK group along with groups from four other countries (Denmark, Finland, Germany and Sweden). As a direct consequence of MTHR intervention, the UK Department of Health and Vodafone have provided additional support to allow further development of the methodologies used in the original MTHR-funded pilot study. It is expected that the full cohort study will start in 2005.

Future of the MTHR programme

An evaluation of international research programmes suggests that not all items on the WHO research agenda are being addressed by current or planned research. There would therefore appear to be considerable merit in continuing the MTHR research programme beyond its current lifetime providing adequate funding is available.

Future funding

The funding for the first phase of the MTHR programme amounted to a total of £8.8 million. All of these funds have now been fully committed.

In order to assess the funding that would be required for a second phase of the MTHR programme, the PMC has recently compared research priorities identified by a number of organisations and bodies including WHO, AGNIR, and COST 281 (see Appendix D) with research that is currently in hand in the UK or elsewhere. The PMC has also taken account of the current initiative to set up an international cohort study of mobile phone users, which it strongly supports. As a result of this exercise, the PMC has identified a number of key priority areas where it believes that further research is necessary, but is not currently in progress, and these were discussed during the open session of the MTHR research seminar in November 2004. The information given below is based on the material presented during that session. The main areas identified are: sensitivity of children; understanding effects on the human body; studies relating to base stations; studies relating to mobile phone handsets; and horizon scanning – the impact of new technologies. The PMC is currently finalising these outline proposals and placing them in priority order.

Sensitivity of children to mobile phone signals

One of the key conclusions of the Stewart Report was that if there were unrecognised adverse health effects of exposure to mobile telecommunications signals, then children may be more vulnerable. Although the PMC wanted to support research in this area during the first phase of the MTHR programme, volunteer studies were felt to be ethically unacceptable, and research was consequently limited to work on the assessment of age-related changes in dielectric properties of tissue. The

potential sensitivity of children remains one of the key outstanding issues, and the importance attached to it by international organisations such as WHO is illustrated by the recent decision to sponsor an international conference on the subject. The PMC attaches a high priority to further research in this area, whilst recognising the difficulties. It has therefore developed a multidisciplinary approach aimed at resolving some of the remaining questions.

It is envisaged that the central plank of future work in this area would be a cohort study of children. The first part of this study would focus on the range of exposures from mobile phones as well as the type of use. It would include studies of how this changes with time and how it differs with cultural and social backgrounds and it may include a sub-study to investigate whether cognitive function is affected by exposure history, if ethical considerations permit. It might also be possible to examine the incidence of, or change in, symptoms over time. The proportion of the population suffering from relatively minor illnesses might be expected to be higher than for the severe illnesses being studied in the international cohort study, so that the sample size could be much smaller for the children's cohort. It is suggested that recruitment should be done through schools.

Whilst it may be possible to include a cognitive sub-study as part of the children's cohort study, this would be limited to investigating the effects of exposure history. The PMC remains convinced that it would be ethically difficult to justify a laboratory provocation study on children. Nevertheless, there is a clear need to establish if the developing nervous system may be more sensitive to RF exposure than a mature one and it is considered that this could be explored in laboratory animals. Such an investigation would involve the effects of long-term RF exposure on well-characterised cognitive and behavioural tasks and would be repeated at multiple periods in development to identify whether particular developmental stages or mechanisms are more sensitive to RF exposure. A synergic advantage of an animal model would be the ability to use physiological and anatomical measures in the same experiments to study the mechanisms responsible for any RF effect.

The MTHR programme has been funding initial work to evaluate a new personal exposure meter, and it is considered that this could have potential as a tool for the assessment of environmental exposures including base station exposures in support of the children's cohort study. The usefulness of the meters would need to be assessed further in a pilot study and there would also be a need to carry out a computational investigation of the interaction between the meter and the body on which it is worn in order to be able to relate meter readings to body-absent field strengths.

It is considered that there is a need for additional dosimetric work in support of the health effects research related to the sensitivity of children. This is likely to include work to resolve the question of whether the absorption of RF power in the head, and particularly in the brain, is greater for children than for adults. It is also considered important to support a UK contribution to the ongoing international effort to develop a realistic numerical phantom of the child.

Understanding effects of RF exposure on the human body

Technical approaches to detection of responses of cells have moved on since the development of techniques for the rapid large-scale screening of the human

genome. It is now possible to screen for changes elicited during exposure to an agent by assaying simultaneously for changes in expression of all of the 30 000 or so genes in the human genome. It is also possible to screen for changes in thousands of proteins and many products of metabolic activity in the same cells. One advantage of these approaches is that they could be applied to serial blood samples taken from healthy volunteers during controlled RF exposure. Hence it may be possible to understand the cellular changes occurring in people rather than the more artificial situation of cells cultured in isolation.

Most of the present knowledge of the deposition of RF energy into human tissues has been determined at fairly low resolution. In order to fully understand the interactions that occur, the PMC considers that it would be helpful to develop techniques in microdosimetry.

The current modelling approaches generally examine the rate of energy deposition into different tissues, but do not take account of the responses of the tissues to the imposed thermal loads. The PMC considers that there is a need for improved thermal modelling of the effects of RF absorption in the head, eye, trunk, embryo and fetus.

Studies relating to base stations

The rollout of the TETRA emergency services network has brought increasing numbers of reports of symptoms following exposure to emissions from base stations. This is an area that is already under investigation by an MTHR project for GSM and 3G (UMTS) mobile phone base stations (being undertaken at the University of Essex). Given their different characteristics, it would appear timely to extend the existing study to include TETRA signals. Experience gained from the existing study should enable this to be done cost-effectively.

It is proposed that there should be a study of methods used to influence the siting of base stations. The publicity generated over the siting of base stations provides a significant contribution to the ongoing debate about health issues relating to mobile phone technology. To understand this contribution better, it is proposed that there should be a systematic study on the methods used by all parties who seek to influence the siting of base stations.

A complaint from people living near to base stations concerns sleep disruption and there have been a number of studies to investigate this. The studies proposed would focus on longer-term, lower-level whole-body exposures. Their aim is to see whether exposure to base station signals really can affect sleep. It would also provide a useful laboratory experimental model for any chronic RF effects.

Despite public concern about their continuous exposure from base stations, no epidemiological studies have been carried out on adults because of the difficulty of obtaining a robust measure of RF exposure from various sources. MTHR has already funded one study looking at children. There are considerable reservations about the possibility of conducting such a study on adults, but the recent development of personal exposure meters could offer a new approach. MTHR has already funded an initial evaluation and plans to carry out additional work in support of the children's cohort study. If the personal exposure meter turns out to be a useful epidemiological tool, it may also be possible to use it in an epidemiological study on adults and their exposures from base stations.

Studies relating to mobile phone handsets

Work during the first phase of the MTHR programme focused on the possible health effects from the use of mobile phone handsets and it is anticipated that this work will have done much to resolve issues in this area. The PMC recognises the need for a large cohort study of mobile phone users to resolve possible issues of latency and effects on a wider range of diseases. It therefore strongly supports the proposals for an international cohort study to be co-ordinated by WHO. In addition to this, the PMC considers that there is a need for additional work in the following areas.

The dangers arising when driving from the distraction caused both by hand-held and hands-free mobile phones are well established. There is a clear need to investigate the extent to which drivers and machine operators are aware of the effect that use of a phone has on their performance and whether this results in them using a phone less. The results of this work should inform efforts to reduce the use of hands-free as well as hand-held phones.

At present the use of hands-free phones while driving is legally permitted so a case can be made for applied research to understand if it is possible to reduce the risk where they are used, although this should not be seen as an alternative to preventing their use. The basis for the approach is that a major contribution to distraction arises from the increase in the driver's response time. This may be at least partly associated with the driver needing to deal with responses coming from two very different locations, an earpiece and the view in front of him. So one topic would be to investigate whether the increase in response time is less if loudspeakers in front of the driver replace the earpiece.

The PMC also proposes work to look further at risk perception by investigating how different publics interpret 'scare' stories. Health concerns can arise through the uncritical reporting of such stories (for example, supposed effects of mobile phone usage on fertility). Explaining this information to the public should be more effective if it is understood how different people interpret such scare stories and how they impact on behaviour.

Finally, the PMC recognises that the outcome of much of the current work on handsets cannot presently be predicted. If any of the current studies were to show a clear effect on brain function then there would be a need to understand the mechanism involved. It is envisaged that this would require an investigation of functional implications through projects in which EEG (electroencephalography) and functional neuroimaging (eg PET, positron emission tomography) are combined with studies of cognitive and behavioural tasks.

Horizon scanning – possible implications of new technologies

Mobile telecommunications technology has evolved rapidly since the introduction of the first true mobile phones in 1985 and it is likely that the pace of technological change will continue for the foreseeable future. To an extent this has meant that health effects research has tended to focus on yesterday's technology. The PMC sees a clear need to understand how future technologies are likely to affect exposures in order to inform the design of health effects research.

One of the likely consequences of future technological development is a trend towards the deposition of RF energy in tissues other than the head, and particularly in abdominal tissues. In support of work to assess the possible consequences of this, there

is a need for the development of realistic whole-body numerical phantoms of the female to complement existing male phantoms. The possible consequences of abdominal exposure during pregnancy are of particular concern and the PMC therefore believes that there is a need for phantoms of pregnant females to be developed as a matter of urgency.

MTHR projects

Project	Lead researcher	Start	Finish
Epidemiology			
Case–control study of risk of brain tumours and acoustic neuroma in relation to use of mobile phones: south-east England	A Swerdlow	February 2002	July 2004
UK case–control study of adult brain tumours	T Mckinney	January 2002	June 2004
Cohort study of mobile phone users (pilot study)	P Elliott	January 2002	June 2003 *completed*
Case–control study of risk of leukaemia in relation to use of mobile phones	A Swerdlow	November 2002	March 2008
Case–control study of cancer incidence in early childhood and proximity to mobile phone base stations	P Elliott	April 2003	March 2005
Volunteer studies			
Effects of mobile phone radiation on blood pressure	A Barker	August 2002	January 2006
Mobile cellular communication and cognitive functioning	R Russo	January 2002	April 2005
Detection of effects of microwave radiation on the electrical activity of the brain*	S Butler	July 2003	December 2004
Study to evaluate the effects of mobile phone usage on labyrinthine function	L Luxon	November 2002	July 2004
Effect of mobile phone use on symptoms and neuroendocrine function in normal and hypersensitive individuals	S Wessely	April 2003	March 2006
Hypersensitivity symptoms associated with EMF exposure (extended to include exposure to 3G signals*)	E Fox	January 2004	December 2005
Conversations in cars	A Parkes	December 2001	December 2002 *completed*
Communicating uncertainty: mobile telecommunication health risks*	J Barnett	January 2004	December 2005

MTHR projects – continued

Project	Lead researcher	Start	Finish
Mechanistic studies			
Effects of RF radiation on brain physiology and function	Z Sienkiewicz	February 2002	January 2005
Effect of pulsed RF EMFs on redox signalling and calcium homeostasis	M Bootman	January 2002	June 2005
Cellular and subcellular effects of microwave radiation in the simple model nematode	D de Pomerei	April 2002	March 2005
Exposure and dosimetry			
Measurement of the dielectric properties of biological tissue *in vivo* at microwave frequencies	C Gabriel	December 2002	December 2004
Interaction of emerging mobile telecommunication systems with the human body	S Porter	April 2002	June 2006
Traceability for MTHR research programme (measurement of emissions from commercial mobile phones)	B Clarke	December 2001	March 2003 *completed*
Assessment of specific energy absorption rate (SAR) in the head from TETRA handsets	P Dimbylow	March 2002	February 2003 *completed*
SAR testing of hands-free mobile phones*	S Porter	July 2002	January 2003 *completed*
International EMF Dosimetry Project*	P Chadwick	March 2002	February 2006
Measurement of the power density of adio waves in the vicinity of microcell and picocell base stations*	S Mann	January 2002	June 2003 *completed*
Non-linear and demodulation mechanisms in biological tissue*	P Excell	September 2004	September 2006
Evaluation of personal exposure meters*	S Mann	October 2004	April 2005
Support projects			
Traceability for MTHR research programme (dosimetry in support of the programme)	B Clarke	December 2001	End of programme
Experimental system and dosimetry for the MTHR system	P Chadwick	March 2002	March 2006
Development of base station exposure system	CDS Europe	August 2004	October 2004

Note: Projects are not shown as completed until a final report has been delivered and approved by the PMC.

* Funded by government or industry as an adjunct to the programme.

TERRESTRIAL TRUNKED RADIO (TETRA)

Recommendations for research in AGNIR report on TETRA

The Home Office recognised that the issues raised by the Stewart Report were not restricted to public mobile phones and that similar considerations would apply in respect of private mobile radio services such as the TETRA system being deployed for use by the emergency services. In particular, the Stewart Report had discussed the possibility that signals that were amplitude modulated at frequencies around 16 Hz might have an effect on calcium exchange in cells, although it also stressed that there was no obvious health risk from this. As a consequence of these concerns, the Home Office asked NRPB to examine the possible health consequences of the use of the TETRA system. The resulting report from the Advisory Group on Non-ionising Radiation was published in the *Documents of the NRPB* in July 2001 and included a number of recommendations for further research as reproduced below (AGNIR, 2001).

(a) The existence of RF-induced changes in calcium efflux and its significance if it occurs in living tissue are much disputed. Further studies on the behaviour of calcium in tissues using modern molecular and cellular biology techniques should be used to determine the extent and significance of any effects that occur. In order to contribute to this field, any new study would have to be well designed, performed 'blind' as to the exact stimulus conditions in each trial, and preferably conducted with identical protocols in more than one well-respected laboratory.

(b) If there are genuine changes in calcium efflux as a consequence of exposure to signals from TETRA, then the most likely effect would be on the functions of nervous tissue. Further studies need to be carried out on effects of amplitude modulation or pulsing on neuronal activity and on signalling within and between nerve cells.

(c) The possibility that modulated RF fields might somehow synchronise the activity of groups of coupled neurons, and hence increase the likelihood of epileptic seizures could be investigated in isolated slices of rodent hippocampus, and also in strains of animals that are especially prone to epilepsy.

(d) Possible mechanisms by which living cells might 'demodulate' amplitude-modulated RF fields should be investigated, using modern patch-clamp techniques. Particular attention should be paid to the identity of any non-linear element in cells that is capable of detecting the carrier frequency and therefore generating a current at the modulating frequency.

(e) Human volunteer studies should be carried out to measure changes in cognitive performance arising from exposure to TETRA handsets. They should include examination of the effect of varying parameters such as the duration of calls and extent of exposure, as well as signal characteristics.

(f) The TETRA system is expected to be deployed widely for use by staff in the emergency services. This is a relatively stable workforce with defined patterns of work. It would be worth carrying out studies to examine working practices and conditions of exposure to RF radiation from TETRA systems. Records of use should be kept, which could be of value in any future epidemiological studies.

(g) The Independent Expert Group on Mobile Phones (IEGMP) recommended an audit of mobile phone base stations. This is now being carried out by the Radiocommunications Agency (now Ofcom). TETRA base stations should be included in

this audit. They should also be included in the database of base stations being developed by government.

(h) Only limited information is presently available on exposures from TETRA hand portables. Further work is needed to provide more information on exposures from hand portables and from any further transmitting equipment that is likely to be deployed for use. Exposures should comply with existing guidelines. Assessments of SAR for hand portables should be carried out using both experimental techniques and computational dosimetry.

Home Office TETRA programme

The Home Office responded to these recommendations by setting up a new research programme focused on the possible health effects of exposure to TETRA signals. This programme is managed by an independent steering committee. In addition, the Home Office has provided funding of over £800 000 to the MTHR programme for work on TETRA-related projects, as described earlier in this appendix under the MTHR programme.

Effects on nervous tissue and brain function

The first research to be funded under the TETRA programme is examining a number of endpoints related to possible effects on nervous tissue and brain function. This work has included studies on calcium efflux from brain tissue, essentially exploring further the possible effects highlighted by the Stewart Report. The work was undertaken by Defence Science and Technology Laboratory, DSTL, and found no effect on the behaviour of calcium ions in either neuronal or heart muscle cell cultures. The DSTL project is also examining possible effects on electrophysiological endpoints and epileptiform activity in brain slices. The results from these studies have not yet been announced.

A human volunteer study will be carried out to examine the possible effects of exposure to TETRA signals on cognitive performance.

Health monitoring study

In May 2003, the Home Office announced funding for a large health monitoring study of police users of the TETRA system. The study will be carried out by Imperial College of Science, Technology and Medicine and will include both a long-term study of a cohort of 100 000 police staff, and a detailed study of a selected subgroup of staff who report specific symptoms. In addition, teams from the Universities of Birmingham and Manchester will carry out a survey to examine patterns of work amongst TETRA users in both urban and rural areas.

Base station exposures

The Radiocommunications Agency (now Ofcom) was asked in 2002 to audit emissions from a small number of TETRA base stations. The results from 12 sites confirmed that exposures were small fractions of the ICNIRP public exposure guidelines in publicly accessible areas (ICNIRP, 1998).

Exposure from handsets

Two studies have been undertaken to improve understanding of the patterns of energy deposition from handsets in normal use. The first was a computational dosimetry study of a TETRA handset, which was undertaken by NRPB as part of the

MTHR programme (see above). The second study, which has been undertaken by Microwave Consultants Limited, MCL, used realistic physical phantoms to measure SAR levels from lapel- or abdomen-mounted radios, and from the use of accessories such as earpieces and remote speaker-microphones. These studies have shown that exposures remain well below current guideline levels.

MCL has also been commissioned to carry out a study to estimate SARs from the use of TETRA equipment in vehicles.

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IEGMP (2000). *Mobile Phones and Health*. Report of an Independent Expert Group on Mobile Phones. Chairman, Sir William Stewart. Chilton, NRPB. Available at www.iegmp.org.uk.

Glossary

The descriptions below are intended to help the reader understand the text; they are not necessarily definitive scientific terms, for which the reader is advised to consult specialist sources. Words in bold are defined separately.

TERMS ASSOCIATED WITH ELECTROMAGNETIC FIELDS

Analogue cellular Original **cellular** technology used in the transmission of speech by Vodafone and Cellnet since 1985, operating as an analogue system at 900 MHz. Typically accessed by high powered phones installed in cars.

AM Amplitude modulation.

Antenna Device designed to radiate or receive electromagnetic energy.

APC Adaptive power control. System used to control mobile phones and base stations in order to ensure that the radiated power does not exceed the minimum consistent with high quality communication. The system effectively operates to reduce average radiated powers.

Base station Facility providing transmission and reception for radio systems. For macrocells, the infrastructure comprises either roof- or mast-mounted antennas and an equipment cabinet or container. For smaller microcells and picocells, the antennas and other equipment may be housed in a single unit.

CDMA Code division multiple access that encodes signals to a number of users, so that all of these users can simultaneously use a single, wide frequency band. Each user's handset decodes the information for that user, but cannot access information for any other user.

Cell/cellular A 'cell' in the context of mobile phone technology is the area of geographical coverage from a radio base station.

CW Continuous wave.

Decibel (dB) A measure of the increase or decrease in power, P, at two points expressed in logarithmic form. Gain $= 10 \log_{10}(P_2/P_1)$.

DECT Digital enhanced cordless telecommunications.

Digital cellular Technology introduced in the 1990s as a method of transmitting speech and data. Offers increased security, and technical advantages with low powered phones.

Dosimetry Measurement of the absorbed dose or dose rate by an object, as in a **radiofrequency** field.

DTX Discontinuous transmission. System regulating mobile phones to reduce the rate at which bursts are transmitted when there is no speech. The system has the effect of reducing the time of exposure to approximately half (assuming an equal conversation).

Effective radiated power (ERP) Power supplied to the antenna multiplied by the gain of the antenna in that direction relative to a half-wave dipole.

EIRP Equivalent isotropically radiated power. This is the power that would have to be emitted in *all directions* to produce a particular intensity and so takes account of the transmitter power plus the characteristics of the antenna.

Electric field Produces a force on a charged object (unit V m^{-1}).

Electric field strength (E) The magnitude of a field vector at a point that represents the force (F) on a point charge (q) divided by the charge: $E = F/q$ (unit V m^{-1}).

Electromagnetic fields Electric and magnetic fields associated with electromagnetic radiation.

Electromagnetic radiation A wave of electric and magnetic energy that travels or *radiates* from a source.

EMF Electromagnetic field.

FDD Frequency Division Duplex.

Frequency Number of complete cycles of an electromagnetic wave in a second (unit **hertz, Hz**).

GSM Global System for Mobile Communications (second generation, 2G). An international operating standard for digital cellular mobile communications. Enables mobile phones to be used across national boundaries.

Harmonics Multiples of the fundamental frequency used for a particular source, eg 50 Hz harmonics are 100 Hz, 150 Hz, 200 Hz, etc.

Hertz (Hz) Unit of frequency. One cycle per second.

Impedance (of free space) Ratio of electric to magnetic field strength of an electromagnetic wave. In free space the value is 377 Ω.

IMT-2000 International Mobile Telecommunications-2000. International name for **UMTS**.

Intensity Power crossing unit area normal to the direction of wave propagation (unit watts per square metre, W m^{-2}). See also **power density**.

Isotropic (radiator) Having the same properties in all directions.

Magnetic field Produces a force on a charged object moving at an angle to it (unit tesla, T). (See also **magnetic flux density**.)

Magnetic field strength (H) A field vector that is equal to the magnetic flux density divided by the permeability (μ) of the medium (unit, A m^{-1}).

Magnetic flux density (B) The magnitude of a field vector that is equal to the magnetic field H multiplied by the permeability (μ) of the medium (unit tesla, T): $B = \mu H$.

Microwave Electromagnetic radiation of ultra-high frequencies between 300 MHz and 300 GHz.

PCN Personal Communications Network. A mobile system principally directed towards the hand portable, domestic user market and operating with **digital** technology at 1.8 GHz.

Plane wave A wave such that the corresponding physical quantities are uniform in any plane perpendicular to a fixed direction.

Power density Power crossing unit area normal to the direction of wave propagation (unit watts per square metre, $W\ m^{-2}$). (See also intensity.)

Power (flux) density (S) Power crossing unit area normal to the direction of wave propagation.

Radiofrequency (RF) Electromagnetic radiation used for telecommunications and found in the electromagnetic spectrum at longer wavelengths than infrared radiation (see Figure 1).

Specific energy absorption rate Rate at which energy is absorbed by unit mass of tissue in an electromagnetic field (unit watts per kilogram, $W\ kg^{-1}$).

Third generation Next evolution of mobile phone technology, based on **UMTS** and expected to result in widespread use of video phones and access to multimedia information.

TDD Time Division Duplex.

TDMA Time division multiple access. System that divides each frequency band into a number of time slots, each allocated to a single user. Allows several users to operate on the same frequency at the same time.

TETRA Terrestrial Trunked Radio system.

UMTS Universal Mobile Telecommunications System.

Wavelength (λ) Distance between two successive points of a periodic wave in the direction of propagation, in which the oscillation has the same phase (unit metre, m).