

Lecture Notes in Networks and Systems 220

Nancy L. Black · W. Patrick Neumann ·  
Ian Noy *Editors*

# Proceedings of the 21st Congress of the International Ergonomics Association (IEA 2021)

Volume II: Inclusive Design



 Springer

# Lecture Notes in Networks and Systems

Volume 220

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Editors

# Proceedings of the 21st Congress of the International Ergonomics Association (IEA 2021)

Volume II: Inclusive Design

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# Preface

The International Ergonomics Association (IEA) is the organization that unites Human Factors and Ergonomics (HF/E) associations around the world. The mission of the IEA is “to elaborate and advance ergonomics science and practice, and to expand its scope of application and contribution to society to improve the quality of life, working closely with its constituent societies and related international organizations” (IEA, 2021). The IEA hosts a world congress every three years creating the single most important opportunity to exchange knowledge and ideas in the discipline with practitioners and researchers from across the planet. Like other IEA congresses, IEA2021 included an exciting range of research and professional practice cases in the broadest range of Human Factors and Ergonomics (HF/E) applications imaginable. While the conference was not able to host an in-person meeting in Vancouver, Canada, as planned by the host Association of Canadian Ergonomists/*Association canadienne d’ergonomie*, it still featured over 875 presentations and special events with the latest research and most innovative thinkers. For this congress, authors could prepare a chapter for publication, and 60% chose to do so. The breadth and quality of the work available at IEA2021 are second to none—and the research of all authors who prepared their publication for this congress is made available through the five volumes of these proceedings.

The International Ergonomics Association defines Human Factors and Ergonomics (HF/E) synonymously as being:

*the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance.*

*Practitioners of ergonomics and ergonomists contribute to the design and evaluation of tasks, jobs, products, environments and systems in order to make them compatible with the needs, abilities and limitations of people.*

*Ergonomics helps harmonize things that interact with people in terms of people’s needs, abilities and limitations. (<https://iea.cc/definition-and-domains-of-ergonomics/>)*

The breadth of issues and disciplines suggested by this definition gives one pause for thought: what aspect in our lives is not in some way affected by the design and application of HF/E? For designers and managers around the world, a similar realization is growing: every decision made in the design and application of technology has implications for the humans that will interact with that system across its lifecycle. While this can be daunting, the researchers and professionals who participated in IEA2021 understand that, by working together across our disciplines and roles, we can achieve these lofty ambitions. This is especially relevant as we continue our collective journey into an increasingly “interconnected world”—the theme for the 21st IEA Congress. With the rise of a myriad of technologies as promulgated by Industry 4.0 proponents, we need now, more than ever, the skills and knowledge of HF/E researchers and practitioners to ensure that these tools are applied in a human-centric way towards resilient and sustainable systems that provide an enduring and sustainable road to prosperity—as advocated in the new Industry 5.0 Paradigm (Breque et al. 2021). Where the trend of Industry 4.0 aims primarily at encouraging technology purchasing and application, Industry 5.0 includes goals of resiliency and sustainability for both humans and our planet. These proceedings provide examples of research and development projects that illustrate how this brighter, human-centred future can be pursued through “*Ergonomie 4.0*”, as stated in the French theme of the Congress.

While the theme of the Congress concerns human interactions within a rapidly evolving cyber-physical world, the devastating impact of the COVID-19 pandemic has given an added dimension to the Congress theme and its delivery model. As the pandemic began to engulf the world, the traditional in-person Congress became increasingly less viable and gave way to the creation of a hybrid model as a means to enhance international participation. In early 2021, it became clear that holding an in-person event would not be possible; hence, the Congress was converted to a fully virtual event. The uncertainty, mounting challenges and turbulent progression actually created new possibilities to engage the global HF/E community in ways that were never previously explored by the IEA. Indeed, one of the scientific tracks of the congress focuses explicitly on HF/E contributions to cope with COVID-19, and readers will find some submissions to other tracks similarly focus on what HF/E practitioners and researchers bring to the world during this pandemic period. This journey epitomizes broader transformative patterns now underway in society at large and accentuates the urgency for resilience, sustainability, and healthy workplaces. No doubt, the notion of globalization will be redefined in the wake of the pandemic and will have far-reaching implications for the connected world and for future society, and with new paradigms emerge a host of new human factors challenges. The breadth of topics and issues addressed in the proceedings suggests that the HF/E community is already mobilizing and rising to these emerging challenges in this, our connected world.

IEA2021 proceedings includes papers from 31 scientific tracks and includes participants from 74 countries across 5 continents. The proceedings of the 21st triennial congress of the IEA—IEA2021—exemplify the diversity of HF/E, and of the association, in terms of geography, disciplines represented, application

domains, and aspects of human life cycle and capability being considered. Our diversity mirrors the diversity of humans generally and is a strength as we learn to weave our knowledge, methods, and ideas together to create a more resilient and stronger approach to design than is achievable individually. This is the strength of the IEA congresses, in the past, in the current pandemic-affected 21st occasion, and in the future. There is no other meeting like it.

A substantial number of works were submitted for publication across the Scientific Tracks at IEA2021. This gave us the happy opportunity to group contents by common threads. Each volume presents contents in sections with papers within the track's section presented in alphabetical order by the first author's last name. These proceedings are divided into five volumes as follows:

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These volumes are the result of many hours of work, for authors, Scientific Track Managers and their reviewer teams, student volunteers, and editors. We are grateful to Springer for making it available to you in book form and are confident you will find these works informative and useful in your own efforts to create a better, more human-centred future.

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# IEA2021 Acknowledgements

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The Organizing Committee is also indebted to those contributors who were instrumental in developing and promoting IEA2021. Joanne Bangs, our freelance Communications Specialist, provided engaging news blogs and other promotional collateral to help get the word out about the Congress. Sadeem Qureshi (Ryerson University), Elizabeth Georgiou, Elaine Fung, and Michelle Lam (Simon Fraser University) helped to create widespread awareness of the Congress as well as the HF/E field and profession through creative use of digital and social media. We are also grateful to those who worked diligently to ensure that the Congress provided meaningful opportunities for students and early career researchers, including Daniel P. Armstrong and Christopher A.B. Moore (University of Waterloo), Owen McCulloch (Simon Fraser University), Dora Hsiao (Galvion, Inc.), Chelsea DeGuzman and Joelle Girgis (University of Toronto), and Larissa Fedorowich (Associate Ergonomist, self-employed). The ePoster presentation option, new to IEA triennial congresses in 2021, was defined with care by Anne-Kristina Arnold (Simon Fraser University). Colleen Dewis (Dalhousie University) was key to

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The organizers are especially grateful to our sponsors, whose generous contributions made the Congress possible and readily accessible to the global HF/E community. Their recognition of the Congress as a valuable opportunity to advance the field of HF/E, as well as their steadfast support throughout a very trying planning period, was critical to the success of the Congress. The IEA 2021 sponsors include:

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# Contents

## Part I: Ageing and Work (Edited by Jodi Oakman)

<b>Ageing Factors and Forecasting Tool for Companies</b> . . . . .	3
Bernard Michez	
<b>Are My Employees Able to and Do They Want to Work? The Baseline Investigation in a Follow up Study Regarding Managers’ Attitudes and Measures to Increase Employees’ Employability in an Extended Working Life</b> . . . . .	10
Kerstin Nilsson and Emma Nilsson	
<b>Management, Measures and Maintenance: Success and Setbacks in Interventions Promoting a Healthy and Sustainable Employability and Working Life for All Ages</b> . . . . .	17
Kerstin Nilsson and Emma Nilsson	
<b>The Retention of Airline’s Customer Service Agents Within the Framework of the Digitalization of the Service Relationship</b> . . . . .	25
Lucie Reboul, Catherine Delgoulet, and Corinne Gaudart	
<b>Analyzing the Influence of Work Demands and Work Organization on Workability Based on Age</b> . . . . .	33
Camila A. Ribeiro, Teresa P. Cotrim, Vítor Reis, Maria João Guerreiro, Susana Candeias, Ana Sofia Janicas, and Margarida Costa	
<b>A Hybrid Approach to the Evaluation and Design of Workstations for Manufacturing Industries: A Tuscan Case Study</b> . . . . .	41
Francesca Tosi, Mattia Pistolesi, and Claudia Becchimanzi	
<b>Aging Workers in Industry and Retail Sector – A Holistic Approach for an Age-Related Evaluation and Design of Work</b> . . . . .	50
Matthias Wolf and Sandra Maria Siedl	

**Part II: Ergonomics for Children and Educational Environments  
(Edited by Lawrence J. H. Schulze)**

**Establishment and Discussion of the Design Criteria for Training Chopsticks for Children . . . . . 63**  
Yu-Hui Chen and Jo-Han Chang

**Study on the Optimal Time for Intervention to Guide the Development of the Static Tripod Grip in Toddlers . . . . . 71**  
Chiao-Yun Cheng and Jo-Han Chang

**The FRAM Error Model Within a System Theoretical Work System to Support Conceptually the Development of a Technical Learning System for Learning from Errors . . . . . 80**  
Marvin Goppold, Sven Tackenberg, Martin Frenz, and Verena Nitsch

**Applying a Systems Approach to Developing Interventions to Increase Physical Activity Among Primary School Children While Distance Learning During the COVID-19 pandemic- the Stand up Kids Study . . . . . 88**  
Judith I. Okoro, Brittany Ballen, Melissa Afterman, Carisa Harris Adamson, and Michelle M. Robertson

**Investigation on Ergonomic Well-Being for Academician’s Work from Home Arrangements by Using Association Rules Technique . . . . . 95**  
Charles Ramendran SPR, Anbuselvan Sangodiah, Lilis Surity Abd Talib, Norazira A. Jalil, Au Yong Hui Nee, and Suthashini Subramaniam

**Workload Level Assessment of Online Classes of College Students in Technological Institute of the Philippines Manila Using NASA Task Load Index (NASA TLX) . . . . . 105**  
Janina Elyse A. Reyes, Karl Bryant P. Buan, Roi Vincent B. Limin, and John Roy D. Marucot

**Investigation on Mental Health Well-Being for Students Learning from Home Arrangements Using Clustering Technique . . . . . 113**  
Anbuselvan Sangodiah, Charles Ramendran SPR, Norazira A. Jalil, Au Yong Hui Nee, and Suthashini Subramaniam

**Ergonomics Checkpoints for Educational Environments . . . . . 123**  
Lawrence J. H. Schulze

**Distance Ergonomics Laboratory Using Flipped Classroom and Smartphone Application as Learning Tools – A Case Study . . . . . 130**  
Liyun Yang, Malin Håkansson, Malin Engquist, Carl Mikael Lind, and Linda Barman

**Part III: Ergonomics in Design for All (Edited by Isabella Tiziana Steffan and Ken Sagawa)**

**Seniors’ Perception of Smart Speakers: Challenges and Opportunities Elicited in the Silver&Home Living Lab** . . . . . 137  
 Leonardo Angelini, Maurizio Caon, Emmanuel Michielan, Omar Abou Khaled, and Elena Mugellini

**Social Presence Despite Isolation - Insights into the Relation Between Psychological Distance and Sensory Synchronization in Computer-Mediated Communication** . . . . . 145  
 Stina Becker, Tim Schrills, and Thomas Franke

**Luminance Contrast Standards, the Boy Who Could, and Visionary Pathfinders** . . . . . 154  
 Penny Galbraith and Richard Bowman

**Research Through Co-design for Connecting Design for All and Policy Ergonomics** . . . . . 163  
 Daniele Busciantella-Ricci and Sofia Scataglini

**A Highly Legible Font for All** . . . . . 172  
 Marco Canali, Christina Bachmann, and Federico Alfonsetti

**An Inclusive Design Approach for Designing an Adaptive Climbing Wall for Children with CP** . . . . . 180  
 Maria Rita Canina, Chiara Parise, and Carmen Bruno

**Ergonomics Aspects in Workstation Development During the Covid-19 Pandemic** . . . . . 189  
 Cristiane Nonemacher Cantele, Fabrício Santin, Jairo Beninca, Tiago Cezne, Maurício Veigel, Samuel Matté Madalozzo, and Jeferson A. Gevinski

**Leef Chair: Application of the Equid Methodology and the Principles of Macro Ergonomics in Product Design** . . . . . 197  
 Cristiane Nonemacher Cantele, Marc Sapetti, Jairo Benincá, and Giovanna Nonemacher

**Opportunities and Challenges of Digital Technologies for Inclusion** . . . . . 205  
 Maurizio Caon, Isabella Tiziana Steffan, and Alessandra Rinaldi

**6Ws in the Ergonomics Review of Macro and Micro Workplace Design** . . . . . 209  
 Justine M. Y. Chim and Tienli Chen

**The Effect of Cognitive Styles on the Effectiveness of Visual Search Tasks with Different Familiarity** . . . . . 217  
 Yu Ju Chiu, Zi Xuan Chen, and Yung Ching Liu

**Designing the University of Manitoba Technology for Assisted Living Project (TALP): A Collaborative Approach to Supporting Aging in Place** ..... 223  
Mohamed-Amine Choukou, Jacque Ripat, Shauna Mallory-Hill, and Reg Urbanowski

**Developing a Standard One-Fits-All Boarding Assistance System as a Universal Accessibility Solution** ..... 229  
Martin Dorynek, Anne Guthardt, and Klaus Bengler

**Inclusion Design and Functionalities of a Personalized Virtual Coach for Wellbeing to Facilitate a Universal Access for Older Adults** ..... 239  
Mira El Kamali, Leonardo Angelini, Maurizio Caon, Francesco Carrino, Carlo Emilio Standoli, Paolo Perego, Giuseppe Andreoni, Filippo Palumbo, Alfonso Mastropietro, Omar Abou Khaled, and Elena Mugellini

**Flat Cushion vs Shaped Cushion: Comparison in Terms of Pressure Distribution and Postural Perceived Discomfort** ..... 247  
Iolanda Fiorillo, Yu Song, Maxim Smulders, Peter Vink, and Alessandro Naddeo

**Accessibility Performance for a Safe, Fair, and Healthy Use of the Elevator** ..... 255  
Elena Giacomello, Mickeal Milocco Borlini, Daniele Pavan, Christina Conti, and Dario Trabucco

**Improving Accessibility and Inclusiveness of Digital Mobility Solutions: A European Approach** ..... 263  
Sabina Giorgi, Rebecca Huetting, Andrea Capaccioli, Floridea di Ciommo, Gianni Rondinella, Andrés Kilstein, Imre Keseru, Samyajit Basu, Hannes Delaere, Wim Vanobberghen, Miklós Bánfi, and Yoram Shiftan

**A Study on the Acceptance Towards Blockchain-Based Access to Biobanks’ Services Using UTAUT2 with ITM and Perceived Risk** ..... 271  
Fouad Hannoun, Francesco Carrino, Omar Abou Khaled, Elena Mugellini, and Maurizio Caon

**How to Increase Users of Products, Services and Environments - Concept and Methods of Accessible Design** ..... 280  
Nana Itoh, Kenji Kurakata, and Ken Sagawa

**Ergonomic Design, Evaluation and Application of a 3-Dimensional Simulation of a Clinical Setting for People with Lower Limb Disabilities** ..... 286  
Stephen Ong, James D. McGlothlin, Bradley S. Duerstock, Philip S. Dunston, and James F. Schweitzer

**Information Design and Plain Language: An Inclusive Approach for Government Health Campaigns** . . . . . 294  
 Claudia Mont’Alvão, Livia Clemente, and Tiago Ribeiro

**“Progetto di Vita” and Design for All: An Integrated Approach in Supporting Collaborative Housing Projects for Persons with Disabilities** . . . . . 299  
 Cristiana Perego, Angela Silvia Pavesi, and Ilaria Oberti

**Humane Design for Inclusion** . . . . . 307  
 Audrey Reinert and David S. Ebert

**Bridging the Gap: An Ergonomically Designed Motorized Tricycle Accessible by Persons with Disability Using Anthropometry and Rapid Entire Body Assessment (REBA)** . . . . . 317  
 Janina Elyse A. Reyes, Carlo John M. Barbosa, Mon Eleazar B. Nonato, Tommy N. Olayres, and Emmerson R. Tamba

**Digital Technologies as Opportunity for Facilitating Social Inclusion and Multicultural Dialogue** . . . . . 325  
 Alessandra Rinaldi and Kiana Kianfar

**Type to Be Seen and Type to Be Read** . . . . . 334  
 Elisabete Rolo

**Usability Evaluations Focused on Children with Down Syndrome: A Systematic Literature Review** . . . . . 342  
 Lizie Sancho Nascimento, Laura Bezerra Martins, Nelson Zagalo, and Ana Margarida Pisco Almeida

**Revising Recommendations for Evacuating Individuals with Functional Limitations from the Built Environment** . . . . . 350  
 Yashoda Sharma, Waqas Sajid, Cesar Marquez-Chin, Brad W. R. Roberts, Abdulrahman Al Bochi, Steven Pong, Mark Weiler, Albert H. Vette, and Tilak Dutta

**From Accessibility to Inclusion in People Centered Design** . . . . . 357  
 Erminia Attaianese, Francesca Tosi, and Isabella Tiziana Steffan

**Good Lighting and Visual Contrast to Improve Accessibility in the Built Environment-A Literature Study** . . . . . 367  
 Gregorio Feigusch, Isabella Tiziana Steffan, and Doris Ossberger

**Towards Innovative Bathroom Solutions for All - A Needs Analysis** . . . . . 376  
 AnnaKlara Stenberg Gleisner, Andrea Eriksson, Mikael Forsman, and Linda M. Rose

**Designing Smart Ring for the Health of the Elderly: The CloudIA Project** . . . . . 384  
 Francesca Tosi, Filippo Cavallo, Mattia Pistolesi, Laura Fiorini, Erika Rovini, and Claudia Becchimanzi

**Passenger Activities, Postures, Dis(Comfort) Perception, and Needs During Train Travel** . . . . . 393  
 Sumalee Udombhoonyanupap, Stella Boess, and Peter Vink

**Part IV: Gender and Work (Edited by Marie Laberge)**

**Working Conditions in Educational Establishments: Research on Ergonomics and Gender Among Teachers in Pandemic Context** . . . 403  
 Pamela Astudillo and Carlos Ibarra

**Agile Development of Prevention Tools in Occupational Health and Safety: A Gender Consideration** . . . . . 413  
 Myriam Bérubé, Marie Laberge, Céline Chatigny, and Denys Denis

**Methods for Considering Sex and Gender During Intervention-Research Studies: What Do Researchers Say?** . . . . . 421  
 Vanessa Blanchette-Luong, Marie Laberge, Véronique Poupart-Monette, and Karen Messing

**“This Is a Job for Women, Isn’t It?”: The Evolution of a Traditional Gendered Occupational Segmentation in a Portuguese Industrial Cluster** . . . . . 429  
 Liliana Cunha, Daniel Silva, and Mariana Macedo

**The Rules, the Strategies and Gender Regarding Safety** . . . . . 438  
 Fabienne Goutille and Alain Garrigou

**Gender in the Literature of Healthcare Workers Operating in War Settings** . . . . . 442  
 Rima R. Habib, Dana A. Halwani, Diana Mikati, and Layal Hneiny

**Training M.Sc. Students in Ergonomics to Integrate a Sex/Gender-Sensitive Approach** . . . . . 450  
 Marion Inigo, Marie Laberge, Martin Chadoin, and Karen Messing

**Considering Sex/Gender in the Design of a Technology-Supported Work Injury Prevention Model Among Adolescents with Learning Difficulties** . . . . . 457  
 Marie Laberge, Myriam Bérubé, Aurélie Tondoux, Céline Chatigny, and Denys Denis

**Work-Related Musculoskeletal Disorders Interventions in a Seasonal Work Context: A Scoping Review of Sex and Gender Considerations** . . . . . 462  
 Marie-Eve Major, Hélène Clabault, and Audrey Goupil

**The “Woke” Ergonomist: How Can We, How Should We Improve Gender Equality as Well as Health?** . . . . . 470  
 Karen Messing and Nicole Vézina

**Facilitators and Obstacles to Sex/Gender-Conscious Intervention-Research on Occupational Health: Researchers and Partners Perspectives** ..... 477  
 Véronique Poupart-Monette, Marie Laberge, Marie-Laurence Genier, Jessica Riel, Karen Messing, and Valérie Lederer

**Laying the Foundations to Build Ergonomic Indicators for Feminized Work in the Informal Sector** ..... 482  
 Sandra Liliana Ruiz-Amórtégui, Sandra Liliana Joaqui-Galindo, and Martha Helena Saravia-Pinilla

**Upper and Lower Limb Work Injuries: A Question of Sex or Gender?** ..... 487  
 Silvana Salerno and Claudia Giliberti

**Dynamic Workstation Exposure: Does Sex Affect Response?** ..... 495  
 Mathieu Tremblay, Nancy L. Black, and Jean-Philippe Morin

**Part V: Human Factors and Sustainable Development (Edited by Andrew Thatcher)**

**Eco-Drivers and Eco-Automation: A Case Study with Hybrid Electric Vehicle Drivers** ..... 503  
 Matthias G. Arend and Thomas Franke

**Scaling Micronarrative with Machine Learning to Model Human and Environmental Wellbeing in Macro, Meso and Micro Systems** .... 512  
 Wendy Elford and Keil Eggers

**Designing Sustainable Situations** ..... 521  
 Myriam Fréjus

**Weaving the Net: Integrating Ergonomics and Sustainability in a Web-Based Co-creation Platform** ..... 530  
 Lia Buarque de Macedo Guimarães

**Emerging Ergonomic Associations: Achievements, Obstacles, and Lessons Learned** ..... 538  
 Bouhafis Mebarki, Rosemary R. Seva, Mohammed Mokdad, Serpil Aytac, and Ng Yee Guan

**Comparing Two Modalities of Urban Solid Waste Collection: Insights from Activity Analysis and Physiological Measurement** ..... 544  
 Talita M. Oliveira, Andréa Regina Martins Fontes, Esdras Paravizo, Renato Luvizoto Rodrigues de Souza, Daniel Braatz, and Márcia R. N. Guimarães

**Buyer Networking in Supplier HSEQ Development – A Macroergonomics Analysis in a CSR Framework** ..... 552  
 Arto Reiman, Henri Jounila, and Osmo Kauppila



<b>Identifying Sustainability Attributes of Products/Services with Ergoecology</b> .....	560
Martha Helena Saravia-Pinilla and Lucas Rafael Ivorra-Peñaafort	
<b>A Comprehensive Overview on ‘Eco-concepts’ Use from Ergoecology Vision</b> .....	566
Martha Helena Saravia-Pinilla, Gabriel García-Acosta, and Carolina Daza-Beltrán	
<b>Supporting Interaction with CO<sub>2</sub> as a Resource with Individual Carbon Footprint Trackers as Everyday Assistants</b> .....	573
Tim Schrills, Laura Rosenbusch, Mourad Zoubir, Jacob Stahl, and Thomas Franke	
<b>The Ergonomics of Recycling Mattresses in Australia</b> .....	582
Elizabeth M. Smith	
<b>Ergonomics Role in Sustainable Development: A Review Article for Updates the Recent Knowledge</b> .....	588
Mohammad Sadegh Sohrabi	
<b>Work Process and Restrictions Related to Activities Carried Out in a Waste Sorting Cooperative</b> .....	603
Renato Luvizoto Rodrigues de Souza, Andréa Regina Martins Fontes, João Alberto Camarotto, and Talita M. Oliveira	
<b>Uncovering Sustainable System-of-Systems Elements in the Design of a Greywater Treatment System for Urban Informal Settlements</b> . . . .	611
Andrew Thatcher	
<b>Part VI: Slips, Trips and Falls (Edited by Richard Bowman)</b>	
<b>How Might Slip Resistance Standards Become More Evidence Based?</b> .....	623
Richard Bowman	
<b>Determining the Risk of Slipping with Slip-Resistant Footwear</b> .....	631
Davood Dadkhah, Danny Cen, and Tilak Dutta	
<b>Alternative Measures for Determining the Risk of Tripping</b> .....	638
Ghazaleh Delfi, Abdulrahman Al Bochi, and Tilak Dutta	
<b>Effect of Test Conditions on COF Measurements on Ice Surfaces Using SATRA STM603 Whole Shoe Tester</b> .....	644
Chantal Gauvin and Yue Li	
<b>Minimum Toe Clearance Estimation Using a Novel Wearable System</b> .....	652
Shilpa Jacob, Geoff Fernie, and Atena Roshan Fekr	

**Can Tribometers and Testing Protocols Affect Slip Resistance Values and Opinions?** ..... 660  
 Timothy G. Joganich, Angela Levitan, and Tamara L. Cohen

**The Misuse of Regulations, Standards and Acceptable Practice in Ambulation-Safety Analysis** ..... 666  
 Mark I. Marpet

**Why, How, and How Effectively Do USA and Canadian Building Codes Address Two Leading Fall Sites in Homes?** ..... 674  
 Jake Pauls and Daniel Johnson

**Effect of Combining Hydrophobic and Hydrophilic Treatments on Slip Resistance for Wet Flat Glass Flooring** ..... 682  
 Kei Shibata, Hirotaka Oguni, Hiromi Wada, Takeshi Yamaguchi, and Kazuo Hokkirigawa

**Estimation of Perceived Hand Force During Static Horizontal Pushing Tasks Using the Zero-Moment Point-Based Balance Control Model** ..... 689  
 Atsushi Sugama, Akiko Takahashi, and Akihiko Seo

**Do Stairs with Visual Cues Lead to Fewer Missteps?** ..... 697  
 Steve Thorpe and Mike Roys

**Part VII: Visual Ergonomics (Edited by Marino Menozzi)**

**Pragmatic Needs-Oriented Evaluation of Visibility, Impressions, Aesthetics and Eye Movement for Platform Display Design** ..... 707  
 Hirotaka Aoki and Naoto Koizumi

**Preferences of People with Vision Impairment with Respect to Visibility of Elements in the Built Environment** ..... 715  
 Mei Ying Boon and Byoung Sun Chu

**Applied Visual Ergonomics - A Compelling Consideration for the New Normal** ..... 723  
 Nivedita Dabir and Prajakta Khanwalkar

**Visual Symptoms and Risk Assessment Using Visual Ergonomics Risk Assessment Method (VERAM)** ..... 729  
 Hillevi Hemphälä, Marina Heiden, Per Lindberg, and Per Nylén

**Effects of the Use of a Widescreen Display on Information Retrieval** ... 736  
 Kaoru Honda

**Dynamic Signs: Appropriate Contrast and Speed for Older Adults and Low Vision** ..... 742  
 Nana Itoh, Ken Sagawa, Hiroshi Watanabe, and Reiko Sakata

**Visual Ergonomics in a Virtual World: Examples of Lighting Assessments Conducted in Cyberspace** . . . . . 749  
Jennifer Long

**Error Rate as Mediators of the Relationships Among 2D/3D TV Environment, Eye Gaze Accuracy, and Symptoms** . . . . . 756  
Yogi Tri Prasetyo and Retno Widyaningrum

**Dynamic Signs: Field Test to Install Signs Around the Stairs** . . . . . 762  
Reiko Sakata, Naoki Furuhata, Atsushi Shimada, Kenta Mishina, Hiroshi Watanabe, Nana Itoh, Hiroyasu Ujike, and Ken Sagawa

**The Influence of Guiding Information Propagated from the Elbow on Foot Proprioception Among Severely Visually Impaired People** . . . . 770  
Tadashi Uno and Tetsuya Kita

**Data Visualization for Interdisciplinary Medical Research (Pilot Study)** . . . . . 775  
Aleksandr Volosiuk, Iaroslav B. Skiba, Alexey Polushin, Daria Plotnikova, Daria Filippova, and Artem Smolin

**Dynamic Signs: Multiple Attributes Determining Visibility** . . . . . 783  
Hiroshi Watanabe, Nana Itoh, Hiroyasu Ujike, Ken Sagawa, Reiko Sakata, and Naoki Furuhata

**Author Index** . . . . . 791



# Improving Accessibility and Inclusiveness of Digital Mobility Solutions: A European Approach

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**Abstract.** This paper presents the main results of the co-creation activities carried out in the first phase of INDIMO (INclusive DIGital MOBility solutions), a three-year EU-funded Horizon 2020 project that aims to extend the benefits of digital mobility and delivery solutions to vulnerable people that currently face barriers in using such solutions due to physical, cognitive and socio-economic limitations. On the one hand, results concern needs, capabilities and requirements of vulnerable-to-exclusion users and non-users of digital mobility and delivery services that have been collected in the five pilot sites of the project. On the other hand, findings highlight drivers and barriers for the development and deployment of inclusive and accessible digital mobility services from the viewpoint of developers, operators and policy makers. These results are the basis for the development of the main outcome of the project, i.e. the Inclusive Digital Mobility Toolbox.

**Keywords:** Digital mobility and delivery solutions · Accessibility · Inclusiveness · User and non-user needs · Requirements · Universal design

## 1 Introduction

The proliferation of smartphones and digital technologies have produced a quickly expanding array of digital services in mobility and logistics. While significant achievements have been made mainly in terms of improving physical accessibility of transport,

digital accessibility and inclusion have marginally been addressed. There is a risk that these new digital mobility and logistics services will not be available and accessible to all members of society. 22% of all European households still do not have access to broadband internet especially in rural areas. Mobile broadband penetration also shows a high variation within Europe with 70 subscriptions per 100 persons in Hungary as a lowest value. In some EU Member States, over 25% of the population still does not regularly go online. Almost 10% of EU citizens have never used the internet, with a high number of non-users among those with low education levels, aged over 55, retired or inactive [1]. This data shows that internet-enabled mobility is not an obvious choice for millions of Europeans although internet access is just one of the reasons why they may be excluded.

Access to digital services may be limited due to physical or cognitive barriers, but digital accessibility has so far only been addressed at the level of websites and applications. In addition, from the inclusiveness perspective, various socio-economic, demographic, financial and functional barriers may prevent people from using digital mobility and logistics services (e.g. educational level, gender, language, immigration status, poor access to transport or digital networks, affordability, etc.) [2].

Digital mobility solutions are mainly developed for general use according to the assessment of the needs of average users. This practice may, however, lead to the exclusion of several groups. Implementing universal design principles and accessibility standards could lead to more inclusive applications: past experience proved that including special features for broadening customer palette increased the overall usability.

Inclusivity features cover two main topics: service related and interface related issues. Improving service inclusivity usually results in the increase of inclusivity of the related application as well. However, improvement may require high investment on service development, especially on informatics and technologies. Development should focus on providing additional information, functions, and options for possible vulnerable users. Increasing interface accessibility refers to adapting universal design [4] in the development process of graphical user interfaces, which may lead to iterative processes and can affect previous steps (e.g., database modelling). The process also requires an extended testing phase to verify inclusiveness.

This paper addresses the lack of accessibility and inclusivity of mobility services and proposes the application of the universal design principles and a co-creation approach to overcome these barriers. It discusses needs, capabilities and requirements of vulnerable-to-exclusion users and non-users of digital mobility and delivery services, and findings highlight drivers and barriers for the development and deployment of inclusive and accessible digital mobility services from the viewpoint of developers, operators and policy makers.

## 2 The INDIMO Project: An Overview

The INDIMO project aims both at filling the knowledge gap about accessible-by-design digital mobility services and improving the inclusiveness and equity of the interconnected transport systems. Pursuing this mission, INDIMO explores needs, capabilities, barriers and requirements of vulnerable-to-exclusion users on the one hand, and the challenges that developers, operators and policy makers face, on the other hand.

To this aim, the main outcome of the project will be the Inclusive Digital Mobility Toolbox, which includes a universal design manual for digital mobility services, guidelines for improving the design of interfaces, guidelines for cybersecurity and personal data protection and a policy evaluation tool for policy makers.

Overall, the INDIMO methodology consists of a user-centric approach. The INDIMO Inclusive Digital Mobility Toolbox will be co-designed with local communities of practices in five pilot sites (i.e. Italy, Belgium, Galilee, Spain, Germany) and with an international co-creation community including policy makers, user representatives, industry, academia, and developers, during the three years of the project.

The INDIMO co-creation process is designed as a five-stage process. *Stage 1* is devoted both to the identification of user and non-user needs, capabilities and requirements, and the investigation of needs and concerns of developers, policy makers and operators when introducing digital mobility and delivery solutions (DMS/DDS). *Stage 2* concerns the co-designs of the INDIMO Inclusive Digital Mobility Toolbox to bridge the digital mobility gap, on the basis of needs, capabilities, requirements and barriers identified in the stage 1. *Stage 3* regards the co-implementation of the tools included in the INDIMO toolbox. Their impact and usability will be tested in the five pilot sites through the redesign of the pilots' digital mobility and delivery solutions and their implementation made according to the INDIMO toolbox guiding principles. *Stage 4* focuses on the co-evaluation, feedback and redesign. Pilots engagement will provide feedback in order to improve the INDIMO toolbox. An evaluation will be carried out, both in terms of inclusion and accessibility assessment of the pilots' digital mobility and delivery services, and of process evaluation of the INDIMO Toolbox. Finally, *stage 5* concerns the transferability assessment and the deployment of the toolbox as an online toolkit.

This paper presents and discusses the results emerged from the research carried out in the first stage of the co-creation process, whose methodology is described more in detail in the next section.

### **3 Identification of Needs, Capabilities, Requirements and Barriers: The Methodology**

In the first phase of the project, needs, capabilities and requirements of vulnerable-to-exclusion users and non-users of digital mobility and delivery services have been collected in the five pilots. The process started with the definition of users' characteristics and the general analysis framework of qualitative data collection. Each pilot site addressed specific user profiles and characteristics and focused on certain digital mobility or delivery services that will be tested and re-designed during the project to be improved from the accessibility and inclusiveness points of view (see Table 1).

In total, 58 semi structured interviews (SSIs) with digital mobility services' users and non-users and 25 interviews with stakeholders representing users have been carried out. SSI structure was set-up according to several dimensions identified in the general analysis framework (e.g. goals/value of using the service; accessibility and inclusion: reasons for not using the service; needs; etc.). SSIs and short interviews were firstly documented in debrief documents by including the more relevant excerpts of the interviews and, secondly, analysed through a coding process. This was performed through

**Table 1.** Pilots' names and user profiles

Pilot name and country	User profiles (and characteristics)
<ul style="list-style-type: none"> <li>Introducing digital technology to enable e-commerce in rural areas (Emilia Romagna-Italy)</li> </ul>	Older people and migrants/ foreign people who receive/send parcels (lack of digital knowledge; residing in peri-urban locations; lack of digital services; lack of dedicated network infrastructures; language barriers; low income, ...)
<ul style="list-style-type: none"> <li>Inclusive traffic lights (Antwerp–Belgium)</li> </ul>	Vulnerable pedestrian (i.e. older people; people with reduced mobility; people with reduced vision)
<ul style="list-style-type: none"> <li>Informal ride-sharing in ethnic towns (Galilee)</li> <li>Cycle logistics platform for delivery (Madrid-Spain)</li> </ul>	Informal ride-sharing users (ethnic minority man/women; residing in the periphery; language barrier; lack of digital skills) Healthy food delivery users (people with reduced mobility; people with reduced vision; socially isolated-unwanted loneliness; not-connected people; low income; COVID-19 isolated)
<ul style="list-style-type: none"> <li>On-demand ride-sharing integrated into multimodal route planning (Berlin-Germany)</li> </ul>	On demand ride-sharing users (caregivers of children/ impaired/ elders; women; lack of services; lack of digital skills, residing in peri-urban locations)

the Quirkos CAQDAS (Computer Assisted Qualitative Data Analysis) software. Relevant verbatims from interviews were labelled with appropriate codes to analyse data in terms of similarities, differences, and relationships. The final step consisted of the thematic analysis to organize the identified codes in meaningful crosscutting themes [3]. The main results emerged from these research activities are relevant themes concerning needs, capabilities and requirements of digital mobility services' users and non-users (see Sects. 4.1 and 4.2).

In order to support changes that can extend the benefits of digital mobility services and applications equally to the vulnerable-to-exclusion groups, it is necessary to understand what the drivers and barriers are for the development and deployment of inclusive and accessible digital mobility services from the viewpoint of developers, operators and policy makers. For this purpose, 10 deployment case studies were performed to investigate how new digital mobility services have been introduced in European cities and regions. The case studies included desktop data collection, 20 semi-structured interviews with developers, service operators and policy makers, and a thematic analysis to determine the key barriers and drivers. The main results concerning this part of the study is described in Sect. 4.3.

## 4 Main Results

### 4.1 Identification of Users and Non-users' Needs

The insight from the pilots, with different user profiles, locations and mobility solutions, allowed us to identify needs of the users and potential users. Also, stakeholders on behalf of specific groups of population, provided their inputs to build a narrative that moves across geographies and profiles. Needs vary across groups, but there are threads as “space”, “time” and “trust” that are points of contact and common areas.

The first thread is the “space”. In the case of environments characterized by scattered rural villages, such as in the pilots of Emilia Romagna and Galilee, digital mobility solutions (e.g. Apps) may compensate the lack of infrastructure, the transport poverty and the difficulties for personal mobility. In the case of Emilia Romagna, there are logistic problems to reach remote areas. The digital locker for deliveries could overcome distances and enhance accessibility, especially for older people for whom picking up parcels demanded a great amount of effort. In the case of Galilee there is a need of mobility alternatives given the lack of public transport and good connectivity in the Arab rural villages. This need is even greater for Arab women, since cultural barriers and a hostile atmosphere prevent many of them to drive and ride the public transit. But there are additional needs related to the spatial configuration of this place. Most of the mobility apps have severe difficulties to match the digital mapping with the real geography. There are rural streets with no names nor numbers; this implies a difficulty for the user to order a ride.

In the Antwerp pilot, people with reduced mobility or reduced vision find a number of obstacles in the physical environment that prevent their everyday activity. The needs have to do with the adaptation of traffic lights but also the adaptation of the surroundings to overcome these limitations: the short time provided by the traffic lights, the uncertainty about when it is going to change, the uneven pedestrian spaces, the height of the button to ask for a traffic light change and so on are the main needs to be addressed.

The second thread articulating needs is “time”. Time is a valuable resource and the importance of making a good use of it appears in the different pilots. It presents a very sensitive treatment in the Berlin pilot, covering a ride-sharing app for caregivers (focusing on women). Time needs to be flexible: the driver and the remaining passengers should be tolerant to the fact that a mother may be delayed (because the child is more unpredictable, he/she doesn't want to go out, the mother spends time picking items needed by the child etc.), and also the caregiver needs the driver to be punctual (because of the difficulty of waiting in the public space with a child or the time constraints typical of the role).

In the case of Madrid, the existence of a food delivery app may save time, and the convenience of it is often remarked. The point here is that an app of delivery allows to give a different quality to time: time to relax instead of time to cook; a gained time instead of a time devoted to a domestic chore. Nevertheless, in Madrid certain vulnerable to exclusion groups perceived the app as an assistance they do not need; as a help that undermines their own autonomy.

Finally, the last thread that may organize the needs across the pilots is “trust” and having human contact behind the digital interface. Human contact is a requirement to



overcome all the fears contained in the digital domain; it is the ultimate safety net for vulnerable to exclusion population that venture into the unknown digital world. In Emilia Romagna, an assistant at the locker spot will be helpful to overcome digital-skills-related problems; in Antwerp, target population are very much depending on the help of passers-by to overcome physical obstacles, this assistance narrowed for fears raised by the COVID pandemics; in Galilee, having direct contact with the driver is a requirement to trust them, to overcome fears related with physical insecurity; in Madrid, the possibility of ordering food through WhatsApp or arranging details of delivery through a call to the rider were very frequents claims to the service; and finally, in Berlin there was a request of humanity directed to the driver: women need drivers to care about the needs of a mother and to help her onboard and offboard. Human contact is a key value to provide all needs in inclusive digital services.

#### **4.2 User Requirements Towards the Digital Interconnected Transport System**

The stakeholders' interviews in each pilot underline the potential of the INDIMO mobility services to meet certain goals that increase opportunities for the target groups in each pilot site. However, the stakeholder interviews show similar basic concerns across the five pilots to meet those goals. Providing an inclusive service by solely working on an easy to use and accessible digital interface (icons, fonts, read-aloud features, etc.), although important, will not be sufficient to engage the different vulnerable end user categories.

Five key activities will be important by the pilots to meet user requirements. Building a trust relationship is the first one. It is only because a certain trusted public or private organization or a trusted individual (relative, friend) recommends using the digital system, that users will know the service and try it out. Pilots will have to develop a good "social" marketing strategy to get their service to the target audience as well as involve such organizations closely in the whole service deployment. Building trust also involves the service agent appearance, tone of voice and behaviour, important for the driver in ride-sharing services (Berlin, Galilee) and the delivery person in delivery services (Madrid). Providing dedicated assistance and support mechanisms are a second key activity. Dedicated training opportunities that go beyond an introduction will be especially needed in the case of older people to tackle digital skills (Emilia Romagna) or blind people for integrating a smart traffic light in their road usage (Antwerp). The third important key activity is being reliable. Since the pilot services are targeting people with specific needs, they also count on these services and their provision in the structuration of their lives. In the case of vulnerable pedestrians, a non-working traffic lights either keeps the person at home (reduce mobility) or forces him to take another route (mobility hindrance). In case the service is not functioning sending out a warning message is important as well as communicating when the service is working again. The fourth activity will be to provide a service that in its strategic choices builds in "flexibility", meaning that it can't be too rigidly organized but should be able to incorporate unanticipated events at the end user side (for example cancelling a ride close to the agreed time or changing a pick-up location). The final key activity is increasing awareness about privacy and data sharing in order to prevent misuse, especially in use cases working with elderly (Emilia Romagna and Madrid) and cognitively impaired persons (Madrid).

### 4.3 Understanding the Process of the Deployment of Digital Mobility Services

In the first stage of the INDIMO project, drivers and barriers related to the development and deployment of accessible and inclusive digital mobility services were also explored from the viewpoint of developers, operators and policy makers.

The results of our case studies and the stakeholder workshop have pointed out several key barriers to the deployment of inclusive and accessible digital mobility services. The regulatory framework is often non-existing or outdated. There may be a lack of co-operation or trust between private and public organisations. The users are often not involved in the development of services. There is a lack of knowledge among developers about potential vulnerable-to-exclusion users. Unstable market pushes development towards ‘typical’ users with no or limited inclusive features. Finally, there is limited willingness to share (mobility) related data and information with public authorities and other operators.

A number of drivers can help to make existing or new services more inclusive and accessible: stable market conditions supported by a comprehensive regulatory framework; the integration of digital services into the public transport service network where minimum accessibility and inclusivity guidelines have been set; consultation with users and their representatives to have more knowledge of potential users can all be beneficial. Using inclusive design as a cornerstone of the service development, bottom-up co-creation events; open communication with other stakeholders, which includes sharing of information about best/worst practices and local support schemes (subsidies or incentives) can further help to introduce accessibility and inclusiveness features.

The differences between the services studied showed that there is no single method to develop more inclusive services. The issues most of the services are struggling with are similar (co-creation, communication, data-sharing etc.), but they might need different approaches depending on the type of service, region and people. The results of the analysis will help to create a framework and guidelines for developing inclusive and accessible digital mobility services, which are more aligned with the needs and expectations of vulnerable-to-exclusion groups.

## 5 Discussion and Conclusions

The INDIMO project’s main contribution concerns the co-creation of the Inclusive Digital Mobility Toolbox. It will cover relevant aspects for fostering the Universal Design approach throughout the planning and design process of digital mobility applications and services, by integrating the perspective of vulnerable-to-exclusion groups since the beginning. Such approach represents a shift of paradigm from the design-as-usual where experts “know what users need”, thus increasing the users’ acceptance of digital mobility and delivery solutions.

We contribute to filling the knowledge gap about accessible-by-design digital mobility services and improving the inclusiveness and equity of the interconnected transport systems by exploring needs, capabilities, barriers, and requirements of vulnerable-to-exclusion users on the one hand, and the challenges that developers, operators, and

policy makers face, on the other hand. This was achieved through various semi structured interviews and co-creation workshop from five case studies in different European sites.

Concerning findings coming up from this first phase of the project, they show that providing an inclusive service by solely working on an easy to use and accessible digital interface (icons, fonts, read-aloud features, etc.), although important, will not be sufficient to engage the different vulnerable end user categories. It is crucial to build trust among users, to provide dedicated assistance and support mechanism for the service to be reliable and provide flexibility, and finally, ensure privacy and prevent misuse in data sharing. Further, the differences between the analysed digital mobility services showed that there is no singular method to develop more inclusive services. The issues most of the services are struggling with are similar (co-creation, communication, data-sharing, lack of frameworks, etc.) but might need different approaches depending on the type of service, region, and people. There is need for co-creation with potential users resulting in a bottom-up approach and improve communication between stakeholders and exchange of knowledge about potential users, especially those vulnerable to exclusion.

Overall, the results offer a qualitative take allowing for a deep grasping of various dimensions of exclusion and inclusion ranging from interface to socio-economic and cultural factors.

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