# THE PROCRUSTEAN APPROACH

## Setting Exposure Standards for Telecommunications Frequency Electromagnetic Radiation

**An examination of the manipulation of telecommunications standards by political, military, and industrial vested interests at the expense of public health protection**

# Chapter 3

## The Development of the IEEE C95.1 RF Standard

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**The Procrustean Approach**

According to ancient Greek legend there once lived in Attica a bandit named Damastus or Polypemon, who was nicknamed Procrustes, or "The Stretcher". He was known to entice, by force if necessary, passing members of the public to lie down on his iron bed. If they were too long he would cut off their limbs in order to fit the bed. If they were too short he would place them on a rack and stretch them until they would fit the dimensions of his bed – referred to as the Procrustean bed. Procrustes was eventually slain by his own method (cover image) by Theseus, a legendary king of Athens who, as a young man, had the habit of slaying robbers and monsters whenever he encountered them on his travels.

One of the derived meanings of Procrustean bed is an arbitrary standard to which exact conformity is forced. It was used to refer to Western radiofrequency (RF) human exposure standard setting by Professor V. V. Parin, a member of the USSR Academy of Medicine and quoted in the Foreword of A. S. Presman's book *Electromagnetic Fields and Life* (1970).

In the case study of the Standards Australia TE/7 Committee: Human exposure to electromagnetic fields (Chapter 5) the central issue of discussion was what constituted a suitable precautionary approach when setting RF exposure standards in order to address scientific uncertainty and provide adequate public health protection. That committee was ultimately disbanded because a suitable definition of a precautionary approach could not be agreed to and the proposed standard, based on the ICNIRP guidelines, was therefore unable to gain the required 80% approval in order to be passed.

This thesis contends that, rather than taking a precautionary approach, Western standard setting organisations such as the IEEE and ICNIRP have actually followed what can best be described as a Procrustean approach. This approach consists of cutting off from consideration scientific data that does not conform to their bed of knowledge. Such an approach can be considered just as inimical to public health protection as was Procrustes' mythical bed for the public of his time.

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# Chapter 3

# The Development of the IEEE C95.1 RF standard

> The weight of evidence approach was used for the [C95.1] standard development. This process includes evaluation of the quality of test methods, the size and power of the study designs, the consistency of results across studies, and the biological plausibility of dose-response relationships and statistical associations.
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> IEEE RF Safety Standard: Statement from the Inter-American Telecommunication Commission, Organisation of American States, June 2007

> The overwhelming [scientific] community commitment to thermal thinking severely limited the creativity of RF bioeffects research. Rather than attempting to learn from reports of athermal effects, the RF bioeffects community by and large devoted most of its attention to clarifying and proving what it already knew or to disproving claims believed to be false. This approach to research encouraged a single-mindedness that rigidly adhered to the thermal solution, a single-mindedness that can be seen in responses formulated when athermal effects were reported.
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> Nicholas Steneck in *The Microwave Debate*, 1984

## Overview

Any analysis on the development of the U.S. RF standard, now under the auspices of the Institute of Electrical and Electronics Engineers (IEEE), would be remiss if it did not acknowledge the significant contribution to the debate by Nicholas Steneck, Director of the Research Ethics and Integrity Program at the Michigan Institute for Clinical and Health Research. Steneck is also Professor Emeritus of History at the University of Michigan and a consultant to the U.S. Federal Office of Research Integrity, Department of Health and Human Services. In 1980 Steneck and colleagues published in *Annals of Science* an analysis of the early research on microwave radiation and in 1984 Steneck published his seminal work, *The Microwave Debate*, that was a case study on the unfolding RF debate over the safety of radiofrequency and microwave technology and the problems involved in assessing and managing possible technological hazards. He raised important questions over conflicting values, the influence of vested interests in influencing the direction of the debate, and the role of scientific uncertainty as it was unfolding in the development and marketing of RF emitting technology. However, Steneck's 1984 analysis stopped before the advent of the mobile phone revolution which had a significant impact on standards development. It also was not able to explore the important later developments on the internationalization of RF standards through the IEEE, the World Health Organisation's International EMF Project (IEMFP) and the International Commission on Non Ionizing Protection (ICNIRP). Another influential books at the time, *The Zapping of America* (1977), *Currents of Death* (1989) and *The Great Power-Line Cover-Up* (1993) by Paul Brodeur played a large part in bringing the public's attention to the microwave controversy but Brodeur's thesis has come under much criticism, including comments from Steneck over shortcomings in Brodeur's analysis and physicist Robert Park (examined later in this chapter). This Chapter draws on Steneck's 1984 work for the early U.S. standard developments because, in this author's opinion, it is the most reliable source available and covers a great deal of historical data not covered in the IEEE's historical review of the standard development.

Another important source of information on U.S. RF standards development used in this chapter is the New York City based newsletter *Microwave News*, edited by Louis Slesin PhD. This newsletter, published bi-monthly, has covered the RF debate since 1981 with extensive personal interviews with the people directly involved in the debate, and direct attendance to a large number of RF related conferences. It has been recognized as a fair and knowledgeable source of information that is not connected with industry or government agencies. Slesin, however, is not without his detractors, for example, physicist Robert Park claimed in his book *Voodoo Science* that *Microwave News* "had given the public a seriously distorted view of the scientific facts". Park's viewpoint needs to be understood in light of his physicist's understanding that while ionising radiation packs enough energy to break chemical bonds and thereby cause DNA damage, non-ionizing radiation does not have sufficient energy to do this. Therefore, according to Park, hazardous EMF biological effects below acute thermal interactions are an impossibility and anyone who claims differently is dabbling in Voodoo Science. [1]In 2003 *Microwave News* ceased a print form of its newsletter to be replaced with an Internet site. *Microwave News* is important for an analysis of the RF debate because much of the detailed information contained in the newsletter is not available elsewhere.

The central feature in the development of the American radiofrequency and microwave (RF/MW - hereafter referred to as RF) exposure standard, from the establishment of the American Standards Association C95 Committee in 1960 to the current C95.1 RF standard sponsored by the Institute of Electrical and Electronics Engineers (IEEE), has been that the only hazardous biological effect[2] from RF exposure to humans is tissue heating at high level exposure. The basis for this concept arose from previous medical experience with the use of RF as a therapeutic medium that was considered at the time to have beneficial effects through selectively heating human tissue. When a number of adverse health effects from RF emitting apparatus were observed, it seemed reasonable to attribute them to excessive heating of tissue from over-exposure to RF. By the mid 1930s the prevailing medical view was that the only biological effect of RF physical therapy (diathermy) treatments was tissue heating and that claims for other biological effects that were not related to heat were without foundation. This concept, or the "thermal-effects-only" school of thought, was given further scientific validity in the 1950s through the writings of Biophysicist Herman Schwan whose calculations indicated that an RF level of 10 milliWatts per square centimetre (10mW/cm2) was a safe level of exposure to avoid excessive tissue heating. This level was adopted by the U.S. Air Force (USAF) and later became the basis for the first American National Standards Institute (ANSI) C 95.1 RF standard of 1966. Acceptance of the thermal concept was also significantly boosted by the emerging Cold War between the U.S. and the Soviet Union.

In 1957 the Soviet Union had a number of spectacular satellite launches that translated into a capability to launch nuclear missiles deep into America. This presented the U.S. military with an urgent imperative to develop high power early warning radar systems to be able to detect a possible Soviet attack. This coincided with the first military RF research program in America, the Tri-Services Program (1957-1960) which essentially

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[1] Park, 2000, *Voodoo Science, The Road from Foolishness to Fraud*, Oxford Univ. Press, Chapter 7, Currents of Fear pp. 140-161.

[2] Other than obvious electroshock and burns from direct contact with a high power RF transmitting source. See: M. Stock, 'Technical Note 124: RF Shock and Burn: Notes from the research side', LBA Group, http://www.lbagroup.com/associates/lbatn124.php , accessed Feb 4, 2009.

had the task establishing 'ground rules' for the development of worker and personnel RF exposure standards that would not threaten the development of new high-power radar systems. By the conclusion of the Tri-Services Program Schwan's 10mW/cm2 thermal limit had been accepted by the majority of interested parties, (the military and manufacturers) as the only scientifically justifiable end-point for standard setting. Subsequent standards development, under the later sponsorship of the industry body, the IEEE, continued the work of further refining the understanding of thermal interactions with human tissue. This also saw the increasing exclusion of any other possible interactions not related to heating as outside the realm of accepted science used in standard setting.

It is important to note that this discussion on the development of the IEEE C95.1 RF standard is not intended to be a critique of the validity of the scientific data-base that underlies the standard. What can be said in defence of C95.1 is that its data base is quite extensive and well researched in relation to the known and well established thermal biological effects of exposure to RF, based on over half a century of laboratory animal research. In this respect C95.1 provides a useful purpose in providing a significant level of protection against thermal biological damage from acute short-term exposures. In its latest (2003) review of over 1,300 research papers the scientific committee overseeing IEEE C95.1 set out a number of "guiding principles" that they followed in their evaluation of the scientific literature base in setting exposure limits. They concluded, in part, that the thermal effect is the only established adverse effect and that only this should be used to base maximum exposure limits on. In relation to non-thermal RF biological effects the committee considered they were not established.

This chapter explores reasons why the thermal paradigm came to be the primary focus in RF standard setting while other possible biological effects were arbitrarily rejected for reasons other than scientific quality control. Seen in the development of the IEEE C95.1 RF standard are how military and corporate interests (users and makers of the technology) were able to assume control over the standard setting debate right from the very beginning and establish faulty risk assessment and science evaluation procedures. These were to their mutual benefit to assure that setting exposure limits would never become a threat to the development of new RF emitting technology, be it for military or commercial purposes.

The contribution of this chapter to the RF standard setting debate is to use the C.95.1 standard development process to argue that hazard risk assessments did not fully evaluate the scientific literature or "weight of evidence" for standard setting in situations where organisations responsible for the creation of the risk to be regulated, effectively control the process. This can also apply to other environmental issues with the central problem on how ensure that conflicts of interest do not bias regulatory outcomes remaining unresolved.

**The foundations of a thermal approach for RF standard setting: electrotherapy & diathermy**

By the end of the 19th Century the many incremental discoveries and advances in wireless telegraphy (in 1896 referred to as telecommunications) heralded in the birth of the modern electronic age. Along with the revolutionary inventions by Edison, Marconi and Tesla, just to name a few of the many pioneers, came an inevitable army of

entrepreneurs wanting to take advantage of the publicity surrounding the new technological revolution. Their contributions to the field consisted of an amazing array of electro-therapeutic devices that it was claimed could cure practically every disease known to man. There were electrical machines for pain relief; electric tubs for treating foot problems, electric baths with vaginal tubes, electric stools, electrical poison extractors, electrical belts for weak and debilitated conditions, and an electric hair brush to prevent baldness, falling hair, dandruff and headache, to mention a few.[3] Of course none of these devices had the slightest evidence as to their efficacy but by 1894 it was estimated that over 10,000 medical practitioners in the U.S. were regularly using some form of electro-therapeutic device to treat their patients[4].

By 1900 most doctors in the United States had at least one electrical therapy device in their office. None of these devices utilised high frequency microwaves but their widespread use imbued in the medical community an awareness of the possibility of electromagnetic fields being used as a therapeutic tool. The widespread use of these many devices in the medical community, coupled with extravagant advertising in popular publications of the day, brought calls for the need of standards for medical education and clinical practice from the medical establishment. This resulted in the passage of the Federal Pure Food and Drugs Act of 1906 [5]and soon after, the publication of the Flexner report in 1910 established science as the basis for medicine and clinical education. Electrotherapy was declared scientifically unsupportable and was legally barred from clinical practice[6]. Although this new regulation, the first ever to attempt to regulate EMF devices, did eliminate a wide range of very dubious devices, the acceptance of using radiofrequency as a therapeutic medium soon was on the ascendancy with the rapid development of radio technology that took off in the early 1920s. This era saw an amazing proliferation of businesses established to manufacture radio sets, and in many cases starting up their own transmitting stations as well. Companies sprang up in many countries, manufacturing radio components and marketing them nationally and globally through new trade magazines and catalogues.[7] It was seen as a wondrous technology and following on from the earlier electrotherapy craze, a new breed of entrepreneurs soon found new therapeutic applications for the technology in name of diathermy. By the 1930's diathermy, using radiowaves to heat tissue as a therapy was widely accepted as a beneficial new use of RF technology by the medical fraternity and it was used to treat everything from backaches and muscle pain to cancer[8]. Besides the diathermy devices, that worked by generating heat, there were other RF emitting medical devices that claimed not to depend upon a heating effect, such as George Lakhovsky's "Multiple Wave Oscillator" that was used in treating cancer[9]. Variants of the Lakhovsky oscillator continue to be used today.[10]

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[3] G. Gadsby, Electroanalgesia: Historical and Contemporary Developments, Section 3.2.11, Electroanalgesia in the 20th Century United States. http://www.drgordongadsby.talktalk.net/page11.htm, Accessed Apr. 17, 2006.

[4] B.H. Lipton, Bioelectromagnetism and Energy-Medicine 2001 http://www.brucelipton.com/bioelectromagnetism.php, Accessed Apr. 17, 2006

[5] U.S. Food and Drug Administration, 'The Long Struggle For The 1906 Law', *FDA Consumer Bulletin*, June 1981, http://www.cfsan.fda.gov/~lrd/history2.html, Accessed April 17, 2006.

[6] Lipton, 2001.

[7] T. White, United States Early Radio History, http://www.earlyradiohistory.us/index.html, Accessed April 7, 2006

[8] N. Steneck, *The Microwave Debate*, MIT Press, 1984, p. 25.

[9] C. Smith, S. Best, *Electromagnetic Man: Health & Hazard in the Electrical Environment*, JM Dent & Sons Ltd. London, 1989, pp. 14-16.

There were warnings as early as 1928 when Helen Hosmer from the Albany Medical College warned General Electric that their employees should use "extreme care" when working on radiowave apparatus due to the risk of extreme heating. In 1930 GE commissioned additional research at the Albany Medical College which consisted of exposing patients to RF heating. Some of the subjects complained of headaches, nausea, and/or dropping of blood pressure during exposure. As these symptoms were also reported during illnesses that cause fever, the General Electric researchers were not overly concerned. They reported that the patients did "not appear to be greatly distressed or fatigued when the maximum temperature is maintained for one hour and then allowed to return to normal while the patient is well blanketed." The researchers concluded that using the technology was safe provided caution was taken in its application.[11] The heating ability of RF fitted in well with the view amongst many physicians at the time that artificially produced fevers could help cure diseases, fevers being associated with the body's natural curing mechanism. In 1928 R.V. Christie from the Rockefeller Institute for Medical research expressed the prevailing view in medical circles that "the only constant effect which is known to be produced by high frequency alternating currents is that of heat production".[12] By 1930 research on the therapeutic use of radiowave-induced fevers was widespread in the U.S. and other countries. The next decade saw international conferences on the topic and hundreds of articles were published extolling the beneficial uses of diathermy heating.[13] Diathermy had become big business.

In the early 1930's a German physician and entrepreneur, Erwin Schliephaki, was quick to capitalise on the use of higher frequencies for the use in diathermy by developing short-wave diathermy machines and publicising his machines in Germany and the U.S. with advertising campaigns making all sorts of claims for the curative power of his short wave devices. As a result of these claims the American Medical Association became concerned, and attacked Schliephaki's claims in a 1935 article published in the Journal of the American Medical Association (JAMA). The article mentioned that many of their membership had been bombarded with "hyperenthusiastic" literature with "extravagant therapeutic claims" about the curative advantages of the therapy".[14] In 1935 the AMA convened its Council on Physical Therapy (CPT) to investigate Schliephaki's claims and the companies marketing his machines. Their findings set the tone for future discussions on non-thermal (athermal) bio-effects. The CPT stated their view that: "the burden of proof still lies on those who claim any biologic action of these currents other than heat production". All bio-effects from diathermy, regardless of frequency used, were simply put down to a heating effect. The CPT ruling had the effect of casting the existence of other possible non-thermal bio-effects as a rather dubious "hyperenthusiastic" claim.[15] According to Steneck, the research-orientated physicians who gave advice to the AMA, "clung firmly to the position that unless indisputable scientific evidence were found to

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[10] Dr. John Holt (now retired) of the Microwave Therapy Centre, Perth, West Australia, using a Lakhovsky derivative device to treat cancer patients, was featured in a series of programs on the Australian national TV *program A Current Affair* in late 2004.

[11] Steneck, 1984, op. cit., p. 27.

[12] H. Cook, N. Steneck, A. Vander, G. Kane, 'Early Research on the Biological Effects of Microwave Radiation: 1940-1960', *Annals of Science*, Vol. 37, pp. 323-351, 1980.

[13] Steneck, 1984, op. cit., pp. 25-26.

[14] Steneck, 1984, op. cit., p. 74.

[15] Steneck, 1984. op. cit., p. 76.

the contrary, there were no athermal effects".[16] This viewpoint was illustrated by a number of medical conferences at the time. For example, in 1937 at the First International Conference on Fever Therapy, held at Columbia University, the overwhelming majority of papers on short-wave therapy stated that there was no other purpose of exposure but to raise tissue temperatures. In that same year at the First International Congress on Short Waves, held at Vienna, Austria, the general agreement was that no other effects besides systemic heating had been proven to exist.[17] It was this viewpoint that was inherited by the military planners when they made assessments over possible hazards from radar microwave emitting technology in the 1940s –1950s.

By the late 1940s, enough evidence had accumulated to indicate that diathermy, and in particular the short wave (microwave) frequencies being increasingly used, could selectively elevate internal body temperatures without the patients feeling the increase due to the pain receptors being located in the skin (thus the possibility of internal damage with no warning until after the event). In addition there was evidence from animal studies that areas with insufficient blood flow to remove excess heat, such as the eyes and testicles, could be damaged. As cataracts took some time to form after exposure, this meant that delayed bio-effects existed. As far as the supposed exposure thresholds for thermal damage, researchers from the University of Iowa found that testicular damage to rats occurred at power levels below these thresholds, causing the researchers to suggest that "damages may result in part from factors other than heat". These concerns, and the obvious implications over the possibility of litigation against physicians who used diathermy machines, led to the abandonment of medical diathermy by the mid 1950s.[18] However the legacy of the previous widespread medical use of diathermy was a general medical opinion that:

- Hazards of RF exposure were solely from excessive heating of human tissue.
- Due to the AMA discrediting Schliephaki's extravagant claims, the issue of other possible effects not related to heating (non-thermal) were 'tarred with the same brush' as being rather dubious.
- A burden of proof was established by the AMA that would later manifest as one that placed this burden on scientists and the concerned public to prove that there were hazards other than thermal, not on the manufacturers and users of RF technology.

**Early research focuses on heating**

It was well known that uncontrolled heating outside the doctor's surgery, such as occupational heat stress, from whatever source (such as the sun), could have serious consequences, such as fatigue, increased pulse rate and heat stroke. For this reason the U.S. Navy's Bureau of Medicine and Surgery in July 1930 started an investigation of possible heat based health hazards posed by powerful new 80 MHz radio transmitters being used. Personnel who were working in the vicinity of these transmitters reported symptoms that clearly indicated body heating was taking place such as an unpleasant warmth and sweating of the feet and legs, general body warmth and sweating, drowsiness, headaches, pains about the ankles, wrists, and elbows, weakness, and

[16] Steneck, 1984, op. cit., pp. 77-78.
[17] Cook, *et al*., 1980, op. cit., p. 329.
[18] Steneck, 1984, op. cit., pp. 78-79.

vertigo.[19] What the Navy needed to know was the severity of the symptoms and if they could lead to permanent damage. The study consisted of six volunteers who were required to stand near an active transmitter until it became unbearable. The tests found that the volunteer's body temperature did increase a few degrees and that there were drops in blood pressure, however all symptoms disappeared when the transmitter was turned off with no apparent lasting ill health effects. Subsequent tests on the subjects did find that symptoms came on faster and recovery was slower, indicating a possible cumulative effect from repeated exposure, but this was simply dismissed as all subjects returned to apparent normal after the tests. Possible long-term effects were not a factor in the tests. As for possible dangers to human health posed by the new transmitters, the conclusion of the Navy investigators was that, as long a proper precautions were undertaken, "from a practical point of view there are none". Precautions would be to keep exposure to a minimum, use protective screening wherever possible, and keep workrooms well ventilated. [20] The Navy's results seemed to confirm that the effects felt by the test subjects were similar to those felt by workers in high-temperature environments. By the mid 1930s a clear consensus began to emerge that the dangers from RF radiation were from heat induced stress, which was not an unreasonable trade-off, given the significant benefits of the technology and that thermal effects were considered tolerable and reversible if kept within reasonable levels, the control of which was considered easily manageable.

In 1942, a year-long U.S. Navy test on 45 personnel who worked with radar including blood tests, physical exams and case histories, reported finding no evidence of significant effects. Some radar operators reported headaches, warming of the extremities and a flushed feeling. As these did not persist after exposure it was considered just a transitory thermal effect with no need for concern, especially as the average power of the units was about the same as some diathermy machines. A similar study by the Aero Medical Laboratory in Boca Raton, Florida in 1945 of 124 servicemen reached essentially the same conclusion. The investigators also made a comparison with maximum radar power levels being in the order of that used in diathermal therapy.[21]

In 1947 the Mayo Clinic in Rochester, Minnesota was able to access a new short-wave microwave generator from the military and their studies confirmed that the higher microwave frequencies provided an effective tool for inducing heating. They could be more easily focused than the older radiowave diathermy units and were more easily absorbed by the body. The microwaves could be readily directed to specific parts of the body. They announced that "Heating by microwaves offered the promise of considerable usefulness in the practice of physical medicine."[22] The important issue now became one of studying just how the body disposed of excess heat and what microwave levels could be tolerated in various parts of the body without causing adverse effects from heating. It was known that the blood circulatory system was the principle mechanism to remove excess heat from the core of the body to the surface, where sweating and evaporation then remove the heat. Two areas of the body, the eyes and testes, however, do not have efficient cooling systems and research had found in the 1940s that infrared, ultraviolet and ionizing electromagnetic radiation could produce

[19] Steneck, 1984, op. cit., pp. 27-28.
[20] Steneck, 1984. op. cit., pp. 28-29.
[21] Steneck, 1984. op. cit., pp. 29-30.
[22] Steneck, 1984, op. cit., p.31.

cataracts. Therefore the question was could microwaves also produce the same bio-effect in these parts of the body?

Research at Northwestern University Medical School in 1947 that focused microwaves directly on the eyes of dogs reported no adverse effects. The researchers said that if the same held true for humans then "this method should be a safe and excellent means for the application of localised heat to the eye." However, a research team from the State University of Iowa funded by Collins Radio (Air Force subcontractors) found an opposite effect. They exposed rabbits to either one brief high power exposure or several low power exposures to microwave and found significant effects. The rabbits given one brief/high power exposure began to develop cataracts three days later. The rabbits given several low-power exposures developed cataracts as long as 42 days later. The researchers wrote that their findings should not in any way discourage the use of microwaves for diathermy but did note "that precautionary measures may be of value to workers and patients frequently exposed to the radiations of microwave generators." When the researchers turned their efforts to the testes they also found evidence of tissue damage and they again issued precautionary advice: "precautions should be taken by those working in the field of high energy electromagnetic generators and by those giving treatments with microwave generators." [23] The researchers concluded in their report to Collins Radio that for both the eyes and testes "definite evidence has been found that injury may occur at relatively low field intensity". As a result of this research, Collins Radio warned in *Electronics* (1949) that "microwave radiation should be treated with the same respect as are other energetic radiations such as X-rays, α-rays, and neutrons". John Clark, writing for Collins Radio said that "it would be highly desirable in the light of these observations to set about establishing standards for the protection of personnel exposed to intense microwave radiation before anyone is injured. We have here a most unusual opportunity to lock the barn door before, rather than after, the horse is stolen".[24]

The research up to the 1950's focused on using brief exposures to high (acute) RF levels in animal studies in order to determine what were the thermal bio-effects of exposure. Low level studies on humans exposed to levels that could be encountered in medical treatment were not conducted and this emphasis on high level thermal effects was to set the pattern for all future research that formed the foundations of U.S. and Western RF/MW standard setting.

**The importance of radar realized during WWII**

In the early years of WWII it became apparent to both the Allied and Axis powers that radar was an important technology to extend the capabilities of both the air and naval forces, primarily in a defensive capacity. For example a chain of radar stations covering the South-East of England allowed Britain to track incoming German warplanes during the Battle of Britain in 1940 and gave Fighter Command an early warning to get their planes airborne in time to respond. Radar also avoided wasting valuable fuel reserves as the radar operators could give exact bearings to the incoming enemy planes. Radar installed in Hawaii in 1941 successfully detected the Japanese attack on Pearl Harbour,

[23] Steneck, 1984, op. cit., pp. 32-33
[24] Cook, *et al*., 1980, op. cit., p. 334.

but unfortunately the radar data was misinterpreted by inexperienced operators. [25] Research into radar was also underway in France, Italy, The Soviet Union and Japan during the war. Germany had an extensive radar development program but internal rivalries and organizational problems hindered its wartime development. [26] In the Soviet Union radar units were in operation as early as 1939 and during WWII a number of ground-based, air-borne and ship-borne radar systems were developed and deployed in the Soviet Union. By the end of the war the Soviets had started a major research development program for military radar systems with priority given to surveillance radars for air defence.[27] In the U.S. the importance of radar was seen in the fact that research on developing radar technology during WWII was given the same priority as research on developing the atomic bomb.[28]

Five years after WWII another impetus for a rapid development of all forms of military radar was the Korean War which saw increased funding for upgrading existing military radar systems to ones that could track the high performance jet fighters that were rapidly replacing propeller aircraft. In addition the Soviet Union was producing large numbers of long-range bombers capable of reaching American cities. This necessitated the development of airborne surveillance radar on all weather fighter aircraft.[29] Radar had become an absolute necessity for effective national defence. Considering this importance, any discussion on the development of RF standards must be seen in light of the corresponding development of military radar.

**The search for standards during the early Post War years**

During WWII radar and other RF/MW emitting equipment had power outputs that were roughly equivalent to the power outputs of diathermy equipment, typically in the tens to hundreds of watts. A direct comparison to diathermy devices was therefore possible – and since diathermy was thought to be beneficial, the hazards therefore were considered minimal, provided precautions were undertaken. By the 50s, however, new radar systems had outputs in the millions of watts and within the decade their power outputs had increased a thousand-fold more. At these power levels comparisons to diathermy were no longer relevant and by the early 1950s evidence started coming out that there may be adverse health consequences for those working with the new systems.

In October 1951 a microwave technician employed by the Sandia Corporation visited the company's medical director, Dr. Frederic Hirsch, complaining of blurred vision, which Hirsch diagnosed as bilateral cataracts and acute inflammation of the retina. Subsequent investigations by Dr. Hirsch found that the technician routinely exposed his head to the antenna radiations when checking to see if it was generating properly. Hirsch estimated the power level to be about 100 mW/cm2. In his report Hirsch recommended that the case was useful "as a means of recalling the attention of ophthalmologists, industrial

[25] C. Trueman, The Radar and the Battle of Britain, http://www.historylearningsite.co.uk/radar_and_the_battle_of_britain.htm, Accessed Mar. 26, 2010.
[26] Aviation During World War II: The German Side of the Story, http://www.century-of-flight.net/Aviation%20history/WW2/german_radar.htm, Accessed March 26, 2010.
[27] V.S. Chernyak, Ya. Immoreev, B.M. Vovshin, 'Radar in the Soviet Union and Russia: A Brief Historical Outline', *IEEE AES Systems Magazine*, Dec. 2003, pp. 8-12.
[28] Cook, et al., 1980, op. cit., p. 330.
[29] R. Strong, 'Radar: The Evolution Since World War II', Aerospace and Electronic Magazine, IEEE, Vol. 20, Issue 1, Jan. 2005.

physicians, and microwave operators to the potentialities of microwave radiations in order that the use of this form of energy will be accompanied by appropriate respect and precautions".[30]

In 1952 an investigation by Dr. John McLaughlin at Hughes Aircraft found numerous cases of internal bleeding in Hughes workers, as well as possible cataract formation amongst employees working with radar. Further investigation by McLaughin of both civilian and Air Force personnel developing radar systems uncovered two reports of leukaemia amongst a group of 600 radar workers and reports of jaundice and headaches in personnel working with microwave equipment. McLaughlin also conducted a literature search that indicated thermal effects may not be the only mechanism causing bio effects and wrote up a report to Hughes that was made public in February 1953. McLaughlin's report clearly stated his case that hazards may exist with exposure to microwaves. It was this report that caused Hughes Aircraft to ask its military clients for research to verify, or not, McLaughlin's findings. Within two months two major military sponsored conferences were convened and a full-scale effort to study the microwave effects issue was created.[31] Even at that early stage a list of potential problems that were to prove to be endemic to the RF standard setting process were raised at the 1953 Navy conference at the Bethesda Naval Hospital. The list is as follows:

- Extrapolation from animal exposure studies to the human body was difficult.
- Research findings interpreted by one researcher as evidence of effects can be interpreted by another as evidence of no effects. This subjective interpretation would therefore affect the standard setting process
- How can an objective interpretation of the data be done by an expert body when that body is of necessity made up of people from the same sector?
- Exposure data collected under field conditions were difficult to control and were usually not replicable.
- There were no outside observers to staff a neutral board with the necessary technical understanding to conduct an objective review, therefore both researcher and reviewed may represent the same school of thought.
- Once a standard is set, some exposed people would then be able to take legal action for perceived harm from previous exposures over that limit. This sets up an incentive for not reducing exposure levels below previously accepted levels.
- There is the problem of basic philosophies on who is to be protected, from what and to what extent.
- Also discussed at the Bethesda conference were other issues, such as funding constraints, peer group pressure and implications of experimental results all having an impact on the course of science progress.[32]

If these points were followed through in the subsequent Tri-Service Program the progress of standard setting may have been far different that what eventuated. As it turned out, however, these concerns were largely ignored in subsequent standard work.

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[30] P. Brodeur, *The Zapping of America*, W.W. Norton & Co., 1977, p. 26.
[31] Steneck, 1984, op. cit., p. 34.
[32] Steneck, 1984, op. cit., p. 46.

As a direct result of the 1953 McLaughlin report the Air Force's Air Research and Development Command directed the Cambridge Research Centre to investigate the biological aspects of microwaves with the aim to determine tolerance levels for both single and repeated exposures.[33] Once tolerance dosages were worked out with experimentation then appropriate exposure standards could be set. As time was to tell however, setting "appropriate" standards would prove not to be that straightforward. The navy also commenced investigations to establish the amount of RF induced heating energy that the human body could absorb and eliminate through normal body functions. Using only calculations an exposure level was initially set at 100mW/cm2. Biophysicist Herman Schwan, working at the University of Pennsylvania, and employee of the Navy from 1947 to 1951, disagreed with that level. Schwan's re-calculations showed that the 100mW/cm2 level was more than twenty times greater than what the body could dissipate. Schwan then recommended a 10mW/cm2 level, based on his thermal model to limit temperature rise.[34] Schwan's 10 mW/cm2 calculated value was supported by experimental data showing that the threshold for eye cataracts was greater than 100mW/cm2, therefore giving a 10 fold factor of safety against a biological effect of considerable interest at that time.[35] By 1960 all three branches of the U.S. military, as well as their industrial contractors, had concluded that the 10 mW/cm2 level was a safe level of exposure to prevent excessive tissue heating. This later became the basis for the first ANSI C 95.1 microwave standard in 1966, which Schwan was instrumental in drafting as chairman of the C95.1 committee.

Schwan's thermal model was based on his assumption that:

> [C]ell membranes are not likely to be affected directly by microwaves since fields of interest can only apply potentials across the membranes that are vanishingly small in comparison with potentials needed to yield significant membrane responses, and significant responses of biopolymers require field strength levels very much higher than those causing undue heating.[36]

This hypothesis, a valid assumption for the early 1950s, went on to become the only accepted mechanism for RF bio-effects in the U.S. and Western standards without ever being critically evaluated in light of subsequent research. It was a bio-effect that was readily observable in animal research. Alternative theories proposed later by Adey, Blackman, Frey and others that proposed other bio-effects that were not related to heating were largely ignored by the standard setting bodies[37]. This avoidance is apparently to do with the fact that these alternative theories undermined Schwan's 10 mW/cm2 thermal hypothesis and therefore threatened the very foundations of the U.S. military/industrial RF standard's risk assessment. To retreat from the 10mW/cm2 basis for standard setting and set a lower level to take into account other mechanisms would

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[33] Steneck, 1984, op. cit., p. 45.
[34] Steneck, 1984, op. cit., pp. 49-50.
[35] J.M. Osepchuk, R.C. Petersen, 'Historical Review of RF Exposure Standards and the International Committee on Electromagnetic Safety (ICES)', *Bioelectromagnetics Supplement* 6, 2003, pp. S7-S16.
[36] H.P. Schwan, 'Physical properties of biological matter: some history, principles and applications', *Bioelectromagnetics*, vol. 3 no.1, 1982.
[37] For a review of the scientific literature on non-thermal RF biological effects and possible mechanisms of interaction see the Bioinitiative Report, August 31, 2007. Available online at: http://www.bioinitiative.org/ , Accessed March 16, 2008

threaten the very basis for the military's assurances of safety for personnel working with the equipment and other people exposed to radar emissions.

**Conflicts of interest endemic**

The problem right from the beginning was that the only organization that had the resources, interest and authority to investigate the dangers from what was at the time primarily military equipment was the military itself. The medical community would have seemed a good candidate but there were concerns raised that many medical professionals were heavily committed, and were firm believers in the therapeutic uses of microwaves by diathermy machines. Thus a conflict of interest would have been inevitable if they were also charged with the conducting of research that was indicating that diathermy level microwaves were a health hazard.[38] Thus in the 1950s the emerging health effects issue was seen as a military problem, radar being primarily a military technology. An obvious conflict of interest with the military developing radar systems for national defence and evaluating the possible hazards of radar technology apparently went unchallenged. This conflict of interest was to prove to be a significant factor in subsequent RF standards development both in the U.S. and internationally as examined in this thesis. The issue of corporate conflict of interest with RF standard setting has been a problem right from the start of the research effort, and is the central theme of this thesis. As far back as 1953, Hughes Aircraft researcher John McLaughlin wrote of his concerns in a memo attached to his report, mentioned above. McLaughlin had claimed that the Raytheon corporation, a major manufacturer of diathermy equipment, was upset by the adverse publicity caused by the publication of reports of microwave cataracts and was putting pressure on the Navy to discontinue funding the research that had led to the reports.[39]

There was a conflict of interest within the military as well. On one hand the operational branches had as their mission an urgency to get new microwave radar equipment deployed in the field, therefore improving their defensive capabilities. After all it was the start of the Cold War with the Soviet Union. On the other hand, the services research branches' mission was concerned with the possible health hazard issue and basic research questions. When the first RF exposure guidelines were devised in the late 1950's the operational branches were not in favour of any restrictions that they perceived might be detrimental to their basic mission to provide an adequate defence for the nation.[40]

**The Tri-Service Research Program**

As an outcome of the two military conferences in 1953, by 1957 the military's newly created *Tri-Service Research Program* (1957-1960) was ready to start its stated mission to clear up any unknowns about microwave exposure and discover the basic mechanisms of microwave-tissue interactions. It was hoped that this would then lead to setting exposure standards to protect civilian and service personnel working on RF/MW generating equipment. The Air Force, however, not willing to wait for the program to come up with guidance, adopted its own 10mW/cm2 in-house exposure standard for RF/MW, based solely on Schwan's thermal calculations, one month before the program

[38] Steneck, 1984, op. cit., p. 35.
[39] Steneck, 1984
[40] Steneck, 1984, op. cit., pp. 36-37.

started in June 1957.[41] As for the goals of the Tri-Service Program, a high ranking Air Force officer testified at a Senate hearing that the objectives were "to acquire through laboratory experimentation, a basis for validating protective criteria to insure a safe radiation environment for personnel at the least possible cost to military operations."[42] His testimony indicated that the Air Force saw the Tri-Service Program not as an open inquiry to investigate all possible mechanisms for RF/MW bio-effects, but simply to validate the Air Force's thermally based "protective criteria" that its in-house standard was based on.

From its inception the over riding research effort in the Tri-Services program was to first find the mechanism of interaction. There was a level of intellectual bias here as any of the medical doctors who assisted in the effort firmly believed, because of diathermy, that the only possible adverse bio-effect from RF exposures was excessive thermal increases. Thermal considerations therefore easily became the main focus to the exclusion of any other possible bio-effect. This viewpoint was also shared by most of the biologists and engineers involved in the Tri-Service program and as a result the emphasis of the studies conducted for the program focused on examining in detail just what happens with RF radiation exposures in the 10mW/cm2 to 100mW/cm2 range. Rats, rabbits, dogs and monkeys were the animals used in the exposure studies, with power densities in the 10 to 100 mW/cm2 range aimed at producing thermal effects. Power density levels in this range seemed to fall in a tolerable range that did not overwhelm the body's normal cooling system.[43]

One of the principal investigators, veterinarian Sol Michaelson from Rochester University, started out by testing animals to known high-level thermal doses of RF energy (165 mW/cm2) to establish the features of thermally caused bio-effects. Other experiments were designed to determine how the excess heat affected the animals' bodies. Unexpectedly, some of Michaelson's research indicated that high-level, short-term exposures produced effects could be duplicated by lower-level, longer-term exposures, - suggesting that duration of exposure may be a factor to consider. The Tri-Service Program concluded however, that the bio-effects of RF energy were only short term and reversible in nature and that the body's natural cooling system could, up to a point, protect it from the potential dangers of RF exposure. Therefore the task was to find the maximum level exposure that the natural defence against excess heat stress provided protection.[44]

Experiments to test the validity of the thermal-only viewpoint by conducting exposure studies below the presumed thermal level to see if any bio-effects still occurred were not done. As stated above, the emphasis with the Tri-Services studies was to clarify the thermal threshold for effects and not to look for other possible interactions that would only bring into question the Air Force's "protective criteria". As the Tri-Service Program progressed, those concerns expressed at the 1953 Bethesda conference on the necessity of independent review boards, objective interpretations and exploring conflicting points of view, etc., eventually disappeared. As Nicholas Steneck pointed out in *The Microwave Debate*:

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[41] Steneck, 1984, op. cit., p. 50.
[42] Brodeur 1977, op. cit., p. 32.
[43] Steneck, 1984, op. cit., p. 37-39.
[44] Steneck, 1984, op. cit., p. 42.

> Conflicting points of view were passed over, scientific ambiguity was ignored, and contrasting philosophies left unexplored as a single-minded approach gradually crept in and came to dominate all decisions.[45]

This single-minded approach saw the Tri-Services program gradually come under the control of just one man, Colonel George Knauf, a military surgeon with experience on the latest high-powered radar systems. Knauf was initially placed in charge of the Tri-Service Program's effort at Rome Air Force Base in Rome, New York. Gradually, however, his interest in the program and enthusiastic statements about its progress led to him being assigned to head the entire program, essentially having the final say in issues of scientific interpretation and application. The emphasis on validating the Air Force's "protective criteria" was apparent in the 1957 statement by Knauf at a Tri-Services conference that "I think this might be a good time to say that up to date there has not been any effect produced or even hinted at power levels which remotely approach our established maximum safe exposure level." At the concluding Tri Services conference in 1961 Knauf enthusiastically said that: "I am indeed pleased to say that up to today we have not seen any research data which shakes our faith in the validity of this arbitrary safe exposure level, which we sponsored some five years ago."[46] Knauf's conclusions were not questioned by the military at all, as it gave closure to the earlier concerns raised by Laughlin at Hughes and others – all was well as long as the 10 mW/cm2 standard was not exceeded. The symptoms reported in the investigations on humans exposed to microwaves in the course of their work was considered as transitory, as symptoms appeared to disappear after exposure ceased. Knauf considered that only immediate permanent damage as a result of excessive heating as a significant biological effect. Minimal overheating was accepted because the body had the ability to cool itself. Testicular damage that could occur around the 10 mW/cm2 level was ignored and cataract damage was considered to occur only above the 100mW/cm2 level.[47]

Colonel Knauf's 'quick-fix' was what the military urgently needed considering the political climate that existed at that time. On October 4, 1957, the Soviet Union successfully launched Sputnik I, the world's first artificial satellite and then followed by another, the successful launch of Sputnik II on November 3rd 1957, carrying Laika, a dog, into orbit.[48] In comparison America's efforts were plagued with a series of failures and it was not until January 31 that they were able to successfully launch Explorer I, America's first satellite.[49] As acknowledged by NASA, the Soviet Sputnik achievements ushered in new political, military, technological, and scientific developments and marked the start of the space age and the American/Soviet space race. [50] What was also important about the Soviet space achievements was that it caused concern in the U.S. that the Soviet's proven ability to launch satellites meant that the Soviets now had the capacity to launch ballistic missiles capable of reaching American cities. According to an Australian ABC

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[45] Steneck, 1984, op. cit., p. 48.
[46] Steneck, 1984, op. cit., p. 50.
[47] Steneck, 1984, op. cit., p. 53.
[48] NASA,'Sputnik and the dawn of the Space Age', Oct. 10, 2007, http://history.nasa.gov/sputnik/index.html, Accessed Apr. 28, 2006.
[49] C.M. Green, M. Lomask, 'Vanguard – A History', NASA Historical Reference Collection, NASA History Office, NASA Headquarters, Washington, DC., 1970, Chap 12: 'Success – and After' http://history.nasa.gov/SP-4202/chap12.html, Accessed Apr. 28, 2006.
[50] NASA, 2007.

TV documentary *Space Race: Race For Satellites* American concerns at that time were that Soviet ballistic missiles were being developed, not to launch satellites, but as the best means for destroying the U.S. [51]

An obvious influence to decisions made during the running of the Tri-Services program and the acceptance of the Air Force's "protective criteria" was the creation of the Defense Advanced Research Projects Agency (DARPA) in 1958 as a response to the Soviet Union's launching of Sputnik. DARPA reported directly to the Secretary of Defense and was given a mission to assure that the U.S. maintained "a lead in applying state-of-the-art technology for military capabilities and to prevent technological surprise from her adversaries".[52] As a primary state-of-the-art technology being developed at the time was high-power early warning radar, discussions of possible adverse effects below the Air force's "protective criteria" would have been viewed with concern and possibly as a threat to national defence (radar development) if allowed to continue. This was an era when a fear of the extent of the Soviet threat to America's very survival was paramount. Senator Joseph Mccarthy was making accusations that the U.S. Army and State Department had been infiltrated by Soviet agents. A communist army had taken over China and thousands of American soldiers had been killed fighting communist forces in Korea. There was an attempted communist takeover in Greece, and strong communist political movements in Italy and France. According to Stephen Kizner, author and veteran New York Times correspondent, during the 1950s the political leadership in the U.S. was "gripped by a fear of encirclement, a terrible sense that it was losing the postwar battle of ideologies".[53] There was, therefore, an urgency to develop and deploy new improved radar systems to detect any Soviet missiles launched over the Arctic Circle. Any consideration of non-thermal bio-effects from radar was seen as having the potential to adversely impact on systems deployment. This was stated by Michaelson when he admitted that if the U.S. adopted stringent RF standards, similar to the Soviets, "the harm that would be done to industry and the military would outweigh any proposed public-health benefit."[54]

By the time the Tri-Service Program was terminated in 1961, the thermal effects only viewpoint, as exemplified by Knauf and Schwan, was well on its way to becoming accepted as the only way that RF microwave exposure interacted with human body. The military's de-facto 10 mW/cm2 "protective criteria" was the favoured standard. The possibility of other biological effects not related to actual heating was clearly rejected in the Tri-Service program. According to Robert O. Becker, author of *Cross Currents*, as more advanced radar was developed, research evidence for non-thermal effects came to be viewed as a threat to national security'.[55] - See the section on PAVE PAWS in this chapter for an example of this. Becker pointed out in his book *The Body Electric* (1985) (co-authored with Gary Selden) that in the year before the book was published the military was essentially buying the science it wanted with two-thirds of the $47-billion federal research budget going into military research projects with those organizations dolling out research finding primarily interested in preserving the current orthodoxies. [56]

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[51] ABC TV (Australia), 'Space Race: Race For Satellites', Oct.15, 2006.
[52] DARPA website, http://www.darpa.mil/body/overtheyears.html, Accessed Aug. 26, 2008.
[53] S. Kinzer, *Overthrow: America's Century of Regime Change from Hawaii to Iraq*, Times Books, 2006.
[54] A. Marino, J. Ray, *The Electric Wilderness*, San Francisco Press, p. 16, 1986.
[55] R. Becker, *Cross Currents*, Jeremy P. Tarcher, Inc. Los Angeles, 1990, p. 299.
[56] R. Becker, G. Seldon, *The Body Electric*, Quill publications, 1985, p. 333.

Becker's point on radar development was in agreement with what was stated in Paul Brodeur's book *The Zapping of America.* According to Brodeur, by the conclusion of the Tri-Services Program the military knew some of its high-powered radar systems already exceeded the 10 mW/cm2 level. For example, leakage from the Air Force's Ballistic Missile Early Warning System could expose nearby personnel to microwaves in excess of that level. As well, the Navy knew that average microwave levels on the flight decks of aircraft carriers exceeded that level and could not be lowered without drastically curtailing their operations.[57] Obviously from the military's point of view, funding research that brought into doubt the safety of military technology, and therefore national defence capabilities, could be considered a threat to national security.

Becker has written in some detail on political attempts to curtail his research programs at the Veterans Administration, apparently as a consequence of his very public involvement in powerline hearings over possible health impacts of a planned transmission line in New York State. Apparently most of the pressure to cut his funding originated from the Department of Defence (DOD).[58] The connection with civilian powerline fields (extremely low frequency fields) and DOD concerns would have been because of Becker's previous work with the Navy on the Sanguine project that used ELF magnetic fields as a world-wide communications medium to communicate with submarines.[59] On New Years day 1981 Becker's lab, as one of the few bioelectromagnetic laboratories outside of DOD control, was disbanded.[60]

**Soviet standards**

Launching satellites was not the only area where the Soviets led the way. By taking a completely different research approach to understanding how RF/MW interacts with living tissue, Soviet scientists came up with radically different conclusions as to what was a safe level of exposure for standard setting and concentrated their research on possible non-thermal hazards. This was in stark contrast to the U.S. Tri-Service Program which focussed on identifying hazardous thermal effects through animal studies using high-dose short-duration microwave exposures (thus dismissing the non-thermal problem as an inconvenience). As mentioned previously in this thesis this fundamental difference was expressed by Professor V. Parin in the Foreword to Presman's 1970 book on Soviet bioelectromagnetic research, *Electromagnetic Fields and Life*:

> EMFs can have nonthermal effects and that living organisms of diverse species – from unicellular organisms to man – are extremely sensitive to EMFs. Some of the discovered features of the biological action of EMFs clearly do not fit the Procrustean bed [61]of the heat theory.[62]

At the same time as the Tri-Services was just concluding its basic thermal research in 1960, the Academy of Medical Sciences in the USSR published a report *Biological Action of Ultrahigh Frequencies* (UHF - 300 MHZ to 3000GHZ) that identified numerous bio-

[57] Brodeur, 1977, op. cit., p. 34.
[58] Becker, Selden, 1985, Postscript, pp. 330 – 347.
[59] Marino, Ray, 1986, pp. 1 – 4.
[60] Becker, Selden, op. cit., 1985, p 347.
[61] Defined as an Arbitrary and often ruthless disregard of individual differences or special circumstances.
[62] V. Parin in Foreword to *Electromagnetic Fields and Life*, by A.S. Presman, Plenum Press, New York-London, Foreword xi, 1970.

effects from both animal and human exposure to radiofrequencies above 300 MHz.[63] Similar to what Schwan found, the Soviet scientists observed a detectable thermal effect at 10mW/cm2 and above. However, in contrast to the Tri-Services high-level (over 10mW/cm2) exposure studies, the Soviet scientists primarily were concerned about bio-effects below the thermal threshold of 10mW/cm2. Much of the work was documenting the actual health impacts on workers working with UHF. Symptoms reported in the Russian literature include: fatigue and slow recovery of energy, muscle weakness, reduced intellectual activity, absent mindedness, diminished sex drive, headaches, sleeplessness, dizziness, heart palpitations, fast or slow heart beat, hair loss, overactive thyroid, changes in the menstrual cycle, breathing problems, etc.[64]
The report concluded that:

> Illness after the influence of UHF (radiofrequency/microwave) is characterized primarily by functional disorders of the nervous and cardiovascular systems, manifested in the development of an asthenic symptom complex, symptoms of vascular hypotension, bradycardia, and dystrophy of the myocardium, and changes in the crystalline lens (cataract) in the case of a considerable intensity of influence.[65]

It was this taking into consideration actual bioeffects of Soviet workers exposed to RF/MW levels below the thermal limit that played a significant part in the Soviet 1958 occupational exposure standard being set at 0.01mW/cm2, 1000 times lower that the U.S. thermal protective standard limit of 10mW/cm2. The Soviets used a safety factor of ten: their standard was one-tenth of the exposure intensity at which symptoms were known to occur in humans. (1mW/cm2 exposure for one hour divided by a ten-hour workday equals 0.1 mW/cm2 exposure level, divided by the safety factor of 10 ). For the Soviet public the exposure limit was set at 0.001 mW/cm2.[66] Other differences between the U.S. and Soviet standards were that the Soviet standard required, by law, pre-employment medical examinations of all prospective RF/MW workers. Applicants who had a history of blood diseases, epilepsy, cataracts, central nervous system diseases, endocrine diseases, ulcers, glaucoma, cardiovascular injuries, etc were deemed unfit to work with UHFs because exposure could exacerbate these conditions. Another consideration of the Soviet standard was the possibility of cumulative effects of non-thermal RF/MW exposures over time, including the possibility of reproductive and genetic effects.[67] It is interesting to compare the Soviet standard's emphasis on actual subjective and objective symptoms of personnel working with RF/MW equipment with the "biological endpoint" of the U.S. RF standard which is based on food motivated learned behaviour in laboratory animals exposed to acute levels of RF/MW.[68] A question arises here on why the Soviet Military planners were apparently not concerned about compliance with strict occupational RF/MW standards that were up to 1000 times lower than the US standard. It may have been the case, as Sol Michaelson claimed, that the

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[63] A.A. Letavet, Z.V. Gordon, (eds). *The Biological Action of Ultrahigh Frequencies*. USSR: Academy of Medical Sciences, 1960. (English edition by the U.S. Joint Publications Research Service.) As quoted in *Microwave Sickness* by Lucinda Grant, Part 1, 1996.
[64] K. Hecht, H.U. Balzer, Biological Effects of Electromagnetic Fields on Humans in the Frequency Range 0 to 3 GHz: Summary and results of a study of Russian medical literature from 1960-1996. German Federal Ministy for Postal Services and Telecommunications, Berlin 1997.
[65] Letavet, Gordon, 1960.
[66] L. Grant, *Microwave Sickness*, 5 part series, *Electrosensitivity News*, vol. 1, no. 6 1996 and vol. 2, no. 1-4, 1997.
[67] Grant, 1996.
[68] Osepchuk, Petersen, 2003.

Soviet military was exempt from compliance and could happily go about its business unfettered by having to meet limits[69]. It may have been the case, however, that the Soviets were far more careful not to expose their service men and women to what they considered harmful microwave levels. This would seem to have been the situation according to the detailed requirements for personnel working with microwave equipment as laid out in the Soviet regulation: *Safety Regulations for Personnel in the Presence of Microwave Generators* (Nov. 1958). These requirements were far stricter than those practised in the U.S. at the time.[70] It is also possible that with the Cold War, the Soviets also saw a possible propaganda advantage in undermining international confidence in the US standard by maintaining a far stricter one. Whatever the case may have been, the Soviet era scientists and standard setters apparently worked in a scientific environment apparently free of interference from a Capitalist military industrial complex. As a result they were able to work out what they considered was a safe level for human exposure to RF/MW free of Western style risk assessment cost-benefit considerations. The fundamental difference in research priorities can be seen in the fact that as microwave research the U.S. declined after the Tri-Services program finished (the military had the answers it wanted), the Soviet (Russian) scientific community and other Eastern Block nations pursued an active research program specifically on identifying low-level, chronic effects. [71] [72]

**Tri-Services Program: pros and cons**

Becker and Brodeur saw a conspiracy in the Tri-Services Program's focus solely on thermal considerations[73] but it must be acknowledged that, at the time, no epidemiological studies of RF exposed populations had yet been conducted, at least outside of the Soviet Union. In addition there was a mindset already established on thermal considerations, largely as a result of diathermy and Knauf, being a medical doctor, would have been well versed in the therapy. Due to the urgency of needing to come up with definitive answers, the most obvious course of action was to concentrate on the known effect of tissue heating, determine a hazardous level, and then to set standards to prevent this. The Tri-Service Project had to go with what limited information it had managed to accumulate and come up with recommendations based on that information. Its recommendations had to be expressed in a framework that would not impede the military's operational imperatives at a time when it was thought the Soviets had a tactical nuclear weapon advantage. The Tri-Services program concluded that perceptible pathological burns were produced by exposure to 100 mW/cm2 microwave radiation and by using a safety factor of 10 came up with Schwan's original calculation of 10 mW/cm2 to protect against thermal hazards.[74] Even though there certainly was a vested interest in maintaining a thermal outlook right from the beginning, it is reasonable to assume that, considering the limited literature base at the time, basing recommendations only on thermal effects may have been the best that they

[69] Correspondence with Andrew Marino, October 20, 2006.
[70] Brodeur 1977, op. cit., p.37.
[71] Cook, *et al*., 1980, op. cit., p. 348.
[72] A detailed discussion of Eastern Block research is given in: K. Marha, J. Musil, H. Tuha, *Electromagnetic Fields and the Life Environment*, (translation) San Francisco Press, 1971.
[73] Becker, 1990, op. cit., p. 299, and Brodeur 1977, op. cit., p. 34.
[74] L. David, 'A Study of Federal Microwave Standards', U.S. Department of Energy, 1980, p. 21.

could do. Allowing that viewpoint to become a paradigm in spite of later research is another matter though.

The Tri-Services Program had a number of significant weaknesses.

- As the Tri Services Program progressed, too much interpretive power was given to just two men, Air Force Colonel Knauf and Herman Schwan. The research program essentially then turned out to be a two-man show, with investigators being free to express opinions, but with no power to influence either Knauf's decision making process or Schwan's belief in his 10mW/cm2 safe level. Therefore, the foundation of the first C95.1-1966 RF standard was not based on decisions of neutral review boards and objective scientific interpretations as was originally proposed at Bethesda, but on an untested assumption of the correctness of Schwan's 10mW/cm2 calculations.

- The Tri-Services Program failed to test the scientific validity of the 10 mW/cm2 level, which was based solely on Schwan's calculations on non-biological models. This is because none of the Tri-Service studies were conducted at intensities below Schwan's level[75], with the majority of experiments using exposures above 100 mW/cm2. [76] Reports by American, German and Soviet scientists that exposures below 10 mW/cm2 could cause biological effects were arbitrarily dismissed as incompetent and not worthy of consideration.[77]

- Unlike their Soviet counterparts, the Tri-Services Program failed to include in its overall work a detailed investigation of the actual symptoms being reported by personnel exposed to microwaves, and at what levels these symptoms were occurring. These symptoms were considered to be only transitory in nature and of no significance, an opinion reinforced by Schwan's belief that reports of non-thermal injuries were anecdotal and unreliable.[78] Shared beliefs in thermal effects combined with the pressures of the Cold War to field high power radar systems for national security made it all too easy and convenient to dismiss the possibility of non-thermal bio-effects from the technology. It was this dismissal that laid the foundation for all Future Western RF/MW exposure standards and led to a scientific confrontation with Russia and China by the start of the 21st Century over which school of thought was most scientifically valid for human health protection. This will be examined in Chapter 4.

- 75% of the research papers that came out of the Tri-Service Program failed to list all the accepted parameters that should be included in a research paper, such as frequency used or type of experimental animal used.[79]

[75] Marino, 1986, op. cit., p. 15.
[76] David, 1980.
[77] Marino, 1986, op. cit., p. 16.
[78] Marino, 1986, op. cit., p. 14.
[79] David, 1980, op. cit., p. 16.

- Problems of dosimetry (determining actual exposure levels) and a lack of replication of findings (a key scientific requirement) brought into question the scientific validity of the overall program. [80]

- Largely due to the influence of Schwan and Knauf, the program concluded that only immediate permanent damage was significant.[81]

**Early and short-lived alternatives to the military's 10 mW/cm2 standard.**

During this time, civilian industry developing microwave technology (mainly radar) for the military was trying to develop guidelines to protect their employees working on the equipment. Bell Telephone Laboratories and General Electric, both major military contractors, sponsored a meeting that put more emphasis on the empirical data (subjective and medical reports of actual harm, similar to what the Soviets were doing) as they were not satisfied that the military's thermal only approach was adequate. Particular attention was paid to the 1952 work of Frederic Hirsch of the Sandia Corporation who found cataract formation in laboratory technicians regularly exposed to microwaves at power levels of around 100mW/cm2, which was the exposure level at which actual thermal damage was known to occur.[82] There was no question about this being a hazardous level but how large a safety margin needed to be to provide protection was in dispute. Therefore in 1954, one year after the 1953 Bethesda Naval conference, General Electric (GE) set its in-house standard of 1mW/cm2, using a 100 fold safety factor and Bell used a 1000 fold safety factor, giving a standard of 0.1 mW/cm2 (100uW/cm2). These limits set by GE and Bell were considered to be "safe under all conditions" whereas any exposure over the military's 10mW/cm2 was considered hazardous[83]. Unlike the Soviets however, these levels were only in consideration of thermal hazards. These lower levels, and alternative viewpoints on providing extra safety margins, questioned the adequacy of the military's 10-fold safety factor for the 10 mW/cm2 standard. This difference was to end after a series of meetings between Knauf and Benjamin Vosburgh, GE's standards consultant. Soon after, in 1958, both GE and Bell acquiesced to the military's 10-fold safety factor thereby validating the 10mW/cm2 standard.[84]

Steneck pointed out however that there was another strong factor for both GE and Bell abandoning their initial strict in-house standards, a factor that was to dominate the RF standard setting scene forever after. New technological advances meant that old safety standards could no longer be maintained as microwave levels steadily increased. GE was able to initially set a 1mW/cm2 standard for its factories but with the steady advancement of higher power radar equipment that level became increasingly more difficult to maintain. In some cases whole areas had to be vacated while new equipment was being tested, thus placing an impediment on technological advancement.[85] Thus began the pattern that continues to this day, where human health protection is

[80] Cook, *et al*., 1980, op. cit., p. 349.
[81] Steneck, 1984, op. cit., p. 53.
[82] B.B. Levitt, *Electromagnetic Fields, A Consumer's Guide to the Issues and How to Protect Ourselves*, A Harvest Original, 1995, p. 22.
[83] Osepchuk, Petersen, 2003, op. cit., p. S7.
[84] Steneck,1984, op. cit., p. 51.
[85] Steneck,1984, op. cit., p. 52.

considered only to the point that it does not impede technological development. This was the case 40 years later in the Australian RF standard setting committee in 1998 as will be examined in Chapter 5. In the Australian case the industry's stated reason to increase the allowable RF limits was to accommodate the new 3G wireless technology that had emissions in excess of the existing Australian / New Zealand RF/MW standard of 200uW/cm2.

When GE's Vosburgh agreed to relax his company's in-house standard to accommodate the military he did express reservations that the safety factor issue may need a re-appraisal. He saw the 10mW/cm2 level as being close to a 'safety-risk' line and he recommended constant monitoring at a 1mW/cm2 level in order to allow for harmonics and spurious waves.[86] Vosburgh also expressed the possibility of non-thermal and cumulative effects. He saw a possible re-appraisal to the safety factor "if and when it has been proven that some important part of that [microwave signal] is absorbed by susceptible tissues in the form of non-thermal energy having a cumulative effect".[87]

Despite Vosburgh's reservations he articulated the growing philosophy on risk versus benefits that was taking shape. Vosburgh said that "[i]t is reasonable to err on the safe side but not so far that it hurts; not so far that progress in the art becomes jeopardised; not so far that we will one day laugh too loudly at our present day fears".[88]

Though the standard setting focus at that time was on occupational and service personnel exposures, those early decisions on "safety factors" as voiced by Vosburgh, meant a shift of the burden of risk to those who are exposed for the benefit of the military and industries developing the new technology. Safety became a goal subservient to the operational requirements of technological development. Uncertainty over bio-effects other than heating was not considered sufficient grounds to impede development. This meant that as long as uncertainty existed, it was not a threat to the development of newer and ever more powerful radar systems. Andrew Marino expressed the situation as one of risks versus benefits, with the risks of harm that could be done to industry and military from a strict standards of far greater weight than any proposed public health benefit.[89] With the Cold War clash with the Soviet Union for global supremacy in full swing by the late 1950's, not placing restrictions on the development and deployment of new technology was a significant consideration in setting US standards.

Robert O. Becker, one of the early researchers into bioelectromagnetics who had served on a panel of experts evaluating a number of Navy funded projects in the early 1970s, described the U.S. military complex as very much like a living organism "constantly sensing its environment, integrating information, and reaching decisions, and then acting on those decisions by using the appropriate weapons systems". Becker described this organism as having a "central nervous system" based on information transmitted by electromagnetic fields with its sensory organs being microwave scanners [radar], satellites, and sensitive listening devices to listen in to the enemy's radio communications. The nerve impulses of this organism were radio communications from

[86] Steneck,1984.
[87] Steneck,1984.
[88] Steneck,1984.
[89] Marino, 1986, op. cit., p. 16.

ELF to microwave frequencies. In order for this organism to operate at a peak level it depended upon the "unrestricted use of all frequencies in the electromagnetic spectrum at unlimited power densities". [90]

**PAVE PAWS: Health concerns or a threat to national security?**

In the late 1970s the U.S. Air Force proposed to increase the range and power levels of its coastal early warning radar systems by installing a new system, PAVE PAWS (Precision Acquisition of Vehicle Entry Phased Array). The new system used more than 10,000 individual fixed antennas (i.e. they did not rotate) that were controlled by computers to create a single beam that could be quickly directed in any direction in a 240-degree field and could detect an object as small as a football up to 1,500 miles away. One was built at Beale Air Base, California and one at Otis Air Force base on Cape Cod, Massachusetts. In both cases citizens' coalitions sprang up in opposition to having the systems in their areas. In Cape Cod apparent cancer clusters heightened community concerns and this led to a number of expert panels giving an all-clear to the PAVE PAWS system. Quite aside from the alleged cancer cluster issue, the PAVE PAWS controversy is important for the theme of this thesis as an example of how novel scientific claims are handled in RF standard setting.

The PAVE PAWS system operated at a carrier frequency of between 420 and 450 MHz and was pulsed at 18.5 hertz. This is very close to the 16 Hz modulation frequency riding on a 450 MHz frequency that Ross Adey[91] and co-workers have identified as a biological frequency window that can alter biological processes at non-thermal levels. In one study, Calcium-efflux was increased in isolated chicken cerebral tissue[92] and in another, this time on live cerebral cortex of cats, the researchers saw alterations in brain chemistry in about 70% of the exposed cats. [93] In his 2002 letter to Dr. Rick Jostes from the National Academy of Sciences Board on Radiation Effects Research (NAS/NRC PAVE PAWS committee) Adey pointed out the conflict of interest and bias problem within the USAF and the IEEE Subcommittee 28 in their refusal to acknowledge the existence existence of nonthermal ELF and microwave biological interactions. Adey stated that "for more than 20 years, the USAF has aggressively asserted that microwave fields have only one mode of biological interaction – through tissue heating. There has been a consistent denial of nonthermal interactions, and as a corollary, that tissues have no capacity to demodulate pulse – or amplitude-modulated microwave fields". Adey also mentioned how the USAF has spread its thermal doctrine internationally through the NATO countries as well as dominating IEEE Standard setting process. [94]

In addition to the concerns expressed by Adey, Dr. Richard Albenese, a USAF physician at Brooks Air Force base in San Antonio, Texas, and colleague Professor Kert Oughstun,

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[90] R. Becker, *Cross Currents*, Jeremy P. Tarcher, Inc, 1990. pp. 297-298.

[91] Ross Adey (deceased) is one of the best known and published bioelectromagnetics researchers in the U.S. He was an elected fellow of the IEEE for his contributions in the fields of radio physics and radio engineering and pioneered the detection system now used in modern broadband detection technology.

[92] S. Bawin, W. Adey, I. Sabbot, 'Ionic factors in release of $^{45}Ca^{2+}$ from chicken cerebral tissue by electromagnetic fields', *Proc. Natl. Acad. Sci.* vol. 75, no. 12, pp. 6314 – 6318, Dec. 1978.

[93] W. Adey, S. Bawin, and F. Lawrence. Effects of Weak Amplitude-Modulated. Microwave Fields on Calcium Efflux From Awake Cat Cerebral Cortex. Bioelectromagnetics. 1982;3(3):295-307.

[94] W. Adey, letter to Dr. Rick Jostes, Senior Program Offices. Board on Radiation Effects research, NAS, JUl. 31, 2002.

researcher and author of the textbook *Electromagnetic Pulse Propagation in Causal Dielectrics* with G.C. Sherman and member of the editorial board of *IEEE Transactions on Antennas and Propagation* also expressed safety concerns. Albanese and Oughstun were concerned that not enough research had been done on the high powered electric and magnetic microwave pulses emitted by the individual elements of the PAVE PAWS radar. Their calculations indicated that the pulses may be powerful enough to generate Brillouin precursors created when a very fast pulse of radiation enters the body and induces a burst of energy that can penetrate far deeper into the body than conventional radar. Far from being a theoretical concept Brillouin precursors are being utilised in recent ultra wide band imaging technologies and in USAF research on improved airborne surveillance.[95] Despite evidence for the existence of Brillouin precursors being of biological significance, however, they were rejected for consideration by the IEEE's standard setting committee. The committee's reason was because there was no "evidence in the peer-reviewed scientific literature supporting Brillouin precursors as being biologically important at RF frequencies".[96] Physicist Robert Adair went further in claiming that Brillouin precursors were far too weak to ever effect biology and that Albanese and Oughstun were practicing voodoo science. Adair also stated that the claims of possible hazards from Brillouin precursors were "damaging to the Air Force and in its role in defence of the United States – *my* country – and *my* Air Force".[97] It can be argued that on one level Adair is correct about the danger posed by work of Albanese and Oughstun on Brillouin Precursors. If their alleged bioeffect on the human body was established by further research/replication studies and peer reviewed publishing it would invalidate the whole concept of safety through SAR calculations that lay at the foundations of both IEEE C95.1 and ICNIRP. This would not only be a problem for PAVE PAWS type radar systems but all manner of new communications and surveillance systems being developed by the military and industrial sectors, a possibility raised by Oughstun. In a 2002 *Microwave News* article, Oughstun mentioned that "as data transmission rates continue to increase, wireless communications systems will approach closer to and may, at some time in the not-to-distant future, exceed the conditions necessary to produce Brillouin precursors in living tissue".

Exactly eight years later (as of April 2010) there is no known further research being conducted on the biological significance of Brillouin precursors (other than possibly restricted military research). This means that the IEEE can rightfully claim that there is no evidence in the peer-reviewed scientific literature supporting Brillouin precursors as being biologically important at RF frequencies.

Keeping with the Procrustean Approach theme of this thesis, what is apparent from the rejection of the research by Adey, et al, Albanese and Oughstun in the PAVE PAWS case was that this body of evidence clearly lay outside of the thermal strictures of IEEE C95.1. For the USAF and the IEEE standard setters to acknowledge this science would be to bring into question the safety of high power systems like PAVE PAWS and therefore undermine the basis of the very standard itself.

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[95] L. Slesin, 'Introducing Brillouin Precursors: Microwave Radiation Runs Deep', *Microwave News*, vol. 22, no. 2, Mar/Apr. 2002, pp. 1, 10-12.

[96] L. Slesin, 'IEEE Says No to Brillouin Precursors', Standards, *Microwave News*, vol. 22, no. 4, Jul./Aug. 2002, p. 16.

[97] L.Slesin, 'Brillouin Precursors: Robert Adair, Albanese and Oughstun' Letters to the Editor, *Microwave News*, vol. 22, no. 3, May/June 2002, pp. 13-14.

**Microwaves get bad press**

During the late 1980s and early 1990s a series of articles by journalist Paul Brodeur were published in *The New Yorker* that served as a vehicle to bring the EMF issue into the public domain. Brodeur's New Yorker articles and later books on the topic were a wake-up call for the general public that poweline EMFs and microwaves from new technology may be a hazard to their health. Brodeur's first book on the issue was provocatively titled *The Zapping of America, Microwaves, Their Deadly Risk, And The Cover-Up* (1977). This was followed by *CURRENTS OF DEATH, Power Lines, Computer Terminals, and the Attempt to Cover Up Their Threat to Your Health* (1989) and *THE GREAT POWER-LINE COVER-UP, How the Utilities and the Government Are Trying to Hide the Cancer Hazards Posed by Electromagnetic Fields* (1993). Although Brodeur's writings caused a storm of controversy and outright condemnation from a number of quarters his work has been credited as being the prime mover in taking the EMF/RF microwave health issue from almost total obscurity to becoming a major environmental priority for the public.[98]

Although agreeing with much of Brodeur's concerns Nicholas Steneck was not in agreement with the way Brodeur researched and wrote his first book, *The Zapping of America*. Quite separate from the reality of the issue, Steneck wrote that Brodeur "employed ambiguity and vagueness as tools to create the sensational cover-up story that has been used to popularise his book". Steneck added: "By confusing chronology, taking statements out of context, ignoring evidence or presenting it in negative ways, relying primarily with sources that agree with his point of view, and many other techniques, he is able to craft a history of the development of the microwave debate that suits his purpose and that supports his conclusions". [99]

Detractors of Brodeur's writings also include physicist Robert Park, who, in his book *Voodoo Science,* devoted an entire chapter to critiquing Brodeur's writings, specially *Currents of Death*. Park accused Brodeur of engaging in baseless conspiracy theories in his claims that microwaves were harmful and that there was a cover-up underway. Park went on to give reassurances of safety from Eleanor Adair (a major author of the C95.1 RF standard development) and Robert Adair (Eleanor's physicist husband – mentioned previously in relation to PAVE PAWS). Eleanor found Brodeur's claims of a supposed cover-up "preposterous" and Robert considered claims of non-thermal hazards (cancer causation) from microwave exposure false because the energy was not strong enough to break chemical bonds necessary for DNA damage. According to R. Adair " there was no known mechanism that could account for reports of health_effects from low levels of microwave radiation", (meaning levels that did not cause a thermal effect).[100] Park also dismissed Brodeur's claims of powerline hazards.

Park makes a number of valid points over Brodeur's interpretation of the scientific evidence and his emotive fear generating language in trying to make his point but in a number of places Park is guilty of committing similar sins. For example, Park accused Brodeur of giving a biased and incorrect recounting of research findings. In his account of the 1996 National Academy of Sciences/ National Research Council (NAS/NRC)

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[98] L .Slesin, 'Why EMF Risks Get No Respect', *Microwave News*, http://www.microwavenews.com/nc_dec2004.html , Accessed Apr. 3, 2010.
[99] Steneck,1984, op. cit., p.196.
[100] R. Park, *Voodoo Science*, The Road from Foolishness to Fraud, Oxford Univ. Press, 2000. pp. 140-149.

review of the power-frequency EMF literature Park simply wrote that the unanimous NAS conclusion was that "the current body of evidence does not show that exposure to these fields presents a human health hazard".[101] Therefore Brodeur's contention that there was a power-line health hazard would have to be disproved.

What Park failed to report, however, was fact the NAS/NRC Committee only considered approximately half the evidence which was available to it. Dr. Kjell Hansson Mild of the National Institute for Working Life in Sweden, asked Dr Stevens, chair of the NRC Committee, how "the report turned out to be so biased in its selection of papers". Mild, past president of the Bioelectromagnetics Society, noted that the report mainly included papers that showed no effect and omitted those that found a biological response.[102] The committee acknowledged that workplace studies "have increased rather than diminished the likelihood of an association between occupational exposure to [EMFs] and cancer". The NAS committee only did what has been called a "superficial overview" of this literature because it claimed it was not directly relevant to the committee's assignment.[103] Because the committee was looking for conclusive evidence of a connection with EMFs, it was able to dismiss all data which failed to meet this criterion. Epidemiology looks for increases in risk factors, it does not deal with conclusive proof. By setting such an impossible standard, the NAS/NRC was able to dismiss a possible EMF link with cancer and announce to the world that there was nothing to worry about. In a paper examining the limitations of the NAS/NRC review this writer concluded that the review appeared to be designed to give an assurance of powerline EMF safety when the overall body of evidence did not warrant that conclusion. [104]

In another brief study analysis by Park, this time the 1997 National Cancer Institute Linet study on childhood leukaemia and EMFs, he claimed the study findings slammed the door shut on any possible EMF health effects. To quote from Park: "The supposed association between proximity to power lines and childhood leukaemia, which had kept the controversy alive all these years, was spurious – just an artefact of the statistical analysis. As is so often the case with voodoo science, with every improved study the effect had gotten smaller. Now, after eighteen years, it has gone entirely".[105]

However Park failed to mention significant limitations of the Linet study in shutting the door. Alasdair Philips from the U.K. pressure group *Powerwatch*, pointed out that in fact the researchers acknowledge, in no less than four places, a statistically significant (24%) increase in acute lymphoblastic leukemia (ALL) in children exposed to powerline magnetic fields in excess of 3 milliGauss. Philips' pointed out that this was a

[101] ibid, p. 158.
[102] K. Hansson Mild, letter to Dr. Charles Stevens, chairman of the NAS Committee as reported in *Microwave News*, vol. 17, no. 1, Jan/Feb 1997, p. 2
[103] L.Slesin, ' NAS Finds No EMF-Cancer Link: Report Stirs Controversy', *Microwave News*, vol. 16, no. 6, Nov/Dec. 1996, pp. 1, 5 – 7.
[104] D. Maisch, 'Power Frequency Electromagnetic Fields and Human Health – Is it time to end further research? An Overview of Three Recent Studies', *JACNEM*, vol. 17, no. 1, June 1998, pp. 5 -16.
[105] Park, 2000, p.159-160.

confirmation of many previous studies which have shown a similar level of association between childhood leukemia and EMF exposure. [106]

On July 4th 1998 this writer contacted Professor Ross Adey,(now deceased) who was one of the best known bio-electromagnetic researchers in the world. Dr. Adey was the author of numerous books and research papers on the bio-effects of EMFs. He had conducted a $3 million research program for Motorola and was a committee chairman on the USA National Council on Radiation Protection and Measurements (NCRP). His comments on the NCI study in reply are as follows:

> A number of us worked on the NCI paper through last weekend. Sam Milham, the Washington State epidemiologist and a pioneer in this field, points out that if they had included the 3 mg level in their cutoff, the conclusions would have been exactly the opposite - that there is a significant risk. And selection of 2 mG is quite arbitrary. David Savitz used 3 mG in some of his work. Obviously there is no steep threshold beyond which risks rise exponentially. At the recent Bologna International Symposium, Schuz from the University of Mainz had a paper combining kids from Berlin and Southern Saxony in high exposure homes to give leukemia odds ratio of 6.8 for young kids (under 4 years). So the dismissive attitude of NCI is totally unrealistic.[107]

Allen H. Frey, author of *On the nature of electromagnetic field interactions with biological systems*, (1994) also conducted an analysis of the NCI Linet study. Frey queried: "are the conclusions of the Linet epidemiological study and associated editorial by Campion justified? I think not. As is often the case in science, the fault is in assumptions made before the study began, assumptions upon which the study is based. If the assumptions can not be shown to be true, then the conclusions are not valid". [108]

In summing up the Brodeur/Park conflicting interpretation of the EMF science, it is argued that Brodeur has emotively overstated the case (EMF hazards) to make his point to the public over an issue in order to popularise his books. Park, on the other hand, has deliberately understated the case by presenting a very one-sided description of the data to conform to his opinion that it is physically impossible for there to be a hazard. This is somewhat ironic as Park accused Brodeur of giving the public a seriously distorted view of the scientific facts.[109] This is very much another example of a procrustean approach on the part of Park who appears in his book to have rejected any research evidence that environmental level EMFs may have a hazardous biological impact. This is because of his understanding as a physicist that non-ionizing radiation has insufficient energy to break molecular bonds, creating charged particles called ions and breaking DNA. Carolyn Miller in her article *"Disciplinary Differences in the Response to Anomaly"*(2005) explored the wide differences in expert understandings on EMF bio-effects between

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[106] A. Philips, The Powerwatch Network Responds - July 2, 1997, Re: RESIDENTIAL EXPOSURE TO MAGNETIC FIELDS AND ACUTE LYMPHOBLASTIC LEUKAEMIA IN CHILDREN, New England Journal of Medicine, July 3, 1997. http://www.feb.se/Bridlewood/NCISTUDY.HTM, Accessed Apr. 5, 2010.
[107] Correspondence with Ross Adey, Jul. 7, 1997.
[108] A. Frey, statement on the NCI Linet study, Jul 13, 1997, . http://www.feb.se/Bridlewood/NCISTUDY.HTM, Accessed Apr. 5, 2010
[109] Park, 2000, p.158.

physicists on one hand and biolelectromagnetic scientists on the other.[110] In one case she recounted how physicists were excluded from a review panel on EMF effects because an insider alleged in a *Science* article that "physicists were considered too sceptical of EMF bioeffects and that they had had trouble accepting what's going on in the field".[111] Considering the views of physicists Park and Adair (above) this may have some validity.

**The Moscow affair: inconvenient signals**

About a year after the end the Tri-Services program, it was discovered that from approximately November 1962 the Soviets had been beaming highly focused microwaves directly into the US Embassy in Moscow at an estimated power density that ranged from .005 mW/cm2 to .018 mW/cm2.[112] Averaged measurements determined that although the intensity reaching the Embassy was approximately 500 times less than the US standard for occupational exposure, it was twice the highest limit allowed in the Soviet standard.[113] This created a quandary for the US, for if they truly believed their thermally-based 10 $mW/cm_2$ standard was safe they could hardly conclude that the level of microwaves at their Embassy was undermining the health of the Embassy staff. Concerns were raised about the purpose of irradiation of the Embassy. Was it eavesdropping or a more sinister attack on the health of the employees? An initial study was done on the Moscow personnel in 1967 that examined a group of 43 workers, (37 exposed and 7 not exposed). They were tested for abnormalities in chromosomes and 20 out of the 37 were above the normal range among the exposed, compared to 2/7 among the non-exposed. In the final report the scientists urged a repeat and follow-up study which was clinically indicated for 18 persons, but was not undertaken by the end of the contract period, June 30, 1969.[114] The evidence of chromosome changes was strong enough to have triggered clinical guidelines that would have recommended ceasing reproductive activity until the condition had improved.[115] At a Superpower summit in June 1967 the irradiation of the Moscow Embassy was the subject of a confidential exchange between US President Lyndon Johnson and Soviet Prime Minister Alexi Kosygin. Johnson asked that the Soviet Union stop irradiating its Moscow Embassy with microwaves and harming the health of American citizens.[116] In 1966 a covert study, called *Project Pandora*, was commenced to study the possible effects on health from the microwave irradiation of the Moscow Embassy staff, who were not told the true reason for the investigation. In a related study, *Project Bizarre*, a primate was exposed to microwaves at half that permitted by the US standard. The findings of this study concluded, "[t]here is no question that penetration of the central nervous system has been achieved, either directly or indirectly into that portion of the brain concerned with the changes in work functions".[117] [118]

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[110] C. Miller, 'Novelty and Heresy in the Debate on Nonthermal Effects of Electromagnetic Fields', in Harris, Randy Allen (ed.) Rhetoric and Incommensurability, Parlor Press, 2005. p. 464 - 505.
[111] C. Miller, 2005, op. cit., p. 475.
[112] J. Goldsmith, 'Epidemiologic Evidence of Radiofrequency Radiation (Microwave) Effects on Health in Military, Broadcasting, and Occupational Studies', *International Journal of Occupational and Environmental Health*, vol. 1, no. 1, Jan.-Mar. 1995.
[113] L. Dalton, *Radiation Exposures* , Scribe Publications, 1991, p. 31.
[114] J. Goldsmith J. 'Where the trail leads', *Eubios Journal of Asian and International Bioethics* vol. 5, Jul. 1995, p 93.
[115] Goldsmith, Epidemiologic Evidence, 1995.
[116] Dalton, 1991.
[117] Dalton, 1991, op. cit., pp 31-32.

A haematologic study by J & S Tonascia in 1976 found highly significant differences between Moscow Embassy employees and other foreign service staff (control group). White blood cell counts were much higher in the Moscow staff as well as several other significant changes noted over time. These results were never published, but obtained under the Freedom of Information Act.[119] At this time there was a US Congressional radiation inquiry underway and the Department of Defense (DoD) was arguing that the US RF/MW Standard was already strict enough. They argued that there was no scientific evidence for the Soviet Standard being set at a level one thousand times lower than the US standard.[120]

The Moscow Embassy employees and dependants were studied for possible health effects of microwave irradiation by a team from John Hopkins University, under the direction of epidemiologist Professor Abraham Lilienfeld. Dr Lilienfeld noted that the study group was quite small and that the follow-up time too short to generally identify significant health effects such as cancer. He recommended that continued health status surveillance should be carried out, but this was not done. The incidence of sickness and death were compared with employees & dependents in other Eastern European embassies, and with the average US rates.[121] The incidence of multiple-site cancers was far more frequent in the Moscow Embassy group than in any other population studied. It was noted that while multiple-site cancers are characteristic of older populations, the Moscow Embassy group was relatively young. According to Goldsmith, concerns of the John Hopkins team were "downgraded" by the state department and the wording of the team report altered to lessen its impact. Lilienfeld strongly recommended that additional follow up studies be undertaken since the latency periods for some types of cancer had been insufficient for cancer to occur, if indeed it were to result from microwave exposure. Nevertheless, according to Goldsmith, the overall findings were consistent with excess cancer incidence both in the Moscow Embassy cohort and in the other Eastern European embassy personnel.[122] Data on exposure and occurrence of some cases of cancer were withheld from Professor Lilienfeld until after his report was completed and it was too late to include in the results. Reviews of the work done by contract investigators were interpreted as inconclusive because the State Department had failed to complete the necessary follow-up work which was recommended by the Lilienfeld team.[123]

Goldsmith concluded that the evidence from the Moscow study was suggestive for four health effects, (a) chromosomal changes, (b) haematological changes, (c) reproductive effects, and (d) increased cancer incidence from the microwave irradiation in Moscow.[124]

In spite of the above, it is interesting to note that in the 1998 published ICNIRP Guidelines, supposedly including only quality peer reviewed research, the Moscow embassy affair is only briefly mentioned in relation to the 1978 Lilienfeld study. ICNIRP

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[118] N. Steneck, *et al.* 'The Origins of US Safety Standards for Microwave Radiation' , *Science,* vol. 208, 1980, pp.1230-7.
[119] Steneck, 1980.
[120] Dalton, 1991. op. cit., p. 32.
[121] Dalton, 1991, op. cit., pp. 52-53.
[122] Goldsmith, 'Epidemiologic Evidence…', 1995.
[123] Goldsmith, 'Where The Trail leads', 1995, op. cit., p. 93.
[124] ibid.

concluded that the study "found no evidence of increased morbidity or mortality from any cause"[125] even though it can be argued that the inadequacies in the study should have prevented it from being referenced as such by ICNIRP.

**The international dimension**

Another challenge for American military planners during the 1950s - 1960s was that as many of their weapons and high power early warning radar systems were being deployed in Western Europe, the stricter RF standards in Russia and the Eastern European countries posed a potential threat to their operations. This was especially so if any of America's Western European allies were tempted to adopt the stricter standards, based on what the Soviet scientists were saying, thus possibly placing restrictions on American radar deployment. This meant that not only was there a need for the US military to discredit the Soviet standards but also to discredit the very basis for those standards - the existence of low-intensity biological effects not related to heating. For maximum effect this attack on Soviet science was best played out in an international setting. This meant that, concurrent to the space/arms race with the Soviets, there was an RF standards race, played out in various international organizations such as WHO and the North Atlantic Treaty Organization (NATO).

After the end of the Tri-Services program in 1961 the careers of Herman Schwan and Sol Michaelson advanced significantly, with both being funded by the Department of Defense (DoD).[126] Both men, especially Michaelson, began being appointed to numerous expert committees and testifying at court hearings as to the safety of both power frequency EMFs and RF facilities, using the 10 mW/cm2 limit as a safe level below which no effects could possibly happen.[127] By 1973, Michaelson was a member of an extensive array of expert committees of the Academy of Sciences, WHO, NATO, the President's Office of Telecommunications Policy, Electric Power Research Institute, Veterans Administration, National Institutes of Health, Walter Reed Army Institute of Research, the Navy and the American National Standards Institute, where he would have worked on developing the C95.1 RF standard.[128] Michaelson, in particular, made a point of viciously attacking the credibility of any researcher who dared release scientific research findings that questioned the 10 mW/cm2 limit, including the Soviet research.[129] It was Michaelson's membership in WHO and NATO committees developing RF standards that served as a vehicle to spread DoD's thermal effects viewpoint to Western European countries. The WHO committee to which Michaelson was appointed was the Task Group on Environmental Health Criteria for Radiofrequency and Microwaves, convened in 1971 by WHO and the International Radiation Protection Agency (IRPA).[130] In 1974, Michaelson and Michael Suess from the WHO Regional Office for Europe (WHO/EURO) jointly authored a paper, titled, *An International Program For Microwave Exposure Protection*, that called for the establishment of an international program on non-ionizing radiation protection, run by an International agency, such as WHO. An

[125] ICNIRP, 'Guidelines For Limiting Exposure To Time-Varying Electric, Magnetic, And Electromagnetic Fields (Up To 300 GHz', *Health Physics*, vol. 74, no. 4, Apr. 1998, pp 494-522.
[126] Marino, 1986, op. cit., p. 23
[127] Marino, 1986
[128] Marino, 1986, op. cit., p. 16-17.
[129] Marino, 1986.
[130] S. Michaelson, M. Suess, 'An International Program For Microwave Exposure Protection', *ITT Transactions on Microwave Theory and Techniques*, Nov. 1974, pp. 1301-1302.

emphasis on only thermal considerations is seen in the reporting on a consensus statement from a 1973 symposium on microwave bioeffects that classified microwave intensities "for convenience and uniformity of approach" in three broad categories. To quote:

- levels above 10 mW/cm2, at which thermal effects occur and in some instances (at high average power densities) may prove hazardous;
- levels below 1 mW/cm2, at which thermal effects are improbable;
- intermediate range in which weak but noticeable thermal effects occur as well as direct field effects.[131]

The 1971 WHO/IRPA Task Group, mentioned above, went on to establish the International Radiation Protection Association (IRPA) which eventually became the International Commission on Non-Ionizing Radiation Protection (ICNIRP) in 1992, established by Michael Repacholi. Repacholi was chairman of a 1979 WHO review meeting on RF/MW criteria, in Washington D.C., with Michaelson a member of the working group. Michaelson also authored a chapter on RF/MW radiation in the 1982 WHO publication, *Nonionizing Radiation Protection* (WHO Regional Publications, European Series, Vol. 25).[132] In addition, both Repacholi and Michaelson spoke at the 1984 NATO conference on the biological effects of low-level non-ionizing radiation.[133] All this indicates a clear lineage from Schwan's original 10 mW/cm2 calculations, on the U.S. DoD 10 mW/cm2 standard that went on to become ASA C95.1 -1966 and the basis for the present day RF standards/guidelines of both IEEE and ICNIRP. This line of inquiry will be examined in more detail in Chapter 4. The vital point to be made here is that opposition to recognition of low-intensity biological effects in RF standard setting appears to be primarily a result of super-power rivalry, and the personal convictions of a few key players in the issue and not due to superior science on part of the US. The consequences of a recognition of low-intensity effects in US RF standards was seen as a potential threat to the development and deployment of high power radar equipment that was necessary to detect a possible Soviet nuclear first-strike. Simply put, recognition of low-intensity effects was seen as a risk to national security where any possible health benefits of such recognition were far outweighed by the risk of national, if not global nuclear annihilation. It was under this threat that the central players such as Knauf, Schwan, Michaelson and Repacholi, developed their concept of what was proper for RF standard setting. Once the commitment to the thermal 10 mW/cm2 standard was cemented into place, there was really no way to retreat from it, even after the collapse of the Soviet Union. It is arguably a surviving legacy of the Cold War years.

**ASA C95.1 (1966)**

In 1958, DoD delegated the task of RF "standardisation responsibility" jointly to the Air Force and the Navy which soon created factionalism between the two military branches over who would control the scientific research effort and who would be in charge of the standardization process. The RF bio-effects research responsibility still resided with Knauf's Air Force laboratories at Rome Air Force base, but in 1959 the Navy took a

[131] Michaelson Suess, 1974.
[132] Correspondence with Louis Slesin, editor Microwave News, Oct. 12, 2006.
[133] B. Dumpe, *X-Rayed Without Consent*, unpublished, Ergotec Association Inc., 1989.

controlling lead in setting standards when its Bureau of Ships enlisted the help of the American Standards Association (ASA), conveniently headed by Admiral G.F. Hussey Jr.[134] Although Colonel Knauf expressed his concerns over the Navy assuming the lead in the standard setting arena, by the end of 1959 the Navy had assumed the leading role in directing the course of the ASA and later ANSI deliberations.[135] It was agreed that the ASA would convene a special committee, called C95, to evaluate the hazards from RF/MW radiation. The Bureau of Ships and the American Institute of Electrical Engineers (AIEE) would then jointly sponsor C95's work[136]. Even before the first meeting faction fighting between the Navy and AIEE created difficulties. AIEE complained that the Navy was pushing ahead without adequately consulting AIEE. The agreed procedure to appoint a chairman also broke down with the Navy asking Herman Schwan (who was not even on the previously agreed to list) to be chairman without consulting AIEE's representative J. Paul Jordan.[137] It is very likely the military preferred Schwan as chairman because of Schwan's firm belief in the military accepted 10mW/cm2 level and his dismissal of low level, nonthermal effects. As chairman of C95.1, Schwan could be counted on to maintain the growing acceptance of the thermal paradigm. Jordan, as Steneck puts it, "hit the roof" and objected to Schwan's nomination. Concerns were raised by another person at the meeting that Schwan would accept no compromise to his own ideas. Jordan however later reluctantly agreed to Schwan assuming the chairmanship, with reservations, and on February 15, 1960 the ASA C95 Committee met for the first time to start work on an occupational RF/MW standard.[138] Schwan set up six sub-committees (C95.I to C95.VI) each with a specific task to investigate and with a quarterly time-table to adhere to, during which progress reports would be tabled and further deadlines set. It was planned that this work would result in enough information gathered to enable C95 to begin drafting a standard within the year.[139] Schwan set this brief time frame because the scientific base of the standard setting effort was to be the work previously carried out by the Tri-Services program[140]. Interpretations of the Tri-Services Project data would form the bulk of the work on which to draft a standard. Schwan's viewpoint was that it was not the function of C95 and its sub-committees to undertake research to fill in any gaps in the knowledge base, but simply to go with what was already known – meaning that Schwan's 10mW/cm2 limit would be the only logical end point to consider. However, all did not go according to plan. A 'turf-war' conflict again surfaced between the AIEE and the Navy over controlling the effort. The sub-committee's work did not progress well, resulting in no quarterly meetings for well over a year and several sub-committees folding. As Steneck reports, the progress of both the C95 full committee and its sub-committees were hampered by members failing to show up for planned meetings, making the preparation of progress reports difficult, if not impossible. Rather than Schwan's ambitious one-year time frame it took six years of squabbling between the factions before an agreed occupational standard could be adopted in May 1966, and that only after several unsuccessful months spent trying to get enough members present to achieve the

[134] Later to become the American National Standards Institute (ANSI).
[135] Steneck, 1984, op. cit., p. 56.
[136] Later renamed The Institute of Electrical and Electronics Engineers (IEEE).
[137] Steneck, 1984, op. cit., p. 56-57.
[138] Steneck, 1984
[139] Steneck, 1984.
[140] David, 1980, op. cit., p.21.

required consensus to approve the standard. That was only achieved by lowering the number required to reach consensus.[141]

When the first occupational standard (C95.1-1966) was finally adopted six years later in November 1966, it took months just to assemble the votes required to pass the standard, and that could only be achieved by lowering the number required to reach a quorum.[142] C95.1 (1966) was based on a simple thermal model that limited absorbed power to 100W with the recommended whole-body exposure limit set at 10mW/cm2.[143] This essentially mirrored the thermal paradigm established by the Tri-services Program. As Steneck stated "The early standard setters accepted thermal thinking as a fact of science and ignored the weaknesses of their evidence through an act of faith."[144] When the 1966 standard was sent out for a vote amongst the full committee members the membership was divided up into interest groups to demonstrate a supposed broad base of support for the standard. It is interesting to note that the organisations listed as representing the consumer interests in the 1966 standard were as follows:

American Petroleum Institute
Armed Forces Institute of Pathology
General Dynamics
National Aeronautics and Space Administration
U.S. Department of the Air Force, Rome Air
U.S. Department of the Army, Environmental Hygiene Agency
U.S. Department of the Army, Material Command
U.S. Department of the Army, Office of the Surgeon General
U.S. Department of the Interior, Bureau of Mines
U.S. Department of the Navy, Bureau of Medicine and Surgery
U.S. Department of the Navy, Bureau Naval Weapons
U.S. Department of the Navy, Bureau of Ships
U.S. Department of the Navy, Marine Corps
U.S. Department of the Treasury, Coast Guard
U.S. Public Health Service.[145]

This list supports Steneck's view that the 1966 standard was developed primarily by producers for industrial and military users, not by consumers or for consumers.[146]

ASA C95.1-1966 was approved as an occupational standard on November 9, 1966, covering 10 Mhz to 100 Ghz. Remarkably, the entire 1966 standard that took six years to adopt was only 1.2 pages in length.[147] Before further work on refining the standard could be started however, Schwan withdrew from active involvement with C95 leaving the issue to a future committee.

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[141] Steneck, 1984, op. cit., p. 59.
[142] Levitt, 1995, op. cit., p. 25.
[143] Osepchuk, Petersen, 2003, op. cit., p. S8.
[144] Steneck, 1984, op. cit., p. 60.
[145] Steneck, 1984, op. cit., p. 61.
[146] Steneck, 1984.
[147] P. Mason, M. Murphy, R. Peterson, 'IEEE EMF Health & Safety Standards', WHO Meeting on EMF Biological Effects and Standards Harmonization in Asia and Oceania, Shilla Hotel, Seoul, Korea, 22-24 October, 2001, http://www.who.int/peh-emf/meetings/southkorea/en/IEEE_EMF_HEALTH_-_Mason.pdf , Accessed Aug. 29, 2006.

Later revisions of the ASA C95.1-1966 were published in 1971 under the auspices of the American National Standards Institute (ANSI C95.1-1971), in 1982 (ANSI C95.1-1982), in 1991 (IEEE C95.1-1991) which became ANSI/IEEE C95.1-1992 . The latest complete revision, ANSI/IEEE C95.1-2006 is still to be approved by the FCC as of January 2009.

Saul Rosenthal of the Polytechnic Institute of Brooklyn took over as chairman of the full C95 committee in June of 1968. Noting that the 1966 standard was based almost exclusively on data collected prior to and during the Tri-Services era, Rosenthal stated that C95.1-1966 was "an excellent one [that] still leaves much to be desired because its data base was deplorable", thus hinting that a vigorous research effort was needed in order to validate the standard.[148]

Arthur Guy took over the chairmanship of the C95.IV sub-committee in June 1970 and set up the following five groups to "identify and document the requirements for additional information needed to modify or improve present standards"[149] These five sub-committees were as follows:

- Near Zone field effects, chaired by John Osepchuk from Raytheon
- Frequency effects chaired by Albert Kall from Ark Electronics and Sidney Kessler from the U.S. Information Agency
- Low-level (athermal) and modulated effects chaired by Allan Frey from Randomline.
- Environment chaired by Bill Mumford from Bell Telephone
- Population Groupings chaired by William Mills from the Bureau of Radiological Health (BRH)[150]

Addressing the perceived limitations of the 1966 standard, ophthalmologist Milton Zaret wrote an open letter to ANSI with a number of recommendations for future revisions. Zaret noted the lack of epidemiological studies on large populations and therefore recommended the standard should state that it was not intended to apply to the general public. Also noting the lack of data, he was of the opinion that pulsed RF radiation with peak powers more than 100 times their average and non-uniform fields should be excluded from the standard. To address other potential problems Zaret suggested requiring wording in the standard stating: "When a radiation generating system either is capable of exceeding the recommendations or is not adequately defined by this guide, then…the user should ensure its safety by performing appropriate biological assay experiments." In order to avoid an impression of certainty where none existed, Zaret recommended changing the phrase explaining the safety of below threshold exposures from "will not" to "is believed not to result in any noticeable effect to mankind."[151] Zaret's recommendations were discussed by the committee and rejected, with vigorous opposition being expressed by industry representatives John Osepchuk (Raytheon) and Paul Crapuchetts (Litton Industries). Had Zaret's proposals been accepted it would have changed the accepted thermal-only protocol for ANSI's RF bioeffects studies and would

[148] Steneck, 1984, op. cit., p. 150.
[149] Steneck, 1984.
[150] Steneck, 1984.
[151] Steneck, 1984, op. cit., p. 151.

have shifted the onus on ANSI to justify its scientific information before issuing a standard. As well, long-term, low level (non-thermal) bioeffects studies would have to be done as well as public and occupational epidemiological studies. Such recommendations would have been more in line with chairman Rosenthal's call for a vigorous and active program of research to validate the standard but unfortunately this was not to be the case. Both the military and industry members on the ANSI C95 committee would been aware that the changes along the lines of Zarat's recommendations would have put the onus on them to further verify the safety of the technology for the people operating it or being exposed to it before the equipment was deployed. Keeping the thermal-only emphasis of the standard brought certainty for the rapidly developing technology for both civilian and military applications. Consideration of other possible lower-level bioeffects not related to thermal increases was fraught with uncertainty and the need to somehow deal with the concept of risk that it implied.

Epidemiological studies may uncover evidence of hazards at low level, prolonged exposures, something that the C95 committee members would have been aware of from what the Russian data suggested. Evidence of low-level environmental hazards could adversely impact on operational requirements of the military. Litigation and product recalls could be a problem for the corporations if their products were found to have emissions implicated with non-thermal hazards. In other words, rejection of Zaret's recommendations could be considered as a strategic decision with little to do with science but all to do with protecting the roll-out of new wireless technology, which at the time was mainly radar. One additional problem would have been that the majority of RF bio-effects researchers on the committees would have been schooled in the thermal-effects-only philosophy, giving an intellectual conflict of interest against recommendations that ran counter to their understanding. As it turned out Rosenthal did not get his call for a "vigorous and active program of research to validate the standard". Instead, the final report from the study groups, "Research Needed for Setting of Realistic Safety Standards" stayed safely within the previous thermal bioeffects structure – conducting animal experiments to learn more about the basic thermal mechanism. Little attention was paid to epidemiological population studies or low-level-long term studies.[152]

Subservience of future revisions to C95.1 to military operational needs was spelt out in a June 5, 1968 letter to Senator Warren Magnuson, chairman of a Commerce Committee hearing testimony on electronic devise emissions and public health. The letter was from the acting general council for DoD. To quote:

> It is understood, however, that the development of product standards to protect the public health will not necessarily preclude the use of devices, e.g., radars, communications transmitters, etc., which are designed to intentionally emit large quantities of radiation. The use of such devices is often essential to meet requirements of the national defense. It is anticipated that in developing standards, the Department of Health, Education and Welfare will give consideration to the use and purpose of these devices and will consult with other federal agencies on the development of standards which could have such an effect on these devices. Moreover, if standards are developed that do have an effect on the operation of

[152] Steneck, 1984, op. cit., p. 151-152.

devices essential to the national defense it is understood that this will be a matter subject to exemption under section 360 (A0 (b).[153]

**ANSI C95.1 – after 1966**

The thermally restricted philosophy embodied in the 1966 standard ensured that the ANSI C95.1-1974 standard would, like its predecessor, also be based on a simple thermal model, limiting the "absorbed power" to less than 100 Watts, a value comparable to the resting metabolic heating of an adult human. The recommended power density limit for whole-body exposure was still 10 mW/cm2 but the 1974 standard added electric and magnetic field limits (E2 and H2) to account for near-field exposures at frequencies below a few hundred MHz. The 10 mW/cm2 value continued to be applied to continuous exposures. However, for short time exposures, a time factor was introduced to come up with the 10mWh/m2, based on an averaging time of 0.1 hour (6 minutes). The 6 minute averaging time was because it was considered an appropriate thermal time constant for important organs, such as the eyes and testes.[154] The same limits applied for both the workplace and the public (a single tier).

In 1978 the IEEE Committee on Man and Radiation (COMAR) held a workshop that included a discussion on an ongoing level of cooperation between Soviet and American engineering and biological scientists that was apparently of mutual advantage to both countries. Most importantly a dismissal of the Soviet sciences was not apparent from what is written about the proceedings. In fact, it is quite the opposite. To quote from COMAR:

> The American delegates have learned that Soviet biological studies often possess an important feature lacking in Western studies: ecological validity – or what might be called experimental modelling that more nearly resembles the way that RF radiation is encountered by people in the real world. Soviet biologists have conducted many long-term experimental studies; only a handful has been reported by western investigators. Soviet physicians have conducted numerous epidemiological surveys; few have been attempted in the West. And finally, the long-term Soviet studies, experimental and epidemiological are closely matched; i.e., animals are exposed in settings that closely resemble those that characterize workers who are exposed to RF fields. The Western scientist can make a good case for the tightly controlled environmental conditions that have characterized his researches, but he is beginning to realize that a pooling of methodologies that incorporate the environmental and dosimetric rigor of the West with the long-term exposures and ecologically valid designs of the East will be necessary if the potential hazards of low-level fields are to receive credible scientific evaluation. In short, the Soviet scientist has profited from U.S. engineering, and the U.S. scientist from Soviet methodology.[155]

In a Department of Energy /NASA study of microwave standards done in 1980 it was reported that there was a trend toward a convergence (harmonization) of the differing RF standards worldwide. The proposals were to lower Western levels while some Eastern European countries increase their standards. For the next revision to ANSI

[153] Brodeur, 1977, op. cit., p. 46.
[154] Osepchuk, Peterson, 2003.
[155] David, 1980, op. cit., p. 17.

standard (1982) the changes would have seen a frequency dependent reduction of exposure limits to 1 mW/cm2 for the 10 – 400MHz range, and 5 mW/cm2 for the higher microwave frequencies.[156] Unfortunately, however, the proposed changes did not carry over to the 1982 ANSI RF standard which re-affirmed the maximum permissible exposure of 10 mW/cm2. It is surmised here that U.S. military planners decided that any departure from the 10 mW/cm2 limit was a defacto acknowledgment of the possibility of non-thermal bio-effects and therefore posed the possibility of impacting on their operational requirements.

A major feature of the 1982 standard was the departure from being a 'flat standard', meaning simply limiting absorbed power to less than 100 Watts with a maximum power density of 10 mW/cm2 regardless of frequency, to a frequency dependent whole-body-average "Specific Absorption Rate" (SAR), measured in Watts per kilogram (W/kg). For a given volume of tissue, the SAR indicates the average rate at which energy is absorbed for each kilogram, or gram of tissue. This change was due to accumulated evidence that RF energy thermal-effects are not simply related to the power density of the energy (mW/cm2) but how much energy is actually being absorbed in tissue, especially sensitive areas such as internal organs, the eyes and testes, for example[157]. Although the introduction of the SAR concept in the 1982 standard gave a far more accurate picture of how microwave energy actually penetrates into the body to be converted into heat, it also introduced a high level of complexity. This was in the recognition that the rate of energy absorption and distribution of energy inside the body depended upon many factors. These include the dielectric composition of the tissue (ability to conduct electricity), the size of the object relative to the wavelength of the energy [158], shape, geometry and orientation of the object, and distance of the object from the radiating source. In addition to making the distribution of energy in an irradiated body extremely complex and non-uniform, a further complexity is the acknowledgment of the creation of "hot-spots" of concentrated energy in body tissue, the location of which depends on the above factors.[159]

SAR calculations acknowledge resonance effects between the energy and human tissue. If the object is equal in size to one wavelength, or certain fractions of that wavelength (1/2, 1/4 , etc.) the tissue is likely to resonate with the energy and thus absorb more of the energy. When there is no resonance much less energy is absorbed as it is simply reflected or passes through the object. Less absorbed energy means less heating. So as the frequency increases in the GHz range, for example, there is a decreasing resonance effect with the size of the body or its organs and therefore less heating takes place. [160] The

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[156] David, 1980, op. cit., p. xii.

[157] As early as1955 Herman Schwan and G.M Piersol reported that there was a danger of causing burns when RF energy is applied over bony prominences. Their explanation for this observed effect was that non-uniformities, such as bone ridges and irregular fat layers caused the energy to be absorbed non-uniformly within the body or head. In: Kane, Robert, *"Cellular Telephone Russian Roulette; A Historical and Scientific Perspective"*, 2000, p. 42.

[158] For example at 1.8 MHz the wavelength is 171 meters and at 460 MHz it is 65 cm.

[159] H. Lai, 'Neurological Effects of Radiofrequency Electromagnetic Radiation', Workshop on Possible Biological and Health Effects of RF Electromagnetic Fields, Mobile Phone and Health Symposium, Vienna, Austria, Oct. 25-28, 1998.

[160] G. Lapin, Understanding SAR, ARRL RF Safety Committee. http://www.arrl.org/rfsafety/lapin/2000/08/29/1/index.html, Accessed May 4, 2006.

frequencies from about 700 MHz to 1,000 Mhz have the greatest resonance with human tissue and therefore yield the greatest energy absorption.[161]

Acute exposure studies had determined that 4 W/kg was the hazard level for thermal damage and by including a safety factor of 10 the standard came up with a safe SAR limit of 0.4 W/kg that was meant to apply to all possible size and age groups of humans, including children.[162] This level, termed the RF Protection Guide (RFPG) limit, applied for frequencies between 100kHz and 6 GHz. The 1982 standard also stipulated that a local SAR limit in any one gram of tissue in the form of a cube averaged over a 6 minute period must not exceed 20 times the whole-body-average limit i.e., 8W/kg.[163]

The SAR 4 W/kg "hazard level", considered the "biological endpoint" on which the 1982 RF standard was based, went on the basis for all subsequent Western RF standards. This "biological endpoint" was simply based on acute short term exposure findings from several laboratories that behavioural disruption[164] of laboratory animals such as rats and monkeys occurred at a whole body average SARs of 4 to 8 W/kg applied for 30 to 60 minutes. [165] [166] In comparison, the "biological endpoint" of the Soviet RF standard was both subjective and objective symptoms reported amongst RF exposed workers.[167]

The problem of dealing with "hot spots" that may actually exceed C95.1 standard limits and cause selective thermal damage to tissue especially in the brain, was avoided by averaging SARs over a 1 gram block of tissue (later increased to 10 grams).[168] This conveniently averaged out hot spot levels for compliance purposes, but of course in the real world exposure situation the hot spots would still be there selectively heating tissue. This was a problem seen in research conducted by Lin, Guy and Caldwell (1977) on rats irradiated in the near-field region. They found hot spot creation with energy levels up to 1,500+ times the expected level. They proposed that even at low SARs microscopic hot-spot destruction may be occurring unnoticed.[169] This is a clear thermal effect not covered by C95.1-1982 and still avoided to this day by averaging in Western RF standards. As seen in the most recent revision of C95.1, explored later in this chapter, simply by increasing the averaging mass for compliance testing effectively increases the allowable exposure levels. Steneck made an interesting comparison about this type averaging methodology:

> The average whole-body momentum delivered by a 1 ounce bullet travelling at 500 feet per second is about one hundred times less than that delivered by a 200 pound

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[161] R. Kane, *Cellular Telephone Russian Roulette: A Historical and Scientific Perspective,* Vantage Press, 2001, p. 4.
[162] IEEE/ICES, Unapproved minutes, SCC-28 Subcommittee 4, 8th Revision Working Group Meeting, National Electrical Manufacturers Association, Rosslyn, VA, Sept. 25, 2003. http://grouper.ieee.org/groups/scc28/sc4/sc-4%208th%20rwg%20minutes-september%202003.pdf, Accessed May 18, 2009.
[163] O. Gandhi, G. Lazzi, 'The ANSI/IEEE RF Safety Standard and its Rationale', invited report for the IEEE Antennas and Propagation, Man and Radiation Committee (undated) http://www.ece.tamu.edu/~eml/AP-S/comar/ANSIstandar1.pdf, Accessed April 18, 2006.
[164] Defined as changes in food motivated learned behavior.
[165] Gaundi, Lazzi, (undated), op. cit.
[166] Osepchuk, Peterson, 2003.
[167] Hecht, Balzer, 1997.
[168] Kane, 2001, op. cit., pp. 42-55.
[169] Kane, 2001.

> football player running at 12 miles per hour. The fact would offer little consolation if the point of impact of the bullet were the heart.[170]

Steneck concluded that the type of logic inherent in C95 .1 RF standard, a logic that aims to maximise the levels of allowable RF energy, is a desire to maximise opportunities to expand the use of RF technology. He also concludes that as the values of the military and Industry are predominant in C95.1-1982, "at heart C95.1-1982 is a military-industrial standard".[171] Steneck noted:

> This conclusion should come as no surprise. C95 activities are coordinated by the navy and IEEE, two user-orientated organizations. Roughly two of every three C95 members represent military or industrial interests. Many of the scientists who advised during the standard setting process, including C95.IV chairman Bill Guy, were funded by the military. At every critical juncture the main input into C95.1-1982 came from the user community. That it should as a result reflect the values of that community is natural.[172]

Like the 1966 and 1974 standards, the 1982 standard was single tier, ie. the same limits applied in the workplace and for the public.[173]

Steneck summed up what the available research indicated by 1982 in that:

- The work related to [product] safety had not been performed;
- The overwhelming indications are of a hazard to near-zone exposure;
- Many types of "hot spot"-generating mechanisms compounded the effects of even low-level radio frequency radiation exposures;
- Humans cannot be used for the potentially deadly experiments to determine safety/hazard levels.[174]

In 1988, the C95 committee was re-named Standards Coordinating Committee 28 (SCC28) under the sponsorship of the IEEE Standards Board. In September 1992, the IEEE Standard Board approved the IEEE Standard: *Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz,* (IEEE C95.1-1991). This standard added the issue of electrostimulation at frequencies below 100kHz and surface heating over 6 Ghz. Averaging times were altered to eliminate the possibility of skin burns for short exposures and limits for induced and contact current were also included. Exposure values for electric and magnetic fields were calculated by spatially averaging over an area equivalent to the vertical cross-section of the human body rather than using the previous local values. This allowed considerably higher limits when non-uniform, rather than uniform, whole-body SARs were involved. For the first time a two-tier level in the 100 kHz to 6 GHz region was added. Rather than define populations as occupational or public the concept of controlled and uncontrolled environments[175] was

[170] Steneck, 1984, op. cit., p. 237.
[171] Steneck, 1984, op. cit., p. 238.
[172] Steneck, 1984, op. cit., p. 239.
[173] Osepchuk, Petersen, 2003.
[174] Steneck, 1984, op. cit., p. 63.
[175] The two-tier approach sets exposure limits both for workers who supposedly knew how to work around an RF environment (controlled), and members of the public that might be exposed (uncontrolled).

introduced.[176] The two-tier system saw the introduction of an additional factor of 5 being applied to the lower tier, resulting in a safety factor of 50 for the uncontrolled environment, which included the general public[177].

In November 1992, the American National Standards Institute (ANSI) approved the IEEE C95.1-1991 standard to be called "ANSI/IEEE C95.1–1992, "Safety levels with respect to Human Exposure to Radio Frequency Electromagnetic Fields", 3 kHz to 300 GHz". What is seen in the history of the C95-1 standards is that the emphasis was on further defining thermal effects and providing safety against those, and how to side step the issue of thermal hot spots by averaging. As newer microwave emitting technology utilised ever higher frequencies a relaxing of the standard was seen under the pretext that higher frequencies penetrated less into the body and thus gave a lower SAR value and allowable power density level at higher frequencies. This was much the argument given in the Australian TE/7 committee as will be examined in Chapter 4.

The original opinions of Knauf and Schwan back during the Tri-Services era as to the non-existence or non-importance of RF bio-effects effects not related to SAR heating of body tissue had become the paradigm in subsequent standard work. To quote from the 1992 ANSI/IEEE standard:

> No verified reports exist of injury to human beings who have been exposed to electromagnetic fields within the limits of frequency and [specific absorption rate] specified by previous ANSI standards . . ."Measurements have shown that routine exposure of users and other persons to low power portable and mobile transceivers and cellular telephones do not induce rates of [radio frequency] absorption that exceed any of the maximum permissible rates of energy absorption defined by these guidelines" [IEEE, ANSI]. Therefore, based on present knowledge, the exposures from low-power transceivers are considered to be without risk for the users and the public.[178]

And as described by IEEE members Osepchuk and Petersen :

> Contemporary RF/Microwave standards are based on the results of critical evaluations and interpretations of the relevant scientific literature. The SAR threshold for the most sensitive effect [heating] considered potentially harmful to humans, regardless of the nature of the interaction mechanism, is used as the basis of the standard. To account for uncertainties in the data and to increase confidence that the limits are below levels at which adverse effects could occur, somewhat arbitrary safety factors (typically 10-50) are applied to the established threshold.[179]

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[176] Osepchuk, Petersen, 2003.
[177] IEEE/ICES, Rosslyn Virginia, 2003, op. cit.
[178] ANSI IEEE C95.1-1992, 'IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz', As stated in the IEEE USAB Entity Position Statement Human Exposure to Radio frequency Fields from Portable and Mobile Telephones and other Communication Devices, December 2, 1992.
[179] Osepchuk, Petersen, 2003.

**Challenges to the 1992 ANSI/IEEE standard**

In May 1991 the Ground Systems Group of Hughes Aircraft, a major military contractor and a subsidiary of General Motors Corporation, effectively rejected the IEEE C95.1-1991 RF standard (accepted by ANSI in 1992) by formally adopting for its employees the 1984 'in-house' RF/MW standard set by Johns Hopkins University Applied Physics Laboratory (JHU-APL).[180] The Hopkins group had set a 'flat' 100uW/cm2 maximum exposure standard for the frequency range of 30 Mhz to 100 GHz. This was 10 times lower than ANSI C95.1-1982 for the 30-300 MHz band and 50 times lower at frequencies above 1500 MHz. [181] JHL-APL's move was prompted by studies by JHL-APL's Henry Kues and the FDA's Jack Monahan that found SAR levels below the accepted ANSI/IEEE threshold level of 4W/Kg could cause persistent eye damage. This cast doubt on the assumption by ANSI/IEEE that there were no adverse health effects of RF/MW radiation below 4 W/Kg. According to *Microwave News* the ANSI/IEEE subcommittee that drafted the 1992 standard largely ignored the research by Kues and Monahan.[182]

In a surprising break with military policy, in 1993 the ANSI/IEEE C95.1-1992 standard was challenged by the Phillips Laboratory at Kirkland Air Force base. In June of that year Dr. Brendan Godfrey, the director of the Advanced Weapons and Survivability Directorate at the Phillips Lab, instituted a policy for their employees that limited exposures to a flat 100 uW/cm2 for frequencies between 30 MHz to 100 GHz, similar to the 1984 JHU-APL RF standard.[183] This new policy was prompted by Dr. Cletus Kanavy, chief of the biological effects group at the Phillips Labs. Kanavy wrote to Godfrey that he had concluded, based on a survey of the scientific community engaged in RF/MW radiation bioeffects research, that there is a "consensus" that "nonthermal effects do exist and that the ANSI/IEEE standards are deemed inadequate to protect human health." According to Kanavy, "The literature published in the late 1980's is abundant with information on nonthermal effects which are produced at levels below the ANSI standards." In the ANSI/IEEE standard, he added, "The existence of nonthermal effects is essentially denied by omission."[184] In September 1993 Kanavy wrote to the Environmental Protection Agency (EPA) that: "We have long felt that the athermal effects are real and that a [continuous wave] thermal standard was not sufficient for human exposure protection."[185] Kanavy therefore highlighted the necessity of including modulation effects in standard setting. The position by the Phillips Laboratory did not go unchallenged, however, as the Air Force's Armstrong Laboratory in Brooks Air Force base in San Antonio Texas disputed the claims of the Phillips Laboratory over the existence of athermal effects. Dr. David Erwin, chief of the Radiofrequency Radiation Division at the Armstrong Laboratory, claimed that his team had reviewed and attempted to replicate claims "concerning athermal and other unsubstantiated bioeffects. Although we still accept the possibility, we have not yet seen any good evidence for

[180] L. Slesin, 'ANSI RF/MW Standard Challenged, U.S. Air Force and Hughes Units Adopt Limits up to 100 Times stricter', *Microwave News*, vol. 13, no.5, Sept/Oct 1993.
[181] L. Slesin, 'Hopkins Lab Sets 100 uW/cm2 RF/MW Safety Standard', *Microwave News*, Nov/Dec 1984.
[182] Slesin, 'ANSI RF/MW Standard Challenged…', 1993.
[183] ibid.
[184] ibid.
[185] ibid.

athermal bioeffects." In a letter to Dr. Brendan Godfrey, Kanavy's supervisor, Erwin said that to use claims of such effects to revise U.S. RF health standards "would be alarmist".[186] Kanavy replied that "It is absolutely shocking to hear the Armstrong Laboratory [Dr. Erwin] deny the existence of any biological effects which are not thermal...Something is drastically wrong here." To support his claims Kanavy wrote a White Paper on the biological effects of RF/MW radiation in which he asserted that the U.S. research community was aware of the Soviet research findings of adverse bio-effects below the ANSI standards. These were initially rejected because they were unable to replicate the Soviet research but by the mid-1980's researchers began to successfully duplicate Soviet findings and started a research program to expand upon and test the Soviet non-thermal theories.[187] Kanavy wrote that "a comprehensive search of [the] worldwide literature" found that "a large amount of data exists…to support the existence of chronic, nonthermal effects…produced at levels below the ANSI standard". Kanavy also claimed that a consensus of RF researchers outside of the Armstrong Lab were in favour of establishing a national program "to investigate the biological effects of electromagnetic radiation under the auspices of an independent committee".[188] Dr. Ross Adey, a leading researcher at the Veterans Administration Hospital in Loma Linda, California, backed up Kanavy's claims at a hearing before a U.S. Senate subcommittee in August 1992. Adey testified that "[a]s a matter of policy, the Air Force denies existence of biological effects attributable to athermal fields. Nevertheless, evidence for athermal bioeffects is incontrovertible for both low-frequency and [RF] exposures."[189]

Both the Armstrong laboratory and the ANSI/IEEE standard were criticised by Dr. Edward Elson from the Department of Microwave Research at the Walter Reed Army Hospital at a meeting in Florida in June 1992. While presenting a paper that challenged the adequacy of the ANSI/IEEE, Elson predicted that his research on high-power microwaves would be stopped if the responsibility for it were transferred to the Armstrong Laboratory.[190] The Armstrong Laboratory also came under criticism in a letter published in *Health Physics* (Feb. 1991) from Dr. Dennis Hjeresen from Los Alamos National Laboratory in New Mexico. Hjeresen said that, "The U.S. Air Force [Armstrong Laboratory] has consistently suggested to us that there are no effects of low-level microwave exposure despite evidence to the contrary presented in the peer-reviewed literature."[191] In an apparent case of intellectual bias, Kanavy's White Paper mentioned that when the Phillips Laboratory attempted to share its extensive literature base on biological effects of microwave radiation with the Armstrong Laboratory, Dr. Dave Erwin at the Armstrong Laboratory proceeded to delete the publications of researchers he believed were not credible. According to Kanavy they were researchers who had reported finding nonthermal effects.[192] One of the recommendations in Kanavy's proposed research program was to conduct a long-term health-monitoring program of microwave workers at the Phillips laboratory. Erwin opposed the research and in a letter to Godfrey made a revealing statement that "the consensus opinion is that such a limited

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[186] ibid.
[187] C. Kanavy, 'Biological Effects of Microwave Radiation: A White Paper', Reproduced in *Microwave News*, vol. 13, no. 5, Sept./Oct., 1993, p. 12.
[188] Kanavy, 1993.
[189] L. Slesin, 'U.S. Air Force v. U.S. Air Force: Labs at Odds over RF/MW Health Risks', Microwave News, vol. 13, no. 5, Sept./Oct. 1993, pp.11-12.
[190] ibid.
[191] ibid.
[192] ibid.

program would yield no legal or scientific benefit to the Air Force and might even have a negative impact."[193]

In early 1993 the Federal Communications Commission proposed adopting the ANSI/IEEE C95.1-1992 RF standard for evaluating RF/MW hazards as part of its responsibilities under the National Environmental Policy Act [194]. Comments were called for on this proposal and about 100 were received in total. A brief examination of some of the main submissions to the FCC are illustrative of the vast chasm that separates public health protection considerations from those of fostering unfettered technological advancement. A similar division was seen in the Standards Australia TE/7 committee, as will be examined in Chapter 5.

The telecommunications industry had long been urging the FCC to adopt the ANSI/IEEE 1992 RF standard. However, several government agencies and professional organizations had reservations about the proposed move. The main points raised against ANSI/IEEE were as follows:

The Environmental Protection Agency (EPA) recommended that the FCC should instead consider the recommendations from the 1986 National Council on Radiation Protection and Measurements (NCRP) report[195] in preference to the 1992 ANSI/IEEE standard. EPA pointed out that NCRP was established by the US Congress specifically to develop radiation exposure recommendations and even though both ANSI/IEEE and NCRP used a similar literature base, NCRP and was more protective of human health for the following reasons:

- ANSI/IEEE increased by twofold the allowable exposure limits in the higher frequencies, whereas NCRP did not.
- ANSI/IEEE's two level controlled and uncontrolled limits were not well described, discretionary and not directly applicable to any population group, whereas NCRP gave exposure limits specifically for both workers and the public.
- ANSI/IEEE's conclusions that there was no evidence of sub-groups of the population who may be at greater risk from RF did not agree with the evidence.
- ANSI/IEEE's claim that their limits were protective of all mechanisms of interaction of RF and the body was unwarranted because the standard's limits were based solely on thermal effects.

EPA recommended that the FCC request NCRP to revise its 1986 report to be able to provide a critical and up to date comprehensive review of the biological effects of RF radiation and recommendations for exposure criteria.[196]

The FDA's Centre for Devices and Radiological Health (CDRH) was more lenient on the 1992 ANSI/IEEE standard and considered most of the provisions in the standard "appropriate" as they considered the changes would provide a greater level of protection to the general public. The CDRH disagreed, however, with the "low-power

[193] ibid.
[194] L. Slesin, 'Standards: FCC Seeks To Adopt 1992 RF/MW Limits', *Microwave News,* Mar./Apr. 1993.
[195] NCRP Report No. 86: Biological Effects and Exposure criteria for Radiofrequency Electromagnetic Fields. See: http://www.ncrponline.org/Publications/86press.html, Accessed Aug. 12, 2007
[196] L. Slesin, 'EPA Assails ANSI RF/MW Standards as Seriously Flawed', *Microwave News*, vol. 14, no. 1, Jan/Feb 1994, p. 10.

exclusion clause" that exempted certain RF devices from the provisions of the standard because they emitted less than a specified amount of power. They considered this disregarded the concept of limiting the SAR induced in the body - thus recognizing the problem of 'hot spots' where SAR levels can exceed the specified limits, an issue not addressed in the standard. In addition, CDRH did not see the standard as addressing the issue of long-term chronic exposures to RF fields.[197]

The National Institute for Occupational Safety and Health (NIOSH) saw the lack of involvement in the process by experts with a public health perspective as a weakness. Associated with this was the rejection of epidemiology studies as not being useful in the standard setting process, something NIOSH disagreed with. NIOSH felt that these limitations should be acknowledged by FCC for regulating both occupational and environmental RF exposures. The standard's two-tier limits, controlled versus uncontrolled, were seen as problematic as the designation very much depended on the workers' knowledge even though the standard did not give any guidance or training to workers to clearly understand the differences. As a result NIOSH recommended taking a more conservative approach and adopting the more restrictive uncontrolled limit for both workers and the public. NIOSH also noted that the standard was based on thermal considerations only and ignored the existence of possible non-thermal biological effects even though they were being reported in the scientific literature and were the subject of ongoing research. NIOSH felt that it should be acknowledged in the standard that health effects may be caused by other interactions than just by heating. Other omissions in the standard, according to NIOSH, were guidance on control measures, medical surveillance, worker training and hazard communication. [198]

The American Radio Relay League's (ARRL) bioeffects group was pointedly critical about the FCC proposal to adopt the ANSI/IEEE guidelines. They considered it as arbitrarily based and not suitable for communications facilities. They saw no justification for the controlled versus uncontrolled environment, and called for the termination of the proceedings.[199] Some of the ARRL committee members recommended the adoption of stricter RF standard limits.[200]

ARRL member Dr. Mark Hagmann acknowledged the importance of some of the new recommendations in the 1992 standard and expressed concern over a bias in the inappropriateness of limiting current measurements to the point of entry on the human body as well as the upper frequency limit for current measurements. He considered this was the result of "a relevant conflict of interest in the leadership of the IEEE SCC28 committee." [201]

What can be seen in the above agency comments is a concern for public health protections over possible non-thermal long term exposures and that the IEEE's thermal limitations were lacking in this regard. Many of these concerns were also expressed by a number of committee members on the Australian RF standard setting committee which will be examined in Chapter 5.

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[197] ibid
[198] L. Slesin, 'Industry Urges FCC Adoption of ANSI/IEEE C95.1-1992', *Microwave News*, vol. 14, no. 3, May/June 1994, pp. 13-14.
[199] ibid.
[200] L. Slesin, 'ARRL Bioeffects Committee Quits in RF/MW Controversy', *Microwave News*, Jul./Aug. 1994, p. 9.
[201] Slesin, 'Industry Urges FCC Adoption…', 1994.

**Industry reasoning in favour of the standard**

Whereas the above agencies and organizations took a critical look at the ANSI/IEEE 1992 standard and highlighted various inadequacies that had implications for worker and public health, the industry took a very different stand by steadfastly supporting their industry voluntary standard. A number of companies called for exemptions from state and local RF regulations that may have stricter limits than the ANSI/IEEE RF standard.

The Cellular Telecommunications Industry Association (CTIA) considered the standard to be "sound and scientifically based" and assured the safety of all new telecommunications products as long as they met all the relevant health and safety requirements. They were concerned that SAR compliance not be a hindrance to manufacturers.[202]

The American Telephone and Telegraph (AT&T) Corporation supported the standard, but recommended that since emission levels from cellular phone base stations and other microwave transmitters did not exceed the new standard limits they should not be required to be tested for compliance. They did say, however, that some types of wireless equipment should not be excluded because emissions from some wireless devices "may exceed the new limits".[203] This would be of interest, especially for people who would be using or be in close proximity to such devices. According to the IEEE's Committee on Man and Radiation in the controlled environment the user/controller is expected to only be aware that the device emits an RF signal. [204] Nothing is said of the awareness of the person as to the power output level or SAR that the device is delivering to their body, which may be exceeding the standard. In the majority of cases a person would not be aware of the power output or SAR level of the device he or she is using, and therefore would not be aware of what they are being exposed to. Without such information being freely provided to users the concept of controlled versus uncontrolled environments is of little value.

The Electromagnetic Energy Policy Board (EEPA) felt that "the large and diverse membership of the IEEE committee reflects a more accurate consensus of the scientific community compared with smaller panels of selected experts such as Scientific Committee 53 of the NCRP and IRPA/INIRC…in adopting a revised RF radiation regulatory scheme."[205] However, it is arguable whether achieving an unbiased consensus of the scientific community is possible, when the IEEE committee has such a large military presence. For example, in 1996 17 of the 31 members of the IEEE standards committee were associated with the Department of Defence.[206]

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[202] ibid.
[203] ibid.
[204] ibid. (According to COMAR "When an excluded device meets the requirement of the controlled environment for the user/controller, who can be expected to be aware that the device emits an RF signal, the device also ipso facto satisfies the uncontrolled specification for the neighbouring/adjacent nonuser.")
[205] Slesin, 'Industry Urges FCC Adoption…', 1994.
[206] L. Slesin, 'ANSI/IEEE v. NCRP: battle for Control of Rf/MW Standards', *Microwave News*, vol. 16, no. 2, Mar./Apr. 1996, p. 1, 12.

GTE Service Corporation believed that the industry was in compliance with the proposed standard and reasoned that it was necessary to block those who opposed the roll-out of new technology. According to GTE, due to "press scares and media hype, consumers have become confused regarding the safety of exposure to RF radiation caused by wireless services". GTE saw this as potentially resulting in "unjustified state and municipal restrictions [that] could have particularly severe consequences in the area of mobile services. The FCC's farsighted efforts…could be derailed by state regulations more onerous than scientific data warrants, inflamed by "press scares and media hype." To counter this possibility, GTE recommended legislation aimed at "pre-empting those that interfere with the development of "a rapid, efficient, nationwide and worldwide wire and radio communications service"[207]

Hammett & Edison Corporation also called for the FCC to pre-empt non-federal agencies from setting RF standards that are more restrictive than the 1992 standard. It also called for the FCC to "specify threshold distances for all facilities beyond which no consideration of RF effects need be made, but within which account must be taken of every such station."[208]

Motorola recommended that the FCC adopt the ANSI/IEEE low-power device exclusion provisions and called for exclusions for other radio types, such as those used in the private land mobile radio services. Motorola did say that with some devices, such as cell phones, it might be necessary to routinely measure SAR levels because the 2.5 cm spacing requirement for exclusion was not met.[209]

The National Association of Broadcasters (NAB) urged the FCC to adopt the standard "in a fashion that will minimise burdens on broadcasters (and other regulatees) yet still adhere to the standard's provisions". NAB recommended that the FCC "continue the 'three-pronged' approach whereby stations generally will be able to avoid making actual measurements to assess and certify compliance. Instead, the majority of broadcasters should be able to determine their compliance through the use of charts and graphs."[210] NAB also urged the FCC to take on the issue of pre-exemption to block "nonfederal opposition to the introduction of new communications technologies." NAB considered that the very implementation of such new technologies was threatened if pre-emption was not introduced.[211]

CBS Corporation gave its reasons why the ANSI/IEEE standard was the best available and mentioned that "the commission should ensure that federal policies are not undermined by inconsistent state or local regulation. Prompted by unsubstantiated fears, several states and municipalities have already prevented commissioned licensees from fully deploying their systems…"[212]

Raytheon supported the concept of the "controlled" and "uncontrolled" environment as they believed that the new standard was correct in rejecting the thesis that "certain subgroups of the population are more at risk than others." Raytheon also supported the

[207] Slesin, 'Industry Urges FCC Adoption…', 1994.
[208] ibid.
[209] ibid.
[210] ibid.
[211] ibid.
[212] ibid

continuing *"categorical exclusions."* They also rejected the inclusion of modulation in the guidelines as they claimed that there was no "scientific rationale" for the practice in the NCRP RF guidelines they said was "authored in 1986 by a small group."[213]

A common theme in the above industry responses, in stark contrast to agency and other criticisms of the proposed standard, was a stated belief that the standard assured that all RF emitting technologies were safe as long as exposures were kept below the recommended limits. There was a concern that the standard should not be an impediment to the deployment of RF technology and that action was needed to counter local or state government legislative opposition to the introduction of new technology. Agency criticisms were ignored, such as evidence for the existence of non-thermal effects, and public concerns were dismissed as being founded on media hype and unfounded fears. The industry stance reflected a shared self-interest in gaining approval for the proposed standard because it would validate their overarching concern - standard limits should not impede technological development.

**Turf Wars: The battle of the standards for FCC approval**

Under the U.S. Telecommunications Act of 1996 the FCC was required to adopt a new RF/MW exposure standard by August 5, 1996. This re-ignited the 1993 debate when the FCC first asked for comments on its proposal to adopt the ANSI/IEEE C95.1-1992 standard. The FCC quickly came under immense corporate lobby pressure to adopt the ANSI/IEEE standard outright and reject the older 1986 NCRP RF standard outright. Comments submitted to the FCC by the corporate sector included concerns that the NCRP standard was "seriously flawed", it "arbitrarily set limits that lack scientific basis", it "has not even been subject to peer review" and contained "unsubstantiated claims of nonthermal effects and modulation" as well as encouraging "prudent avoidance philosophies".[214] Other industry concerns were that if the FCC adopted the NCRP standard it would "result in increased nuisance litigation for persons and companies involved with RF radiation". Adopting the lower NCRP 5 mW/cm2 limit in preference to the ANSI/IEEE's 10 mW/cm2 would "increase litigation concerning products, services and installations previously approved by the FCC." They continued that the NCRP "recommendations cannot be considered to be the product of scientific method"and that "the NCRP report does not even constitute a conclusive academic study of the problem at this stage and, therefore, it should not be used to guide an industry."[215] All this was in sharp contrast to several federal agencies' concerns, previously mentioned, that the ANSI/IEEE 1992 standard had "serious flaws". The opposition expressed by the communications industry against the NCRP RF guidelines can be seen to be due to possible restrictions placed on some new technologies by the NCRP guidelines and the NCRP's consideration of non-thermal biological effects.

In a letter to the FCC, urging it to adopt the ANSI/IEEE standard, Hewlett Packard representative Cynthia Johnson wrote that HP's new class of short-range computer communications devices that will operate at 59-64 Ghz would be "impractical" if the NCRP limit of 5 mW/cm2 were applied. Johnson claimed that the NCRP standard

[213] ibid.
[214] L. Slesin, 'Industry Pressures FCC To Adopt ANSI RF/MW Exposure Standard', *Microwave News*, vol. 16, no. 2, Mar./Apr. 1996, p. 11.
[215] ibid.

"cannot be considered to be the product of scientific method" and that limitations were unnecessary because "scientific data simply does not exist for health effects of power levels at these frequencies."[216] In other words, when new technology was being developed that operated at frequencies where no bio-effects research had yet been conducted, that meant that as there was no evidence of a health hazard no limitations were necessary. Hewlett-Packard's argument was that at the millimeter wave band the energy (heating) only penetrates up to four-tenths of a millimeter into the skin but did admit that an area of possible concern was the eye.[217]

The 1986 NCRP standard did take into consideration nonthermal (a-thermal) effects, an unpopular concept to the industry and the IEEE as it undermined previous IEEE statements. As NCRP member Ross Adey explained:

> [T]he U.S. National Council on Radiation Protection and Measurements has recently established a committee with the sole mandate of reviewing the role of modulation effects with health implications, in conditions where athermal exposures are paramount. Committee 53 of NCRP published its Report 86 in 1986 and drew attention to the potential importance of ELF modulation patterns in determining health-related effects. Indeed, the very existence of modulation frequency-dependent effects bespeaks a-thermal interactions.[218]

Adey's statement on non-thermal (athermal) interactions was similar to points made some years later in an IEEE White Paper by L. Heynick. At a June 2001 IEEE SCC-28 committee meeting Heynick mentioned that his paper included "a list of citations on non-thermal effects considered established."[219] E. Mantiply from the FCC asked at the June SCC-28 meeting whether "non-thermal effects that are considered established would be considered by the committee." The answer was yes.[220]

In a critical 1989 SCC28 meeting that was voting on provisions for the next C95.1 standard revision, approximately a quarter of those present represented various sections of the military. In addition there were representatives from military's civilian defence contractors, including AT&T, General Electric, IBM, Lockheed, and Raytheon. Representatives from the broadcasting and communications industries were also present.[221] This illustrates that the interests of the military, manufacturers and users of RF/MW technology were an important consideration. In contrast the NCRP was a congressionally chartered organization with a degree of public accountability. It was this accountability that favoured consideration of bioeffects not considered by the IEEE's SCC28 subcommittee.[222] As mentioned in *Microwave News* in April 1996, if the FCC decided to adopt the NCRP standard it would likely diminish the influence of the

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[216] L. Slesin, 'Millimeter-Wave Eye Research Funded by Hewlett-Packard', *Microwave News*, vol. 16, no. 2, Mar./Apr. 1996, pp. 9-10.
[217] ibid.
[218] Communication with NCRP committee member Ross Adey, Aug. 1995. Cited in: Maisch D, Mobile Phones and Their Transmitter Base Stations: The Evidence For Health Hazards, *Australian Senate Hansard*, Apr. 1996.
[219] IEEE, SCC-28, Radisson Riverview Hotel, St. Paul, Minnesota, 2001, http://grouper.ieee.org/groups/scc28/sc4/sc-4%20minutes-june%202001.pdf, Accessed May 15, 2006.
[220] ibid
[221] L. Slesin, ' Revising ANSI RF/MW Limits: Debate Often Contentious", *Microwave News* reprint service, RF/MW Standards, Sept./Oct. 1989.
[222] ibid.

industry and military dominated IEEE SCC-28 committee. As *Microwave News* editor Louis Slesin put it: "AT&T, the CTIA, Raytheon and the DoD know a good thing when they have it and are fighting to regain control."[223]

In an effort to forestall any chance that the FCC would adopt the 1986 NCRP standard in preference to the ANSI/IEEE guidelines, in May 1996 the Cellular Telecommunications Industry Association's (CTIA) president Thomas Wheeler met with EPA administrator Carol Browner with a request that her staff "back off" from its objections to the ANSI/IEEE standard. Browner still continued, however, to support the EPA's recommendation to adopt the stricter NCRP RF standard.[224] In spite of strong industry pressure, the FCC, going largely on the advice of the EPA, adopted new RF/MW regulations largely based on those of the 1986 NCRP RF guidelines[225]. As examined by *Microwave News*, provisions of the FCC standard meant that the FCC:

- Rejected the ANSI/IEEE exclusion clause for low powered devices and followed the recommendations of the Food and Drug Administration by requiring that all new cellular and personal communications services (PCS) hand held phones be tested to ensure that emissions were not over 1.6 W/kg SAR. Compliance was to be either by computer modelling or laboratory measurements.
- Denied industry requests to extend federal preemption of state and local RF/MW health regulations for personal wireless services to all communications facilities.
- Acted "out of an abundance of caution" to require routine evaluation of cellular and PCS antennas if they are mounted lower than 10 meters above the ground and have a total power output over 1kW.
- Endorsed the distinction between "occupational" and "general population" as defined in the NCRP standards.
- Set limits of 1mW/cm2 for public exposures and 5mW/cm2 for occupational exposures above 1500 MHz. This provision was up to ten times more stringent than those recommended by ANSI/IEEE.
- The FCC however rejected the NCRP consideration of modulation effects as "premature".[226]

The new FCC RF standard soon came under fire from the industry group the Electromagnetic Energy Alliance[227], the Department of Defense, other industry companies, as well as several activist groups. The industry wanted the FCC regulations to preempt local and state regulation on the siting of all RF/MW transmitters. In addition to the Electromagnetic Energy Alliance industry group, Ameritech Mobile Communications called on the FCC to preempt state and local regulation of the operation of Personal Communications Systems (PCS) facilities and to rule on the issue

[223] ibid.
[224] L. Slesin, 'Cellular Phone Notes', *Microwave News*, vol. 16, no. 3, May/June 1996, p. 9.
[225] L. Slesin, 'FCC RF/MW Rules Favor NCRP Limits; Cell Phones To Be Tested for Safety', *Microwave News*, vol.16, no. 4, Jul./Aug, 1996, pp. 1, 13.
[226] ibid.
[227] The Electromagnetic Energy Alliance (EEA) made up of members from AT&T, General Electric, Motorola, Raytheon, the National Association of Broadcasters and the American Radio Relay League, who had changed their previous stand against the ANSI/IEEE standard.

of liability for "environmental effects of RF emissions". In other words AMC wanted a rule that as long as industry complied with the standard they would be protected against any health hazard liability.[228] A desire on part of industry and the military to stick solely with the ANSI/IEEE standard was expressed by the Department of Defense and US West when they criticised the FCC for not sticking firmly to the ANSI/IEEE standard.[229]

In spite of the exemptions laid out in the Telecommunications Act and an executive order by President Clinton expediting the use of federal land and buildings, the issue of continuing opposition, especially community siting moratoriums, continued to be a sore point with the Industry. The CTIA's stand on moratoriums was that they "violate the rights of wireless service providers."[230] No mention was made about violating the rights of local communities and governments to have a say in siting decisions. In Jan 1997 the CTIA's Wheeler petitioned both the FCC and President Clinton. The CTIA's complaints listed 150 communities that had moratoriums in place against towers that Wheeler claimed were "too often being used as a subterfuge to avoid complying with federal law". Wheeler also complained that local and state governments were still attempting to set their own RF/MW standards in spite of the Act. Wheeler wrote to president Clinton that "the wireless telecommunications industry continues to experience significant antenna siting resistance from far too many federal agencies in defiance of your order and the law."[231] Supporting the CTIA's efforts the Personal Communications Industry Association (PCIA) also petitioned the FCC to preempt moratoriums longer than three months and to end the prohibition of preemption for antennas on existing buildings.[232]

On August 25, 1997 the FCC reaffirmed its previous decision to base its RF standard mainly on the NCRP RF recommendations of 1986. FCC spokesperson Robert Cleveland stated that "we have based our guidelines on the recommendations of the Environmental Protection Agency, the Food and Drug Administration and the National Institute for Occupational Safety and Health."[233] All of these agencies had long opposed the FCC adopting the industry standard ANSI/IEEE C95.1–1992 apparently as a result of these agencies' mission to address human health and safety issues. In contrast, the IEEE C95.1 Committee's mission represented the interests of industry and military users of RF technology. For example, IEEE's SCC-28 committee chair John Osepchuk for many years represented Raytheon on the standards committees. Dr. Eleanor Adair as vice-chair (and later chair) was a senior researcher at the Brookes Air Force Base and the secretary Ron Peterson was from Lucient Technologies. The chairs of SCC-28 IV were Dr. C-K Chou from Motorola and John D' Andrea from the Naval Medical Research Institute at Brookes AFB.[234]

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[228] L. Slesin, 'Industry, Activists Challenge FCC's New RF/MW Rules', *Microwave News,* vol. 16, no. 5, Sep./Oct. 1996, pp. 9-10.
[229] ibid.
[230] L. Slesin, 'FCC Reaffirms Health Rules Based on NCRP Limits', *Microwave News*, vol. 17, no. 5, Sept/Oct 1997, p. 10-11.
[231] L. Slesin, 'Wireless Notes', *Microwave News*, vol. 17, no. 1, Jan./Feb. 1997, p. 8.
[232] ibid.
[233] Slesin, 'FCC Reaffirms Health Rules…', 1997.
[234] L. Slesin, 'IEEE Adopts Some Changes in Standards for RF/MW Exposure', *Microwave News*, vol. 19, no. 3, May/Jun. 1999, pp. 5-6.

The FCC decision was apparently in line with a central tenet of this thesis: When vested interests control the standard setting process over their activities, the primary consideration is that standard limits should never be an impediment to their various operational requirements. According to those interests, public health considerations must therefore conform to that requirement. The FCC decision was apparently due to the concerns raised by federal agencies that the IEEE proposed RF standard was insufficient for public health protections.

**The Radiofrequency Interagency Work Group (RFIAWG)**

The Radiofrequency Interagency Work Group is a governmental interagency committee reconstituted in February 1993 as a result of an oversight meeting by a telecommunications sub-committee of the House of Representatives' Committee on Commerce. Agency membership includes the Food and Drug Administration (FDA), the Center for Device and Radiological Health (CDRH), the National Institute for Occupational Safety and Health (NIOSH), the Environmental Protection Agency (EPA), the Occupational Safety and Health Administration (OSHA), the National Telecommunications and Information Administration (NTIA), and the Federal Communications Commission (FCC).[235] With this work group make up, a significant difference of opinion was expressed over the adequacy of the proposed standard, compared to that of the industry make up of the IEEE standard setting committee SCC-28. This again illustrates the differing scientific interpretations of the same scientific literature base depending on one's affiliations. This can be generalized as agency public health considerations as opposed to industry operational requirements.

On June 1999, Gregory Lotz, representing NIOSH on the RFIAWG, presented the Chairman of the SCC-28 subcommittee IV a list of issues that RFIAWG considered needed to be addressed in the IEEE RF standard. The list was in response to previous requests from the work group for greater participation in SCC-28 discussions on RF standards.[236] In particular, RFIAWG criticised the biological rationale of the standard on a number of fronts. A fundamental issue was the standard's failure to address chronic (low intensity/prolonged) as opposed to acute (high intensity/short term) exposures. This was seen in the standard's limiting the definition of an "adverse effect level" to only acute exposure situations and the use of time-averaged calculations that were not suitable for prolonged exposure situations and therefore may not adequately protect the public. RFIAWG recommended that a clear rationale needed to be developed to also include chronic exposures.[237] Another concern was the standard's incorrect assumption that all tissues are equally sensitive (other than the eyes and testicles) to RF. This failed to take into consideration the differing sensitivity of human tissue when calculating SAR limits.[238] There was also a concern expressed about failure to include consideration of the body of research on the biological effects of exposure to ELF-modulated and pulse modulated RF that was relevant to public exposures. In addition, the SAR time-averaging calculations as used in the standard hid any biological effects resulting from

[235] E. Jacobson, Deputy Director, Center for Devices and Radiological Health, FDA Letter Regarding Cellular Phones, May 5, 1997, http://www.osha.gov/SLTC/radiofrequencyradiation/fda.html, Accessed Oct. 3, 2007.
[236] G. Lotz, RFIAWG, RF Guideline Issues: Identified by members of the Federal RF Interagency Work Group, June 1999, letter from Gregory Lotz to Richard Tell, Chair of IEEE SCC28 IV, http://www.emrnetwork.org/position/exhibit_a.pdf, Accessed June 23, 2006
[237] Lotz, op. cit., p. 1-2.
[238] ibid.

modulated RF exposures.[239] RFIAWG also questioned the biological validity of the IEEE's two-tier exposure classification, "controlled" vs. "uncontrolled". Besides not being adequately explained, a rationale needed to be given as to why people in uncontrolled environments needed to be protected to a greater extent than persons in controlled environments, when such situations historically were based on biological considerations.[240] Another issue for RFIAWG was the rationale for the relaxation of the exposure limits above 1.5 Ghz that "caused concern that the standard is not restrictive enough for continuous exposures at lower microwave frequencies where new wireless applications for consumers could make this an issue in the future."[241] To address these concerns the working group recommended a comprehensive review of long-term, low-level exposure studies that had relevance to environmental chronic occupational RF exposures and neurological-behavioural effects to better define the adverse effect level for RF, and micronucleus assay studies with relevance to carcinogenesis.[242]

**IEEE SCC-28 Subcommittee 4 tackles the mobile phone compliance problem.**

An ongoing problem for the cell phone manufacturers in the U.S. was ensuring that their phones were in compliance with the FCC'S SAR mobile phone limit of 1.6 W/kg averaged over 1 gram of tissue. This was seen in testing by Motorola's Libertyville Cellular Electromagnetics Laboratory in Illinois in 1993 and 1994 when testing Motorola phones for compliance with the FCC limit. The Motorola laboratory found wide variations in SAR measurements (up to 4 fold) and in many situations the phones were in excess of the FCC limit.[243] In addition, Dr. Om Gandhi from the University of Utah, found in 1999 that under the 1.5 W/kg and 1 gram criteria, many U.S. phones violated the FCC limits because of high exposures to the ear.[244] This compliance problem was solved when SCC-28 SC-4 voted in Sept 2000 to reclassify the human ear as an "extremity", thereby increasing the allowable limit for the ear from a mobile phone from 1.6 W/kg averaged over 1 gram of ear tissue to 4.0 W/kg averaged over 10 grams of tissue.[245]

How to address compliance issues was a major discussion point in the June 8-9, 2001 meeting of IEEE SCC-28 Subcommittee 4. During the discussions over revisions to the C95.1-1991 standard Richard Tell summarized various points on a questionnaire sent out to members. An important issue on the agenda was whether or not the 1-gram averaging mass for SAR levels should be increased. The majority of the responses were in favour of an increase. Co-chairman C-K Chou from Motorola did not mention any implications for bio-effects issue, but said that "a small change in the averaging volume could have a large impact on industry, for example on cellular phone manufacturers." He then went on to say "a realistic low-power device exclusion is needed". Chou suggested that "unless there are reasons not to, the ICNIRP peak spatial-average SAR limits should be considered." Such a change would increase the averaging volume to 10 grams of tissue

[239] Lotz, op. cit., p. 5.
[240] Lotz, op. cit., pp. 3-4.
[241] Lotz, op. cit., p. 6.
[242] Lotz, op. cit., p. 7.
[243] L. Slesin, 'Motorola Memos: Small Changes in Manufacturing or Test Procedures Can mean Big Changes in SARs', *Microwave News*, vol. 19, no. 5, Sept./Oct. 1999, p. 12.
[244] L. Slesin, 'Industry Seeks Higher Exposure Limit for the Ear', *Microwave News*, vol. 19, no. 6, Nov/Dec. 1999, pp. 1, 11,
[245] L. Slesin, 'SCC-28/SC-4 Okays Ear as "Extremity', *Microwave News*, vol. 20, no. 5, Sept./Oct. 2000, p. 5.

which would serve the purpose of averaging out peak exposures, the so called "hot spots" that occur when a mobile phone is held close to the head of the user. The larger the volume to be measured, the more peak exposures can be averaged away, a concern expressed by RFIAWG. This proposal was later successfully incorporated in C95.1-2005. R. Peterson from Lucient technologies agreed that "a low-power device exclusion should be included in the revision but the exact values could not be determined until the averaging volume issue was resolved". Peterson said "[t]he consensus is to move to a larger volume and perhaps higher limits for the spatial average SAR, e.g., adopt the ICNIRP limits." J. Osepchuk then reviewed his proposal for new averaging times. He pointed out that the reason for a change is to "resolve the issue of the eyes and testes caveat in the partial body relaxation."[246] In other words, by increasing the averaging times in the proposed relaxation, this eliminated the problem of exposures to the eyes and testes possibly being in excess of the limits. The solution was to increase to a 10-gram mass to average out peak exposure levels.

The problem the cell phone industry has with the FCC's compliance limit was highlighted on the U.S. *"20/20"* ABC TV cell phone investigative documentary, aired on October 20, 1999. When the program decided to test five mobile phones for compliance with the FCC emissions standard they found that all four US testing labs approached to do compliance testing refused to do the work. It was suggested on the program that this refusal might have been because anyone who did the testing would be blacklisted by the industry. *20/20* then went to Dusseldorf, Germany, at the institute for mobile and satellite technology, a research laboratory which does work for both industry and government in Germany and was on a list supplied by the American FCC. Dr. Achim Bahr ran the tests for 20/20. Following standard compliance testing it was found that, depending on the position of the phone during the tests, four out of the five analogue phones tested were over the FCC prohibited SAR measurement of 1.6 W/kg. In other words a phone could be in or out of compliance depending on the test position. These tests were normally done by the industry with their results then submitted to the FCC. When asked about this on *20/20* Dr. George Carlo, former head of the Cellular Telephone Industry Association's (CTIA) Wireless Technology Research group (WTR), said, "It is possible for the industry to submit the findings that are favourable to them and have the FCC only review those. In fact this industry is regulating itself."[247]

In a report from the ARRL RF Safety Committee[248] to its board of Directors in July of 2000 concerns were raised about the reliability of wireless equipment testing and measurements used in its environmental assessments as a result of the *20/20* program.[249] It was also mentioned in the ARRL report that possibly as a result of the *20/20* program, the FCC's Dr. R. Cleveland (also a member of SCC-28 Subcommittee 4) embarked on a study of how cellular phones were usually held, with the goal to improve the testing requirements for FCC Maximum Permissible Exposure (MPE) compliance.[250]

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[246] IEEE SCC-28 Subcommittee 4, Radisson, St Paul, Minnesota, 2001, op. cit.
[247] ABC News, 'Worried About Your Wireless?' 20/20 program transcript, Brian Ross (interview reporter), Oct. 20, 1999, http://www.junkscience.com/oct99/2020tran.htm, Accessed Sept. 12, 2006.
[248] The Amateur Radio Relay League (ARRL) is the peak organization that represents American Short Wave ham operators and has representation on the IEEE SCC-28 RF Safety committee.
[249] ARRL, 'Report of the RF Safety Committee to the ARRL Board of Directors', Jul. 2000, http://www.arrl.org/rfsafety/Rpt-7-00.htm, Accessed May 12, 2005.
[250] ibid.

With concerns being in the media about cell phone compliance with FCC limits the industry now faced the problem of how to ensure that cell phones being sold in the U.S. adequately met U.S. compliance standards. The industry had at least three options to ensure that mobile phones are in compliance with FCC regulations:

- To redesign phones so that they had lower emission levels (at least in all test positions) and therefore meet the FCC's Maximum Permissible Exposure (MPE) limits. This would obviously be a very expensive exercise.
- To gain a "low-power" exemption to avoid the issue altogether for cell phones. This was difficult proposition given the concerns expressed by RFIAWG in 1999 and the adverse publicity from the *20-20* program in 2000.
- Relax the relevant IEEE standards on averaging times and tissue mass used in calculating compliance with localized MPE's, then lobby the FCC to adopt the relaxed IEEE standards in preference to those of the stricter NCRP.

What is apparent from examining the 102 page minutes from the June 8-9, 2001 meeting is that the prime consideration of the SCC-28 Subcommittee 4 members was the third option, to ensure that the standard complies with the service requirements of whatever new wireless technology is in the offering. This is plainly seen through the ongoing efforts of SCC-28 Subcommittee 4 to push through a relaxation of the limits. The 1999 recommendations of the RFIAWG to the IEEE were not addressed in the June 2001 meeting, other than possible in veiled comments, such as from L. Heynick when mentioning non-thermal effects. He stated that he was not sure "how to proceed with other 'low-field' effects" and pointed out "that it is important to proceed because of misplaced criticism and attacks on the IEEE for not including these studies."[251] Such an emphasis on service requirements is perhaps understandable when the list of those attending the conference is considered. Out of 60 attendees present (64 members in total) 30 were from the wireless industry sector (6 from Motorola alone), 12 were from the military, 7 "consultants" who do work for the industry, 4 from various U.S. government health agencies, 2 from other foreign agencies, and 5 academics. Unlike the practice in other committees, such as SCC-34 where member organisations are limited to one vote, in SCC-28 each attendee gets a vote, thus giving Motorola, for instance, more voting power than all federal health agencies combined. The Chairman of SCC 28 was John Osepchuk, who had represented Raytheon from the very beginning of the standards process before becoming an "independent consultant". Co chairs were J.A. D'Andrea, from the Naval Health Research Detachment and C-K Chou from Motorola.[252]

**Other uses of microwaves**

At the same time Osepchuk was a member of IEEE C95.1 Subcommittee IV (later renamed SCC-28 Subcommittee 4), validating the 1997 edition of the 1991 RF/MW exposure standard, he was also promoting microwave technologies designed to cause thermal effects that the standard specifically set out to prevent. In an interview with *New Scientist*, in December 1996, Osepchuk and Charles Buffler, another member of C95.1 Subcommittee IV, who was also working on the standard, both spoke in favour of experimental research on developing the use of microwaves as a home heating device. It is very likely that Osepchuk and Buffler were talking "tongue-in-cheek" with their

[251] IEEE SCC-28 Subcommittee 4, Radisson, St Paul, Minnesota, 2001, op. cit.
[252] ibid.

promotion of the idea but at the very least it speaks of an underlying intellectual belief in a benign nature of microwaves, even at thermal levels. Such an attitude coming from people very much involved in the setting of exposure limits, especially with Osepchuk as chairman of the SCC-28 standards committee, indicates that any serious consideration of non-thermal health effects was a non-issue. The system Osepchuk and Buffler discussed with *New Scientist* was one being developed by the Microwave Research Centre in Marlborough, New Hampshire, U.S.A.. The system used a conventional 800 watt microwave oven transmitter, placed behind a hole in a wall, that heated by beaming microwaves into the room. The report in *New Scientist* describes how researchers at the Microwave Research Centre were acting as "guinea pigs" for the experimental home heating system, which warms people by exciting the body's water molecules, thus raising body temperature. The researchers discovered that they felt some warmth at microwave levels that were "several hundred times less than the level inside a microwave oven". The article does not say what that level may be, but the "normal leakage" of a microwave oven is about 50 $\mu$W/cm2 at about 12 inches from the case,[253] so given that, "several hundred times less" than the level inside the oven would have to be well in excess of 50-100 $\mu$W/cm2, especially if the actual room microwave levels were designed to give a heating effect. Compare this level to the levels measured in a large-scale five-year study on people living near a short-wave transmitter in Schwarzenburg, Switzerland, where 55% of residents suffered from disturbed sleep, and 35% from full insomnia. The researchers reported that "sleep difficulty was especially disturbing. This leads on to increasing fatigue and reduced feelings of well-being." The sleep disturbance was associated with power density exposures from 0.7 uW/cm2 to the maximum found of 1.85 uW/cm2. The study found a statistically significant association between extremely low intensity RF exposures averaging 0.236 uW/cm2 and a wide range of health and well-being variables. Interestingly the researchers were able to have the transmitter turned on and off on different nights and symptoms were greatly reduced when the transmitters were turned off.[254]

Charles Buffler, who worked at the Microwave Research Centre, said that the heating system would be a highly efficient way of keeping warm. He calculated that microwave heating systems could cut household heating bills by 75%. An added bonus would be that since microwaves cause light bulbs to fluoresce, such a heating system could also double as the power supply for a system of wireless lights. Osepchuk, stated to *New Scientist* that "Getting public acceptance of the idea will be the biggest problem"..."At the moment we have a pervasive electrophobia. People are scared stiff of the prospect".[255] As mentioned in the New Scientist article, There are several other problems with such a heating system, other than "pervasive electrophobia", which may make microwave home heating a hard sell to the public:

- Microwave heating would not necessarily make you feel warmer because while microwaves would heat up internal organs, the skin always remains in contact with cool air so the occupant still could feel cold.

[253] Correspondence with Cindy Sage, Sage Associates, Feb 6, 2005.
[254] Swiss Federal Office of Energy, 'Study on Health Effects of the Shortwave Transmitter Station of Schwarzenburg, Berne, Switzerland (Major Report)', BEW Publication Series, Study No. 55, August 1995. Also see, N.Cherry, 'Swiss shortwave transmitter study sounds warning', http://www.emfacts.com/forum/issue2/mag_9.html, Accessed Aug. 17, 2006.
[255] P. Moore, 'Not cooking but Warming', *New Scientist*, vol. 152, no. 2061/2, 21-28 Dec. 1996.

- Furniture would have to be covered in a material that also heats up with exposure to microwaves so that it wouldn't feel cold to the touch.
- The microwaves would interfere with radio and TV reception, as well as distorting TV and computer monitors.
- Small metal objects, such as keys and coins, would become extremely hot.
- As Buffler admitted in the article, heat might build up in parts of the body that are particularly exposed or poorly supplied with blood. "The main areas of concern are the cornea and the testicles"[256].

Osepchuk went on in the *New Scientist* to proclaim how he believed microwaves could transform society. "One of the things I foresee is a solar satellite system - satellites that collect solar power and beam it to the earth using microwave radiation" he said. "This radiation could be used to heat an entire state, perhaps even preventing frost and the millions of dollars of damage it does to citrus crops." Of course anyone in the area would also heat up, whether they wanted to or not, a prospect that is nothing to worry about, says Osepchuk. "Let's face it, as it's freezing they'd appreciate a little bit of heat", he told New Scientist.[257] Osepchuk and Buffler's proposal to use microwave energy to heat buildings was based on work by Harvard Professor and Nobel Laureate Robert Pound who wrote a paper in 1980 that advocated using microwaves to heat homes.[258] Buffler and Osepchuk's attitude toward microwave energy may seem a bit extreme but their enthusiasm is not unusual for the IEEE SCC-28 fraternity. A case in point is senior SCC-28 member Dr. Eleanor Adair who has for many years worked on microwave induced behavioural thermoregulation for the US Air Force and has been a driving force in establishing the IEEE's RF standard. As a member of IEEE's Committee on Man and Radiation (COMAR) she has been an outspoken advocate of "quality science and science-based health and safety standards". Between 1996 and 2001 she served as Senior Scientist in Electromagnetic Radiation Effects for the Human Effectiveness Directorate of the Air Force Research Laboratory (AFRL). Since 2001 she continued her work as a member of the AFRL Senior Scientist Emeritus Corps[259]and as a member of the senior executive service at Brooks Air Force Base holds the equivalent rank of Brigadier General.[260] In an interview with the *New York Times* in January 2001 Adair expressed her deep faith in the absolute safety of microwave radiation. Adair explained that, unlike gamma and X-rays, which can break chemical bonds and therefore damage cells and cause cancer, microwaves can only heat cells. According to Adair, cell death can only occur at high levels (like in a microwave oven), therefore cell phones are harmless. She explained that the quantum energy in the microwave band is so low it "can't do any damage to the cells whatsoever". Adair claimed that in her many years of microwave research on monkeys, starting in 1975, she never saw any adverse effects and in fact the monkeys "would really thrive on the microwave radiation…we never saw any cancer in any animal. We never saw anything but happy, healthy, thriving monkeys". According to Adair when they took the animals out of the chamber after the experiments "the animals that were taken out of the microwaves would sort of pine away. It was as though they were saying, "Come on. It's about time to go back in

[256] ibid.
[257] ibid.
[258] R.V. Pound, 'Radiant Heat for Energy Conservation', *Science*, vol. 208, p. 494, May 2, 1980.
[259] M. Murphy, 'Dedication: Eleanor Reed Adair', *Bioelectromagnetics Supplement* 6, pp. S1-S2, 2003.
[260] G. Kolata, 'A Conversation with Eleanor R. Adair; Tuning In to the Microwave Frequency', *The New York Times*, Jan. 16, 2001.

the box."[261] Even though this observation indicated the possibility of an addictive reaction to the microwave exposure, with possible implications for mobile phone users, it apparently was not picked up.

In relation to microwave home heating mentioned previously, Adair said that, when they heard about Pound's proposal, "A lot of us had thought, Oh, gosh, wouldn't this be a great way to heat yourself in a cool house?" She then claimed that "we are still pushing it as one of the peaceful uses of microwave energy". As for the research effort on possible health hazards from powerline EMFs, cell phones and radar Adair stated that the money could better be spent on other health issues, "because there is really nothing there".[262] The central role of Adair in evaluating research on behalf of SCC-28 (renamed the International Committee on Electromagnetic safety (ICES) in March 2001) can be seen in the Minutes of the SCC-28 subcommittee 4 of June 29, 2002. Attachment 4 is titled: "Setting a Science-Based Standard for Safe Human Exposure to RF Electromagnetic Fields: A Tribute to Dr. Eleanor R. Adair, U.S. Air Force Laboratory Workshop".[263] Attachment 6 of the minutes lists the total number of In-Vivo papers reviewed for SCC-28 by each of the 34 reviewers listed. The time frame is pre-1998 to 2001. Adair tops the list with 143 papers evaluated during this time.[264]

**Standard setting, 2001-**

In September 2001 the revision working group within SCC-28 SC-4 circulated a draft proposal of their exposure standard to the full sub committee for comments. This draft was developed as a result of discussions that took place during and after the June IEEE SCC-28 SC-4 meeting (above). Under the new draft the specific absorption rate (SAR) limit for mobile phones would increase from 1.6 W/kg to 10 W/kg (local exposure) and change the way SARs are measured, from 1 gram of tissue to 10 grams. The effects of these two changes would increase the allowable exposure to cell phone radiation by a factor of 12.[265] The SC-4 committee also decided to opt out of the two-tier exposure level of the 1991 IEEE standard and go for one tier. Thus the 0.4 W/kg for controlled environments (workers) would also apply for the general population (uncontrolled environments), increasing the 0.08 Kg limit for uncontrolled environments to the 0.4 Kg level. This change meant that the power density limits for the general public would increase from 200uW/cm2 between 100 and 300 MHz to 1,000uW/cm2, with higher power densities allowed at higher frequencies.[266] Dr. Eleanor Adair, who had by then taken over from Osepchuk as chair of SCC-28 (ICES), had pushed for an even greater relaxation of those limits – from 0.4 W/kg to 1 W/kg. That would have meant a 10-fold increase in allowable public exposure.[267] When the revision working group met again in January 10-11, 2002, however, they rejected many of the central elements in the draft standard. They decided to keep the two-tier approach, the whole-body average SAR of

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[261] ibid.
[262] ibid.
[263] IEEE/ICES, Unapproved Meeting Minutes, SCC-28 Subcommittee 4 Meeting, Hotel Loews Le Concorde, Quebec, Canada, June 29, 2002, p. 21, http://grouper.ieee.org/groups/scc28/sc4/sc-4%20minutes-june%202002.pdf, Accessed May 15, 2006.
[264] ibid., p. 23.
[265] L. Slesin, 'IEEE Drafts Major Relaxation of RF/MW Human Exposure Limits', *Microwave News*, vol. 21, no. 5, Sept/Oct 2001, pp. 1 & 10.
[266] ibid.
[267] ibid.

0.4 and 0.08 W/kg, and leave the peak SAR value and average volume at 1 gram of tissue.[268] This was done with the insistence of the attending members of the federal agencies. Dr. Robert Cleveland from the FDA said of the changes: "I think we are moving in the right direction toward a scientifically supportable standard." Dr. Niels Kuster from the Laboratories for Research on Information Technologies in Society (IT'IS) in Zurich said that, "[t]he earlier draft was based on faulty concepts and we are back to a more acceptable proposal."[269] These statements are at odds with the U.S. Air Force's Dr. Eleanor Adair (new Chair of SCC-28) who said of the draft relaxation revisions: "The IEEE charged our committee to produce a science-based standard."[270] Surprisingly the four Motorola members at the working group meeting appeared to support the federal agency's revisions, as Dr. Greg Lotz said to Microwave News: "Motorola's participation was definitely helpful in revising the proposal drafted by the Revision Working Group."[271]

When the full SCC-28 (4) met only a week later, however, its larger membership voted to 'edit' the wording made by its working group. Mention of "unknown health consequences"[referring to non-thermal bioeffects] was struck out; reference to the WHO temperature workshop in respect to determining averaging volume and peak SAR limits was struck out; and the word "keep" in reference to retaining the two-tier approach, peak SAR value and averaging volume was changed to "reconsider" – thus keeping the issue on the agenda for possible change.[272] The reason for the change in heart was that those representing the federal agencies *failed* to attend the later full meeting[273] – a rather surprising lapse, considering the agencies' opposition to relaxing the standard. Why they failed to attend is not known but it was very 'convenient' for it allowed industry and military representatives on the standards committee to pass what they wanted without opposition. This again illustrates the subjective nature of RF standard setting, when industry and military vested interests on the committee were given a free pass to write into the standard what they wanted based on their own risk assessment. This was done in order to protect their interests at the meeting without opposition from other members who had a different viewpoint on the science more in line with the public interest. The divisions within SCC-28 over provisions in the draft standard were between the federal agencies concerned with health protection and members working for, or allied with, the Department of Defense (DoD), who were only concerned with service requirements and getting new technology on–line as quickly as possible. The federal agencies made it clear that they would not support a standard that significantly relaxed key provisions of the existing standard. In particular, Robert Curtis from the U.S. Occupational Safety and Health Administration (OSHA) said that "[a] standard that does not recognize the need for safety factors for different members of the population would have little value."[274] This conflict prompted some members of SCC-28 to back away from a full-scale revision in favour of making small, incremental changes[275]. The problem for the cell phone industry however, as stated by Chou at the

[268] L. Slesin, 'Revision of RF/MW Standard Stalls As IEEE Panel Is Split on Key Issues', *Microwave News*, vol. 22, no. 1, Jan/Feb 2002, pp. 1 & 7.
[269] ibid.
[270] Slesin, 'IEEE Drafts Major Relaxation…', 2001.
[271] Slesin, 'Revision of RF/MW Standard Stalls…', 2002.
[272] ibid.
[273] ibid.
[274] ibid.
[275] ibid.

June 2001 SCC-28 SC-4 meeting, was that the SAR averaging change "could have a big impact on . . . cell phone manufacturers". This was especially urgent because of the uncertainties of cell phones meeting the FCC SAR compliance limits, as raised by the 20/20 program. The issue was put on hold by SCC-28 until after a WHO/Motorola organised thermo-regulation workshop on March 21-22 in Geneva, where it was hoped the proposed relaxation in the IEEE's standard could gain further 'science-based' justification.[276]

Reflecting differing views within the IEEE itself, in the August issue of IEEE Spectrum, Raymond Kasevich, chief scientist of CS Medical technologies, a developer of microwave treatment technology for prostate and cardiology treatments based in Great Barrington, Maine, expressed a view supporting the concerns of the federal agencies. Kasevich called for the RF/MW standard to be revised "using all of the available results and information – not just the data that fit previously held assumptions." He wanted the work of Drs. Richard Albanese, Henry Lai and Dariusz Leszcxynski (all work examining non-thermal mechanisms) to be taken into account. Kasevich added, "[t]he telecommunications industry, which is in deep denial, needs to face reality."[277]

**SCC-28's Risk Assessment Working Group on revisions**

As "risk assessment" is a key theme running through this thesis it is worthwhile to consider a few pertinent points from SCC-28's Risk Assessment Working Group (RAWG) on the standard revisions. These are taken from internal emails circulated within RAWG and obtained by *Microwave News*.

Richard Tell, from Richard Tell Associates Inc., made the point that the 4W/Kg threshold level for a non-hazardous effect was determined in the context of very short duration exposures only. Tell said that "most of the researchers who have developed this data agree that this threshold would turn into a really hazardous threshold if the exposure had been longer…So, sometimes, I sense that we are sort of talking like the 4 W/Kg figure is no big deal, but we know better".[278]

James Hatfield from Hatfield and Dawson Consulting Engineers, took a more philosophical view that belied Adair's belief that the process was bases on sound science. "We are obsessed by our own definition of 'science.' This standard is a lot more than science whether we like it or not. There have always been politics and sociology in the setting of MPE limits. Where do you think the lower public MPEs come from? Not quite the tooth fairy." Hatfield said.[279]

Vitas Anderson from EME Australia Ltd. and later an associate investigator at the Australian Centre for Radiofrequency Bioeffects Research (ACRBR) took a viewpoint mirroring John D. Graham's use of unrelated risk comparisons (Chapter 1). Anderson compared the 0.4 W/Kg whole-body-average SAR limit heat load "to other sources of heating that are routinely accepted by the community without any qualms, including for

[276] ibid.
[277] L. Slesin, 'Standards', *Microwave News*, vol. 22, no. 4, Jul./Aug. 2002, p. 16.
[278] L. Slesin, 'IEEE RF/MW Exposure Limits: Revise or Stand Pat?', *Microwave News*, vol. 22, no. 4, Jul./Aug. 2002, p. 9.
[279] ibid.

example: increasing the ambient air temperature by a few degrees; stepping out into the sunshine; hugging your children; almost any form of physical exertion, including tapping out these words on my computer."[280]

Dr. David Black from *Enviromedix IT* New Zealand, came right out against the guiding principle used in radiation protection, the ALARA principle[281]. "I don't support the use of ALARA in RF standards … there are good reasons to believe that there are true thresholds with RF below which there is no effect at all even across a large population. Using ALARA in RF weakens its importance in IR [ionising radiation]. We have deliberately removed it from the Australian and NZ standards for that reason."[282] Black did not mention the significant amount of opposition within the Australian TE/7 standards committee to removing that provision (more accurately debated around a precautionary approach) to the point that TE/7 was dissolved because it failed to agree to its removal. This will be examined in detail in Chapter 5.

The above quotes illustrate the subjective nature of IEEE's RF standard setting science. Tell pointed out the significant limitation of the basic 4W/Kg supposed threshold level for non-hazardous effects in that it is only based on short-term exposures. Hatfield acknowledged the inclusion of political and social factors in determining the exposure limits. Anderson took a page right out of John Graham's revisionist risk analysis primer covered in detail in Chapter 1 and Black resorted to a disingenuous re-interpretation of history in trying to make his point. The significance of Anderson and Black's statements, in particular, are two-fold. First they show a complete alignment with the thermal viewpoint, without any reservations whatsoever - to the point of stretching the truth in trying to make their points. Secondly, both Anderson and Black were also prominent members on the Australian TE/7 Committee, as will be examined in Chapter 5.

By 2003 it was clear that the proposed IEEE SCC-28 RF relaxed standard was facing an uphill battle to be accepted by the FCC , EPA and other federal agencies who continued to oppose IEEE's relaxed standard in preference to the stricter FCC NCRP based RF standard. For example in 2002, the Cellular Telecommunications Industry Association (CTIA) put pressure on the EPA to reconsider its advice to the FCC in favour of the IEEE standard. In Sept 15, 2002 the EPA responded in a letter to the CTIA reaffirming its support for the FCC's RF exposure standard.[283]

**Harmonization with ICNIRP on the agenda**

In 2001, the name of the SCC-28 committee was changed to the "International Committee on Electromagnetic Safety" (ICES)[284] "in order to continue its work globally" according to Osepchuk.[285] Harmonization with the International Commission on Non-

[280] ibid.
[281] The guiding principle behind radiation protection is that radiation exposures should be kept "As Low As Reasonably Achievable (ALARA)," economic and social factors being taken into account. This common-sense approach means that radiation doses for both workers and the public are typically kept lower than their regulatory limits. Taken from the Health Physics Society: http://hps.org/publicinformation/radfactsheets/radfact1.html
[282] Slesin, 'IEEE RF/MW Exposure Limits…', 2002.
[283] L. Slesin, 'EPA: Current RF Limits Are Adequate for Thermal Risks', *Microwave News*, vol. 22, no. 5, Sept./Oct. 2002, p. 8.
[284] Osepchuk, Petersen, 2003.
[285] ibid.

Ionizing Radiation Protection (ICNIRP) was on the agenda for the June 8-9, 2001, IEEE SCC-28 (4) meeting (mentioned previously). In that meeting Osepchuk reported that members of SCC-28 leadership had met twice with ICNIRP members during the past year. A joint workshop on thermophysiology[286] had been planned with an agreement to exchange documents. Osepchuk stated that another meeting with the leadership of SCC-28 and ICNIRP might be held in December 2001 if SCC-28 met in Luxembourg. Osepchuk also discussed WHO goals for establishing a framework for global standards.[287]

SCC-28 Chair Eleanor Adair elaborated on the planned SCC-28/ICNIRP workshop, the goal of which was to develop a single model that could be used to predict the effects on humans exposed to RF fields, based on thermophysiology and dosimetry. Dr. Om Gandhi from the University of Utah moved a motion that SCC-28 SC4 consider harmonizing with ICNIRP on the peak and average SAR limits. The motion was tabled until more information was obtained.[288]
Peterson reported at the meeting that "the consensus is to move to a larger averaging volume…and perhaps higher limits for the peak spatial-average SAR, e.g., adopt the ICNIRP limits."[289]

Consideration of harmonizing with ICNIRP was not on the agenda three years earlier when members of IEEE SCC-28 committee and ICNIRP met at a Forum on EMF safety Standards and Science, sponsored by the U.S. Air Force in Munich, Germany on June 11, 2000. Both groups trying to 'claim the high ground' in regards to which RF standard was most based in science. As one participant put it to the publication *Microwave News*, "It's a turf battle, pure and simple". Soon after the meeting however, the two groups held a further meeting that apparently resulted in constructive exchanges and an agreement that harmonization of non-ionizing radiation was "the prime objective of both organisations."[290] The standards setting stalemate that continued well after 2000 may have convinced SCC-28 that ICNIRP was a viable option, provided it was presented in such a way to be accepted by the FCC and other federal agencies.

Although the IEEE is primarily an American organisation with its roots dating back to the founding of the AIEE in 1884, it has long been actively involved in RF standard setting internationally with about one third of its 325,000 current members from outside the United States.[291] Its international members, besides telecommunications corporations, include many of the representatives on various national RF standard setting and regulatory bodies, ensuring that IEEE viewpoints are widely disseminated internationally. Through IEEE's SCC28 committee (later ICES) the development of

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[286] Defined as the science concerned with how the normal vital processes of the living organism are affected by heat. Obviously this would exclude any consideration of non-thermal effects and indicates the bias against non-thermal RF bio-effects.
[287] IEEE /ICES, St. Paul, Minnesota, 2001. op. cit. Also see: WHO Standards and Guidelines http://www.who.int/peh-emf/standards/EMF_standards_framework%5b1%5d.pdf Accessed August 24, 2006.
[288] IEEE /ICES, St. Paul, Minnesota, 2001. op. cit.
[289] ibid.
[290] L. Slesin, 'Efforts to Harmonize RF/MW Exposure Standards in Disarray', *Microwave News*, vol. 20, no. 4, Jul./Aug. 2000, pp. 1,8-9.
[291] P. Mason, M. Murphy, R. Peterson, IEEE EMF Health & Safety Standards, WHO Meeting on EMF Biological Effects and Standards Harmonization in Asia and Oceania, Shilla Hotel, Seoul, Korea, 22-24 Oct., 2001, http://www.who.int/peh-emf/meetings/southkorea/en/IEEE_EMF_HEALTH_-_Mason.pdf , Accessed Aug. 29, 2006.

internationally recognized voluntary standards was a priority[292], reflecting the IEEE's mission of "Networking the World".[293] As IEEE members Om Gandhi and Gianluca Lazzi explained: "… following the lead of the 1982 ANSI/IEEE C95.1 Standard "RF safety standards all over the Western World were altered to Frequency-dependent SAR exposure limits that recognized resonance of the human body, and limited exposures to whole-body averaged SARs of 0.4 W/kg for occupational exposures and 0.08 W/kg for general public."[294] Thus the model for SAR values, first seen in the C95.1-1982 standard became the template for most of the Western world's RF safety standards, including those of the U.K. National Radiological Protection Board (NCRP). North Alantic Treaty Organisation (NATO), the U.S. Department of Defense (DoD), and the RF guidelines from the International Commission on Non-Ionizing Radiation Protection (ICNIRP)[295] and the Australian Radiation Protection and Nuclear safety Agency (ARPANSA).

Disregarding the advice from the federal agencies, ICES (SCC- 28) pushed ahead in late 2002 with its proposal to relax the limit for exposures to mobile phone radiation. Researcher Dr. Om Gandhi, from the University of Utah, stated in a December 2002 open letter to ICES that their proposal would create "the most relaxed RF safety standard in the world". Gandhi pointed out that the proposed changes would make the IEEE SAR limit "3 to 5 times higher than the limit set by ICNIRP." Gandhi said to *Microwave News* that the newly proposed ICES/IEEE RF safety standard would potentially allow cellular telephone radiations that would be 8 to 16 times those currently allowed in the U.S. According to Gandhi, "they would also be larger than twice those allowed under the ICNIRP Guidelines – this vitiating the desire to have a harmonized safety standard for cellular telephones."[296] The ICES committee, chaired by Motorola's C-K Chou and the U.S. Navy's John D'Andrea also voted to increase the averaging volume used in calculating SARs from 1 gram to 10 gram, relax the SAR limit from 1.6 W/kg to 2 W/kg. These two changes brought the mobile phone limits in line with ICNIRP's limit of 2 W/kg over 10 grams of tissue. Committee members also wanted to relax the exposures to the outer ear (the pinnae) from 1.6 W/kg over 1 g. to 4.0W/kg over 10 g.[297] These proposals to increase the IEEE standard in order to make cell phones sold in America compliant are all examples of the Procrustean Approach. This is especially seen by the Motorola proposal to relax the standard for the pinnae – essentially cutting off the outer ear because it did not conform to the standard limits.

The trend towards harmonization of RF standards, the one promulgated by IEEE and that of ICNIRP is an inevitable consequence of globalisation, the growth of international telecommunications corporations and the global deployment of U.S. military technology. Be it a cell phone or a missile defense radar system, the prime consideration for the manufacturers and users of the technology is to be able to market globally without inconvenient national standards standing in the way of trade or competing standards suggesting a disagreement in health protection. It may be that IEEE's significant relaxation of its standard in the latest revision was, in fact, a sort of 'ambit claim' when negotiating details with ICNIRP over harmonization in order to get the best deal for the

[292] ibid.
[293] As stated on the IEEE web site: http://grouper.ieee.org/groups/scc28/, Accessed Aug. 18, 2006.
[294] Gandhi, Lazzi, 'The ANSI/IEEE RF Safety Standard…', undated, op. cit.
[295] Mason, Murphy, Peterson, 2001.
[296] L. Slesin, 'IEEE Move To relax Cell Phone SAR Exposure Limit Under Fire', *Microwave News*, vol. 23, no. 3, May/Jun. 2003, p. 4.
[297] ibid.

cell phone industry. What is apparent from this is that harmonisation is not about better health protection but all about international trade, be it civilian or military. This can only be achieved, unfortunately, by a continuing denial, or maintaining a continuing ignorance and uncertainty over the possibility of health hazards that are not related to the simple thermal model that was developed in the 1950s and maintained to this day.

**ICES meeting of September 2003**

The ICES SCC-28 Subcommittee 4 "unapproved minutes" accounts the meeting between ICES SC-4 and the Federal Government's RF Interagency Work Group (RFIAWG) on Sept 25, 2003. At this meeting the FCC, FDA/CDRH and the EPA each had three representatives. As well, OSHA and the NTIA had one representative each. [298]
The overwhelmingly wireless industry/military make up of ICES SC-4 was reflected in the ICES representatives at the meeting: C.K. Chow and M. Swicord from Motorola, D'Andrea from the US Navy, Peterson (Ex, Lucient Technologies - now "independent"), R. Tell (Richard Tell Associates – "independent") and an observer from Siemens Corp.[299]

The purpose of the meeting was to discuss the approach to standards as well as discussing the concerns, examined earlier in this chapter, that had been sent to SC-4 by the RFIAWG. During the September 2003 meeting discussions involved reviewing and attempting to resolve definitions of "margin of safety", "safety factor", and "margin of uncertainty"[300]. The members selected to do this work were M. Meltz from the University of Texas and John Osepchuk. Considering that Osepchuk has previously supported microwave home heating, his viewpoint on margins of safety etc. may be biased in regards to what constitutes a safe level of microwave exposure. Other working groups were assigned tasks to refine "spatial averaging", "thermal/nonthermal", "penetration depth and "partial-body exposure".[301]

A report by the Risk Assessment Working Group by Richard Tell examined the rationale behind safety factors for the two-tier exposure system introduced in the 1991 IEEE standard. A paper by Vitas Andersom and Richard Tell was discussed that argued that the safety factor should be more solidly based. However J. Osepchuk and L. Heynick (independent consultant) both criticised the Anderson/Tell paper as not being scientific. At this point David Fichenberg an activist from the Cellular Phone Taskforce, added (by phone) that "given a lack of scientific basis for the safety factors, risk assessment methods should be used".[302] It was then added by the meeting secretary at this point that "[t]here is a huge literature on risk assessment, including reports to Congress", this being an apparent reference to John Graham's and Robert Hahn's risk assessment reports to congress[303] mentioned in Chapter 1 and 2 of this thesis.

Proposals to relax the compliance standard from a 1 gram cube of tissue at 1.6 W/kg to the EU compliance of 10 gram cube at 2 W/kg were discussed with reference to

[298] IEEE/ICES, Rosslyn, Virginia, 2003, op. cit.
[299] ibid.
[300] ibid.
[301] ibid.
[302] ibid.
[303] J. Graham, 'Making Sense of Risk: An Agenda for Congress', *EMF Risk Perception and Communication*, Proceedings of the International Seminar on EMF Risk Perception and Communication, WHO, Ottawa, Ontario, Canada, Aug. 3–Sep. 1, Repacholi MH, Muc A (eds), pp. 1 – 31.

harmonizing with ICNIRP. Swicord reviewed the existing hazard level of 4 W/kg, based on work stoppage in animals that was accompanied by an increase in temperature of 1 degree C. A paper by Adair and Black was discussed that conveniently suggested the RF safety factors could be raised (thus increasing the standard limits). According to Adair and Black, the RF exposure safety factors were largely based on rodent data, and small animals are poor models for human beings, who exhibit far better, thermoregulatory response. The authors stated that, "the conclusion is inescapable that humans demonstrate far superior thermoregulatory ability over other tested organisms during RF exposure at, or even above current human exposure guidelines."[304] It was stated that if the safety factor of 10 was then applied to the 4 W/kg level (based on rodent studies) this level (tier 1- controlled or occupational) "would be well within the daily fluctuations of body temperature, even in an impaired person."[305] Adair wrote that a SAR of 0.4 W/kg was only 35% of the resting Metabolic heat production of a human adult "and was the equivalent of donning a light sweater"[306]. The minutes of the meeting then record that it was "clear to all that the present rationale for the lower tier is not good".[307] The inference was that if the first tier (controlled/occupational) was protective against harmful thermal increases in body temperature, a stricter lower tier (for the public) was unnecessary. This paper is briefly examined later in this chapter in the section on the review papers in Bioelectromagnetics Supplement 6. At the close of the first day Richard Tell brought up the problem presented by calculations by Dimbylow on the SARs for small children exposed above 1 Ghz. For example, above 1 Ghz, data for children go to a SAR of 0.167 W/kg when they are exposed at the MPE of 0.08 W/kg (a factor of 2 above the basic restriction.[308] In issue no. 24 of the minutes the question of the impact of the Dimbylow/Gandhi data was raised on SAR's and children. The comment was "that when this work is done, regulators will have a problem with 2 W/kg instead of 1.6 W/kg. The new numbers are based on biology (1.6 W/kg), but we like round numbers and the whole world, other than US, Canada, Taiwan and South Korea is using the 2 W/kg limit."[309] It was also briefly mentioned that Vitas Anderson had shown that temperature rise is better correlated with a 10 gram average that with 1 gram.[310] It was also announced at the meeting that Motorola's C.K. Chow would take over the SC-4 web site.[311] What is clearly seem from reviewing the minutes of the above meeting is a continuing effort to scientifically justify reasons to increase the RF limits, with the main emphasis apparently on ensuring that cell phones and other new technology operating in the Ghz range would, with a Procrustean Approach, be in compliance with the standard under all test situations. In other words, the standard was being revised to suit the needs of the industry.

**ANSI/IEEE-C95.1 (2006)**

The IEEE's Standards Board on October 3, 2005 formally approved the IEEE standard C95.1-2005, prepared by ICES (formerly SCC-28). Titled *"Standard for Safety Levels with respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz*" it

[304] IEEE/ICES, Rosslyn, Virginia, 2003, op. cit.
[305] ibid.
[306] ibid, p. 7.
[307] ibid.
[308] ibid, p. 10.
[309] ibid, p. 16.
[310] ibid.
[311] ibid, p.17.

replaced the previous 1991 IEEE C.95.1 standard [312]. In November 2, 2006, the American National Standards Institute (ANSI) approved the new IEEE standard to be designated ANSI/IEEE C.95.1-2006.[313] This standard, being a complete revision from all previous standards, can be considered the summation of almost 50 years of U.S. RF standard setting that began in 1957 with the establishment of research for the Tri-Services Program. The next step for IEEE was to petition the FCC to adopt the standard and its increased limits for the FCC's compliance requirements[314]. However, as of June 2, 2009, this has not yet happened.[315] According to C-K Chou from Motorola and co-chair of SC4, a major revision criteria for the new standard was harmonisation with ICNIRP's RF guidelines[316] however there are several important differences from both ICNIRP and C95.1-1991 that favour the interests of the cellphone industry with compliance issues.

A significant change is the exposure relaxation from the previous 1991 IEEE standard's basic restriction SAR value for localized exposures of 1.6 W/kg averaged over any 1 gram of tissue (and used by FCC). This was increased to 2 W/kg averaged over any 10 gram of tissue (ICNIRP is 2 W/kg averaged over any 1 gram of tissue). This increases further with the exclusion of the outer ear from the rest of the head, mentioned earlier in this chapter. The basic SAR restriction for the ear therefore increases from the new 2 W/kg basic restriction for localised exposure to 4 W/kg over 10 grams. According to ICES member James C. Lin in his article in *IEEE Microwave Magazine* (2006), the increase in tissue mass from 1 to 10 grams "can have a profound influence on the actual quantity of RF energy allowed to be deposited in tissue by the new exposure standard". Lin considered the 1991 SAR mass of 1 gram of contiguous tissue as "scientifically a more precise representation of localized RF or microwave energy absorption and a more biologically significant measure of SAR distribution inside the body or head."[317] This relaxation was first introduced by C-K Chou from Motorola at a SC4 meeting on October 17, 1999, basically for "decisions on compliance testing". At that meeting Dr. Veli Santomaa from Nokia gave a presentation, explaining the reason behind the proposal. According to Santomaa, the SAR level is highest in the ear (when using a cell phone) and since the outer ear "is not a vital organ" it was not necessary to "protect the [outer ear] against RF exposure at the same level as the brain." The reason for the need to relax the allowable SAR level in the ear was so that "maximum power of phones will not be limited unnecessarily" according to Santomaa.[318] This was clearly an admission that a Procrustean Approach was being followed. For comparison, in the ICNIRP Guidelines, the pinnae are treated as an integral part of the human head.[319] According to Dr. Om Gandhi from the University of Utah, when provision for an ear is removed from plastic dummy heads used by the industry for SAR cell phone compliance testing, the earless model head can underestimate the peak SAR by as much as 40%-60% of the actual SAR

[312] J. Lin, 'Health Effects: Update of IEEE Radio frequency Exposure guidelines', *IEEE Microwave Magazine*, Apr. 2006, pp. 25-26.
[313] L. Slesin, 'ANSI Approves Revised IEEE RF/MW Standard', *Microwave News*, vol. 26, no. 6, Nov. 2006, p. 1.
[314] L. Slesin, 'Will the FCC Adopt Looser Cell Phone Safety Standards?', *Microwave News,* vol. 27, no. 5, Apr. 2007, p. 4.
[315] Correspondence with Louis Slesin, June 2, 2009.
[316] C-K Chou, 'New IEEE RF safety standard C95.1-2005', *info-CITEL electronic Bulletin*, No. 25, Jul. 2006, http://www.citel.oas.org/newsletter/2006/julio/rni-ieee_i.asp, Accessed Sept. 5, 2006.
[317] ibid.
[318] Slesin, 'Industry Seeks Higher Exposure Limit…', 1999.
[319] Lin, 2006.

level.[320] In addition to the Procrustean act of chopping off the test dummy's ear, averaging over the larger mass of 10 grams artificially flattens out the SAR distribution resulting in a lower overall SAR value and smooths out peak points of energy (hot spots) when compared to the 1-gram mass. An example given by Lin is the spherical shaped human eye with a mass of about 10 grams. To quote:

> The use of an averaging volume as large as 10 grams does not attribute any distinctions among tissues in the eye and completely ignores the wide variation of SAR distribution throughout the eyeball. The choice of 2 W/kg over a 10-g tissue volume in the shape of a cube could permit the deposition of RF or microwave energy in different parts of the eye that exceeds the basic SAR restriction by a large margin, while keeping the SAR for the entire eye below 2W/kg.[321]

Athough ICNIRP also uses a 10 gram tissue volume in its SAR calculations, an important difference from the IEEE's 10 gram mass is that ICNIRP uses 10 grams of contiguous tissue. The difference is that 10 gm of contiguous tissue means the volume to be considered can be filled with tissue of different types. The 1996 ANSI/ IEEE standard considers only a specific tissue and any lack of that particular tissue within that volume is considered as air with zero SAR[322]. Thus, the IEEE exposure standard is based on a testing model that treat human beings as merely a jelly filled phantom with certain electrical properties that can be measured in the laboratory. According to Lin, who took over the position of associate editor of Bioelectromagnetics from C-K Chou, IEEE's method is rather ambiguous and could result in a wide range of SAR values. Lin considers ICNIRP's 10-gram contiguous tissue as a more scientifically precise representation of energy absorption of RF/MW energy and a more biologically significant measure of SAR distribution in the body or head than the IEEE/ICES method.[323] What is apparent from this method is a greater level of uncertainty in exposure assessment. According to Lin, the process of harmonisation must not proceed just for harmonisation's sake but aim toward improved SAR calculations and less uncertainty in exposure assessment to give a more scientifically based and commonly recognized exposure standard.[324] Of course both methods are only relevant to thermal effects and do not apply to possible biological effects that are not related to heating. The importance of Lin's critique of the ANSI/IEEE C95.1-1996 RF standard is that even the standard's ability to provide health protection against thermal exposures is questioned.

In ANSI/IEEE C95.1-1996 the definition of, "established adverse health effects" is restricted to heating effects only for telecommunications frequencies. They are defined as: (1)"aversive or painful electrostimulation due to excessive RR internal electric fields, (2) RF shocks and burns due to contact with excessively high RF voltages, (3) heating pain or tissue burns due to excessive localized RF exposure, and (4) behavioural disruption, heat exhaustion or heat stroke due to excessive whole body RF exposures. The standard states that, in their definition, adverse effects do not include: "biological effects without a harmful health effect, changes in subjective feelings of well-being that are a result of anxiety about RF-effects or impacts of RF infrastructure that are not

[320] ibid.
[321] ibid.
[322] ibid.
[323] ibid.
[324] ibid.

physically related to RF emissions, or indirect effects caused by electromagnetic interference with electronic devices".[325] This strict definition of an adverse health effect is at odds with the definition as stated in the WHO Framework for developing EMF Standards (2003). To quote:

> Annoyance or discomforts caused by EMF exposure may not be pathological per se but, if substantiated, can affect the physical and mental well being of a person and the resultant effect may be considered as an adverse health effect. A health effect is thus defined as a biological effect that is detrimental to health or well-being. According to the WHO Constitution, health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity.[326]

In the December 2005 ICES TC95 Subcommittee–4 meeting D'Andrea said that the WHO statement that "include effects related to feelings of well being" may be "an important stumbling block regarding harmonization".[327] The IEEE's strict definition of an adverse health effect, ignoring 'well-being' from RF exposure, shows a fundamental misunderstanding of the concept of 'risk' in an advanced technological society. No room is given to either the public's concerns over possible adverse consequences from new wireless devices or alternative voices from within the scientific community over the existence of non-thermal biological hazards not related to heating. A related change in the 1996 standard is its definition of the microwave (RF) hearing effect as a "benign biological sensation" whereas ICNIRP considers it to be an "adverse effect".[328] The ICNIRP definition would be in line with a paper by Frey (1962) on microwave hearing research that concludes that the microwave hearing effect is a "biologically significant phenomenon"[329]

Of relevance to new generation wireless devices operating in the GHz range, the upper frequency boundary of the basic restriction, based on the whole body averaged SAR, was reduced from the 1991 6 GHz level to 3 GHz. Also, the upward ramp that starts for the relaxation of the power density limits for localized exposure has been reduced from 6 GHz to 3 GHz.[330] This was an issue raised in June 1999 by the Radiofrequency Interagency Work Group (RFIAWG). The Work Group suggested, at the microwave frequencies, a ramp function somewhere between 30-100GHz is more realistic in order to be consistent with the laser standard. They saw no justifiable reason for a lower ramp and mentioned that using a much lower ramp would raise "concerns that the standard is not restrictive enough for continuous exposures at lower microwave frequencies where new wireless applications for consumers could make this an issue in the future." It

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[325] IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields 3 kHz to 300 GHz, IEEE Std. C95.1 – 2005, IEEE International Committee on Electromagnetic Safety (SCC39), 19 April 2006.

[326] M. Repacholi, E.van Deventer , WHO Framework for Developing EMF Standards, Proceedings of the International Conference on Non-Ionizing Radiation at UNITEN (ICNIR 2003) Electromagnetic Fields and Our Health, Oct. 20-22, 2003.

[327] IEEE/ICES TC95 Subcommittee 4, Unconfirmed Minutes, San Antonio, Texas, Dec. 10, 2005, pp. 3, 5, http://www.ices-emfsafety.org/documents/Minutes/TC95_december%202005%20minutes.pdf, Accessed Apr. 25, 2006.

[328] ibid.

[329] A. Frey, 'Human auditory system response to Modulated electromagnetic energy', *J. Applied Physiology*, vol.17, no.4, 1962, pp. 689-692.

[330] Lin, 2006.

would seem to be the case that this downward relaxation in the 2005 standard may be to ensure that new high frequency devices operating over 3 GHz will not be in non-compliance with the standard. There are other areas of difference in ANSI/IEEE C95.1-1996 with both the 1991 standard and that of ICNIRP, but the most significant change is that increasing the SAR limit to 2 W/kg as well as increasing the averaging volume to 10 grams effectively eliminates the compliance problem by doubling the allowable amount of radiation absorbed from a mobile phone.[331] At the December 2005 meeting of ICES TC95 SC4 the issue of harmonization with ICNIRP was discussed, with Osepchuk stating that he was not optimistic about co-operation with ICNIRP.[332]

**A syndrome of paranoia and neglect**

Looking at the evolution of RF standard setting in the U.S. which has led to ANSI/IEEE C95.1-1996, it is apparent that public concerns over telecommunications technology, and the ever increasing development of new devices, are dismissed by the IEEE standard setters as simply based on public ignorance and unfounded fears. As examined in Chapter 1, this mind-set was clearly stated by John D. Graham as keynote presenter at the International Seminar on EMF Risk Perception and Communication (1999). Graham, speaking to an audience deeply involved in EMF standard setting, called public concerns over technological risks as simply a "syndrome of paranoia and neglect". Graham's solution was a series of recommendations to the U.S. Congress to require quantitative risk assessment before making any protective decisions.[333] Central to these recommendations was that the Environmental Protection Agency (EPA) should ignore public concerns in regulatory decision making, but base its decisions solely on so-called "scientific assessments on the level of risk".[334]

Shades of Graham's "syndrome of paranoia and neglect" can be seen in the ICES meeting of June 26, 2005 in Dublin, Ireland, where committee member Ralf Bodemann, gave a presentation reporting on the outcomes of the WHO IAC meeting, June 13-14, 2005. Bodemann's concluding point stated:

> [E]lectrically hypersensitive"persons do not exist. …These persons suffer not due to their exposure to EMField, but because they develop a psychosomatic syndrome. […]All known facts can be explained by the ESS syndrome (Environmental Somatization Syndrome). […]Nevertheless, the complaining people may be hypersensitive indeed, but not to electromagnetic fields. They are hypersensitive to rumours, alarming messages, false reports, false alarm and fictitious news. They do not trust to the scientific results and develop psychosomatic syndrome, often quite serious. Their troubles should be treated by a psychologist or by a psychiatrist, not by lowering the EMF limits or by removing the alleged sources of EMFs. [335]

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[331] Email correspondence with Lloyd Morgan, a director of the United States Central Brain Tumor Registry, Aug. 28, 2006.
[332] IEEE/ICES TC95, San Antonio, Texas, 2005, op. cit.
[333] Graham, 1998.
[334] W. Freudenburg, 'Risky Thinking: Irrational Fears About Risk and Society'. The Annals of the American Academy of Political and Social Science, vol. 545 annals 44, May 1996.
[335] R. Bodemann, 'Report on WHO IAC meeting June 13-14, 2005'. IEEE ICES TC95 Meeting, Approved Minutes, Dublin, Ireland, June 26, 2005, http://www.ices-emfsafety.org/documents/Minutes/TC95_june%202005%20minutes.pdf, Accessed Apr. 28, 2006.

It is important to note that the IAC is an advisory body to the WHO's International EMF Project (IEMFP) with the role of approving documents published by WHO.[336]

Central to the IEEE's definition of an RF/MW adverse health effect (electrostimulation, RF shocks and burns, heating pain or tissue burns or behavioural disruption, heat exhaustion or heat stroke), that can only result from high level RF/MW exposure, is a dismissal from consideration the issue of low-intensity, non-thermal biological effects. This was clearly stated by C-K Chou and D'Andrea in their Introduction to the RF reviews in *Bioelectromagnetics Supplement 6* , commissioned by ICES as a justification for the 1995 IEEE standard. They state that "nonthermal RF biological effects have not been established and none of the reported nonthermal effects are proven adverse to health."[337]

### *Bioelectromagnetics Supplement 6* and IEEE's compromised peer review process

The literature base of C 95.1–2005 is quite large, with over 1300 papers having been reviewed by ICES members from the Engineering Evaluation Working (EEWG) Group. The peer review process consisted of each paper being evaluated by two randomly selected members from EEWG and two members of the appropriate Biological Evaluation Working Group (BEWG). Summaries of these evaluations were then sent to the Risk Assessment Working Group (RAWG) "to evaluate the levels of possible risk to humans and define the lowest threshold SAR above which potentially adverse effects are likely to occur."[338] As SAR is a unit of energy absorption most of which is converted to heat and SAR limits are based on preventing adverse effects from this heat. By referring to SAR, RAWG is stating that only research relevant to thermal-regulatory responses are useful in setting standards. As a result of this review process, at a 2002 U.S. Air Force Research Laboratory Workshop *"Setting a Science-Based Standard for Safe Human Exposure to RF Electromagnetic Fields"*, 14 review papers were presented that were commissioned by Subcommittee 4 (SC4) of ICES. These papers were to assist with the Working Group's assessment of the RF literature. 12 of these papers were subsequently published in the *Bioelectromagnetics Supplement 6 (2003*), "Reviews of the Effects of RF Fields on Various Aspects of Human Health "[339].

Publishing in a peer review journal was meant to place the literature summaries before the bioelectromagnetics scientific community and the public[340] as a definitive evaluation of the science. It was the publication of Supplement 6 that clearly raises the issue of a possible, and perhaps inevitable, potential for a conflict of interest and resultant bias in both RF/MW standard setting and independent peer review of RF research literature. As examined in this chapter, an apparent conflict of interest and bias in interpreting the scientific literature has been an ongoing controversial issue in the almost half-century history of RF standard setting in the U.S.

The potential for conflict of interest is inevitable in evaluating the scientific literature for RF standard setting, considering that the majority of the various committee members

[336] Bodemann, 2005, op. cit., p. 6.
[337] C-K. Chou, J. D'Andrea, 'Reviews of Effects of RF Fields on Various Aspects of Human Health: Introduction', *Bioelectromagnetics,* Supplement 6, 2003, pp. S5-S6.
[338] Chou, D'Andrea, 2003.
[339] ibid.
[340] B. Greenbaum, 'Editor's Note: Reviews of the Effects of RF Fields on Various Aspects of Human Health', *Bioelectromagnetics,* Supplement 6, 2003, pp.S3-S4.

who determine the standard limits, define what constitutes an adverse health effect and funding research, also are affiliated with organisations fully committed to developing wireless technology, either for civilian or military purposes. Of course, having a conflict of interest does not translate to an inability to evaluate the literature objectively. Epidemiologist Kenneth Rothman in an article about conflict of interest in the *Journal of the American Medical Association* expressed the situation well with his referring to conflict of interest as temptation and then asking "but is temptation sin?"[341]

When making judgements about the scientific objectivity of studies on the health effects of RF, specifically on mobile phone use, however, the potential for financial conflicts of interests affecting scientific outcomes must be seriously considered. This is the conclusion of a study by Huss et al, published on Sept 15, 2006. This study reviewed human exposure studies (electroencephalogram, cognitive, cardiovascular function, hormone levels, symptoms and subjective wellbeing) on controlled exposures to RF relevant to mobile phone use. The authors found that "the studies exclusively funded by industry were indeed substantially less likely to report statistically significant effects on a range of endpoints that may be relevant to health. Our findings add to the existing evidence that single source sponsorship is associated with outcomes that favour the sponsors' products (Bakelman et al 2003; Davidson 1986;Lexchin et al. 2003; Stelfox et al. 1998)."[342] The authors concluded that, "Our study indicates that the interpretation of the results from existing and future studies of the health effects of radiofrequency radiation should take sponsorship into account."[343]

As mentioned elsewhere in this thesis, the problem of financial conflict of interest was examined in 2003 by the International Committee of Medical Journal Editors (ICMJE) and it is worthwhile to compare this to both Bioelectromagnetics *Supplement 6* and the entire IEEE ICES peer review process. ICMIE found that conflicts of interest can exist even if an individual believes their funding situation does not influence their scientific judgement. They concluded that "Financial relationships … are the most easily identifiable conflicts of interest and the most likely to undermine the credibility of the journal, the authors, and of science itself."[344]

Eliot Marshall (1992) contends, however, that financial conflict of interest issues are simple when compared to intellectual conflicts of interests which have been an issue scientists have long had to deal with. Marshall explains that scientists are also human beings and "often begin their work with a hypothesis and become deeply invested in it…Along the way to proving a thesis…scientists must be sustained by something that approaches faith." Marshall quotes palaeontologist and historian Stephen-Jay Gould: "It is a pervasive fact of human existence as social beings that we find it extraordinarily

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[341] K. Rothman, 'Conflict of Interest: The New McCarthyism in Science', *JAMA*, vol. 269, issue 21, June 2, 1993, pp. 2782-2784.
[342] A. Huss, 'Source of Funding and results of Studies of Health Effects of Mobile Phone Use: Systematic Review of Experimental Studies', NIEHS, *Env. Health Perspectives*. Online, Sept. 15, 2006 http://dx.doi.org/ , Accessed Sept. 28, 2006.
[343] ibid
[344] International Committee of Medical Journal Editors, Uniform Requirements for Manuscripts Submitted to Biomedical Journals: Writing and Editing for Biomedical Publication, Nov. 2003, p. 8 http://wwwicmje.org/index.html#peer , Accessed Sept. 28, 2006.

difficult to step out of our own convictions and see them through the eyes of a detached observer." [345]

This thesis argues that long held intellectual convictions over how RF/MW interacts with biological tissue have had an inordinate influence it comes to objectively evaluating the scientific literature. When long held convictions are combined with financial relationships, the ability of science to advance in research areas in conflict with these factors is severely limited.

Concerns have been raised that *Bioelectromagnetics Supplement 6* was financed by a single vested interest group, the U.S. Air Force[346], an organisation that for the past half century has been fully committed to the thermal-effects-only viewpoint and, as examined in this chapter, has long discouraged consideration of non-thermal effects in standard setting.

A very significant mobile phone industry presence is seen in the editorship of Supplement 6. Until 2003, the Associate Editor of "Bioelectromagnetics", whose responsibility was to edit papers on high-frequency RF fields, was C-K Chou, Chief EME Scientist and Director of the Corporate EME Research Laboratory at Motorola Laboratories, Florida.[347] The role of BEMS Newsletter Editor was then taken over by Mays Swicord, also a senior researcher at Motorola Laboratories.[348] [349] As mentioned previously in this chapter, Chou was instrumental in incorporating the exclusion of the outer ear from the rest of the head, thus increasing the SAR limit from 1.6 W/kg to 2 W/kg for reasons of compliance testing – a move of obvious benefit to Motorola. Motorola had four members on ICES SC4 that prepared the 2005 standard, two of whom also authored a RF risk assessment on children's use of mobile phones. That Motorola risk assessment involved RF exposure studies on laboratory animals during early life to young adulthood. It was conducted in order to identify studies pertaining to the effects of RF exposure on the developing nervous system of children. This risk assessment concluded that there was no evidence in the scientific literature that there was a health risk for children who use mobile phones. A significant conflict of interest exists in Motorola's conclusions because Motorola had previously signed a contract with Walt Disney to tap the 6 to 12 year old "customer electronics market". New 'kids orientated' products include a range of wireless phones.[350]

In the January / February 2006 issue of the *Bioelectromagnetics Newsletter*, the issue of possible conflict of interest and bias was addressed with the newsletter editor simply asking "all contributing writers to submit a sentence or short statement on their affiliation and or disclosing possible conflict of interest along with items they send to the

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[345] E. Marshall, 'When Does Intellectual Passion Become Conflict of Interest?', *Science*, vol. 257, July 31, 1992, pp. 620-623.
[346] C. Sage, 'Comment on Reviews of the effects of RF fields on various aspects of human health, *Bioelectromagnetics* Supplement 6 (2003)', *Bioelectromagnetics*, vol. 26 issue 2, 2003, pp.157-158.
[347] M. Swicord, (ed.), 'C-K Chou will receive the 2006 D'Arsonval Award' *Bioelectromagnetics Newsletter,* no. 188, Jan./Feb. 2006, pp. 1, 3.
[348] ibid.
[349] L. Slesin, 'Industry Rules RF Controlling Research, Setting Standards and Spinning History', *Microwave News*, Aug. 9, 2004, http://www.microwavenews.com/IndustryRulesRF.html, Accessed Sept. 27, 2006.
[350] D. Maisch, 'A Corporate Risk Assessment or RF Bioeffects Studies Relevant to the Use of Mobile Phones by Children: Is it Really Science?', *International Conference: Childhood Leukaemia, Incidence, Causal Mechanisms and Prevention*, London England, Sept 6-10, 2004.

Newsletter".[351] Merely stating one's affiliation or other possible conflicts of interests – assuming honesty in doing this - does not remove a possible bias, but is perhaps merely being a bit more open about it. However, finding out one's affiliations for members of ICES SC4 is not always so easy. To take four examples:

- On the ICES Subcommittee 4 membership list, Eleanor Adair's affiliation was given as "Independent Consultant" [352]whereas in *Bioelectromagnetics Supplement 6* she is listed as "Air Force Senior Scientist Emeritus."[353]
- In *Bioelectromagnetics Supplement 6*, Louis Heynick is listed a an Independent Consultant but a search through "Storming Media", the internet source for official Pentagon Reports, lists a number of papers by Heynick on RF issues "pertinent to Air Force operations". Before becoming an independent consultant, Heynick was listed as being affiliated with the U.S. Air Force School of Aerospace Medicine.[354]
- Supplement 6 lists Martin Meltz as affiliated with The University of Texas Health Science Center, but in the ABC documentary "20/20" in October 1999, he is introduced as "a scientist at the University of Texas and a paid industry consultant whom the industry said we should talk to."[355] The University of Texas is in financial and "educational partnership" with the Brooks City Air Force Base, both located at San Antonio, Texas.[356]
- SCC-28 Subcommittee 4 lists Dennis Blick's affiliation as an independent consultant, but a paper in Bioelectromagnetics gives his affiliation as the Systems Research Laboratories Inc., located at Brooks Air Force Base.[357]

In the Editor's Note for *Bioelectromagnetics Supplement 6* it is mentioned that the 12 review papers published in the supplement were commissioned by ICES Subcommittee 4 (SC4) to assist the discussion within the committee. However, in a departure from previous standard setting processes, it was decided to publish the papers in order to make the information widely available to the scientific community and the public. After being reviewed by the ICES review committee the papers then underwent the usual Bioelectromagnetics journal peer review process. Specific acknowledgement was given to C-K Chow (Motorola) for his help in getting the papers finished and submitted, Michael Murphy and the Air Force in encouraging publication and underwriting the cost of producing the supplement. In addition the supplement was dedicated to Eleanor Adair on the occasion of her retirement from the Air Force Laboratory.[358] In the overview of the papers in Supplement 6, by Chow and D'Andrea it is mentioned that 11 out of the 12 papers were written by SC4 members and that the supplement "serves in a large

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[351] M, Swicord, (ed.), 'New Disclosure Policy Begins With This Issue', *Bioelectromagnetics Newsletter,* no. 188, Jan./Feb. 2006, p. 4.
[352] Internal membership list "SCC28_SC4_Active_1" supplied by SC4 member anonymously, Nov. 1997.
[353] E. Adair E, D. Black, 'Thermoregulatory Responses to RF Energy Absorption', *Bioelectromagnetics, Supplement 6*, 2003, pp. S17 – S38.
[354] L. Heynick LN, A Comprehensive Review Pertinent to Air Force Operations, USAF School of Aerospace Medicine, Brooks Air Force Base, Texas, Final Report USAFSAM-TR-87-3, 1987.
[355] ABC News, 20/20 program transcript (report on cell phones), Oct. 20, 1999. http://www.junkscience.com/oct99/2020tran.htm, Accessed Sept 23, 2006.
[356] 'Brooks City-Base diversifying its strategy', *San Antonio Business Journal*, Sept. 1, 2006.
[357] D. Bick, E. Adair, W. Hurt, C. Sherry, T. Walters, J. Merrit, 'Thresholds of microwave-evoked warmth sensations in human skin', *Bioelectromagnetics*, vol. 18, no. 6, Dec. 6, 1998, pp. 403-409.
[358] B. Greenebaum, 'Editor's Note: Reviews of the Effects of RF Fields on Various Aspects of Human Health', *Bioelectromagnetics, Supplement 6*, 2003, pp. S3-S4.

measure as a scientific basis for the IEEE C95.1 standard revision, but will be a valuable reference on the subject for many years to come." [359] (See Table 1, next page)

**Table 1: Authors affiliations for the 13 papers in Supplement 6, (including introduction):**

| Author | Affiliation/Specialisation | No. of papers contributed to |
|---|---|---|
| C-K Chou | Motorola | 3 |
| Joe Elder | Motorola | 3 |
| John D'Andrea | Navy | 3 |
| Louis Heynick | USAF (former) | 3 |
| Eleanor Adair | USAF | 2 |
| Shelia Johnston | Neuroscience consultant | 2 |
| Patrick Mason | USAF | 1 |
| James Merritt | USAF | 1 |
| John Osepchuk | Industry Consultant | 1 |
| Ron Peterson | (formerAT&T/Bell labs/Lucent) | 1 |
| Mark Ellwood | Epidemology | 1 |
| John de Lodge | Researcher | 1 |
| David Black | Academic/Industry consultant | 1 |
| Martin Meltz | Academic/Industry consultant | 1 |

What can be seen in the above table is the significant involvement in the writing of the review papers by both the telecommunications sector and the military. In addition, as mentioned previously, the publication of Supplement 6 was underwritten by the U.S. Air Force.

In the ***Introduction*** by Chou and D'Andrea the overall theme for the entire group of papers is set with the rejection of non-thermal bioeffects as not being established and not proven hazardous to health, essentially ignoring the concerns raised by RFIAWG. Therefore, the thermal effect was deemed the only established adverse health effect that can be considered in setting safety standards. Chou and D'Andrea list 12 "guiding principles"[360] that ICES Subcommittee 4 used in revising the RF standard. To Quote:

- The RF safety standard should be based on science.
- RF safety standard revision should be derived from peer reviewed publications and documents that are reviewed by the SC4.
- The adverse effect level remains at 4 W/kg subject to revision following completion of the literature evaluation and review papers.
- The maximum exposure limits should be based on established adverse effects [thermal] after inclusion of an appropriate safety factor(s).

[359] C-K. Chou, J. D'Andrea, 'Reviews of the Effects of RF Fields on Various Aspects of Human Health: Introduction', *Bioelectromagnetics, Supplement 6*, 2003, pp. S5-S6.
[360] Chou, D'Andrea, 2003. P. S6.

- Safety factor(s) should consider uncertainties in the biological database (e.g., measurements, environmental conditions, exposure duration, individual variability, and other factors.
- Nonthermal RF biological effects have not been established and none of the reported nonthermal effects are proven adverse to health (does not apply to electrostimulation). Thermal effect is the only established adverse effect.
- The microwave hearing effect is not adverse and should not be used for setting the peak power limit.
- The shape and size of the averaging volume and the peak SAR limit are still to be determined. The important end point is the temperature change.
- The RF standard should be harmonized with other international standards [ICNIRP] to the extent where scientifically defensible.
- Rationales must be documented for all changes relative to the current standard.
- The editorial committee will add in the informative section a paragraph dealing with potentially sensitive sub-populations, such as children.
- Reconsider the two tier approach (whole body average SAR 0.4 and 0.08 W/kg), the peak SAR value and the averaging volume.[361]

Despite the fact that the "guiding principles" of ICES SC4 dismiss low intensity (non-thermal) effects some of the authors of the 12 papers in *Bioelectromagnetics Supplement 6* acknowledged the possibility of adverse RF bio-effects, even at exposure levels below the RF standard limits. This is illustrated below with a few selected quotes from the papers.

Adair and D'Andrea admitted that a number of behavioural studies found evidence for other kinds of behavioural changes that may not be thermally caused. They stated that, "Conclusions regarding health and safety cannot be drawn from the few human cognitive studies until additional research is done…It is difficult to draw any conclusions at this time because there are too few studies with human subjects." They conclude that further research on cognitive performance in humans under RF exposure "would add greatly to our understanding of RF biological effects".

Ellwood examined the epidemiological evidence and concluded that most of the studies suffered from deficiencies and that the possibility of a connection between RF exposure and an increased risk of cancer could not be ruled out. Ellwood recommended further research be carried out, including focusing on brain tumours and cell phone use. Despite the uncertainty, however, Ellwood did not consider that the epidemiological evidence indicated that the RF standards needed to be revised downwards.[362]

D'Andrea, Chou, Johnston and Adair acknowledge in their paper that there "are some reports of biological effects that cannot be explained by thermal mechanisms are in the scientific literature" but that in such reports "it is difficult to draw conclusions concerning hazards to human health. The many exposure parameters such as frequency, orientation, modulation, power density, and duration of exposure make direct comparison of many experiments difficult". Consideration of these factors in setting

[361] ibid.
[362] M. Ellwood, 'Epidemiological Studies of Radio Frequency Exposures and Human Cancer', *Bioelectromagnetics Supplement 6*, 2003, pp ; S63 – S73.

standards are dismissed by the authors because they state that in setting limits for RF standards, "it is often necessary to make assumptions about underlying mechanisms" and to define an established mechanism "as one where effects on a living person and the thresholds of reaction are understood". The authors conclude that "the only firm conclusion that may be drawn is the potential for hazardous thermal consequences of high power RF exposure". [363]

An illustration of the level of uncertainty in the historical RF literature is the admission by Adair and Black in their paper that "most of the published research on thermo-physiological responses in the presence of RF fields has been conducted on laboratory animals, with a heavy emphasis on laboratory rodents (e.g., mice, rats, and hamsters). These small animals are poor models for human beings because their physiological heat loss mechanisms are limited". This is referring to thermal research, not possible non-thermal bio-effects, but the authors imply that the 'weight-of-the-evidence' for Western RF thermally-based standards is founded on a poor and inadequate data base.[364]

The overall 'message' of the above papers published in *Bioelectromagnetics Supplement 6* is to banish consideration of non-thermal effects in standard setting. The authors of the review papers in Supplement 6 have careers within a technological peer community that has long accepted the thermal mechanism as the only established and well understood mechanism with RF exposure. Researchers who focus their investigations to further refine thermal thresholds under different conditions are at the cutting edge of EMF research but researchers who dare focus on non-thermal effects risk being branded as "extra-scientific". This would be because of their "beliefs or speculations" about non-thermal bio-effects, to quote from Osepchuk and Peterson's *Bioelectromagnetics Supplement 6* paper.[365] Evidence that RF bio-effects not directly related to heating were arbitrarily dismissed by the ICES Subcommittee 4 is contained in the "Consensus Statement" that was initially placed on the Internet from the COST281 [366]workshop, held in Helsinki, Finland, April 28-29, 2004. This statement contained in the opening paragraph the sentence: "Based largely on the evidence presented at the workshop, there is no substantiation of the hypothesis that RF exposures result in the induction of stress proteins." The statement was soon pulled from the web site after Dariusz Leszczynski from Finland's Radiation and Nuclear Safety Agency complained to the COST281 chairman as well as the head of FGF, Germany's wireless industry research group. Leszczynski, who hosted the workshop, has published a number of papers showing that RF can activate heat shock proteins. Leszczynski pointed out that the offending sentence was not in the earlier (May) circulated version of the consensus statement. As for who changed the previously agreed consensus statement, according to FGF, it was Blair Henderson from Austria's Innsbruck University and Martin Meltz from the University of Texas[367] who is a member of ICES Subcommitee 4, and author of the paper in Supplement 6, as examined previously. An examination of the book of abstracts of the Helsinki workshop finds three papers that invalidate the "consensus" statement improperly inserted by Henderson and Meltz. These papers are: Leszczynski D. et al

[363] J. D'Andrea, C-K. Chou, S. Johnston, E. Adair, 'Microwave Effects on the Nervous System', *Bioelectromagnetics Supplement 6*, 2003, pp. S107 – S147.
[364] Adair, Black, 2003.
[365] Osepchuk, Petersen, 2003.
[366] Acronym for "European Cooperation in the Field of Scientific and Technical Research".
[367] L. Slesin, 'News & Comment: What's New', *Microwave News* , Jul. 22, 2004, http://www.microwavenews.com/nc_ja2004.html, Accessed Sept. 30, 2006.

"Effects of RF-EMF on Cellular Stress Response, Gene and Protein Expression"; Goodman R, Weisbrot D, and Blank M, "Biological Effects on growth and Development from Exposures to Radiofrequency" and Kwee S, "The Generation of Heat-Shock Proteins in Cells Exposed to RF Electromagnetic Fields".[368] Another inconsistency with actual events was seen in Motorola's Mays Swicord's write-up of the Helsinki heat shock workshop in the Bioelectromagnetics Newsletter, May/June 2004. Much of the data presented at the workshop that indicated a heat-shock effect from RF exposure was somehow omitted from Swicord's article and the research by Leszczynski, presented at the workshop, failed even to get a mention.[369]

**Conclusions**

Common to all the standards and guidelines examined in this chapter is a scientific assumption that the only hazardous biological effect from RF exposure is thermal in nature. This viewpoint was originally established by just a few individuals charged with setting an American military exposure standard in the 1950s during the Cold War, when the Soviet Union appeared to be winning the nuclear arms race. The overriding problem confronting standard-setting military planners at the time was the need to provide health protection to personnel developing and working on new high power radar systems while at the same time not restrict the development of the technology that was considered essential for national survival in the event of a possible Soviet nuclear attack. Considering this, and the urgency to quickly come up with a workable standard in the midst of an escalating nuclear arms race, the best fit for addressing the problem was to rely on the already existing medical opinion that had built up since the late 1920s that as long as thermal increases to body temperature were restricted to tolerable limits, no adverse or irreversible biological effects were possible.

Initial exposure standards based on this thermal model fit the planner's problem nicely. Radar development could continue while assurances of safety could be given. Research could be conducted to further understand the thermal-regulatory capacity of the body (both animal and human) when exposed to RF/MW, thus strengthening the literature base that, in turn, supported the standard. Standards could then be updated and refined to provide protection against thermal biological damage without restricting the development of new technology being developed by both the military and private corporations. When there were questions in later years over the standard limits providing adequate protection against newly developed higher frequency technology, such as mobile phones, there was room available to further relax the standard's thermal limits to accommodate increasing exposure levels from that technology. All this was in general agreement with what was historically known about acute RF exposure levels – it could heat up tissue and thereby cause obvious biological damage.

Although early assumptions on RF biological hazards (heating) may be somewhat justified during the 1950s Cold War conflict with the Soviet Union, those assumptions quickly became a paradigm that excluded considerations of possibly adverse biological effects not related to heating. As seen in the ANSI/IEEE C-95.1 – 1996 RF standard, industry concerns over possible cell-phone compliance issues have led to adopting

[368] Abstracts: FGF-Workshop: *"Influence of RF Fields on the Expression of Stress Proteins"*, Helsinki, Finland, 28-29 April 2004.
[369] Slesin, 'Industry Rules RF…' 2004.

measures that allow increasing the limits in order to accommodate technological operational requirements while relegating research into non-thermal biological interactions with RF as operating on a level of "beliefs and speculations" an therefore being "extra-scientific". This relegates research that questions the thermal paradigm as somewhat tainted and beneath serious consideration.

With members linked to the 'military-industrial complex' firmly in control of the IEEE's RF standards committees right from the beginning, their continuing task was essentially to further refine the thermal paradigm by encouraging research to further add validity to the thermal theory and not to test its basic assumptions. It is apparent that those actively involved in revising the latest 2005 C95.1 standard, writing various research papers for an updated risk-assessment of RF as well as those conducting peer review of papers for consideration have been thoroughly trained in the paradigm to the extent that any other non-thermal biological interactions with RF were well beyond consideration.

This chapter has tracked the development of the IEEE C95.1 RF standard from its foundations in the early 1950s and through various revisions by IEEE standard setting committees to illustrate the continual resistance to acknowledging the possibility of non-thermal effects in setting exposure limits. This resistance is linked to committee members' ties to industrial and military organizations with a vested interest in maintaining the thermal paradigm. This paradigm has been challenged on a number of occasions by knowledgeable experts and government agencies but without success. As is seen in the various IEEE standards committee meetings the central arguments over standard revisions are technical, such as increasing the averaging volume of tissue to assure cell phones can safely meet compliance testing. These technical changes are seen in the light of working within the thermal paradigm to assure that the standard is always in compliance with the needs of the technology. What is apparent from this continuing situation is that an essential ingredient for the maintenance of the thermal paradigm is for supporters of that paradigm to control the standard setting process through their membership on RF standard setting committees. In this regard, conflict of interest has long been an essential policy to block the possibility of change inimical to those who control the process. The importance of this chapter is to expose the subjective nature of the existing RF standard setting process as it has played out in the U.S. This Chapter takes the view that objective scientific hazard risk assessments in the public interest cannot function in the standards setting arena when those directly affected by regulation control the process. It is important to note that this situation can also apply to a wide range of other potential environmental hazards where those responsible for the potential hazard try to control the debate. In this context, the problem of conflict of interest in standard setting committees remains as the proverbial 1000-pound gorilla long ignored in the corner of the room.