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Technological Imagination in the Green and Digital Transition

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Eugenio Arbizzani · Eliana Cangelli ·
Carola Clemente · Fabrizio Cumo ·
Francesca Giofrè · Anna Maria Giovenale ·
Massimo Palme · Spartaco Paris
Editors

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Editors
Eugenio Arbizzani
Dipartimento di Architettura e Progetto
Sapienza University of Rome
Rome, Italy

Carola Clemente
Dipartimento di Architettura e Progetto
Sapienza University of Rome
Rome, Italy

Francesca Giofrè
Dipartimento di Architettura e Progetto
Sapienza University of Rome
Rome, Italy

Massimo Palme
Departamento de Arquitectura
Universidad Técnica Federico Santa Maria
Antofagasta, Chile

Eliana Cangelli
Dipartimento di Architettura e Progetto
Sapienza University of Rome
Rome, Italy

Fabrizio Cumo
Dipartimento Pianificazione, Design,
Tecnologia dell'Architettura
Sapienza University of Rome
Rome, Italy

Anna Maria Giovenale
Dipartimento di Architettura e Progetto
Sapienza University of Rome
Rome, Italy

Spartaco Paris
Dipartimento di Ingegneria Strutturale e
Geotecnica
Sapienza University of Rome
Rome, Italy

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Foreword by Antonella Polimeni

Good afternoon to all participants, ladies and gentlemen, and welcome to Rome.

On behalf of the Community of Sapienza University of Rome, it is a real pleasure to welcome all of you to the first edition of the International Conference "Technological imagination in the green and digital transition". I am also pleased to give my best welcome to Dr Antonio Parenti, Head of the European Commission Representation in Italy, and to Prof. Mario Losasso, President of the Italian Society of Architectural Technology, as well as to all guests, students and colleagues.

The conference that we are about to open, organised by the Department of Architecture and Design and directed by Prof. Alessandra Capuano in cooperation with Sapienza Foundation, is to be a moment of methodological debate about built environments and the rise of contemporary urban challenges, so engaging for public and private institutions at national and international level.

The proposed key points of this conference—namely Innovation, Technology, Environment, Climate Changes and Health—are all interconnected priorities that cannot be further postponed, representing in the meantime strategic research and education activities for our University, perfectly aligned with the Italian National Recovery and Resilience plan, to be implemented in Italy as well as European member States, in order to overcome the present financial and social challenges.

I truly believe that Universities are, by definition, places of imagination, where planning the future is intended as an unavoidable "existential condition" as well as an essential moment of collective participation for an accomplished society.

Thank you for your attention, and I wish you a fruitful continuation of the conference.

Antonella Polimeni
Magnificent Rector
Sapienza University of Rome
Rome, Italy
antonella.polimeni@uniroma1.it

Foreword by Eugenio Gaudio

My warmest greetings to Dr. Antonio Parenti, Head of the European Commission Representation in Italy, to the President of the Italian Society of Architectural Technology Mario Losasso, to the Director Alessandra Capuano, and to Pietro Montani who will open with a Philosophical Lecture the Conference "Technological imagination in the green and digital transition".

A special greeting to Prof. Anna Maria Giovenale, my dear colleague and friend, who invited me to be here today. Thank you Anna Maria.

Let me also greet all other speakers as well other participant that will follow this Conference organized by the Department of Architecture and Design, together with the Fondazione Roma Sapienza.

From the very beginning, as President of the Fondazione Roma Sapienza, I supported the initiative of an international Conference on the theme of "Technological Imagination" having clear in mind that human imagination is inseparable from the "technical practice" with which it is entangled from the earliest origins of mankind, as Pietro Montani states in his book, *Technological destinies of the imagination.*

When the contents of the Conference were increasingly defined and focused around the areas of the green and digital transition, I realized that the very core of the Conference was becoming an attempt to respond to the contemporary challenges of the National Recovery and Resilience Plan, in their key role of revitalization for Research and University.

In this sense, the potential of technological culture is reaffirming its role of strategic tool for the conceiving, design and validation of future scenarios.

The sessions into which the Conference is structured, namely: Innovation, Technology, Environment, Climate Changes and Health, identified in order to outline the evolutionary scenarios of architectures and cities, allowing us to reflect at different levels on innovative models of building and management process, as well as design and products.

The goals of promoting digital transformation, supporting innovation in the production system, improving sustainability and ensuring an equitable environmental transition, find their clarification in the elaborations and experimentation presented through the contributions in the different sessions.

Modern technological innovation allowing multiple possibilities in all areas: nowadays digital technologies are enabling us to interact with people and things, all over the world.

There are astonishing, yet untapped potentials, suggesting that digitization, rather than a strict sense adaptive development, should be seen as an important evolutionary phenomenon and in the meantime a great opportunity.

Innovations connected with new technologies can provide to civil society a better quality of life, both at indoor and urban scale settings, addressing scientific development toward an effective culture of sustainability, reuse and security.

The employment of new technologies, a careful approach to the containment of land consumption as well as a careful consideration towards soil coverage modality and urban density, the recycling strategies and technological and typological redevelopment of degraded areas and buildings applying an energetic and eco-systemic approach, are the key elements for the conception of healthy and resilient urban habitats, able to adapt to the present global changes, as well as promoting prosperity, inclusiveness and social equity.

Last but not least, “health” issues, that need to be conceived at the very core of the potential determined by ’technological innovation and processes of ecological and digital transition.

The structure of the Conference is rooted on all these interrelated themes, and on that same basis also research needs to be reoriented.

I am confident that this first edition of the Technological imagination conference will contribute to pave the way of an innovative and interdisciplinary scientific approach to technology and policies for built environments, considered the real human challenge of the twenty-first century.

Thank you so much for your attention and enjoy the Conference.

Eugenio Gaudio
President
Fondazione Roma Sapienza
Rome, Italy
eugenio.gaudio@uniroma1.it

Foreword by Antonio Parenti

New European Bauhaus

Good morning,

Magnificent Rector of Sapienza University of Rome Professor Antonella Polimeni
President Fondazione Roma Sapienza Professor Eugenio Gaudio,
Director Department of Architecture and Design Professor Alessandra Capuano
and others.
Ladies and Gentlemen,

It is my pleasure to address you today and to open this International Conference "Technological Imagination in the digital and green transition" organized by Sapienza University of Rome.

Let me say that the title, the contents, and the proposals envisaged by the Conference match perfectly with the main pillars of the flagship initiative shaped by the President Ursula von der Leyen and launched in September 2021: the New European Bauhaus.

The New European Bauhaus is by nature transdisciplinary: it invites architects, designers, artists, scientists, engineers, artisans and citizens to share their expertise in preparing for the future.

With the New European Bauhaus, we want to make the European Green Deal tangible and "palpable".

We want to add a cultural dimension to the economic and technological transformation. This is essential to achieve our overarching goal: making Europe the first climate neutral continent by 2050. And thus reconciling our way of life with nature.

To get there, we need both: a real transformation of our economy and society, and a debate about how we can live in respect of nature and our planet.

The historical Bauhaus was founded in Weimar and Dessau. It turned into a worldwide movement. This did not happen by chance. Some ingredients of what made the historical Bauhaus a success can also be an inspiration for the New European Bauhaus.

Let me mention three.

The first ingredient: The historical Bauhaus was created in a time of **profound transformation**. People were facing the challenges of industrialisation. Gropius and the founders wanted to respond to the emerging needs of a new era. They aimed for solutions that were functional, affordable, but also beautiful. With this principle in mind, they shaped buildings, fabrics and furniture. They always aimed higher than just innovative design. The New European Bauhaus is also striving for this mix of aesthetics and affordability. But we want to add another element: sustainability. Because the New European Bauhaus wants to match sustainability with style.

Now, the second ingredient: **The historical Bauhaus boldly promoted new materials like steel and cement**. Today, we also need to look into new building materials. But this time, it is about sustainability. It is about materials that need less CO_2 in their production process. The New European Bauhaus wants to accelerate the transition of the built environment. It wants to scale up nature-based materials, to support circular design and architecture. Buildings are responsible for 40% of our energy consumption. And if we manage to change this, we have a chance to keep global warming below 1.5 degrees.

The third important element from the historical Bauhaus is **interdisciplinarity**. We want to convene people from different backgrounds and with different competences to share and grow their ideas and visions. We can create a better tomorrow, if culture and technology, innovation and design go hand in hand.

For our New European Bauhaus, the European Commission needs scientists, activists, artists, designers, architects and entrepreneurs. We want to include the ideas and perspectives of all ages and all backgrounds.

Today, at this conference we can contribute to this evolving New European Bauhaus network.

This project is a project of hope. It is a project of change and of economic transformation.

So I hope that this conference can contribute further to making the transformation happen and to connecting more and more people who want to make it happen.

Thank you very much and have a great conference.

Antonio Parenti
Head of the European Commission
Representation
Rome, Italy
antonio.parenti@ec.europa.eu

Foreword by Mario Losasso

Presentation of CONF.ITECH 2022

The green and digital transition represent in the contemporary research field the two new challenges for the evolution of technology within the themes of sociotechnical innovation. Consequently, technology and innovation in contemporary world must adapt to this general objective. Innovation in its hard and digital components once again becomes a central factor in the experimental propulsion that the project is assuming within a processuality and technologies that enable its conception and implementation.

Today, research is increasingly characterised by the need to focus on specialisms that lead to and contribute to the advancement of knowledge and the predictive value of what is studied in the disciplinary fields. However, with respect to the evolving complexity of phenomena, research requires continuous disciplinary interactions to be developed because we understand that one disciplinary field cannot alone address the most important challenges of contemporary society.

New forms of coexistence must be organized in a vision of interdependence and connection, while the green transition requires the definition of the limits of design action and the characteristics of the transformation processes. The new perspective of co-evolution will have to express a design attitude that allows to repair and, where necessary, rebuild the lost links between man, technology and nature.

The green and digital transition represent the two new challenges for the evolution of technology within the themes of social innovation. The Italian society of architectural technology SITdA has been working for a long time on the topics of the relationship between technology and urban and building development within a process-oriented and eco-systemic approach. In the field of technological design of architecture, the scientific society of the technology of architecture has activated research and training sensitivities on the themes of design experimentation framed within process and ecosystem dynamics, aimed at optimising the efficiency of products and processes by reducing inefficiencies and waste.

The SITdA supports research and spin-off outcome on territories through the activities of its scientific clusters. The Scientific Society SITdA has granted its patronage to the CONF.ITECH 2022 Conference, sharing its importance and topicality in view of the new challenges identified in the urban construction and environmental fields by the Next Generation EU Programme and the implementation programmes in the various nations of the European Union.

The topics that will be addressed during the three-day conference are fascinating and challenging, linking innovation, technology, environment, climate change and health.

These topics are strongly interrelated themes in which we are realising that it is impossible to deal with them separately, arriving in the most recent reflections at considering a single health for human beings and for the entire environment which is their living environment.

I would like to remind that the topic of digital culture, nature and technology was the central topic of the SITdA Naples 2020 Conference held last July with a delay due to pandemic difficulties, while the 2022 Conference of the Scientific Society is focused on the topic of the centrality of processes. As we can see, the work carried out in the Departments of Architecture and by the Scientific Societies in the area of architecture is an activity that has picked up significantly, foreshadowing new approaches, new fields of enquiry and new paradigms necessary for the new complexities that constitute the reference scenario of the future.

The experience of this Conference can provide a significant contribution to the sustainable and environmental evolution of the design area in its trans-scalar, multidisciplinary and challenging dimension, overcoming technocratic responses to a demand that requires the integration of the humanistic and technical-scientific dimensions.

Mario Losasso
President
Italian Society of Architectural
Technology—SITdA
Rome, Italy
mariorosario.losasso@unina.it

Foreword by Orazio Carpenzano

Welcoming Address from the Dean

On behalf of the Faculty, I wish to thank the organisers for asking me to give this opening address, while congratulating them on their efforts to bring together, in an international encounter, various perspectives on topics of such decisive importance for the future of our respective territories, as well as their people, living organisms and architecture.

My thanks go to Anna Maria Giovenale, Fabrizio Cumo, Eugenio Arbizzani, Carola Clemente, Eliana Cangelli and Francesca Giofrè, who will be giving talks on technological innovation, the environment, climate change and public health.

Thinking of energy in terms of how it relates to architecture during the green and digital transition means cultivating a *technological imagination*, a topic which leads to the broader question of the man–nature relationship and the possibility that architecture, by applying innovative ideas and concepts while promoting a growing social and emotional intelligence of its own, can contribute to inventing of new types of habitat for mankind on the planet earth, under a new pact for survival that allows all elements, both artificial and natural, to coexist in a sustainable balance which can serve as a preventive measure against the intrinsic destructive force of the Cosmos, an especially pressing problem where mankind has neglected certain methods for dissipating the energy of calamitous events made available by both ancient wisdom and scientific advances.

The 2021 Architecture Biennial, entitled "How Will We Live Together?", implicitly drew the attention of visitors to the need for a new approach to the man–nature relationship, following a thorough review of its historical and ethical premises. Hashim Sarkis, the curator of the exposition's seventeenth edition, passed on the following message: "In a scenario of exasperated political divisions and growing economic inequality, we call upon architects to imagine spaces in which we can all live in fruitful fellowship".

The man–nature relationship has always been a distinctive feature of humanistic and artistic thought on things technical, expressed in the construction of the *civitas*, the physical and political synthesis of civilisation. Medieval mysticism viewed nature as a foreboding wilderness, while the Renaissance redeemed the sense of *technè*, and the Romantic Period, with its high-strung, emotive outlook, led to the elaboration of the concept of the sublime.

Controlling and putting to use the energy generated by nature through sources of heat and movement (wind, sun, water), first through manual effort and then using the tools and machines produced by human ingenuity, was also a topic and challenge that led architecture to express, during the Modern Movement, boundless enthusiasm for the theories of Taylorism, which Corbusier summed up by interpreting human dwellings as machines of habitation.

But it is from the time of Vitruvius that architecture, engaged more or less explicitly with the triad of *utilitas-firmitas-venustas*, has addressed the problem of dissipating heat (or thermal inertia), as well as kinetic and elastic energy (in the case of earthquakes), at various latitudes of the globe, drawing on the available resources and raw materials. Historic Italian buildings, for example, built with walls roughly a metre thick and a structural layout measuring 4 × 4 or 5 × 5 m, have offered excellent thermo-hygrometric performance (in terms of energy consumption), as well as structural dependability (against seismic risk). In both cases the objective is to "mitigate", a term used by many modern-day scholars, the dissipation of different types of energy.

The history of architecture is filled with archetypes that need to be updated and reinvented. Think of the ingenuity it took to build Venice atop a giant underwater forest, or the aesthetic quality of the Tu'rat walls constructed by Southern Italian peasants, the windmills of Northern Europe and countless other magnificent examples of *swarm intelligence* collected by Bernard Rudofsky in his well-known book *Architecture without Architects: a short introduction to non-pedigreed architecture*, published by Doubleday & Company Inc., Garden City, (in 1964), following an exhibition at New York's Museum of Modern Art. Though, in truth, Roberto Pane and Gino Capponi had already touched on the topic in articles on the architecture of Ischia published in "Architettura e Arti decorative" in 1927, as did Giuseppe Pagano at the Milan Triennial "Rural Italian Architecture", published in the Notebooks of the Milan Triennial by Hoepli in 1936.

Looking beyond the confines of architecture, a recent reconsideration of the topic of Cinema and Energy can provide potentially useful points of affinity with architecture, especially in the collection of essays found in issues 7 and 8 of the periodical Imago, under the title *Cinema & Energy. Interdisciplinary Outlooks Combining Science, Aesthetics and Technology*, edited by Marco Maria Gazzano and Enrico Carocci (and published by Bulzoni in 2013). In an essay entitled *Dissipation and Aesthetic Experience*, the physicist Giuseppe Vitiello, in commenting on the film Transeurope Hotel by Luigi Cinque, writes: "The brain [which leads me to think of *swarm intelligence*] is described as an open system engaged in continuous exchanges

with its surrounding environment. In both models and films, antinomies such as information/knowledge, feeling/knowing, blend with each other in the aesthetic experience, the favourable connection between ‘me and the object’ that characterises our existential dimension.”

Dissipation, therefore, should be seen as part of the evolution of our ecosystem, of our contemporary habitat. It gauges the possibilities for losing and exchanging, through a rekindling of collective emotional intelligence and technical and intellectual micro-revolutions. It is a risk that we must continue to face, as otherwise architecture will die, depriving man of an indispensable tool for managing the complexity of the physical habitat through creativity, in order to transfigure energy in a way that, at times, can prove so unreal, and yet so effective and indispensable, that it leads to the construction of new values and sublime beauty.

Orazio Carpenzano
Dean
Faculty of Architecture
Sapienza University of Rome
Rome, Italy
orazio.carpenzano@uniroma1.it

Acknowledgments

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The Magnificent Rector of the Sapienza University of Rome, Prof. Antonella Polimeni, and to the President of Foundation of the Sapienza University, Professor Eugenio Gaudio;

Dr. Antonio Parenti, Head of the European Commission's Representation in Italy, to Prof. Mario Losasso, President of the Italian Society of Architectural Technology, and to Prof. Orazio Carpenzano, Dean of Faculty of Architecture of the Sapienza University of Roma;

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The Scientific Committee, all the reviewers and the Organizing Committee.

Contents

Contributors

Sofia Agostinelli Sapienza University of Rome, Rome, Italy

Hosam Al-Siah Sapienza University of Rome, Rome, Italy

Davide Allegri Polytechnic University of Milan, Milan, Italy

Maria Beatrice Andreucci Sapienza University of Rome, Rome, Italy

Eugenio Arbizzani Sapienza University of Rome, Rome, Italy

Marianna Arcieri Polytechnic University of Milan, Milan, Italy

Maria Vittoria Arnetoli University of Florence, Florence, Italy

Stefano Arruzzoli Polytechnic University of Milan, Milan, Italy

Davide Astiaso Garcia Sapienza University of Rome, Rome, Italy

Nazly Atta Polytechnic University of Milan, Milan, Italy

Gigliola Ausiello University of Naples Federico II, Naples, Italy

Maria Azzalin Mediterranean University of Reggio Calabria, Reggio Calabria, Italy

Meri Batakoja Ss. Cyril and Methodius University, Skopje, North Macedonia

Silvia Battaglia Polytechnic University of Milan, Milan, Italy

Oscar Eugenio Bellini Polytechnic University of Milan, Milan, Italy

Carla Álvarez Benito European University Foundation (EUF), Brussels, Belgium

Roberto Bianchi Mercatorum University, Rome, Italy

Leonardo Binni Polytechnic University of Marche, Ancona, Italy

Martina Bocci Polytechnic University of Turin, Turin, Italy

Andrea Bocco Polytechnic University of Turin, Turin, Italy

Arthur Bohn Polytechnic University of Turin, Turin, Italy

Roberto Bologna University of Florence, Florence, Italy

Steven Boon Housing Anywhere, Rotterdam, Netherlands

Martina Bosone Research Institute on Innovation and Services for Development of the Italian National Research Council (CNR-IRISS), Naples, Italy

Andrea Brambilla Polytechnic University of Milan, Milan, Italy

Timothy Daniel Brownlee University of Camerino, Camerino, Italy

Erica Brusamolin Polytechnic University of Milan, Milan, Italy

Maddalena Buffoli Polytechnic University of Milan, Milan, Italy

Francesca Caffari ENEA, Rome, Italy

Nicolandrea Calabrese ENEA, Rome, Italy

Gisella Calcagno University of Florence, Florence, Italy

Guido Callegari Polytechnic University of Turin, Turin, Italy

Maria Canepa University of Genoa, Genoa, Italy

Eliana Cangelli Sapienza University of Rome, Rome, Italy

Monica Cannaviello University of Campania "L. Vanvitelli", Aversa, Italy

Stefano Capolongo Polytechnic University of Milan, Milan, Italy

Cheren Cappello University of Sassari, Sassari, Italy

Barbara Cardone University of Roma Tre, Rome, Italy

Tecla Caroli Polytechnic University of Milan, Milan, Italy

Giovanni Castaldo Polytechnic University of Milan, Milan, Italy

Giulia Centi ENEA, Rome, Italy

Francesca Ciampa University of Naples Federico II, Naples, Italy

Andrea Ciaramella Polytechnic University of Milan, Milan, Italy

Adriana Ciardiello Sapienza University of Rome, Rome, Italy

Federico Cinquepalmi Sapienza University of Rome, Rome, Italy

Carola Clemente Sapienza University of Rome, Rome, Italy

Marta Cognigni Polytechnic University of Milan, Milan, Italy

Raffaella Colombo Istituto Comprensivo Rinnovata Pizzigoni, Milan, Italy

Alessandra Corneli Polytechnic University of Marche, Ancona, Italy

Nataša Ćuković-Ignjatović University of Belgrade, Belgrade, Serbia

Fabrizio Cumo Sapienza University of Rome, Rome, Italy

Laura Daglio Polytechnic University of Milan, Milan, Italy

Anna Dalla Valle Polytechnic University of Milan, Milan, Italy

Francesca Daprà Polytechnic University of Milan, Milan, Italy

Roberto D'Autilia University of Roma Tre, Rome, Italy

Alberto De Capua Mediterranea University of Reggio Calabria, Reggio Calabria, Italy

Jacopo Dell'Olmo Sapienza University of Rome, Rome, Italy

Valentina Dessì Polytechnic University of Milan, Milan, Italy

Raffaela De Martino University of Campania L. Vanvitelli, Aversa, Italy

Stefania De Medici University of Catania, Catania, Italy

Maria Giovanna Di Bitonto Polytechnic University of Milan, Milan, Italy

Marco Di Ludovico University of Naples Federico II, Naples, Italy

Mohamed Eledeisy Sapienza University of Rome, Rome, Italy

Lidia Errante Mediterranea University of Reggio Calabria, Reggio Calabria, Italy

Daniele Fanzini Polytechnic University of Milan, Milan, Italy

Emilio Faroldi Polytechnic University of Milan, Milan, Italy

Marco Ferrero Sapienza University of Rome, Rome, Italy

Maria Fianchini Polytechnic University of Milan, Milan, Italy

Irene Fiesoli University of Florence, Florence, Italy

Maria F. Figueira International Union of Property Owners (UIPI), Brussels, Belgium

Antonio Fioravanti Sapienza University of Rome, Rome, Italy

Rossella Franchino University of Campania L. Vanvitelli, Aversa, Italy

Caterina Frettoloso University of Campania L. Vanvitelli, Aversa, Italy

Valentina Frighi University of Ferrara, Ferrara, Italy

Matteo Gambaro Polytechnic University of Milan, Milan, Italy

Pablo Garrido Torres Universitat Politécnica de Catalunya, Barcelona, Spain

Vincenzo Gattulli Sapienza University of Rome, Rome, Italy

Marko Gavrilović University of Belgrade, Belgrade, Serbia

Emanuela Giancola UiE3-CIEMAT, Madrid, Spain

Francesca Giglio Mediterranea University of Reggio Calabria, Reggio Calabria, Italy

Elisabetta Ginelli Polytechnic University of Milan, Milan, Italy

Francesca Giofrè Sapienza University of Rome, Rome, Italy

Serena Giorgi Polytechnic University of Milan, Milan, Italy

Matteo Giovanardi Polytechnic University of Turin, Turin, Italy

Anna Maria Giovenale Sapienza University of Rome, Rome, Italy

Salvatore Giuffrida University of Catania, Catania, Italy

Evelyn Grillo Mediterranea University of Reggio Calabria, Reggio Calabria, Italy

Daniele Groppi Sapienza University of Rome, Rome, Italy

Maria Teresa Gullace Polytechnic University of Milan, Milan, Italy

Guillaume Habert ETH Zürich, Zürich, Switzerland

Sam Haghdady Islamic Azad University, Mashhad, Iran

Zakia Hammouni CRIR (Centre for Interdisciplinary Rehabilitation Research of Greater Montréal), Université de Montréal, Montréal, Canada;
Université McGill, Montréal, Canada;
Université du Québec à Trois-Rivière, Trois-Rivière, Canada

Giulio Hasanaj University of Florence, Florence, Italy

Mohammad Hassani Islamic Azad University, Kerman Branch, Iran

Tihana Hrastar University of Zagreb, Zagreb, Croatia

Azim Heydari Sapienza University of Rome, Rome, Italy;
Graduate University of Advanced Technology, Kerman, Iran

Dušan Ignjatović University of Belgrade – Faculty of Architecture, Belgrade, Serbia

Nataša Ćuković Ignjatović University of Belgrade – Faculty of Architecture, Belgrade, Serbia

Alexander Achille Johnson Vagelos College of Physicians and Surgeons, Columbia University, New York, USA

Fuat Emre Kaya University of Sassari, Sassari, Italy

Farshid Keynia Graduate University of Advanced Technology, Kerman, Iran

Alara Kutlu Polytechnic University of Milan, Milan, Italy

Adel Lakzadeh Islamic Azad University, Kerman Branch, Iran

Mario Lamagna Sapienza University of Rome, Rome, Italy

Massimo Lauria Mediterranean University of Reggio Calabria, Reggio Calabria, Italy

Francesco Leali UNIMORE, Modena, Italy

Adriano Magliocco University of Genoa, Genoa, Italy

Camilla Maitan Polytechnic University of Milan, Milan, Italy

Mariateresa Mandaglio Mediterranea University of Reggio Calabria, Reggio Calabria, Italy

Silvia Mangili Polytechnic University of Milan, Milan, Italy

Paola Marrone University of Roma Tre, Rome, Italy

Riccardo Marzo NCLAB, Rome, Italy

Luciana Mastrolonardo University G. d'Annunzio, Pescara, Italy

Redina Mazelli Polytechnic University of Turin, Turin, Italy

Eleonora Merolla Polytechnic University of Turin, Turin, Italy

Marco Migliore Polytechnic University of Milan, Milan, Italy

Martino Milardi Mediterranea University of Reggio Calabria, Reggio Calabria, Italy

Nikola Miletić University of Belgrade – Faculty of Architecture, Belgrade, Serbia

Jelena Milošević University of Belgrade, Belgrade, Serbia

Pietro Montani Honorary Professor of Aesthetics, Sapienza University of Rome, Rome, Italy

Ilaria Montella University of Roma Tre, Rome, Italy

Carol Monticelli Polytechnic University of Milan, Milan, Italy

Lucia Montoni University of Florence, Florence, Italy

Michele Morganti Sapienza University of Rome, Rome, Italy

Marco Morini ENEA, Rome, Italy

Noemi Morrone Istituto Comprensivo Rinnovata Pizzigoni, Milan, Italy

Erica Isa Mosca Polytechnic University of Milan, Milan, Italy

Elena Mussinelli Polytechnic University of Milan, Milan, Italy

Francesco Muzi Sapienza University of Rome, Rome, Italy

Francesco Nardi NCLAB, Rome, Italy

Giuliana Nardi University of Roma Tre, Rome, Italy

Ludovica Nasca University of Catania, Catania, Italy

Benedetto Nastasi Sapienza University of Rome, Rome, Italy

Berardo Naticchia Polytechnic University of Marche, Ancona, Italy

Maicol Negrello Polytechnic University of Turin, Turin, Italy

Aleksandra Nenadović University of Belgrade, Belgrade, Serbia

Antonio Novellino ETT SpA, Genoa, Italy

Filippo Orsini Polytechnic University of Milan, Milan, Italy

Giuseppe Orsini Sapienza University of Rome, Rome, Italy

Maria Giovanna Pacifico University of Naples Federico II, Naples, Italy

Giancarlo Paganin Polytechnic University of Milan, Milan, Italy

Massimo Palme Universidad Técnica Federico Santa María, Valparaíso, Chile

Elisabetta Palumbo University of Bergamo, Bergamo, Italy

Giulio Paparella Sapienza University of Rome, Rome, Italy

Spartaco Paris Sapienza University of Rome, Rome, Italy

Francesco Pasquale UNIMORE, Modena, Italy

Lorenzo Mario Pastore Sapienza University of Rome, Rome, Italy

Jelena Pavlović University of Belgrade, Belgrade, Serbia

Maura Percoco Sapienza University of Rome, Rome, Italy

Giacomo Pierucci University of Florence, Florence, Italy

Claudio Piferi University of Florence, Florence, Italy

Maria Rita Pinto University of Naples Federico II, Naples, Italy

Anna Pirani Centre for Theoretical Physics, Trieste, Italy

Giuseppe Piras Sapienza University of Rome, Rome, Italy

Nicola Pisani Colouree S.r.l., Genoa, Italy

Matteo Poli Polytechnic University of Milan, Milan, Italy

Riccardo Pollo Polytechnic University of Turin, Turin, Italy

Alice Paola Pomè Polytechnic University of Milan, Milan, Italy

Gianluca Pozzi Polytechnic University of Milan, Milan, Italy

Giulia Procaccini Polytechnic University of Milan, Milan, Italy

Donatella Radogna University "G. D'Annunzio" of Chieti-Pescara, Pescara, Italy

Alberto Raimondi University of Roma Tre, Rome, Italy

Andrea Rebecchi Polytechnic University of Milan, Milan, Italy

Rosaria Revellini IUAV University of Venice, Venice, Italy

Diletta Ricci Sapienza University of Rome, Rome, Italy;
Delft University of Technology, Delft, Netherlands

Guglielmo Ricciardi Polytechnic University of Turin, Turin, Italy

Alessandro Rogora Polytechnic University of Milan, Milan, Italy

Manuela Romano Polytechnic University of Milan, Milan, Italy

Rosa Romano University of Florence, Florence, Italy

Sabri Ben Rommane Erasmus Student Network AISBL (ESN), Brussels, Belgium

Laura Rosini University of Roma Tre, Rome, Italy

Massimo Rossetti IUAV University of Venice, Venice, Italy

Federica Rosso Sapienza University of Rome, Rome, Italy

Irina Rotaru Saint Germain-en-Laye, France

Helena Coch Roura Universitat Politécnica de Catalunya, Barcelona, Spain

Ana Šabanović University of Belgrade, Belgrade, Serbia

Samaneh Safaei Graduate University of Advanced Technology, Kerman, Iran

Ferdinando Salata Sapienza University of Rome, Rome, Italy

Sara Sansotta Mediterranea University of Reggio Calabria, Reggio Calabria, Italy

Antonello Monsù Scolaro University of Sassari, Sassari, Italy

Paolo Simeone Polytechnic University of Turin, Turin, Italy

Francesco Sommese University of Naples Federico II, Naples, Italy

Tianzhi Sun Polytechnic University of Milan, Milan, Italy

Chiara Tagliaro Polytechnic University of Milan, Milan, Italy

Maurizio Talamo Tor Vergata University of Rome, Rome, Italy

Andrea Tartaglia Polytechnic University of Milan, Milan, Italy

Chiara Tonelli University of Roma Tre, Rome, Italy

Agata Tonetti IUAV University of Venice, Venice, Italy

Matteo Trane Polytechnic University of Turin, Turin, Italy

Antonella Trombadore University of Florence, Florence, Italy

Maria Rosa Trovato University of Catania, Catania, Italy

Massimo Vaccarini Polytechnic University of Marche, Ancona, Italy

Carlo Vannini Sapienza University of Rome, Rome, Italy

Konstantinos Venis Polytechnic University of Milan, Milan, Italy

Maria Pilar Vettori Polytechnic University of Milan, Milan, Italy

Giulia Vignati Polytechnic University of Milan, Milan, Italy

Serena Viola University of Naples Federico II, Naples, Italy

Antonella Violano University of Campania "L. Vanvitelli", Aversa, Italy

Walter Wittich CRIR (Centre for Interdisciplinary Rehabilitation Research of Greater Montréal), Université de Montréal, Montréal, Canada

Alessandra Zanelli Polytechnic University of Milan, Milan, Italy

Edwin Zea Escamilla ETH Zürich, Zürich, Switzerland

Bojana Zeković University of Belgrade – Faculty of Architecture, Belgrade, Serbia

Alberto Zinno Stress Scarl, Naples, Italy

Nour Zreika Polytechnic University of Milan, Milan, Italy

Franca Zuccoli University of Milano-Bicocca, Milan, Italy

Milijana Živković University of Belgrade, Belgrade, Serbia

Maša Žujović University of Belgrade, Belgrade, Serbia

Chapter 24
Technologies for the Construction of Buildings and Cities of the Near Future

Eugenio Arbizzani

Abstract The objectives and solutions that become necessary, within the green and digital transition, can radically interfere with existing methods for designing and producing buildings and portions of cities. The "factory" and the "construction site" were one and the same thing, in the production of buildings, up until the seventies of the last century. Following the advent of prefabrication, the factory has gradually been separated from the construction site, to the point where industrial manufacturing now accounts for much of the production value of buildings through the dry-assembly of factory-made products and components. The development of enabling technologies involves knowledge-intensive technologies associated with a high level of research and development, rapid innovation cycles, substantial investment costs and highly qualified jobs. The development of this field could produce a new chain of industrial services for companies based in our country.

Keywords Factory-made building components · Smart robot assembly systems · Enabling technologies · Hybrid structural systems · Man–machine active interaction

24.1 Introduction

In the green and digital transition currently underway, the objectives and solutions that become necessary can radically interfere with existing methods for designing and producing buildings and portions of cities, seeing that they have to optimize the use of energy resources and the flows of materials, whose largest single consumer is the built environment.

The ongoing evolution of Industry 4.0 towards 5.0 has inevitably made the preservation and improvement of the existing ecosystem a key factor in the development of our constructed environment. As a result, processes and systems of production need to be radically restructured, orienting technological innovations of the digital

E. Arbizzani (✉)
Sapienza University of Rome, Rome, Italy
e-mail: eugenio.arbizzani@uniroma1.it

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era towards decarbonisation, while, at the same time, supporting new paradigms of social living.

The green and digital transition has brought to the fore objectives and solutions that radically interfere with existing methods for the planning, design and production of goods and services, as well as with the utilization of energy and material resources.

24.2 Building Factory Versus Construction Site

In the production of buildings, the "factory" and the "construction site" were one and the same thing up until the seventies of the last century. Fifty years later, in Tokyo, the dismantling of the Nakagin Capsule Tower by Kisho Kurokawa is underway.[1] That iconic building was the result of the Japanese Metabolist utopia, whose goal was to arrive at the industrial, off-site production of housing modules designed to colonize buildings equipped with the most up-to-date technologies, in accordance with pre-established maintenance programs and planned life cycles.

The history of this building, and of built architecture in general, proceeded—fortunately, in my opinion—in other directions. These proved more respectful of the cultural context of cities, but also less aware of the need for production with more sustainable environmental impacts and—even more importantly—of the advantages of taking into consideration, in the design process, the optimal use of resources, as well as their eventual recycling at the end of their life cycles.

The fact is that, following the advent of prefabrication, the factory has gradually been separated from the construction site, as over the last 30 years an increasingly evolved industrial manufacturing sector has developed, to the point where it now accounts for much of the production value of buildings through the dry-assembly of factory-made products and components.

With the advent of robotization, it is easy to imagine that our sector's production cycle will undergo further transformations. However, it should be emphasized that urban context and cultural heritage will always constitute an "unicum" whose social and cultural value cannot simply be reproduced. The "second machine age"—referred to as "Industry 5.0" in the programs of the European Commission—is unlikely to see machines prevail over the work of humans, though there will be substantial changes in methods of design and in interactions between man and his built environment.[2]

This revolution will be significant enough to lead to an evolutionary change in the direction of a new collective imagination capable of allowing us to conceive—albeit unconsciously—of new and unpredictable scenarios for the development of interactions between man, machines and the built environment.

New technologies are designed to transform the system of habitation and the urban context by integrating ICT systems with technical spaces and components, as well

[1] Cfr: https://www.greyscape.com/nakagin-capsule-tower-preservation-and-restoration-project/.

[2] Cfr: https://ec.europa.eu/info/news/industry-50-towards-more-sustainable-resilient-and-human-centric-industry-2021-jan-07_en.

as with artificial intelligence and the robotization of connected and collaborative construction processes, both in production facilities and at work sites.[3]

These innovations can provide users and civil society with a better quality of life in indoor and urban environments while orienting scientific advances towards an effective culture of sustainability, reuse and safety.

For this reason, there is now an unavoidable need to balance the demand for innovative production systems able to guarantee the quality and cost-effectiveness of projects with the obligation to preserve the environmental heritage, which otherwise the planet risks tragically losing.

The topics of the session were specifically designed to maintain the connection between research on the industrialization of the construction sector and that on the development—sustainable, human-centric and resilient—of the environment to be built in the near future.

The technology session presented three short interviews on these topics, both to introduce the theme of the latest research and to outline a vision of the discipline that draws meaning from its origins, so as to proceed even further, towards a scenario which appears to lay the groundwork for a thoroughgoing change.

In the first interview, Yotto Koga, a young software designer and researcher at the Autodesk Robotics Laboratory in San Francisco, discusses his research on "smart robot assembly systems".[4]

In the second interview, Professor Fabrizio Schiaffonati, one of our principal schoolmaster of discipline, is asked to lay out his vision of the relationship between the factory and the construction site, as well as the future role of design.[5]

In the last interview, architect Sara Codarin, who earned her Ph.D. at the University of Ferrara with a thesis on "Building Robots",[6] and is now an assistant professor at Lawrence Technology University, College of Architecture and Design, illustrates her research on robots in higher education.

Also invited to the Technology Session, in the role of discussant, was Francesco Leali, full professor at the Enzo Ferrari Department of Engineering of the University of Modena and Reggio Emilia and Dean of the Master's Program in Advanced Automotive Engineering and Coordinator of the Unimore Automotive Academy project.

The Master's Degree Programme in Advanced Automotive Electronic Engineering is an interuniversity, international course of study established as a collaborative initiative of the Universities of Bologna, Ferrara, Modena and Reggio Emilia and the University of Parma, working together with the world's most prestigious automotive companies headquartered in Italy.

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[3] Arbizzani, E. (2017). Informatizzazione nel processo di trasformazione dell'ambiente costruito. In: Civiero P. (Ed.). *Tecnologie per la riqualificazione. Soluzioni e strategie per la trasformazione intelligente del comparto abitativo esistente.* Maggioli Editore, IT: Sant'Arcangelo di Romagna.

[4] Cfr.: https://www.universal-robots.com/case-stories/autodesk/.

[5] Cfr.: Schiaffonati, F. (2021). *Lettera a un aspirante architetto.* Milan, IT: Lupetti.

[6] Cfr.: Codarin, S., (2020). *Innovative Construction Systems within Building Processes. An Approach to Large-scale Robotic Additive Layer Manufacturing for the Conservation of Cultural Heritage.* Thesis for an International Doctorate in Architecture and Urban Planning, University of Ferrara.

Professor Leali was invited because it is the automotive sector that has had the technological and organizational innovations of Industry 4.0 in place for the longest time. In this sector, advances in manufacturing have gone hand-in-hand with the revolution in approaches to planning and design.

The scenario that he outlined might appear far removed from the architectural culture and the urban reality that surrounds us, but I believe we will soon see a progressive hybridization of the various production contexts. Just think of the interactions already taking place between electric vehicles, the energy production systems of our buildings and the urban infrastructures of the most advanced cities. The resulting technological imagination appears much more immersive and exciting than might seem to be the case in these difficult times.[7]

Five reports were presented during the session, illustrating the outlined scenario, together with proposals for innovations in teaching at faculties of architecture.

The combination of the interviews, our discussant speech and the session papers provided us with glimpses of what we can imagine for the future, highlighting certain aspects of particular relevance to the scientific community centred around themes of technological design in the contemporary era.

The coexistence of urban districts still in search of new environmental and social balances, together with the very latest technological research in construction, points to the possibility of progressing towards a society in which innovation not only benefits the shareholders who hold the keys, but also moves in the direction of more generally increasing the well-being of all stakeholders.

In the case of the drivers of technological innovation which we addressed in this session, they can be classified according to five lines of research and development that appear worthy of note, less because of how widespread they are than based on their ability to drive the innovative processes necessary for a vigorous recovery of production in the construction sector. They can be summarized in four key terms: key enabling technologies; new technological teaching of design; energy-conscious buildings; hybrid building technologies.

24.3 Enabling Technologies

The development of enabling technologies[8] involves: “knowledge-intensive technologies associated with a high level of research and development, rapid innovation cycles, substantial investment costs and highly qualified jobs”. Such technologies are of systemic importance, because they feed the value of the production-system chain and have the capacity to innovate processes, products and services in all economic sectors of human activity. Furthermore, a product based on enabling technology uses

[7] Camorino, A., (2016). L’immaginario tecnologico. Un’analisi sociologica della cosmologia contemporanea, A Journal of the Social Imaginary. www.imagojournal.it.

[8] The Ministry of Economic Development, (2018). *National Plan for Industry 4.0. Investments, Productivity and Innovation.*

advanced manufacturing technologies and increases the commercial and social value of a good or service.

With regard to our production sector, the most applicable enabling technologies concern:

- additive manufacturing, off-site and on-site, for the production of components, parts of buildings and housing modules on demand;
- augmented reality and artificial intelligence, to support the creative and design processes of buildings and cities;
- horizontal and vertical integration of information, to create production and distribution process chains for industrialized building products, from the manufacturer to the designer and the user, to be integrated into construction and urban-development projects;
- cloud and big data, to manage large amounts of data on open systems and on digital twins of buildings and urban districts;
- robotics and wearable smart tools, to ensure better safety conditions for construction workers, in factories and on construction sites.

All these process innovations seem able to generate noteworthy progress in teaching and training systems for construction and urban design. In the near future, they will be significantly transformed to adapt to user requests. On the one hand, they must become increasingly self-explanatory, user-friendly and virtually immersive, so that students can learn with greater ease and interest, while, at the same time, they need to more effectively support the new skill requirements of the construction industry.

A third field of investigation, perhaps the most popular and thoroughly tested to date, concerns technological innovations in materials, products and systems to ensure the energy efficiency and the energy balances, of buildings. This theme requires a new vision of the interface between building components and plant systems. "Integrability" was a performance design concern of the 1980s, but it was a concept limited to aspects of the physical interfaces between building elements. Today, it is a question of giving content to the functional interface, along with the reciprocal benefits that such a dialogue can produce by ensuring a proper balance between the energy demanded and the energy produced.

The goal of zero-energy buildings can already be reached today, at least in new constructions, but soon we will see, with smart automotive construction and positive energy districts providing support as well, buildings make a notable contribution to lowering the overall demand for energy and reducing climate-altering emissions.[9]

[9] Cfr: United Nations Environment Programme (2020). *2020 Global Status Report for Buildings and Construction: Towards a Zero-emission, Efficient and Resilient Buildings and Construction Sector*. Nairobi.

24.4 Evolution of Construction Technologies

This first encounter of ours offered only glimpses of a sector with enormous prospects for technological innovations in construction and built architecture. I am referring, in general, to the evolution of construction technologies, which for many years have shown only minor advances involving individual materials or fragmented processes, with adequate solutions yet to be offered to the new problems involving the resilience and sustainability of the built environment.

These have to do with the redesigning of natural materials in terms of their production and use, as well as the hybridization of various technological cycles: wood, steel, concrete, glass; but also bamboo, natural fibres and bio-plastics.[10] The integration of different component materials can determine which technical elements and portions of the construction best satisfy performance requirements, making appropriate use of materials in those instances where they are most efficient. An example is the rapid evolution of hybrid structural systems that combine wood, steel and concrete, and which already make it possible to design tall hybrid wooden buildings.[11] Also of interest is the opportunity for increasingly lighter buildings, with materials optimized for their specific uses, meaning that ever smaller quantities are needed. This particular innovation contributes to lowering the demand for non-renewable quarry materials while reinforcing the recycling and reuse chain and promoting heightened awareness of the fact that the goal of zero emissions is indeed possible.

The development of this field could produce a new chain of industrial services for companies based in our country, along with the possibility of exporting this experience to emerging countries that do not yet emit climate–changing gases at invasive levels, but may soon become involved in processes of social and economic progress, which could play a decisive role in establishing a renewed balance of the anthropized environment.

While these are the specialized topics that we wish to highlight, in more general terms, it can be said that the themes addressed in the five sessions proposed some elements pertinent to various sectors, in particular for the development of innovation in a sector that is now widely aware of the challenges ahead:

- the opportunity, or rather the urgent need, to use all forms of innovation in instruments, processes and products to support the level of well-being of people while working towards a balanced readjustment of the built environment;
- the massive availability of new solutions and equipment, but, at the same time, the difficulty our sector has in exploiting its potential, due to a scenario in the construction industry which is still underdeveloped compared to other sectors of civil society and the production apparatus;

[10] Cfr: Antonini, E., Boeri, A., Giglio, F. (2020). *Emergency-Driven Innovation. Low-Tech Buildings and Circular Design.* Springer. http://doi.org/10.1007/978-3-030-55969-4.

[11] Cfr: CTBUH 2022 Steel-Timber Hybrid Buildings Conference, 23–24 May, Chicago, https://ctbuhsteeltimber.com.

- with the mass media now spreading the message that everything proposed by the market is "sustainable" (sustainable cars, sustainable basil, sustainable holidays …), the need to develop methodologies and control systems which are able to support, under recognized scientific parameters, true sustainability—social, production-related, economic and environmental—of every production activity.

One factor has always hindered the development of a truly industrialized construction sector: the need to customize urban and construction products on the basis of information provided by the end user and the constraints of the existing building stock.

But given the evolutionary process currently underway, new opportunities can be found, thanks to technologies such as cloud computing, the Internet of Things, virtual and augmented reality, for controlling production processes through dialogue between machines, or between machines and humans, or by offering the possibility of foreseeing problems and proposing timely, effective solutions, including measures geared towards limiting emissions of pollutants and social inequality, as well as others designed to protect the rights and safety of workers (Arbizzani E., 2017).

Under the European Commission's vision, the Industry 5.0 of the near future must increasingly become a "resilient provider of prosperity" able to ensure that the production of goods and services regains respect for the limits of the planet and places the well-being of users and workers at the centre of production processes. Nowadays, only large companies can implement digital technologies in their production processes, while small and medium-sized companies—typical of almost all enterprises in the construction sector—are unable to follow this trend.

The objective set by the European Commission for the development of technology, as the main tool for ensuring the sustainability of evolved production systems, appears to go in the direction of supporting precisely those sectors, such as construction, which are most fragile and faced with difficulties in their technological evolution, so as to encourage any process promoting circular economics, while providing increased skills and employment for workers.

As will be the case in all the most advanced industrial sectors, the make-up of new construction workers will be shaped by their interaction with technology, rather than by any replacement of those workers by machines. Workers supported by exoskeletons, augmented reality or virtual reality, or who are equipped with new-generation safety devices or connected to artificial intelligence or big data, or workers who work alongside robots, all appear to be futuristic visions. But, it is precisely the active interaction between man and machine which appears to be best suited to the evolution of a sector featuring intensive employment of human personnel, such as the construction sector.

With the decision taken recently by the government, we have come to the end of the construction boom that was temporarily underway in our country, thanks to the measures of economic support provided to the construction sector. Soon, there will be an urgent need to train and retool everybody working in the industry with the new digital production skills.

Initiatives carried out under a multidisciplinary, data-driven digital strategy can respond to the growing demand for higher quality, based on a predictable timetable in a complex environment, as well as to the need to satisfy requirements of environmental, social and economic sustainability, in combination with both technological and cultural considerations.

24.5 Conclusions

In all the latest reports on Europe as a whole and on individual countries, business enterprises are shown to be struggling with a scarcity of technical and digital skills, while the institutional bodies responsible for training appear incapable of meeting such demands. There can be no more putting off the need to return, even in our faculties of architecture, to an approach, both in teaching and scholarship, which combines both theory and practice.

Or better yet, an approach which preserves the paradigms of theoretical teaching for which our faculties are universally renowned, while resuming, with the utmost creative, organizational and technological effort, teaching of the discipline based on practical and productive project activities.

An approach both multidisciplinary and trans-disciplinary must be put in place, regarding which this conference has simply offered food for thought by inviting leading scholars from other disciplines to present their visions of innovation in scientific research in the sector.

We all believe that technology has always consisted of a striving on the part of mankind, a reflection of people's aspirations to improve their cultural situations, their very lives. The teaching of the discipline of design based on practical experience and immersion in constructed reality constitutes, at present, an unavoidable necessity, but one that can be used to expand the strengths of the sector in the direction of increasingly innovative, inclusive and sustainable scenarios for our surrounding environment.

The students who graduate from our faculties must be prepared to operate in their chosen field, but above all they must be able to use their skills as designers to produce a positive impact on the environment by applying their creativity to the real world. At the same time, there is an emergency that must be faced by a category of professionals obliged to undergo a rapid evolution of their knowledge and even more importantly of their cultural approach, in order to prepare them for a multidisciplinary profession in which the new tools of project support play a significant role.

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