POSITION PAPER SUPPORTING HUMAN FACTORS AND ERGONOMICS PRACTITIONERS IN FORENSICS

(March, 2014 Revision)

Forensics Professional Group (FPG) of the Human Factors and Ergonomics Society (HFES)

Purpose

The purpose of this document is to provide forensic human factors and ergonomics experts, and attorneys who have retained them, legitimate arguments that rebut challenges to including expert human factors or ergonomics (HFE) testimony (or motions to place limitations upon such testimony) and to provide a rationale for allowing such testimony to be presented.

Background

Opposing attorneys in personal injury, product liability, workplace injury, transportation injury, or other civil and criminal cases sometimes challenge the proposed testimony of human factors and ergonomics experts. An attorney may oppose the introduction of human factors and ergonomics testimony because:

1. The challenging attorney has chosen not to use the services of a human factors or ergonomics expert for his/her own case presentation. That attorney may then realize, at a time nearer to trial, that the testimony of the opposition's human factors or ergonomics expert likely will be effective and may thereby be harmful to the challenging attorney's interests and positions.

2. The challenging attorney believes that the human factors and ergonomics discipline provides information that jurors would know based on their own experience or "common sense," and, therefore, challenges its utility in assisting judicial decisions.

3. The challenging attorney, citing the "Daubert" decision giving judges more

responsibility in admitting evidence based on their opinion of the scientific credibility and acceptance of that evidence, challenges the acceptance of the human factors and ergonomics discipline and its scientific credibility. The United States Supreme Court case *Daubert v. Merrell Dow Pharmaceuticals Inc.*, 113 S. Ct. (1993) defined boundaries for acceptable expert testimony. The Supreme Court decided that the trial judge, in federal cases, is responsible for ensuring the relevance and reliability of expert testimony. The Supreme Court provided four factors that a federal judge can consider when evaluating expert testimony:

- Can the theory being offered by the expert be (or has it been) tested? Does the expert make statements capable of empirical testing?
- Has the basis of the expert's testimony been subjected to peer review or publication?
- What is the reliability (i.e., the known or potential rate of error) of the scientific evidence offered by the expert?
- Has the theory or subject matter of the expert's testimony achieved "general acceptance" in the scientific community?

4. The challenging attorney contends that the proposed human factors and ergonomics testimony will "invade the province" of the jury.

5. The challenging attorney may question whether the expert's conclusions and opinions have been reviewed by other human factors professionals. If the expert has relied upon any empirical evidence in developing his/her opinions and conclusions, the challenging attorney may address the basis of those opinions and whether they are consistent with other published results.

In addition to challenges directed at the human factors and ergonomics discipline, the challenging attorney may also question the qualifications (background, education, experience, and/or training) of the individual expert. Human factors and ergonomics experts must be prepared to describe their qualifications in order to support their being

considered a competent and credible expert.

Arguments Supporting the Admission of Human Factors and Ergonomics Expert Testimony

1. Human factors and ergonomics is an established, internationally recognized scientific discipline and systems-design profession.

1.1 Overview:

The human factors and ergonomics discipline has roots stemming from engineering, psychology, physiology, and pedagogy, and serves a unique system design function. More than 70 years ago, military and industrial systems designers recognized that traditional approaches to selecting and training operators and maintenance personnel did not ensure acceptable or safe system performance. Consequently, a new body of knowledge and skills began to form based upon scientific study of human capabilities and limitations, and the application of this knowledge to issues of personnel selection and training, workplace design, equipment selection and development, and to overall systems development.

Scientifically developed knowledge about human capabilities and limitations, and skill in applying this knowledge to system design and development, is the basis for the human factors and ergonomics profession. Human factors and ergonomics professionals strive to ensure that systems and equipment are designed to be compatible with known human biomechanical, physiological, psychological, information processing, and anthropometric characteristics. Human factors and ergonomics professionals play a significant role in the design of consumer products, medical devices, construction and agricultural equipment, complex aircraft and spacecraft, pedestrian and vehicle transportation systems, manufacturing facilities and processes, office environments, hospital and healthcare delivery systems, and a multitude of other applications. They also work to properly develop the procedures (e.g., instructions, training programs, user support documents) necessary to ensure that these systems are used effectively. In these ways the human

factors and ergonomic professionals help to increase the productivity, comfort, health, and safety of the human beings who interact with and use those systems in their daily lives.

1.2 Professional Societies:

Professional societies are serving the needs of human factors and ergonomics professionals in over 50 countries. Based on estimates from the International Ergonomics Association (IEA), there are more than 25,000 people working as human factors and ergonomics professionals around the world. The first professional society serving the ergonomics discipline, The Ergonomics Society, was established in 1949 in Great Britain. This society later was renamed the Institute of Ergonomics and Human Factors.

The principal professional society representing the needs of human factors and ergonomics professionals in the United States is the Human Factors and Ergonomics Society (HFES), originally established (in 1957) as the Human Factors Engineering Society of America. The HFES (www.hfes.org) maintains its global connection to ergonomic researchers, academicians, and practitioners in countries throughout the world through its affiliated-organization status within the IEA.

There are about 5000 members of the HFES, representing 47 different countries. There are 23 technical groups within the HFES – affording HFE professionals opportunities to further pursue their respective interests in subareas of the discipline. (A complete listing of these technical groups appears later in the paper). One of those technical groups, the Forensics Professional Group, has sponsored this position paper. More than 1300 members typically attend the annual meetings of the HFES, where they participate in scientific / educational workshops, panel discussions, symposia, and technical paper presentations that are published in the *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*. Other publications of the HFES include the highly respected research journals, *Human Factors*, the *Journal of Cognitive Engineering and Decision Making*, *Reviews of Human Factors and Ergonomics*, and a practice-oriented

magazine, *Ergonomics in Design*. Approximately 15% of HFES members report having been engaged in expert witness work at some time in their careers – efforts frequently conducted in parallel with their other professional activities and/or employment.

1.3 Design Guidelines and Standards:

The human factors and ergonomics profession plays a pivotal role in providing the scientific and technical foundation for many of the federal rules and standards that underlie regulatory and certification requirements. And, human factors and ergonomics professionals have contributed by authoring many important system and equipment design guidelines and standards that are accepted and followed throughout the world.

The U.S. Department of Defense Military Standard (MIL-STD-1472) on "*Human Engineering Design Criteria for Military Systems, Equipment, and Facilities*" has been a significant resource for military and non-military system designers for over 40 years. The ANSI/HFES-100 standard for designing hardware related to computer workstations is recognized as the most comprehensive human factors and ergonomics standard to follow when designing computer workstations. And, the ANSI/HFES-200 standard is an important tool used in the design of software user interfaces. Human factors professionals served an important role in evaluating the causes of the 1979 Three Mile Island nuclear power plant incident and in authoring guidelines for designing future process control centers so as to avoid the types of human-machine-interface problems that contributed to that incident.

Additionally, the U.S. Department of Transportation / Federal Aviation Administration's *Human Factors Design Standard* (DOT/FAA/CT-03/05 Report No. HF-STD-001, originally published in 2003, and now being revised/updated in 2014, has served to combine and integrate many of the prior HFE guidelines, standards, and specifications into a single annotated reference source – one intended to be used both in guiding the design and development of new systems, as well as in the selection and acquisition of commercial-off-the-shelf (COTS) system components.

In addition to producing equipment-oriented design guidance, human factors and ergonomics professionals also help to drive science based decisions about the application and use of those equipment systems, as well as standards for operator certification and training. For example, there is a recent aviation rule requiring that all new avionic systems have to be designed and evaluated in a manner to show what human errors might occur in their use, and how such errors would be mitigated.

Human factors and ergonomics professionals continue to serve on standards committees sponsored by organizations such as the American Society for Testing and Materials (ASTM International), American National Standards Institute (ANSI), the Association for the Advancement of Medical Instrumentation (AAMI), and the International Organization for Standardization (ISO) – with the latter producing a number of human factors and ergonomics standards in world-wide use.

2. The academic and scientific bases for the human factors and ergonomics discipline are well established and continue to grow.

2.1 Academic Degree Programs:

Highly respected academic programs offering advanced degrees in human factors and ergonomics exist in many countries throughout the world. Within the United States, there are currently 76 university programs offering graduate degrees at the MS or PhD levels in human factors and ergonomics. These programs exist at state and private universities in 33 different states – usually embodied within either the Psychology or Industrial Engineering Departments at those schools. Fifteen of those 76 programs have applied for and earned accreditation from the HFES Accreditation Committee, based upon their having met stringent criteria regarding the program's curriculum of relevant courses, number of qualified faculty and staff personnel, number of enrolled graduate students, and the provision of opportunities for obtaining practical work experience in parallel with their academic coursework.

Academic research conducted in these programs continues to add important new knowledge, tools, and skills that form the basis of the human factors and ergonomics profession. This research contributes to our understanding of such issues as human response time, sensory and perceptual processes, memory, human information processing, cognition, and decision-making. The majority of human factors and ergonomics practitioners working in the United States have received graduate degrees, either in a program devoted specifically to human factors and ergonomics or in one of the primary disciplines such as engineering or psychology, with a specialization in human factors/ergonomics studies.

In addition to academic research activities, HFE professionals are also involved in a continuing process of developing and promulgating analytical tools, techniques, methods, and recommended research practices that are used to effectively expand the discipline's knowledge base. A few examples of works that have helped to define, extend, and refine HFE research methodologies and empirical analysis techniques include those published by Chapanis (1959); Kaplan (1964); Meister (1971); Weimer (1995); Stanton, Hedge, Salas, Hendrick, & Brookhaus (2004); and Stanton, Salmon, Rafferty, & Walker (2013) – more complete references for these efforts are provided later in the paper.

2.2 Government Sponsored Research:

U.S. Government agencies (e.g. Department of Defense, NASA, NIOSH, Department of Energy, Department of Interior, and Department of Transportation) have long records of sponsoring research and contributing significantly to the growing body of human factors and ergonomics knowledge. Human factors and ergonomics professionals help to shape national research priorities as chairs or members of the many committees and projects of the National Research Council, National Academy of Sciences, and the National Academy of Engineering.

2.3 Industrial Research / Development:

Commercial firms creating products or services that compete in the world's marketplaces

employ a large number of human factors and ergonomics practitioners. Human factors and ergonomics research and development efforts, conducted by these companies in support of their respective goals, provide valuable contributions to the scientific basis for the discipline. An abbreviated, but representative, listing of commercial firms dependent upon and benefitting from the contributions of human factors and ergonomics practitioners performing important design, analysis, and evaluation roles is provided in Section 4 of this paper.

2.4 Scientific Journals and Textbooks:

Considerable information about the human capabilities and limitations applicable to system and equipment design has appeared in peer-reviewed publications over the last 60 years. Examples of the types of knowledge available in this well-established and growing database include scientific information about: a.) human physical characteristics (such as body dimensions, weight, strength capabilities, and motor skills); b.) human sensory, perceptual, and cognitive processes (such as vision, audition, reaction time, decision making, attention, memory, learning, and information processing); c.) human responses to physical environmental factors (such as noise, vibration, temperature, acceleration, stress, and lighting); d.) personal factors (such as age, experience, and intelligence); and e.) organizational factors (such as work incentive programs, workload level measurement, and work system designs – including safety and health systems).

Notable publications documenting the human factors and ergonomics database include:

A Guide to the Ergonomics of Manufacturing by M. Helander, 1995.

An Introduction to Human Factors Engineering by C.D. Wickens, J.D. Lee, L. Yili, and S. Gordon-Becker, 2nd Ed., 2004.

Dreams—Design and Destiny. *Human Factors*, 29(1), 111-121, by R.J. Hornick, 1987.

Elements of Ergonomics Programs, DHHS (NIOSH) Publication 97-117, 1997.

Encyclopedia of Human Factors/Ergonomics edited by W. Karwowski, 2nd Ed., 2006

Engineering Data Compendium: Human Perception and Performance edited by K.R.

Boff and J.E. Lincoln, 1988.

Engineering Psychology and Human Performance by C.D. Wickens, 1990.

Ergonomic Checkpoints: Practical and Easy-to-Implement Solutions for Improving Safety, Health, and Working Conditions by the International Labour Office in collaboration with the International Ergonomics Association, 2nd Ed., 2010.

Ergonomics Guidelines and Problem Solving edited by A. Mital, A. Kilbom, and S. Kumar, 2000.

Ergonomics Program Management Guidelines for Meatpacking Plants, OSHA, 1993.

Evaluation of Human Work edited by J.R. Wilson and E.N. Corlett, 4th Ed. 2005.

Fitting the Task to the Human, 5th Ed., by K.H.E. Kroemer and E. Grandjean, 1997.

Forensic Aspects of Driver Perception and Response, 2nd Ed., by P.L. Olson and E.I. Farber, 2003.

Handbook of Human Factors edited by G. Salvendy, 4th Ed., 2012.

Handbook of Human Factors in Litigation, edited by Y.I. Noy and W. Karwowski, 2005.

Handbook of Human Vibration by M.J. Griffin, 1990.

Handbook of Warnings edited by M.S. Wogalter, 2006.

HFES Guide to Forensic Human Factors, edited by K. Nemire, J. Cohen, & H. Cohen, 2014.

Human Engineering Guide to Equipment Design by H.P. Van Cott and R.G. Kinkade, 1972.

Human Error by J. Reason, 1990.

Human Factors and Ergonomics Methods edited by N. Stanton, A. Hedge, E. Salas, H.W. Hendrick, and K. Brookhuis, 2004.

Human Factors Design Handbook, 2nd Ed., by W.W. Woodson, B. Tillman, and P. Tillman, 1992.

Human Factors Engineering for Forensic and Safety Specialists by W. Woodson, 1998.

Human Factors in Engineering and Design, 7th Ed., by M.S. Sanders and E. McCormick, 1993.

Human Factors in Lighting, 3rd Ed., by P.R. Boyce, 2014.

Human Factors in Traffic Safety by R.E. Dewar and P.L. Olson, 2001.

Human Factors Issues in Handgun Safety and Forensics by H. Hendrick, P. Paradis, &

R. Hornick, 2008.

Human Factors Methods: A Practical Guide for Engineering and Design by N.A. Stanton, P. Salmon, L. Rafferty, & G. Walker, 2013.

Human Performance Engineering, 2nd Ed., by R. Bailey, 1989.

Human Factors: Theory and Practice by D. Meister, 1971.

Introduction to Ergonomics by R.S. Bridger, 3rd Ed., 2008.

Kodak's Ergonomic Design for People at Work, 2nd. Ed., by Eastman Kodak Co., combines Vol. 1 (1983) and Vol. 2 (1986), 2003.

Macroergonomics: An Introduction to Work System Design by H.W. Hendrick and B. Kleiner, 2001.

Macroergonomics: Theory, Methods and Applications edited by H.W. Hendrick and B. Kleiner, 2002.

Manager's Guide to Workplace Ergonomics, Business Legal Reports, Inc. (periodically updated).

Managing the Risks of Organizational Accidents by J. Reason, 1997.

National Safety Council Accident Prevention Manual for Industrial Operations: Engineering and Technology (periodically updated with new editions).

National Safety Council Accident Prevention Manual for Industrial Operations: Administration and Programs (periodically updated with new editions).

Occupational Biomechanics by D.B. Chaffin, G.B. Anderson, and B.J. Martin, 4th Ed., 2006.

Research Techniques in Human Engineering by A. Chapanis, 1959.

Research Techniques in Human Engineering edited by J. Weimer, 1995.

Reviews of Human Factors and Ergonomics, different editors, Vol. 1-8, 2006-2013.

Stress and Human Performance edited by J. Driskell and E. Salas, 1996.

The Conduct of Inquiry by A. Kaplan, 1964.

The Design of Everyday Things by D.A. Norman, 2002.

Warnings: A Research Perspective by J. Edworthy and A. Adams, 1996.

Warnings and Risk Communication edited by M.S. Wogalter, D.M. DeJoy, and K.R. Laughery, 1999.

Warnings and Safety Instructions: Annotated and Indexed, 4th Ed., by J.M. Miller and

M.R. Lehto, 2000.

Work Design, Industrial Ergonomics, 5th Ed., edited by S. Konz and S. Johnson, 2000.

Work-Related Musculoskeletal Disorders (WMSDs): A Reference Book for Prevention edited by I. Kuorinka and L. Forcier, 1995.

Work-Related Musculoskeletal Disorders: A Review of the Evidence, National Research Council, 1998.

Work Organization and Ergonomics edited by V. Martino, and N. Corlett, 1998.

Work Design by S. Konz, 1995.

Work Practices Guides for Manual Lifting, NIOSH, 1981; 1993.

Some notable peer-reviewed scientific journals in which human factors and ergonomics findings are published include:

Accident Analysis and Prevention
Applied Cognitive Psychology
Applied Ergonomics
Ergonomics
Human Factors
IEEE Transactions on Systems, Man and Cybernetics
IIE Transactions
Information Display
International Journal of Ergonomics in Manufacturing
International Journal of Industrial Ergonomics
International Journal of Man-Machine Studies
International Journal of Occupational Safety and Ergonomics
Journal of Applied Psychology
Journal of Cognitive Engineering and Decision Making
Journal of Experimental Psychology
Journal of Sound and Vibration
Journal of the Acoustical Society of America
Journal of the Optical Society of America
Safety Science
Theoretical Issues in Ergonomics Science
Vision Research

In addition to the above, many important HFE papers are published in the *Proceedings of the Human Factors and Ergonomics Society Annual Meeting* and in journals published by professional ergonomics societies around the world, including those in Europe and the Pacific Basin.

It is also worth noting that from time to time human factors and ergonomics experts are sometimes asked to submit articles for scholarly law publications and/or to speak about human factors topics at gatherings or meetings of lawyer organizations. One such example was a paper prepared by R. Olsen (1992) and published in the *Products Liability Law Journal*, titled "Human Factors Experts and Product Design". Other ecumenical or "out-reach" types of interchanges between HFE and legal professionals have included a series of mock trial type exercises in which a hypothetical incident is assumed to have occurred having human-factors-relevant issues at stake, and about which litigation has ensued. In conducting such mock trial scenarios, prominent FPG members have often been asked to play the roles of HFE experts retained by attorneys for both the plaintiff and defense sides of the case, and local litigators – attorneys and/or judges – have volunteered to play the roles of the legal counsel and the presiding judge in the case. Such events have consistently been well attended, have sparked enthusiastic discussions, and have provided valuable learning opportunities for all parties (including those in attendance and as well others who have subsequently viewed video recordings of the proceedings). [Note: Two FPG mock trial videos are available for purchase via the www.hfes.org website, under the menu tabs: Publications; Videos.]

3. Certification of human factors and ergonomics professionals' credentials and accreditation of human factors and ergonomics academic degree programs are established.

Another measure of the professional status of a discipline is achieved when certification of practitioners and accreditation of academic degree programs have been established. Two independent organizations based in the United States, the Board of Certification in Professional Ergonomics (BCPE) and the Oxford Research Institute (ORI), have been providing certification and professional development services to human factors and ergonomics practitioners since 1992. Similar professional certification boards exist in Europe for the European Union, as well as in Canada, Japan, Australia, and New Zealand. The Human Factors and Ergonomics Society (HFES) Accreditation Committee

has accredited 15 graduate degree programs in the United States. Certification of practitioners and accreditation of academic degree programs, although relatively recent developments, demonstrate the continuing advancement of the human factors and ergonomics profession.

4. The utility and value of the human factors and ergonomics discipline have long been recognized by government and corporate groups that support the discipline's growth.

There are many HFE practitioners employed throughout academia, government, and industry. Some notable entities that have recognized the utility and value of their human factors and ergonomics practitioners are:

U. S. Government

National Aeronautics and Space Administration (NASA)
National Highway Traffic Safety Administration (NHTSA))
National Institute for Occupational Safety and Health (NIOSH)
National Transportation Safety Board (NTSB)Occupational Safety and Health
Administration (OSHA)
Office of Science and Technology
U.S. Air Force
U.S. Army
U.S. Navy
U.S. Coast Guard
U.S. Department of Home Land Security / Transportation Security Admin.
U.S. Department of Interior
U.S. Department of Labor
U.S. Department of Transportation
U.S. Federal Aviation Administration
U.S. Federal Railway Administration

Standards Organizations

American National Standards Institute (ANSI)
American Society for Testing and Materials (ASTM)
International Standards Organization (ISO)
Society of Automotive Engineers (SAE)

Industry

Abbott Laboratories
Apple Computer
AT&T Corporation
Baxter Healthcare
BAE Systems, North America
Boeing Corporation
Carpenter Technology Corporation
Caterpillar Inc.
Chrysler Corporation
Deere & Company
Eastman Kodak Company
Exxon Mobil Corporation
Ford Motor Company
General Electric
General Motors Corporation
Harley-Davidson
Hayworth Inc.
Herman Miller Corporation
Hewlett-Packard Company
Hughes Aircraft Company
IBM Corporation

Intel Corporation
Johnson & Johnson
Lennox International Inc.
Lenovo
Liberty Mutual Insurance Company
Lockheed Martin
McDonnell Douglas/Boeing
Medtronic
Michelin
Microsoft Corporation
Oracle Corporation
Raytheon Corporation
Steelcase Corporation
Sysco Corporation
The Coca-Cola Company
Texas Instruments Inc.
Toyota Motors North America
United States Postal Service
Xerox Corporation
3M Corporation

Within the HFES organization there are 23 technical groups, each of which was formed by members expressing a common set of technical and research interests. These technical groups (TGs) each focus on a particular aspect of the human factors field, and hold regular meetings, publish newsletters, sponsor a website, sponsor local or regional events and special activities, provide annual reports, and/or sponsor technical sessions at the HFES Annual Meeting. These TGs include:

Aerospace Systems
Aging
Augmented Cognition
Cognitive Engineering and Decision Making
Communications
Computer Systems
Education
Environmental Design
Forensic Professional
Health Care
Human Performance Modeling
Individual Differences in Performance
Internet
Macroergonomics
Occupational Ergonomics
Perception and Performance
Product Design
Safety
Surface Transportation
System Development
Test and Evaluation
Training
Virtual Environments

Summary

The purpose of this document is to present legitimate arguments that rebut typical challenges to or limitations requested to be placed upon expert human factors and ergonomics testimony. Although greater detail could be given for each of the arguments, it is clear even with this brief presentation, that, in fact:

1. Human factors and ergonomics is an established, internationally recognized scientific discipline and system design profession.
2. The scientific bases for the human factors and ergonomics discipline are well established and continue to grow.
3. Certification of human factors and ergonomics professionals and accreditation of human factors and ergonomics academic degree programs are well established and internationally recognized.
4. The utility and value of the human factors and ergonomics discipline are recognized by the U.S. government, educational, and industrial communities. These groups support the development of and apply the scientific knowledge and principals that this professional discipline develops. The successful operation of these organizations is very much dependent upon the scientific knowledge base that human factors and ergonomics helps to advance.
5. The objectives of the civil and criminal justice systems are well-served by having a scientific basis for evaluating human factors deemed relevant in court deliberations and judgments.

Members of the Forensics Professional Group (FPG) of the Human Factors and Ergonomics Society (HFES) prepared an initial version of this document in 1996. A revised version was created in July 2004, and this third revision was released in March 2014. The FPG is concerned with applying ergonomics and human factors knowledge,

data, and techniques to “standards of care” and accountability established within legislative, regulatory, and judicial systems. The FPG serves to provide a scientific and technical focus on issues being interpreted by legal theory and procedures. The FPG was established in 1984 and has had between 250 and 300 HFE professional members in each of the last ten years.

The 2014 revision of this document was developed based upon inputs from HFES FPG members: J.R. Duncan, R.J. Hornick, E.W. Karnes, K.E. Nemire, R.A. Olsen, M.S. Wogalter, and D.R. Lenorovitz – who also served as coordinator/editor for the effort.

The authors also wish to acknowledge the valuable contributions of the following HFES professionals – who reviewed and provided helpful comments on selected topic areas within the paper:

B. Bradtmiller
B.S. Chaparro
P.B. DeLucia
D.J. Gardner-Bonneau
P. Krois
K.R. Laughery, Sr.
K. Monroe