

International Encyclopedia of Ergonomics and Human Factors

Contents

About the editor	xvii
Board of Associate Editors	xix
International Scientific Advisory Board	xxi
Foreword	xxv
Acknowledgements	xxvii

Part 1 General Ergonomics

An annotated review of selected military and government sources of human factors design related criteria	3
Australia: Ergonomics Society of Australia	8
Biosketch: Corwin Bennett	10
Biosketch: Etienne Grandjean	11
Biosketch: Jean-Marie Faverge	13
Biosketch: Longin Paluszkiwicz	14
Biosketch: Paul Branton	15
Biosketch: Paul Morris Fitts	17
Biosketch: Ross A. McFarland	19
Biosketch: Wojciech Bogumil Jastrzebowski	21
Cognitive engineering	22
Core competencies in ergonomics	25
Cultural ergonomics	31
Defining ergonomics/human factors	35
Design	38
Ecological approach	39
Epistemological issues about ergonomics and human factors	43
Ergonomics in the Nordic countries	47
The European Union's policy in the occupational safety and health sector	48
Exposure assessment of upper limb repetitive movements: a consensus document	52
Finnish Ergonomics Society	67
Fundamental concepts of human factors	68
Germany: Gesellschaft für Arbeitswissenschaft	71
Greece: Hellenic Ergonomics Society (HES)	72
History of human factors in United States	73
A history of human factors/ergonomics in power systems	76
History of the Gesellschaft für Arbeitswissenschaft (GfA)	88
History of work-related musculoskeletal disorders	91
Human factors, politics and power	94
Human-machine systems: written and symbolic communication	97
Iceland: Icelandic Ergonomics Society	100
IEA definitions of ergonomics	102
The International Ergonomics Association (IEA)	103
International ergonomics standards: ISO/TC 159	106
Ireland: Irish Ergonomics Society	109
ISO and CEN Standardization Committee for Ergonomics (1999): Organizational structure	110
Israel: Israel Ergonomics Society	122

Italian Society of Ergonomics (Società Italiana di Ergonomia, SIE) 123
Macroergonomics 124
Ontology 126
An outline of ergonomics, or the science of work based upon the truths drawn from the science of nature 129
Person-centered ergonomics 142
Poland: Polish Ergonomics Society 145
Professional certification in ergonomics in the USA 146
Scenario-based design 160
South Africa: Ergonomics Society of South Africa (ESSA) 164
Spain: Spanish Ergonomics Association 165
Symvatology: the science of an artifact–human compatibility 166
Taiwan: Ergonomics Society of Taiwan 171
Task analysis 172
Training and acquisition of complex tasks 175
United Kingdom: The Ergonomics Society 178
United States: Human Factors and Ergonomics Society 180
Universal design for the aging 182

Part 2 Human Characteristics

Alternative controls 187
Anaerobic threshold 190
Anthropometric databases 191
Anthropometry of children 193
Anthropometric terms 197
Anthropometry 198
Body sizes of US Americans 199
Control of rapid actions: motor programming 202
Dynamic muscle strength 205
Dynamic properties of human limb segments 207
Engineering anthropometry 211
Ergophthalmology: the visual system and work 212
Event-related potentials 219
Force exertion: pinching characteristics and strengths 223
Force exertion for (consumer) product design: information for the design process 226
Force exertion for (consumer) product design: problem definition 229
Force exertion for (consumer) product design: research and design 232
Gaze-based control 234
Gesture-based control 237
Hand grip strength 240
Hand-grip torque strength 247
Handgrip characteristics and strength 252
Human muscle 255
Information processing 256
Lifting strategies 260
Maximum holding times of static standing postures 263
Models of attention 266
Multiple resources 271
Muscle strength 276
Muscle terms – glossary 277
Musculo-skeletal system 278
Physical ability testing 279
Physical strength in the older population 282
Physical work capacity (PWC) 285
Postural adaptation 287
Principles of simple movements 292
Psychophysiological fitness for work 296

Push and pull data 299
Pushing and pulling strengths 317
Recumbents 320
Sleeping postures 323
Static and dynamic strength 327
Static muscle strength 328
Strength testing 330
Torque data 334
Trunk muscle force models 343
Visual perception, age, and driving 348
Workload and electro-encephalography dynamics 350

Part 3 Performance Related Factors

Activity 355
Activity theory 358
Allocation of functions: past, present and future perspectives 363
Arousal states and human performance 370
Attention and human performance: a cognitive neuroscience approach 374
Body postures 378
Brain and muscle signal-based control 379
Burnout 382
Cognitive modeling in human-computer interaction 387
Cognitive psychophysiology in ergonomics and human factors 392
Combination manual handling tasks 395
Comfort-discomfort phase change 399
Constraints in design decision-making 403
Cross-cultural comparison of computer anxiety: concept, measures and related variables 406
Cybersickness in virtual reality 410
Databases for psychophysically acceptable maximum weights and forces in manual handling tasks developed by Liberty Mutual 413
Databases for psychophysically acceptable maximum wrist torques in manual tasks for females developed by Liberty Mutual 423
Design cognition 426
Designing for body strength 431
Driver perception and response 433
Dynamic situations 436
Ergotoxicology: towards an operational prevention of chemical risk in the working environment 454
Fatigue and driving 446
Fire-fighting and rescue work in emergency situations and ergonomics 449
Human control of the behavioral environment 454
Human error 463
Human reliability analysis 466
Learning and forgetting 470
Lifting techniques 476
Loads on the lumbar spine during dynamic work 479
Manual materials handling in unusual postures 484
Manual materials handling: multi-person lifting 485
Manual work and back stress in industrially developing countries 487
Mental fatigue and related phenomena 491
Mental models 493
Mental workability and an increasing life span 497
Mental workload 500
Mental workload measurement 504
Mental workload: theory, measurement and application 507
Models of human performance for application to military simulation 510
Monitoring an operator's psychophysiological fitness for work 513
Noise: measuring, evaluation, and rating in ergonomics 516
Occupational stress mechanisms 524

Physical demands of work 526
Psychophysical risk assessment in manual handling 536
Rating scales for perceived physical effort and exertion 538
Signal detection theory 542
Signal detection theory – alternatives 546
Situation awareness 551
Situation awareness in teams 555
Skill learning: augmented feedback 558
Skill learning: conditions of training 562
Sleeping systems: current status 566
Sleeping systems: design requirements 571
Standing work 577
Static load 580
Static work capacity 583
Stimulus–response compatibility 586
The substance of cognitive modeling 590
Tolerance to shiftwork 593
Visual display terminals: age and psychophysiology 597
Visual measurement: modern methods 599
Visual perception under night driving conditions 602
Work ability 604
Work design: age related policies 606
Work hazards and risk assessment in human performance 609
Working with age: an ergonomic approach to aging on the job 613

Part 4 Information Presentation and Communication

Alarm initiated activities 623
Auditory warnings 625
Augmented reality 628
Automatic speech recognition 631
Chinese keyboard input 636
Convergence of telephony, television and computing in the home 640
Cross-cultural issues in human–computer interaction 644
Cultural aspects of user interface acceptance 648
Describing and predicting human interaction with technology 651
Design of menus: choosing names, organization and selection devices 655
Ecological interface design – theory 659
Ergonomics of CAD systems 663
Functional systems design versus interface design 668
HCI hypermedia: usability issues 670
Human acceptance of information technology 673
Human–computer interaction (HCI) standards 676
Human factors and digital networks: intranets, extranets, and the internet 680
Human speech digitization and compression 683
Human ecology: developing ecological auditory warnings 686
Human–Computer Interaction (HCI) 689
Hypertext and hypermedia 691
Information design: warning signs and labels 695
Interactive speech technology 698
Internet and the World Wide Web 701
Knowledge management in HCI design 705
Knowledge-based man-modeling: job design procedure 711
Models of graphical perception 715
Multimedia production 720
Natural language communication 725
Product sensorial quality 728

Speech-based alarm displays 733
Structured Integration of human factors and software engineering methods 735
Top ten mistakes in web design 738
Universal design in human–computer interaction 741
Use of modern Chinese language 746
User requirements in information technology 750
User-centered graphic design 754
Video telephony 757
Virtual environments 765
Virtual reality 768
Virtual reality: virtual and synthetic environments – technologies and applications 772
VR technology for ergonomics design 783

Part 5 Display and Control Design

Auditory Warnings and Displays: issues relating to design and selection 791
Calibration and characterization of color displays 795
Chinese characters and computer input 798
Computer mouse use 802
Design issues: action research in control room operations 806
Design and use of displays 808
Handwheels 812
Input devices and controls: manual controls 816
Keyboards 832
Manual control devices 835
Multivariate visual displays 840
Pointing devices 844
Systematic control of exposure to machine hazards 847
Visual display technology 850
Visual fatigue and stereoscopic displays 856
Warning design 860

Part 6 Workplace and Equipment Design

Active safety in car design 865
Analysis of office systems 869
Anthropometry for design 875
Anthropometry: definition, uses and methods of measurement 879
Biomechanics of wrist in computer keyboarding 883
Consumer product design 888
Design of automobile interiors 892
Design of visual displays for teleoperation 897
Ergonomic design of factory buildings in tropical countries 901
Ergonomic product design 906
Ergonomic workstation design 911
Evaluation of work chairs 921
Facility and workspace layout problems in ergonomic design 927
Handtools 933
Instrument and design 938
Laptop computer use 941
Performance prosthetic hands 944
Principles of handtool design 947
Product development approach 951
Safety in public offices in Italy 954
Ships and maritime systems: design process 958

Ships and maritime systems: requirements and issues 963
Tactical cockpit technology 967
Virtual workplace design 971
Visual display units: positioning for human use 975
Wearable computers 978
Wheelchairs 981
Workstations organization 985

Part 7 Environment

Environmental ergonomics 995
Flight motion effects on human performance 1000
Free flight 1005
Human exposure to vibration 1009
Human aspects of lighting in working interiors 1011
Illumination: basic definition 1016
Lighting equipment 1022
Mental workload under thermal stress 1026
Noise at work 1029
Noise: definitions 1033
Performance effects of high G environments 1047
Physiological costs of noise exposure: temporary threshold shifts 1050
Tolerance to sustained +G_z acceleration 1057
Toxicology 1060
Working clothing – thermal properties and comfort criteria 1063

Part 8 System Characteristics

Accident analysis and “human error” 1073
Adaptive automation 1077
Affordances 1080
Automation in vehicles 1084
Compatibility 1087
Computer systems design for psychophysical safety of human operations 1091
Creating pleasurable products 1095
Engineering principles of ergonomics 1098
Ergodynamics 1099
The ergonomic qualities of products 1105
Evaluation of software usability 1110
Fuzziness, requisite compatibility and system design 1113
Human factors testing and evaluation 1119
Human factors and ergonomics testing 1122
Human factors system design 1125
Integration of quality, ergonomics, and safety management systems 1129
Integration of risk management into complex management systems 1136
Intelligent transportation systems 1139
Operator testing and non-destructive evaluation performance 1144
Process control 1148
Rail transport 1151
Systems modeling. Physical–control–information approach to decompose systems for modeling 1155
Usability evaluation 1159
Utility analysis 1163

Part 9 Work Design and Organization

- Air traffic management 1167
- Air traffic management system design 1170
- Air traffic inspection: A computer-based training program 1176
- Balance theory of job design 1181
- Changes in modern manufacturing practices 1185
- Change management 1194
- Collaborative engineering: spanning time and space 1197
- Community ergonomics: applications 1201
- Cross-cultural factors in macroergonomics 1205
- Design of shift systems for shift work 1210
- Distributed mission training 1214
- The ergonomic buddy system 1218
- Ergonomic process in small industry 1223
- Ergonomics and production philosophies 1227
- Ergonomics/human factors audits 1230
- Ergonomics in a design engineering environment 1233
- Exposure assessment of upper limb repetitive movements: work reintegration criteria 1236
- Healthy work organization 1239
- Historical development of macroergonomics 1243
- Human factors and total quality management 1246
- Inspection 1249
- Kansei engineering and Kansei evaluation 1254
- Management of work-related musculoskeletal disorders: clinical perspective 1257
- Organizational change and supporting tools 1263
- Organizational culture and development 1267
- Participation 1271
- Participation and collaboration in workplace design 1274
- Participation of users in architectural design 1278
- Participatory ergonomics 1282
- Participatory ergonomics – a Scandinavian approach 1287
- Participatory ergonomics at the shop floor level 1290
- Prevention and compensation of shiftwork effects 1293
- Principles and strategies for team training 1296
- Psychosocial and work organization risk factors for work-related musculoskeletal disorders 1299
- Quality and ergonomics in concert 1303
- Quality inspection task in modern manufacturing 1308
- Quality management continuous improvement and total quality management 1312
- Quality of life and usability engineering 1317
- Rapid macroergonomic redesign 1322
- Risk management 1327
- The role of the ergonomist in a design engineering environment 1334
- Safety culture 1337
- Safety, ergonomics and total quality management 1341
- Self-managed work teams 1344
- Service quality and ergonomics 1347
- Shift work 1350
- Shiftwork and Sleep 1355
- Shiftwork health consequences 1359
- Shiftwork Stress 1362
- Situational awareness issues at work 1365
- Sociotechnical systems analysis 1367
- Socio-technical theory 1370
- Systems approach to training 1374
- Task analytical methodology for design of an aircraft inspection training program 1378
- Team effectiveness and competencies 1384
- Team performance 1388

Team training 1391
Team training for aircraft maintenance 1394
Teamwork 1401
Technology transfer 1405
Tools to design and evaluate new forms of work organization 1411
Training system development in ergonomics 1419
Usability and product design 1426
User-centered systems analysis in aircraft maintenance 1429
User-centred design: needs analysis 1433
Work design: barriers facing the integration of ergonomics into system design 1437
Work organization interventions 1441
Work organization, job stress and occupational health 1446

Part 10 Health and Safety

Agriculture 1453
Anthropometry for the needs of rehabilitation 1457
Assessing the risk of upper limb disorders 1461
Assessment of combined occupational low back disorder risk factors 1466
Back belts 1469
Building and the construction industry 1472
Construction 1486
Diagnosis of work-related musculoskeletal disorders 1489
Epidemiology: principles and approaches to prevention of occupational injury 1493
Ergonomics considerations for reducing cumulative trauma exposure in underground mining 1497
Exposure assessment of low back disorders: manual material handling limits 1501
Exposure assessment of low back disorders: assessment criteria for manual handling tasks 1503
Exposure assessment of low back disorders: criteria for health surveillance 1505
Exposure assessment of upper limb repetitive movements: criteria for health surveillance 1507
Exposure assessment of upper limb repetitive movements: Epidemiology 1510
Exposure assessment of upper limb repetitive movements: ergonomic principles for prevention 1512
A framework for assessment of work-related musculoskeletal hazards 1515
Health and safety ergonomics 1522
A heuristic dose–response model for cumulative risk factors in repetitive manual work 1523
Maximum loads and manual materials handling 1527
Micro- and macro-ergonomic interventions in industrially developing countries 1533
Motor vehicle safety 1537
Obstacles to recovery from work-related musculoskeletal disorders 1542
Occupational biomechanics 1545
Occupational epidemiology with special focus on ergonomics and musculoskeletal disorders 1558
Occupational health and ergonomics 1562
Occupational injuries and medication use 1566
Occupational injury 1569
Occupational injury epidemiology: principles and approaches to prevention 1573
P₅–P₉₅ syndrome 1578
Risk factors for non-specific musculoskeletal disorders 1579
Risk factors of musculoskeletal disorders: demographic, social and work change aspects in France 1582
Robot safety standard – R15.06 1585
Slaughterhouses 1588
Slip, trip and fall accidents 1591
Slips and falls 1594
The strain index 1598
Surveillance for work-related musculoskeletal disorders 1601
System safety engineering and risk assessment 1604
Work organizations: health and productivity issues 1608
Work organization and psychosocial work factors: definitions 1612
Work-related musculoskeletal disorders of upper limb and back: review of guidelines for their prevention 1617

Work-related musculoskeletal disorders: general issues 1621
Work-related musculoskeletal disorders: overview 1625
Work-related musculoskeletal disorders in dental care workers 1633

Part 11 Social and Economic Impact of the System

Analysis of worker's compensation data 1641
Collaborative learning environment in higher education: implementing job and organizational learning theories in academia 1644
Communication processes in small groups 1648
Community ergonomics theory: applications to international corporations 1651
Community ergonomics: planning and design solutions for urban poverty 1655
Economic models for ergonomists 1659
Education: the teaching of ergonomics 1662
Enhancing industrial performance 1669
Ergonomics and quality of life 1675
Forensic human factors/ergonomics 1678
Job demands and occupational health 1683
Legal considerations for the human factors specialist 1689
Low-cost ergonomics improvements 1692
Management perspectives for workplace ergonomics 1694
Production standards and performance feedback: a strategy for improving worker productivity and satisfaction 1699
Psychosocial work factors and work organization 1705
Social policy and industrial development 1709
Socially centered design 1712
Sociotechnical analysis of work system structure: applying empirical models of sociotechnical system elements 1715
Sociotechnical systems theory: the sociotechnical systems model of work systems 1720
Telework 1723
Trade union approaches to workplace improvements 1726
Types of organizational designs 1730

Part 12 Methods and Techniques

Activity and other sampling methods 1735
AET ergonomic job description questionnaire 1742
Basic ergonomics checklists 1747
Biomechanical modeling of human strength 1751
Biomechanics of low back: guidelines for manual work 1754
Bivariate anthropometric design for workspaces and products 1758
Cognitive systems engineering 1768
Computer simulation: applications to human factors and ergonomics 1771
Content analysis: hypermedial design 1775
Design methodology 1778
DIALOG: human reliability assessment 1780
Digital human models for ergonomics 1783
Ecological ergonomics: theory in context 1787
Ecological interface design: applications 1790
Electromyography: fundamentals 1795
Electromyography: methods and techniques 1801
Ergograms 1805
Ergonomic data for the design and evaluation of technical systems 1811
Ergonomics methods: selection criteria 1817
Goals operators methods and selection rules (GOMS) 1822
Heart rate as strain index 1826
Human body positioning analysis 1831
Human factors: reliability and risk assessment 1836

Human factors design tools for consumer–product interfaces	1839
Human sensory measurement application technology (HMSAT)	1843
Human systems engineering process and methods	1846
Job analysis and ergonomic assessment after injury	1850
Job load and hazard analysis	1857
Medical equipment usability testing: an introduction	1859
The MUSE method for usability engineering	1864
MUSE–JSD: structured integration of human factors and software engineering methods	1867
Noise: metrics and equipment	1870
The OCRA method: assessment of exposure to occupational repetitive actions of the upper limbs	1875
OWAS – a method for analysis of working postures	1880
Prevention of work injury	1884
Psychophysiological methods	1889
Scientific management influences on ergonomic analysis techniques	1896
Survey design	1899
A survey of ergonomics methods	1903
Task analysis for error identification	1908
Task analysis in Industry	1911
Work stress quantification and evaluation using ErgoMOST™	1915
Published ergonomics literature	1920
Bibliography	1940

About the Editor

Waldemar Karwowski, Ph.D., P.E. is Professor of Industrial Engineering and Director of the Center for Industrial Ergonomics at the University of Louisville, Louisville, Kentucky, USA. He holds an M.S. (1978) in Production Engineering and Management from the Technical University of Wroclaw, Poland, and a Ph.D. (1982) in Industrial Engineering from Texas Tech University. He is also a Board Certified Professional Ergonomist (BCPE). His research, teaching and consulting activities focus on prevention of work-related musculoskeletal disorders, workplace and equipment design, human and safety aspects of advanced manufacturing, and theoretical aspects of ergonomics science.

Dr Karwowski is currently (2000-2003) President of the *International Ergonomics Association* (IEA), and is past President of the *International Foundation for Industrial Ergonomics and Safety Research*, as well as past Chair of the US TAG to the ISO TC159: Ergonomics/SC3 *Anthropometry and Biomechanics*. He is the author or co-author of over 200 scientific publications in the area of human factors engineering, industrial ergonomics and safety, mathematical modeling in human factors, and fuzzy systems, and has edited 25 books.

Dr Karwowski serves as Editor of the *Human Factors and Ergonomics in Manufacturing* international journal, Co-Editor of the *International Journal of Occupational Safety and Ergonomics*, and Consulting Editor of the *Ergonomics* journal. He is also a board member for *Human Factors*, *Applied Ergonomics*, *International Journal of Human-Computer Interaction*, *Universal Access to the Information Society: An International Interdisciplinary Journal*, *Occupational Ergonomics*, *Industrial Engineering Research: An International Journal of IE Theory and Application* (Hong Kong).

Dr Karwowski is also the Editor-in-Chief of the new journal *Theoretical Issues in Ergonomics Science* (TIES), launched in 2000, and designed to stimulate and develop a theoretical basis for the unique science of ergonomics.

Dr Karwowski is Fellow Member of the Human Factors and Ergonomics Society and recipient of the highest recognition in occupational safety and health in Poland, *Pro Labore Securo* (2000). He received the University of Louisville Presidential Award for Outstanding Scholarship, Research and Creative Activity in the Category of Basic and Applied Science (1995), and the W. Jastrzebowski Medal from the Polish Ergonomics Society (1995). He served as Fulbright Scholar, Tampere University of Technology, Finland (1990-1991), and was named an Outstanding Young Engineer of the Year by the Institute of Industrial Engineers (1989).

