Volume XIV: Number 2 (2003)

Human Systems IAC

GATEWAY

Published by the Human Systems Information Analysis Center

The Current State of Human Factors Standardization

Alan Poston

In June 1994, Secretary of Defense William Perry issued new rules for the use of military specifications and standards. The memorandum stated:

> Performance specifications shall be used when purchasing new systems, major modifications, upgrades to current systems, and non-developmental and commercial item for programs in any acquisition category. If it is not practicable to use a performance specification, a non-government standard shall be used. Since there will be cases when military specifications are needed to define an exact design solution because there is no acceptable non-governmental standard or because the use of a performance specification or non-government standard is not cost effective, the use of military specifications and standards is authorized as a last resort, with an appropriate waiver.

Other key provisions of the memorandum were:

- To encourage contractors to propose non-government standards and industry-wide practices that meet the intent of the military specifications and standards
- That the specifications and standards listed in DoD Instruction 5000.2 are not mandatory for use and should be viewed as guidance
- That first-tier references cited in contracts are mandatory for use while lower tier references are for guidance only, and are not contractually binding

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http://iac.dtic.mil/hsiac

inside:

The Human Systems IAC is a United States Department of Defense Information Analysis Center administered by the Defense Technical Information Center, Fort Belvoir, Virginia, technically managed by the Air Force Research Laboratory Human Effectiveness Directorate, Wright-Patterson Air Force Base, Ohio, and operated by Booz Allen Hamilton, McLean, Virginia.

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- To use management and manufacturing specifications for guidance only
- To develop a procedure for identifying and removing obsolete military specifications and standards and data requirements
- To develop non-government standards for replacement of military standards where practicable, and review the federal supply classes and standardization areas to identify candidates for conversion or replacement
- To reduce direct government oversight by substituting process controls and non-government standards

As a result of military specification reform, the number of human factors-related standardization documents was reduced from 21 to 11; the other ten documents were canceled. (Overall, the number of military specifications and standards were reduced from approximately 45,500 to approximately 28,300.) Of the 11 remaining documents, four were handbooks, three were converted to handbooks, two were designated as Design Criteria Standards (including MIL–STD–1472), one was designated as an Interface Standard, and one was designated as a Standard Practice. The major impact of the military specification reform on the human factors standardization area was that most of the human factors-related standardization documents were converted to handbooks or designated as design criteria standards; in effect, they were relegated to "guidance only" documents.

As used in the context of this article, human factors standardization means meeting the design criteria of the various human factors-related documents; it does not mean that items should look alike.

As part of the military specification reform, Coopers and Lybrand conducted a study of the cost premiums (the amount of additional costs that would be incurred) by requiring various military standards on a contract, as reported by industry. MIL–STD–1472 was one of the documents that was included in the study because it was cited by industry as a cost driver. The report of the Coopers and Lybrand study listed the top 105 cost drivers. MIL–STD–1472 was number 58 on the list, and Coopers and Lybrand estimated that the inclusion of human engineering requirements added a cost premium of 0.4 percent to the research and development (R&D) cost.

Operations and support (O&S) costs for a system are much greater than R&D costs, therefore early assessment of lifecycle costs has significant benefit to total program cost. Most lifecycle costs are determined by decisions made during the earlier phases of the acquisition process. Decisions made with little regard to human capabilities and limitations may cause expensive solutions, e.g., equipment changes, developing or modifying procedures, increasing staffing levels, requiring skills not in the current workforce, increasing training requirements. The proper application of human engineering costs very little when included from the beginning. While there may be a small increase in the R&D cost (0.4 percent according to Coopers and Lybrand), the proper application of human engineering requirements and standards will lead to a savings, or cost avoidance, in total program cost.

Advances in technology make human factors standardization even more important. Technology, if mis-applied, will impose human performance requirements that cannot be satisfied. Many technologies are evolving rapidly; the human is not. For example, manufacturers tout modern displays that can provide over 14,000,000 colors, yet the human will be able to discriminate only a small fraction of these colors, and be able to effectively use only a handful of different colors. The result is that 99.999 percent of those colors add no value to the system. The speed and number of instructions that can be manipulated by today's processors is growing at a tremendous rate, yet the human processing ability has remained relatively constant. Situational awareness displays can readily be updated quicker than the human operator can assimilate this changing information. The inability of the human operator to keep up with a rapidly changing display will lead to frustration and an ultimate reduction in his or her performance. Any reduction in human performance yields a similar reduction in system performance. The end result is that the benefits of the new technology will not be realized due to the failure to consider the human's capabilities and limitations during the interface design and development effort.

With the shift from detail design acquisitions to performance-based acquisitions, there is a perception that oversight of the contractor's product is not needed. While one can easily understand why the contractor would not want close scrutiny during the design and development effort, oversight of the product's performance is essential to the government. Without solid human performance requirements, compliance to "good" or "accepted" human engineering practice is open to interpretation by the contractor, and the government has little recourse for the contractor's failure to perform.

MIL–STD–1472 was first promulgated in February 1968 and was largely a compilation of standards that the U.S. Army Human Engineering Laboratory published based on their research and participation in testing and evaluation events. It has been the primary source of human engineering material for 35 years. In that time, the document has remained substantially unchanged; that is, the requirements have stood the test of time. The capabilities and limitations of humans have shown little change over the years, and the associated design principles for the human-system interface are still valid. The human factors standards describe design limits on the human-system interface to ensure that the fielded system will be effectively, efficiently, safely, and inexpensively operable and maintainable by its intended users (both men and women).

MIL–STD–1472 is the pre-eminent human engineering document in the world, not only within DoD, and is often referenced by other government agencies, contractors, and other nations. It is the base document for the *Federal Aviation Administration's Human Factors Design Guide*, *the Department of Energy's Human Factors/Ergonomics Handbook for the Design for Ease of Maintenance*, and the British Defense Standard 00–25, *Human Factors for Design of Equipment*.

MIL–STD–1472 is not a process or management document but a design document. It provides time-tested design limits as requirements or guidelines. These represent performance standards in the sense that most of its criteria are human performance-driven. Failing to meet these minimum standards will cause performance to be degraded. By specifying performance-based design limits for various elements of the human system interface, the designer avoids repeating past mistakes, focuses effort on the new human systems issues, and has the flexibility to be innovative within relatively liberal design limits.

Even though the current emphasis is on the use of performance-based standards, they must be supplemented with specific design-related requirements to assure safe, efficient, and effective performance in order to reduce the likelihood of human error. In reality, the human factors standards are performance standards since they provide design criteria that allow users to safely, efficiently, and effectively operate and maintain the system with minimal error, and because most of the criteria contained within them are human performance-based. This is the essence of the human factors standardization.

Commercial products rarely have to operate and be maintained in highly stressful environments such as that found on the modern battlefield, in air traffic control facilities, or in deep space missions. Equipment designed for use in air-conditioned offices will fail when operated in many places in the world where our military may deploy. Taking commercial products designed for office, or factory use to extreme temperature climates or otherwise hostile environments can quickly convert high tech equipment into expensive doorstops. The design may have to accommodate operation and maintenance by military personnel wearing protective equipment and clothing, such as chemical and biological protective gear that retain body heat, reduce mobility, and limit accessibility. Commercial products rarely have a need to deal with such issues. There is no right price for the wrong product. Human factors standards ensure that the equipment can be operated and maintained by the intended user population, wearing appropriate protective clothing, in its operational environment.

The 5000-series defense acquisition policy is being revised. A memorandum, dated October 30, 2002, signed by the Deputy Secretary of Defense canceled DoD Directive 5000.1, The Defense Acquisition System; DoD Instruction 5000.2, The Operation of the Defense Acquisition System; and DoD 5000.2–R, Mandatory Procedures for Major Defense Acquisition Programs (MDAPs) and Major Automated Information Systems (MAIS) Acquisition Programs effective immediately. The reason stated was to "create an acquisition policy environment that fosters efficiency, flexibility, creativity, and innovation."

Human factors standardization has a history of cyclic trends, traveling between a strong emphasis on the standardization process to very little emphasis. The new acquisition policy diminishes the emphasis on human factors standardization. As the policy provides less and less guidance and gives the contractor more and more discretion, standardization is neglected. History contains numerous acquisition programs that have not achieved their full potential due to failure to satisfy human factors requirements.

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Furthermore, as the new acquisition policy dilutes standardization, fewer problems will be discovered. The new policy appears to take the discipline out of the acquisition process; acquisition programs need the discipline that comes from oversight. The cost of complying with stated rules is very small compared to the cost overruns due to failure to provide a system the user can operate, maintain, and support. Cost overruns and schedule delays are rarely the result of cumbersome acquisition regulations. The bottom line is that fewer requirements mean less program visibility, and fewer problems discovered in time to solve them.

We cannot afford to wait until a major acquisition program completely fails due to neglect of its human-technology interfaces to realize that failure to attend to human factors considerations and compliance with standards is high risk and costly. If it takes that to reverse the current trend, it is a most costly means of education.

A close examination of the human factors standardization area will expose the myths about human factors restricting design and innovation during the acquisition process, about human factors being a cost driver, about human factors not adding value, and about human factors causing undue oversight. A close examination will reveal that human factors standardization is not an unnecessary nuisance but a vital component of the acquisition process.

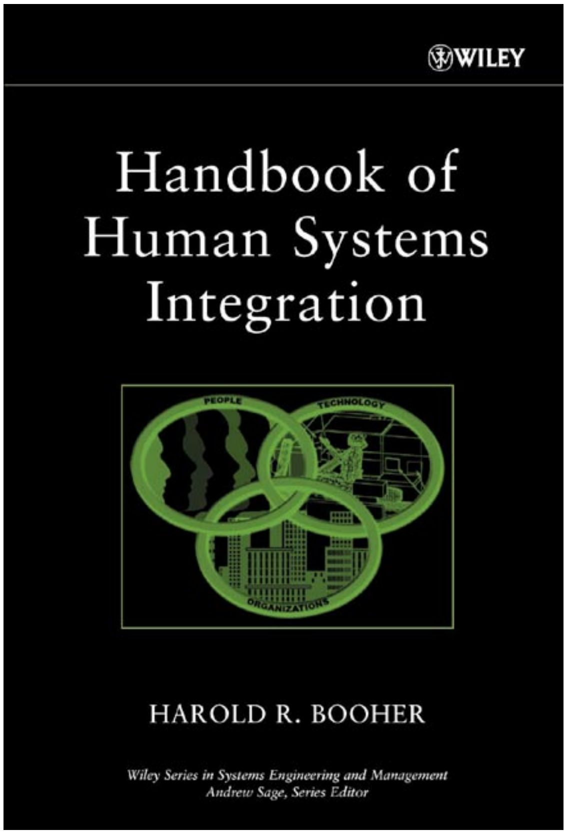
References

Memorandum, Subject: Specifications & Standards—A New Way of Doing Business, Secretary of Defense, Washington, DC, June 29, 1994.

Coopers & Lybrand/TASC, The DoD Regulatory Cost Premium: A Quantitative Assessment, December 1994.

Department of Defense, MIL–STD–1472, Human Engineering, August 23, 1999.

Memorandum, Subject: Defense Acquisition, Deputy Secretary of Defense, Washington, DC, October 30, 2002.



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The Handbook of Human Systems Integration outlines the principles and methods that can be used to help integrate people, technology, and organizations with a common objective toward designing, developing, and operating systems effectively and efficiently. Handbook of Human Systems Integration is broad in scope, covering both public and commercial processes as they interface with systems engineering processes and emphasizing the importance of management and organization concepts as well as the technical uniqueness of HSI. Price is $120.00. Special HSIAC offer to members of SAFE, HSI community, HFES, HFE TAG, and Government for $82.00 including shipping.

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The Human Systems Information Analysis Center (HSIAC) is looking for a sponsor to help defray the cost of converting the NASA Task Load Index (TLX) program from its current DOC configuration to a WINDOWS operating environment. Even though the NASA TLX is DOS based it is still one of the best known and used subjective workload assessment tools. NASA TLX allows users to perform subjective workload assessments on operator(s) working with various human-machine systems. NASA TLX is a multi-dimensional rating procedure that derives an overall workload score based on a weighted average of ratings on six subscales. These subscales include Mental Demands, Physical Demands, Temporal Demands, Own Performance, Effort, and Frustration. It can be used to assess workload in various human-machine environments such as aircraft cockpits; command, control, and communication (C3) workstations; supervisory and process control environments; simulations, and laboratory tests.

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History of the Military Human Factors Engineering Standards

Joe McDaniel, Ph.D.
Gerald Chaikin

Joe McDaniel, Ph.D. is a principal industrial engineer with more than 27 years of research and development experience at the Air Force Research Laboratory at Wright-Patterson AFB, Ohio; and represents the Air Force on joint-service standards committees.

Gerald Chaikin passed away on October 20, 2001. He is best know for his work with the military human factors standards, specifications, and handbooks, first as a civil servant, where for 20 years he chaired the Human Factors Standardization Steering Committee (HFSSC), and later as a contractor supporting the Lead Standardization Activity for Human Factors at Redstone Arsenal, Alabama.

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Standardization reform was the cornerstone of acquisition reform. Many believe that all military specifications and standards are gone or that they cannot be used. However, the human factors engineering (HFE) standardization documents that were streamlined and consolidated during the process of standards reform were revalidated as important to military acquisition.

Because standards and guidelines should be used with the understanding of when and how they were developed, this article discusses the history of the human factors engineering standardization documents, how they evolved into today's forms, and how the currently approved ensemble can best be used.

During the rapid evolution of digital electronics, military specifications and standards could not keep up, and became burdensome on industry. On June 29, 1994, Secretary of Defense, William Perry, issued a policy memorandum that gave preference to performance specifications and non-government standards (NGSs) over military standards and specifications. The major impact was that most of the retained HFE standardization documents lost their influence by re-designating them as non-binding guidance documents (handbooks) or as design criteria standards that require a waiver.

Human factors engineering design criteria standards began as responses to accidents resulting from human error. Still today, human error is the leading category of causes of all accidents. So-called "lessons learned" are merely frequently occurring errors that we hope not to repeat.

World War II provided the disastrous accidents that motivated what we know today as human engineering. The rush to build war materiel resulted in many "horror stories." Military pilots were required to fly different types of aircraft, and in those days, there was no standard control arrangement in cockpits. The generation of standards for the arrangement of controls and switches in cockpits all but eliminated this type of accident. As these proliferating documents became more numerous and costly to maintain, each of the services began to consolidate them into more general-purpose specifications and standards.

But it was the missile and space programs of the late 1950s and early 1960s that provided both the impetus to elevate organizational HFE standards to military standards. Before the National Aeronautics and Space Administration (NASA) was formed, the manned space program was run by the Air Force Ballistic Missile (AFBM) Division in Inglewood, California and the Army Ballistic Missile Agency (ABMA) of the Army Ordnance Missile Command (AOMC) at Redstone Arsenal, Alabama, later the Army Missile Command (MICOM); now the Aviation and Missile Command (AMCOM). In 1967, MICOM was selected as the Department of Defense's (DoD's) Lead Standardization Activity (LSA) for the Human Factors (HFAC) standardization area to consolidate the principal service-peculiar human engineering specifications and standards into one tri-service specification and one tri-service standard.

Working together over the last 40 years, human factors engineers from the three services, industry, and technical societies jointly developed a small set of consensus type military standards that embody accumulated HFE knowledge. The first true human factors military standard was AFBM 57–8A Human Engineering Design Standards for Missile System Equipment (November 1, 1958) that superseded a policy exhibit 57–8 dated August 1, 1957. This standard had the following major sections: general requirements, visual displays, controls, physical characteristics (components), ambient environment, workplace characteristics (anthropometry), hazards and safety.

The material in AFBM 57–8A was drawn from a number of technical reports, many of which eventually became chapters in the Joint Services Human Engineering Guide to Equipment Design (1). With some minor changes, AFBM Exhibit 57–8A was reformatted as a military standard and released as MIL–STD–803 (USAF, November 5, 1959) Human Engineering Criteria for Aircraft, Missile, and Space Systems, Ground Support Equipment. MIL–STD–803 then evolved into a three volume set: MIL–STD–803A–1 (January 27, 1964) Human Engineering Design Criteria for Aerospace System Ground Equipment), MIL–STD–803A–2 (December 1, 1964) Human Engineering Design Criteria for Aerospace System Facilities and Facility Equipment, and MIL–STD–803A–3 (May 1967) Human Engineering Design Criteria for Aerospace Vehicles and Vehicle Equipment.

In March 1960, the Army approved ABMA XPD–844, PERSHING Weapon System Human Factors Engineering Criteria. In October 1961, this was updated and expanded to include all missile systems as ABMA–STD–434, Weapon System Human Factors Engineering Criteria. Typical source documents for ABMA–STD–434 were the same as those used for MIL–STD–803. The Army's MIL–STD–1248, Missile Systems Human Factors Engineering Criteria (January 20, 1964) was essentially a military standard-formatted version of ABMA–STD–434A. The MIL–STD–803A series, together with MIL–STD–1248, were the seminal documents for the original tri-service MIL–STD–1472 (February 9, 1968) Human Engineering Design Criteria for Military Systems, Equipment, and Facilities.

The General Family of DoD Human Factors Engineering Documents

An important outcome of the standardization reform initiative of the late 1990s was the cancellation of most of the single-service standards and the consolidation of their materials in a few DoD standards and handbooks. Because of the criticality of aircraft design, there continues to be two primary categories of human factors documents: general (MIL–STD–1472 and related handbooks) and aircraft (JSSG–2010 and related handbooks). The general family of DoD human factors documents includes the following six documents—

- **MIL–STD–1472F (August 23, 1999) Department of Defense Design Criteria Standard Human Engineering**
  This standard contains a mix of requirements and guidelines to facilitate achieving required human performance and ensuring that design is compatible with human characteristics of operators and maintenance personnel. MIL–STD–1472 provides time-tested design limits and guidance for systems, equipment, and facilities that warfighters, other operators and maintainers can use effectively. It includes by reference ANSI/HFS 100 on Visual Display Terminal (VDT) Workstations, and defers to JSSG–2010 on issues relating to aircraft crew stations, including aircraft passenger accommodation. Since JSSG–2010 does not address aircraft maintainability, MIL–STD–1472 is the appropriate guidance on design for maintenance issues for all systems, including aircraft.
- **MIL–HDBK–46855A (May 17, 1999) Human Engineering Program, Process, and Procedures**
  This handbook guides DoD and contractor program managers and practitioners regarding analysis, design, and test and evaluation aspects of the human engineering program. It covers the tasks to be performed in conducting a human engineering effort, including: defining and allocating system functions, equipment selection, analysis of tasks; preliminary system and subsystem design, studies, experiments, and laboratory tests (mock-ups, simulation, etc.), equipment detail design drawings, work environment, crew stations and facilities design, human engineering in performance and design specifications, equipment procedure development, human engineering in test and evaluation, and failure analysis.

MIL–H–46855 was originally a consolidation of one Army, two Navy, and one Air Force specifications. On May 26, 1994, pursuant to a re-definition of the term standard, MIL–H–46855B was revised and converted to a military standard, MIL–STD–46855. On January 31, 1996, as part of standardization reform, MIL–STD–46855 was downgraded to a handbook, MIL–HDBK–46855, Human Engineering Guidelines for Military Systems, Equipment, and Facilities. Since MIL–HDBK–46855 and its companion guidelines, DoD–HDBK–763, Human Engineering Procedures Guide,

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Managing the Human Factors Standardization Effort

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Overall management of standardization documents within the Department of Defense (DoD) is accomplished through a Lead Standardization Activity (LSA). The LSA is a management activity in a military department or a defense agency that guides DoD standards efforts for a Federal Supply Group (FSG), a Federal Supply Class (FSC), or a standards area through the development of standardization program plans, authorization of standardization projects, and identification and resolution of standards issues.

The Defense Standardization Program Office (DSPO), in consultation with the Departmental Standardization Offices (DepSOs) designates the appropriate office to manage each FSG, FSC, and standardization area. These designations are made on the basis of overall technical expertise, interest, and resources.

The U.S. Army Aviation and Missile Command (AMCOM) located at Redstone Arsenal, Huntsville, Alabama, is the DoD LSA for the Human Factors (HFAC) standardization area. As identified in Standardization Directory 1 (SD–1), the HFAC standardization area is one of 36 standardization areas and "encompasses human factors engineering, which incorporates human characteristics and considerations into design of military systems, equipment, and facilities. The HFAC area includes tasking requirements and technical data for analysis, design (including initial design and analysis of user tasks), test, and evaluation during acquisition. It also includes design criteria, expressed as requirements and guidelines, as they apply to those who will operate, control, maintain, supply, or transport the materiel. The area also encompasses environmental considerations including limits for maximum exposure, human performance, habitability, and vulnerability. Manpower, personnel, and training (MPT) considerations apply only to the degree that they affect the human performance aspects of design."

The role of the LSA is defined in DoD 4120.24–M and is to:

- Manage and coordinate standardization efforts to ensure the optimal degree of standardization across DoD to:
  - Ensure interoperability with our allies and among the military departments
  - Reduce total ownership costs
  - Allow for rapid insertion of new technology to promote modernization of equipment
  - Reduce cycle time for the development of systems and acquisition of parts
- Maintain awareness of standardization needs and activities in the DoD
- Serve as the DoD-wide technical focal point
- Evaluate and approve (or disapprove) requests for standardization projects, assign numbers for approved projects, and ensure that no standardization documents are developed or revised that do not comply with the policies and procedures of the defense standardization program
- Suggest alternative approaches to requestors when standardization projects are disapproved
- Recommend changes to standardization policies and procedures
- Resolve standardization problems between standardization management activities, or elevate the problem to their DepSO for appropriate action
- Identify chronic standardization problems or noncompliance with policies and procedures
- Help Preparing Activities identify standardization document custodians
- Help non-government standardization bodies (NGSBs) to identify DoD personnel to serve on technical committees or adopting activities

Table 1 lists some of the main human factors-related military standards and handbooks that fall under the purview of the Human Factors LSA. In addition to these documents, the AMCOM also has purview over several human factors-related data item descriptions and non-government standards that have been adopted by the DoD.

In addition to its role as the LSA for human factors standardization, AMCOM also serves as the Preparing Activity for many of the documents in Table 1. The role of the Preparing Activity (also defined in DoD 4120.24–M) is to:

- Develop, update, inactivate for new design, cancel, and validate standardization documents
- Coordinate standardization documents with custodian, review activities, other DoD activities, civilian agencies, and industry as appropriate
- Consider all comments and incorporate or resolve essential comments
- Submit any essential comments that cannot be resolved to the responsible LSA
- Approve standardization documents after resolving all essential comments
- Submit documents for printing, distribution, and indexing
- Prepare and submit standardization project status data
- Respond to user feedback
- Create, maintain, and archive official files for their standardization documents

As one can see by its multifaceted roles as both a LSA and Preparing Activity, AMCOM plays a vital and prominent role in many aspects of human factors standardization. ■

References

DoD 4120.24–M, DSP Policies & Procedures, OUSD (Acquisition, Technology and Logistics), Washington, DC, March 2000

SD–1, Standardization Directory, DoD Single Stock Point, Philadelphia, PA, September 2002

Document Number	Title
MIL–STD–1472	Human Engineering
MIL–STD–1474	Noise Limits
MIL–STD–1477	Symbols for Army Air Defense System Displays
MIL–STD–1787	Aircraft Display Symbology
DOD–HDBK–743	Anthropometry of U.S. Military Personnel
MIL–HDBK–759	Human Engineering Design Guidelines
MIL–HDBK–767	Design Guidance for Interior Noise Reduction in Light-Armored Tracked Vehicles
MIL–HDBK–1473	Color and Marking of Army Materiel
MIL–HDBK–1908	Definitions of Human Factors Terms
MIL–HDBK–46855	Human Engineering Program Process and Procedures

Table 1. Human factors-related documents

calendar

jul

New York, NY, USA. July 8–10, 2003
Eastern Ergonomics Conference and Exposition (EECE)
Contact: Lenore M. Kolb • Tel: 212/370–5005, ext. 23 • E-mail: lkolb@ergoexpo.com
URL: http://www.ergoexpo.com/index.asp

Boston, MA, USA. July 31–August 2, 2003
Cognitive Science Society Conference (CogSci) 2003
E-mail: cogsci2003@cs.braneis.edu
URL: http://www.cognitivesciencesociety.org/conf03

aug

Ottawa, Ontario, Canada. August 4–8, 2003
21st International System Safety Conference
Contact: Bob Fletcher, Technical Program Chair
E-mail: fleter@navcanada.ca
URL: http://www.system-safety.org

Arlington, VA, USA. August 6–8, 2003
2003 Interaction Technologies Conference
Contact: SALT, 50 Culpepper Street, Warrenton, VA 20186
URL: http://www.salt.org

Austin, TX, USA. August 11–14, 2003
American Institute of Aeronautics and Astronautics (AIAA) Modeling and Simulation Technologies Conference and Exhibit
URL: http://www.aiaa.org/calendar

sep

Udine, Italy. September 8–11, 2003
5th International Symposium on Human-Computer Interaction with Mobile Devices and Services
URL: http://hcilab.uniud.it/mobilehci/index.html

Dublane, Scotland, UK. September 8–11, 2003
Human Factors of Decision Making in Complex Systems
E-mail: decision-making@abertay.ac.uk
URL: http://www.abertay.ac.uk/schools/shs/Psychology/Cook_Conference/web/home.htm

Jacksonville, FL, USA. September 22–24, 2003
2003 SAFE Symposium
Contact: SAFE Association, P.O. Box 130, Creswell, OR 97426
Tel: 541/895–3012 • Fax: 541/895–3014 • E-mail: safe@peak.org
URL: http://www.safeassociation.com/2003symposium1.htm

St. Louis, MI, USA. September 23–25, 2003
5th Annual Technologies for Public Safety in Critical Incident Response Conference & Exposition
Contact: Center for Technology Commercialization, Public Safety Technology Center
P.O. Box 11344, Alexandria, VA 22312
Tel: 888/475–1919 • Fax: 703/933–0123 • E-mail: jtelander@ctc.org
URL: http://www.nlectc.org/conf/nij2003.html

# of events

oct

Denver, CO, USA. October 13–17, 2003
Human Factors and Ergonomics Society 47th Annual Meeting
Contact: Human Factors and Ergonomics Society, P.O. Box 1369, Santa Monica, CA 90406–1369
Tel: 310/394–1811 • Fax: 310/394–2410 • E-mail: info@hfes.org
URL http://www.hfes.org/

nov

Memphis, TN, USA. November 2–4, 2002
The Second International Conference on Mobile Health
Contact: International Mobile Health Association
1058 Haight Street, San Francisco, CA 94117–3109
URL: http://www.intlmobilehealthassn.org

Phoenix, AZ, USA. November 3–6, 2003
Department of Defense Human Factors Engineering Technical Advisory Group
Contact: Sheryl Cosing, 10822 Crippen Vale Ct., Reston, VA 20194
Tel: 703/925–9791 • Fax: 703/925–9694
E-mail: scosing@comcast.net
URL: http://hfetag.dtic.mil/meetschl.html

dec

Orlando, FL, USA. December 1–4, 2003
Interservice/Industry Training, Simulation, and Education Conference (IITSEC)
Contact: Bill Walsh, BLACKHAWK Management Corporation
4242 Woodcock, Suite 101, San Antonio, TX 78228
Tel: 212/370–5005 • Fax: 212/370–5699
URL: http://www.ergoexpo.com/index.asp

Las Vegas, NV, USA. December 8–11, 2003
National Ergonomics Conference and Exposition (NECE)
Contact: Walter Charnizon, President, Continental Exhibitions
370 Lexington Avenue, New York, NY 10017 • Tel: 212/370–5005 • Fax: 212/370–5699
URL: http://www.ergoexpo.com/index.asp

jan

Reno, NV, USA. January 5–8, 2003
42nd AIAA Aerospace Sciences Meeting and Exhibit
Contact: AIAA, 1801 Alexander Bell Drive, Suite 500, Reston, VA 20191–4344
Tel: 703/264–7500 or 800/639–AIAA • Fax: 703/264–7551
E-mail: custserv@aiaa.org

New Orleans, LA, USA. January 20–24, 2004
48th Annual Human Factors and Ergonomics Society Meeting
Contact: Human Factors and Ergonomics Society, P. O. Box 1369, Santa Monica, CA 90406–1369
Tel: 310/394–1811 • Fax: 310/394–2140
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SAFE Association

Story by Christy Cornette

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The SAFE Association is an international, non-profit organization dedicated to ensuring personal safety and protection in land, sea, air, and space environments. Originally standing for "Space and Flight Equipment," SAFE has come to encompass much more and is no longer an acronym, but a name reflecting all aspects of safety.

SAFE members represent diverse backgrounds and fields of expertise. Financially, SAFE depends solely on the dues of its corporate and individual members as well as the annual symposia. The Association has various chapters located throughout the U.S. and abroad that meet and promote its goals and objectives. The chapters are a key element to the strength and growth of SAFE.

The Association's goals include stimulating safety and survival research and development. This is accomplished by means of an annual symposium, educational scholarships, association achievement awards, newsletters, and technical publications. SAFE strives to provide its members with opportunities for professional development, achievement, and recognition. Another important objective is to educate the public, industry, and the government to improve human effectiveness and safety in system designs and operation.

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I'll Take the Screaming Cows, Please…

Vicki Ahlstrom

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In a sense, we are victims of our own technological success. Not many years ago, there were only a handful of system options available to us. Mice came in two varieties, the one-button mouse and the two-button mouse, both beige, and approximately the same size and shape. Now, we have innumerable input devices that come in a variety of colors, shapes, and sizes. Alarms were once limited to buzzers, sirens, and bells. Now, the range and complexity for alarms are limited only by the limits of our imagination. Almost daily, new technological advances lead to new possibilities in nearly every aspect of computer-human interfaces.

Although advances in technology and computing can have great benefits to the user, they can also cause new problems. Whereas before, we did not have enough choices, now we are sometimes faced with too many choices. This was illustrated to me when I spoke recently to a contractor who was working on auditory alarms for a new system. The new system was going to use digitized sound for the alarms. The contractor's problem was that the possibility for alarms was too limitless. He illustrated this by playing a range of digitized sounds for me. Among other, more traditional sounds were the sounds of people screaming, squealing brakes, and cows mooing. He said it was even possible to combine the digitized sounds to make, for example, screaming cows. All of these choices were possible technologically, but were they the right choice for the system?

Increases in possibilities due to technological advances lead to a concomitant increase in the number of decision points. A single vendor, developing a computerized system for the Federal Aviation Administration (FAA) will face hundreds of human factors-related decisions through the development of that system. The vendor will not have time, resources, or money to thoroughly investigate the human factors implications of each of these decisions. Different vendors may make different decisions at these points. The result for the FAA is a proliferation of diverse systems and equipment with limited consistency or standardization between systems developed by different vendors.

To help system developers make wise decisions when faced with the proliferation of possibilities, solid, reasonable standards are a necessity. To address this problem, the FAA compiled their own human factors guidelines in 1994 and published them in 1996 as the Human Factors Design Guide. Since 1994, however, technology has continued to move on, and the FAA has realized the need to change the document to keep pace with current technology and the needs of the users. The result is the Human Factors Design Standard (HFDS).

The HFDS is the result of several years of work sponsored by the FAA's Human Factors Division and conducted by the Human Factors Group at the William J. Hughes Technical Center. A team of Engineering Research Psychologists and Human Factors Engineers identified areas that were most in need of updating due to technological advances. The computer human interface chapter was one of the most frequently accessed chapters, and also one of the areas where there have been the most changes over time. The recent years have also seen an increase in the availability and use of automation. With the increasing use of automation, there is an increase in the need for automation-specific guidance. These considerations led to major updates on information dealing with automation and human computer interface, including hundreds of new rules, definitions, examples, and guidelines. Table 1 shows the chapters of the HFDS.

A reference book like the HFDS is only as useful as it is usable. Therefore, the research team analyzed how acquisition and development programs used the guideline and standard documents. This led to a reorganization of material to better match the needs of the users, including placing some information that was previously scattered throughout the document into a single location, based on how it had been used in the past. One example is the input devices information, which now has its own chapter. Other user comments identified the need for additional explanations and definitions clarifying trade-offs related to the rules and guidelines. The HFDS provides additional explanations and definitions so that users can make more informed decisions and better understand the consequences of their actions.

The HFDS has been available since January 2003 in draft form for comment at the web site: http://hf.tc.faa.gov/hfdg/index.html. The final document is expected to be available both on the Internet and on CD-ROM in summer 2003. Tomorrow's developers and designers will be able to use this resource to help make reasonable design decisions. As for the screaming cows, maybe they can use them in the video game industry. ■

Chapter Number	Title
1	Introduction
2	General Design Requirements
3	Automation
4	Designing for Maintenance
5	Displays and Printers
6	Controls and Visual Indicators
7	Alarms, Audio, and Voice Displays
8	Human Computer Interfaces
9	Input Devices
10	Workplace Design
11	System Security
12	Personnel Safety
13	Environment
14	Anthropometry and Biomechanics
15	User Documentation

Table 1. HFES chapters

Joint Service Specification Guides

Joe McDaniel, Ph.D.

Joe McDaniel, Ph.D. is a principal industrial engineer with more than 27 years of research and development experience at the Air Force Research Laboratory at Wright-Patterson AFB, Ohio; and represents the Air Force on joint-service standards committees.

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When standardization reform placed all specifications and standards in jeopardy, the military aviation community, led by the Joint Aeronautical Commanders Group (JACG)[1], reorganized and completely replaced the entire system of specifications and standards with a new system of Joint Service Specification Guides (JSSGs). These JSSGs cover all aspects of military aviation systems, not just human systems. However, designating "Crew Systems" as one of the ten top-level domains gives human-system integration unprecedented visibility in the aviation development. Table 1 shows the architecture of the JSSG system.

The concept of the "specification guides" evolved out of the Air Force's MIL–PRIME initiative. These documents have two major parts: one is a draft specification (e.g., JSSG–2010) with key numbers and requirements replaced by blanks. The second part is a set of fourteen handbooks (e.g., JSSG 2010–1 through JSSG 2010–14) that discuss the issues for filling in the blanks. The actual filling in of the blanks can be a joint decision of military and contractors. Once filled in, these guide specifications become a binding part of the contract. The JSSG, then, avoided the problems of getting a waiver by not being standard, yet becomes contractually binding in the final form. Since some of the data in the JSSG series is restricted, it was decided to limit the distribution of all JSSGs to DoD and DoD contractors[2].

Joint Service Specification Guide JSSG–2010, Crew Systems

JSSG–2010 summarizes a unified process for applying the required disciplines to the development, integration, test, deployment and support of military aircraft crew systems. This document supports a human-centered crewstation approach to the acquisition process, where the platform is designed around the human and human-generated requirements for human performance as the driving force. JSSG–2010 has 14 accompanying handbooks as follows:

- JSSG–2010–1 provides systems engineering guidance for the design of crewstations in fixed and rotary wing aircraft
- JSSG–2010–2 provides guidance for the development requirements and verifications for crew systems
- JSSG–2010–3 provides guidance for the criteria to optimize cockpit/crewstation/cabin designs without hindering the development of new, improved systems, including fixed and rotary wing
- JSSG–2010–4 provides guidance for the design and verification of aircrew alerting systems.
- JSSG–2010–5 provides guidance for the development requirements and verifications for interior and exterior airborne lighting equipment, including specific requirements for interior lighting compatible with type I or II and class A or B night vision imaging systems
- JSSG–2010–6 provides guidance for the design and test information for sustenance and waste management systems for the support of aircrew and passengers
- JSSG–2010–7 provides guidance for the development requirements and verifications for occupant crash protection and for crash protective aspects of seating, restraint, and crewstation and passenger/troop station design
- JSSG–2010–8 provides rationale, guidance, lessons learned and instructions for the energetic systems (explosive actuators)
- JSSG–2010–9 provides guidance for the development requirements and verifications for aircrew personal protective equipment

- JSSG–2010–10 provides guidance for the development requirements and verifications for an aircraft oxygen system and its components
- JSSG–2010–11 provides guidance for the development requirements and verifications for aircraft emergency escape systems
- JSSG–2010–12 provides guidance for the development requirements and verifications for deployable aerodynamic decelerator (DAD) system or subsystem. (Parachutes are DADs.)
- JSSG–2010–13 provides guidance for the development requirements and verifications for an airborne survival and flotation system and its components. This includes provisions for emergency egress, life support, descent, and land and water survival for extended time periods until recovery
- JSSG–2010–14 provides guidance for the performance, development, compatibility, manufacturability, and supportability requirements and verification procedures for an aircraft windshield/canopy system and its components

The JSSG–2010 limits its discussion in two areas:

1 Aircraft maintainability is covered in the general-purpose MIL–STD–1472

2 Aircraft symbology is covered by MIL–STD–1787C (January 2001) Department of Defense Interface Standard: Aircraft Display Symbology

MIL–STD–1787C was originally planned to be one of the handbooks included in JSSG–2010, but was approved as an interface standard (that may be cited without a waiver) before the JSSG series was finished. Since an interface standard has more authority, it was decided to leave MIL–STD–1787 as a stand-alone document. ■

References

1. The JACG is comprised of senior military and civilian representatives from the Army, Navy, Air Force, Marine Corps, Coast Guard, Defense Logistic Agency, National Aeronautics and Space Administration, and Federal Aviation Administration. The JACG's charter is to develop and continuously improve joint processes and procedures that will facilitate the design, development, and acquisition of aviation systems that are identical (to the maximum extent possible) or common, and that maximize interoperability.
2. Qualified users can order JSSG–2000 by regular mail at ASC/ENOI, 2530 Loop Road West, Wright-Patterson AFB, OH 45433–7101 or E-mail at Engineering.Stan dards@wpafb.af.mil

Joint Service Specification Guide	Approval Date
JSSG–2000A Air System	October 8, 2002
JSSG–2001A Air Vehicle	October 22, 2002
JSSG–2002 Training	Incomplete
JSSG–2003 Support Systems	Incomplete
JSSG–2004 Weapons	Incomplete
JSSG–2005 Avionics	October 30, 1998
JSSG–2006 Structures	October 30, 1998
JSSG–2007 Engines	October 30, 1998
JSSG–2008 Air Vehicles Control & Management	October 30, 1998
JSSG–2009 Air Vehicles Subsystems	October 30, 1998
JSSG–2010 Crew Systems	October 30, 1998

Table 1. JSSG architecture

Human Factors DIDs: Navy to the Rescue!

Jennifer McGovern Narkevicius, Ph.D.
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How do you ensure that you will get the information you need from a design program to ensure you can successfully implement the program? How do you know how the design evolved and where that evolution might take you? How do you ensure that in ten years, when you are no longer supporting a program because its been passed on to a more junior member of the team that you do not have to dig details of design, design rationale, and program needs out of memory to ensure the continued success of the acquisition? Use Data Item Descriptions (DIDs), of course!

The DIDs are documents that can be used to help answer these questions. The various DIDs provide descriptions of design information and detail required of the vendor that will help government engineers review, evaluate and test programs under design, throughout the development process and beyond.

There are numerous DIDs that cover generic requirements and many other, more specific DIDs for specialized disciplines. Often, a generic DID can be tailored to be useful to many disciplines. For example, the Test Plan DID can be tailored to include the information required for test plans for many technical areas. The Department of Defense (DoD) and the Federal Aviation Administration (FAA) have Human Engineering DIDs (HE–DIDs), although they are slightly different. The FAA and the DoD have worked closely on the HE–DIDs to ensure that the essence of the information required is preserved for the requirements of Human Engineering in acquisition of defense and civil systems.

The DoD HE–DIDs originally were contained in MIL–H–46855, which was later converted to a standard, MIL–STD–48655. Under acquisition reform, MIL–STD–46855 was converted to a handbook (MIL–HDBK–48655). As a result, the HE–DIDs were in jeopardy of being cancelled as a handbook cannot serve as the implementing document for a DID. In fact, several HE–DIDs were cancelled. Furthermore, the U.S. Army Missile Command (now the U.S. Army Aviation and Missile Command), the Lead Standardization Activity for Human Factors, was restrained in their ability to maintain the HE–DIDs. The Naval Air Systems Command (NAVAIR) agreed to take responsibility to ensure the maintenance of the HE–DIDs and determined to revise those maintained DIDs to reflect the current Integrated Product Team structure of Defense Acquisition. Steps have been initiated to transfer the Preparing Activity for these HE–DIDs from the Army to the Navy.

The six HE–DIDs that NAVAIR is assuming responsibility are:

- Human Engineering Program Plan (HEPP) (DI–HFAC–80740)
- Human Engineering Simulation Concept (DI–HFAC–80742)
- Human Engineering Systems Analysis Report (HESAR) (DI–HFAC–80745)
- Human Engineering Design Approach Document-Operator (HEDAD–O) (DI–HFAC–80746)
- Human Engineering Design Approach Document-Maintainer (HEDAD–M) (DI–HFAC–80747)
- Task Analysis/Task Allocation Report (DI–HFAC–81399)

The HEPP describes the contractor's human engineering program, identifies its elements, and explains how the elements will be managed.

The Human Engineering Simulation Concept describes the contractor's intended use of mock-ups and simulators in support of human engineering analysis, requirements definition and implementation, design support, and test and evaluation.

The HESAR describes the human engineering efforts conducted as part of the system analysis and present results. The data are used by the procuring activity to evaluate the appropriateness and feasibility of system functions and roles allocated to operators and maintainers.

The HEDAD–O describes equipment that interfaces with operators. This document provides a source of data to evaluate the extent to which equipment having an interface with operators meets human performance requirements and human engineering criteria. This is not simply a description of equipment but rationale based on the human interface.

The HEDAD–M describes design/interface requirements of equipment that must be maintained. This document provides a source of data to evaluate the extent to which equipment having an interface with maintainers meets human performance requirements and human engineering criteria. This is not simply a description of equipment but rationale based on the human interface.

The Task Analysis/Task Allocation Report describes the results of analyses of tasks performed by the contractor to provide a basis for evaluation of the design of the system, equipment, or facility. The evaluation will verify that human engineering technical risks have been minimized and solutions are in hand.

A copy of the existing DoD Human Engineering DIDs, drafts of the six DIDs for which NAVAIR is seeking to assume responsibility, and the five FAA DIDs can be found at http://hfetag.dtic.mil/hfs.docs.html. ■

Usability Assurance Workshop in Monterey, California

HSIAC, in collaboration with the Navy Post Graduate School in Monterey, California, is planning a workshop this fall to introduce the idea of "usability assurance." Based on *ISO 13407: 1999, Human-centred design processes for interactive systems* and expanded in *ISO PAS 18152:2003, A specification for the process assessment of human-system issues*, the workshop will be tailored to government and support contractor personnel involved in developing interactive computer systems for command and control, crew interaction, and data and information management. Special guests Brian Sherwood Jones and Jonathan Earthy, from the United Kingdom, have been active in developing and implementing these standards.

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Human Factors Engineering Requirements for the International Space Station—Successes & Challenges

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Advanced technology coupled with the desire to explore space has resulted in increasingly longer human space missions. Indeed, any exploration mission outside of Earth's neighborhood, in other words, beyond the moon, will necessarily be several months or even years. The International Space Station (ISS) serves as an important advancement toward executing a successful human space mission that is longer than a standard trip around the world or to the moon. The ISS, which is a permanently occupied microgravity research facility orbiting the earth, will support missions four to six months in duration.

The ISS poses unique challenges to National Aeronautics and Space Administration (NASA) in the area of Human Factors Engineering (HFE). First, mission duration is always a critical issue for human factors because small design flaws or stressors on the user can accumulate over time to cause more serious performance failures. In addition, user preparedness to respond as well as fluctuations in vigilance and psychological issues of morale and team interaction all increase in importance as mission duration increases. Secondly, the ISS is not only a research facility but also a home; therefore it must be designed to support very different crew operations. Human factors design guidelines and issues vary with the type of activity being performed. Thirdly, modules, systems and equipment for the ISS are being manufactured all over the world and assembly in space requires diligent and detailed planning, training and integration. Finally, this effort is the product of an international partnership among the United States, Russia, Europe, Japan, Canada and other nations and HFE standards vary across nations and cultures.

In planning for the ISS, the NASA developed an agency-wide set of human factors standards for the first time in a space exploration program. The Man-Systems Integration Standard (MSIS), NASA–STD–3000, a multi-volume set of guidelines for human-centered design in microgravity, was developed with the cooperation of human factors experts from various NASA centers, industry, academia, and other government agencies. The MSIS covers a range of topics including anthropometry, control and displays, human restraint and mobility requirements for zero-gravity environments, maintainability, and safety. This standard was the basis for the ISS Flight Crew Integration Standard, SSP 50005, which is a requirements document specific to the ISS Program. Elevating human factors to the status of a "system" with its own set of unique requirements was a real advancement for habitability and human factors as a discipline at NASA. However, NASA's first experience with human factors requirements in a Program did identify some challenges.

One of the main challenges is maintaining a balance between specifying contractually binding requirements which must be verifiable and ensuring that the intent of the requirement is accurately manifested in the design. Intuitively, it seems that these two objectives are compatible; however, that is not always the case. For example, one good HFE design principle is to use the perceptual principle of grouping by proximity for the design of labels and controls to enable accurate association between a control and its label. To facilitate perception and comprehension, a related design consideration is to reduce clutter in favor of order—that is, for a series of controls, labels should be placed relative to each associated control in a common manner. To make such a design goal verifiable and objectively demonstrable, it was necessary to define parameters within which the design requirement is met. Thus, a requirement was generated to place a label within two inches of the interface. This specification does not appear to be problematic until the designer encounters hardware that does not have surface area within the immediate surroundings of its interface. In an attempt to apply the actual letter of the requirement rather than meet the intent of the requirement, the designers constructed a dedicated surface area, mounted to a rod, such that it could support a label in the area within two inches of the interface. This inadequate design implementation is a consequence of the occasional conflict that is created when the intent of a requirement is lost during modification to verifiable and objectively demonstrative language.

There is no question that it is indeed necessary to the extent possible to provide HFE design requirements that are measurable and verifiable. However, there is a need to ensure that the intent is maintained, and that inadequate designs that meet requirements but do not promote human-system performance are avoided.

In order to address this challenge, the ISS program formed a human factors team analogous to any major engineering subsystem. This team develops and maintains the human factors requirements regarding end-to-end architecture design and performance, hardware and software design requirements, and test and verification requirements. It is also responsible for providing program integration across all of the larger scale elements, smaller scale hardware, and international partners. As part of this integration effort, the human factors team promotes a balanced approach between commonality and case-by-case assessment; it is this effort that is addressing the challenge of requirements verifiability and intent. The team promotes commonality by systematically determining consensus among its members and other HFE personnel on requirement intent and documenting that consensus to be generically applicable to all hardware. However, the team also employs a case-by-case strategy by dedicating qualified HFE personnel to each major and minor piece of the ISS to evaluate specific issues of requirements application and design in the interest of quality HFE. Dedicated human engineering assessments are performed to address and resolve issues and concerns. These studies include human factors and habitability assessments, computer modeling analyses, lighting evaluations, and compiling human factors lessons learned from previous space and analog missions.

Regardless of the challenges, the adoption of human factors requirements represented a major cultural change for NASA. Prior to ISS—e.g., when preparing equipment, software, and procedures for the Space Shuttle—individual crew involvement was the major, if not sole, source of usability and human factors input. Since most activities performed in space were performed by only one crewmember, and the crew would consist of four to eight people who would receive two years of training for a two to three week mission, this intense tailoring of hardware and software to specific users was feasible. However, with ISS, there has been a paradigm shift with longer missions where hardware will be staying onboard throughout its life cycle, and the missions and crews have different capabilities, preferences and training needs. Thus, it has been crucial to systematically provide both HFE requirements and a team of HFE experts to oversee the implementation of these requirements for an effective experience onboard ISS. This integrated approach helped facilitate standardization of software and hardware user interfaces, and procedures in a very complex system with numerous payloads and onboard subsystems. This is not to say that other programs such as the Shuttle program do not have important human factors considerations. However, as illustrated earlier, the ISS missions and short duration Shuttle missions are different for human factors. Additionally, the fact that ISS is manufactured across the world and according to different schedules increases the need to ensure that strict interpretation of verifiable requirements does not result in a poor design.

The next challenge for the HFE community is to revisit the MSIS and critically question each requirement's wording whether it focused too much on giving a specific design solution, or conveying the intent of the design principle involved. This activity will provide us better-defined and more effective requirements that will complement the effective HFE oversight activity established for working with specific programs such as ISS or any other future vehicles. ■

…continued from McDaniel article page 7
were now both handbooks, it was decided to consolidate them into a new handbook. The superseded DoD–HDBK–763 (canceled on July 31, 1998) covered human engineering methods and tools. MIL–HDBK–46855A adopted or revised only those traditional methods in DoD–HDBK–763 that have remained stable over time:

- **MIL–STD–1474D, Notice 1 (August 29, 1997) Department of Defense Design Criteria Standard: Noise Limits** Implementing the policies of standardization reform, this standard was updated as a tri-service design criteria standard. MIL–STD–1474 was first issued March 1, 1973, as an Army standard on noise limits, based on U.S. Army Human Engineering Laboratory (HEL) standard HEL–STD S–1–63C. Since then it has been extensively revised and expanded. As a result of recent consolidations, MIL–STD–1474D now serves as the DoD Design Criteria Standard on Noise Limits that is used by all services.
- **MIL–HDBK–1908B (August 16, 1999) Department of Defense Handbook: Definitions of Human Factors Terms** This handbook (previously a standard, but converted to a handbook in accordance with standardization reform) is the single source of definitions for all documents in the HFAC standardization area. The use of this handbook avoids conflicting definitions of the same terms in human factors documents as each is developed or revised.
- **MIL–HDBK–759C, Notice 2 (March 31, 1998) Department of Defense Handbook: Human Engineering Design Guidelines** This handbook is a companion to MIL–STD–1472 and provides design data and extended guidelines. It includes data removed from MIL–STD–1472F.
- **DoD–HDBK–743A (February 13, 1991) Anthropometry of U.S. Military Personnel** This handbook contains statistics from about 40 military surveys, including the 1988 Army Anthropometric SURvey (ANSUR) of 1,774 men and 2,208 women with more than 132 measures. (Digital files from recent surveys are available from Human Systems Information Analysis Center.)

HFE Standards in the Modern DoD Acquisition Process

Because HFE design guidelines are based on human performance and human characteristics, they are relatively immune to becoming obsolete. MIL–STD–1472 does not specify any solutions; it provides time-tested design limits as requirements or guidelines. An HFE design standard should properly provide criteria for which there is common agreement. This means that the technology has settled down to the point where a consensus can be reached on a needed human engineering design provision. If there is no consensus on design limits or process issues, a standard is premature. So when we say that the HFE military standards are current, we mean that all its provisions reflect current consensus.

When we talk about military systems and equipment, we are referring to systems and equipment to be used by the “combat military”—those military men and women who are deployed somewhere in the world and performing or training for the traditional military mission, either fighting a war or keeping the peace. Consumer products are rarely suitable in a military combat environment because they are usually designed for use in an air-conditioned home or office, and will not function reliably in any other environment. However, despite its economical price and ready availability, it is likely to fail to perform in a combat military environment.

A major benefit of using HFE design guidelines from the beginning is the potential for great savings of avoiding fixing problems found during test and evaluation. Dealing with problems postponed until late in the program can be difficult and prohibitively expensive. Experience has shown that industry and DoD can agree on reasonable HFE design standards, provided the decision is made outside the context of a specific program. Once the program begins, schedules, existing designs, and profit incentives tend to cloud the issues and make resolution expensive and contentious.

There are two fundamental reasons why the military should have its own HFE standards. First, the mission and weapons functions are unique to the military. The military should retain control of performance requirements for all equipment the troops take to the field in a military action. These requirements are almost always life critical, with mission performance and system safety at stake. Certainly, these standards do not have to be applied to the everyday equipment used by military and DoD civilian personnel in performance of non-combat duties. Second, the military needs an integrated HFE standard, not a large number of piecemeal standards. The mixing and matching from a set of hundreds or thousands of commercial standards is not only inefficient for HFE requirements, it will likely lead to omissions of important considerations. When the military considers commercial off-the-shelf (COTS) equipment, it should always be tested to determine if it is compatible with the military environment. When modified COTS equipment is developed, it should be consistent with the military's human-system interface standards.

Using HFE standards to design performance into the routine aspects of the system leaves more engineering labor to apply to the new design issues. Without HFE standards, every detail of every aspect of the human-system interface must be researched, designed, and tested. A great deal of time is spent "re-inventing the wheel." In most programs, the HFE budget is limited. Using accepted military standards frees up labor for solving new issues. ■

Footnotes

1. This was later published as Human Engineering Guide to Equipment Design, Morgan, Cook, Chapanis & Lund, eds., McGraw-Hill Book Co., Inc., New York, 1963. Popularly called "the HEGED," it was widely used as a textbook.

Human Factors Standardization SubTAG

The mission of the Human Factors Standardization (HFS) SubTAG of the Department of Defense Human Factors Engineering Technical Advisory Group (DoD HFE TAG) is to foster open communications and coordination of human factors-related standardization activities among the DoD, other government agencies, nongovernment standards bodies (NGSB), technical societies, and industry groups. The objectives of the HFS SubTAG are to:

1. Identify needed programs and initiatives to applicable organizations such as DoD Human Factors Standardization Area (HFAC) and other government lead standardization activities, custodians, preparing activities, and offices of primary record
2. Provide advisory support to ensure successful coordinated efforts in implementing planned HFAC and related actions
3. Avoid duplication among DoD standardization projects and activities
4. Maximize and enhance the exchange of standardization information between the DoD human factors community and other government, non-government standards bodies (NGSB), and other technical societies and industry groups.

The scope of HFS SubTAG interests includes standardization documents (current and potential) and programs within the DoD HFAC Standardization Area, other government organizations, and NGSB (domestic and international). The HFS SubTAG:

- Identifies problems and opportunities of the HFAC and other government HFE standardization activities, suggesting proposed actions to address the problems and exploiting opportunities for government-industry cooperation in resolving them
- Identifies technical points of contact for accomplishment of cooperative efforts
- Identifies effective and efficient means of using HFAC, other government HFE documents and NGS in acquisition programs, consistent with acquisition reform policies
- Maintains liaison with NGSB and other industry groups and technical societies
- Periodically advises the DoD HFE TAG regarding HFAC accomplishments, status, and plans, and obtains inputs from the DoD HFE TAG
- Assists in developing and preparing DoD HFE TAG documents, as requested, and otherwise supports the DoD HFE TAG

The HFS SubTAG web site is a public site and can be found at http://hfetag.dtic.mil/hfs.html and contains various standardization documents (Human Engineering Design Data Digest, Index of Non-Government Standards, and a link to purchase the Human Engineering Principles and Practices), data item descriptions, standards and handbooks (MIL–STD–1472, MIL–STD–1474, MIL–HDBK–759, MIL–HDBK–1908, MIL–HDBK–46855, and NASA–STD-3000), SubTAG meeting minutes, and SubTAG hot topics. Notices and requests for information can be posted to the web site bulletin board feature, when activated. Additional links can be made to the Human Systems Information Analysis Center (HSIAC) and the Human Factors and Ergonomics Society (HFES) Newsletter. For more information about the HFS SubTAG, contact the current Chair:

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Human Systems Integration in System Engineering Standards

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It has been said that the best characteristic of commercial standards is that if you do not like the contents of one, there are plenty of others to choose from. There are four major systems engineering process standards commonly in use, providing both the opportunity to select an appropriate standard and the potential for confusion.

But why does the selection and use of a systems engineering standard impact the human-systems integration (HSI) or human factors engineering (HFE) practitioner? For the researcher, these standards may very well be irrelevant. For the design practitioner, however, knowledge of these standards can be critical since HSI and HFE cannot be practiced in a vacuum.

A framework is needed—of both processes and terminology—for the HSI practitioners to effectively work both with systems engineers and with other disciplines. The ultimate goal of the HSI practitioner should be to improve total system performance, not just human performance. Armed with an understanding of what HSI activities are included in these standards, the HSI practitioner can be more effective in integrating those activities into the system development process.

ISO/IEC 15288: Systems Engineering System Life Cycle Processes

First released in 2002 in collaboration with the International Electrotechnical Commission (IEC), the International Organization for Standardization (ISO) systems engineering standard is more general than other domain standards. It covers the complete system life cycle and five groups of processes—Agreement, Enterprise, Project, Technical, and Tailoring—with lists of outcomes and activities for each process.

Despite being both the most general and the shortest of the four major standards, ISO/IEC 15288 provides an excellent treatment of HSI concepts and activities. Explicit definitions of user and operator are provided, and the standard discusses the fact that whether humans are seen as outside the system or as system components, their inclusion in the development process is crucial. The activities of human task design and operator training are listed alongside hardware design and fabrication and software design and coding. The best feature of this standard is its tight linkage with numerous lower-level ISO standards and papers that provide complete details on the activities necessary for effective and usable systems. The only drawback of this standard is the comparatively low level of emphasis placed on users and operators in system test and evaluation and verification and validation activities.

EIA–632: Processes for Engineering a System

Also organized into five groups of processes, the meat of this Electronic Industries Alliance (EIA) standard is a set of 33 “Requirements” detailing how effective systems are engineered. Released in January 1999 as an update to an interim standard of the same number, it bears little resemblance to its predecessor, but has common deficiencies in HSI integration.

The standard is written to cover a range of activities comparable to that in ISO/IEC 15288, but with very little in the way of HSI concepts or activities. There is an almost random coverage of individual HSI issues, including identifying user requirements and making function allocation decisions with human performance in mind. But the primary “stakeholders” discussed throughout the standard are the acquirers of the system, not the users, and activities relating to the human are called out in much less detail than those relating to hardware and software. From an HSI perspective, the most problematic part of the standard is the detailed Process Task Outcomes that include only sparse information on HSI products, focusing instead on hardware and software deliverables.

EIA/IS–632: Systems Engineering

This interim standard (IS) is a commercialized version of the never-released MIL–STD–499B, Systems Engineering. Although it has been superseded by EIA–632, it is still used in many programs due to the availability of tailored guidance. Its general requirements are divided into the activities of Requirements Analysis, Functional Analysis/Allocation, Synthesis, and Systems Analysis and Control.

Throughout the standard, there are hidden nuggets of HSI activities, including analysis of personnel task loading and cognitive skill requirements. The verification of human performance requirements, personnel selection, training, and man-machine interfaces is also addressed.

These positive attributes, however, are undermined by a lack of HSI activities and products in the standard's multiple stages of technical reviews. The terminology of the standard can also cause problems for HSI practitioners. "Functional Allocation" is defined not as the assignment of functions to hardware, software, and humans or combinations, but instead to the assignment of performance requirements to portions of the system's functional architecture.

IEEE–1220: Standard for Application and Management of the Systems Engineering Process

The structure of this Institute of Electrical and Electronics Engineers (IEEE) standard is comparable to that of EIA–632, but the level of detail is noticeably greater. First released in 1995, development of the 1998 update included a concerted effort to integrate HSI activities into the standard.

Unlike the detailed requirements of EIA–632 and EIA/IS–632, design artifacts in IEEE–1220 such as an Integrated Data Package and the System Breakdown Structure are defined to include manpower, personnel, and training specifications and documents along with task analyses and human workspace and interface drawings. Five of the HSI domains (manpower, personnel, training, human engineering, and safety) are specifically described as life cycle concepts that must be addressed early in design. In sections on verification, human performance and workload are included as testing criteria.

Perhaps the biggest potential problem in application of IEEE–1220 is the level of detail. Since it includes many more specifics on systems engineering (and HSI) processes, it can be much more difficult to tailor this standard for use in a given program or project.

Summary

Each of these four standards provides a different level of specificity in systems engineering activities, but the standards also differ greatly in the ease with which HSI plans and activities can be tied to higher-level systems engineering plans and activities. If a project references a systems engineering standard with more linkages to HSI, then the integration of HSI activities will be easier. If such a standard is not referenced, then the HSI practitioner will have to work harder to ensure that the necessary tailoring of the systems engineering processes is achieved. ■

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United Kingdom Defence Technology Centre for Human Factors Integration Defence Community Awareness Programme

The contract for the UK's Defence Technology Centre (DTC), focusing on Human Factors Integration (HFI), was signed by the Ministry of Defence on 21 March, 2003 in the presence of the Centre's prime contractor, Aerosystems International of Yeovil. Also participating are Lockheed Martin, SEA, MBDA and VP Defence from the industrial sector and, from academia, Birmingham, Brunel and Cranfield Universities.

Our aim is to ensure that the defence community at large benefits from the MoD's investment in this very important area.

To this end, we have instigated an awareness programme, designed to disseminate information to those organizations expressing a desire to be kept abreast of HFI developments, not only from within the DTC but from the much wider international HFI community. Such information may include results from research and experimental programmes, emerging HFI standards (including those generated from within the civilian sector), conference notices and reports, case studies, technology reviews and so on, distributed via electronic or paper media.

The Human Factors Integration DTC will be collecting personal and organizational data, including names and addresses, in a number of different ways in order to perform its business. We are committed to maintaining any information you supply in a manner which meets the requirements of the UK Data Protection Act (1998) and will take all reasonable steps to ensure that your personal data are kept secure against unauthorized access, loss, disclosure or destruction. Furthermore, we will be managing personal and organizational data in accordance with the UK Data Protection Act's eight "Data Protection Principles", as listed at: http://www.dataprotection.gov.uk/principl.htm.

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Human Systems IAC **GATEWAY** is published and distributed free of charge by the Human Systems Information Analysis Center.

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