



# Proceedings of the 21<sup>st</sup> International Conference on Engineering Design

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## ICED17

21st International Conference on Engineering Design  
Vancouver, Canada 21-25 August 2017

**Organised by:** The Department of Mechanical Engineering  
at the University of British Columbia and the Design Society



THE UNIVERSITY OF BRITISH COLUMBIA



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# PREFACE BY THE PROGRAMME CHAIRS

Dear Reader,

Welcome to the proceedings of the 21<sup>st</sup> International Conference on Engineering Design (ICED17). Each of the 413 manuscripts provides its own contribution to the vibrant community of design researchers and practitioners. The individual contributions come together to make a significant collective impact on this year's conference theme: Resource-Sensitive Design.

We are delighted to present an exciting scientific programme that acknowledges the rich tradition of the ICED conference series, manifests the collective creation of bodies of insights, connects across topics, and provides vantage points for the role and importance of designing emergent futures.

We placed particular emphasis on the young by introducing a design competition in form of a High-School Student Design Fair, by opening the conference also to the wider public that afternoon, by fostering research talent in the PhD Forum, and by providing a platform for visions and dreams of and for the Design World to come through the Young Members' Event.

Reviews have been invaluable for the ICED17 programme team in making their final acceptance decisions, grouping papers into the conference topics, and connecting to the conference theme. As a result, resource-sensitive design, design processes, design organisation and management, design research applications and case studies, product, services and systems design, design methods and tools, design for X / design to X, design information and knowledge, design theory and research methodology, human behaviour in design, and design education are all well represented in podium and discussion sessions. The attentive observer will also pick up weak signals of upcoming trends through the papers and presentation sessions. We trust that the careful selection of session chairs will amplify these signals.

The papers have been collated into a multiple range of formats: a programme and abstracts book, a memory stick of full proceedings, and nine volumes of proceedings, available for download from the Design Society website. These have been numbered against both Design Society and ISSN/ISBN referencing. The ICED conference proceedings are included in the Thomson Reuters Conference Proceedings Citation Index. This will enable more extensive access and increase citations.

We hope that you will enjoy the programme, and that you will participate actively in what is arguably the premier engineering design research conference in the world. We also hope that you will find the time to enjoy Vancouver, catch up with old friends and make some new ones.



Anja M. Maier  
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## WELCOME BY THE CONFERENCE CHAIRS



*Mike Van der Loos*

Mike Van der Loos  
*Conference Chair*



*Filippo Salustri*

Filippo Salustri  
*Assistant Conference Chair*



*Antony Hodgson*

Antony Hodgson  
*Assistant Conference Chair*

Welcome to Vancouver, Canada! The Organizing Committee of the 21<sup>st</sup> International Conference on Engineering Design (ICED17) is honoured to bring this premier Design conference to Canada for the first time in the history of the Design Society.

If you are reading this at the conference venue on the University of British Columbia campus, then you can readily see why UBC is considered one of the most stunning university settings in Canada, and indeed the world. Overlooking Vancouver Island to the west, and the wooded and craggy Coast Mountains to the north towards Whistler, you can readily appreciate why we chose “**Resource-Sensitive Design**” as the conference theme. Beyond the beauty of the setting, Vancouver is also home to vibrant forestry, natural resource, electronic media, biotech and transportation sector industries, and is a magnet for foreign engineers and students from all corners of the globe. These strong factors, along with the powerful First Nations presence in this region, underpin the conference’s three subthemes: *design for resource-limited societies*, *design to protect critical resources*, and *design to embrace resource limitations*. We sincerely hope you will join in celebrating this conference theme and, leave Vancouver with a renewed appreciation of the professional responsibility held by the membership of the Society to design our way to a better planet.

Beyond the conference theme, returning ICED attendees will see many familiar topics and will also see how these fields have evolved since the last ICED, joined by several new topics as well. The main Podium- and Discussion-format sessions are preceded by the more cutting-edge Monday Workshops organized by the Design Society’s Special Interest Groups: together these sessions are designed to provide attendees with ample opportunity to present, discuss, reflect on and contribute to the advancement of ideas in a wide variety of engineering design fields.

As in the past, ICED17 keynote lectures will unify the meeting, giving experts in the field the opportunity to communicate their visions for the future of the world in apposition to the themes of the conference. The six keynote speakers span the Design sector: from architecture to biotech, from materials to creativity, from regulatory agencies and government to engineering practice in society. We will all be wiser after hearing their reflections.

The Organizing Committee has created a conference that is rich in opportunity and nurturing in comforts – culinary, cultural and climate. We wish ICED17 attendees a most enjoyable experience in each other’s company and in fruitful scientific exchange.

## PREFACE BY THE DESIGN SOCIETY PRESIDENT



A handwritten signature in black ink, appearing to read 'D. Marjanović', written in a cursive style.

Dorian Marjanović  
*The Design Society President*

Design thinking involves sensitivity for the past and the legacy that belongs to all, awareness of the present and current needs, envisioning of the future and the implications created by design. The ICED17 conference theme “Resource - Sensitive design” reflects these aspects: the local heritage, contemporary living and strivings as well as The Design Society goals and mission: “...to contribute to the broad and established understanding of all aspects of design and to promote the use of design to the betterment of humanity”.

ICED17 participants have a chance to experience the dynamics of the UBC campus and Vancouver that reflects all of the design dichotomies the old and new, the art and technology, the research and practice, the chaotic and systematic.

Since the first ICED conference held in Rome in 1981, the conference has become the event where the variety of design research from all the continents is presented, and all aspects of design explored. Design as a field has expanded tremendously, and the conference programme has become more interactive and involved, opening new opportunities and challenges.

Organising a conference with such a history takes an enormous amount of work and attention to details. The programme of ICED17 is the result of a joint effort from great teams that have been working together since the last ICED conference in Milan. ICED17 schedule is the result of continuous improvements in every aspect of conference organisation. These efforts provided an exciting opportunity for all the participants to learn about the latest developments in design research and practice.

On behalf of The Design Society, I would like to express sincere thanks to Organising Committee Chair Mike Van der Loos and all the colleagues in the Organising Committee and the team of The University of British Columbia who have made this conference happen.

Special thanks also to Programme Committee Chair Anja Maier, Assistant Programme Chair Stanko Škec and all the members of Programme Committee for their tremendous work in creating an exciting programme and for ensuring the high quality of the conference.

Finally, thank you to all the participants whose attendance and input are a constant sign that ICED conference and design as a field are going in the right direction. The Society extends its gratitude to all the authors who have submitted their contributions and all the reviewers who have helped to select papers ensuring an outstanding conference experience for all participants. A special thank you goes to all the presenters and Session Chairs who will make this experience possible.

The ICED17 conference continues the efforts and intention of The Design Society to foster design research in all the design facets.

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