SCIENCE + TECHNOLOGY + ARTS: Lessons Learned from a Decade of European Transdisciplinary Innovation

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S+T+ARTS

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Foreword

KRISZTINA STUMP (HEAD OF UNIT, EUROPEAN COMMISSION, DG CONNECT, MEDIA POLICY MEDIA CONVERGENCE AND SOCIAL MEDIA)

At first glance, arts and science may seem worlds apart—each powerful, each with its language and logic. Yet over a decade of STARTS has shown us that when they meet, something exceptional happens. Their alliance sparks curiosity, empathy, and imagination—and gives people the opportunity to turn ideas into action. Together, the arts, science, and technology in STARTS offer Europe a creative engine for addressing real-world challenges.

This book, *SCIENCE+TECHNOLOGY+ARTS: Lessons Learned from a Decade of European Transdisciplinary Innovation*, captures that journey: it shows how creativity, evidence, and engineering—working hand in hand and connecting with citizens—can unlock new paths for Europe's digital, sustainable, and socially inclusive transitions.

The results speak for themselves—and they speak louder and more clearly than words ever could. When water scarcity and pollution demanded fresh thinking, STARTS brought together artists, researchers, regions, and ports to prototype solutions that drive place-based innovation along Europe's river basins and coasts. In fashion, designers joined forces with materials scientists and engineers to develop circular textiles, on-demand manufacturing, and low-impact finishing—proving that aesthetics and sustainability can reinforce, not contradict, one another. In cities, algorithmic design and environmental data have inspired gardens that favor pollinators, transforming gardens and public spaces into living artworks. And as artificial intelligence reshapes society, STARTS has supported bold cultural inquiry into creative rights, transparency, and accountability—helping make complex technologies accessible to citizens and policymakers alike.
Beyond these examples also lies something deeper: community. Over the years, STARTS has nurtured a vibrant network of artists, industry, SMEs, universities, cultural venues, cities, and citizens, many of whom return to work with one another again and again. This community builds skills, strengthens trust, advances media and data literacy, and accelerates the uptake of innovation—turning prototypes into pilots and pilots into shared European capabilities.

At the European Commission, we launched STARTS to bridge two worlds that had rarely been brought together: the laboratories of science and the studios of art. We did this with the belief that Europe's most resilient innovations emerge where technology meets human creativity. Over the years, we have sustained this vision through prizes, residencies, "Lighthouse" programmes, and policy experimentation that embed artists in research, industry, and public services. Seeing STARTS evolve from an idea into a thriving community has been one of the most inspiring aspects of our work. Looking ahead, the experience of STARTS will continue to inspire how we think about Europe's innovation policies—encouraging new ways to connect artistic vision, scientific excellence, and technological progress. Its methods and partnerships offer valuable models for the challenges and opportunities that lie ahead.

May the lessons in these pages inspire you to adapt and scale STARTS models—whether to steward water, decarbonize fashion, regenerate landscapes for biodiversity, or shape AI with democratic values at its core. The next decade will demand nothing less of us than creativity with consequence.

Acknowledgements

This book is the result of a collective journey. Over more than a decade, STARTS has grown from an idea into a European movement, shaped by the commitment, curiosity, and courage of countless individuals and organisations across Europe and beyond. It would not exist without the many professionals who believed in the value of collaboration across disciplines, sectors, and cultures—and who were willing to step into unknown territory together.

We would like to thank all the artists, scientists, technologists, researchers, educators, entrepreneurs, policymakers, and cultural practitioners who have contributed their time, expertise, and imagination to STARTS projects, residencies, prizes, academies, regional centres, and technical pilots. Their work has demonstrated again and again that innovation is strongest when it is open, critical, and rooted in society.

In particular, we wish to acknowledge the leading role of artists within STARTS. Artists have not merely contributed creativity; they have shaped questions, challenged assumptions, and opened new perspectives. Through their practices, they have broadened the understanding of innovation, ensuring that science and technology remain connected to human values, social realities, cultural contexts, and helping to translate complexity into shared understanding.

S+T+ARTS

INTRODUCTION

Science, Technology, and Arts Collaboration

PETER FRIESS (EC, DG CNECT), PETER BURIAN (EC, DG CNECT) AND RALPH DUM

ART AND TECHNOLOGY FOR SOCIETAL TRANSFORMATION

In an era defined by rapid technological advancements and profound societal shifts, the convergence of Science, Technology, and the ARTS has emerged as a powerful framework for fostering innovation and addressing global challenges. Governments worldwide recognize the urgency of steering this convergence toward equitable, sustainable, and inclusive outcomes. The integration of science, technology, and the arts embodies this vision, emphasizing the transformative potential of collaboration across disciplinary boundaries to design solutions that are not only functional but also socially meaningful and ethically sound. As Bruno Latour suggests with his statement "We have never been modern", the boundaries we draw between the worlds of science, technology, and art are not as rigid as they seem.

From a governmental perspective, collaboration between science, technology, and the arts is far more than a simple exercise—it is a strategic approach to empowering communities, unlocking economic potential, and addressing the urgent needs of citizens. Such partnerships align with public policy objectives, enhance societal well-being, and provide a blueprint for integrating human-centered innovation into governance frameworks.

THE ROLE OF SCIENCE, TECHNOLOGY, AND ARTS COLLABORATION IN A CHANGING WORLD

ADDRESSING COMPLEXITY THROUGH CROSS-DISCIPLINARY COLLABORATION

Governments today are faced with increasingly complex challenges: climate change, social inequalities, and digital ethics. Traditional policy responses may struggle to address the interconnected nature of these issues. Science, technology, and arts collaborations offer a novel paradigm, bringing together scientists, technologists, and artists to generate holistic solutions that account for human values, cultural contexts, and long-term impacts.

For instance, projects arising from these collaborations have demonstrated how artistic interventions can humanize technology, making it accessible and relatable to citizens. Whether in designing urban spaces, developing human-friendly robots, exploring AI for music, or creating digital tools for education, these partnerships challenge conventional approaches and introduce fresh perspectives. Governments can harness this potential by embedding such methodologies into their policy- and decision-making processes, ensuring that innovation is guided by creativity and empathy.

PROMOTING SUSTAINABLE DEVELOPMENT

The global commitment to the United Nations' Sustainable Development Goals (SDGs) calls for systemic innovation that is environmentally conscious, socially just, and economically viable. Science, technology, and arts collaborations can serve as a catalyst for such innovation by inspiring solutions that are not only technologically advanced but also ecologically and culturally sustainable.

Vilem Flusser articulates this beautifully: "To design is to invent new relationships". Through these collaborations, governments can foster a design-driven approach to sustainability, rethinking relationships between resources, people, and ecosystems. By aligning these projects with national and regional sustainability strategies, governments can amplify their impact and demonstrate leadership in fostering a greener future.

EMPOWERING CITIZENS THROUGH CREATIVITY AND TECHNOLOGY

REDEFINING PUBLIC ENGAGEMENT

One of the most significant contributions of science, technology, and arts collaboration lies in its potential to redefine the relationship between governments and citizens. In a world where trust in institutions is often fragile, participatory approaches inspired by these collaborations can bridge the gap by involving citizens in co-creating solutions for the public good. Through artistic and technological partnerships, governments can foster dialogue, empathy, and shared ownership of public initiatives.

Public spaces transformed through science, technology, and arts collaborations serve as examples of this engagement. Whether through interactive installations, augmented reality applications, or community art programs, these initiatives invite citizens to explore the intersection of technology and creativity, encouraging a deeper understanding of societal challenges and inspiring collective action.

CULTIVATING DIGITAL LITERACY AND CULTURAL COMPETENCE

As digital transformation reshapes societies, fostering digital literacy is a critical priority for governments. However, literacy must go beyond technical skills to include cultural competence, ethical awareness, and the ability to critically engage with technology. Science, technology, and arts collaborations provide a model for cultivating these competencies by embedding artistic perspectives into digital education and public programs.

For instance, workshops inspired by such collaborations in schools and communities can help demystify AI, quantum computing, and other emerging technologies while encouraging participants to think critically about their implications and create collective meaning. By integrating such programs into national education strategies, governments can prepare citizens not only to navigate the digital age but also to shape its future.

DRIVING ECONOMIC AND CULTURAL INNOVATION

FOSTERING CREATIVE ECONOMIES

The intersection of art, science, and technology is a fertile ground for economic innovation. Science, technology, and arts collaborations often result in prototypes, intellectual property, and new proto business models that can drive economic growth while prioritizing social and environmental values. Governments have a crucial role to play in nurturing these creative ecosystems by providing funding, infrastructure, and policy support.
Creative hubs, innovation labs, and public-private partnerships inspired by these collaborations can become engines of regional development, attracting talent and investment while addressing local needs. Additionally, supporting startups and SMEs that emerge from these partnerships can create jobs, boost competitiveness, and strengthen cultural industries.

On the other hand, art stands apart as one of the few disciplines outside today's constraints of capitalism. Unlike science and technology, often tied to market demands, art creates space for critical reflection and experimentation beyond profit-driven imperatives. As Bruno Latour suggests, it has the power to "reassemble the social", challenging dominant systems and exploring values like empathy and collective well-being.

CELEBRATING CULTURAL HERITAGE AND DIVERSITY

At its core, science, technology, and arts collaboration celebrates diversity—not only across disciplines but also across cultures. By integrating regional traditions, histories, and narratives into technological innovation, these partnerships enrich the cultural fabric of societies while ensuring that innovation remains inclusive and context sensitive. Governments can leverage this aspect to promote cultural heritage, support minority communities, and position their countries as leaders in culturally conscious innovation.

A CALL TO ACTION FOR POLICYMAKERS: STRENGTHENING INNOVATION THROUGH INTERDISCIPLINARY COLLABORATION

Engaging with science, technology, and arts collaboration presents governments with a unique opportunity to address twenty-first-century challenges in innovative, inclusive, and impactful ways. These collaborations provide a promising framework for fostering holistic solutions that balance technological advancement with societal well-being. To fully realize their potential, policymakers can play a vital role by supporting and encouraging initiatives that integrate artistic, scientific, and technological perspectives.

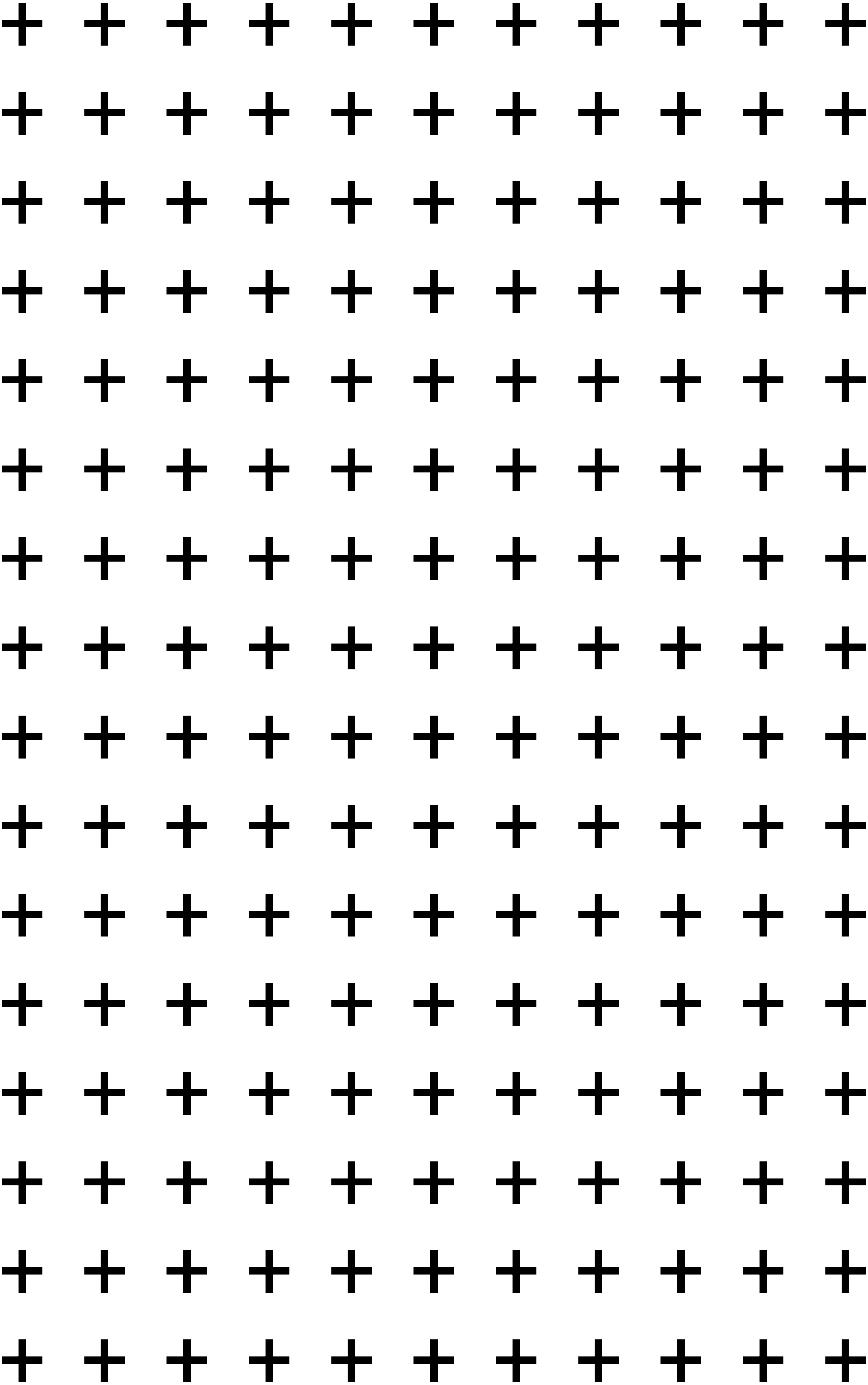
Some potential key areas for making a meaningful impact may include:

- **Investing in Interdisciplinary Research:** Governments should establish dedicated funding mechanisms that encourage the blending of scientific, technological, and artistic perspectives beyond benchmarking in silos. These could, for example, include grants for projects addressing urban resilience through nature-inspired designs or AI-powered tools for cultural preservation.

- **Creating Platforms for Collaboration:** Public initiatives should create accessible platforms where artists, technologists, and scientists can collaborate and engage with citizens. National or regional hubs, cross-disciplinary events, and digital platforms could facilitate knowledge sharing, co-creation, and storytelling. Public residencies, innovation challenges, and showcases in cultural or civic spaces can help address societal challenges and foster an inclusive dialogue on innovation.

- **Embedding Collaboration into Policy Frameworks:** Governments can integrate interdisciplinary methodologies into broader policy areas such as urban planning, education, and environmental sustainability. For example, urban projects could prioritize participatory design where artists and architects collaborate to create inclusive, vibrant spaces. Sustainability strategies can leverage art-driven community campaigns or immersive technologies to raise awareness and promote collective action on critical issues such as climate change.

Science, Technology, and ARTS collaborations exemplify the power of interdisciplinary thinking, creativity, and collective intelligence. By supporting this approach, governments can respond more effectively to today's challenges and lay the foundation for a brighter, more inclusive future for all.



From Bauhaus to S+T+ARTS:

CHRISTOPHE DE JAEGER (GLUON)

INTRODUCTION
The European STARTS initiative emerged in Brussels primarily because the city hosts the European institutions and naturally gathers together cultural, scientific, and policy actors from across the continent. Within this environment—where policymakers, researchers, and cultural practitioners regularly intersect—the first concepts behind STARTS began to take shape. A visit by Ralph Dum, Scientific Officer at DG CNECT to the *Art & Development* program at the University of Brussels proved to be an importing starting point. This program, created under the leadership of rector Caroline Pauwels, brought artists into dialogue with the university's ICT experts, reflecting her conviction that curiosity is the foundation of knowledge. These initiatives did not arise in isolation, and echoed a longer European tradition of cultural institutions already working at the interface of art, science, technology, and society, but it served as a major inspiration for a large-scale European program supporting collaborative practices between art and research and connecting existing players with a larger network of companies, research institutions, and more traditional cultural actors such as museums and foundations.

Institutional Paths of Art–Science Collaboration

From its inception, STARTS emerged from the cultural and research ecosystems of European cities—environments long recognized as cradles of innovation. Cities such as: Berlin, Linz, Karlsruhe, Ljubljana, Milan, Amsterdam, Cluj, and Barcelona provided fertile ground where cultural institutions historically forged alliances with research centers, bringing artists and scientists together through numerous residency programs, workshops, and exhibitions. Many of them focused on shared urban challenges and the role technology and scientific developments play in them. And this around very different topics: the future of education and work, sustainable water and food systems, the impact of digital technologies on democracy, or nature related topics such as climate change, biodiversity loss, and pollution.

It is within this broader context that we should situate STARTS. The program entered the existing ecosystem with a clearly defined set of economic expectations. From the outset, STARTS was driven by the idea that creativity—and the collaboration between artists, researchers, cultural institutions, and industry—could contribute to Europe's digital innovation and competitiveness. Over the years, the program has produced hundreds of innovative collaborations, resulting in speculative prototypes and artistic works that question dominant technological narratives and open up new, unexpected possibilities. Strengthening the connection between the cultural sector and industry has consistently been a core ambition of the policymakers behind STARTS. Yet the level of industry engagement has varied, highlighting a key area for improvement in the future.

BAUHAUS ORIGINS

The European STARTS approach resonates with—while distinctly advancing—a lineage that reaches back to the early twenty century. The Bauhaus, founded by Walter Gropius, was an early attempt to unite art, technology, and craftsmanship in response to rapid industrial transformation. Gropius argued that artists must engage directly with modern technological culture, articulating the influential principle of "art and technology – a new unity" (Bauhaus online, 1919). The Bauhaus emerged amid profound changes in the urban Lebensraum: rapidly expanding cities, the spread of electricity and new communication systems, and the rise of a consumer society. Findeli (1987) notes that these developments raised pressing questions about their impact on individuals, such as the meaning of life in a technologically accelerated world and the significance of newly-constructed environments and their aesthetic qualities.

The school also played a pivotal role in redefining the societal perception of the artist. It challenged the nineteenth-century image of the artist as an isolated or marginal figure. As Dickerman (2009) notes, the artist was no longer seen as someone reproducing classical plaster models in traditional academy halls, but as a creative agent attuned to contemporary technological developments. Yet the Bauhaus's relationship with industrial production was complex—characterized by significant innovations but also notable contradictions. After its closure in 1933, Bauhaus teachers and ideas migrated to the United States, where they profoundly reshaped art and design education. Institutions such as Harvard's Graduate School of Design, the New Bauhaus in Chicago, and Black Mountain College carried the Bauhaus ethos into a new era (Dickerman, 2009).

Computers Influencing the Arts in the United States

One of the most interesting institutions originating from the exodus of Bauhaus teachers was the Centre for Advanced Visual Studies (CAVS) at MIT. It was founded by former Bauhaus teacher György Kepes in 1967 and was a fellowship program for artists. Kepes was an important theoretician and to this day is an inspiration to organizations initiating collaborations with artists, not least the STARTS program, which is not based on fellowships but rather interdisciplinary residencies. Kepes understood that if you bring artists together with specialists from different fields they need a common goal: for CAVS, this was a shared interest in the public space. Kepes could develop his ideas of interdisciplinary research thanks to the latest developments at MIT (Bijvoet, 1997). Driven by the need to fight World War II, a secret research group came together at MIT in 1942: the Radar Laboratory. The development of a new electromagnetic radar system or anti-ballistic missile system in 1952 required the establishment of the first "interdisciplinary" (a new term in that time) lab at MIT: the Research Laboratory of Electronics.

In the United States, new artist groups with cross-disciplinary interests in science and technology fostered unprecedented collaborations between artists and specialists in the emerging field of computer science—a development that would have been unlikely in Europe at the time, given that computer technology was being advanced primarily in the U.S. Notably, many of these initiatives were led by European émigrés such as Billy Klüver, Pontus Hultén, and György Kepes. Their influence helped shape what became known as the Art and Technology Movement, a significant force in the evolution of collaborative practice. As Bijvoet observes, this was not a movement defined by a shared style or unified ideology, but rather a series of events, exhibitions, and initiatives in the 1960s that signaled a shifting attitude among artists, engineers, and curators toward science and technology.

In the 1960s, this trajectory culminated in *Experiments in Art and Technology* (E.A.T.), founded by Billy Klüver, who worked as a member of the technical staff at Bell Telephone Laboratories in New Jersey, and the artist Robert Rauschenberg. Rather than aspiring to a new grand synthesis, E.A.T. embraced a flexible network model, creating informal meeting spaces where artists and engineers could freely exchange knowledge long before such networking became commonplace. Their activities laid an important groundwork for later art and technology collaborations.

Klüver and Rauschenberg did not want E.A.T. to become an idealistic fusion of natural sciences and art; nor did it have to become a new Bauhaus. They wanted E.A.T. to be a dynamic and open network of artists and technologists (long before the advent of the World Wide Web that would make communication much easier). They ran an office in New York where on Sundays artists and technicians met for informal discussions. They organized visits for artists to technical institutions such as Bell Labs in New Jersey and the IBM laboratories in New York. They also arranged meetings at the Institute for Electrical and Electronics Engineers where artists could present their work and tried to win the engineers over to their ideas. Many lectures for artists were held in colleges and universities on themes such as computer languages, computer animation, acoustics, laser, and holography. Already in 1968, four hundred and sixty-seven technicians were members of E.A.T. (Kluver and Martin, 1997). In the 1970s, E.A.T. would expand even more by constructing the Pepsi Pavilion at the World Exhibition in Osaka and by engaging the business world in artistic projects.

NEW ART & TECH INSTITUTIONS IN EUROPE

In the late 1970s and early 1980s, various cultural and artistic actors across Europe recognized the profound impact that computer technology would have on the cultural sector and sought to engage with these emerging developments. With support from national governments, new initiatives were launched that ultimately led to the establishment of several major institutional centers, including IRCAM, ZKM, and Ars Electronica.

The Institute for Research and Coordination in Acoustics and Music (IRCAM) was one of the earliest in Europe to engage artists and scientists in collaborative practice. It was founded in 1977 by the avant-garde composer, Pierre Boulez, under the aegis of the Centre Pompidou and the French Ministry of Culture. It was to become one of the world's largest public research centers dedicated to both musical expression and scientific research. It attracted a select group of excellent composers, but without programming experience. They were assisted by skilled technicians and technologies required to produce contemporary music. In 1993 IRCAM started to engage in commercial developments. The valorization department had to promote, develop, and put to good use IRCAM research.

IRCAM received many commissions from companies. They created sound for future electric cars, designed new acoustics for teleconferences (France Telecom), and created a software application that blended different voices to create a fantasy castrato voice for the film Farinelli in 1994. Another notable achievement was the breakthrough of the MAX software for morphing sound. Numerous licenses of its technology were granted to companies in the fields of audio and music technology, cultural industries, telecommunication, and computers. A visual counterpart to IRCAM emerged much later with the founding of the Zentrum für Neue Medienkunst (ZKM)—often referred to as the "Electronic Bauhaus"—established in Germany in 1991 by art historian Heinrich Klotz. In preparation for this institution, a German delegation led by Professor Behringer visited leading U.S. centers working at the intersection of art and technology, including the Centre for Advanced Visual Studies, then directed by Otto Piene, the MIT Media Lab, The Kitchen in New York, and others. The delegation concluded that the new ZKM should focus on communication technologies, which were already driving profound economic, cultural, and social change (Reith, Zec, and Ringler, 1988). Even before the emergence of the internet and the World Wide Web developed by Tim Berners-Lee and Robert Cailliau, they recognized the transformative impact these technologies would have on society. ZKM was therefore conceived as a place offering the necessary context, infrastructure, and tools for scientists, artists, students, and visitors to explore both the opportunities and risks of these technologies. To support this mission, it included an *Apparatenpark*—a computer laboratory—and studio spaces designed for individuals or interdisciplinary teams to work collaboratively (Behringer and Bergmann, 1988).

The Ars Electronica Centre, a building along the Danube in Linz, Austria, devoted to art and technology, was conceptualized at the same time as the ZKM, i.e. between 1991 and 1995. This new museum was finished in 1996. It was supported by the city of Linz. The city officials wanted to position Linz as a leading center in Europe for the New Economy. Information technology, global markets, and the Internet shaped the new industries. In 1999, Hannes Leopoldseder described the Ars Electronica Centre as follows: "The centre, which has been understood as a 'house in progress', wants to be a living organism, and be seen, above all, as one thing: a house of awareness of the digital transformation, of the radical nature of the digital media gap and thus of the new stage of digital culture, which begins to unfold before us" (Stocker, Leopoldseder, and Schöpf, 2010).

HYBRIDIZATION AND LAB CULTURES IN THE 1990S

Since the early 1990s, cultural policy makers in both the U.S. and Europe have used the idea of hybridization to describe the process of changing the organizational structures of cultural institutions. It is employed as an alternative to the often-used term privatization. Those organizations kept working with artists, mostly through residency programs. Artists were offered financial support, technology, and expertise, but in many cases those organizations started to pay more attention to the benefits for companies and researchers in those collaborations. The impact of institutions such as MIT in the United States on Europe in the 1990s was enormous. It inspired universities, cultural institutions, companies, and even individuals to set up labs that experimented with the latest technologies and raised both private and public support.

Founded in 1985 by Nicholas Negroponte, the MIT Media Lab established an unprecedented model for unrestricted, corporate-sponsored research. Its methodology, funding structures, and interpretation of the artist's role within collaborative environments have deeply influenced many European institutions. Alan Kay's well-known dictum—"the best way to predict the future is to invent it"—captured the Lab's philosophy: a focus on science and engineering over traditional scholarship, and an emphasis on invention rather than studies, surveys, or critique. By the late 1980s, the Media Lab was producing pioneering demonstrations and prototypes in areas such as digital publishing, human-machine interfaces, advanced television, spatial imaging, computer music, animation, computer graphics, future education models, and visual languages (Stewart, 1987).

In Europe, Waag Society is widely regarded as one of the most progressive labs in advancing collaborative practice. Founded in 1994 by Marleen Stikker and Caroline Nevejan as the "Maatschappij voor Oude en Nieuwe Media" (Society for Old and New Media), Waag evolved into an interdisciplinary media laboratory dedicated to research and development, fostering experimentation with technology and the arts. Through its labs, it brings together research institutions, companies, governments, and civil society to pursue innovation across public domains such as healthcare, culture, education, and sustainability. Unlike the MIT Media Lab, Waag placed a strong emphasis on social innovation, ensuring that technological development is closely tied to societal needs and public value (Van Dijk et al., 2011).

S+T+ARTS TODAY AND TOMORROW?

Many of the institutions discussed here played foundational roles in shaping STARTS and have been deeply involved in its various programs. From the outset of the twenty-first century, Ars Electronica took the lead in supporting the initiative. Its organization of the STARTS Prize—honoring innovative collaborations between artists and non-cultural actors, as well as artistic practices that make visionary use of emerging technologies and scientific advances—established STARTS as one of the most respected art-science-technology programs worldwide. As a result, the STARTS ecosystem expanded rapidly, attracting an increasingly diverse range of participants. Over the course of ten years, the program and its partners hosted 381 artist and researcher residencies, allowing STARTS to develop into a European initiative comparable in significance to the E.A.T. program in the United States.

The future of the STARTS program appears precarious, with support for its continuation diminishing for various reasons. Nevertheless, several initiatives are being undertaken by actors within the existing ecosystem to sustain its activities—or at least to ensure that the lessons learned are carried forward into new European programs and initiatives, such as the New European Bauhaus Movement. Throughout history, artists have played a crucial role in exploring the intersection of technology, science, and society. In one of his inspiring texts, György Kepes (CAVS) indirectly refers to Ezra Pound's explanation of the importance of artists: "Artists are living seismographs, as it were, with a special sensitivity to the human condition. Their immediate and direct response to the sensuous qualities of the world helps us to establish an entente with the living present" (Kepes, 1965). Artists give form to abstract ideas, making critical change tangible and discussable. Some collaborate with researchers to create speculative prototypes, alternative processes, services, and tools that exponentially increase the potential for serendipitous innovation. Artists act like particles moving through matter—absorbing, processing, and re-emitting everything they encounter: intuitive, critical, radical, and hypersensitive. Their contribution to the future of Europe is indispensable.

NOTE TO THE READER

Due to space limitations in this STARTS book, the historical overview has been reduced to a select few key players. It is important to acknowledge that many institutions—particularly institutions in Eastern Europe—are not represented here. Numerous influential actors, including artist collectives that emerged alongside the rise of the internet in the region, have played significant roles in collaborations between artists and ICT experts.

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The S+T+ARTS Framework:

VERONIKA LIEBL (ARS ELECTRONICA)

STARTS stands for Science + Technology + the ARTS. At its simplest, it is an initiative of the European Commission that asks a deceptively straightforward question: What happens when artists, researchers, and technologists do not merely collaborate occasionally, but truly work together as equal partners in shaping Europe's future? The answer, as a decade of practice has shown, is that innovation looks profoundly different. It becomes more inclusive, more critical, more imaginative, and more attuned to the needs of society at large.

Technical Pilots, Residencies, Prizes, Academies, and a Movement for Change

STARTS is both a programme and a movement. It has grown from early pilot residencies into a Europe-wide ecosystem that today spans research labs, creative industries, universities, start-ups, regional centers, and classrooms. It has become a reference point for art-driven innovation in Europe and beyond, inspiring similar approaches in Asia, Africa, South America, and across the globe. If Europe today is seen as a leader in art-science collaboration, it is also thanks to STARTS.

This recognition can be measured not just in reputation but in concrete achievements. Over the past years, STARTS has funded over 380 residencies with more than €19 million, enabling artists and scientists to collaborate in research laboratories, technology companies, and universities. The STARTS Prize competition has attracted 18,900 submissions from 124 countries, honoring 298 prize-winning projects and creating one of the largest global showcases of art-science innovation. 21 Regional Centers, involving 32 institutions, have anchored this work in local ecosystems, proving that transdisciplinary innovation is not only for cultural capitals but can thrive in rural or peripheral regions. Academies have trained the next generation of thinkers and practitioners, from school children experimenting with AI through creative play to doctoral candidates developing new forms of knowledge at the intersection of arts, technology, and society. And the visibility of STARTS has shaped European policy itself: it is increasingly common to see calls in Horizon Europe and other frameworks asking explicitly for cultural, societal, and artistic contributions to research and innovation.

What sets STARTS apart is that from the beginning it recognized that no single format is sufficient. A residency alone cannot build the infrastructures of trust, skills, and ecosystems that are required. A prize alone cannot sustain long-term research. A school program cannot influence policy. But together—residencies, prizes, academies, regional centers, industry collaborations, matchmaking events—they create a dense, diverse fabric of activities that mutually reinforce one another. This diversity is not an accident; it has been a strategic design principle of STARTS. Because transdisciplinary innovation is not "one size fits all", STARTS deliberately built a constellation of formats that allow for depth, visibility, education, local anchoring, and policy influence.

This philosophy has yielded results that are as diverse as they are impactful. Some projects have led to technological prototypes that have now been developed further in industry. Others have generated critical debates in policy circles, influencing how Europe thinks about AI, sustainability, or digital sovereignty. Still others have taken root in local communities, giving agency to groups that are too often excluded from innovation processes. The lesson is clear: the richness of STARTS lies precisely in its plurality.

But perhaps the most important reason STARTS matters today is that it demonstrates a different conception of what innovation is. Too often, the prevailing model imagines innovation as linear progress: from research to technology to market. In such a model, art is seen as decoration, communication, or at best an add-on that injects "creativity". STARTS has overturned this view. It has shown, again and again, that art can rethink entire systems. Artists do not simply illustrate technologies; they reframe the questions, expose blind spots, and make visible the social, ethical, and ecological dimensions that science and technology alone cannot resolve. They reveal the hidden assumptions under which systems operate and imagine alternatives that would otherwise remain invisible.

This is why STARTS is so vital in the present moment. Europe faces challenges that are systemic: the climate crisis, the disruptive impacts of artificial intelligence, rising inequalities, crises of trust in institutions and democracies. These are not problems that can be solved by technological fixes alone. They demand new forms of imagination, participation, and cultural legitimacy. They demand what STARTS has cultivated: ecosystems of care and critique, methods of collaboration that cross disciplines and sectors, and a conviction that innovation must be judged not only by efficiency or market success but by its contribution to the common good.

In a world where innovation is too often equated with speed, scale, and competition, STARTS offers a different vision. It insists that innovation must also be about meaning, about inclusion, about agency. It shows that artists are not outsiders to innovation but essential actors who can expand what is thinkable, contest what is taken for granted, and build bridges between technology and society.

For Europe, this is more than a cultural flourish. It is a strategic necessity. By placing the arts at the heart of science and technology, STARTS equips Europe with a distinctive model of innovation—one that is socially grounded, culturally diverse, and globally relevant. In doing so, it strengthens Europe's capacity to respond to crises, to lead responsibly in technological development, and to imagine futures that are both sustainable and just.

STARTS is not just about adding creativity. It is about rethinking innovation itself—and in doing so, rethinking the role of Europe in a rapidly changing world.

Hermia Yrityskehitys Oy
Tallinn University
Latvian Federation of Food Companies / Food Products Quality Cluster
Art Hub Copenhagen
F6S Network Limited
University College Dublin
Beta Festival
Dublin City University
ADAPT Centre
Technovative Solutions
The University of Manchester
WESOUND
Next Media Accelerator
Film University Babelsberg Konrad Wolf
Berlin University of the Arts
Analog Native
Studio Other Spaces
GESTALT Robotics
Wear It Berlin
STATE
Bydgoszcz Industrial Cluster Tool Valley
Hortimare VM
Waag
University of the Creative Arts
Queen Mary University of London
Open Data Institute
The Shadow Robot Company Limited
Zaha Hadid Architects
King's College London
V2_Lab for the Unstable Media
In4Art
IMPAKT
NethWork
VITO
Datascouts
BOZAR
GLUON
LUCA School of Arts
IMEC / Vrije Universiteit Brussel
time.lex
The Royal Museum for Central Africa
Snowball
KIKK
KU Leuven
DEN Institute
Maastricht University
Leibniz University Hannover
Deutsches Zentrum für Luft- und Raumfahrt e.V
Nurogames
FundingBox
Industrial Research Institute for Automation and Measurements PIAP
TUD Dresden University of Technology
CLUTEX–Cluster of Technical Textiles
Max Planck Institute for Empirical Aesthetics
Frankfurter Buchmesse
STRATASYS
High Performance Computing Centre Stuttgart
Fraunhofer IPA
Media Solution Center Baden-Württemberg
Brno University of Technology
Mendel University
Thyssen-Bornemisza Art Contemporary–TB21
University of Art and Design Linz
Vienna University of Technology
Klimat Biennale–Kunsthaus Wien
INFOTECH
Slovakia National Centre of Robotic
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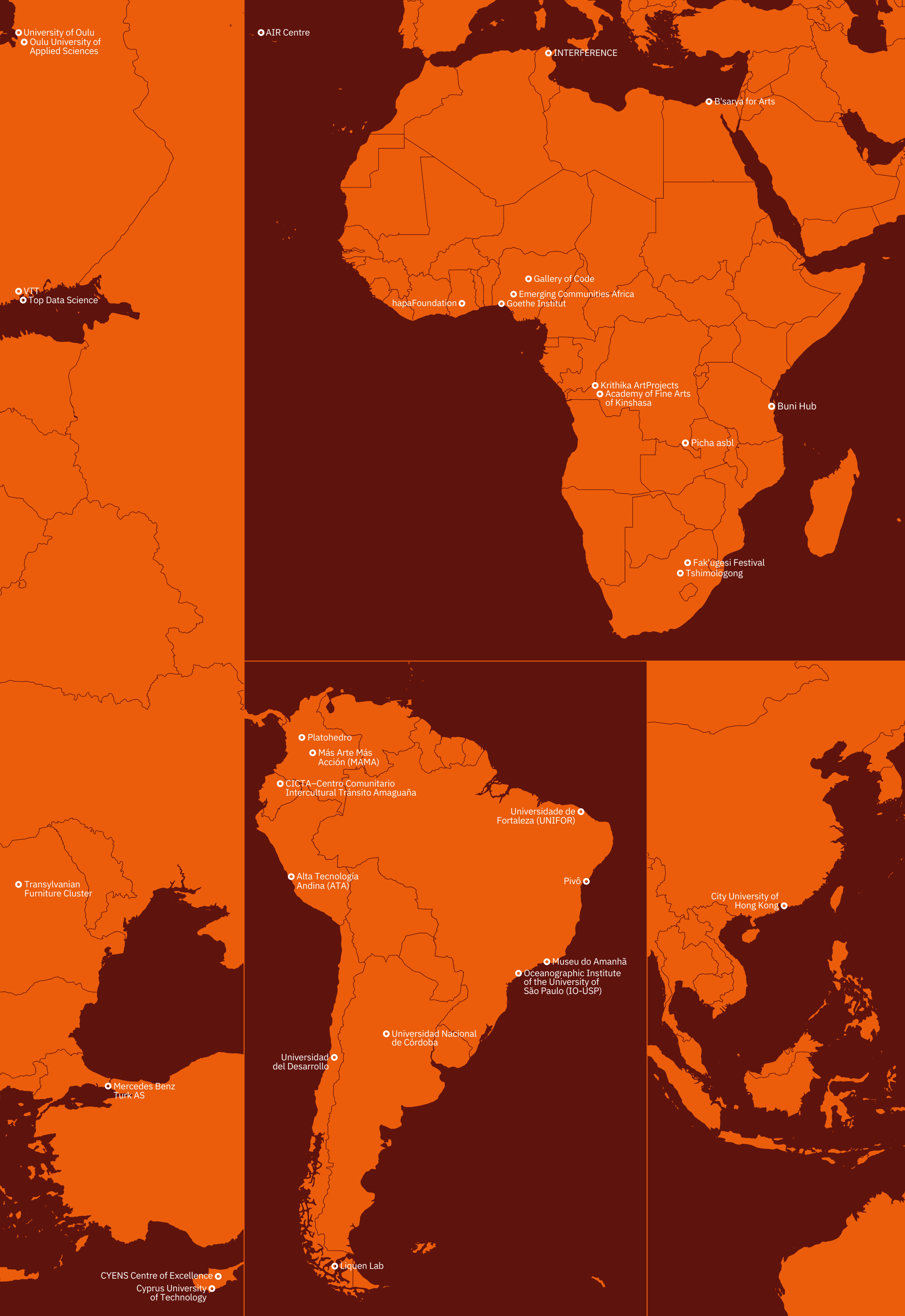
CentQuatre
Maurice Benayoun
E-Seniors
SONY CSL Lab
Fortiss GmbH
Haratech
Ars Electronica
Creative Region Linz & Upper Austria
Johannes Kepler Universität Linz
Salzburg Festival
PROFACTOR
PEMÜ Plastic Processing Co.Ltd.
Pro Progressione
Pôle EMC2
EMPA–Swiss Federal Laboratories for Materials Science and Technology
École Polytechnique Fédérale de Lausanne
SUPSI–The University of Applied Sciences and Arts of Southern Switzerland
Holonix
MUSE–Museo delle Scienze
TECOS–Slovenian Tool and Die Development Center
Kersnikova
Chamber of Commerce and Industry of Pécs-Baranya
Global Network of Water Museums (WAMU-NET)
Universal Research Institute
Cittadellarte–Fondazione Pistoletto
MADE
Istituto Europeo di Design
Blumine
Politecnico di Milano
Ab.Acus
PiNA
Drugo More
CRA–Carlo Ratti Associati
MEET
Osai Automation System SpA
OGR Torino
CINECA
Fondazione Nesta Italia
Kontor 46 s.a.s.
KILOWATT
University of Genova
Istituto Italiano di Tecnologia
La French Tech Grande Provence
CHRONIQUES
Camargo Foundation
ICT Cluster
National Digital Assembly
Bulgarian Chamber of Commerce and Industry
AIMEN Technology Centre
PAL Robotics
RCR LAB·A
Universitat Pompeu Fabra
Universitat de Barcelona
Sónar
Ajuntament De L´Hospitalet
McNeel
Barcelona Super Computing Center
Esproneda
Eurecat Technology Centre of Catalonia
CCCB
Fundacion Epica La Fura dels Baus
HacTe
Mobile World Capital Barcelona
Rio Neiva–Associação de Defesa do Ambiente
Libelium
The Serralves Foundation
INOVA+
INESC TEC
Coliseu Porto Ageas
Artshare
Universitas Nebrissensis S.A.
Tree Technology S.A.
Acciona Construcción S. A.
Universidad Politécnica de Madrid
Zabala Innovation Consulting
Robotnik Automation SLL
+ATLANTIC CoLAB
LUISS University
Sony CSL–Rome
MAXXI Museum
T6 Ecosystems
Officina Keller Lanificio Napoli S.R.L.
Aristotle University of Thessaloniki
Thessaloniki Concert Hall
CERTH
Care Applications
The Textile and Cosmetic Industry Research Association–AITEX
Consorzio Arca
Onassis Stegi
European Dynamics
Up2metric
Ohi Pezoume / UrbanDig Project
Made Group


University of Oulu
Oulu University of Applied Sciences
VTT
Top Data Science
Transylvanian Furniture Cluster
Mercedes Benz Turk AS
CYENS Centre of Excellence
Cyprus University of Technology
AIR Centre
INTERFERENCE
B'sarya for Arts
Gallery of Code
Emerging Communities Africa
hapaFoundation
Goethe Institut
Krithika ArtProjects
Academy of Fine Arts of Kinshasa
Buni Hub
Picha asbl
Fak'ugesi Festival
Tshimologong
Platohedro
Más Arte Más Acción (MAMA)
CICTA–Centro Comunitario Intercultural Tránsito Amaguaña
Universidade de Fortaleza (UNIFOR)
Alta Tecnología Andina (ATA)
Pivô
Museu do Amanhã
Oceanographic Institute of the University of São Paulo (IO-USP)
Universidad Nacional de Córdoba
Universidad del Desarrollo
Liquen Lab
City University of Hong Kong

Editorial Note

MASHA ZOLOTOVA (ARS ELECTRONICA)

SCIENCE+TECHNOLOGY+ARTS: Lessons Learned from a Decade of European Transdisciplinary Innovation invites readers to look closely at what long-term, art-driven collaboration can teach us about how innovation cultures evolve. Within this context, STARTS offers one of the most sustained examples of how such collaborations take shape and mature over time. Over the past decade, the STARTS community has built substantial practical knowledge about how cross-disciplinary approaches can be initiated, supported, and sustained. This book brings together those insights—not as a comprehensive record of everything STARTS has accomplished, but as a reflection on what has been learned and what may be valuable for those developing similar approaches. As transdisciplinary work becomes more widely adopted, the need for concrete examples and tested methodologies continues to grow. Hundreds of institutions and practitioners were involved in the realization of the STARTS projects, giving the initiative a rare understanding of how collaborations between artistic, scientific, and technological fields can take shape and create lasting value.

The book brings together a collection of 19 essays and 51 artworks to carefully represent STARTS diversity. It focuses on representative experiences, perspectives, and methodologies that can meaningfully support practitioners developing transdisciplinary programs. Many texts were commissioned specifically for this publication and written by active participants in the STARTS ecosystem. Their contributions range from analytical reflections to detailed case examples, policy insights, and methodological observations. While diverse in tone and scope, these voices provide insight into the initiative's internal dynamics: the challenges of cross-sector collaboration, the evolution of methodologies, the emphasis on the practical experience, and the systemic shifts that have emerged through practice over the past decade.

The book is, therefore, structured into three parts, each offering a different entry point into the STARTS ecosystem.

Part I brings together a variety of perspectives from across the STARTS ecosystem. Cultural practitioners, researchers, transdisciplinary facilitators, and other actors involved in the realization of STARTS projects reflect on their experiences and trace how the initiative's achievements, core pillars, key learnings, and collaborative practices have been formed and tested over time, shaping the STARTS framework as it is known today.
Achievements maps the scope of the initiative and traces how STARTS has developed into a global ecosystem. It illustrates how STARTS's distinctive value proposition positions artistic practice as a catalyst

for systemic change, embedding creativity, critical reflection, and social relevance at the core of European research and innovation.

Pillars introduces the formats through which STARTS operates—the Prize, Residencies, Academies, and Regional Centers—and provides an overview of them. Here, the methodologies and roles of each pillar are summarized, showing how they respond to different needs: from awarding excellence and enabling in-depth collaboration to building capacities and strengthening regional innovation networks.

Learnings brings together the methodological and epistemological insights that have emerged across STARTS. This chapter outlines how artistic inquiry reorients research processes and how shared languages develop within cross-sector teams, revealing forms of impact that point to the need for more flexible and context-sensitive ways of evaluating such work. It highlights the conditions that make these collaborations effective and offers guidance for strengthening transdisciplinary practice.

Collaborations brings the focus to the dynamics of cross-sector partnerships. While collaboration is woven throughout the previous sections, this chapter examines how it unfolds across various fields, from manufacturing and high-performance computing to the food sector, sound research, and water management. These examples reveal the dynamics of transdisciplinary exchange that define the STARTS approach and demonstrate how creative collaboration generates new knowledge, innovation, and shared responsibility for shaping more sustainable futures.

Part II presents the best-case artistic projects from the STARTS initiative over the past ten years—highlighted by the STARTS Prize and developed in STARTS Residencies, Technical Pilots, and Regional Centers. Rather than grouping projects by industry area or the technology applied, this section organizes them into six clusters that reflect different artistic ambitions and modes of engaging with technology. The first, *Disrupt*, brings together projects that challenge dominant technological paradigms and propose counter-models. *Re-Imagine* includes works that repurpose existing tools, revealing overlooked possibilities or rethinking their intended purpose. *Innovate Responsibly* highlights socially grounded forms of innovation, shaped through participatory processes and with a clear focus on equity, care, and public responsibility. *Invent* focuses on applied experimentation, prototyping, and material research, demonstrating how artistic inquiry contributes directly to new fabrication methods and design approaches. *Explain* showcases artistic research that generates new epistemic insights or ways of understanding complex systems. Finally, *Raise Awareness* features projects that aim at strengthening media, digital, and ecological literacy by revealing infrastructures, biases, or power dynamics that tend to remain invisible. Each cluster combines in-depth coverage of the highlight projects with shorter examples and artistic interventions, offering readers multiple ways to navigate the diversity of practices. This clustering is not meant to be definitive; it is just one viewpoint on the rich legacy of STARTS. Readers are encouraged to explore these works based on their own interests—by the technology applied, by the industry areas addressed, or by the types of collaboration they represent. The textual descriptions of the works have been adapted specifically for this book together with Stella Diakou and Matvey Fridman to make visible the relevance and contribution of these artistic endeavors to the STARTS approach. For those seeking further inspiration and wishing to dive deeper, both the STARTS Prize and the STARTS Residencies Archives offer extensive documentation of additional projects and provide further context.

Part III shifts the focus outward by tracing the expansion of the STARTS methodology beyond Europe and looks ahead. It includes contributions from the practitioners involved in shaping STARTS projects in both Africa and South America, and offers insights into the adaptations developed in response to different cultural, environmental, and political contexts. These essays show how the model evolves when situated in new ecosystems and how transdisciplinary innovation can foster equitable, locally-grounded forms of change. The book concludes with a forward-looking perspective on the future of STARTS and the broader field of transdisciplinary, socially-engaged innovation. It outlines the conditions needed to sustain meaningful collaboration between artists, scientists, technologists, and institutions—emphasizing long-term support structures, responsible methodologies, and systemic thinking.

Ultimately, this book is a collaborative effort that spans years of work, numerous contributors, multiple continents, and a wide range of disciplines and institutions. It demonstrates the commitment of its community to strengthen the role of artistic practice within innovation ecosystems by integrating artistic imagination into technological and scientific environments, to foster new forms of knowledge production, and to demonstrate that innovation can—and must—be socially grounded, ethically aware, and culturally meaningful. This publication aims to support readers in developing their own transdisciplinary programs, rethinking institutional structures, or expanding collaborations that reach across sectors and geographies.

The collaborative nature of this book is not only an expression of how STARTS projects are realized but also of what they stand for. While innovation remains a central goal, we hope the practices and perspectives shared here offer practical tools and starting points for those working toward more connected and thoughtful forms of transdisciplinary work.

S+T+ARTS Projects Actively Involved in the Book Production

S+T+ARTS EC(H)O
Fostering ECOlogically conscious and Human compatible digital technology.

In an age of societal and environmental emergency states when individual disciplines seem to have hit the ceiling in terms of innovation, science, technology, and the arts outline new approaches, alternative perspectives, and creative solutions that promise to inspire progress and accelerate development. STARTS Ec(h)o supports practices at this intersection, recognizing the most successful artist-led, creative experimentations through the STARTS Prize, STARTS Residencies, and the annual AIxMusic program at Sónar.

Partners
Ars Electronica (AT), INOVA+ (PT), La French Tech Grande Provence (FR), Media Solution Center Baden-Württemberg (DE), High Performance Computing Center Stuttgart (DE), Salzburg Festival (AT), Sónar (ES), T6 Ecosystems (IT), TUD Dresden University of Technology (DE).

Duration
1.1.2024–31.12.2026

STARTS Ec(h)o is funded by the European Union under Grant Agreement 101135691.

HUNGRY ECOCITIES
Hungry EcoCities puts forward a high-level alliance between science, technology, and the arts, to effectively explore how digital technologies and applications can lead in turn to reduced food waste, more sustainable value chains, eco-friendly attitudes, and a more ethical approach to food consumption. In this project, we bring together some of the world's most renowned art studios with leading AI and agricultural experts and a network of over 40 leading European agricultural companies to develop ways of creating a more healthy, sustainable, and affordable agri-food system for all.

Partners
Brno University of Technology (CZ), KU Leuven (BE),

CRA – Carlo Ratti Associati (IT), Studio Other Spaces (GE), In4Art (NL), Mendel University (CZ), NethWork (NL), FundingBox (PL).

Duration
1.1.2022–28.2.2026

Hungry EcoCities is funded by the European Union's Horizon Europe research and innovation programme under Grant Agreement 101069990.

MUSAE

MUSAE is pioneering a new approach to digital transformation by integrating Design Futures and Art Thinking to help businesses innovate with emerging technologies. By bridging art, design, and technology, MUSAE empowers SMEs, mid-caps, and public sector organizations across the EU to envision future scenarios and create cutting-edge solutions to accelerate the digital and green transformation.

Partners
Politecnico di Milano (IT), Ab.Acus (IT), Universitat de Barcelona (ES), MADE (IT), PAL Robotics (ES), Gluon (BE), University College Dublin (IE), the University of Manchester (UK), School of Electrical Engineering – University of Belgrade (SB).

Duration
1.9.2022–31.8.2025

MUSAE is funded by the European Union's Horizon Europe research and innovation programme under Grant Agreement 101070421.

RESILENCE

ReSilence supports the development of art-driven technologies for designing the soundscape of future cities through the collaboration of artists, architects, urban designers, scientists, engineers, and researchers. It aims at increasing citizens' awareness and participation in shaping the sounds of the future, which can enhance the wellbeing of citizens while also increasing economic activity and productivity.

Partners
CERTH (GR), Aristotle University of Thessaloniki (GR), Maurice Benayoun (FR), Max Planck Institute for Empirical Aesthetics (DE), Maastricht University (NL), Thessaloniki Concert Hall (GR), the University of Genova (IT), Universitat Pompeu Fabra (ES), WESOUND (DE).

Duration
1.9.2022–28.2.2025

This project has received funding from the European Union's Horizon Europe research and innovation programme under Grant Agreement 101070278.

S+T+ARTS4WATERII

Now more than ever, it's vital for researchers, industry leaders, technology providers, and the cultural sphere to reimagine innovation, laying the groundwork for a more sustainable future. STARTS4WaterII facilitates interdisciplinary collaboration, collective critical thinking, research, experimentation, and co-design led by artists through collaborative art residencies, international educational workshops, exhibitions, conferences, and networking activities that bring together artists, researchers, stakeholders, and ICT experts. These collaborations focus on addressing specific local or regional water challenges and envisioning future water management through creative, critical artistic works, novel digital solutions, and public engagement.

Partners
VITO (BE), Waag Futurelab (NL), GLUON (BE), Camargo Foundation (FR), OGR Turino (IT), Thyssen-Bornemisza Art Contemporary – TB21 (ES), Beta Festival/Dublin City University Adapt Centre (IE), PiNA (SL), Drugo More (CO), Arca Futuris (GE).

Duration
15.1.2024–14.11.2025

STARTS4WaterII is funded by the European Union under the STARTS – Science, Technology, and Arts initiative of DG CNECT under Grant Agreement LC-02629312.

S+T+ARTS AFROPEAN INTELLIGENCE

Afropean Intelligence aims to critically explore the uses of AI by identifying its impacts and collectively addressing its challenges in local contexts. By bringing together CCI experts, artists, technologists, and scientific figures, the project promotes a reflexive intercultural dialogue through artistic innovation and takes a critical look at technologies such as (generative) AI. Through these intersecting voices, STARTS Afropean Intelligence aspires to question Afro-European narratives and promote a global humanist discourse while taking care to preserve cultural heritage and ancestral knowledge.

Partners
GLUON (BE), Ars Electronica (AT), CHRONIQUES (FR), the Royal Museum for Central Africa (BE).

Associated Partners: B'sarya for Arts (EG), INTERFERENCE (TN), Fak'ugesi Festival (ZA), Gallery of Code (NG), Academy of Fine Arts of Kinshasa (CD), Krithika ArtProjects (CD).

Duration
1.1.2025–30.6.2026

STARTS Afropean Intelligence is funded by the European Union under the STARTS –Science, Technology, and Arts initiative of DG CNECT under Grant Agreement LC-03568051.

S+T+ARTS AQUA MOTION

STARTS Aqua Motion aims to revolutionize water management in Europe through an interdisciplinary approach that merges artistic experimentation with cutting-edge technological innovations. Through 25 residencies, the project harnesses the creativity of artists to develop sustainable solutions for pressing water challenges across Europe's diverse regions with a focus on four critical basins—Atlantic-Arctic, Mediterranean Sea, Baltic-North Sea, and Danube-Black Sea.

Partners

INOVA+ (PT), Ars Electronica (AT), AIR Centre (PT), +ATLANTIC CoLAB (PT), Hortimare VM (NL), KIKK (BE), MUSE – Museo delle Scienze (IT), Pro Progressione (HU), Rio Neiva – Associação de Defesa do Ambiente (PT), Global Network of Water Museums (WAMU-NET) (IT), Vienna University of Technology (AT), Waag Futurelab (NL).

Duration

1.1.2025–31.12.2026

STARTS Aqua Motion is funded by the European Union under the STARTS – Science, Technology, and Arts initiative of DG CNECT under Grant Agreement LC-03568055.

S+T+ARTS BUEN-TEK

STARTS Buen-TEK explores how indigenous knowledge and advanced technologies can jointly tackle socio-environmental challenges and inspire resilient ways of living. Over 18 months, artists will collaborate with researchers, local communities, and cultural institutions in South America and Europe to develop creative responses rooted in the principles of Buen Vivir and Lo-TEK. STARTS Buen-TEK seeks to reimagine how we approach ecological sustainability, culture, and innovation by bridging these worldviews with contemporary science and technology.

Partners

IMPAKT (NL), HacTe (ES), SONY-CSL Rome (IT), Thyssen-Bornemisza Art Contemporary – TB21 (ES), Barcelona Super Computing Centre (ES), GLUON (BE).

Duration

1.1.2025–30.6.2026

STARTS Buen-TEK is funded by the European Union under the STARTS – Science, Technology, and Arts initiative of DG CNECT under Grant Agreement LC-03568052.

Overview of All S+T+ARTS Projects

BETTER FACTORY
Partners
VTT (FI), INOVA+ (PT), INESC TEC (PT), SUPSI – The University of Applied Sciences and Arts of Southern Switzerland (CH), AIMEN Technology Centre (ES), Cyprus University of Technology (CY), Fraunhofer IPA (DE), Slovakia National Centre of Robotic (SK), GLUON (BE), Waag Futurelab (NL), European Dynamics (GR), FundingBox (PL), time.lex (BE), Mobile World Capital Barcelona (ES), Hermia Yrityskehitys Oy (FI), Holonix (IT), Top Data Science (FI), INFOTECH (SK), GESTALT Robotics (DE), IN4ART (NL), University of Oulu (FI), Transylvanian Furniture Cluster (RO), TECOS – Slovenian Tool and Die Development Center (SI), ICT Cluster (BG), Latvian Federation of Food Companies/Food Products Quality Cluster (LV), Bydgoszcz Industrial Cluster Tool Valley (PL), CLUTEX – Cluster of Technical Textiles (CZ), Chamber of Commerce and Industry of Pécs-Baranya (HU).

Duration
1.10.2020–30.09.2024

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement 951813.

MEDIAFUTURES
Partners
King's College London (UK), IRCAM (FR), LUISS University (IT), Zabala Innovation Consulting (ES), Next Media Accelerator (DE), Eurecat Technology Centre of Catalonia (ES), Open Data Institute (UK), DEN Institute (BE), KU Leuven (BE).

Duration
1.9.2020–31.8.2023

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement 951962.

MINDSPACES
Partners
CERTH (GR), Maastricht University (NL), Universitat Pompeu Fabra (ES), Aristotle University of Thessaloniki (GR), McNeel (ES), Up2metric (GR), Nurogames (DE), Zaha Hadid Architects (UK), Maurice Benayoun (DE), Espronceda (ES), E-Seniors (FR), Ajuntament De L'Hospitalet (ES), City University Of Hong Kong (CN).

Duration
1.1.2019–31.12.2021

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement 825079.

RE-FREAM
Partners
Creative Region Linz & Upper Austria (AT), Wear It Berlin (DE), The Textile and Cosmetic Industry Research Association – AITEX (ES), Care Applications (ES), Consorzio Arca (IT), EMPA – Swiss Federal Laboratories for Materials Science and Technology (CH), Fraunhofer (DE), Haratech (AT), Instituto Europeo di Design (IT), PROFACTOR (AT), STRATASYS (DE), University of Art and Design Linz (AT).

Duration
1.12.2018–30.11.2021

This project is funded by the European Union's Horizon 2020 research and innovation programme under Grant Agreement 825647.

S+T+ARTS4AFRICA
Partners
INOVA+ (PT), Ars Electronica (AT), GLUON (BE), PiNA (SI).

Associated Partners: Emerging Communities Africa (NG), Buni Hub (TZ), Hapa Foundation (GH), Picha Asbl (CD), Goethe Institut (DE).

Duration
1.5.2023–31.10.2024

STARTS4Africa has received funding from the European Commission's Directorate-General for Communications Networks, Content, and Technology under Grant Agreement LC-01960720.

S+T+ARTS4WATER
Partners
LUCA School of Arts (BE), Thyssen-Bornemisza Art Contemporary – TB21 (AT), Universal Research Institute (HR), V2_Lab for the Unstable Media (NL), Ohi Pezoume/UrbanDig Project (GR), Cittadellarte – Fondazione Pistoletto (IT).

Duration
1.4.2021–31.12.2022

The project is funded by the European Commission's Directorate-General for Communications Networks, Content, and Technology.

S+T+ARTS AIR

Partners
Media Solution Center Baden-Württemberg (DE), High Performance Computing Center Stuttgart (DE), Barcelona Super Computing Centre (ES), SONY-CSL Rome (IT), In4Art (NL), Fundacion Épica La Fura dels Baus (ES), PiNA (SI), RCR LAB·A (ES).

Duration
1.4.2023–30.11.2024
This project is funded by the European Union from call CNECT/2022/3482066 – Art and the Digital: Unleashing Creativity for European Industry, Regions, and Society under Grant Agreement LC-01984767.

S+T+ARTS GRIN

Partners
Johannes Kepler Universität Linz (AT), Artshare (PT), KILOWATT (IT), CINECA (IT), Coliseu Porto Ageas (PT), Oulu University of Applied Sciences (FI).

Duration
1.2.2023–31.9.2024

GRIN is a STARTS regional centers preparatory action that aims to develop effective solutions for Europe's digital and ecological transition under Grant Agreement LC-01984769.

S+T+ARTS ECOSYSTEM

Partners
INOVA+ (PT), Ars Electronica (AE), IRCAM (FR), La French Tech Grande Provence (FR), GLUON (BE), the University for the Creative Arts (UK)

Duration
1.4.2019–30.11.2021

With the support of the European Union's Horizon 2020 programme under the STARTS – Science, Technology, and the Arts initiative under Grant Agreement 824950.

S+T+ARTS IN THE CITY

Partners
GLUON (BE), Ars Electronica (AT), HacTe (ES), INOVA+ (PT), Kersnikova Institute/Kapelica Gallery (SI), MEET | Digital Culture Center (IT).

Duration
1.4.2023–30.11.2024

STARTS in the City has received funding from the European Commission's Directorate-General for Communications Networks, Content, and Technology under Grant Agreement LC-01984766.

S+T+ARTS PRIZE 2017–20

Partners
Ars Electronica (AT), BOZAR (BE), Waag Futurelab (NL).

Duration
1.1.2017–31.12.2020

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement 732019.

S+T+ARTS PRIZE 2021–23

Partners
Ars Electronica (AT), BOZAR (BE), La French Tech Grande Provence (FR), Waag Futurelab (NL), INOVA+ (PT), T6 Ecosystems (IT), Frankfurter Buchmesse (DE).

Duration
1.1.2021–31.12.2023

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement 956603.

S+T+ARTS REGIONAL CENTERS – PILOT

Partners
BOZAR (BE), Ars Electronica (AT), La French Tech Grande Provence (FR), MEET | Digital Culture Center (IT), Made Group (GR), Film University Babelsberg Konrad Wolf (DE), GLUON (BE).

Duration
1.6.2019–31.12.2020

This project is co-funded by the European Commission's DG CNECT, in the framework of the Horizon 2020 programme of the European Union, under the STARTS program's Regional STARTS Centers.

S+T+ARTS REGIONAL CENTER – REPAIRING THE PRESENT

Partners
Snowball (BE), MAXXI Museum (IT), Art Hub Copenhagen (DK), STATE (DE), Onassis Foundation (GR), In4Art (NL), MEET | Digital Culture Center (IT), CCCB (ES), Ars Electronica (AT), SONY CSL Lab (FR), Kersnikova Institute/Kapelica Gallery (SI), CYENS Centre of Excellence (CY).

Duration
1.6.2021–31.12.2022

This project has received funding from the European Commission's Directorate-General for Communications Networks, Content, and Technology under Grant Agreement LC-01641664.

S+T+ARTS REGIONAL CENTER – TOWARDS SUSTAINABILITY
Partners
The Serralves Foundation (PT), Artshare (PT), KIKK (BE), CentQuatre (FR), Fondation FIMINCO (FR), Fondazione Nesta Italia (IT), National Digital Assembly (BU), Tallinn University (ES).

Duration
1.3.2020–30.6.2021

VERTIGO
Partners
IRCAM (FR), INOVA+ (PT), École Polytechnique Fédérale de Lausanne (CH), La French Tech Grande Provence (FR), LIBELIUM (ES), Fraunhofer (DE), Artshare (PT).

Duration
1.12.2016–31.5.2020

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement 732112.

VOJEXT
Partners
Fortiss GmbH (DE), Industrial Research Institute for Automation and Measurements PIAP (PL), Pôle EMC2 (FR), The Shadow Robot Company Limited (UK), Robotnik Automation SLL (ES), Istituto Italiano di Tecnologia (IT), Tree Technology S.A. (ES), Technovative Solutions (UK), Universitas Nebrissensis S.A. (ES), Kontor 46 s.a.s. (IT), F6S Network Limited (IR), Bulgarian Chamber of Commerce and Industry (BG), Waag Futurelab (NL), Officina Keller Lanificio Napoli S.R.L. (IT), PEMÜ Plastic Processing Co. Ltd. (HU), Acciona Construcción S. A. (ES), Osai Automation System SpA (IT), Deutsches Zentrum fuer Luft- und Raumfahrt e.V (DE), Mercedes Benz Turk AS (TU).

Duration
1.1.2020–31.12.2023

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement 952197.

WEARESUSTAIN
Partners
IMEC/Vrije Universiteit Brussel (BE), Queen Mary University of London (UK), Blumine (IT), Datascouts (BE), the University for the Creative Arts (UK), Berlin University of the Arts (DE), Digital Spaces Living Lab (BG).

Duration
1.1.2017–1.2.2019

The WEAR project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement 732098.

PART 1

PRACTICE

S+T+ARTS

Since its inception, STARTS has grown into a dynamic ecosystem of more than 150 institutions across Europe, jointly fostering transdisciplinary collaboration between art, science, and technology. Over the past decade, it has supported hundreds of residencies, large-scale collaborations, and international projects that demonstrate the transformative power of artistic engagement. The following essays provide an overview of these achievements, mapping the scope of the initiative and illustrating how its distinctive value proposition positions art as a catalyst for systemic change—embedding creativity and critical reflection at the core of European research and innovation.

ACHIEVEMENTS

S+T+ARTS Results: Shaping a Global Ecosystem of Art, Science, and Technology

PATRICIA CARVALHO (INOVA+), SARA BRANDÃO (INOVA+) AND PATRICIA VIEIRA (INOVA+)

Since its establishment in 2016, the STARTS initiative has evolved into a trailblazing European platform that reimagines the interplay between art, science, and technology. At a moment when global issues such as climate disruption, digital upheavals, and societal divides demand nuanced solutions, STARTS elevates artistic ingenuity as an essential catalyst for breakthrough innovation. The program challenges the conventional narrative that technology and science alone drive progress, revealing instead how artistic inquiry can disrupt assumptions, uncover novel viewpoints, and open pathways toward systemic renewal.

The initiative's philosophy rests upon fundamental tenets that steer its vision and outcomes. First, interdisciplinarity: STARTS deliberately cultivates robust collaborations across disciplines traditionally siloed. Artists contribute experimental mindsets, critical scrutiny, and rich narrative sensibilities that complement the precision and analysis of scientific practice. This blend stimulates innovation that would be unachievable by either domain on their own. Second, societal pertinence: STARTS projects are deeply rooted in addressing pressing real-world challenges, from environmental sustainability and public health to social equity and ethical technology. Innovation here is purpose-driven, intimately connected to the communities and contexts it serves. Third, systemic evolution: beyond isolated outputs, STARTS seeks to weave artistic methodologies into the fabric of research, education, policy, and institutional cultures. This long-view approach ensures that creative perspectives become embedded within how society develops and governs emerging technologies.

Over the years, STARTS has expanded its reach and ambition. The 21 major collaborative projects under its umbrella have brought together more than 165 partners from 26 countries, weaving an extraordinary network spanning universities, research centers, museums, pioneering tech enterprises, SMEs, innovation agencies, and public institutions. This broad coalition enriches the initiative with multifaceted expertise and unlocks new sectors and geographies for creative collaboration. This wide territorial engagement allows the initiative to embrace a rich tapestry of cultural contexts and regional challenges, nurturing innovation approaches grounded in local realities yet informed by broader perspectives. The year 2024 marked a pivotal milestone with the launch of STARTS4Africa, which extended the initiative's methodology to five African nations (Nigeria, Tanzania, the Democratic Republic of Congo, Ghana, and Senegal). The residencies carried out there affirmed the universal adaptability of STARTS' principles, proving their relevance across distinct social, technological, and environmental contexts. Building on this momentum, 2025 witnessed further international growth with STARTS Afropean Intelligence and STARTS Buen-TEK, enabling 18 residencies across eight countries in Africa and six in South America. These initiatives highlighted how the STARTS framework can operate as a global engine for creative innovation. Over the year, these projects have spanned themes such as artificial intelligence, sustainable manufacturing, biodiversity, and climate resilience; these projects act as experimental arenas where artists and scientists engage as equals. They establish institutional synergies bridging academia, industry, government, and civil society, building durable networks that persist beyond individual project timelines. For instance, projects interrogating AI have probed algorithmic biases and ethical quandaries, revealing the human narratives behind technological systems. Other sustainability-focused initiatives have merged artistic interventions with ecological data, cultivating responsive environmental strategies.

Embedded in these projects, the STARTS residencies have been the beating heart of STARTS, offering a unique arena where artistic imagination meets scientific and technological expertise. In total, 381 residencies have been supported, representing an investment of more than €19 million. These immerse artists in diverse environments (ranging from university labs and manufacturing plants to governmental bodies and innovation hubs) allowing them to collaborate directly with researchers and engineers. The results frequently transcend traditional art forms, generating innovative ways to visualize information, question technology's societal role, and rethink scientific communication. Many residencies have fostered enduring partnerships, with artists and scientists continuing their joint work well beyond the residencies' conclusion, highlighting the deep integration of artistic inquiry within innovation ecosystems. Beyond generating artworks or prototypes, these partnerships have given rise to pioneering methodologies, fresh business paradigms, and influential policy perspectives. By embedding artists alongside scientists, engineers, technologists, and industry experts, the initiative fosters fertile ground where creativity and expertise intersect to tackle complex societal concerns with subtlety and inventiveness.

Parallel to the residencies, the annual STARTS Prize has become a global benchmark for creativity at the nexus of science, technology, and the arts. Since 2016, it has received more than 18,000 submissions from over 120 countries, resulting in the recognition of 20 Grand Prize winners and numerous distinctions. In 2024, the Prize expanded with the launch of the STARTS Prize Africa, which has so far awarded two Grand Prizes and ten Distinction Awards. Altogether, €480,000 have been distributed to winners, with €40,000 euros allocated annually to each Grand Prize, and laureates now representing fourteen different countries. The reach of the Prize has helped to extend the international visibility of the initiative, catalyzing collaborations that persist well beyond the award cycle.

Ultimately, the initiative's accomplishments have been underpinned by a significant investment of over €65 million from the European Union between 2016 and 2025. This funding underscores a strategic acknowledgement at the highest echelons of policy-making that culture-driven innovation is vital to Europe's digital and green transitions. Beyond financing residencies and projects, the investment supports capacity-building, educational efforts, and knowledge-sharing activities, amplifying the initiative's influence across sectors.
While the quantitative metrics such as hundreds of residencies, dozens of projects, and millions invested, offer a compelling narrative, the true achievement of STARTS lies in its qualitative impact. It has fostered a robust, credible innovation ecosystem that embraces creativity as a vital counterpart to scientific and technological mastery. The initiative has normalized artists' presence in environments where they were previously absent, illustrating that artistic inquiry can profoundly shape research trajectories, ethical frameworks, design strategies, and systemic transformation.

Moreover, STARTS has opened up fresh pathways for public engagement, institutional learning, and forward-looking reflection. By bridging diverse ways of knowing and imagining, it nurtures an innovation that is not only technically sophisticated but socially resonant and ethically attuned. As Europe confronts accelerating digital transitions, ecological imperatives, and the quest for social cohesion, the relevance of STARTS intensifies. Its validated model offers a scalable blueprint for integrating art at the core of innovation ecosystems, fostering novel partnerships across disciplines, sectors, and continents. In an era marked by complexity and unpredictability, STARTS shines as a guiding light demonstrating that the future unfolds most compellingly when creativity and technology advance in tandem, illuminating new horizons, deepening understanding, and driving inclusive, conscientious progress.

S+T+ARTS in European Research: Moving Beyond Technocentric Approaches

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As a pioneering force within Europe's Research and Innovation landscape, STARTS exemplifies a bold rethinking of how knowledge is produced and shared. Rooted in three core frameworks, namely Responsible Research and Innovation, Transdisciplinary Inquiry for Addressing Complex Problems, and the 5-helix Model of Collaboration, STARTS does not merely align with these schemes—it actively advances them. By embedding artistic practice at the core of systemic inquiry, STARTS exposes the limitations of technocentric innovation and insists on a more holistic, culturally grounded, and democratically-shaped research future where artistic experimentation drives new forms of inquiry, offering visionary approaches that strengthen and evolve the very foundations of the European research agenda.

European research policy strongly builds on each of these frameworks. While each of them proposes and mandates distinct elements, such as anticipation, reflexivity, inclusion, and responsiveness, in practice they often remain elusive in terms of how they can be operationalized in real-world research settings, particularly those involving complex, creative, and cross-sectoral collaborations. STARTS not only aligns with European policy directives on ethical, sustainable, and socially-attuned innovation (Von Schomberg, 2013), but also brings these principles to life through deeply participatory and culturally embedded approaches. Rather than viewing societal engagement as an add-on, STARTS projects embed it from the outset—foregrounding artistic practices that are capable of surfacing community knowledge, confronting normative assumptions, and fostering shared agency. As such, "agency" is a critical component that the STARTS scheme embeds and brings forth to European research culture. It requires more than ensuring that multiple stakeholders are engaged. This type of research involves truly participatory and non-extractive research methods which build on the interests, concerns, knowledge, and competencies of the communities involved. Consequently, arts become symbiotically integrated into the knowledge creation process, one that thrives on working with societal partners, instead of working for them. Therefore, the STARTS scheme provides models, knowledge, and collaborative know-how for how most complex forms of transdisciplinary research can be developed as a transversal research trajectory.

“More-than-solution” is another distinct angle that STARTS creative works bring to the innovation and transdisciplinary research ecosystem in Europe. Transdisciplinarity is one of the pinnacles of European research directives, aiming to provide solutions to complex problems and involving multiple disciplines and stakeholder participation (Bernstein, 2011; Pohl and Hadorn, 2008; Nowotny et al., 2001; Muller et al., 2015). However, adequate and effective solutions can be elusive and out of reach, often remaining as abstract and unrealized ideals, not necessarily because such problems are beyond our intellectual capacity to overcome, but rather due to the fact that certain proposed steps to solve these issues sometimes run the risk of obscuring the problems themselves and ignoring the root causes. To paraphrase Donna Haraway (2016), we can simply tune out by failing to stay with the trouble. Therefore, sensitizing and making things visible helps to ground us in different ways

Hence in the STARTS scheme, research and creative expressions move beyond solutions; they invite critical thinking, mattering, challenge underlying assumptions, subscribe to embodiment, and enact with agency.

Furthermore, STARTS projects reveal a layered and nuanced understanding of “novelty”. Here novelty and innovation go beyond the economic sense of productivity and utility. These projects demonstrate real life examples of what constitutes systemic and critical approaches to complex urgencies, helping to unpack loaded terms and concepts such as social and ecological innovation. In this sense, novelty unfolds as both new and creative ways of using and repurposing technology. It also invites new ways of seeing through different forms of visualization, opening up new pathways. Most strikingly STARTS is home to creative research which boldly explores unusual connections and uncharted territories for new trajectories. Last, but by no means least, STARTS has shifted the notion of aesthetics, innovating with, in, and through art. These works boldly engage with creative tensions and paradoxes (as we see in the case of “Anatomy of an AI System” by Kate Crawford/AI Now Institute and Vladan Joler/SHARE Lab). While doing so, they generate creative expressions with a distilled, balanced sense of new aesthetics; and, as a result, produce transversal works which cannot be easily claimed by either art, science, or technology alone.

Over the course of nearly a decade, the STARTS program has pioneered a major cultural shift in how we deliver innovation at different levels, by bridging the gap between art, science, technology, and society. In this respect, the program has generated successful examples and validations of how such cultural shifts can achieve long-lasting legacies beyond the individual projects themselves. The STARTS program created a pipeline for radically different research, innovation, and political aesthetics, which lie at the nexus of art, science, and technology. Most notably, the STARTS scheme actively infused several key concepts into the European innovation and research ecosystem, such as “agency”, “more-than-solution”, “care”, and “embodied urgency”. Moreover, through such cultural shifts, the STARTS model pioneered concern- and value-driven research, grounding art in the transdisciplinary (creative) research domain, and achieving the long-standing ambitions of the European research ecosystem in terms of bridging the gap between disciplines from distinctly different research paradigms (SHAPE-ID).[1]

Throughout its evolution, STARTS has manifested a compelling set of value propositions—spanning not only the content and outcomes of its projects, but also the deeper cultural and philosophical foundations of its approach. What emerges as a new thought paradigm is a unique ecology of culture and practice where artistic thinking, technological innovation, and societal engagement are brought into meaningful dialogue. Over the past decade, STARTS has also built robust infrastructural frameworks that do more than support collaboration—they actively shape and refine how such collaboration is conceived and practiced. Flagship initiatives such as Better Factory, STARTS Ec(h)o, and STARTS4Water, to name only a few, have played a pivotal role in testing, iterating, and validating concrete methodologies and tools, offering transferable models for the wider European research and innovation ecosystem (see the following publications: STARTS Collaboration Toolkit, Creativity Meets Industry, A Practical Guide to Transformative Partnerships, etc.).

The STARTS scheme is moving to the next level with its established models and radical visions around research and innovation in the midst of complex societal transformations. The European research ecosystem can benefit on a grand scale by supporting this transition, further integrating the value, knowledge, know-how, models, methodologies, and cultural accessibility of research through the novel and societally-engaged platforms of STARTS.

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1. See https://www.shapeid.eu/.

S+T+ARTS Value Proposition:

SIMONA DE ROSA (T6 ECOSYSTEMS)
AND STELLA DIAKOU (T6 ECOSYSTEMS)

Since 2016, STARTS has empowered communities to co-create, reinterpret, and transform culture. The STARTS model dissolves boundaries between disciplines. By linking artists, scientists, engineers, and entrepreneurs, STARTS shows that the culture and creative industries (CCIs) are not passive recipients of technology but co-authors of it. STARTS is more than just funding or collaboration—it intervenes in the very logic of innovation (Nowotny et al., 2002). The aim of this chapter is to respond to two important questions: Why does STARTS matter? Why must it be protected and scaled up at EU, national, and regional levels? The multidimensional nature of STARTS is precisely what makes it impactful. However, to understand the importance of the STARTS value proposition, we first need to focus on and recognize its distinctive traits.

Transdiciplinary Collaboration Towards Systemic Change

The first trait of the STARTS framework is interdisciplinarity and transdisciplinarity. While interdisciplinarity is a common aspiration, STARTS goes further by fostering transdisciplinary practices—those that not only combine domains but also allow new forms of practice and thought to emerge. Artists and researchers act as epistemic agents, challenging assumptions, reframing problems, and revealing blind spots (Loots et al., 2025). STARTS also tackles siloed ecosystems. By connecting artists with research institutions, tech developers, and policymakers, its projects break disciplinary boundaries and expand the ecosystem into new domains. This bridges a long-standing gap in innovation: the lack of human-centered, socially-aware, and environmentally-conscious approaches (Schwab, 2016). Creative experimentation fosters interdisciplinary fluency, enabling participants and audiences to engage in cross-sectoral dialogue that translates technical progress into societal benefit.

The second trait regards reskilling and upskilling. Projects foster digital and green skills through artistic engagement with frontier technologies, among others Artificial Intelligence, high-performance computing, and data simulation. Artists in STARTS residencies are not only introduced to these domains but actively contribute to them by developing human-centered and sustainable pilots. Through this, they gain and share competences such as critical thinking, systems innovation, collaboration, and problem-solving. STARTS also cultivates entrepreneurial skills by promoting creativity and experimentation in real-world contexts. Artists are empowered as co-creators who challenge assumptions, open pathways for innovation, and define the role of values, ethics, and aesthetics in progress. This reinforces entrepreneurial mindsets grounded not only in opportunity recognition but also in ethics and foresight. STARTS addresses skill gaps in integrating humanistic and ecological perspectives into technological innovation. While digital transformation often focuses narrowly on technical proficiency, STARTS emphasizes the value of artistic thinking as a driver of inclusive innovation. This includes tackling major challenges such as enhancing cognitive health through immersive tech, making AI more trustworthy, creating sustainable tools for city planning, and ensuring cultural heritage is both preserved and activated.

Thirdly, STARTS fosters transformative knowledge—insights that shift perspectives and reconfigure relations among people, technologies, and environments. Projects catalyze new conceptual models, imaginaries, and ethical frameworks. These transformations are subtle and long-term, not easily captured by KPIs, yet central to STARTS value. Artistic practices act as engines of cognitive, affective, and systemic change. They expand the epistemic boundaries of innovation, opening spaces for new inquiry and collaboration.

The fourth trait relates to methodologies. At its core, STARTS is a process capable of altering how industry understands creativity, collaboration, and value. Without the imaginative power generated by the convergence of art, science, and technology, our ability to conceive alternative futures remains constrained. The epistemic value lies not only in what this convergence produces but in how it reconfigures the terms of production and innovation. The value of STARTS is as much in its methodology as in its results. Analysis shows that successful projects often begin not with deliverables but with openness and trust. The process—i.e. the meeting point between diverse disciplines and paradigms—has intrinsic significance. This inquiry is not limited to cultural or academic contexts; it is sector-agnostic. All industries seeking to adapt their value chains or innovate responsibly can benefit from the knowledge production STARTS enables. Innovation value must be redefined: not as final products or measurable outcomes but as evolving relationships and capacities sustaining systemic change (Mazzucato, 2018).

Once the unique features of the STARTS framework are clear, we can focus on its value propositions in three aspects: (1) STARTS as a tool for cultural diplomacy; (2) STARTS as a driving force for social change; and (3) STARTS as a contributor to economic and industrial transformation.

S+T+ARTS AS A TOOL FOR CULTURAL DIPLOMACY

STARTS is not only a framework for innovation. In 2024, the first STARTS Prize Africa was launched. A milestone in international cooperation through ten residencies across Nigeria, Egypt, Tunisia, South Africa, and the Democratic Republic of Congo, the initiative "Afropean Intelligence" is exploring AI's impact and its associated challenges from local, grounded contexts. In parallel, STARTS Buen-TEK explores how indigenous knowledge and advanced technologies can be jointly mobilized to address ecological crises. STARTS has grown into a globally respected reference for transdisciplinary innovation. By opening up to other international programs, Europe's role as a leader in society-centered innovation is further amplified, and STARTS has informed ministries, innovation agencies, and decision makers around the globe on the methodologies developed and outputs delivered in STARTS. This is not just cultural exchange, it is systemic learning. STARTS dynamically showcases how Europe integrates artistic creativity, scientific excellence, and ethical innovation in addressing global challenges. The STARTS projects build cross-border and cross-sector partnerships, reinforcing the EU's internal cohesion and external cultural influence. Through its international platforms and festivals, the engagement of diverse audiences, projects that align digital technologies with human values, and the promotion of internationally relevant topics, the STARTS framework extends the EU's soft power, allowing its creative and research communities to influence global norms and practices in both tech development and sustainability.

S+T+ARTS AS A DRIVING FORCE FOR SOCIAL CHANGE

A key finding across the STARTS ecosystem is the centrality of social value—not as an outcome but as its operating system. STARTS shows that socially grounded innovation is essential to transformation. In the 2021–23 STARTS Prizes, 35% of projects evaluated social impact as the most important impact dimension of their project (Diakou and De Rosa, 2024). Far from a limitation, this is the ecosystem's most distinctive trait. In times of distrust and civic disengagement, social innovation must be a core objective, not a by-product. Analysis highlights four recurring dimensions: bridging and bonding social capital, inclusion, and citizen engagement (Diakou and De Rosa, 2024). These underscore how STARTS functions as relational infrastructure (Williams, 1997). The social dimension is not a soft add-on but a catalyst for disruption. Projects rooted in social contexts often reframe problems, shaping design, ethics, and user experience in profound ways. Social impact also permeates political, economic, and environmental domains. STARTS projects strengthen civic participation, community trust, and public engagement, nurturing informed citizens who are then able to make responsible choices, defend democratic values, and adopt sustainable lifestyles—fostering real behavioral change (UNESCO, 2019).

CASCADING EFFECTS: FROM SOCIAL VALUES TO ECONOMIC AND INDUSTRIAL IMPACT

Innovation policy often separates social and economic value. STARTS counters this by showing that social value is the very infrastructure of economic relevance. Its projects demonstrate that socially grounded practices create innovation that is resilient, ethical, and adoptable, challenging the false divide between artistic experimentation and industrial impact. Traditional measures—productivity, scalability, exploitation—fail to capture this. Impact assessments like the STARTS Prize and STARTS Ec(h)o show that while projects may seem to underperform by conventional metrics, their transformative potential lies in linking social, political, environmental, and economic change. Social value is not secondary but the core that makes innovation ethical, inclusive, and sustainable. STARTS projects strengthen civic engagement, democratic participation, and behavioral change, thereby shaping responsible citizens and consumers. For industry, these processes are not only compatible but essential. Faced with ecological crises, social fragmentation, and resource scarcity, art-science-technology collaborations provide the imagination and methods for new models of production and consumption built on sustainability, circularity, and inclusion. STARTS reshapes how industries think and innovate by embedding ethics and foresight at their core. It is not just about better products but about transforming the conditions of production itself. In this sense, STARTS is sector-agnostic and future-oriented: a model where co-creation is the method and social value the foundation of resilience.

CONCLUSIONS

At a time when innovation faces global challenges—climate change, digital transformation, social fragmentation—rethinking global foundations is an urgent necessity. The STARTS initiative pioneers this shift by building a transdisciplinary ecosystem where creative, critical, and systemic thinking generate new knowledge, problem-solving methods, and future visions. Often described through creativity, innovation, and disruption, STARTS's true value lies in grounding these in social conditions and transformations. Social value is not secondary but the basis of its economic, technological, and political relevance. Recent evaluations show that social impact drives STARTS's disruptive potential. This is seen not just in engagement or inclusion metrics, but in relational, process-based, and transformative collaborations that reshape how innovation is conceived and evaluated. STARTS is not an accessory to innovation but a model of socially grounded innovation. By reframing what counts as innovation and how it is measured, STARTS offers a twenty-first-century paradigm of creativity, ethics, and collaboration to design more equitable, imaginative, and resilient futures (Mulgan, 2019).

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The STARTS initiative stands on several interlinked pillars—Prize, Residencies, Academies, and Regional Centers—each shaping a distinct yet complementary dimension of its ecosystem. Together, they form a living structure that nurtures experimentation, recognition, and learning across art, science, and technology. The following essays outline how these formats respond to different needs: awarding excellence, enabling collaboration, building capacities, and strengthening regional innovation networks. They present an overview of the relevant methodologies and outline the learnings that have emerged from over a decade of practice.

PILLARS

S+T+ARTS Prize:

Honoring Innovation at the Intersection of Art, Science, and Technology

MASHA ZOLOTOVA (ARS ELECTRONICA)

The STARTS Trophy was designed by Nick Ervinck. The Belgian artist explores the boundaries between various media, fostering a cross-pollination between the digital and the physical. He applies tools and techniques from new media, in order to explore the aesthetic potential of sculpture, 3D prints, animation, installation, architecture, and design. Nick Ervinck, TAWSTAR, 2016. Photo credits: Peter Verplancke.

The STARTS Prize was launched by the European Commission in 2016 as one of the flagship pillars of the STARTS initiative. It was founded on the recognition that the most pressing challenges of our time—climate change, digital transformation, social cohesion, and economic resilience—cannot be solved by science and technology alone. Equally, artistic and cultural practices must reach beyond their traditional domains to play an active role in shaping the future. The STARTS Prize was therefore created to respond to the need for cross-disciplinary innovation, identifying and rewarding those projects and people working at the intersection of science, technology, and the arts that demonstrate the potential to generate a more sustainable and inclusive society. It demonstrates the transformative role of artistic imagination within innovation ecosystems, while also strengthening Europe's position as a global leader in transdisciplinary collaboration.

A DECADE OF THE S+T+ARTS PRIZE: METHODOLOGIES, OUTCOMES, GLOBAL REACH

From its beginning, the STARTS Prize was more than just an award. It was conceived as a platform to demonstrate how artistic thinking can influence both technological development and social change. Between 2016 and 2025, it attracted nearly 19,000 submissions from 124 countries, making it the largest and most visible global competition at the nexus of art, science, and technology. These numbers point not only to the scale of engagement but also to the widespread recognition of the STARTS Prize as a trusted framework for transdisciplinary excellence, not only in Europe but on a global scale.

The competition invites project submissions by either artists and creative professionals or the researchers and companies involved that present ground-breaking collaborations and projects driven by both technology and the arts; all forms of artistic works and practices with a strong link to innovation in technology, business, and/or society; all types of technological and scientific research and development that have been inspired by art or involve artists as catalysts of novel thinking. Applications are reviewed by a multidisciplinary jury of experts from the arts, sciences, industry, and policy, with criteria extending beyond aesthetic or technical quality to include societal relevance and alignment with European priorities such as the Green Deal, the New European Bauhaus, and the Digital Agenda. This inclusive approach has ensured that the Prize consistently elevates projects that are disruptive, ambitious, socially relevant, and go beyond awareness raising.

The Prize is awarded in two complementary categories:

- The Grand Prize for Artistic Exploration honors artistic research and works whose adoption by the arts has great potential to influence or change the use, application, or perception of technology.
- The Grand Prize for Innovative Collaboration rewards collaborations between industry, technology, and the artistic (and creative) sector that open up new pathways for innovation.

Together, they create a balanced framework: one that acknowledges both the intrinsic value of artistic imagination and the practical importance of collaborative, cross-sectoral approaches.

Along with the Grand Prize winners, the jury members identify ten honorary mentions and 18 nominations from the submitted projects. The openness of the STARTS Prize and the number of selected projects also allow it to capture a broad range of topics and practices: from artificial intelligence, biotechnology, robotics, and quantum technologies to performance, design, gaming, and social innovation. In many cases, projects recognized by the Prize have anticipated debates and policy concerns before they entered mainstream discussions. By doing so, the Prize acts as an early-warning and early-vision system, signaling both risks and opportunities for economic, social, and technological development.

A key advancement in recent years has been the introduction of new thematic and regional editions of the STARTS Prize, such as the STARTS Prize for Social Good, which broadens the initiative's scope to directly address societal needs and promote innovation with measurable social impact. Building on this momentum, the global expansion of the Prize further reflects the worldwide relevance of arts-driven innovation. The launch of the STARTS Prize Africa (2024 and 2025) and STARTS Prize South America (2025) marked key steps in recognizing and supporting local creative ecosystems. These editions adapt the Prize's methodology to regional contexts while fostering cross-continental exchange. Even though the STARTS Prize has always been open to applicants worldwide, the creation of regional editions makes it possible to give voices from the Global South more focused recognition and dedicated attention. By deliberately highlighting projects from regions often underrepresented in global debates, the Prize strengthens cultural diplomacy and contributes to building more balanced global innovation ecosystems.

THE S+T+ARTS PRIZE AS CATALYST FOR CHANGE

The STARTS Prize is far more than a competition. It is a catalyst for systemic change, building trust in the role of culture within technological development and fostering a shared narrative of inclusive progress.

As one of the central pillars of the STARTS initiative, the Prize has become a necessary policy instrument. By awarding pioneering projects and giving them international visibility, it strengthens the credibility of collaboration at the nexus of arts, science, and technology. For artists, this recognition often proves transformative—opening doors to new partnerships, funding, and participation in research or policy debates. It affirms their role as innovators whose contributions extend beyond cultural domains into technological and societal arenas.

The selected projects also act as benchmarks for the field at large. They serve as reference points for cultural institutions, research organizations, industries, and policymakers by demonstrating how artistic imagination can shape innovation in practice. These exemplary cases inspire replication, guide new initiatives, and provide tangible illustrations of how transdisciplinary work can address urgent challenges.

Over time, the STARTS Prize has contributed to redefining the very notion of excellence in art, science, and technology collaborations. In doing so, it has highlighted the diversity of models through which such excellence can emerge—extending well beyond traditional residency formats. The projects honored by the jury members illustrate a wide range of pathways: from independently developed initiatives to collaborations facilitated through institutional frameworks, across different domains, and with varying degrees of access to infrastructures and resources. Thus, the STARTS Prize has been established as an instrument that not only celebrates outstanding results but also acknowledges the multiplicity of contexts, scales, and methods through which impactful transdisciplinary work can take shape.

In strategic terms, the Prize acts as both recognition and intervention. It sets standards, provides direction, and accelerates the adoption of transdisciplinary models that can respond to Europe's urgent green, digital, and social transitions. The importance of the Prize lies precisely in its dual nature: it honors past achievements while simultaneously shaping future trajectories. By embedding artistic imagination within broader innovation systems, it ensures that technological progress remains socially meaningful and culturally grounded.

Academies: Insights into Educational Practices

MAJA DROBNE (PINA) AND BORUT JERMAN (PINA)

INTRODUCTION AND CONTEXT

At their heart, STARTS projects are not only about creating new artistic or technological outputs, they are also about shaping the ways we learn, collaborate, and reflect together. Innovation is never born in isolation; it emerges from people who share knowledge, question assumptions, and build capacities to act. For this reason, education must be treated as a foundational dimension of every STARTS initiative.

Education in this context is not about formal instruction or top-down teaching. It is about creating frameworks for preparation, experimentation, and reflection that enable residencies and collaborations to thrive. When artists, scientists, and technologists enter a residency without shared language or critical tools, the risk is that ideas remain fragmented or unimplemented. When participants are supported by structured learning whether through training, mentoring, or peer exchange the creativity gains clarity, planning becomes more purposeful, and their projects stand a greater chance of lasting impact. The Academy exists to embed preparation, skill-building, and reflection into the lifecycle of STARTS projects, so that every idea emerging from a residency is supported by solid planning, informed decision-making, and cultural awareness. In this way, it directly serves the broader mission of STARTS: fostering interdisciplinary collaboration between science, technology, and the arts, while ensuring that such collaborations deliver both creative excellence and societal relevance.

In this sense, education is the red thread that binds STARTS projects together. It equips practitioners with the skills to navigate complex challenges, fosters a culture of reflection that grounds innovation in context, and ensures that the knowledge created does not end with a single prototype but contributes to building resilient ecosystems for the future. STARTS4AFRICA was one of them, where the impact and the added value of the educational cycle were showcased.

ROLE AND UNIQUE CONTRIBUTION

The Academy has the potential to act as the capacity-building engine of STARTS, enabling participants to enter residencies with the knowledge, skills, and confidence needed to make the most of their time. It prepares artists, scientists, and technologists through shared conceptual frameworks, practical project management tools, and opportunities to reflect critically on their work. It strengthens the planning process so that creative concepts can be translated into concrete, achievable roadmaps. By embedding reflection at every stage, it ensures that projects are not only inventive but also culturally responsive and ethically grounded. In addition, the Academy integrates multiple forms of knowledge bridging ancestral traditions with cutting-edge technologies so that participants can build work that is rooted in both heritage and innovation. In doing so, it lays the foundations for robust ecosystems of practice that extend far beyond the life of individual projects.

At the same time, collaboration among scientists, technologists, and artists requires all sides to transcend their own established ways of thinking, communicating, and valuing expertise. Each discipline comes with its own language, priorities, and systems of relevance, which can easily become barriers if left unaddressed. For innovation to flourish, participants must be willing to step outside their comfort zones, learn to listen across disciplinary divides, and build trust by recognizing the validity of different perspectives. Education plays a crucial role in this process, equipping both artists and scientists with the competencies needed to bridge these differences and cultivate a shared space of understanding. In this sense, the Academy not only strengthens individual capacities but also enables the conditions for truly collaborative, cross-disciplinary innovation.

METHODOLOGIES AND PRACTICES

The Academy's methodological approach is grounded in the belief that learning should be co-created, context-driven, and iterative. Every program begins with a process of listening and dialogue, ensuring that the educational content grows directly from the needs and realities of its participants. In practice, this meant that before the first training or webinar took place, program designers engaged in on-the-ground consultations with hub managers, local creatives, community leaders, and potential participants. This preliminary phase is not an accessory; it is the foundation of the Academy's relevance, allowing each learning journey to respond to concrete challenges while also opening space for unexpected synergies. From this basis, the Academy builds its activities using a hybrid learning model. Online components provide a shared starting point: thematic webinars introduce key concepts, tools, and frameworks that all participants can draw upon, regardless of their geographical location. These sessions are designed to create a "common language" across disciplines, which is essential in STARTS, where artists, scientists, and technologists must communicate across different vocabularies and working cultures. For example, the webinar on "Needs Analysis" offered by AI researcher Chris Emezue not only provided technical insight but also demonstrated how rigorous diagnostics can guide creative decision-making, bridging artistic vision with practical feasibility.

The in-person training deepens this shared foundation by immersing participants in experiential and participatory learning. These sessions combine collective visioning with hands-on exercises, enabling participants to test ideas in a collaborative environment. In Lagos, for instance, LEGO® Serious Play was used as a mapping tool, helping participants visualize the alignment between their personal ambitions and broader sectoral needs. This method encouraged abstract concepts to be externalized and made visible, allowing for richer group discussion and co-design. In Dar es Salaam, collective visioning exercises began with storytelling rooted in community narratives, anchoring technological aspirations in lived experience before moving into strategic planning and funding pathways.

Another key methodological strand is the integration of ancestral knowledge with contemporary innovation. In Dakar, Theatre of the Oppressed techniques enabled participants to explore power dynamics in their communities, fostering empathy and a nuanced understanding of the social landscapes in which their projects would operate. Field visits to local social-innovation initiatives connected abstract concepts to tangible examples, while workshops on ancestral knowledge challenged participants to situate their technological solutions within their cultural heritage. In Accra and Kumasi, action-planning and pitch refinement activities deliberately drew on traditional craft perspectives, showing how heritage techniques can inform digital fabrication, materials innovation, and sustainable production.

Throughout the program, iterative feedback loops are embedded to mirror the trial-and-error dynamics of creative and scientific processes. Peer critiques create space for constructive challenge while one-to-one mentoring sessions address individual obstacles in depth.

Workshops held during the STARTS4Africa project.
Photos by Délio Sá and Raquel Brandão.

Masterclasses act as targeted accelerators, delivering specialized knowledge exactly when participants need it, whether in immersive sound design, advanced research methods, or strategic project management. This responsive structure ensures that learning is not static but evolves with the participants' own progress, keeping the Academy adaptable and relevant.

Finally, the Academy cultivates an ecosystem-oriented approach. Learning is not conceived as an individual gain alone but as a contribution to a broader network of practice. Activities are designed to foster connections across disciplines and borders, enabling the sharing of resources, ideas, and opportunities long after the official program ends. This ecosystem thinking is central to the STARTS ethos: it ensures that capacity-building is not just about the immediate success of a residency but about strengthening the entire innovation environment in which that residency takes place.

IMPACT AND VALUE

The Academy has shown that education transforms participation into ownership. Participants in residencies who have been through Academy processes arrive with greater readiness, enabling more advanced and ambitious work from the outset. Training helps to turn broad visions into actionable plans, increasing the likelihood of sustainability. Projects that emerge from this process are anchored in cultural and societal contexts, making them more relevant and impactful. In STARTS4AFRICA, over 140 hours of mentoring allowed innovators to address individual challenges, from refining technical specifications to navigating funding opportunities. The networks formed across Nigeria, Ghana, Tanzania, and Senegal have created a cross-border community of practice capable of exchanging resources and collaborating long after the program's formal end. Beyond the immediate participants, the Academy's methodologies offer models for cultural and innovation policy, demonstrating how education can be embedded in the heart of innovation frameworks both in Africa and in Europe.

FUTURE AND LEGACY

The integration of education into STARTS projects has made it clear that innovation and learning are inseparable. Residencies become more impactful when they are supported by preparatory training; planning becomes sharper when guided by structured methodologies; and reflection becomes transformative when embedded in every stage of the process. The challenge now is to deepen and institutionalize this approach. Formalizing alumni networks will sustain the relationships and synergies built during the Academy, ensuring that knowledge continues to circulate beyond individual project cycles. Advanced modules on scaling, fundraising, and policy engagement will give innovators the means to move from prototypes to broader societal impact. Impact-tracking mechanisms will capture what works, creating learning loops that inform both future residencies and policy design.

The legacy of the Academy will be a resilient, interconnected community of practitioners who can imagine, prototype, and implement solutions that are artistically inspiring, technologically advanced, and socially transformative. Education will remain the red thread that weaves together creativity, technology, and culture, ensuring that the true product of STARTS is not only a collection of artworks or prototypes, but the strengthened capacity of individuals and communities to drive change in an increasingly complex world.

S+T+ARTS Residencies: Towards Responsible and Sustainable Innovation

ANA MARIA CARABELEA (ARS ELECTRONICA)

The STARTS ecosystem is built on a variety of pillars that sustain and strengthen it. Within this constellation, the STARTS Residencies serve as spaces where new shared practices and forms of collaboration are tried and tested.

Before the separation walls between the studio and the lab were built and art and science and technology were positioned in opposition to one another, they were almost indistinguishable disciplines.[1] This reminds us that what counts as a challenge now for initiatives like STARTS is not to break a natural order of things, but a purposefully constructed one. The question of how to create these third spaces—neither studio nor lab, but ones that allow for the meeting of different epistemologies, practices, and practitioners—might find a more fitting answer through a look at the social, political, and economic reasons behind their dissolution.

In their quest to become such spaces, the STARTS Residencies take on the task of dismantling long-lasting narratives about the place of art in knowledge production and technological innovation. The STARTS Residencies have been a key pillar since the start of the initiative—a way to formalize the meeting between art, science and technology. In the 10 years since its launch, STARTS has hosted over 350 residences. Their success cannot always be measured with traditional tools. More often than not, these tools are borrowed from the business sector, dictating objectives and goals and imposing standards that these collaborations cannot and *are not supposed to fulfil*. Such measuring tools can only offer partial accounts of the (often long-term) impact of these collaborative frameworks. As such, STARTS Residencies also challenge the tools that measure success and build the foundation for a multi-dimensional framework for evaluating arts-science-technology collaborations, as Stella Diakou, Simona De Rosa, and Tere Badia outline later in the book.

Since STARTS Vertigo—the first project of the initiative that hosted STARTS Residencies— their methodology has come a long way. While Vertigo invited artists to ponder innovative (and perhaps *subversive*) use-cases of technologies, today's STARTS Residencies have moved towards integrating art, into science, technology, and industry practices. In doing this, STARTS Residencies move beyond a definition of artistic value focused on commentary, critique and thinking outside the box, to prove the value of art-led innovation—a value that does not always translate into numbers, but speaks to the complex processes behind *responsible and sustainable innovation*. Instead of suggesting quick fixes to problems, these residencies have given artists the keys to spaces of innovation, asking them to question them, but also to make them thrive in ways they would not if they had not been challenged.

On the one hand, the STARTS residency projects reveal how deep-seated practices can result in innovation uncontaminated by the complications and messiness of everyday, which often fails to ask ethical questions. They challenge a status quo that yields solutions that, while solving some issues, bring forth others. Projects like Maria Arnal's *Impossible Larynx* or Anna Schaeffner's *Soft Collisions* are great examples of the type of innovation sought by STARTS: one that centers the human and asks important questions before proceeding to development.

In doing so, these projects reveal not only the weaknesses of existing models of innovation, but also the ways to improve them. Artists enter these collaborative processes not as guests, observers, or critics, but as active participants. They move between disassembling in a critical process and reassembling in an imaginative one. As such, they prepare for the integration of artistic practice at the prototyping level—typically reserved for science. Take, for example, the work of Samira Benini Allaouat, who developed a prototype for a self-sustaining public illumination powered by bacteria that generate electricity while purifying the soil. Geo-llum is more than critique, it's an active intervention.

On the other hand, apart from dissecting industry and scientific practices, these collaborations force an opening into artistic practices as well. Artists themselves are challenged and go through extensive learning processes. The STARTS Residencies' process views itself as a training for artists who, during their residencies, go through an iterative process of knowledge exchange with multiple actors. Beyond the natural exchange that arises from its close and extensive collaborations, STARTS Residencies equip artists with new skills developed through incubation and mentorship programmes, workshops and feedback sessions with experts. In an effort to avoid the instrumentalization of artistic practice, the Residencies are often designed to benefit the artists involved, by pairing them up with "enrichers", trainers, mentors, innovation catalysts or local expert groups that can help them navigate these types of cross-collaborations.

In their role as mediators, hosting organisations create these constellations as support networks for artistic research, as much as for scientific, industry or business stakeholders. Aware of the challenges of involving a plurality of voices, they prepare the environment for a constructive dialogue between stakeholders with different views and interests. Throughout the different stages, from the formulation of the residency topic, the selection of the artists, partners and experts, to mapping out the stages of each residency, hosts have to consider the specificities of their constellation. This requires the Residency model to have a certain adaptability and responsiveness to the context.

The variety of partners involved in the STARTS Residencies throughout the years, from scientists to industry leaders and policymakers, speaks to the plurality of voices needed to solve the deluge and complexity of current crises. Residencies like those conducted in BETTER Factory and MUSAE brought together artists and designers with mentors (aka 'enrichers') and SMEs across Europe. These actors worked together to reimagine more sustainable everyday products or develop more responsible production processes in fields like furniture and fashion design, product design, logistics, agriculture, and construction. More recently, the STARTS Residencies in Hungry Ecocities called on artists and SMEs to collaborate on redefining our food production by rethinking the entire food chain.

In addition to that, STARTS Residencies in projects like STARTS4Water, STARTS Aqua Motion, GRIN called on artists, scientists, researchers, local policy makers and local government, as well as ICT experts to rethink infrastructures. These are just a few examples of the work done so far. The number of research facilities,

1. Fuller, Matthew and Weizman, Eyal. 2021. *Investigative Aesthetics: Conflicts and Commons in the Politics of Truth*. London: Verso.

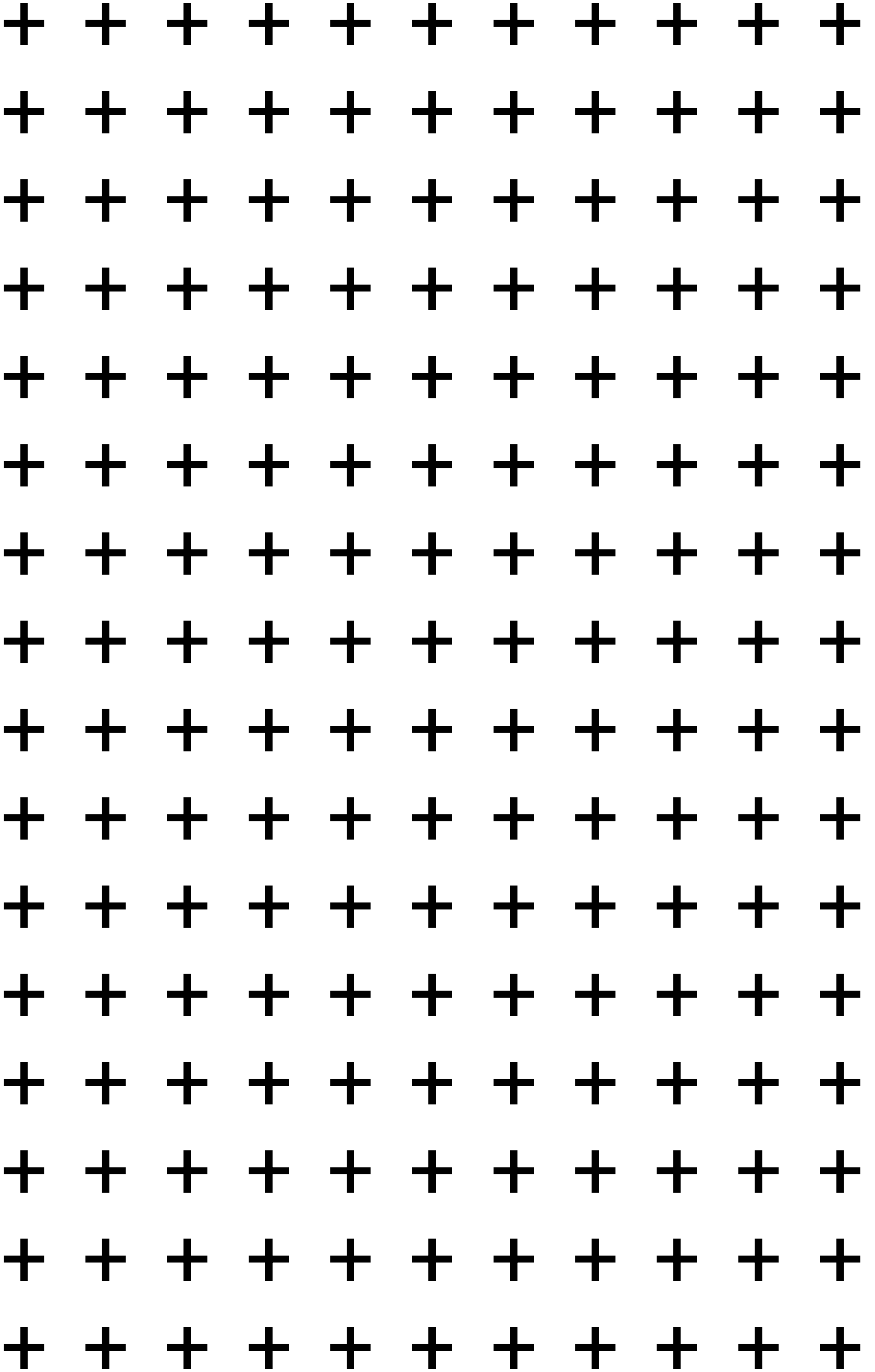
universities, business and industry partners involved in them highlights not only the need for these cross-disciplinary collaborations that all sectors feel, but also the need for these frameworks to be expanded across different disciplines and at various scales. One could regard the STARTS Residencies as a testbed for practices and models, one that can and must be scaled.

Their outcomes, from the tangible prototypes for products and services that can enter the market or redesigns of tools, methods, and approaches to innovation, to the more intangible ones like research publications, investigative mapping, or policybriefs are essential to a society facing multiple and complex crises—political, environmental, economic—and its policymakers.

By allocating the arts a major role in innovation and research, the STARTS Residencies level the playing field that has long created hierarchies and divisions between disciplines. They suggest a shift from a competitive mindset to a collaborative one. 10 years of experience have taught all those involved a lot about how this translates into practice, and how collaboration can be done. The effort to build STARTS Residencies is one that continuously zooms in and out, from unpacking universal mis/preconceptions, challenging the status-quo and envisioning alternatives, to the granular, down-to-earth questions of developing a framework in which new visions take concrete shapes and become the realities of our everyday lives.

When engaging in such work, whether as an artist, scientist, industry leader or mediator, one must be equipped with patience, a tolerance to failure, and the agility to respond to a dynamic context. Change starts with big narratives, but ultimately takes over through granular changes that often go unnoticed. The future of STARTS Residencies depends as much on the outcomes it produces as it does on the ability to read and interpret their value beyond market-driven performance indicators. As the initiative moves into its second decade, perhaps the most valuable lesson it can carry across is that responsible and sustainable innovation takes time and effort, but it is also the only way forward.

The following sections of this publication provide an overview of the learnings from some of the residency programs and zoom in on the different aspects that make up their uniqueness.



S+T+ARTS Regional Centers: Territories of Inspiration

TERE BADIA (HACTE) AND ANNA PINOTTI (HACTE)

Drawing on the experience accumulated over the last decade of operating the STARTS program, and in light of a growing awareness of the need for complex thinking and transdisciplinary, cross-sectoral collaboration to establish an open innovation model for sustainable economic growth and social well-being, new policy-making frameworks have emerged at regional, national, and European levels. One of the most effective tools for articulating these frameworks has been the “Regional STARTS Centers” (RSCs). During the ten years of the STARTS initiative, 32 institutions in 21 European regions have been appointed as RSCs, with the aim of establishing regional hubs for the program and addressing local environmental and social challenges.

These centers are gradually being consolidated as key instruments for a European innovation model and have taken the form of organizations, hubs, and more or less formal networks. They function as advanced transdisciplinary centers that actively demonstrate the effectiveness of systematically integrating artistic practices and research into broader frameworks linked to science, technological development, and society (ASTS) within regional innovation ecosystems.

RSCs are strategically located in sensitive areas of high density and diversity of knowledge, economic, scientific, and industrial development. As regional catalysts, they primarily respond to the need to create complex, dynamic, and competent ecosystems that have a tangible impact on society, establishing them as key players in promoting creative and interdisciplinary collaborations. The growing and sustained cross-sectoral collaborations in those European regions that have RSCs highlight the need to consolidate these collaborations and focus efforts on effective collaboration with policymakers at all relevant levels (local, regional, national, and European). Therefore, a fundamental challenge for RSCs is to ensure the sustained commitment and support of policymakers at all levels.

A MULTI-CHANNEL AND SUSTAINABLE EXPERIENCE

Analysis of the methodologies and strategies used by RSCs reveals practices which, although diverse, have been effective in integrating cross-cutting and transdisciplinary approaches into territorial systems of open innovation and advanced knowledge.

The varied experience of RSCs is an example of their multifaceted value propositions. On the one hand, they are capable of operating as a device for regional cohesion in their territories, integrating diverse perspectives and fundamentally acting as a channel and conduit of connection, not only between the agents they mobilize in their programs and actions but also between other organizations acting in a similar way in various European territories. Undoubtedly, these initiatives facilitate peer learning spaces that allow for the transfer of experience, expertise, and experimentation. Their unique strength lies in their interstitial position, which allows them to bring together diverse institutions, sectors, communities, and regions in a "testing ground" for the application of effective policies to address current ecosystem challenges in the digital, climate, social, cultural, or economic spheres. This "inhabiting the interface" allows RSCs to act as catalysts and mediators between diverse European innovation models and emerging practices and local expertise. These synergies are essential for achieving viable systemic change and fostering a shared ASTS identity.

RSCs also represent another way of understanding sustainable infrastructures as they embody a commitment to attracting complementary and distributed existing infrastructure, maximizing resources and fostering genuine interrelationships between the agents involved. In this sense, on the one hand, they activate connections between different communities and, on the other, they aggregate existing knowledge and are capable of creating new knowledge. They are dedicated, balanced (between agents, disciplines, institutions), open, and dynamic meeting spaces. They function as a "structuring structure" that fosters trust, cooperation, and equity, and weaves a complex network of diverse resources (material and immaterial). Research centers, technology hubs, universities and schools, and artistic spaces are organized around RSCs to defragment sectors and disciplines, bringing together needs and projections, infrastructures, organizations, and ways of doing things. They operate in a matrix-like manner, by moving back and forth throughout the value chain, and because they are assembled from multiple sources, in a multi-dependent and decentralized manner, while at the same time being strongly linked through the tools deployed for collaboration and joint work. They are relational objects and common spaces at the same time, in constant transformation, inhabiting the in-between of sectors and disciplines and working from their resistance and efforts.

EXPANDING THE LEGACY: STRATEGIES TO SUPPORT DESIRABLE FUTURES

Ambition must extend beyond the experience accumulated during the STARTS initiative's first decade, integrating the RSC paradigm into additional regional ecosystems and schemes. This involves exploring the legacy of the STARTS Regional Centers in leading transdisciplinary innovation to face regional challenges, as well as promoting cross-regional collaboration across Europe. The goal should be to establish strategic investment lines that facilitate the development of projects promoting interdisciplinary cooperation within the framework of the knowledge economy, as well as in the area of European innovation, with positive environmental, social, and ethical impacts at the local level. However, in order to build on the experience of the RSCs and follow this path, critical systemic factors must first be addressed. Firstly, ambitious, coherent, interdisciplinary funding plans are required to ensure the sustainability of this accumulated experience. Funding structures that explicitly support the interdisciplinary mission of the RSCs are needed, such as the unique coherence of DG CNECT's STARTS initiative. While the work of the RSCs encompasses research, culture, science, industry, digital policy, and education, many current regional investment models primarily rely on funding from cultural departments. Therefore, long-term, interdepartmental funding commitments are necessary to reflect a coherent narrative and ensure operational stability.

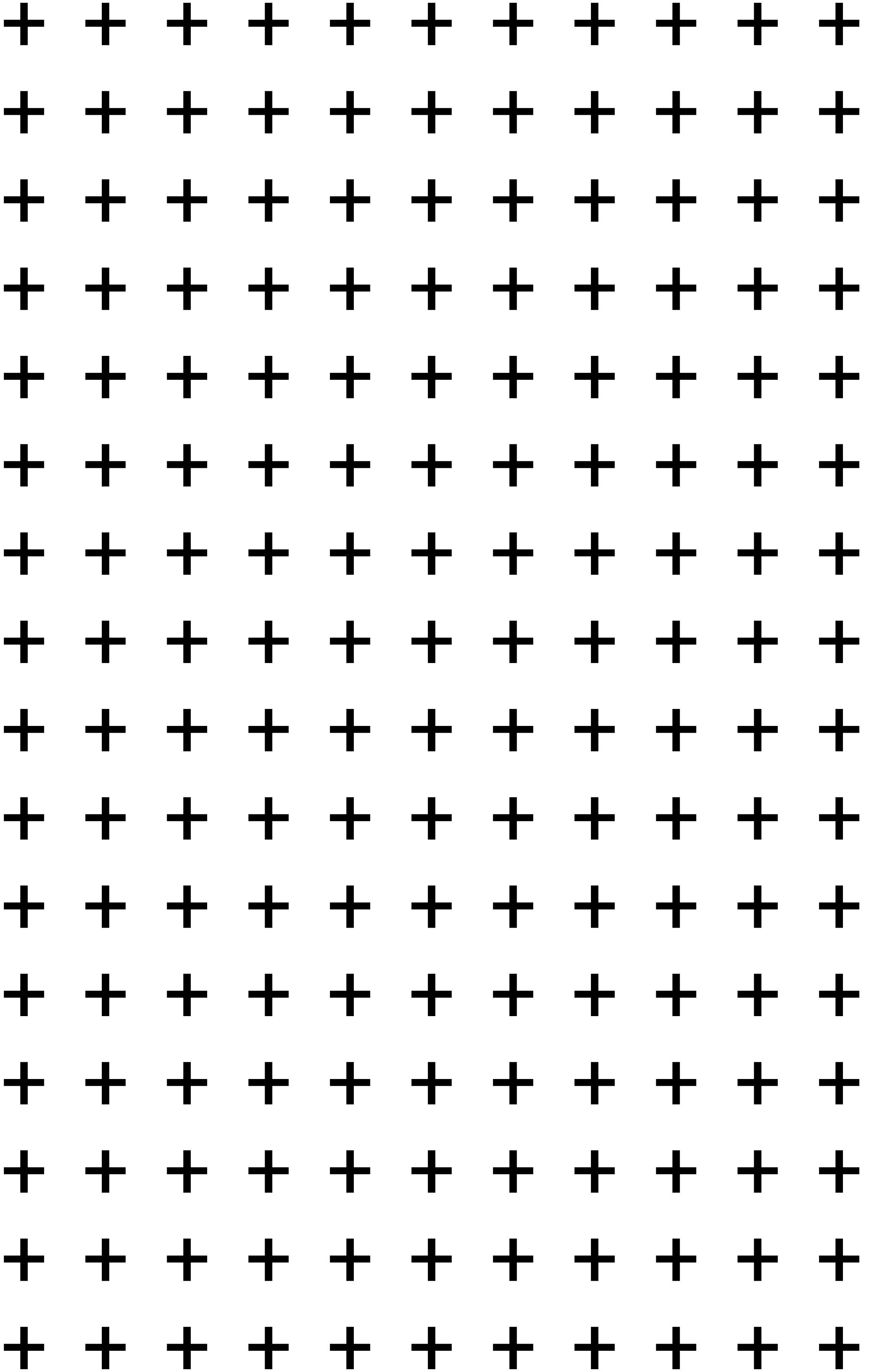
Secondly, it is important to promote the knowledge gained from testing prototyping methodologies within the STARTS framework. These methodologies embrace trial and error as part of the process. In this sense, processes must be valued and work must be carried out with open models that are constantly changing and evolving. To this end, new training in processual mediation between diverse parties is as necessary as changing the paradigm for measuring impact. Demonstrating the transformative power of STARTS collaborations requires new metrics and broad timeframes to highlight the non-linear and emerging value generated at disciplinary intersections.

Thirdly, RSCs have the potential to suggest changes to governance models. They should aim for a form of multilevel governance that embodies different policy levels (local, regional, state, and European) in its management. This would allow for the development of cross-cutting policies and multiple meanings of proximity. They should also aim for governance between different actors, forming a coalition of shared initiatives to ensure solidity and the interdependence of what has been achieved.

THE LASTING LEGACY: RSCS AS A TRANSFORMATIVE THIRD SPACE

The unique contribution of the STARTS initiative lies in its decade-long cultivation of a fertile "liminal space" for intersectional research and practice. It has facilitated a paradigm shift by consolidating collaborations between diverse entities such as quantum physics laboratories, supercomputing centers, festivals, communities, art centers, and universities. These collaborations are now accepted as natural and essential rather than being questioned. STARTS has successfully created a “third place” dedicated to open dialogue and honest collaboration between different epistemologies, organizations, and individuals. This space now fosters a sense of mutual recognition as peers, respecting the distinctive qualities and capabilities of each discipline while navigating creative friction. A necessary structure that sustains a diverse and multi-layered ecosystem encompasses research, knowledge aggregation, experience-based advice, networking logic, access to existing and decentralized infrastructures, the collection and dissemination of transdisciplinary methodologies, values, practices, and results, and functioning at both local and international levels.

The profound legacy of STARTS, which now lives on in the RSCs, is the achievement of fostering mutual trust and shared goals based on the conviction that diverse perspectives lead to greater collective understanding. The RSCs offer a replicable model that demonstrates how concerted political will, attentive listening, and dedicated frameworks can bridge disciplinary and institutional divides. In a Europe that urgently needs a better future, the RSCs demonstrate the indispensable value of working together to see, reframe, and build things differently.



The STARTS initiative has generated a wealth of knowledge about how artistic, scientific, and technological collaborations create impact—often in ways that escape conventional evaluation models. The following essays draw on recent impact assessments to explore these learnings, highlighting the need to move beyond standard, output-oriented frameworks toward multidimensional approaches that recognize cultural, social, and ecological transformation. They show that true impact in transdisciplinary innovation lies not only in measurable results, but in the processes, relationships, and long-term shifts that redefine how knowledge and creativity drive systemic change.

LEARNINGS

Closing the Loop: S+T+ARTS Prize

ZEYNEP BIRSEL (WAAG FUTURELAB),
MARGHERITA SOLDATI (WAAG FUTURELAB)
AND MIHA TURŠIČ (WAAG FUTURELAB)

The *Closing the Loop* study was launched to strengthen the internal capacity of the STARTS initiative by drawing concrete lessons from the STARTS Prize, with the aim of supporting the sustainable development of future innovation actions. Rooted in insights from award-winning projects, the study uncovers value and impact beyond initial expectations around art, science, and technology collaborations to contribute to an evidence-based foundation for the STARTS initiative.

Excellence Pathways

The goal was to identify excellence pathways for art-driven, collaborative innovation. Reflecting on insights emerging from this exploration of a near decade-long legacy of the STARTS Prize, we uncover the reinforcing links between the STARTS Prize, innovation actions, and the broader ecosystem through a community-based approach that engages diverse stakeholders around pressing challenges. By exploring untested collaborative methods found in Prize projects, the study also aimed to bridge cultural and methodological gaps in residency programs. In doing so, it advocated for wider adoption of art-based research and responsible innovation practices across research, technology, policy, and industry sectors—demonstrating how artistic excellence can have systemic impact on the EU's research and innovation agenda.

STARTS stands out by extending the vision of key European research frameworks, such as Responsible Research and Innovation (RRI), transdisciplinarity, and the 5-helix model, which are often difficult to implement in practice. The study shows how STARTS Prize projects exceed these frameworks by embedding ethical and cultural responsiveness in research, fostering critical thinking, and addressing complex challenges. These projects operationalize the 5-helix model, balancing economic, social, and ecological dimensions, and including other-than-human perspectives. STARTS projects bridge gaps left by traditional research, offering a unique, policy-embedded model for innovation, and has been praised internationally as an example to follow.

EXCELLENCE IN S+T+ARTS: AN EMERGENT MAP

It is time we retire the shallow rhetoric of "state-of-the-art" innovation and instead embrace something far more transformative: the kind of excellence that STARTS Prize projects exemplify. These are not just clever integrations of science, technology, and art; they are deeply value-driven interventions, forming a new cartography of excellence—one that challenges conventional ideas about innovation, participation, and even knowledge itself.

STARTS Prize projects do not define excellence as efficiency, productivity, novelty for its own sake, or market fit. Rather, excellence here emerges from a fusion of care, criticality, and creative disruption. It is plural, situated, and often withholding tensions, politics of technology, research, and aesthetics—and that is exactly the point. At the heart of this redefinition are seven interlocking qualities: novelty, concern, boundary work, agency, criticality, change, and value-embedded research. These are not abstract themes; they are active forces shaping alternative pathways to research and knowledge creation.

Novelty in STARTS is not about being the first or beyond state-of-the-art. It is about radically rethinking the materials, mediums, objects, and meanings embedded in research. Think of Yakushimaru's I'm Humanity, where genetic code becomes both storage medium and musical composition—a poetic future archive embedded in life itself. It repositions the very function of creativity within biotechnology. It opens up new possibilities and unleashes unconventional connections to be explored in future research.

Concern-driven practices manifest in many Prize projects. They begin not with outputs but with profound disturbance, grief, urgency—affective, ethical starting points that traditional research frameworks are often detached from. These works do not just diagnose crisis, they intervene in it. From climate justice to algorithmic exclusion, they insist that the world must be experienced before it can be fixed.

Then there is boundary work—the kind of collaboration that is not content with token interdisciplinarity. Projects such as SimCath or Anatomy of an AI System illustrate this beautifully. They unsettle disciplinary borders, not to blend everything into an indistinct mix but to generate new hybrid aesthetics and ways of knowing—ones that are poetic, rigorous, and politically urgent all at the same time.

Agency is another cornerstone. Unlike conventional citizen science or participatory design efforts, STARTS projects strive for a genuine redistribution of power. Agency is not just about humans; it is about giving voice and role to the nonhuman, the marginalized, the excluded. Pollinator Pathmaker or Oceans in Transformation are exemplary in placing the "other-than-human" not as passive subjects but as co-actors in reshaping futures.

This brings us to criticality—arguably the hallmark of STARTS. These works do not just engage with technology, they interrogate it. They expose the invisible labor, ecological damage, and cognitive dissonance that underpin our digital lives. In Sociality, for instance, Paulo Cirio reveals the grotesque normalcy of patented technologies for manipulation—a quiet scream against the commodification of the social.

The concept of change, though overused in policy rhetoric, takes on renewed substance here. Change is not linear or purely outcome-driven; it is cultural, systemic, and affective. Projects like Library of Ourselves or Holly+ are not content with small tweaks. They provoke a shift in how communities relate, how rights are conceived, and how knowledge is shared.

Finally, value-driven research asks an uncomfortable question: Whose values are we embedding, and for whom? STARTS projects resist neutrality. They expose the value-laden nature of all research, insisting instead on transparency, empathy, and accountability. These are not side notes to scientific rigor—they are the rigor.

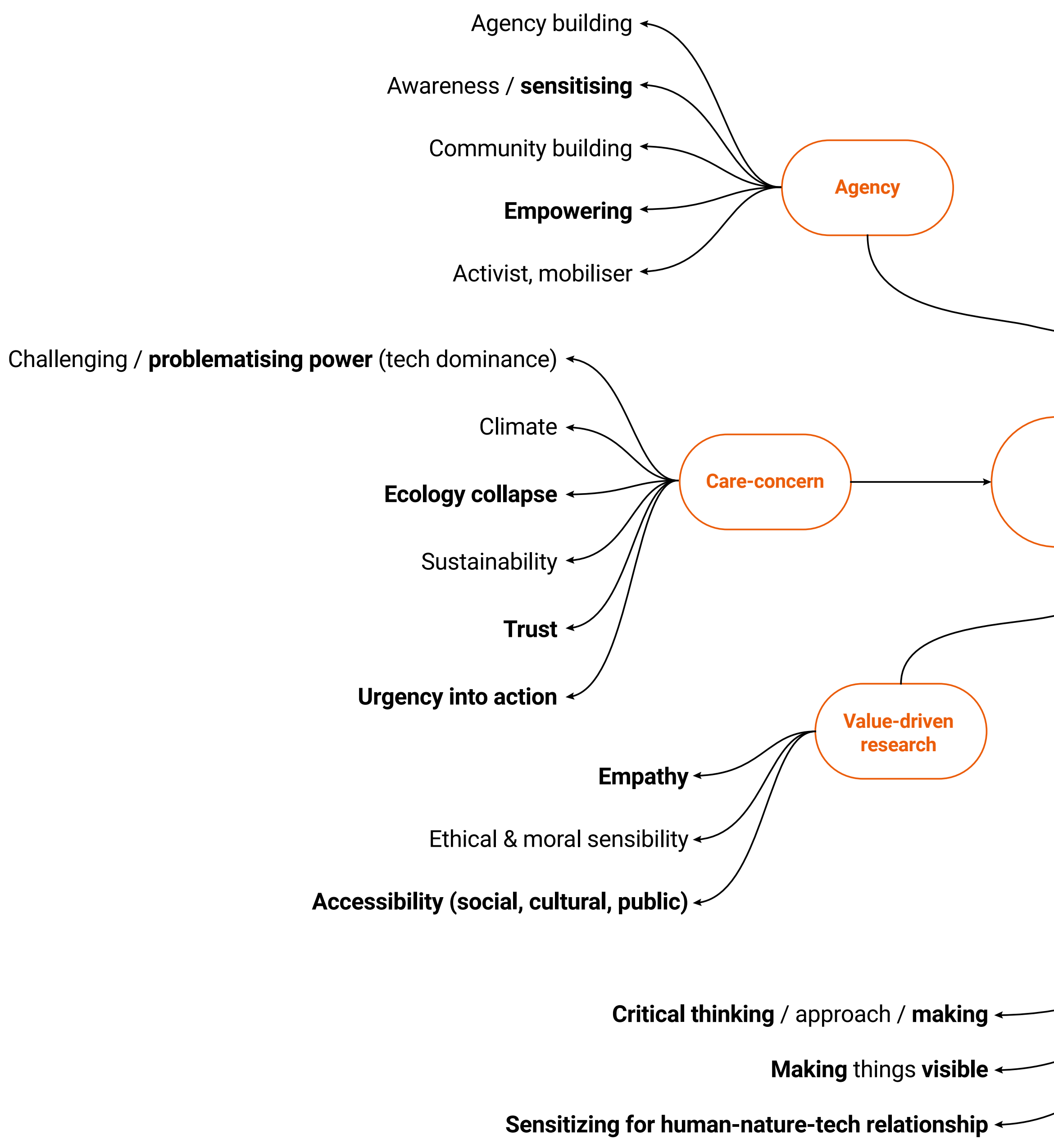
What emerges from this constellation is not a checklist but a philosophy of practice—one that confronts the crisis of relevance and legitimacy facing contemporary research and innovation. This model does not seek to compete with commercial Research and Development (R&D); it offers a parallel route—slower, messier, but profoundly more humane.

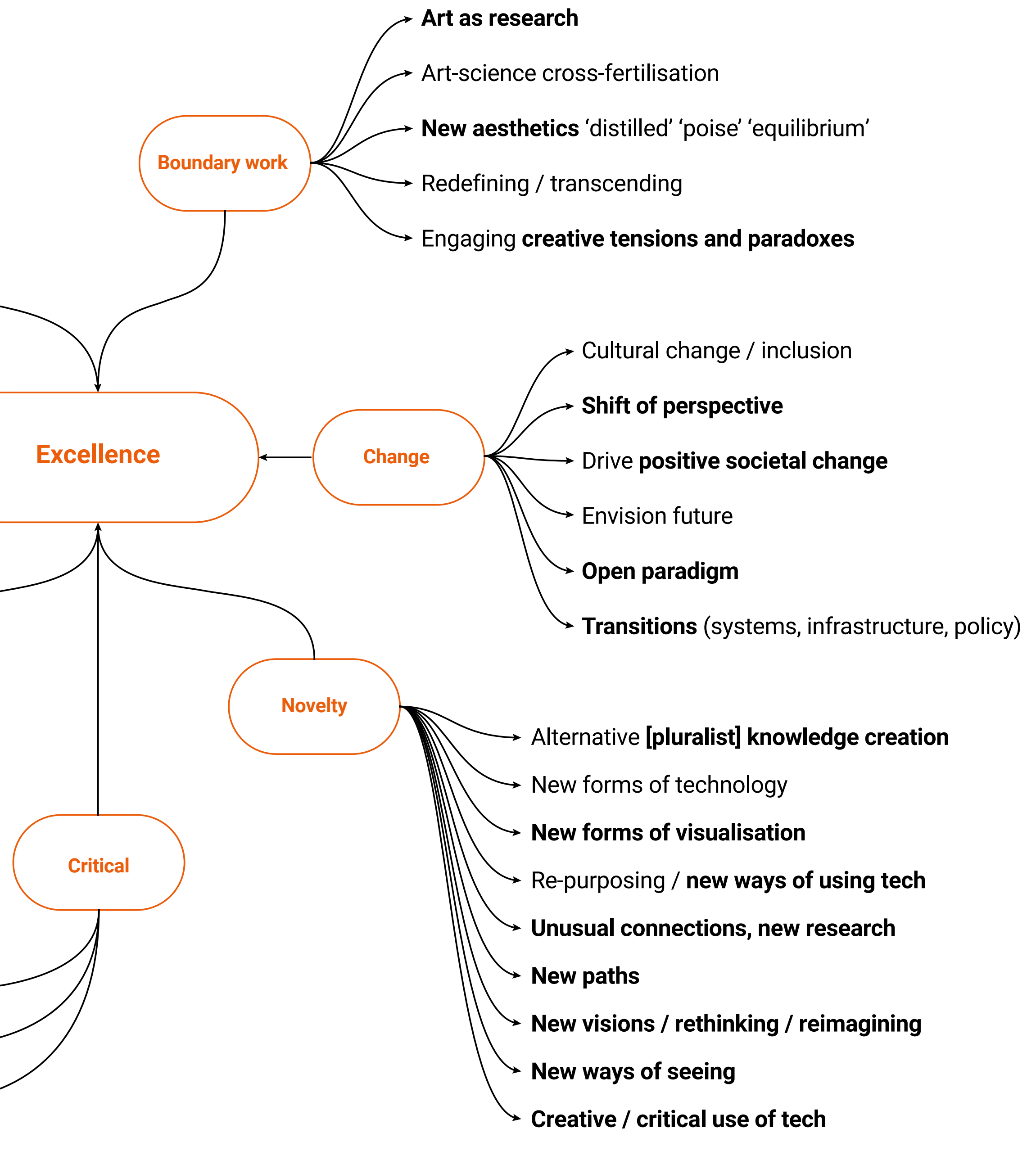
If we want European research culture to remain not just globally competitive but culturally meaningful, then we must stop asking art to "add value" to science and instead ask how science and technology might become more responsible, poetic, and plural by connecting with artistic practices such as these. Excellence, in the STARTS sense, is not a gold standard. It is a constantly evolving terrain—one worth navigating together.

UNDERSTANDING EXCELLENCE PATHWAYS/CONDITIONS

When developing programs that involve artists, such as residencies, EU-funded collaborations, or cross-disciplinary initiatives, certain factors should be taken into account from the outset. These include the motivations driving the work, the formats through which it is carried out, the type of results aimed for, and the stage of development of both the project and the people involved.

The STARTS Prize framework offers a nuanced way to understand excellence in the intersection of science, technology, and the arts by identifying four key categories: drivers, activity formats, results, and levels of maturity. These categories reveal that excellence is


Agency
Agency building
Awareness / **sensitising**
Community building
Empowering
Activist, mobiliser
Care-concern
Challenging / **problematising power** (tech dominance)
Climate
Ecology collapse
Sustainability
Trust
Urgency into action
Value-driven research
Empathy
Ethical & moral sensibility
Accessibility (social, cultural, public)
Critical thinking / approach / **making**
Making things **visible**
Sensitizing for human-nature-tech relationship


Boundary work
Art as research
Art-science cross-fertilisation
New aesthetics 'distilled' 'poise' 'equilibrium'
Redefining / transcending
Engaging **creative tensions and paradoxes**
Excellence
Change
Cultural change / inclusion
Shift of perspective
Drive **positive societal change**
Envision future
Open paradigm
Transitions (systems, infrastructure, policy)
Novelty
Alternative **[pluralist] knowledge creation**
New forms of technology
New forms of visualisation
Re-purposing / **new ways of using tech**
Unusual connections, new research
New paths
New visions / rethinking / reimagining
New ways of seeing
Creative / critical use of tech
Critical

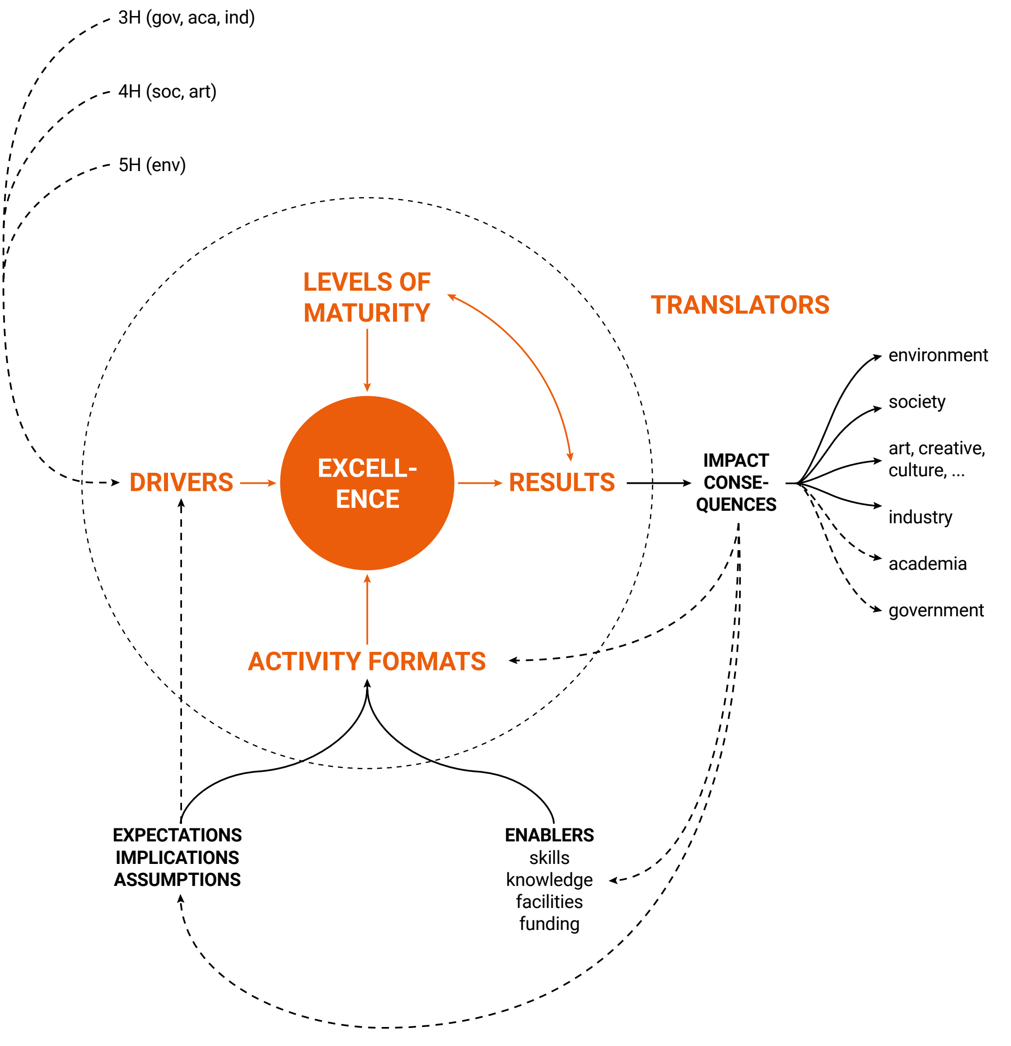


Figure 1. *Mapping Excellence*

not a fixed endpoint but a dynamic process shaped by diverse motivations, methods, outcomes, and stages of development.

Drivers: Artists and innovators in this field are motivated by a wide range of factors—from personal experiences and ethical or political commitments to urgent environmental challenges or questioning dominant societal structures. Others are driven by inclusion, justice, or a connection to nature. This diversity shows that artistic excellence emerges from multiple entry points, extending beyond traditional impact frameworks to engage social, ecological, technological, and personal dimensions.

Activity Formats: Project formats are equally varied: experimentation, manifestos, mapping, participatory practices, residencies, multidisciplinary teams, lab explorations, co-creation, and spin-offs. This plurality reflects a shared ethos of collaboration and research. Excellence thrives where individual and collective inquiry coexist, where structured residencies meet open-ended experiments, and where concepts evolve into tangible prototypes. No single model defines excellence; it arises from the interplay of diverse approaches.

Results: Outcomes range from installations and performances to new economic models, biological machines, learning methodologies, maps, critical discourse, urban interventions, publications, and novel tools. This variety underscores a key principle: results should not be predefined. Artist-led processes often lead to unexpected, context-specific outcomes that challenge conventional expectations. Who benefits and who can access these results is equally important, emphasizing inclusivity and open knowledge-sharing.

Levels of Maturity: Excellence also depends on recognizing a project's developmental stage. Knowledge production often starts within expert communities and expands to wider publics. As work progresses from research to prototyping to demonstration, it tends to move toward open knowledge-sharing and public engagement.

Translators (the Missing Link): Translators bridge disciplines and make complex artistic and scientific work accessible. Acting as mentors, facilitators, and interpreters, they help projects navigate from conception to impact, making their role vital for long-term success.
As we shape a broader framework for excellence, it becomes clear that certain enabling conditions consistently support ambitious, high-quality work. Access to infrastructure and mentoring, interdisciplinary environments, sufficient time, strong communities, and reliable funding are essential for innovation and impact.
Access to Infrastructure and Mentoring: Labs, hackerspaces, residencies, and informal networks give artists the time, space, and tools for long-term experimentation—conditions that encourage risk-taking and sustained inquiry.

Interdisciplinary and Cross-Pollinating Spaces: Environments where people, knowledge, and methods move freely across disciplines foster collaboration among artists, scientists, technologists, communities, and policymakers, enabling unexpected partnerships and discoveries.

Time: Projects with room to evolve over months or years allow for iteration, adaptation, and deeper inquiry, avoiding the limitations of rigid timelines or premature conclusions.

Community: Both a starting point and an outcome, community offers ecosystems of support. Existing networks often seed projects, while the work itself can activate new communities.

Funding: Stable, diverse funding, from cultural funds, commissions, EU projects, private foundations, public investment, and other sources, supports not only production but the ongoing research and relationships that sustain impactful work.

Beyond these tangible supports, qualities such as care, trust, imagination, empathy, playfulness, and openness to uncertainty are equally critical. These human elements often distinguish art-driven innovation, pointing to its ability to open unconventional and deeply human pathways toward excellence.

Excellence, in this view, is not a fixed achievement but a living, evolving process, shaped by diverse motivations, collaborative formats, open-ended results, developmental maturity, and the interplay of both infrastructure and intangible human qualities.

CONCLUSION

STARTS Prize projects pave the way for an alternative viewpoint on what constitutes excellence in creative and transdisciplinary research. These projects position art distinctly and clearly on the map of research and innovation. The STARTS model of excellence pathways amplifies the necessity to see the ecosystem in relation to context, which unfolds through drivers, activity formats, and results, all contributing in different ways to notions of excellence. In many ways, this is reminiscent of the instrumentality of "Enablers" which are layered tools of infrastructures, interdisciplinary contamination spaces, community, long-term sustained research, and compatible funding.

Ideals of excellence are equally nuanced. Through the STARTS Prize we start changing and reforming the lexicon of what constitutes excellence in inter/transdisciplinary research to include key notions such as agency, criticality, (systemic, social) change, value-driven research, and boundary work. Therefore, re-defining transversal research and its building blocks.

In essence, we invite validated ideas of how artistic research and innovation projects achieve relevance. Though most of the projects are unique in terms of their perspectives, there are shared learnings that can benefit not only future collaborations, but also the ways in which cultural organizations develop and facilitate future STARTS programmes, as well as inform policy-makers in integrating art into wider EU Research and Innovation (R&I) agenda.

REFLECTION: REDEFINING EXCELLENCE THROUGH S+T+ARTS

The STARTS Prize has done more than reward innovation—it has helped reframe how we understand it. Artistic research, long peripheral to traditional R&I frameworks, has shown not only its capacity to generate meaningful impact, but to reshape the very conditions that make innovation possible. What is emerging is a plural and situated model of excellence, one that embraces complexity, marginal voices, and challenges linear narratives of progress.

Excellence in STARTS does not result from isolated genius. It is cultivated through specific conditions: access to resources, space for experimentation, time to grow, and critically, people who can navigate between worlds. This is where the notion of "Translators" comes to the fore—figures who make sense across disciplines, mediate between institutions, meanings, and adapt outcomes for broader publics. They are the connective tissue of transdisciplinary collaboration, and their absence is often the point at which projects falter.

In many cases, we have seen projects mature from protected, experimental beginnings into public-facing experiences. This transition is more than a communication challenge—it is a shift in mindset. It reflects an understanding that innovation must speak to the world beyond its origin, and that this world includes ecological concerns, social tensions, and underrepresented perspectives. STARTS does not just advocate for inclusivity, it redefines it, placing what is often marginal at the center.

This demands a different kind of excellence—one that values process over product, mutual learning over disciplinary dominance, and relevance over novelty. Such a model disrupts conventional metrics but offers a richer, more humane foundation for future research and innovation.

RECOMMENDATIONS FOR POLICYMAKERS

Recognize artistic research as innovation. Artistic research must be acknowledged as a valid and powerful methodology in EU and national R&I strategies—especially where social and environmental complexity defies purely technical solutions.

Integrate the STARTS model across R&I programs. STARTS methods are integral to Horizon Europe and national programs, including through value-driven criteria, participatory formats, and non-traditional impact assessment.

Fund further research into collaborative practices. Effective art-science collaboration requires explicit roles—translators, mentors, and mediators—to bridge divides and support long-term, trust-based exchange.

RECOMMENDATIONS FOR CULTURAL ORGANIZATIONS

Strengthen the STARTS community. Beyond project cycles, artists and researchers need sustained connection. Cultural organizations can take the lead by hosting dedicated community initiatives for peer support and cross-project learning.

Develop comprehensive capacity-building programs. Excellence must be cultivated. Organizations should invest in skills for inclusive collaboration, public engagement, and responsible innovation—across all actors involved.

Create and host translation-focused initiatives. Language matters. Translation programs should be established to make artistic outcomes legible across sectors and to improve mutual understanding between collaborators.

The authors would like to thank the wider expert group: Alexander Mankowsky, Asako Tomura, Giulia Tomasello, Javier Masa, Jennifer Kanary, Jurij Krpan, Lindsey Walsh, Lizbeth Goodman, Lucas Evers, Manuela Naveau, Monica Bello, Nicolas Maigret, Tere Badia, Tim Murray-Browne, Ulrike Kuchner, Valery de Smedt, Veronika Liebl, Vladan Joler, Xenia Beltran who generously shared their time, knowledge and insights with us. Their contribution to expert interviews and workshops was instrumental in making and grounding a broad range of findings.

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Holly+ by Holly Herndon, Mat Dryhurst, and Herndon Dryhurst Studio
Sociality by Paolo Cirio
I'm Humanity by Etsuko Yakushimaru
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How (not) to get hit by a self-driving car by Tomo Kihara and Daniel Coppen
The Exploded View Beyond Building by Biobased Creations, Pascal Leboucq and Lucas De Man

1. See https://research-and-innovation.ec.europa.eu/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe/horizon-europe-work-programmes_en.

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Toward a Multidimensional Framework for Evaluating Art-Science-Technology Collaborations

STELLA DIAKOU (T6 ECOSYSTEMS), SIMONA DE ROSA (T6 ECOSYSTEMS) , ANNA PINOTTI AND TERE BADIA (HACTE)

Collaborations among artists, scientists, and technologists are increasingly recognized as powerful drivers of innovation, reflection, and systemic change. Yet their evaluation often remains fragmented, constrained by short-term, output-oriented criteria such as market uptake or competitiveness, which risk overlooking more profound cultural, social, and ecological transformations. The complex benefits of Art-Science-Technology (AST) projects—shifts in public consciousness, cross-sector innovation, and new forms of knowledge—frequently escape conventional frameworks. This chapter addresses these gaps by proposing a multidimensional approach to impact assessment, one that values long-term processes and transformations alongside measurable outcomes.

OUR METHODOLOGY: A RETROSPECTIVE

The STARTS impact assessment framework draws on both critical literature and practical experience in European research projects. Scholars such as Reeves (2002), Moriarty (1997), and Williams (1997) have shown that purely quantitative models fail to capture the intangible and transformative dimensions of cultural practice. These perspectives guided the framework's mixed-method and iterative orientation, designed to reflect both measurable outcomes and subtle cultural shifts.

This orientation was operationalized through T6 Ecosystems' experience in earlier EU projects, using the impact value chain model (IAIA, 2009) to combine quantitative and qualitative tools. Tested in contexts from digital innovation to citizen science (e.g., Passani et al., 2014; Bellini et al., 2014; 2016; Passani et al., 2015; 2020), the approach now informs STARTS initiatives such as the Prize (De Rosa et al., 2022; Diakou et al., 2023) and Ec(h)o (Diakou and De Rosa, 2024a; 2024b).

In parallel, HacTe developed a complementary framework within the STARTS in the City residencies (Anglada et al., 2024), centered on Key Transformative Indicators (KTIs) that foreground collaboration dynamics, legacy, and lived experience. Its process-oriented, participant-driven focus resonates with Colombo's Cultural Impact Perception model (2016) but adapts it with a stronger taxonomy of cultural effects and attention to host communities.

AN OVERVIEW OF THE DEVELOPED METHODOLOGIES

Both T6 Ecosystems and HacTe have been central in shaping evaluation methods for assessing the STARTS framework, through interviews, case studies, and collaborative testing, converging on a common vision that captures layered and often intangible outcomes of artistic-led innovation. The objective is to propose a more dynamic and responsive methodology, which is better equipped to capture the layered, interdisciplinary, and often intangible impacts of artistic-led innovation. The impact assessment methodology developed for the STARTS Prize reflects the hybrid nature of artistic research at the intersection of science and technology. As Bublitz et al. (2019) note, art can act as a catalyst for transformation by fostering community engagement and innovative thinking, yet its impact is often hard to quantify.

Five core areas of impact were identified for the STARTS impact assessment framework: social, economic, technological, political, and environmental. Each impact area was subdivided into specific dimensions and translated into a set of operational indicators. These guided the formulation of semi-structured interview protocols and questionnaires, deployed across seven consecutive editions of the STARTS Prize (2017–23) and currently deployed for the assessment of the STARTS Ec(h)o residencies. So far, data collection has included 41 interviews and 32 questionnaires combined with web ethnography and project documentation, allowing for an in-depth case study approach, ensuring the gathering of both qualitative and quantitative data, while at the same time respecting the diversity and specificities of each project. By aggregating the results of these case studies, we were able to generate an evidence-based, yet interpretive, mapping of impact across the STARTS Prize and STARTS Ec(h)o projects.

In parallel, HacTe employed a dual-methods framework to evaluate the impact of the STARTS in the City residency program. This framework combined quantitative and qualitative methods. The monitoring process was complemented by qualitative insights to capture both measurable results and deeper experiential perspectives. The quantitative analysis focused on structured data from participants' tracking sheets, mapping progress across the residencies' five key dimensions. These metrics provided tangible evidence of engagement, outcomes and short-term effects. However, numerical data alone are insufficient to convey the residencies' full richness, so the study used three qualitative methods to deepen its analysis:

Participant's field diaries, in which artists and Innovation Catalysts (ICs) submitted reflective reports at key stages documenting their evolving experiences, challenges, and satisfactions. These diaries incorporated a synthesis of qualitative and quantitative data, including personal narratives and structured comments.

In-depth interviews with artists, scientists, and ICs exploring expectations, collaborations, and unforeseen obstacles. By comparing these perspectives from initial enthusiasm to final reflections, the study uncovered patterns in the development and perception of interdisciplinary collaborations.

Focus groups were used to facilitate dynamic discourse on systemic challenges, methodological strengths, and recommendations for future iterations. This collective reflection introduced a crucial dimension of peer learning into the evaluation process.

Overall data collection entailed: 22 artists' diaries, 22 written reports from Innovation Catalysts, 27 semi-structured interviews with artists, scientists, and Innovation Catalysts, and one focus group. By marrying metrics with lived experiences, this evaluation does not just tally outputs, it reveals how and why certain residencies succeeded, where friction arose, and what might sustain impact beyond the program. While the quantitative data offers snapshots of progress, the qualitative layers give those numbers meaning, illustrating the human dynamics behind innovation. For future assessments, the study highlights a need for longitudinal tracking, because the true test of such residencies lies not just in what they create, but in what they leave behind.

A COMPARATIVE REFLECTION

One of the principal shortcomings of previous approaches to impact assessment lies in their predominant focus on the outcomes of action. This orientation, while aligned with established evaluation frameworks such as the impact value chain (IAIA, 2009), risks reducing the complexity of artistic and cross-disciplinary innovation to its most visible effects. In the early stages of STARTS implementation, our methodologies were largely guided by this conventional understanding of impact, which privileges measurable results and tends to align with institutional accountability requirements. However, as we engaged more deeply with the inner workings of the ecosystem—through interviews, case analyses, and direct observation—it became increasingly clear that the assessment of impact should begin much earlier than anticipated. The drivers behind participation, the tools and infrastructures that enable experimentation, and the context-specific motivations of artists, researchers, and technologists all play a critical role in shaping the initiative and its transformative potential. Impact, therefore, is not solely a matter of what is produced, but of how and why it emerges.

A comparative reflection of the methodological frameworks used across the STARTS Prize, STARTS Ec(h)o, and STARTS in the City reveals shared conceptual ground and complementary strengths. The proposed frameworks adopt a mixed-method approach that combines qualitative richness with analytical structure. They recognize the limitations of linear or solely quantitative models and seek to uncover deeper layers of meaning, particularly in relation to interdisciplinary collaboration, social transformation, and emergent value. Each introduces refined indicators, whether qualitative operationalized indicators in the case of T6, or Key Transformative Indicators (KTIs) in the HacTe model—to articulate the complex, often intangible outcomes of hybrid artistic-scientific practices.

The T6 approach offers scalability, systemic coherence, and policy relevance, aggregating impact from micro to macro levels within a structured value-chain logic. The HacTe approach brings relational depth, foregrounding situated collaboration, mutual influence, and temporal dynamics through KTIs. Rather than competing, they are complementary, pointing to a shift from output-based evaluation to process-sensitive assessment. Rather than being in tension, these two approaches reflect the evolution of impact assessment within STARTS, from institutional responsiveness to participatory reflexivity, from macro-level outcomes to micro-level processes. Their coexistence within the same ecosystem signals a mature methodological landscape capable of accommodating diverse perspectives and evaluative needs. This insight leads us to a methodological shift: from an output-based to a process-sensitive approach.

REFRAMING IMPACT: FROM OUTPUTS TO TRANSFORMATION

Drawing upon prior evaluation experiences and incorporating the strengths of the methodologies developed by T6 and HacTe, we propose a new framework for impact assessment tailored to the distinctive nature of art, science, and technology (AST) collaborations. This framework is informed by ongoing consultations with high-level stakeholders and emergent practices in the field of transdisciplinary evaluation.

A central challenge in evaluating AST projects stems from their inherent heterogeneity. These initiatives often cross epistemological, institutional, and methodological boundaries, resisting reduction to standard disciplinary metrics. As such, the application of a rigid, one-size-fits-all evaluation model is not only inadequate but potentially counterproductive, as it may obscure the unique value, process, and context of each project. Instead, our approach adopts a flexible, layered methodology that accommodates the dynamic, emergent, and pluralistic nature of AST collaborations.

The first layer of the framework seeks to contextualize the collaboration through three core dimensions:

- **Motivations**: The underlying rationale for initiating an AST collaboration may be very heterogeneous, spanning from epistemological, instrumental, or strategic.
- **Objectives**: AST projects typically aim to produce value, foster innovation, and achieve tangible or intangible impact across a variety of domains.
- **Means**: The methodologies and tools deployed to operationalize the collaboration, which often include novel combinations of artistic practices, scientific research, and technological integration.

These three dimensions—**reasons**, **objectives**, and **means**—form the foundational matrix of the impact assessment. This triangulation enables evaluators to understand the unique configuration of each project and to map its potential for hybrid knowledge production and systemic transformation.

The **second layer** builds upon the concept of **change agency**, as articulated by Loots and Van Andel (2025), and is aimed at identifying the structural and operational identity of the project by focusing on the aspects more related to “agency”. This involves mapping:

- **Inputs**: Resources, knowledge bases, and initial conditions.
- **Activities**: Core collaborative and creative processes.
- **Outputs**: Immediate and tangible results of the project (e.g., prototypes, exhibitions, publications).

This layer serves as an intermediate step between project intent and transformative potential. It emphasizes the relational dynamics between actors and activities, helping to assess how agency is distributed and exercised within the collaborative process.

The third layer focuses on the concept of impact, understood not as a static end-goal but as a multidimensional and often emergent phenomenon. Within this framework, impact is conceptualized in two interrelated ways: (1) as an intentional objective pursued by the project team; and (2) as a set of unplanned but significant outcomes arising from the interaction of artistic, scientific, and technological practices. Drawing from the models proposed by T6 and HacTe, the framework identifies six primary impact domains:
Social
Economic

Political
Environmental
Technological
Scientific
Artistic

For each domain, traditional indicators (e.g., number of stakeholders reached, products developed, papers published—see for example Diakou et al., 2023) are to be complemented by transformational indicators, which assess qualitative dimensions of change such as shifts in perception, inclusion, or sustainability practices. To guide data collection and reporting, the framework incorporates a schema of measurable outcomes inspired by the Cultural Development Network's TAKSO framework (Dunphy and Smithies, 2018; Dunphy et al., 2020). This includes:

- **Cultural outcomes**: e.g., creativity stimulated, artistic capacities enhanced.
- **Social outcomes**: e.g., well-being improved, social cohesion increased.
- **Environmental outcomes**: e.g., ecological awareness raised, nature restored.
- **Governance outcomes**: e.g., civic trust enhanced, participatory processes supported.

These categories are not intended as prescriptive metrics but as narrative entry points that can support diverse storytelling approaches to impact, aligning project documentation with broader societal missions. The layered approach recognizes that outcomes are often interdependent and cumulative, emerging both as qualitative transformations (e.g., increased inclusivity, novel ways of thinking) and quantifiable results (e.g., startups founded, research publications, policy recommendations).

DATA GATHERING AND ANALYSIS

To operationalize the proposed three-layered impact assessment framework, we adopt a mixed-methods data gathering strategy that integrates quantitative indicators, qualitative observations, and narrative-based storytelling.

Recognizing that impact often unfolds in unpredictable and context-specific ways, we incorporate storytelling as a core evaluative tool. Narrative accounts from participants, stakeholders, and communities involved in the project offer rich, grounded insights into how change is experienced and perceived. Storytelling not only facilitates reflexivity and meaning making but also functions as a communication bridge between actors from different domains (e.g., artists, scientists, technologists, funders, publics).

This triadic methodology—combining metrics, meaning, and memory—is essential to the epistemological pluralism required in AST evaluations. It allows the framework to remain rigorous yet flexible, and to capture both planned and emergent impacts across temporal and spatial scales. Moreover, this integration respects the non-linear and dialogic nature of creative collaboration, where impact is often co-produced, co-perceived, and co-narrated.

This triangulated approach is critical to ensuring that the assessment process reflects the complexity, diversity, and emergent nature of AST collaborations. Analysis is conducted using quali-quantitative methods. By combining quantitative, qualitative, and narrative data, the evaluation achieves:

- **Triangulation**: Increasing validity by cross-verifying findings through different types of evidence.
- **Inclusivity**: Incorporating multiple voices and perspectives, especially from underrepresented or non-institutional actors.
- **Comprehensiveness**: Capturing both micro- (individual, project-level) and macro-level (societal, systemic) change.
- **Actionability**: Generating insights that are useful for improvement, strategic planning, and policy alignment.

This integrated approach strengthens the robustness of the evaluation while preserving the interpretive richness and contextual specificity that AST projects demand.

The proposed framework is currently under development and represents an evolving effort to create a robust and context-sensitive tool for assessing the impact of AST collaborations. Recognizing the importance of inclusivity and relevance, the framework will be further refined and expanded through co-design sessions with stakeholders, including artists, scientists, technologists, policymakers, and community representatives. This iterative and collaborative process is essential to aligning the assessment model with the pluralistic and dynamic nature of AST ecosystems.

CONCLUSION AND RECOMMENDATIONS: TOWARDS TRANSFORMATIVE INDICATORS

At the heart of the STARTS initiative lies transdisciplinarity: the creation of new knowledge and practices that cannot be contained within a single discipline. Such collaborations bring together diverse skills, contexts, and perspectives, but their impacts are difficult to capture with conventional evaluation tools focused on productivity or short-term results. Real transformation often emerges gradually, through paradigm shifts, novel collaborations, and lasting changes in mindsets. To reflect this complexity, impact assessment must move beyond linear metrics and embrace approaches that foreground processes, relationships, and long-term societal value.

The framework proposed in this chapter already points towards such an approach: it emphasizes layered evaluation, combining motivations, agency, and impact domains, and it integrates qualitative methods and storytelling alongside quantitative indicators. Building on this design, the following recommendations outline how impact assessment within STARTS can evolve further:

1. **Beyond traditional metrics**: the emphasis on quantifiable outcomes (e.g., the number of artworks, exhibitions, papers, patents, etc.) in quantitative data has been identified as a potential limitation in fully capturing the intricate dynamics of transdisciplinary collaboration, creativity, and transformation. Adding qualitative data (interviews, case studies or observations) provides insight into the underlying processes at work. A multimethod approach strategy is imperative, combining qualitative and quantitative tools to capture the full scope of the STARTS initiative.

2. **Including evaluation of long-term impacts** is a critical component. Transformation initiatives frequently seek to achieve long-term shifts in culture, science, technology, or society, but their evaluation is limited to short timeframes. A wider temporality for assessment beyond the finalization of the STARTS projects is needed to fully grasp the transformative impact of any given project on the diverse stakeholders who participated.

3. **The evaluation process must be considered from the outset of the project design**, with a focus on the interplay between creativity, scientific innovation, technological advancement, and societal impact. It is first necessary to propose a holistic set of quantitative and qualitative indicators that define the objectives of the impact assessment and adopt ad hoc, co-design methods in order to define the evaluation goals from the beginning (as these change from project to project).

4. **Iterative assessment processes**, which integrate ongoing feedback and reflection at multiple stages, enable the design of impact assessments to modify and adapt parts of the methodology that are not currently providing sufficient information. This ensures continuous improvement and refinement of projects and their evaluation methodologies over time.

5. **More time, resources, and processes are needed to evaluate the transformational capacity of transdisciplinary projects**, which is closely associated with the innovation ecosystem. This transformation involves systemic changes in innovative ecosystems, making the disciplines more adaptable to challenges. Transformation can be observed in various ways, such as novel patterns of collaboration emerging, a shift in mindset, and new approaches to contemporary challenges being developed.

6. **Transdisciplinary projects can impact not only the creation of new knowledge, but also the perspectives and methodologies of the knowledge domains and sectors involved**. Standard KPIs focus on short-term outputs but fail to measure deeper transformative effects like paradigm shifts or new collaborative fields. Transdisciplinarity requires a more ambitious evaluation framework.

7. **The measurement of transdisciplinary research processes encounters challenges related to intangible and unpredictable qualities**. These include the establishment of trust, mutual recognition, and appropriate credit; a balanced and open participation of actors from various sectors; and possibilities for renegotiating at least some of the established rules, norms, and demands according to new participants and shifting needs. To evaluate these processes properly, a transformative measurement assessment is required.

8. **Heading towards a transition from Key Performance Indicators (KPIs) to Key Transformative Indicators (KTIs)**. Adding qualitative measurement to quantitative metrics facilitates a more profound comprehension of the mechanisms underlying transformation, particularly in the case of intricate, transdisciplinary processes. Currently, there is no evaluation system that includes these particularities in transdisciplinary projects, which is why further work is required to allow the elaboration of a comprehensive set of indicators to better capture long-term societal and systemic changes and assess the dynamics that drive long-term innovation.

Overall, the STARTS community views the integration of KTIs as a means of refining existing metrics and more accurately capturing and quantifying the outputs of transdisciplinary projects. The goal is to produce more robust, comparable data with which to assess project success, justify funding allocations, and demonstrate societal influence within a predictable, controlled evaluation framework. The development of KTIs challenges the current KPI paradigm and facilitates the identification and assessment of transdisciplinary projects and their potential to engender long-term impacts and systemic change.

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Collaboration is a defining principle of the STARTS approach, which has shaped its vision and practice over the past decade. Over this time, the initiative has brought together numerous artists, scientists, technologists, and industry partners to address pressing societal and environmental challenges. The following essays provide valuable insights into how these collaborations unfold across diverse domains—from manufacturing, high-performance computing, and the food industry to sound research and water management. Together, they reveal the dynamics of transdisciplinary exchange that define the STARTS approach, demonstrating how creative collaboration can generate new forms of knowledge, innovation, and shared responsibility for shaping sustainable futures.

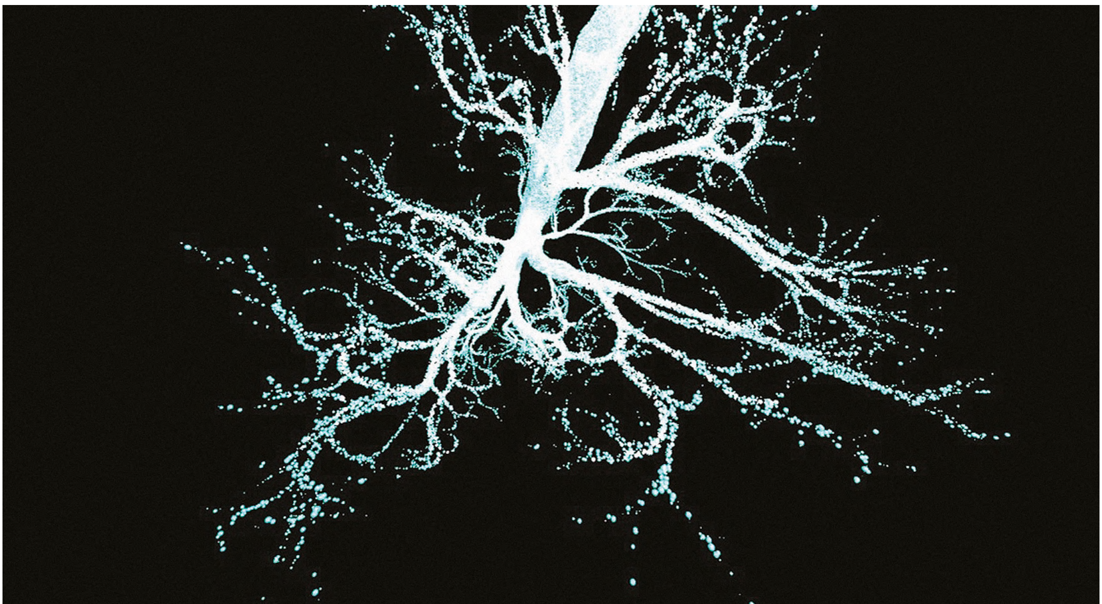
COLLABORATIONS

Transdisciplinary Collaborative Innovation: Creating Pathways Beyond Traditional R&D

LIJA GROENEWOUD VAN VLIET (IN4ART)

The STARTS program represents a decade of experimentation in bridging art, science, and technology to address contemporary challenges. Across domains ranging from manufacturing to food systems, these initiatives demonstrate how artistic experimentation serves as a viable route to innovation and how collaboration between artists and other stakeholders is crucial in this. This article showcases how creative practitioners experiment in such collaborations not merely through cultural contributions but as innovation partners capable of reframing challenges and introducing unexpected perspectives and prototypes to enable responsible innovation. In general innovation literature, the studios of artists across Europe researching and exploring technologies, materials, and theories are not considered, yet they do form a significant part of available experimentation facilities. These artists have built and tend to facilities that are unique, because there is freedom to question the matter at hand and conduct experiments, without preset rules, codified norms, or "lock-in effects". Innovative ideas flourish in environments where experimentation can occur, especially if they are brought to the proverbial table where different stakeholders are seated. These connections to real-life challenges lead to context-based outcomes that could never have been anticipated at the outset of any given project.

Through the lens of STARTS projects that have focused on manufacturing (Better Factory 2020–24), biodiversity and urban planning (AIR, 2023–24; Repairing the Present 2021–22), and food system changes (Hungry EcoCities, 2022–26), this article looks at how collaborative efforts between artists, scientists, and businesses have consistently placed circularity, biodiversity restoration, and responsibility at their core, with art-driven innovation serving as the catalyst. To illustrate this point, we begin with some examples from various projects that share common characteristics: diverse teams bringing complementary sets of skills,



Top to bottom:

Figure 1. David Rickard, Smart Envelope – Floating Borders, 2024

Figure 2. Filippo Nassetti and Barcelona Supercomputing Center, bronchial tree model of the human lung, 2024

well-defined challenges, and committed resources for exploration and prototyping. Everything that emerges is ideated and executed at a point when time, space and funds have already been committed—this is the crucial ingredient that STARTS offers in order to make these transdisciplinary collaborations work.

In the SmartEnvelope project (Better Factory), the envelope-producing SME Plast-Farb and the conceptual artist David Rickard drew inspiration from Copernicus, in whose birthplace, the city of Toruń in Poland, the company is located. Pondering the way in which Copernicus re-orientated our place within the solar system, they translated and adapted this concept in order to develop a revolutionary, new style of envelope that can be turned inside out. The team then integrated produced versions of this smart envelope into a participatory, artistic project exploring European borders and how water, embedding information, flows. This approach directly tested how post offices across Europe would accept and process this new type of envelope. The results led to Plast-Farb winning a Polish national award for innovative products, whilst simultaneously enabling David Rickard to realize a conceptual artwork that would tour European museums (see Fig. 1).

Another example of changing perspectives can be found in the metaphor used in the project Breathing Architecture (AIR), where the structure of trees is used as a reference point to understand human lungs: from the great branches that resemble our bronchi (larger tubes) to the thousands of tiny air cells in the alveoli, where gas exchange occurs—just as in leaves. Artist Filippo Nassetti's approach to viewing the human body's interior as architecture, combined with the computational expertise of scientists at the Barcelona Supercomputing Center, produced a sophisticated lung dynamics model with applications spanning art, medical science, and architecture. It resulted in a peer-reviewed scientific publication, which sought to model flows that until then had been unmodelled, as well as in a theatrical installation where an individual could immerse themselves in this breathing architecture (see Fig. 2).

In the Straw Return (Hungry EcoCities) project, the collaboration between the circular agricultural waste venture Staramaki and the material research artist Isaac Monté exemplifies how partnerships evolve through iterative material exploration. Staramaki transforms wheat stems into biodegradable straws, but production generates secondary waste—rejected stems that are typically used as horse bedding. The collaboration began with a simple question: Could this "waste of waste" become a high-value material? Through over 100 material experiments encompassing dying, weaving, shredding, and pressing techniques, the partnership developed a natural bio binder using wheat starch. Combined with rejected stems, this creates composite materials with acoustic absorption, fire retardancy, and structural properties whilst maintaining complete biodegradability, so that after being discarded, the material eventually returns to the soil as organic matter. The process required both Staramaki's straw expertise and Isaac's boundary-pushing material experimentation—as neither could have achieved the final result independently (see Fig. 3).

This iterative, hands-on collaboration exemplifies a pattern visible across STARTS projects: initial outcomes represent just the beginning of longer innovation journeys. Understanding how these collaborations develop and sustain impact requires mapping the networks, relationships, and follow-up activities that emerge from residencies.

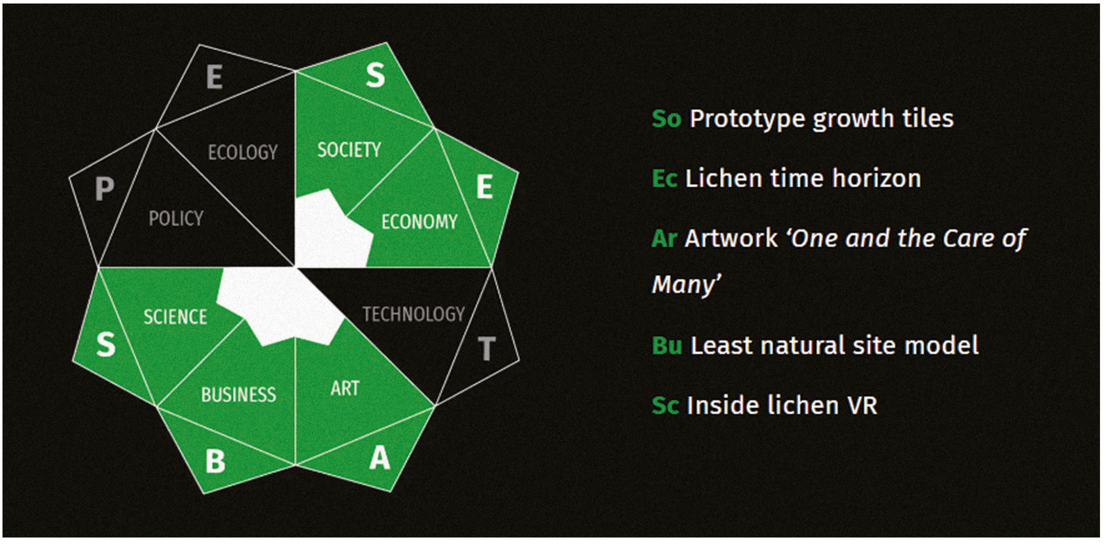
A TREASURE MAP TO UNRAVEL THE COLLABORATIVE INNOVATION DEVELOPMENT PROCESS

These diverse examples share a common characteristic: their most significant impacts often materialize well beyond the formal project boundaries. The critical question arises: What impact is created? How do these STARTS collaborations benefit SME innovation positions, societies, or European Union innovation ambitions? We have seen business awards, scientific publications, art exhibitions, social intervention proposals and initial business propositions. Whilst visibility and demonstration hold value, we must remember that not everything valuable can be measured, and not all measurable things hold value.

Successful innovation implementation requires long-term breadth and continued ownership. The direction of innovation can take many different routes, as demonstrated by the PESETABS acronym—a diffusion framework that shows eight directions for spill-over potential: policy, ecology, society, economy, technology, art, business, and science.

The Repairing with Lichen (Repairing the Present) project exemplifies this approach. Bio artist Penelope Cain and the engineering company Witteveen+Bos conducted an in-depth investigation into lichen, which led to several prototypes that have potential across various fields. The Inside Lichen VR, co-developed with HLRS Stuttgart, for example, allows micro-navigation through lichen interiors, enabling the observation of symbiosis processes up close. Whereas another completely different direction produced models capable of calculating the "least natural places" in cities, which would be of interest to city planners and ecologists. In total, five impact directions were identified that would all follow separate, independent paths in order to pursue potential (see Fig. 4).

Yet across all these dimensions, "growing" very much comes after "sowing". In STARTS collaborations, by nature limited by the time frame of a given residency, certain foundational elements should be formed to offer support after project uptake: strong and clear partner roles and expectations, insight into who develops what part, effective preparation and selection of expected outcome benefits, and allocated time for safe



Top to bottom:

Figure 3. Isaac Monté, Straw Return, second harvest applications for wheat stems, 2025

Figure 4. In4Art and Penelope Cain, PESETABS Repairing with Lichen

exploration. With these fundamental basics in place, specific triggers can support collaboration development for future impact.

Projects can typically achieve technology readiness levels 4–7, a reference used to show the maturity of a given prototype, upon residency completion. This serves as proof of feasibility, first real environment testing, and the many insights gleaned into what went wrong and failed. This makes program completion the foundation for further development, yet temporal mismatches between project timelines and innovation development can create systematic evaluation challenges. Many projects lack the possibility of any follow-up or further support for residency outcomes over longer periods, creating fundamental evaluation gaps—i.e. attempts to measure innovation impact before it materializes. Often the impact materializes well after formal completion, as participants continue to explore new territories and, through the first results, other stakeholders, with a bit of serendipity and luck, start to embrace and interact with this impact.

Hence, after the residencies, the critical development phases begin, requiring new collaborations, efforts, and structures to achieve the desired impact. Impact can emerge across multiple dimensions: societal contribution, ecologically beneficial outcomes, or new research directions. However, we need to acknowledge that the seeds planted during intense collaboration may take years to bloom, particularly when addressing complex systemic challenges. The “treasure” for societal, economic, or ecological impact might only be found ten years from now.

Take, for example, Vegetable Vendetta (Hungry EcoCities). After extensive exploration and iteration with art-driven innovation mentors, AI artist Jeroen van der Most created a prototype system that acts as an AI Robin Hood. It appropriates communication and branding strategies from luxurious brands and large, unhealthy food multinationals and redistributes them to small sustainable growers through AI-generated content. This compelling artistic concept has gained significant traction, leading to exhibitions, presentations at industry events, and media coverage ever since the closure of the residency. Some months later, it became a starting point for SMEs to get acquainted with AI and to see whether this might be a viable option for their own operations. This led to the development of five SME AI pathways for using generative AI in their communication strategies—a new outcome that benefits companies like Axia Seeds, which emerged as a direct spill-over from Vegetable Vendetta (see Fig. 5).

We call such reconstructions “treasure maps”. It identifies which collaborators and contributors were involved, how the network has evolved, which new projects are direct follow-ups or have been inspired by the initial outcomes, and which media, stages of festivals, and exhibitions offered to display the works. To support the development of such a treasure map, facilitating intensive physical collaboration periods in the program serve as a trigger. In-person interaction provides the basis for long-term connection and network leverage that virtual tools cannot replicate. Better Factory demonstrated this across two rounds with 16 collaborative experiments. First-round teams that chose not to meet early in the process experienced numerous misunderstandings and divergent expectations. Second-round teams, in contrast, were required to spend productive time together initially, which served to eliminate these issues on a program level. A good practical example is the three-day La Vila retreat that took place during STARTS AIR, which brought together over 50 participants from science, art, and industry, creating cross-pollination opportunities that would be otherwise impossible at distance. Early physical kick-offs prove particularly valuable for establishing shared language, vision alignment, and practical contextual understanding. Breathing Architecture became a true team, although they were just temporary project partners, all of whom were committed to the project’s potential and who continued to collaborate afterwards. The Straw Return project’s development was accelerated through intensive material sessions at the facilities of project’s mentor Carlo Ratti Associati. Here, Staramaki’s straw production expertise merged with the Carlo Ratti Associati’s architectural prototyping capabilities and Isaac’s experimental material approaches. These face-to-face explorations allowed for immediate iteration—such as testing binding techniques, observing material behavior, and adjusting parameters in ways that remote collaboration could never achieve.

Another essential trigger is publicly shareable documentation as an invitation for collaboration extension. Video documentaries capture not just outcomes but collaborative processes—journeys of discovery, challenges encountered, and strategies that emerged. Much value lies in intermediate moments: learnings from dead ends, encapsulated ideas, and development stages that inform future work. Video documentaries serve multiple functions: direct participants use them for promotion and marketing; they function as starting points for future relationships, keeping works alive and shareable whilst helping parties determine next steps; they provide powerful network tools enabling better conversations; they support artistic outcomes in exhibitions, providing context and depth whilst showing collaborative innovation journeys. GitHub repositories prepare for follow-up beyond residencies, enabling others to build upon open-source foundations and extending collaborative networks.

Approaching demonstrations as experiments in dissemination shifts focus away from final artworks to prototypes supporting innovation development. This increases willingness to show intermediate results whilst building networks for future collaboration and spillovers. Testing environments where prototypes meet implementation-capable stakeholders prove essential. Formats range from industry networking events and scientific conferences to innovative performances and design week integrations—expanding beyond art-minded audiences to produce a much wider array of innovation-stimulating encounters.

STARTS successfully cultivates new ideas, but the challenge lies in realizing innovation potential. Success requires collaboration partners to build sufficient strength and networks in order to create impact through various configurations—individually, together, with new partners, or through third-party dissemination. By embracing experimental open-endedness, interdisciplinary risk-taking, and art-driven approaches that look beyond conventional boundaries, STARTS residencies have unlocked avenues for growth, sustainability, and technological advancement. It is about nurturing diverse ideas and releasing them into the world, accepting the fact that losing control is ultimately beneficial for broader impact. The last decade of STARTS experimentation demonstrates that when artists, SMEs, and researchers collaborate within structured yet open frameworks, they create innovation pathways that neither traditional R&D nor pure artistic practice could achieve alone. The challenge moving forward lies not in proving these collaborations work, but in scaling the conditions that make them flourish—from physical meeting spaces to documentation practices to networks that bridge residency outcomes with real-world implementation. The treasure maps will be drawn as we progress. For now, they need to guide future collaborators toward these art-driven sustainable innovation territories in order to be further implemented.

Figure 5. The Vegetable Vendetta at NVIDIA's GTC Paris AI Art Gallery, 2025.
Credit: Jeroen van der Most.

NOTE ON ATTRIBUTION

This essay synthesizes collective learnings and insights from In4Art's participation in multiple STARTS projects, acknowledging the contributions of consortium partners, artists, and SMEs across these various collaborations.

AI&Music Powered by S+T+ARTS:

ANTÓNIA FOLGUERA (SÓNAR)

Music has been intertwined with AI since the very beginning. The term "Artificial Intelligence" was first coined in 1956 at the famous Dartmouth Conference by John McCarthy, Marvin Minsky, Allen Newell, and Herbert Simon, and just a year later the first known composition with the help of a computer was created. In 1957, at the University of Illinois at Urbana-Champaign, researcher and musician Lejaren Hiller composed the Illiac Suite for String Quartet. It was an algorithmic work generated with the Illiac computer—one of those machines that filled an entire room. The piece was composed by a machine but performed by humans.

What Music Can Be Done with AI That Couldn't Be Possible Without It

Top to bottom:

Marije Baalman's talk A Musical Understanding of AI as Resonance at Sónar 2025. Photo: Cecília Díaz-Betz

Rebecca Fiebrink's talk Design Your Dream AI Music Tool at Sónar 2025. Photo: Cecilia Díaz-Betz

Maria Arnal's presentation of AMA at Sónar 2025. Photo: Leafhopper

What counts as "AI" has shifted across the decades. Different flavors of machine intelligence and algorithmic systems have been used to make music, though for a long time almost nobody paid attention—perhaps because the rest of us were not ready to understand it. During the 1970s and 1980s, two key figures—true AI and generative music OGs—laid the groundwork for many of today's practices. They pioneered the idea of software as a "collaborator"—taking care of the technical heavy lifting so musicians could lose themselves entirely in the act of making music.

One key figure is David Cope, a composer and professor of music at the University of California, Santa Cruz. Beginning in the 1980s, Cope developed Experiments in Musical Intelligence (EMI), a system that analyzed large bodies of existing works and generated new compositions "in the style of" Bach, Mozart, or even Cope himself. These experiments—sometimes released as Virtual Bach or Virtual Beethoven—sparked both fascination and controversy, raising questions about authorship, originality, and the role of the composer in an age of algorithmic creativity. As Cope later reflected: "Somehow the computer program was a threat to that unique human aspect of creation".

Another pivotal figure was synthesist and engineer Laurie Spiegel, who worked at Bell Labs—the legendary research center where artists and engineers collaborated under initiatives like Experiments in Art and Technology (EAT). In the mid-1980s, she created Music Mouse—an "intelligent instrument" for the Commodore Amiga and early Macintosh computers. Designed to make electronic composition accessible, it allowed anyone with a computer to explore generative music. As Commodore Magazine put it in 1986: "With Music Mouse, a novice in the world of computer music can create an electronic masterpiece by simply pushing around a mouse". This pretty much sounds like any other AI software that exists today.

Spiegel and Cope were not alone. Other pioneers—from Iannis Xenakis experimenting with stochastic processes, to Brian Eno exploring generative systems, to George Lewis with improvising computer partners—all contributed to the early vocabulary of algorithmic and computer-assisted composition. Their work laid the groundwork for what would come decades later.

Fast forward: we are now about ten years into the era when today's forms of AI—first emerging from research and big tech labs—began to enter the work of pioneering musicians. These artists did not just use AI to make new sounds; they saw it as a chance to do things only AI could do, and to question the implications of these technologies.

Back in 2015, few could have imagined that AI would advance at such speed, becoming so easy to use and so widely accessible. Some artists did warn early on about what AI might mean for musical labor, and what its impact could be on the wider industry.

Artists like Holly Herndon have been central in opening up this conversation: with Spawn, a vocal model trained on her ensemble's voices, she turned machine learning into a collective experiment in authorship and identity. Similarly, Maria Arnal has explored AI as a way of extending the voice, weaving Iberian singing traditions into new sonic forms that question where the human ends and the synthetic begins. Their work highlights both the creative possibilities and the cultural stakes of AI in music, and points us toward the broader practices we see emerging today.

Within the STARTS initiative, the AI&Music platform has become a space for experimentation and interdisciplinary exchange, showcasing how artificial intelligence can intersect with musical practice. Across the festivals held so far, the focus has often been on the most artisanal, hands-on uses of AI: in instrument design, sound design, and in the way it is integrated into musicians' workflows. The most exciting developments lie in these diverse creative approaches, while we are still collectively exploring **how** to make music with AI—and what kinds of music only AI can make.

INSTRUMENT DESIGN AND EMBODIMENT

Many of the most interesting AI&Music practices today are less about "press a button, get a song" and more about reimagining instruments themselves. Artists design their own sensors, interfaces, and interactive systems to turn gestures, light, or textiles into sound. Live coding and other performance practices also emphasize failure, messiness, and embodiment—qualities often erased in the drive for efficiency. Together, these approaches point toward a culture of instrument-making where AI is folded into performance as a live material, expanding the role of the body and underscoring that creativity with machines is never disembodied.

AI AS COLLABORATOR/CO-COMPOSER

Rather than handing music over to machines, most current practices treat AI as a collaborator. Distinctions can be made between "co-composition", where musicians use AI to support or extend their creative intent, and "hands-off composition", where text-to-music tools generate finished tracks. The former dominates in experimental and underground contexts, where artists seek to retain artistic agency while exploring new possibilities. In this sense, AI becomes a sparring partner: suggesting ideas, remixing motifs, or nudging a piece in unexpected directions, while leaving the human firmly in the loop.

CULTURAL IDENTITY AND LOCAL SOUNDS

A recurring theme in contemporary AI and music is the use of algorithms not to flatten music into generic outputs, but to amplify cultural identity. Many systems are trained on specific voices, languages, or local soundscapes, using datasets rooted in particular traditions and places. This shows how AI can serve as a tool for reinterpreting heritage rather than erasing it. Thinking

Top to bottom:

Maria Arnal's presentation of AMA at Sónar 2025. Photo: Leafhopper

Audiostellar's presentation Territorios sonoros emergentes at Sónar 2025.
Photo: Nerea Coll

from the “margins” is crucial, ensuring that non-Western and non-dominant practices shape how these tools evolve. In this way, AI becomes a medium for cultural specificity rather than homogenization.

DESIGNING AI AT A HUMAN SCALE

AI in music does not necessarily require massive datasets or universal solutions. Increasingly, musicians design their own bespoke AI tools, trained on small, personal collections of sounds, gestures, or performances. In workshops and collaborative contexts, participants imagine AI systems aligned with their own values and artistic needs rather than defaulting to the models offered by big tech. This reframes AI not as an external authority, but as a set of flexible tools musicians can adapt and repurpose—highlighting the potential for AI to serve creativity at a human scale.

CRITICAL AND ETHICAL PRACTICES OF AI AND MUSIC

Equally important are the ways artists expose the politics of AI. Critical practices remind us that the same infrastructures powering creative tools are also used for surveillance and even warfare, raising questions about complicity and refusal. Others critique the hype around “intelligence”, suggesting that AI is often closer to complex pattern recognition. These approaches highlight the hidden costs—energy, labor, and resource extraction—behind generative systems. By embedding critique into performance and practice, AI and Music is not just about sound, but about reimagining the values and ethics that shape technology in culture.

LOOKING AHEAD

The story of AI and music is not only about technological progress but about how musicians, thinkers, and communities choose to shape it. From the early days of the *Illiac Suite* to today’s experiments with cultural identity, new instruments, and critical practice, artists have consistently bent AI toward creative and ethical ends. As the tools become more accessible and their impact on labor, culture, and society deepens, the challenge will be to keep music-making both imaginative and accountable—a space where experimentation with machines can also mean reimagining what it is to be human.

RESIDENCIES

Fluid Strategies: Artistic Methodologies for Water in Crisis

EWEN CHARDRONNET

The STARTS4Water program aims to mobilize interdisciplinary collaboration between art, science, and technology in order to innovate in response to one of the crucial challenges of our time: water management.
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The STARTS4Water program was launched in 2020–21 in parallel with the consultation phase of the Horizon Europe program's mission board for Healthy Oceans, Seas, Coastal and Inland Waters (Lacroix et al., 2021). The latter took shape in September 2021 with the establishment of the EU Mission: Restore our Oceans and Waters, which aims by 2030 to "protect and restore the health of our oceans and waters through research and innovation, citizen engagement and blue investments", in line with the European Green Deal and the goals of the United Nations.[1]

The first STARTS4Water residency program served as a pilot project between April 2021 and December 2022, with ten residencies and a series of ideation workshops, explorations, and meetings to identify challenges and opportunities for action. The second, "Ports in Transformation", brought together 20 artistic projects focused on the complex environmental and societal challenges facing European ports and port cities, drawing on land-sea relationships, sensitive bio-indicators of industrial impacts on ecosystems, and calling for better integration of citizens in discussions on the future of ports. The third, "Aqua Motion", in 2025, brings together 25 artistic residencies that focus on major challenges at the intersection of science and technology, society, and the blue economy in four countries with large European river basins: Portugal for the Atlantic area, the Netherlands for the North Sea, Italy for the Mediterranean, and Austria for the Danube-Black Sea river basin.

1. From the outset, STARTS4Water has concentrated its efforts on, and set the challenges guiding the artist residencies around, the United Nations Sustainable Development Goals SDG6, "Clean water and sanitation", and SDG14, "Life below water", with a strong focus on sub-goals 6.3 "improve water quality by reducing pollution", 6.5 "implement integrated water resources management at all levels", and 6.6 "protect and restore water-related ecosystems". These build upon 14.2, "sustainably manage and protect marine and coastal ecosystems", and align with target 14.1, "By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution".

AMBITIONS

The structural framework offered by STARTS4Water is ambitious, and the program facilitators and artists involved are undoubtedly motivated by the crucial environmental issues raised by the EU Mission: Restore our Oceans and Waters.

Indeed, according to a report by the European Environment Agency (2024), in the last decade European aquatic ecosystems have undergone accelerated degradation, affected by intensive agricultural practices, urbanization, and climate change, further putting biodiversity and essential ecosystem services at risk.

In coastal regions, waterways, wetlands, and watersheds are particularly subject to multiple pressures: diffuse pollution from intensive agricultural practices (fertilizers, pesticides), pharmaceuticals, fecal contamination, petrochemical industries, land artificialization, disappearance of hedgerows, alteration of aquifers, a higher number of extreme weather events (droughts and floods), and the weakening of ecological corridors. This situation affects water quality and the health of living environments.

In river basins, agrochemical and organic pollution has a direct impact on the environment: eutrophication, bacterial proliferation (Escherichia coli, Cyanobacteria, etc.), threats to mussel and oyster farming, decline in amphibians, and the disruption of ecological continuity. At the same time, wetlands, which are essential for hydrological regulation and natural filtration, are disappearing, leading to soil erosion and a weakening of their buffering role.

The scope of the task is vast, and while it clearly feeds into the investigative skills of many of the program's participants, their role is certainly not to provide techno-solutionist scenarios, but rather to inspire reflection on the serious issues of our time. The artistic process or the final results may eventually catalyze social transformation at citizen level and among public decisionmakers.

ARTISTIC METHODOLOGIES

Faced with intensifying ecological pressures on aquatic systems, artists working within STARTS4Water have developed a diverse set of methodologies to approach water not only as a subject, but also as a material, medium, and co-actor. These practices take place at the intersection of environmental research, technological research, and aesthetic speculation, forming a body of work that is as critical as it is experiential.

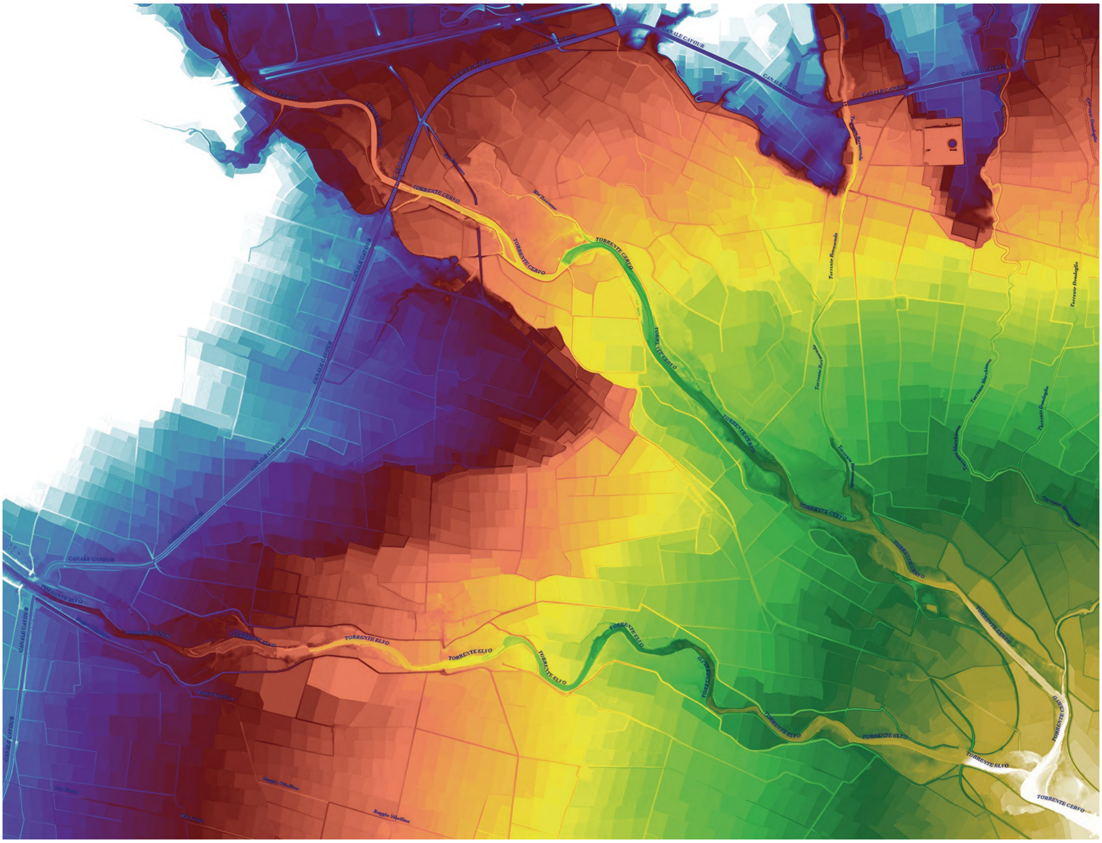
A defining characteristic of these approaches is their grounding in practice and in fieldwork. Artists immerse themselves in specific aquatic environments—rivers, wetlands, ports—not only as observers, but also as collaborators in the space they explore. Through direct collaboration with ecologists, engineers, and local communities, the artworks harmonize with the rhythms, vulnerabilities, and political dimensions of the place. The approach can even be described as eco-ethnographic, as the histories of hydrological spaces are also considered in terms of their cultural history.

We could mention Joshua G. Stein's project *Sediment as Cultural Heritage* with Cittadelarte – Fondazione Pistoletto where he collected and analyzed natural and anthropogenic sediments along the banks of the Torrente Oropa, one of the tributaries of Italy's Po River, as an attempt to trace and visualize the origin of the sediments, their trajectories—both natural and artificial waterways—and their deposits downstream.

A recurring approach is to create speculative prototypes to imagine alternative futures for water-related infrastructure and policies. Drawing on the expertise of hydrologists, ecologists, engineers, or port authorities, these works often blend fiction and functionality, proposing new models of interaction with aquatic environments, whether speculative devices for analyzing water and ecosystems or reinvented hydrological systems. These proposals are not solely or necessarily critical, but also visionary proposals for a different coexistence in the realm of the more-than-human dimension of the hydrosphere. See, for example, two projects focused on circular water management systems inspired by cistern traditions on the islands of Vis in Croatia (Matko Šišak, with Drugo More, for STARTS4WaterII) and Sifnos in Greece (Learning from Poulati by DECA Architecture, with Ohi Pezoume/UrbanDigProject, for STARTS4Water).

The sonification of water flows and ecosystems, bioacoustics, and the art of listening also play an important role as a means of interpreting aquatic stress. Through the use of hydrophones or listening prototypes, the sonification of data, or field recordings of explored water spaces, the projects transform invisible processes into immersive auditory experiences. This mode of sensory practice emotionally connects the audience to systemic issues and invites them to listen to water and the hydrosphere at large as a complex ecological voice. As one of the many sound projects, we can here mention Spanish artist Carlos Monleón (with BOKU University and PART International Art Residency in Austria for STARTS4WaterII) who, in *Parliament of Streams: Turbine Chapel*, explores the impact of hydropower plants on rivers and fish, immersing visitors in sonic representations of currents and disturbances in rivers.

Material experimentation and bio-art practices further deepen this engagement. By working with organic materials, biodegradable substances, site-specific waste, micro-performativity of water life, or bioremediation techniques, artists construct works that respond to the chemical and biological conditions of their environment. These evolving artworks embody ecological processes of decomposition, contamination, or regeneration. Good examples of this are several STARTS4WaterII projects, for example Nandita Kumar's work on phytoremediation of polluted waters



Top to bottom:

Joshua G. Stein / Radical Craft, High-resolution satellite topographic scan rendered with colors of historical synthetic dyes reveals the terraformed landscape of the rice fields of Vercelli, 2022

Adelita Husni Bey, Il Fiato di Suolo, performance and forum theatre, at the TBA21 Solstice Festival, June 2025, Ocean Space, Venice. Photo: Enrico Fiorese in Venice with TBA21–Academy, or Kat Austen's work on microplastics in Ireland with BETA Festival & ADAPT Centre.

Through their practices, artists invite citizens to reflect on the past and present evolution of local biocenoses and biotopes. To do so, they draw on new approaches in cultural geography (evolutionary, affective, and bodily) or on revealing human impacts on various bioindicator species (mussels, oysters, sea urchins, blue crabs, symbiotic species, algae, etc.). For instance, Slovenian artists Robertina Šebjanič and Marjan Žitnik worked with sea urchins as bioindicators of anthropogenic pollution in the Adriatic (a STARTS4Water project with the UR Institute in Dubrovnik, Croatia); and the trio Marko Vivoda, Luka Murovec, and Luka Frelih worked on non-invasive biomonitoring techniques of oysters or blue crabs, which is brought to the audience in a snorkeling-like immersive exhibition (a STARTS4WaterII project with PINA in Koper, Slovenia).

These artistic projects incorporate the translation of sensory data, using real-time environmental sensing to transform abstract data sets into tangible, visual, kinetic, or auditory experiences. These forms offer new ways of perceiving water-related data, making complex systems more accessible and engaging. Transforming invisible or abstract water-related data into concrete multisensory experiences is a central strategy, making data "tangible" rather than readable, going as far as using augmented/virtual reality, artificial intelligence (AI), or immersive spatial design to simulate aquatic stress.

It is important to note that many of these practices are process-based and participatory. Art is not seen as a static outcome, but as an open system involving co-creation with citizens, scientists, and multiple actors ranging from policymakers to environmental activists. Public workshops, citizen science actions, and co-creation challenge traditional boundaries between artists and audiences, emphasizing water as a common good that requires collective attention. To some extent the works may recall the history of industrial pollution at the sites explored and stories of human trauma in order to open up participants and audiences to a shared shift toward ecological time.

A striking example of this approach is that of Adelita Husni-Bey for STARTS4WaterII, which provided a detailed re-examination of the historic Porto Marghera trial in Venice, one of the first high-profile cases in the 1970s to reveal the links between industrial petrochemical pollution and cancer among workers at the sites concerned. Husni-Bey recounts the case in great detail, but also puts it into perspective within the context of post-colonial industrial practices in Italy and the EU in Africa, which are often less regulated and even more toxic.

The artists thus highlight the harmful impacts of industrial practices, suggesting that they should be a thing of the past. By aligning themselves with seasonal cycles, tides and historical patterns of water use, they propose disrupting the linear temporality of extractivism and the industrial approach to ecology, which views ecosystem "services" as something to be managed. Proposing instead more fluid, cyclical, and restorative narratives that view water not as a resource to be managed but as a living system with which we must renegotiate our relationship.

Collectively, these artistic strategies resist simplification. They cultivate attention, propose alternatives, and model forms of care and collaboration that we urgently need to navigate the uncertain future of water.

#SAVEOUROCEAN

Reaching almost the halfway point of the EU Mission: Restore our Oceans and Waters' 2030 target, on June 4, 2025, the European Union adopted the European Water Resilience Strategy.[2] Its announcement coincided with the beginning of the third UN Ocean Conference (UNOC) in Nice, France. The STARTS4WaterII program was promoted at many of the UNOC events, including the One Ocean Science Congress (Blue Zone), The Whale (Green Zone), and its own *Porous. Ports as Interspecies Dwelling* event,[3] organized by TBA21–Academy at the Villa Arson art center.

The Coastal Cities Coalition, an international initiative that aims to combat the effects of climate change and sea level rise on coastal cities and regions, was officially launched at the UNOC's Blue Zone on June 7, and STARTS4WaterII was invited to present its program, offering the opportunity to Irish artist Siobhán McDonald to showcase her work to the many coastal cities representatives.[4]

A new high-ambition coalition for a quieter ocean was also launched in Nice. This coalition aims to combat underwater noise pollution, which threatens marine life. Ocean noise pollution and Ocean sound is an important topic tackled by STARTS4Water, and Belgium sound artist Stijn Demeulenaere performed soundscapes that revealed anthropogenic influences in the North Sea at the *Porous* event in Nice.

At the UNOC, twelve European countries affirmed their commitment to jointly create the Mercator International Centre for the Oceans.[5] This new international organization will place digital technologies at the heart of public decision-making and ocean protection, including an Ocean's digital twin, one of the priorities of the

2. See Directorate-General for Environment of the European Commission, 2025. Among the main objectives are the following: "Restore and protect the water cycle from source to sea to ensure resilience against floods, droughts and water scarcity, by effectively implementing the already existing EU laws for freshwater"; and "Adopt water-smart practices and green infrastructure to improve water retention on land, prevent water pollution and tackle pollutants in drinking water, including per- and polyfluoroalkyl substances (PFAS)".
3. *Porous. Ports as Interspecies Dwelling* (June 7–8, 2025) was curated by María Montero Sierra for TBA21–Academy, with the collaboration of the Villa Arson art center and the support of STARTSWater II.
4. Siobhán McDonald was in residency in the Port of Dublin, Ireland, with BETA Festival & ADAPT, as part of STARTS4WaterII.
5. 5. For more information see: https://www.mercator-ocean.eu/.

European Ocean Pact presented by the President of the European Commission, Ursula von der Leyen. Among the STARTS projects, the Territorial Agency collective, supported by Belgium organizations GLUON Art&Research and VITO (Flemish Institute for Technological Research) in STARTS4WaterII, specifically addresses issues relating to the representation of Space Remote Sensing data for coastal areas.

A global initiative on seaweed, the United Nations Global Seaweed Initiative (UNGSI), was announced in Nice to promote the sustainable development of the seaweed sector. The UNGSI aims to catalyze global action on algae, including the conservation, restoration, and sustainable management of algal ecosystems. In this regard, STARTS Aqua Motion is implementing several residencies that reflect on coastal ecosystems and the emerging seaweed industry in Portugal and the Netherlands.

CONCLUSION

Classifying and promoting societal activities according to their dual importance to society and their impact on nature offers a balanced approach to water management. This holistic thinking recognizes the interdependence between people and their environment, making issues of environmental and social justice inseparable. In this regard, while STARTS4Water places great importance on issues of aesthetics, hydrology, technology, and ecology, the program also recognizes that social issues must have their place in the debate. Many of the projects incorporate social innovation into their approach in order to reinforce the impact of methodologies linking art, science, and technology through the contribution of the humanities or by listening to the advocacy of non-governmental organizations in the fields explored. This approach reinforces the impact of STARTS on public policy, even opening up the program to be reinterpreted as “S+T+ART+S” for “Science+Technology+ART+Society”.

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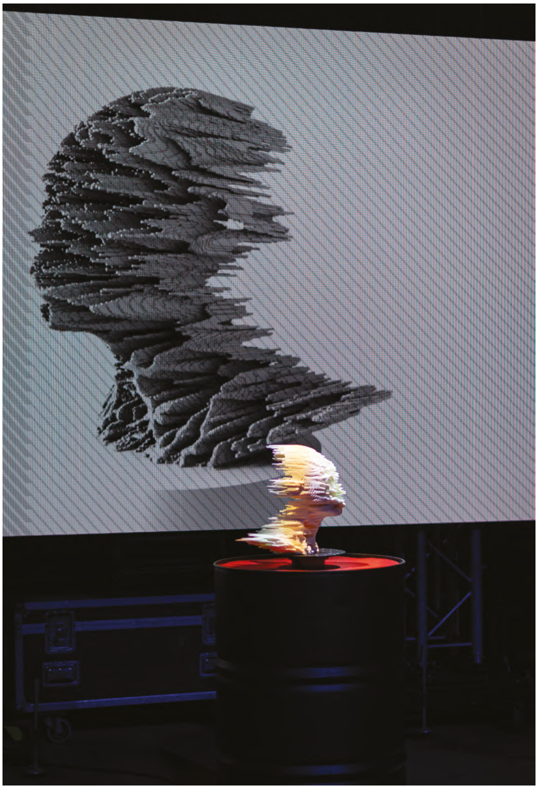
Simulation + Imagination: A European Perspective on Art and Supercomputing



Postnatural Head by Filippo Nassetti, an algorithmic sculpture born from simulated erosion, at the STARTS AIR Festival 2024. Photo: Epica Foundation La Fura dels Baus

MATVEY FRIDMAN (MSC/HLRS) AND
FERNANDO CUCCHIETTI (BSC)

High-Performance Computing (HPC, or supercomputing) is key to accelerating not only frontier research, but also innovation across sectors like manufacturing, automotive industry, and health, or in response to complex challenges such as climate resilience, emergency services, and energy security. The HPC infrastructure in Europe is distinguished by its coordinated, continent-wide strategy led by initiatives such as the EuroHPC Joint Undertaking, which pools resources from EU member states, the European Commission, and industry. This European HPC approach emphasizes shared infrastructure, cross-border access, and alignment with common strategic priorities such as climate modelling, energy transition, drug discovery, and AI training. Furthermore, supercomputing is one of the main blocks of the European strategy in the global technology competition around digital sovereignty, semiconductor dependency, and AI leadership. Europe is investing heavily into top systems and co-design approaches that integrate HPC with quantum computing and large-scale AI, positioning itself as both a scientific and geopolitical actor.

European HPC is increasingly converging with AI—a strategic push visible in the design of new systems optimized for traditional simulation as well as for training and deploying large AI models. Rather than competing head-on with commercial cloud providers, Europe's strategy aims at sovereign capacity for domains of strategic importance, and a strong emphasis on social impact and protection, openness, and trustworthiness. It is within this strategy that the need for inter- and trans-disciplinary approaches emerges: technological and societal partners working together in holistic ways to find novel frameworks and solutions to complex challenges. Within this context, both art and artists can play a pivotal role not only representing and interpreting societal needs but also bringing their own skills to the research activities.

Recently, the AIR project acted as a pilot study within the broader STARTS initiative, testing methodologies for art-science-technology collaboration in the highly specialized realm of HPC. While STARTS has long been active in creating opportunities for artists to engage with emerging technologies, AIR was the first project to include supercomputing centers as active partners. The Barcelona Supercomputing Center (BSC) and the High-Performance Computing Center Stuttgart (HLRS) opened their infrastructures, their scientific teams, and their expertise to artists in residence. The facilities, designed for highly specialized computational research, became laboratories for new ways of thinking about data, simulation, and society. The experiment meant not only connecting artists with state-of-the-art technology in a wide range of fields but also testing out how to integrate them into technical and industrial research groups and activities.

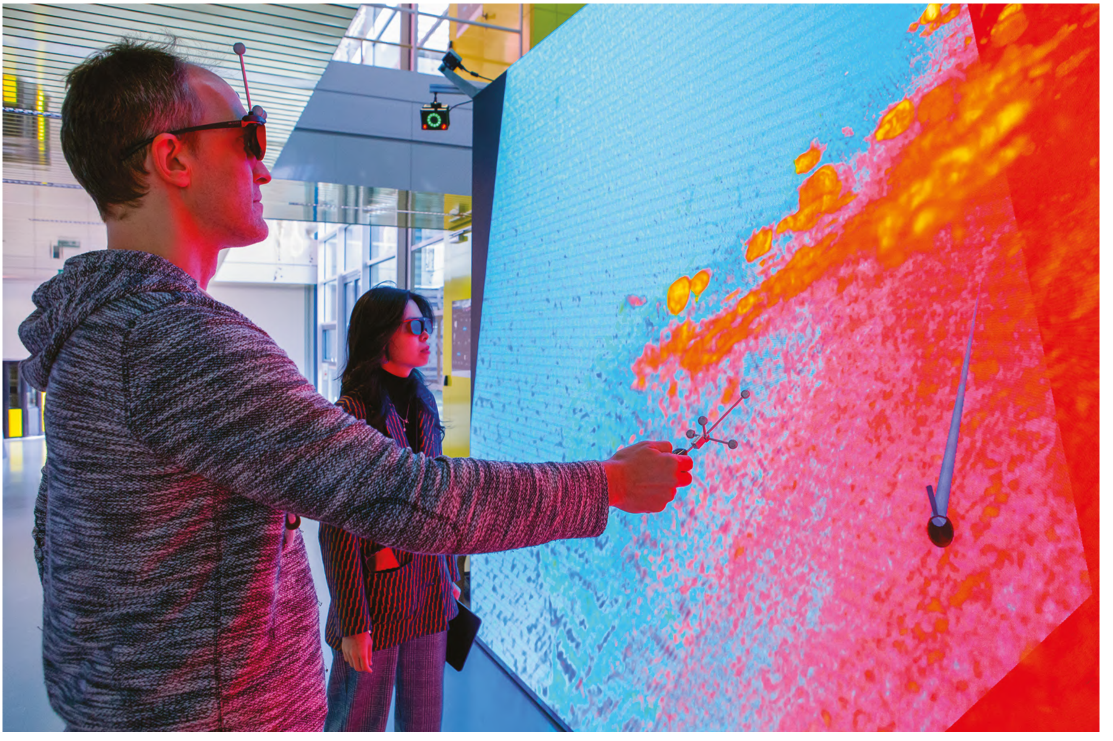
THE UNIQUE CHALLENGE

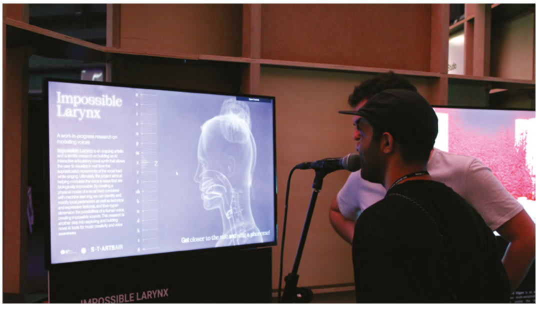
One of the defining challenges of this initiative was how to incorporate artists meaningfully into the world of HPC—an infrastructure typically removed from cultural or artistic contexts. HPC environments are usually dominated by highly technical considerations—hardware performance, algorithmic efficiency, data access policies—in a very wide range of application fields: from deep science of the oceans and atmosphere, or individual responses to drugs or treatments, to the minute engineering details of wind turbines and fusion energy reactors, or the societal impact of various policies. These entangled levels of knowledge can make this environment not immediately legible to outsiders, let alone to artists whose practices may typically value intuition, metaphor, and sensory engagement. Thus, the residencies required significant translation and mediation, not only in terms of vocabulary and processes, but also in terms of expectations and working culture. The specific challenges work on top of the usual ones we expect to encounter in interactions between artists and scientists. Scientists and engineers at HPC centers often work for multiple years on deep technical dives, refining technology, and attempts to expand knowledge in a single field, with validation coming from publications in journals or adoption by industry. In their environment, failure is a constant (i.e., ideas frequently do not pan out) yet still valid outcome that might unlock progress towards a long-term goal. Whereas artists, on the other hand, are more accustomed to iterative, experimental, and sometimes deliberately open-ended processes, where unfinished, unpolished work-in-progress is not ready for publication. This divide in terms of goals and time scales creates a tension that can either break an on-going collaboration or prevent it from happening altogether: some artists approach scientific challenges primarily as sources of inspiration, while some scientists expect clear, reciprocal contributions to their research questions. These differences can lead to frustration or misalignment, yet it was precisely in navigating these challenges that some of the most meaningful exchanges emerged, creating new spaces of possibility where representatives of both worlds could stretch beyond their own comfort zones.

Logistical challenges can also arise. Data access can prove difficult in some contexts, especially where strict governance frameworks constrain flexibility. The steep learning curve to using supercomputer resources demands significant onboarding, as artists have to learn new concepts, languages, and workflows. The limited duration of residencies can also prevent deep immersion in relation to complex scientific questions, forcing collaborations to remain at the level of prototypes or explorations rather than mature, co-driven research outcomes.

OPPORTUNITIES FOR ARTISTS

For the artists, HPC centers offer unprecedented access to computational resources that dramatically expanded the scope of what can be explored. Access to supercomputing power allow for experiments with fluid dynamics at resolutions impossible on conventional machines, simulations of biosystems and ecological processes that could be turned into realistic immersive artistic experiences, or the processing of massive cultural or behavioral datasets that would otherwise remain opaque. These opportunities are not only technical but also conceptual: artists are able to engage with phenomena usually hidden from human perception—climate models spanning centuries, molecular dynamics unfolding at scales invisible to the naked eye, or AI models trained on vast swathes of data.
In addition, collaboration with artists allows for the reimagining of how complex data can be communicated and felt. The ability to transform abstract, scientific representations into tangible, sensory forms—whether visual, auditory, or spatial—opens up new pathways for public engagement with science. In doing so, artists act as mediators, making the invisible visible and the inaccessible accessible, creating bridges between specialized scientific knowledge and broader societal understanding. In this sense, HPC centers provide a unique opportunity for artists: by working together with researchers and technologists from a wide range of fields, artists are provided with greater opportunity to closely align their own goals with the relevant research activities.





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Artist Hiền Hoàng exploring a dataset of vibration and resonance of urban trees under human movement at the HLRS High-Performance Computing Center Stuttgart. Photo: Matvey Fridman

Postnatural Head by Filippo Nassetti, an algorithmic sculpture born from simulated erosion, at the STARTS AIR Festival 2024. Photo: Epica Foundation La Fura dels Baus

Person using the Impossible Larynx app, developed during the S+T+ARTS AIR residency with Maria Arnal, at Sonar 2025. Photo: Paula Fernandez Vergara

OPPORTUNITIES FOR THE HPC FIELD

As has been shown in many fields of science, artists bring with them audiences and modes of dissemination that extend the visibility of HPC research far beyond its usual circles. Where supercomputing can be perceived as opaque, distant, or even intimidating, artistic projects create points of entry for public engagement, helping citizens to see supercomputing as relevant to societal challenges and cultural imagination. For the centers themselves, this means an enhanced capacity to communicate their work in ways that resonate outside of academia and industry, reinforcing their role as actors in broader cultural and political landscapes. However, for HPC centers and researchers the arrival of artists can be transformative. Artists can introduce new use cases and perspectives that challenge the conventional framing of HPC as a purely scientific or industrial tool. For instance, in the AIR project some artistic projects used aesthetic approaches to scientific visualization, encouraging researchers to reflect on how choices of form, color, or representation affect perception and interpretation. This was not only a matter of aesthetics, but also of methodology: rethinking visualization through an artistic lens provided new ways of questioning the assumptions built into scientific models, which lead to a quantitative improvement in the simulation models.

RECIPROCAL INSPIRATION

The reciprocal nature of the exchanges became one of the most powerful outcomes of AIR. Artists benefited from immersion in cutting-edge computational environments, gaining not just technical access but also conceptual proximity to the scientific questions driving HPC research. Scientists, meanwhile, were exposed to alternative conceptual frameworks—ways of thinking that questioned assumptions, reframed problems, and suggested novel avenues of inquiry. In some cases, artists approached data as material to be sculpted, visualized, or sonified, offering researchers specific domain knowledge outside of their expertise, which became useful for their own models.

METHODOLOGY AND LESSONS LEARNED

The AIR project provided valuable methodological insights into how collaborations between artists and HPC teams can be structured. A crucial lesson was the importance of starting out strong: making expectations clear on both sides, facilitating data and compute access early, and organizing immersive onboarding workshops. These initial steps helped artists get up to speed quickly, while also reassuring scientists that the collaboration would be meaningful.

Equally critical was the cultivation of “eye-level collaboration”, where both sides approached the process with open-mindedness and mutual respect. In particular, a thorough interview and matching phase, followed by a negotiation period to determine the specific research goal and activities to be performed, allowed both parties to align their focus to develop a mutually beneficial program. Recognizing the different rhythms of work—iterative prototyping in artistic practice and long-term validation cycles in scientific practice—was essential. Mediation played a central role: mentors or facilitators who could bridge the terminology gap between art and HPC often determined the success of exchanges. The use of small, tangible prototypes proved effective as milestones, aligning expectations and creating opportunities for serendipitous discovery.

Flexibility emerged as another key element. While structured mentoring and planning provided the necessary scaffolding, leaving room for unpredictable, exploratory, and even playful outcomes enriched the collaboration. In this respect, longer, staged, or frequent interaction (once a week, long sessions or more) residencies were identified as a particularly promising model, allowing enough time for trust to build, for technical onboarding to succeed, and for deeper, reciprocal benefits to emerge.

CONCLUSIONS

HPC-art collaborations are both promising and challenging, and their potential impact is considerable. They open up new pathways for innovation, stimulate public engagement, and generate conceptual frameworks that neither domain could develop alone. The AIR project showed that artists can transform highly technical environments into spaces of cultural imagination and societal relevance. Both HLRS and BSC are now building on this momentum, opening their doors to further artistic collaborations and embedding cultural practices into their infrastructures.

Beyond its immediate outcomes, the arts at HPC experience provides a transferable methodology. Its lessons can be applied not only to future residencies but also to other cutting-edge fields such as quantum computing, AI research labs, or climate modelling initiatives, where artists’ skills and perspectives can be of importance, and artistic curiosity is high. The deeper value of this experience lies in its demonstration that infrastructures of science and technology can become spaces where art and culture play an active, co-shaping role. In this sense, its long-term impact goes beyond individual projects: it gestures toward a future in which science and art together shape the narratives, imaginaries, and possibilities of Europe’s technological and cultural trajectory.

TECHNICAL PILOTS

Social and Potential of Sound Research-Creation Framework

NEFELI GEORGAKOPOULOU (CERTH), ANTONIO CAMURRI (UNIGE), MANUEL CIRAUQUI (EINA) AND BEATRICE DE GELDER (MAASTRICHT UNIVERSITY)

INTRODUCTION: RESILENCE AND THE SOCIAL DIMENSIONS OF SOUND

In a time of sensory overload and visual dominance, sound in the city is often neglected or downgraded to background noise, a by-product of our urban environments rather than a medium for social and ecological awareness. The ReSilence project challenges this passive approach by tuning into the subtle dynamics of sonic experience. It proposes an alternative way of engaging with cities: not just by designing their forms, but by attending to their aural atmospheres, emotional vibrations, and affective ecologies. ReSilence reimagines urban space through the lens of sound and silence, treating them not only as sensory phenomena but as relational, political, and cultural forces. In this context, silence is not the absence of sound but a dynamic interval—a pause that makes listening possible, a space where meaning and cohabitation emerge. At its core, ReSilence is driven by a Research-Creation framework, integrating artistic practice, academic research, and technological experimentation. This approach enables the formation of transdisciplinary and cross-sector collaborations that probe the social potential of sound in urban life. By developing new tools, methodologies, and speculative scenarios, ReSilence fosters a deep engagement with sonic environments—one that is participatory, situated, and open-ended.

SOUND AND URBAN COEXISTENCE: EXPANDING AURAL AWARENESS

One of the most profound learnings from ReSilence is the recognition that sound is not just a sensory phenomenon but a social one. Sound mediates how we coexist in shared spaces, it constructs boundaries, invites or excludes, soothes or agitates. Yet conventional urban planning often perceives cities solely through their built forms, reducing the sonic to either nuisance or absence. ReSilence counters this tendency by treating urban soundscapes as critical fields of encounter where affect, power, memory, and possibility converge. Through art-driven explorations that draw from science and technology, the project reclaims sound as a relational medium that reveals the emotional, spatial, and political textures of everyday life.

ReSilence gathers the outcomes of fifteen residencies, each situated in diverse and often politically charged contexts—gentrified neighborhoods, football stadiums, war-torn cities, industrial ports, public parks, and even the interior sonic landscapes of the human body. These residencies do not treat sound as an object to be analyzed, but as a mode of relational practice, a way of encountering the world that is attentive, embodied, and transformative. This expanded notion of listening is not neutral. It responds to the affective and ecological crises of our time by foregrounding the emotional charge of sound and its capacity to foster belonging—or exclusion. As cities become increasingly mediated by data and designed for efficiency, ReSilence proposes an alternative: sonic interventions that slow down perception, amplify marginalized voices (including non-human ones), and open new pathways for coexistence. In this way, sound becomes not just a sensory phenomenon but a socio-political force—a means of reimagining public space as shared areas for connection and harmony instead of places filled with noise.

RESEARCH-CREATION AS METHOD: BRIDGING ART, SCIENCE, AND SOCIETY

At the heart of ReSilence lies a commitment to **Research-Creation**—a hybrid methodology that merges making and knowing through embodied, affective, and iterative practices. As Paquin (n.d.) argues, this is not about illustrating research through art, but about treating the creative act as a rigorous form of inquiry. In ReSilence, this approach allowed artists and researchers to engage with sound as a relational medium, letting questions emerge through material encounters and situated listening. This resonates with Manning and Massumi's concept (2014) of "thought in the act", where knowledge arises through sensory and affective engagement. As highlighted in recent French academic debates (Glicenstein, 2024), such practices challenge institutional norms by positioning art not as a supplement to research, but as an entangled mode of knowledge capable of critical and public intervention.

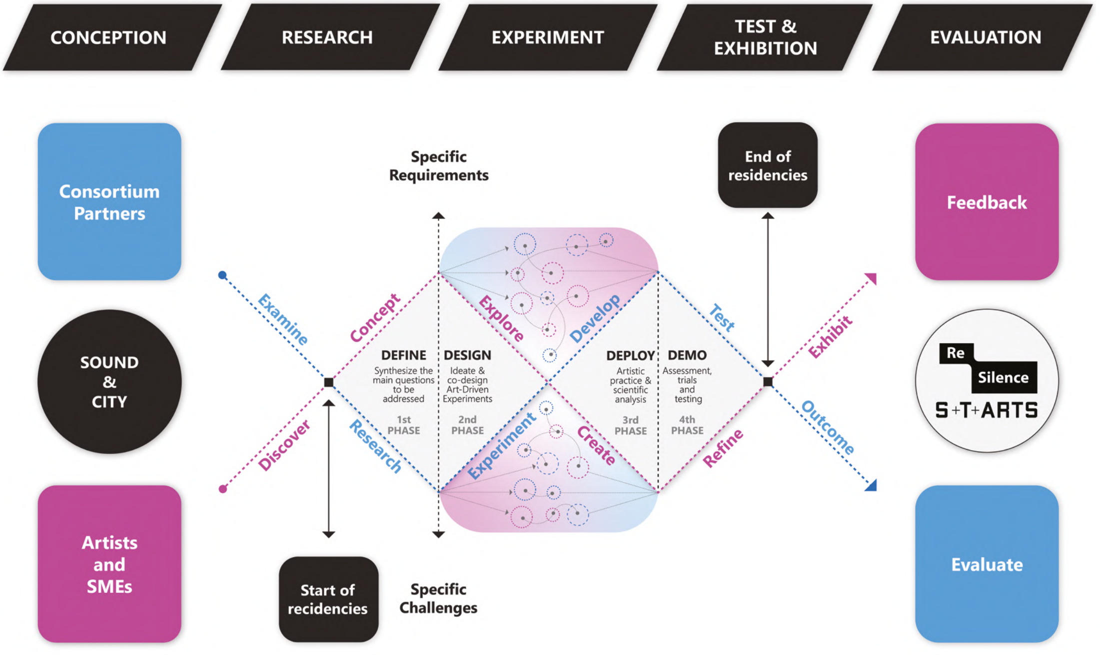
ReSilence's methodological commitment to Research-Creation was operationalized through an evolving metadesign[1] framework that privileges experimentation over execution. It recognizes that in transdisciplinary collaborations—particularly those involving artists, scientists, and technologists—what emerges is often more valuable than what is predefined. This led to a working ecology in which design thinking was complemented by emergent thinking, which embraces complexity, uncertainty, and surprise. The four-phase model of design thinking that evolved—define, design, deploy, demo—did not simply manage residencies; it created the space for experimentation and allowed unexpected synergies to surface (Fig. 1). This space for experimentation in the ReSilence methodological diagram—where experimentation replaces a singular point of problem definition—can be interpreted as a form of what has been described as the "collaboration groan zone" (Jiang, 2023) transformed to growth zone. This is the phase in a collaborative process where different perspectives, languages, and goals collide, often resulting in confusion, discomfort, or productive friction. Instead of bypassing this phase through premature consensus or rigid structures, ReSilence held open this zone as a space of generative complexity. The collaboration between artists and consortium partners was not always frictionless—but it was precisely in those moments of communicative mismatch that new forms of knowledge began to grow. An example is the Sonic Drift CDA (Caroline Claus): artistic dérive methods and AI-based acoustic analysis initially appeared incompatible, but the resulting tension became productive ground for co-developing new approaches to mapping affective sonic space. These explorations, in turn, showcased how forthcoming densification and compact-city policies could transform the local soundscape.

ReSilence's methodological stance also opened up new pathways for those working in cognitive science and technology development. The challenge of designing scientific experiments to study the impact of intrusive soundscapes (Andrea Cera) on social wellbeing, for example, prompted a departure from conventional scientific methodologies. By working in close dialogue with artistic practice, we were able to develop hybrid methods that integrated embodied interaction design with established protocols from psychology and cognitive science. Rather than isolating variables in controlled settings, the experiments were reframed as situated, multisensory experiences charged with affect and embodiment—closer to how sound is lived and perceived in real environments.

TOOLS FOR SONIC TRANSFORMATION: THE RESILENCE TOOLKIT

The ReSilence Toolkit emerged from the lived exchanges between artists, scientists, and technologists—materializing their shared exploration of how sound might be used to foster awareness, dialogue, and transformation. ReSilence's toolkit embodies a metadesign approach—an open framework for others to design their own sonic interventions. It provides modular components, including DIY hardware, design methodologies, interactive modules and web tools, participatory methods, and art-driven scientific experiments addressing a number of challenges. Users of the ReSilence Toolkit can reconfigure and explore its modules for a wide range of contexts such as noise pollution and sound intrusiveness, with works raising awareness of urban sound overload and its impact on social well-being. Music generation and AI composition explores algorithmic and real-time sound creation, while movement analysis and sensory interfaces translate bodily gestures and breathing patterns into sonic experiences. Datasets and data sonification transform complex information into audible forms; immersive pedagogies enable public engagement and learning. Finally, acoustic urban interventions use sound to reshape perception and activate space. This empowers communities to repurpose the (methodological as well as

1. Metadesign as a level of critical-reflective knowledge production.



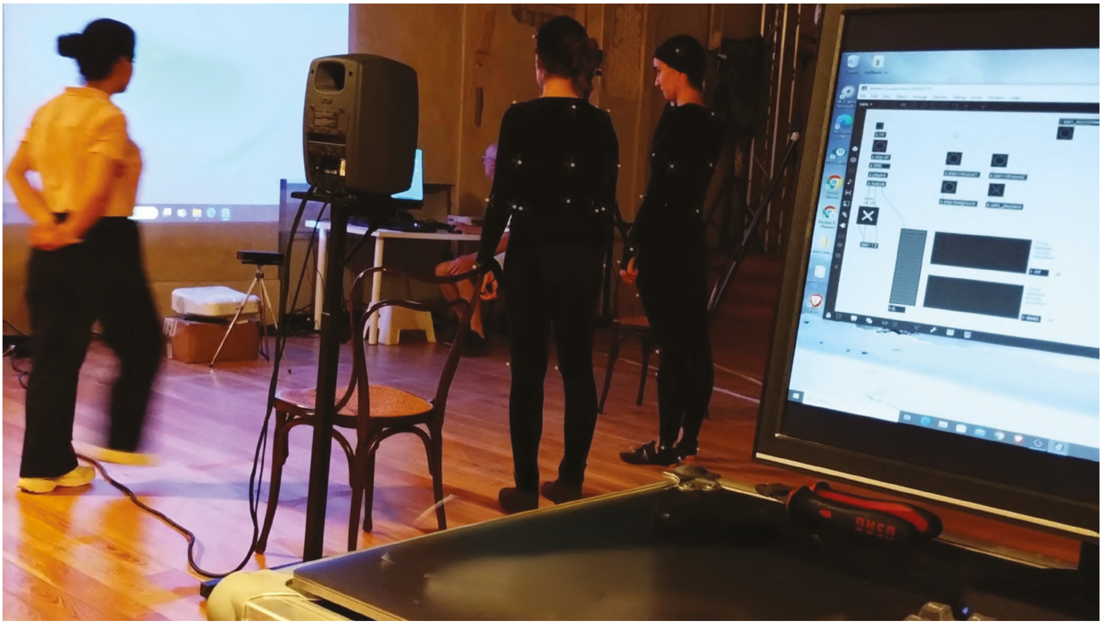


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Figure 1. *ReSilence Methodology Diagram*
Andrea Cera, *Moving Soundscape*. Photo Credit: Andrea Cera

technological) tools while maintaining core principles of collective listening and sonic agency.

The resulting metadesign framework reflects these dynamics by enabling flexible, context-sensitive adaptations rather than fixed outputs. It positions collaboration itself as a mode of inquiry and innovation, recognizing that complex urban soundscapes require multifaceted approaches, responsive to social, political, and ecological dimensions. By foregrounding these partnerships, the toolkit exemplifies the STARTS ethos of transcending disciplinary boundaries to address urgent societal challenges through creative technological experimentation. It invites us to reconsider collaboration not just as a means to an end, but as a transformative practice that reshapes how knowledge is made, shared, and enacted.

REFLECTIONS AND TAKEAWAYS

A central takeaway from ReSilence is the way it reorients the role of urban sound—shifting it from being a problem to be muted to a resource to be refined. This echoes a broader shift in a new way of thinking, as articulated in *The Future of Urban Soundscapes: Beyond Noise Reduction*,[2] which argues that instead of seeking sterilized silence, cities should embrace and design beneficial acoustic environments that shape how people feel, connect, and belong. Within ReSilence, this paradigm is enacted rather than theorized: sound is not merely a subject of investigation, it is a methodological and relational tool. ReSilence residencies reframed sound as a sensorium of possibility, a way to attune to hidden ecologies and emotional landscapes.

2. See http://prism.sustainability-directory.com.

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FROM VISION TO IMPACT: TATIANA EFREMENKO (POLITECNICO DI MILANO), MARITA CANINA (POLITECNICO DI MILANO), CARMEN BRUNO (POLITECNICO DI MILANO), EVA MONESTIER (POLITECNICO DI MILANO), FILIPPO STRINGA (MADE COMPETENCE CENTER INDUSTRY 4.0), AOIFE O'GORMAN (UNIVERSITY COLLEGE DUBLIN), GIZEM BOZDEMIR (PAL ROBOTICS), MARIA BULGHERONI (AB.ACUS), ELENA NOVELLI (AB.ACUS), PETIA IVANOVA (UNIVERSITY OF BARCELONA), ELOI PUIG (UNIVERSITY OF BARCELONA), RAMON PARRAMON (UNIVERSITY OF BARCELONA), RAMONA VAN GANSBEKE (GLUON), FRANCESCO SEMERRARO (UNIVERSITY OF MANCHESTER) AND MAJA TRUMIC (UNIVERSITY OF BELGRADE)

From Vision to Impact:

Outcomes and Learnings from the MUSAE Factory Model

INTRODUCTION

In today's fast-changing world, sustainability and innovation are not merely technical but also planetary, ecological, and systemic challenges. Addressing them requires cross-sector collaboration and inclusive engagement, where creativity, combined with critical thinking and emotional intelligence, becomes a strategic asset. Art-tech collaborations offer unique potential: artists can reveal blind spots, provoke reflection, and translate complexity into shared experiences (Mitchell et al., 2003; Whitaker, 2016). Yet such collaborations often struggle with misaligned goals, differences in language and timelines between artists and companies, and a lack of frameworks to ensure long-term impact (Strauß, 2017; Raviola and Schnugg, 2016). The MUSAE Factory Model addresses this gap with a structured, vision-led, and modular approach that merges art, design, technology, and futures thinking to foster responsible, future-driven innovation (Bühring and Liedtka, 2018; De Smedt et al., 2013).

MUSAE FACTORY MODEL PACK

The Factory Model, developed over the three-year MUSAE project, supports organizations and companies in merging artistic experimentation with advanced technologies to envision futures and co-create solutions. The Factory Model Pack (Fig. 1) comprises Methodological, Organizational, and Community resources. It offers adaptable tools and guidelines that balance creativity with structure, fostering collaboration across industries, from innovation hubs to education and training. The entire pack is released as open-source material on the MUSAE Factory Model webpage.[1] By clicking on each square of the Model (Fig. 5), users can download guidelines, templates, meditation soundtracks, and all the materials needed to apply the Model in a design challenge.

METHODOLOGICAL RESOURCES: DESIGN FUTURES ART-DRIVEN (DFA) METHOD AND DFA PROJECTS AND USE CASES

The DFA Method is a structured, open-source method that blends Design Futures with Art Thinking in a four-phase process: Horizon Scanning, Visioning, Ideating, and Prototyping. It enables stakeholders to anticipate emerging challenges, imagine alternative futures, and co-create Technology Readiness Level 5 (TRL5) prototypes that are socially and environmentally responsible. It follows a clear workflow including workshops, individual exploration for creatives and companies, and check-ins to align with industry goals. A unique aspect of the DFA method is the exploration of AI as a co-creator—not just as a tool, but a generative partner in the ideation and design process. This opens new ethical and emotional dialogues and invites speculation around human-AI collaboration. The DFA Method is not limited to a single sector—it was first tested in the domain of Food as Medicine but is designed to be adaptable across a wide range of fields, supported by facilitation tools, templates, canvases, and adaptable workshop formats. Importantly, it is accessible to non-experts, although experienced facilitation is advised for better outcomes.

Insight: DFA is not just about producing futures—it builds capacity for imaginative future alignment and research between diverse actors. Tools like the Shared Compass, immersive workshops, and meditations help participants find common ground, fostering empathy and shared purpose across sectors.

ORGANIZATIONAL RESOURCES: OPEN CALL, RESIDENCY, TRAINING, AND MENTORING FORMATS

Organizational resources structure and support art-tech collaboration within the Factory Model. The "Open Call" format provides a transparent entry point through public launch, submissions, and expert evaluation. In the "Residency" format, partnerships deepen as artists and companies follow a scheduled process to co-create artistic, commercial, or experimental outcomes. The "Training" format builds mutual understanding by introducing artists to technologies and companies to creative and futures methods, supported by DFA tools. "Mentoring" complements this with diverse external perspectives from art, tech, and domain experts, ensuring reflection, balance, and future focus.

Insight: Effective collaboration requires flattened power dynamics, trust, and shared vision, while training grounds creativity in context and technology, and mentoring provides critical external perspectives to challenge assumptions and stay future-focused.

COMMUNITY RESOURCE: INTEGRATED STAKEHOLDER NETWORK

To foster long-term collaboration, MUSAE developed a semi-open network of artists, tech providers, domain experts, and European Digital Innovation Hubs that have adopted the Factory Model. This network facilitates matchmaking for future projects and encourages shared learning across the ecosystem. It is particularly valuable for art-industry collaboration, as it enables communication between different profiles and entities that could form potential project teams, with the added advantage that participants are already familiar with interdisciplinary collaboration.

Insight: This type of network is essential for scaling art-tech collaborations. It ensures that partnerships are not one-off events but part of a living ecosystem of exchange, experimentation, and capacity-building.

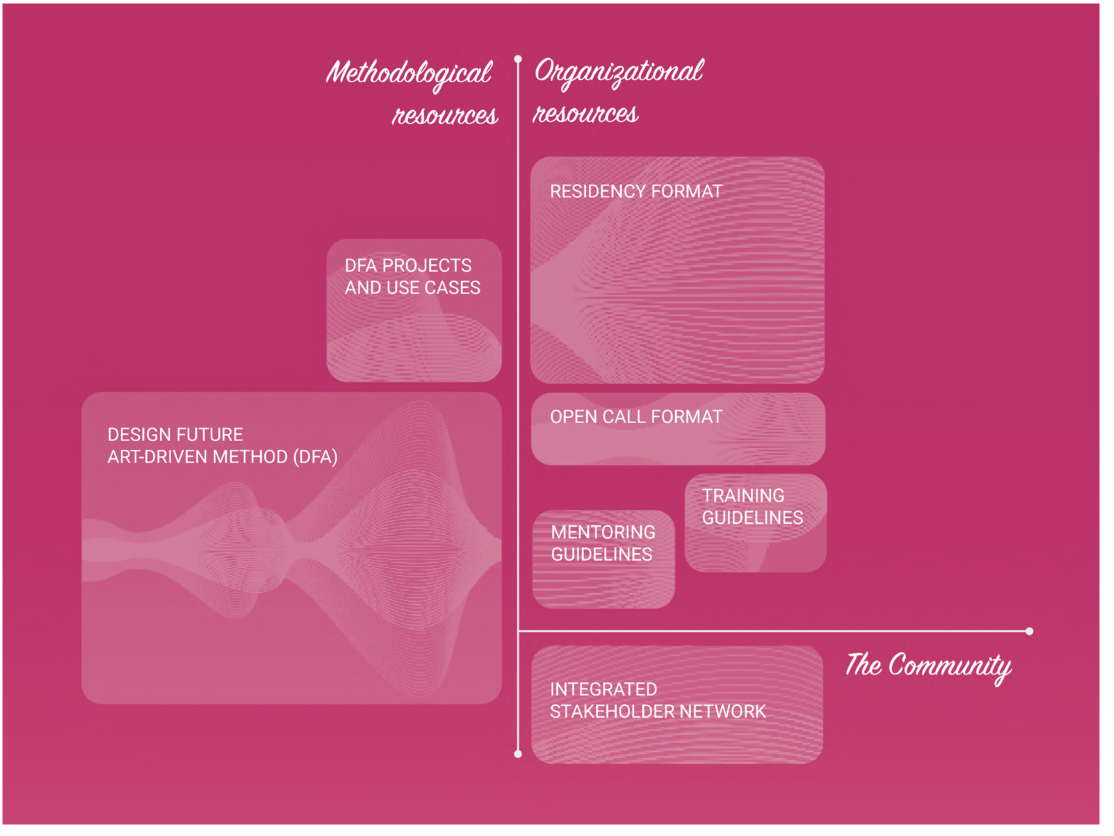
APPLICATION OF THE MUSAE FACTORY MODEL IN THE FOOD DOMAIN

FUTURE SCENARIOS AND PROTOTYPES

The MUSAE Factory Model was piloted in two art-tech residencies under the theme Food as Medicine, reimagining food practices to support both human and planetary wellbeing. The first residency engaged twelve artists in developing future scenarios that explored visionary responses to emerging food trends. These scenarios—rich in narratives, future artefacts, and personas—acted as catalysts for innovation, highlighting opportunities and challenges that are often overlooked in conventional R&D. In the second residency, eleven artist-SME teams selected one scenario each and co-developed future-driven prototypes at TRL5.

This two-step process, moving from scenarios to prototypes, established a shared language and aligned values among diverse stakeholders. Unlike conventional R&D, which often begins with a problem statement, the Factory Model starts by imagining futures grounded in shared values. These scenarios are neither utopian nor dystopian but offer positive, actionable outlooks that provide fertile ground for innovation. This approach shifts the focus from current needs to anticipated future needs and solutions, enabling stakeholders to explore systemic issues and opportunities in new ways.

1. See https://musae.starts.eu/factory-model-pack/.



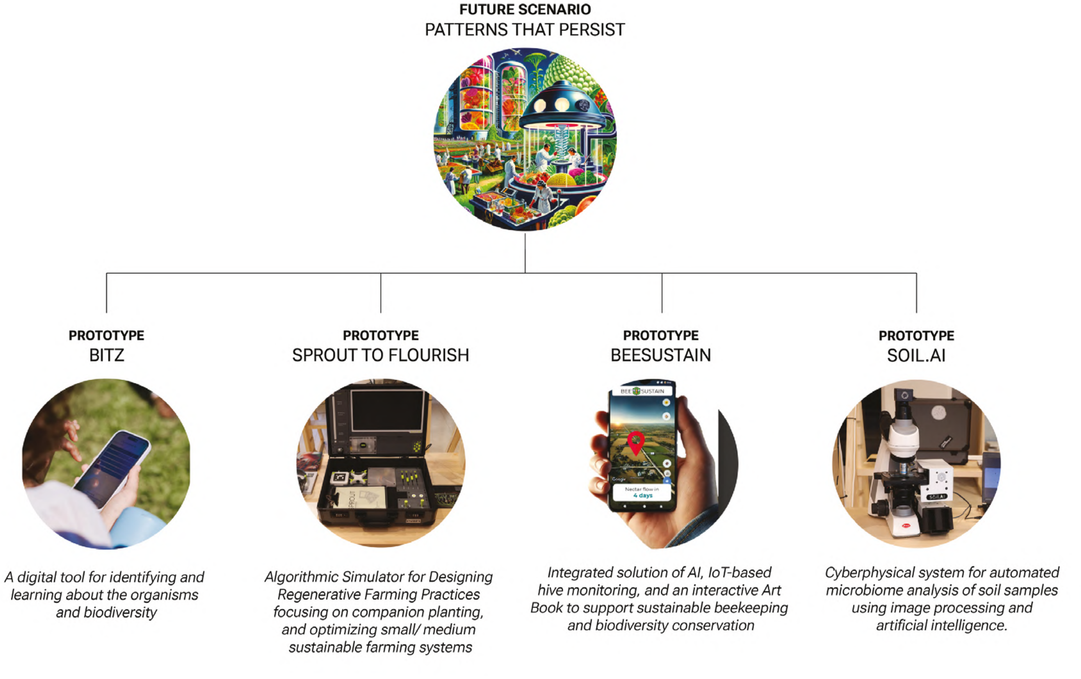


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Figure 1. Scheme of MUSAE Factory Model Pack resources

Figure 2. Future scenario “Patterns that Persist” and four TRL5 prototypes that emerged from it

Applied to food, the Factory Model helped to generate a wide range of future scenarios addressing systemic challenges such as biodiversity loss, climate change, waste management, industrial farming pressures, and evolving food cultures. Beyond identifying areas for technological development, the scenarios envisioned how the world might change—new relationships between soil and humans, shifting dietary practices, regulations centered on biodiversity, and more. This narrative-driven exploration broadened perspectives and seeded multiple pathways for innovation.

A compelling example is the scenario "Patterns that Persist" (Fig. 2) created by the Center for Genomic Gastronomy during the first MUSAE residency. It inspired four distinct prototypes by different artist-SME teams in the second residency, ranging from tools for biodiversity measurement and regenerative farming design to AI-enabled beekeeping support and soil microbiome monitoring. This illustrates how a single, well-crafted future narrative can spark diverse, cross-sectoral innovations addressing ecological and societal challenges.

FROM SCENARIO TO PROTOTYPE: EXPLORING THE CONNECTION BETWEEN "SOIL SKINSHIPS" AND SOIL

Another illustrative example of the Factory Model is the transition from the "Soil Skinships" scenario, created by Lisa Mandemaker, to the *SOIL* prototype by artist Letizia Artioli and the SME Uptoearth. The scenario envisioned a tech-enhanced, embodied connection between human skin and soil, emphasizing tactile intimacy and ecological awareness. Building on this vision, *SOIL* became a wearable device that translates soil data into tactile and sonic feedback, fostering a sensory and emotional bond between farmers and the land. This collaboration brought together an artist, an SME, farmers, and a clothing designer, combining diverse expertise and perspectives. The future scenario provided a clear conceptual framework, the Factory Model provided structure for collaboration, and mentorship supported reflection, troubleshooting, and planning. Beyond technical development, the poetic narrative embedded in the "Soil Skinships" scenario shaped *SOIL*'s design, adding a critical and emotional dimension. This case demonstrates how future scenarios can guide innovation that not only produces prototypes but also reshapes user experiences and cultural narratives around soil care.

CONCLUSION

The MUSAE Factory Model Pack, based on the Design Futures Art-driven method, supports envisioning and co-creating future opportunities through a blend of visionary and pragmatic tools. Its focus on up to the next ten years expands innovation beyond market-driven R&D, but can also feel too distant for SMEs focused on short-term outcomes. The MUSAE residencies revealed several key insights into how future thinking and art-tech collaboration can work in practice. Future-driven innovation needs shared understanding. Future-driven innovation requires early alignment between artists and SMEs on purpose and expectations. Without strong mentoring, SMEs may default to short-term priorities, losing sight of visionary goals. Mentors play a critical role in balancing immediate objectives with visionary aspirations.

Creative tensions foster innovation. Interdisciplinary teams often face divergent perspectives and interests, yet these frictions sparked fresh ways of addressing complex challenges. The Factory Model's structured facilitation helped turn tensions into productive outcomes.

Technology and ethics must evolve together. Artistic scenarios not only inspired new technological directions but also surfaced ethical and emotional dimensions, often neglected in traditional R&D. Prototyping with users was key for testing acceptance and refining functionality, but required SMEs with sufficient technical capacity—or careful management of external partners.

Value for Digital Innovation Hubs (DIHs). The Factory Model offers DIHs a replicable framework to integrate art into innovation pipelines. This enables them to expand services, orchestrate interdisciplinary projects, and foster responsible experimentation, positioning DIHs as catalysts for socially impactful innovation among SMEs.

Food and nutrition innovation. In the residencies, artists grounded speculative visions in scientific evidence, combining creativity with rigor. This combination of science and imagination supported credible, forward-looking solutions beyond typical R&D approaches.

Overall, the MUSAE Factory Model, rooted in the Design Futures Art-driven method, demonstrated how future-driven art-tech collaborations can thrive on rich interdisciplinary exchange, structured guidance, and a commitment to both scientific and poetic inquiry—together creating innovations that are not only technologically sound but also culturally and socially meaningful.

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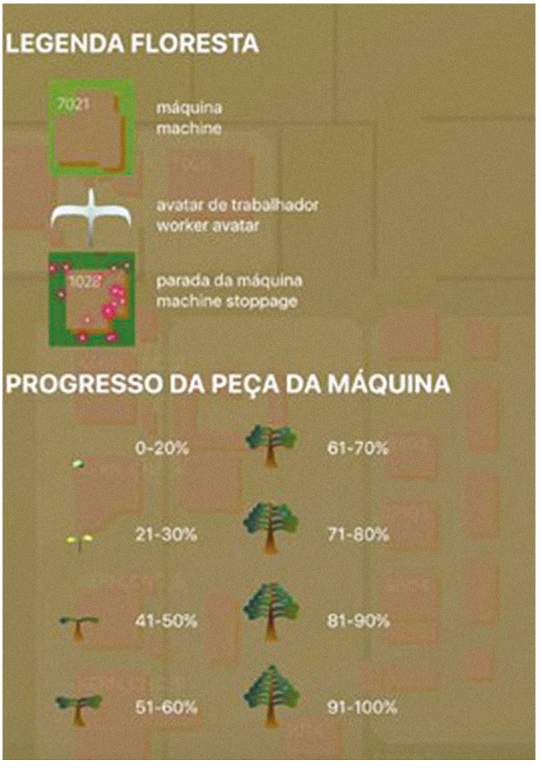
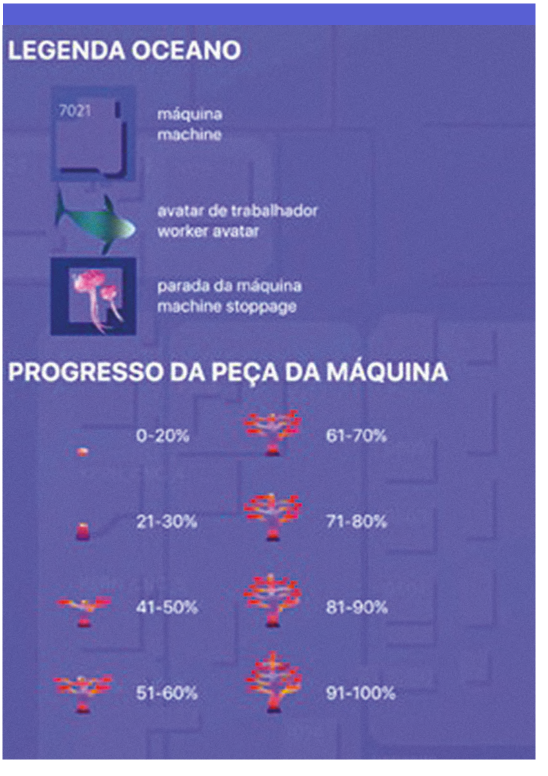
Making Better Factories

RODOLFO GROENEWOUD VAN VLIET (IN4ART)

Over the course of several STARTS programs, industrial companies have been positioned at the heart of transformative questions about manufacturing's future. The most notable project pursuing this vision was "Better Factory", in which a group of 28 partner organizations from industry, science, technology, and the arts came together to produce 16 experiments over a period of four years. Each of these experiments set out to support a small or medium-sized European manufacturing company, i.e. a factory, to become an even better factory. But this raises the question: What does it mean to become a better factory?





Top to bottom:

Figure 1. Govert Flint, NUDE Chair Green, 2024

Figure 2. Kristina Pulejkova, SMART VIEW Prototype Ocean, 2024

The notion of "better" relates to concepts such as superiority, recovery, excellence, or desirability. In the context of a competition, the better competitor prevails over the rest. In the context of bodily health, becoming "better" relates to overcoming an illness or injury. In this case, we might think of better in terms of excellence and desirability. Through various experiments, the factories were challenged and pushed in order to achieve a state of excellence in relation to the ways in which they worked or in respect of their production. Excellence, that is, in the sense of "to excel" in comparison to the competition by means of gaining a competitive advantage.

This raises further questions: What does it mean to excel in European manufacturing in the second decade of the twenty-first century? And in what areas should this excellence be pursued? The answer lies in the notion of desirability, i.e. to achieve excellence in what Europe collectively considers desirable across science, arts, and industry. This desirability has different aspects: the desire to become sustainable, the desire to act responsibly, the desire to act fairly and justly, the desire to beat the competition, the desire to protect against dependence, the desire to preserve resources, and so forth. All of these desires must be weighed against the shifts currently reshaping the world: changing climates, shifting geopolitical power structures, demographic changes, and rapid developments in digital technologies. This context points to two directions for "betterness": green making and care making.

- Green making desires could be, for example, waste reduction, cleaning production, using resources efficiently and responsibly, regeneration practices, and circular practices.
- Care making desires could be, for example, the empowerment of people, increasing transparency, improved safety and ergonomics, fair and just practices.

"Better", therefore, emerges as a quest to realize more desirable ways of production, transforming factories into places of meaningful making. Let us take a look into some of these industrial factory floors, drawing learnings and insights directly from the field on how transdisciplinary projects work out in the industrial context.

PORTUGAL: SPECIALTY MOLDS

Located in Marinha Grande, a rural area between Porto and Lisbon in Portugal, a highly specialized factory designs and produces precision molds. Having grown and merged with other companies in recent years, the staff of at Famolde began to experience a problematic disconnect between the floor workers and the office employees. They entered the "Better Factory" project with this particular difficulty in mind, questioning how they might, with the aid of technology, close the gap between their workers on the factory floor and those based in the offices. This perceived challenge presented an opportunity for the artist Kristina Pulejkova to create a digital and social tool that could potentially solve the problem. Puzzled by the unnaturalness of factory environments, she developed "The Animated Factory Interface". This is a genuine interface that workers can use to track production processes and receive relevant notifications; however, that is where most comparisons with traditional interfaces effectively end. The interface reimagines the sterile world of data visualization, known for its abundance of numbers and graphs, by creating a vibrant digital ecosystem of animals, visuals, and sounds. It even responds to the weather outside, giving workers the sense of still being part of a natural environment. This artistic interpretation of factory data not only engages workers more deeply but also provides them with an intuitive understanding of complex manufacturing processes. In doing so, it addresses the issue of digital comprehension and social engagement in increasingly automated and digitalized environments.

It is fair to say that this example illustrates how an artist, once they have been immersed in the reality of a given manufacturing environment, can come up with a genuinely innovative approach to address social and digital problems inside the factory walls. It is through these creative endeavors that we can learn to look beyond our traditional ways of increasing engagement between workers and to embrace entirely different approaches that have the potential to open up new routes and directions, thereby shifting the needle for SMEs both socially and digitally.

ROMANIA: OFFICE CHAIRS

How about a chair? In the northwest of Romania, close to the beautiful city Cluj-Napoca, resides one of Romania's largest producers of office chairs. With aspirations to become a leader in the transition towards circularity within their respective field, Antares Romania turned to the "Better Factory" project for help in reimagining office chair furniture design for circularity. This was not just an ecological endeavor, which if successful would result in waste reduction and extended material use, but also an economic challenge, as switching to a circular production process would require significant changes inside the factory. This challenge was eagerly embraced by the artist/designer Govert Flint, who began by questioning what a chair actually is, and to what extent it can be stripped down while retaining its core ergonomic function and sense of comfort. After a series of experiments, he created Nude, a fully circular, demountable, and re-manufacturable office chair. By eliminating screws, bolts, and glue, the chair became a blueprint for what an aesthetic, ergonomic, functional, and sustainable office chair could potentially look like in the context of a circular economy. Flint immersed himself in the factory for weeks, engaging in discussions, sketching, and prototyping alongside the workers to determine how the chair should be constructed. Solutions emerged through the cross-fertilization of ideas, some of which were unprecedented and truly novel. One example is the way in which the Nude chair holds its material layers together without support materials such as bolts, screws, or glue. To achieve this, the transdisciplinary team took inspiration

Top to bottom:

Figure 3. Gareth Neal Studio, The New Raw, Digitally Woven, 2023

Figure 4. OnSite Studio, MyCoop Myco Factory Concept, 2024

from the human mouth. In the final product, the outer wooden base is designed with "teeth" and elastic ropes hold the components securely together—a simple yet highly effective and elegant answer to a long-standing problem to which a sustainable solution had not previously been identified.

THE NETHERLANDS: OUTDOOR FURNITURE

What connects state-of-the-art, large-scale 3D printing technologies with traditional human crafts like basket weaving, sewing, or knitting? On the surface, this may seem a rather odd question, as these things appear to belong to entirely different worlds. However, this is no longer necessarily the case. Indeed, in the city of Rotterdam, the innovative printing company The New Raw, which exclusively works with recycled plastics, and the artist and designer Gareth Neal have successfully presented an answer to this question.

Additive manufacturing, commonly known as 3D printing, has long promised to revolutionize production but has faced persistent challenges relating to cost, speed, and material limitations. The reasons for this are well understood: 3D printing is overly expensive, quite limited in scale, generally slower than alternatives, somewhat inconsistent, and requires highly skilled workers to operate and troubleshoot. On the other hand, it remains a highly promising technological field for customization, personalized production, complex prototyping of intricate shapes, waste reduction, and low-volume (single-batch) on-demand manufacturing anywhere in the world.

To overcome these barriers, we must explore new ways to design, print, and expand the range of printable materials. This is precisely what Gareth Neal achieved by turning to traditional human crafts. "Digitally Woven" is a revolutionary new printing method that transcends the limitations of layered printing, enabling more fluid and dynamic forms, all by having a printing robot mimic the processes of basket weaving, knitting, or crocheting. The result is not only a technological advancement inspired by traditional human crafts but also a democratization of large-scale 3D printing. By expanding the possibilities for complex geometries and increasing tolerance for error, this innovation makes the technology more accessible and reliable for both businesses and home users. This example illustrates how professionals from the cultural and creative industries (CCI)—such as artists and designers—can find inspiration in seemingly unrelated domains and translate them into tangible, innovative solutions through collaboration, cross-fertilization, and iteration.

ROMANIA: MYCELIUM CONSTRUCTIONS

The Nobel Prize-winning writer, George Bernard Shaw, once said: "If I have an apple and you have an apple and we exchange these apples, then you and I will still each have one apple. But if you have an idea and I have an idea and we exchange these ideas, then each of us will have two ideas". Ideas cross-fertilize when they are conceived, shared, and nurtured across disciplines. We believe this happens most effectively when collaborators with diverse yet complementary areas of expertise face challenges that push them beyond their existing knowledge base. This is also precisely what happened in an experiment that brought together the Romanian Mycelium start-up RONGO[1] , the robotics technology SME SPE Labs from Poland, and the artist Sebastien Wierinck (OnSite Studio). RONGO had developed a new recipe to grow mycelium structures from post-harvest farming waste streams. Recognizing that the best way to utilize these streams was to produce mycelium where the waste was generated, they sought a smart solution to achieve this. SPE Labs were able to customize a robotic system for this very purpose. But what function could the robot serve? And how would the waste be turned into mycelium products without requiring the relevant farmers to change their existing businesses? Enter the artist. Wierinck, who is known for his visionary structures and material treatments, had no prior experience working with living material such as mycelium. However, through transdisciplinary collaboration, his creative approach opened up new possibilities beyond what either SPE Labs' robotics team or RONGO had originally envisioned. The transdisciplinary team developed MYCO Factory, a visionary mycelium robotic cell inspired by the organic growth patterns of fungi, where robots control the cultivation of mycelium-based products. The cell was designed entirely from scratch, integrating novel robotic features—such as a custom gripper—with an artistic approach to mid-process customization, a capability previously considered impractical in robotic manufacturing. The concept, which has been prototyped and accompanied by a forward-looking documentary showcasing its potential integration into farming operations, encouraged the mycelium SME to optimize their recipes for mid-process customization. Moreover, it pushed the artist to translate his knowledge about steel structures and apply it to the creation of a honeycomb robotic cell for mycelium production, while the technology SME developed a robotic process designed to interact with humans mid-way through the process.

By exchanging and evolving their ideas—both within their own disciplines and through this cross-disciplinary future vision for on-site mycelium product production—this collaboration demonstrates how the cross-fertilization of ideas can bring new futures to life.

CONCLUSION

The Better Factory program set out to reflect upon the potential of the arts in advancing industrial innovation. Drawing from real examples of transdisciplinary and cross-border innovation collaborations, where we positioned artists and designers at the heart of ambitious attempts to deliver economical, ecological, digital, as well as societal, innovation. After conducting 16

1. Work by Artists Sebastian Wierinck (OnSite Studio) in the MICOCRAFT project, p. 23.

experiments with the participation of 76 organizations across 20 EU countries, the conclusion is that the arts are uniquely positioned to harness innovative solutions that promote environmental regeneration, entrepreneurial impact, and human-centered approaches. With 19 innovations to show as tangible results coming out of the “Better Factory” program, there is certainly proof for this statement.[2]

However, it is also notable that the positioning of artists and designers is fragile and insufficiently recognized for this critical role. Too often, creative professionals are overlooked, ignored, or not taken seriously when it comes to co-exploring, co-designing, and co-building the technologies, the products, the materials, and the processes needed for Europe’s green and just transition. Even the factories that joined the “Better Factory” program were skeptical at first—most manufacturing SMEs could not imagine artists as productive collaborators in their own innovation journeys. Only after intense, guided, and facilitated art-driven mentoring processes did they change their views and applaud the potential of artists and designers for art-driven innovation. Projects like these thrive on the time, attention, and safety to explore together, allowing seemingly unconventional ideas to evolve into groundbreaking technological advancements.

The evident success of the “Better Factory” program suggests that art-driven innovation is far more than a fleeting experiment; it represents a viable strategy for industrial companies looking to remain competitive in a rapidly evolving manufacturing landscape, and making use of the latest technological possibilities. By embracing the open-ended nature of experiments, taking the risk to work in an interdisciplinary way, and embracing artists’ ability to see beyond conventional boundaries, manufacturing companies can unlock new avenues for growth, sustainability, and technological advancement.

NOTE:
The approach implemented in all 16 transdisciplinary collaborations within the “Better Factory” initiative is documented in the booklet (https://betterfactory.eu/wp-content/uploads/2024/10/Booklet_2024_10_25.pdf) and results are shown in the comprehensive videos on the Better Factory’s YouTube Channel.

2. See https://www.in4art.eu/publication/art-driven-innovation-the-unlikely-muse-of-manufacturing-smes/.

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PART 2

ART IN PRACTICE

DISRUPT

Disrupt brings together projects that challenge dominant technological logics by rethinking how systems are built, governed, and used. The artists question established norms and assumptions and offer alternative systems and interfaces that disrupt industries and markets. These works interrogate power structures embedded in data extraction, automation, and digital infrastructures, proposing solutions that resist surveillance and dependency. From DIY noise-making devices that subvert algorithmic profiling to parasitic interfaces reclaiming user agency, from community-driven infrastructures that operate on ecological principles to experiments in biological or synthetic computation, the projects in this cluster expose the assumptions behind mainstream innovation and offer operational counter-prototypes. While their approaches vary from hijacking smart assistants, and disrupting platform logics to redistributing voice and authorship, reimagining computation through solar or microbial processes, and reframing AI for investigative justice, they share a commitment to redefining how technologies are developed and deployed. Together, they demonstrate how artistic intervention can unsettle entrenched norms and open up pathways toward more equitable and transparent technological futures.

HOLLY +

HOLLY HERNDON, MATT DRYHURST
AND HERNDON DRYHURST STUDIO (US)

STARTS pillar
STARTS Prize
(Grand Prize for Artistic Exploration, 2022)

Creation time
2021–ongoing

Stakeholders involved
artists, DAO, technical experts, the public

Technology applied
AI voice model, Blockchain/Web3

Industry areas addressed
music industry, AI/ML research,
digital rights and IP

Holly+, by Holly Herndon and Matt Dryhurst, received the Grand Prize for Artistic Exploration in the 2022 STARTS Prize. The project is an open experiment in identity, authorship, governance, and machine learning. At its core is Herndon's digital twin—an AI-generated voice model trained on her vocal recordings—which anyone can use to create music, performance, or media. Rather than protecting her likeness through restrictive copyright, the artist chose to allow open access to her AI voice model under a shared governance model, enabling the public to use, transform, and co-create with it under a system of collective stewardship. This gesture marks a significant shift in how we understand intellectual property in the age of synthetic media, proposing a framework built on permission, transparency, and shared benefit.

The research question at the heart of *Holly+* is deceptively simple: What does it mean to own a voice? In an era when deepfakes, synthetic speech, and voice cloning technologies are becoming ubiquitous, this question touches on broader ethical and legal challenges surrounding authorship, consent, and digital sovereignty. Through the development of custom instruments, machine learning models, and a public-facing platform, Herndon and Dryhurst created a new ecosystem in which a digital voice—rather than being commodified or co-opted—can become a shared space for experimentation and innovation.

The project's outcomes span across technology, governance, and artistic creation. The *Holly+* platform[1] allows users to upload audio and receive it back rendered in Herndon's voice. Beyond this, further instruments have enabled real-time live performance, score-based synthesis, and compositional tools, all built through collaborations with AI developers like Never Before Heard Sounds and Voctro Labs. To oversee the ethical use of the voice, a Decentralized Autonomous Organization (DAO) was established, allowing token-holding members to vote on which artworks can be officially licensed and monetized. The DAO also receives a portion of profits from approved works, which are sold as NFTs via platforms like Zora, creating a regenerative creative economy. Over 70 artworks have already been released under this model.

Photos: Andrés Mañón

1. https://holly.plus

Following the award of the STARTS Prize, the project has continued to grow in ambition and scope. Herndon has coined the term "Identity Play" to describe this permissive use of AI likenesses, challenging dominant narratives around deepfakes and copyright infringement. The project also introduces the concept of "Spawning", a proposed corollary to sampling, where artists can build upon the likeness of others with attribution and profit-sharing. These new practices are not merely speculative but legally and technically implemented within the *Holly+* system, setting precedent for broader applications of AI art ethics and voice rights.

Holly+ is deeply aligned with the values of the STARTS initiative, demonstrating how artistic experimentation can directly influence how new technologies are used, perceived, and governed. It is a rare example of a project that is both highly conceptual and materially grounded, offering a working prototype for shared authorship in the age of AI. The development of the DAO, the public tools, and the revenue-sharing infrastructure show that *Holly+* is not just a critique of the existing system—it is a functioning alternative.

Within the Disrupt cluster, the project exemplifies how artists can challenge the assumptions behind current technological development and propose radically different use cases. Rather than reject machine learning, Herndon and Dryhurst redirect it toward a new ethics of co-creation. The system they have built questions power structures in IP law, subverts extractive models in AI development, and proposes a framework for respectful, distributed engagement with digital identity. *Holly+* is a prototype for a future in which creative technology is not controlled by a few platforms or corporations, but governed collectively by artists and their communities.

Holly Herndon, Matt Dryhurst, Herndon Dryhurst Studio
The first *Holly+* performance was presented in collaboration with Sonar AI and Music Festival, supported by STARTS. This was the first performance of live machine learning "identity play" in history.


plus

P2P

EVA AND FRANCO MATTES (IT, US)

STARTS pillar
STARTS Prize (Honorary Mention, 2024)

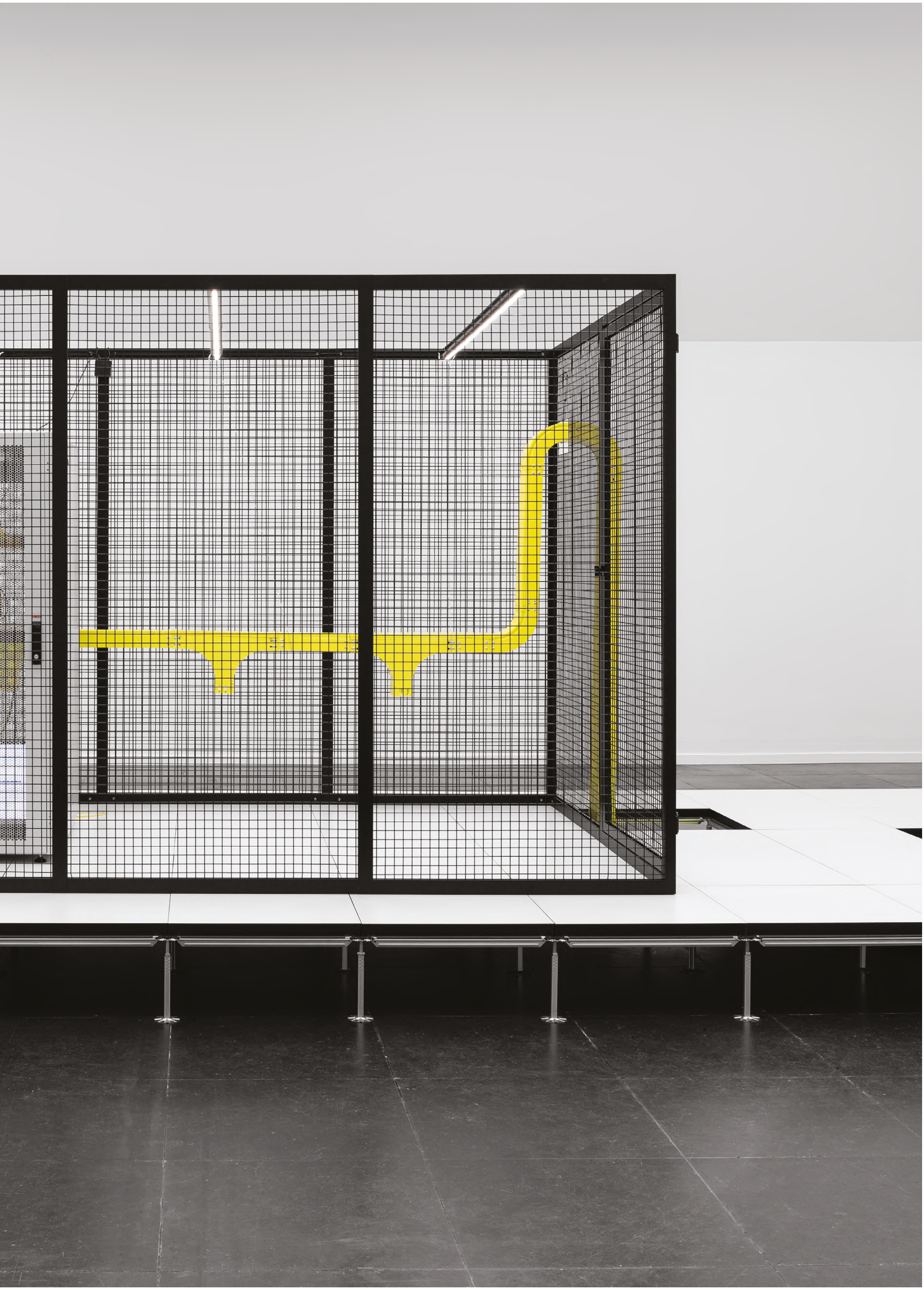
P2P, by Eva and Franco Mattes, transforms the hidden infrastructure of the internet into a public artwork. Installed as a functioning server encased within a cage, the project connects directly to peer-to-peer networks from inside art institutions, where it seeds and shares digital artworks by a wide range of contemporary artists. Visitors are not only spectators but potential participants, able to download and circulate works through the network themselves.

By relocating a server—normally the invisible core of commercial data centers—to the museum, *P2P* exposes and reclaims the architecture of digital exchange. The project disrupts the dominance of centralized cloud platforms by demonstrating a decentralized alternative, one that resists surveillance, extraction, and corporate control. In doing so, it also reframes the role of cultural institutions: rather than merely exhibiting digital works, they become active nodes in their preservation and distribution.

Minimal in form yet radical in implication, *P2P* challenges audiences to reconsider how culture circulates online, who owns the infrastructures of sharing, and what the future of digital commons might look like when artists and institutions take control of the network itself.

With support from: Frankfurter Kunstverein; KW Institute for Contemporary Art, Berlin

Photo: Melania Dalle Grave for DSL Studio



Impossible Larynx

MARIA ARNAL DIMAS (ES)

STARTS pillar
STARTS Residency (AIR, 2023-24)

Creation time
2023–24

Stakeholders involved
research institution, artists

Technology applied
high-performance computing (HPC), digital twins, machine learning, AI-driven voice synthesis, simulation, real-time visualization

Industry areas addressed
medicine (speech therapy, voice recovery, gender-affirming care), music and sound production, AI research

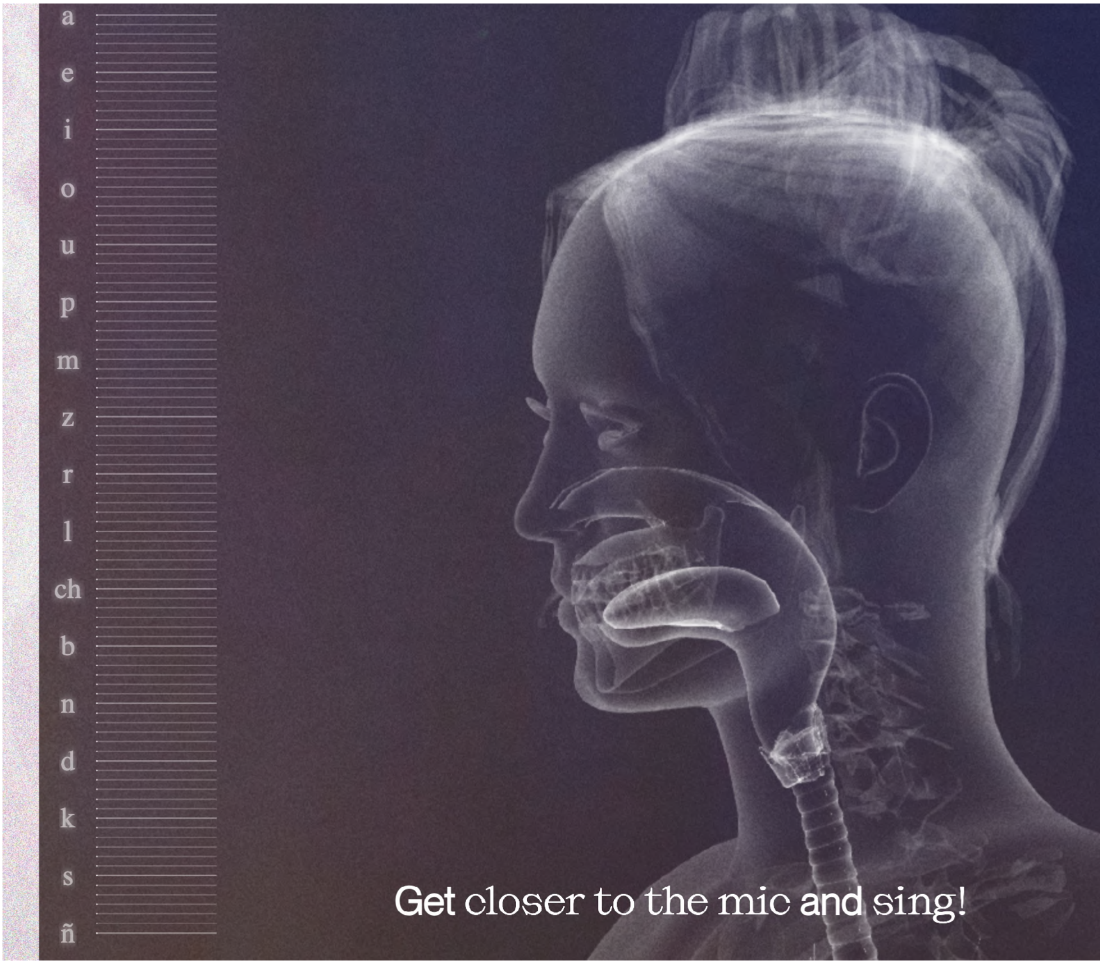
High Performance Computing (HPC) and Digital Twins are able to help humanity with many things: we can simulate a huge variety of processes on a multitude of scales—from molecular interactions to organ functions and even urban ecosystems—and we can make conclusions and take action based on the results. Modeling these processes and their intricate components is incredibly complex and scientists can sometimes reach the limits of their toolkits. Within STARTS AIR two supercomputing centers embarked on a journey to find out how artistic perspectives can contribute to the understanding, modeling, and communication of such complex systems.

Impossible Larynx is the residency project of Catalan singer Maria Arnal and (primarily) the Barcelona Supercomputing Center (BSC). After a previous collaboration for the public installation *Maria CHOIR*, which was awarded a STARTS Prize Honorary Mention in 2024, for turning the training of an AI model into a shared experience by collecting 11,000 voices to create one of the largest choirs in history, the team was excited to take things to the next level and investigate the physical and technological limits of the human voice. What possibilities open up when a physically-based vocal tract model is combined with Artificial Intelligence to manipulate voice in real time? Can we use this technique to synthesize any possible voice? How about an impossible one? What does it mean for a voice to exist without a physical body?

Feeding off Maria's unique artistic approach and the scientific rigor of the team at BSC, a prototype of an AI-driven articulatory vocal synth capable of real-time interaction and voice transformation was developed. For this, multiple AI voice processing models were created using diverse, curated datasets of people singing Flamenco and other traditional a cappella songs. Combining these models with a Digital Twin of the human larynx and a custom evaluation protocol based on traditional singing techniques made it possible to create new sonic and musical expressions beyond the biological limitations of humans. An accompanying 3D visualization tool shows the simulated vocal tract in real time, making the voice transformation visually perceptible.

The project successfully demonstrates how the STARTS values of human-centered innovation through interdisciplinary collaboration can make AI technologies more transparent, participatory, and artistically expressive—inventing a tool relevant not only to the arts sector but also academia and industry. The latter is especially interesting, as the potential applications for speech therapy, voice recovery and gender-affirming care look very promising indeed. In this context the project also poses creative as well as ethical questions around AI development in the realm of health, wellbeing, and inclusive technologies—especially in relation to identity, consent and disembodied voices.

The potential for the music industry is enormous as well—the methodologies and software developed during the residency offer new paradigms for AI audio tool developers and music producers alike. Maria herself has already started incorporating the tools' outputs into her records and live performances—providing not only engaging and artistically excellent but also educational experiences around AI, voice, and embodiment to the general public.



María Arnal describes the Impossible Larynx app, developed during the STARTS AIR residency with BSC. Photo: Paula Fernandez Vergara.

Project Alias

BJØRN KARMANN (DK) AND TORE KNUDSEN (DK)

STARTS pillar
STARTS Prize
(Grand Prize for Artistic Exploration, 2019)

Creation time
2018–19

Stakeholders involved
artists, designers, open-source communities, DIY technologists

Technology applied
Raspberry Pi, embedded neural networks, local voice recognition, open hardware

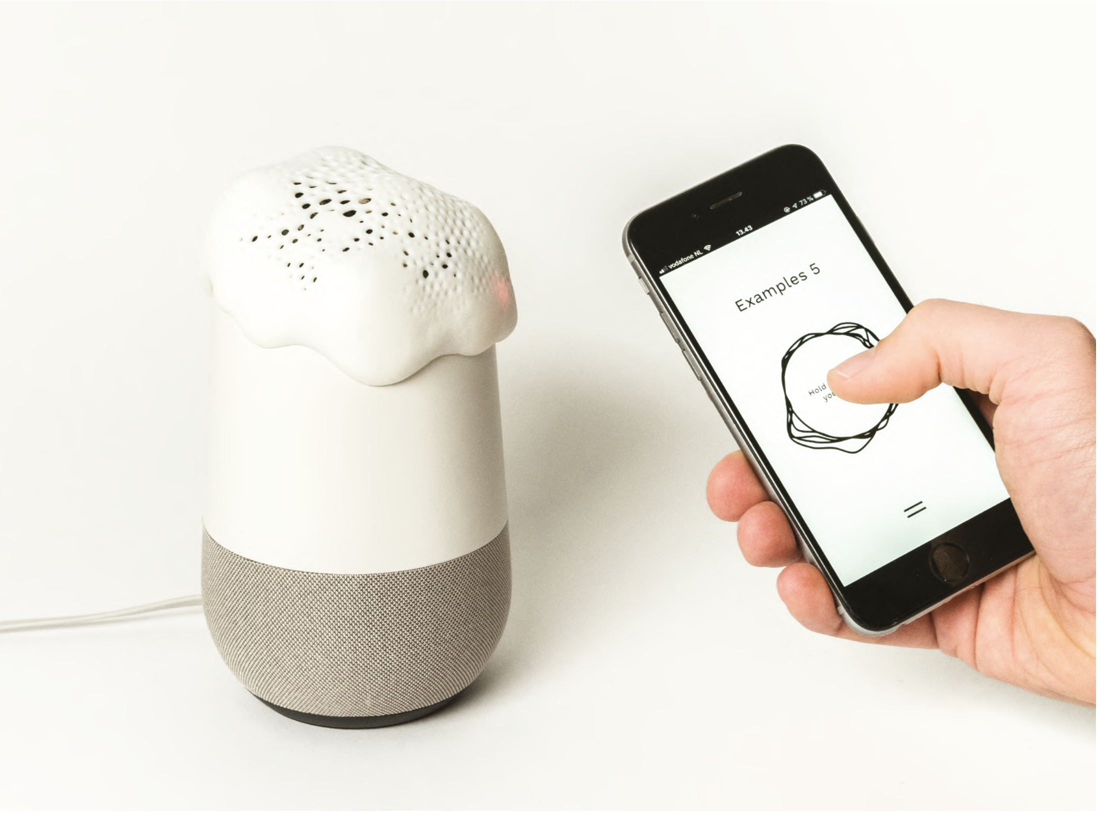
Industry areas addressed
smart home technologies, data privacy, human-machine interaction

Project Alias is a speculative design and open-source art project that reclaims user agency in the age of smart home technologies. Conceived as a "parasite" for voice assistants like Amazon Alexa and Google Home, the device sits physically on top of the speaker, both visually and functionally hijacking it. Built from a Raspberry Pi and a small neural network running entirely offline, Alias listens not to the assistant's default wake word but to a custom user-defined cue. When inactive, it continuously emits a low layer of noise that blocks the assistant's microphone, ensuring it cannot listen or transmit sound. Once triggered by the personalized wake word, Alias silences the interference and activates the assistant with a recorded sound of its original command, allowing it to operate as usual—only now under the user's control.

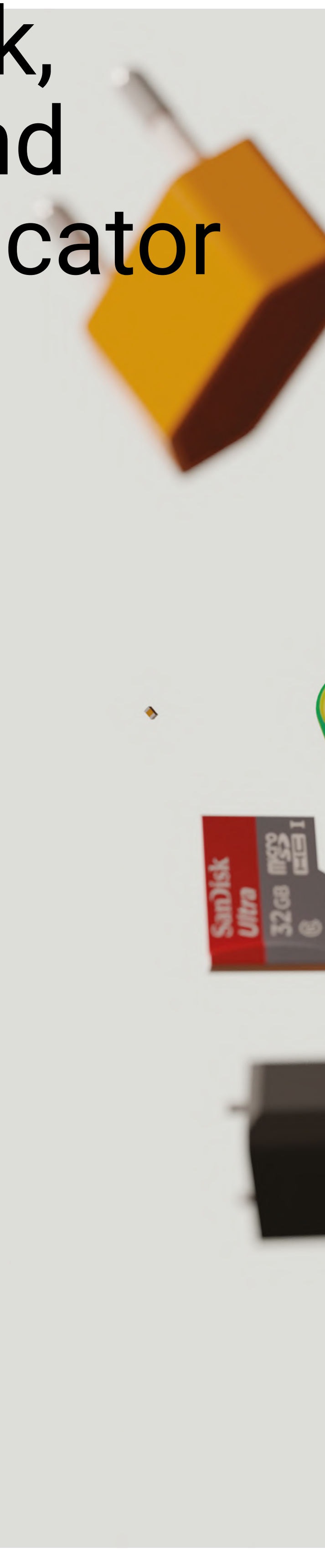
Acting as an intermediary, Alias transforms the smart assistant into a more transparent and customizable technology. Through its companion interface, users can train, reset, or disable the device without any cloud connection, keeping all operations local. This design approach counters the dominant, data-driven paradigm of "always listening" consumer devices that prioritize convenience over privacy.

The project draws inspiration from biological metaphors such as the Cordyceps fungus, which takes over and redirects the behavior of its host. In this spirit, Alias poetically reimagines the relationship between humans and machines, showing how parasitic appropriation can become an act of empowerment. By making commercial devices hackable and adaptive, the project redefines what "smart" technology means—something that is not imposed from above but shaped collaboratively through artistic and user-driven intervention.

More than a privacy device, *Project Alias* functions as a critical and poetic commentary on surveillance culture and technological dependency. It exposes the hidden mechanisms of smart assistants and turns their logic inside out—transforming a tool of passive listening into one of active resistance. As an open-source project, it demonstrates how artistic experimentation and maker culture can offer tangible alternatives to the centralized, opaque systems that shape everyday life, returning a sense of agency and authorship to the user.


Examples 5

FANGØ a Facebook, Amazon, Netflix and Google Obfuscator



MARTIN NADAL (ES)

STARTS pillar
STARTS Prize (Nomination, 2023)

FANGØ is an artistic intervention against surveillance capitalism disguised as an everyday object. Presented as a standard phone charger, the device secretly contains a microcontroller that takes control of any smartphone it is plugged into—automatically performing random searches, liking posts, and watching videos on major platforms such as Google, Amazon, and YouTube. By generating meaningless digital activity, *FANGØ* floods data collection systems with noise, confusing data brokers and reducing the value of extracted information. Thus, the project exposes how today's most powerful tech companies profit from user surveillance by turning personal experiences into marketable data. Like industrial capitalism commodified labor and nature, surveillance capitalism commodifies human behavior itself.

Through artistic and technical ingenuity, *FANGØ* proposes a playful yet critical defense mechanism that reclaims individual agency in an age of algorithmic control. Distributed as an open-source DIY project, it invites anyone to build their own device, transforming a symbol of dependence—the smartphone charger—into a tool of digital resistance.

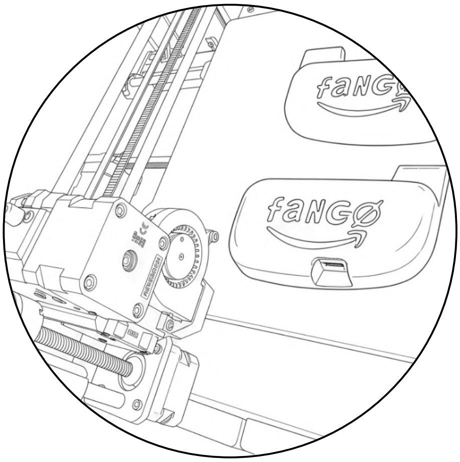
Thanks to: EMAP/Onassis Stegi 2020/2021, Deutscher Künstlerbund NEUSTART Modul D 2022, mur.at 2023


GPIO
ELPIDA
HDMI
PWR
USB
RUN

Assembly and Use Guide

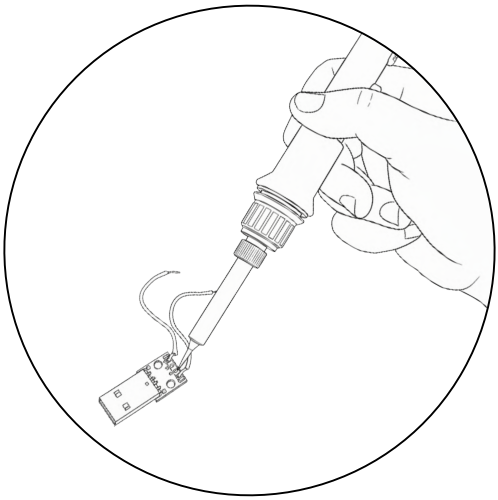
A Facebook, Amazon, Netflix & Google Obfuscator.

2025 Martin Nadal



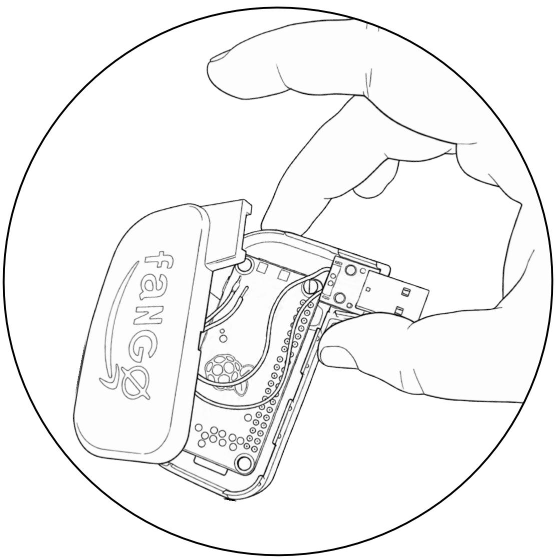
Step 1: Print the Case

Download the 3D file from the official project repository and print it on any 3D printer. Use a high-quality filament to ensure durability and a perfect fit for the other components.



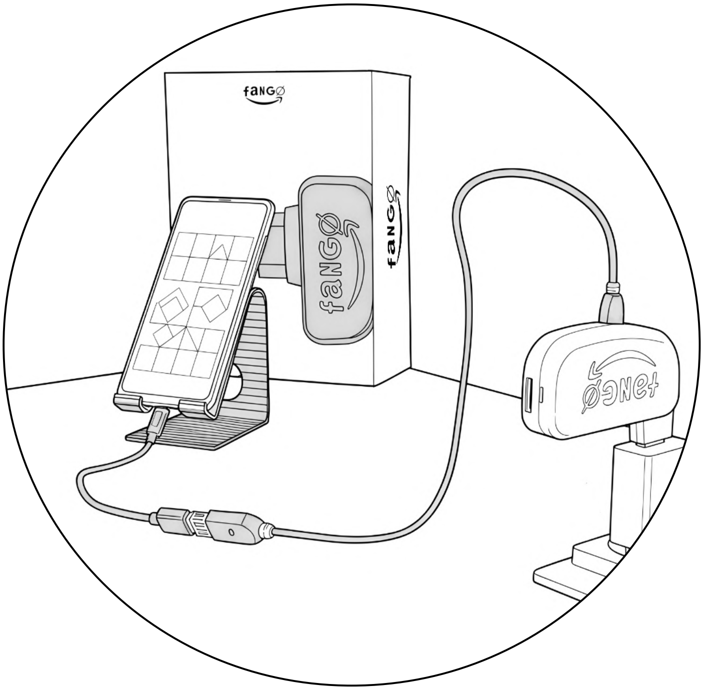
Step 2: The USB connector

Carefully solder the USB Type A connector to the corresponding ports on the Raspberry Pi Zero. This connection is crucial, as it will allow FANGØ to communicate with your phone. Check the polarity and avoid solder bridges.



Step 3: Secure the board

Secure the Raspberry Pi Zero board inside the printed case using standard screws. Make sure the board is securely fastened.



Step 4: Connect and Activate

Connect your FANGØ to your phone via USB to automatically begin its obfuscation mission. Disguised as a common charger, it will take control of your smartphone to generate random queries on platforms like Google, Amazon, and Meta. This activity deceives data brokers by polluting their data streams, making your information difficult to transform into accurate predictions. **The result is the devaluation of your extracted data, all while your battery charges.**

The Value of FANGØ

Beyond its technical functionality, FANGØ represents an act of digital sovereignty. This project encourages a more conscious and critical relationship with technology, where users can reclaim control over their personal information. By promoting tools that prioritize the individual, FANGØ contributes to a more ethical technological ecosystem centered on the fundamental right to privacy, empowering individuals against opaque practices.

Support received from

EMAP/Onassis Stegi 2020/2021
Deutscher Künstlerbund NEUSTART Modul D 2022

ONASSIS
STEGI

EMAP

Important Legal Notice

FANGØ is an art and technological protest device. Its main purpose is to encourage reflection and debate on privacy in the digital age. It is not a commercial product. By proceeding with the construction of FANGØ, you agree and understand that you do so at your own risk.

Contact

martin@muimota.net
http://martinnadal.eu

fanGØ

Archean Memory Farm

WHERE DOGS RUN (SI/RU)

STARTS pillar
STARTS Regional Centers
(STARTS in the City, 2023–24)

Archean Memory Farm is an installation that turns bacteria into a medium for storing and displaying information. At its core is a bioreactor where magnetotactic bacteria grow—microorganisms that naturally contain tiny magnetic crystals. A portion of these bacteria is moved into a transparent display chamber, where controlled magnetic fields guide their movement. By changing these magnetic fields, the system can "write" and "read" simple information in the shifting patterns of the bacteria. As the bacteria complete their life cycle, their remains settle into thin layers of biomagnetite, creating physical traces that preserve this information over time. Through a robotized setup, visitors can watch how this living, slow-moving system records and processes data, revealing a form of computation rooted in biology rather than electronics.

By transforming microorganisms into a functional memory technology, *Archean Memory Farm* proposes radically different use cases for computation. Instead of treating bacteria as subjects of laboratory research, the project repositions them as active agents in data processing, challenging assumptions about efficiency, scale, and the boundaries between biological and digital systems. This exploration of biocomputing disrupts conventional models of storage and hardware by experimenting with energy-efficient, non-extractive, and materially grounded alternatives. Through this speculative but operational prototype, the artists open pathways toward rethinking how technologies might be developed, deployed, or repurposed, offering a provocative model for more equitable and ecologically attuned computational futures.

Scientific consultants: Veronika Kozyaeva, Tatyana Kurgina, Kristijan Tkalec
Programming: Sergey Mashkov, Gleb Andreev, Dmitry Shishov
Produced by: Kersnikova Institute within the framework of STARTS In the City – STARTS (Science, Technology, and the Arts) in collaboration with BioTehna Laboratory
Co-funded by: European Commission, Ministry of Culture of the Republic of Slovenia, City of Ljubljana – Department of Culture, CYLAND Foundation

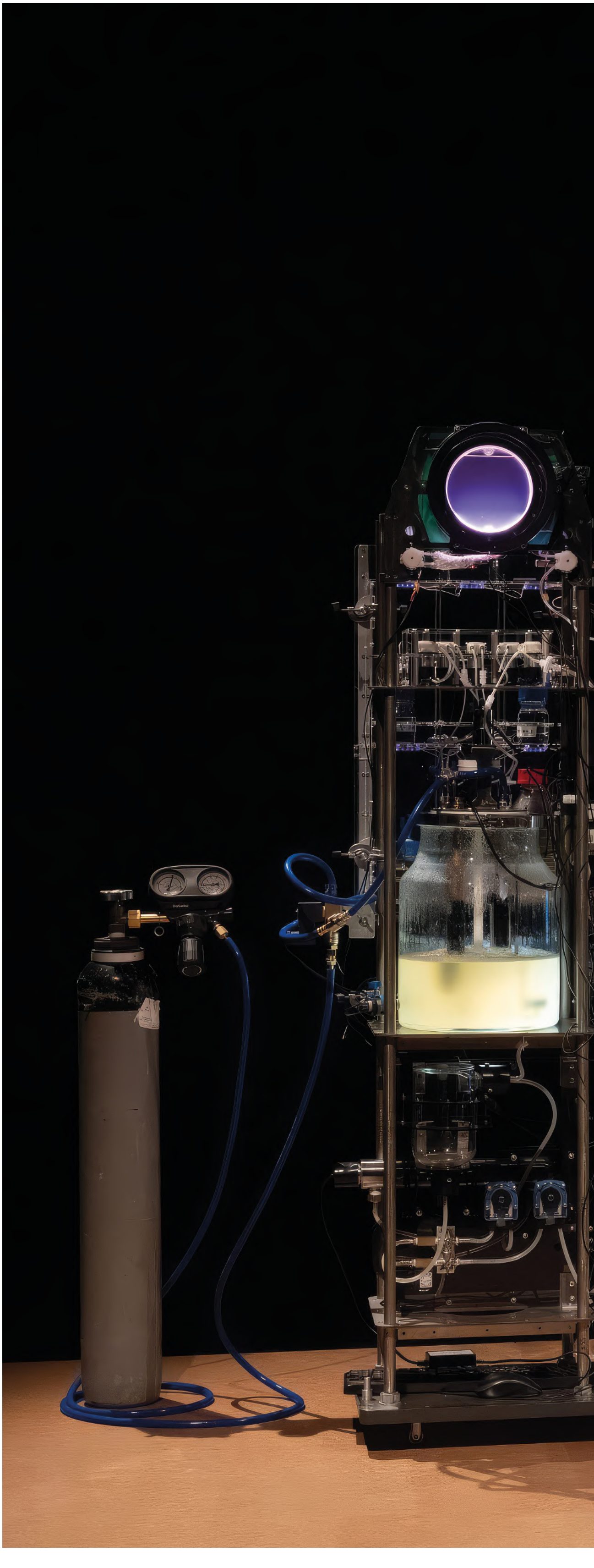


Photo: Nada Žgank

Solar Protocol

SOLAR PROTOCOL COLLECTIVE LED BY
TEGA BRAIN, ALEX NATHANSON,
AND BENEDETTA PIANTELLA (M)

STARTS pillar
STARTS Prize
(Nomination, 2024)

Creation time
2021–ongoing

Stakeholders involved
artists, technologists, volunteer communities

Technology applied
solar energy systems, custom hardware, web architecture, Raspberry Pi computing, environmental automation

Industry areas addressed
renewable energy, digital infrastructure, sustainability, open-source software

Solar Protocol is a planetary-scale network of solar-powered servers that reimagines how digital infrastructures can operate within ecological limits. Created by the artists and technologists Tega Brain, Alex Nathanson, and Benedetta Piantella, the project poses a fundamental question: *What if the internet were powered and governed by the rhythms of the sun rather than the logics of efficiency, scale, and artificial intelligence?* By reorganizing computation around environmental variability, Solar Protocol challenges the dominant paradigms of automation and offers a working prototype for sustainable, energy-aware web hosting.

The project operates through a distributed network of custom-built solar servers installed and maintained by volunteer "server stewards" in geographically diverse sites such as New York, Alice Springs, Nairobi, and Trent. The network collectively hosts the Solar Protocol web platform, which is served to users from whichever server is receiving the most sunlight at a given moment. In this configuration, routing and computational decisions are automated through what the artists term *natural intelligence*—an algorithmic system based on environmental conditions like season, time of day, and weather patterns, rather than on machine learning.

On the technical level, Solar Protocol has developed a fully functional low-carbon infrastructure. The system uses PHP networking, Apache servers, and Python-based visualizations rendered server-side to minimize client-side computation and ensure that processing cycles are powered by renewable energy. The deliberate exclusion of JavaScript and other browser-side processes reduces energy consumption for users, embodying an "energy-centered design" ethos that prioritizes accountability and transparency in computational practices. The entire infrastructure is open source, and anyone can participate by setting up their own solar server and joining the network. Detailed technical documentation and setup guides are publicly available on the Solar Protocol website[1], supporting the project's growing community of contributors worldwide.

Solar Protocol presented in the Renaissance 3.0 exhibition at ZKM Karlsruhe.
Photo: Tobias Wootton

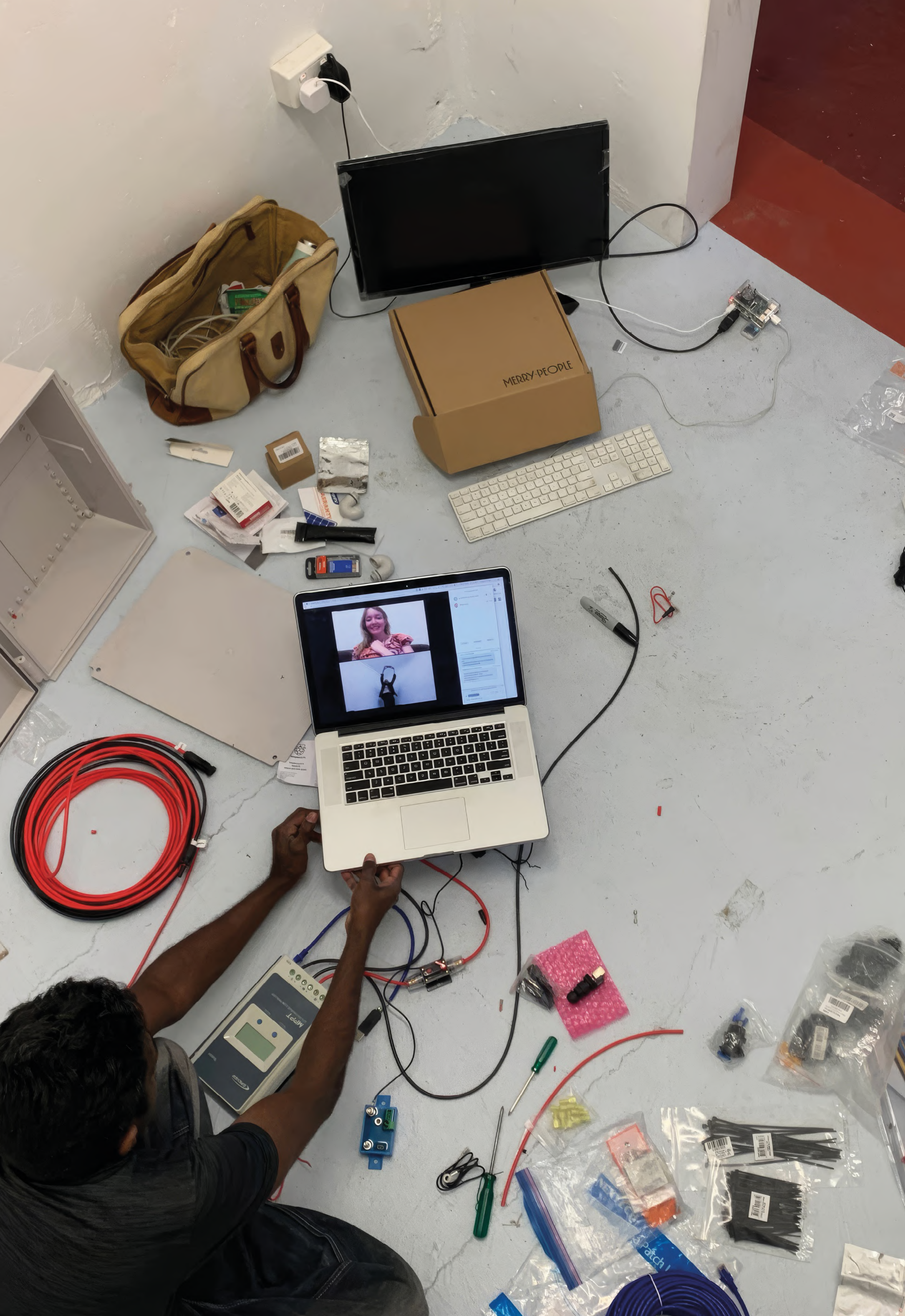
1. See https://solarprotocol.net/guides.html.

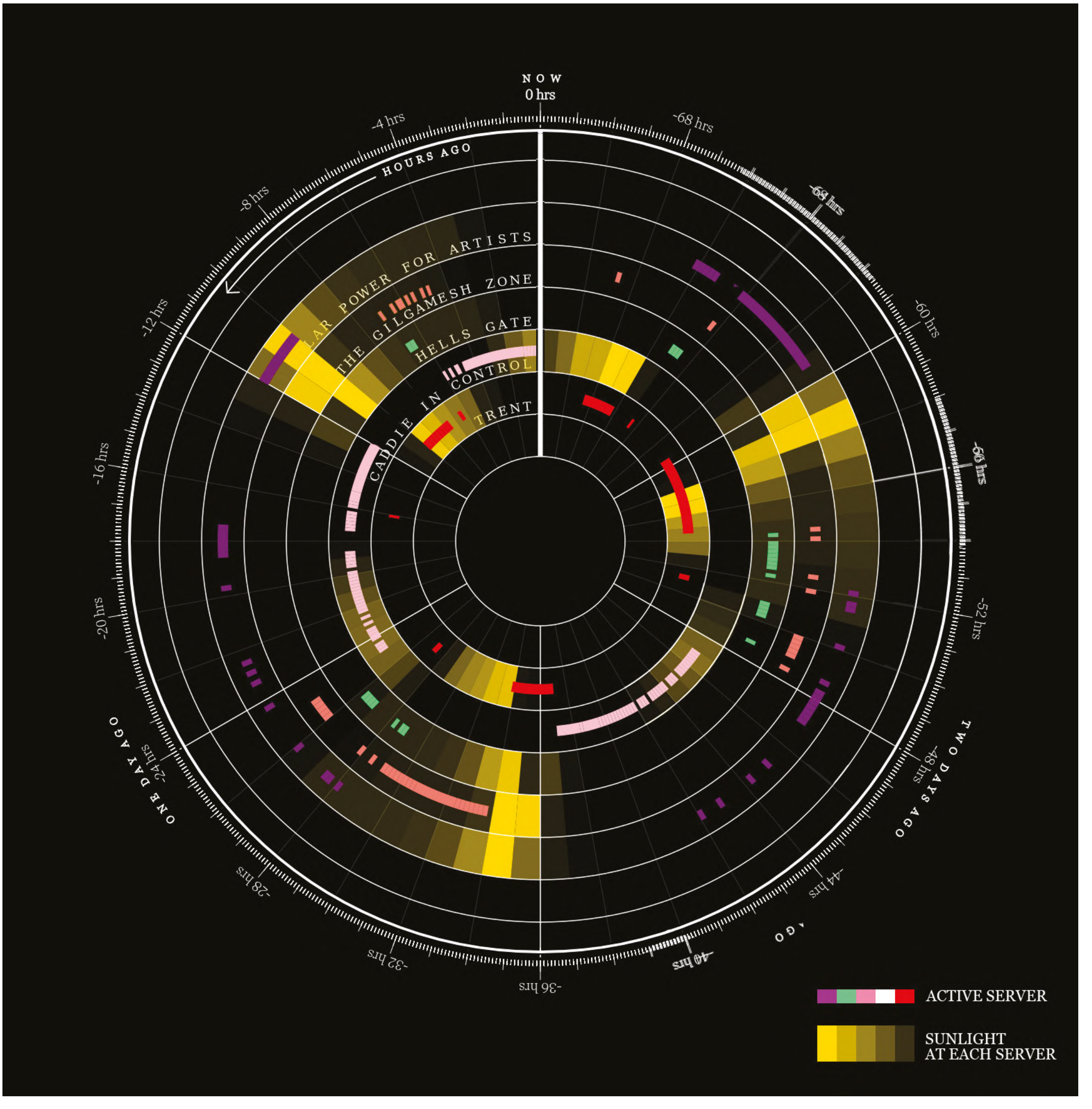
Beyond its technical achievements, Solar Protocol also operates as a cultural and curatorial platform. It hosts exhibitions such as *Sun Thinking*, alongside educational resources that promote awareness of solar computing and sustainable web design. The platform supports a community of contributors experimenting with ways to align digital culture with ecological processes.

Through this synthesis of art, engineering, and environmental design, Solar Protocol demonstrates how infrastructural systems can embody ecological intelligence rather than extract from it. The project critiques the assumption that digital networks must be seamless, fast, and continuously available, proposing instead a model of the internet that embraces intermittency, locality, and planetary energy cycles. In doing so, it repositions computational logic within the material realities of the biosphere—transforming the act of networking into a collective, solar-powered collaboration with the planet itself.

The Solar Protocol Collective is led by Tega Brain, Alex Nathanson, and Benedetta Piantella and includes. Project contributors and stewards: Anne Pasek , Caddie Brain, Brendan Phelan, John Samoza, Camilo Rodriguez Beltran, Daniel Ñuñez, Alejandro Rebolledo, Graham Wilfred Jnr, Tim Chatwin, Bridgit Chappell, Baoyang Chen, Denzel J. Wamburu, Cyrus K, Chris Stone, Jesse Li, Zoë Horsten, Jarl Schulp, Crystal Chen and Jonathan Dahan.

With support from: Eyebeam Rapid Response for a Better Digital Future program, Code for Science & Society's Digital Infrastructure Incubator, and a Mozilla Creative Media Award.


MERRY·PEOPLE
MPPT



Left to right:

Steward Graham Wilfred Jnr building a server in Alice Springs, Australia.
Photo: Caddie Brain

Visualization of 3 days of network activity and solar data.
Image: Tega Brain.

Solar Protocol Manifesto

TEGA BRAIN (AU), ALEX NATHANSON (US) AND BENEDETTA PIANTELLA (US)

The Solar Protocol network reconfigures internet protocols by using a kind of natural rather than artificial intelligence. The network routes internet traffic according to the logic of the sun, where page requests are sent to whichever server is enjoying the most sunlight at that particular time. We are working with people around the world who have built and installed servers that host this site alongside their own web content. When their server becomes the active node of the network, their online materials (if any) then become visible on the site.

If intelligence is the capacity to synthesize knowledge as logic and apply that logic to make decisions, then the Solar Protocol platform relies on an intelligence that emerges from earthly dynamics: specifically, that of the sun's interaction with the Earth. Our lives have always been directed by a range of natural logics that emerge from the intermittent dynamics of our shared environment. Weather, seasons, tides, and atmospheric conditions all dictate our behavior, enabling and constraining our movements, food production, and cultures. Solar Protocol uses these logics to automate decisions about how the network operates and what content is shown at different times of the day. How, then, can we learn or relearn in order to design with natural intelligence?

The present-day image of the internet is one that has been enabled by an energy regime reliant upon damaging fossil fuels. And the result? An online culture that valorizes speed, self-expression through ever larger media, and data-driven intelligence that requires more and more energy. Machine learning, for example, requires enormous datasets typically collected through private efforts in online digital surveillance that collect every click, keypress, view, and page scroll a user might make. This data is then utilized to train models that are used to automate decisions about what content to display to the user. These energy hungry technologies are only made possible by extractive energy systems and labor practices.

In response, and by working within natural limitations, we have deliberately chosen not to use large assets nor energy-intensive tracking technologies on this website.[1] A solar-powered web could reduce the opportunity for these kinds of surveillance and data-driven practices and the business models that go with them, something that is likely to have desirable political effects. For, as Timothy Mitchel points out in Carbon Democracy, different energy regimes create different political possibilities.[2]

1. This approach was also used by the Solar Powered website, which was published by Low Tech Magazine (2019). We have taken much inspiration from this groundbreaking project.

2. See Timothy Mitchell's book, *Carbon Democracy: Political Power in the Age of Oil* (2011), which discusses the political consequences of different energy systems.

Towards a Natural Intelligence

ENERGY-CENTERED DESIGN

Solar-powered technologies catalyze a need for energy-centered design where the energetic dimension of cultural production is centered. On a solar-powered server, it is advantageous to minimize the amount of data being transmitted and, therefore, it is desirable to reduce the size of the media published. The intermittency of solar energy production also produces environmentally programmed downtime, where a server might sleep at night, or for the long evenings in the winter, demanding that the user stops working and focuses their attention elsewhere.

Energy-centered design is also about accountability. In building this website, we have attempted to do the computation work required to generate the visualizations on the server-side, rather than by using JavaScript in the client's browser. In other words, our servers do all the heavy lifting as opposed to the user's computer. In this way, we are assured that these computational cycles are powered by solar energy rather than fossil fuels. This inverts a capitalist logic that incentivizes the export of costs to someone else and somewhere else, a drive that has produced a multitude of ecological crises.[3] Instead, we call for new forms of cultural production that embody a politics of accountability.

3. Joana Moll's *Hidden Life of an Amazon User* project demonstrates this through the case study of buying Jeff Bezos's book from the Amazon website. Moll audits the eyewatering amount of computational work and energy expenditure that is outsourced to a user's computer by the Amazon website (presumably in order to track their behaviors and to show them "relevant" ads).

VFRAME: Computer Vision for OSINT/OSI Research

ADAM HARVEY (US), JOSH EVANS (US)
AND JULES LAPLACE (US)

STARTS pillar
STARTS Prize
(Nomination, 2018; Honorary Mention, 2023)

Creation time
2017–ongoing

Stakeholders involved
NGO, activists, academia, industry

Technology applied
photogrammetry, 3D printing,
(procedural) image generation, AI&ML,
custom AI tool

Industry areas addressed
human rights, AI training (synthetic data),
open source software

VFRAME / Adam Harvey, Josh Evans, Jules LaPlace

VFRAME is a computer vision project that develops open source image processing software and neural network models for human rights related research and conflict zone monitoring. Started in 2017 with the goal of bridging the gap between industry, namely commercially aligned AI, and the needs of investigative research, *VFRAME* is now a pioneer in the development and application of new techniques that combine 3D photogrammetry, 3D rendering, and 3D printing to generate synthetic data for training neural networks.

Instead of following industry trends to scrape data from online sources, which can inherit problematic biases, *VFRAME* uses an artist-first approach that combines digital fabrication, sculpture, photography, and 3D artistry to create a virtually unlimited source of training data.

The process begins with photogrammetry, using a DSLR camera and automated turntable to capture high-resolution images of an inert, undamaged submunition. These images are then used to construct a highly accurate 3D model of the object, forming the foundation for subsequent synthetic data generation. With its help, VFRAME generated a large synthetic dataset by rendering over 10,000 images with variations in lighting, backgrounds, damage, dirt, and camera angles. This allowed for greater control over image diversity and annotation accuracy, helping to reduce data bias and improve training results. To further increase realism and reduce the risk of overfitting in relation to synthetic images, the team created 3D-printed replicas of the munition. These life-size models were photographed in real outdoor environments, producing images that closely resemble field conditions. By combining digital rendering with physical staging, this hybrid helped to bridge the gap between simulated and real-world visuals. *VFRAME* also built a benchmark dataset made up of test images showing the munition in different terrains, seasons, and lighting conditions. These were used to evaluate the detector's performance and adjust detection thresholds based on the context of use, for example, scanning large-scale videos or conducting on-site surveys.

The result is powerful computer vision models that can automate the detection of illegal cluster munitions in million-scale video datasets from conflict zones.

Since the beginning, *VFRAME* has partnered with Mnemonic.org, an organization dedicated to helping human rights defenders effectively use digital documentation of human rights violations for justice and accountability, to apply this technology to their large archives and bring understanding to the massive corpus of video they have collected.

The first successful pilot project during 2022 resulted in the detection of over 1,000 videos containing the RBK-250 cluster munition bomb in the Syrian Archive, with over 3 million videos and approximately 10 billion image frames, a task that would otherwise be impossible. In 2024, *VFRAME* partnered with Tech4Tracing.org, an NGO based in Europe and the United States that works on arms control and deployment of artificial intelligence for humanitarian applications, for future developments of this project by gaining direct access to real munitions for 3D scanning. This important new step allowed the *VFRAME* project to finally scale up development efforts to build more computer vision detection models for application in conflict zone monitoring, which are all available open source.

Thus, *VFRAME* employs an innovative, art-driven, and data-centric methodology to develop high-performance object detectors for rare and hazardous submunition items. Recognizing the limitations of existing online imagery, *VFRAME* bypasses conventional data sources by starting with ground-truth material.

Director, founder, computer vision: Adam Harvey
3D design and emerging 3D technologies: Josh Evans
Information architecture and front-end development: Jules LaPlace
With support from: Prototype Fund (Bundesministerium für Bildung und Forschung); NLNet Foundation and Next Generation Internet (NGI0); NESTA; SIDA; Tech 4 Tracing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RE-IMAGINE

Re-imagine gathers projects that expand the use of existing technologies by placing them in unfamiliar contexts, by uncovering capacities overlooked in conventional applications, or by envisioning creative adaptations. Through this lens, technologies are rethought across diverse fields: AI is redirected from extractive logics toward social good and emotional care; design and computation incorporate nonhuman needs and ecological reciprocity; agricultural practices are reworked to support regeneration while creating new cultural moments for communities; everyday communication tools become reusable and low-waste; industrial processes are refined to reduce environmental impact; robotics in industry evolves toward tactile, collaborative interaction; and VR moves beyond entertainment to foster empathy and support mental-health education. These reorientations demonstrate how relatively small shifts in purpose and outsider's input, in those cases an artistic intervention, can generate meaningful innovation across agriculture, mental health, environmental stewardship, cultural practices, and industry. By reconsidering what familiar tools are designed to prioritize, the projects show how reimagining what technologies or processes are designed for—rather than reinventing them—can open up space for more attentive, reciprocal, and socially grounded modes of use across different fields.

Pollinator Pathmaker

ALEXANDRA DAISY GINSBERG (UK)

STARTS pillar
STARTS Prize
(Grand Prize for Artistic Exploration, 2023)

Creation time
2021–ongoing

Stakeholders involved
pollinator experts, AI researchers,
horticulturists, ecological scientists

Technology applied
custom algorithmic design tool, AI,
ecological data modelling

Industry areas addressed
environmental conservation, biodiversity
and ecology, artificial intelligence
and ethical technology

Top to bottom:

Pollinator Pathmaker DIY Edition Roche School. ©Roche

Pollinator Pathmaker Serpentine Edition, 2022. Courtesy the artist

The Pollinator Pathmaker online tool. © Alexandra Daisy Ginsberg

Pollinator Pathmaker in Human Vision, 2023. © Alexandra Daisy Ginsberg

Pollinator Pathmaker is a unique interspecies artwork by Alexandra Daisy Ginsberg. The project responds to the growing ecological crisis and the alarming collapse of biodiversity by asking a simple but radical question: What would a garden look like if it were created not for human pleasure, but for pollinators? To explore this, Ginsberg developed a custom algorithmic tool in collaboration with pollinator experts, AI researchers, and horticulturists. This tool enables the creation of planting designs based not on human aesthetics, but on the foraging needs and seasonal behaviors of bees, butterflies, moths, beetles, and other pollinating species. The result is a living artwork—complex, empathetic, and climate-positive—planted and maintained by humans, but designed for other species.

At the center of *Pollinator Pathmaker* is a powerful conceptual and technological proposition: to encode empathy into an algorithm. In this case, empathy is defined as designing in a way that maximizes pollinator diversity. The planting designs are generated using curated regional “Plant Palettes”, built from a combination of scientific literature, expert consultation, and local ecological data. The algorithm then computes unique arrangements that suit a wide range of pollinator preferences, creating unconventional, non-anthropocentric gardens that offer ecological sanctuary.

So far, three large, commissioned editions of the project have been planted: at the Eden Project in Cornwall, in Kensington Gardens, London (commissioned by the Serpentine), and in Berlin at the Museum für Naturkunde (commissioned by LAS Art Foundation). These physical installations serve as public sculptures—living, growing artworks that are simultaneously habitat, data visualization, and activist intervention. They are complemented by DIY Editions made available through the project’s online platform,[1] where individuals, schools, and communities can create and plant their own algorithmically generated garden. Whether planted in a museum or a backyard, each edition is a unique expression of the same idea: art made for another species.

The project’s outcomes are both tangible and transformative. It has generated permanent gardens that act as decentralized beacons for public engagement, developed tools for environmental action that are free

1. See https://pollinator.art.

and widely accessible, and launched an expanding platform for collaborative ecological stewardship. The development of new regional Plant Palettes with each international commission furthers this decentralized model, creating a global network of biodiversity-supporting sites, bound together by a shared algorithm and artistic vision.

Pollinator Pathmaker challenges conventional uses of algorithmic and horticultural technologies by proposing a radically different application: designing not for humans, but for other species. At its core, the project rethinks both the purpose and agency of technology—what it is for, who it serves, and how it can be redirected toward non-human needs. Ginsberg's algorithm does not optimize for aesthetics or human satisfaction, but instead encodes empathy for pollinators, creating a new kind of design logic that prioritizes ecological relationships over anthropocentric ideals. By developing this tool, the artist questions the dominant narratives of control, utility, and efficiency that typically underpin computational tools. Instead, the algorithm becomes a vehicle for ethical redirection—an attempt at what Ginsberg terms "altruistic technology". This reimagining of user engagement, where the end user is not human but ecological, creates space for cross-disciplinary collaboration and public participation, while also proposing an alternative model for how AI can function in the context of the planetary crisis.

Pollinator Pathmaker exemplifies how artistic research can generate viable and scalable alternatives to widely accepted solutions. It opens new relationships between humans, technology, and the natural world—relationships based not on mastery or extraction, but on reciprocity and care. By weaving together insights from art, ecology, artificial intelligence, and landscape design, the project offers a blueprint for how creative technologies can be reimagined to foster biodiversity, resilience, and long-term sustainability. As Ginsberg notes, this is an artwork that asks more of its participants than passive appreciation. "Whether it's a public commission or a DIY Edition, you have to do the work to find a space for it, to plant it, and to look after your artwork". Through this act of shared labor, *Pollinator Pathmaker* invites us to reimagine our relationship with the natural world—and to make space, quite literally, for those we so often overlook.

Artist: Alexandra Daisy Ginsberg
Algorithm developer: Dr Przemek Witaszczyk
Designer and Researcher: Iman Datoo
Horticulture: Colin Skelly
Producers: Hannah Andrews, Ruby Dixon
Studio manager: Freire Barnes
Originally commissioned by the Eden Project and funded by Garfield WestonFoundation.
Additional founding supporters: Gaia Art Foundation
Collaborators: Google Arts & Culture.
The International Edition Founding Commissioners are LAS Art Foundation.

Synthetic Memories

DOMESTIC DATA STREAMERS (ES)

STARTS pillar
STARTS Prize (Honorary Mention, 2025)

Synthetic Memories uses generative AI to reconstruct and safeguard personal memories that are either at risk of being lost or were never visually documented. Through guided sessions, participants describe their special memories, and trained interviewers then transform these memories into AI-generated visual representations—tangible images refined collaboratively to strengthen emotional connections. This process supports individuals affected by displacement, conflict, or neurodegenerative diseases in reconnecting with their past and retaining a sense of identity. By working with institutions such as the University of Toronto, the University of British Columbia, the University of Amsterdam, and the University of Southern California, the project continues to expand through scientific research and explores the impact of this method in supporting people with early-stage dementia.

Positioned at the intersection of art, technology, and social innovation, *Synthetic Memories* demonstrates how AI can be redirected toward social and emotional care rather than extractive or exploitative purposes. It encourages intergenerational and cross-cultural dialogue while addressing the ethical frictions between subjective memory and AI-generated content. The project serves as a prototype for public institutions, health organizations, museums, and cultural spaces to engage with memory preservation as a shared creative process. Thus, *Synthetic Memories* reimagines how technology can be used to amplify human connection—showing that AI's future potential could lie not in dominance or control, but in care and understanding.

Artist collective: Domestic Data Streamers
Curation: Domestic Data Streamers and José Luis de Vicente
Design and mediation of participatory workshops: Anais Esmerado
Associate researcher: Prof. Alex Mihailidis
Guest artist: Anna Roura
With support from: BIT Habitat – Innovation agency from Barcelona City Council; Disseny Hub Barcelona (DHub); Institut Ramon Llull

Photos: Domestic Data Streamers


Synthetic Memories
Image-Generator
MacBook Air


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WHEN THE WAR WAS AB
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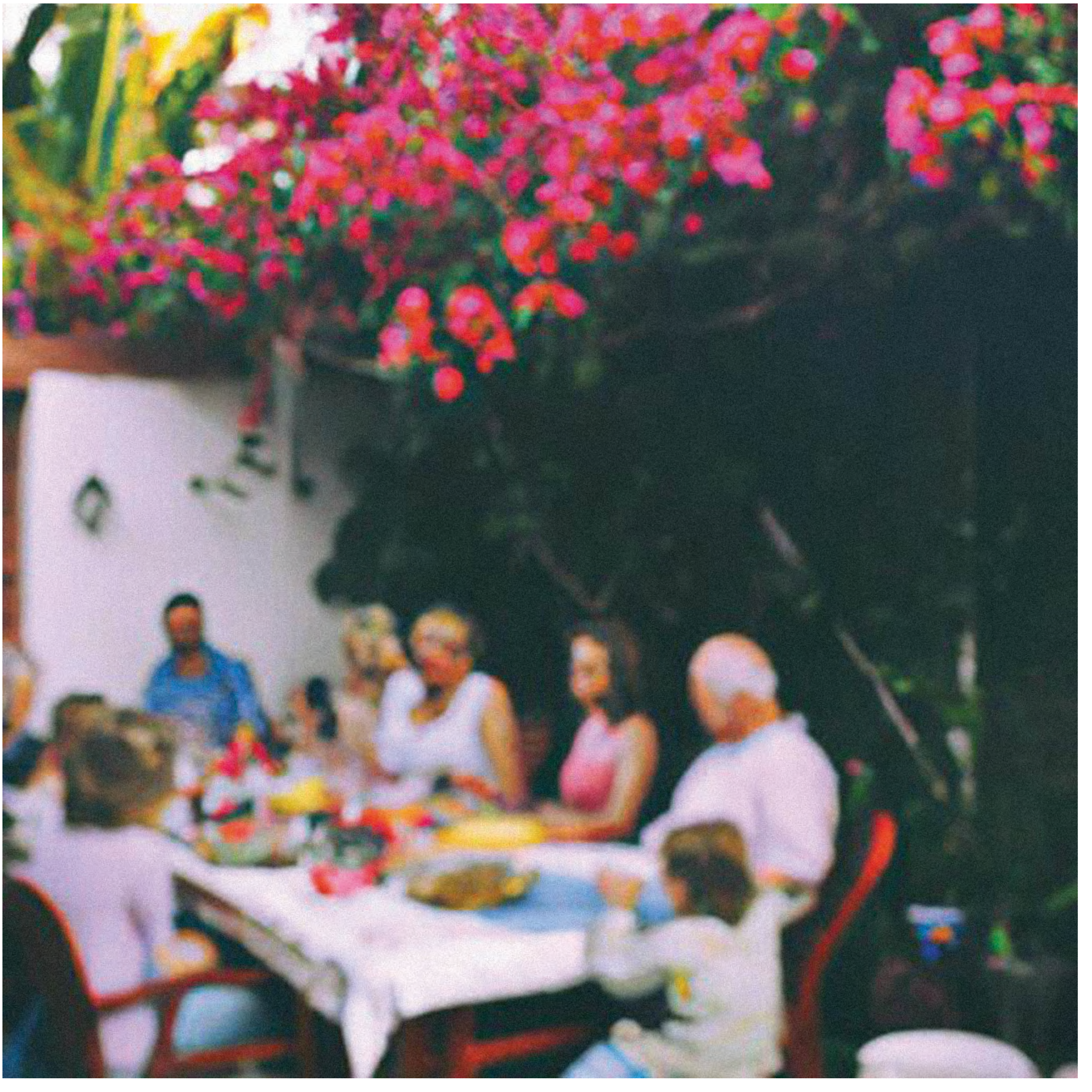


MEMORY	I REMEMBER FAMILY LUNCHES AT “LA CASITA”
NAME	Dulce
DATE	1980
LOCATION	Barcelona, Spain
DESCRIPTION	Dulce’s family has a house in Barcelona that they call “La Casita”. For her, this place hold-great sentimental value, as it is where the family gathers to spend good times together. She fondly remembers the courtyard with white walls, where bougainvilleas hung, filling the corner with color and providing shade in the summer. When she and her sister were young, their parents organized family lunches, bringing the whole family together around the table and filling the afternoon with conversations and smiles.
PROMPT	A blurry dream of a family, having dinner on the patio with a garden, metal table and chairs, bougainvillea, Spain summertime, 1970s.

MEMORY **I REMEMBER THE FIRST TIME I DROVE**

NAME	Mariam
DATE	1968
LOCATION	Dubai, UAE

DESCRIPTION

Mariam recalls her teenage years in 1968, just after getting her license at the age of 15. It was a time when it was not common for young women to drive, especially not at that age. Yet, she would drive her white Suzuki through the neighborhood, the wind blowing through the open windows. The traditional homes and the sandy streets of Dubai were her backdrop as she embraced the freedom of the road, feeling both the thrill and the defiance of the moment.

PROMPT

Girl driving, a white car, Suzuki, wearing dress, traditional homes, sand, 1968, Dubai, bird's-eye view.

MEMORY	I REMEMBER SINGING WHILE THE BOMBS WERE FALLING
NAME	Sílvia
DATE	1937
LOCATION	Barcelona, Spain
DESCRIPTION	During the bombing of Barcelona in the Civil War, Sílvia and her family hid in the shelter in front of their house when the siren sounded. The shelter, despite being a long and dark tunnel, did not scare her. With the presence of her family and her beloved teacher, she felt the space to be a safe and familiar place. While waiting for the enemy planes to pass, Sílvia's mother encouraged her to climb onto some stone seats and sing to calm the people down. Sílvia found refuge in music, discovering fun and joy amidst the moments of uncertainty and danger that surrounded her life.
PROMPT	Blurry black and white image of a small, three-year-old girl, in a dark tunnel, standing on a stone chair, surrounded by a group of people, with little lights on the ceiling, singing, 1930s, Spain.

MEMORY	**I REMEMBER THE TIME I SPENT WITH MY COUSINS PLAYING IN THE FIELDS**
NAME	Christa
DATE	1969
LOCATION	Austria
DESCRIPTION	Christa remembers her little village in Ohlsdorf, Austria, during the mid-1960s and early 1970s, where she enjoyed a wonderful childhood. Together with her cousins and her brother, who were all of a similar age, there were always plenty of children to play outdoors with in nature. One vivid memory is of a beautiful meadow filled with vibrant flowers, where the children would play during summer days, surrounded by sunshine and bright colors. They were full of energy—jumping, shouting, and having endless fun.
PROMPT	A five-year-old girl with a group of five blonde children, different ages, girls and boys, playing in a meadow of colorful flowers, the boys wearing leather trousers and rompers, Heidi, Ohlsdorf, summertime, 1969.

Soft Collision

ANNA SCHAEFFNER (FR)

STARTS pillar
STARTS Technical Pilot (VOJEXT, 2020-23),
STARTS Prize (Nomination, 2024)

Creation time
2022–24

Stakeholders involved
engineers, research institutions, robotics labs, industrial partners

Technology applied
soft robotics, pneumatic systems, tactile sensors, human-robot interaction design

Industry areas addressed
manufacturing, robotics, human-machine interfaces, safety design

Soft Collision is an artistic research and technological exploration that redefines what happens when humans and robots physically meet. Instead of preventing contact—the dominant paradigm of industrial robotics—the project embraces collision as a site of communication. Through a tactile, deformable interface, it transforms the moment of touch into an act of expression and understanding between human and machine.

Developed within the VOJEXT project (Value of Joint Experimentation), which explores human-robot collaboration in manufacturing and creative industries, *Soft Collision* brings an artistic perspective to technical research on robotic interaction. The collaboration between artist Anna Schaeffner and technical partners from the Universidad Politécnica de Madrid (UPM), Nebrija University, and ITT was central to expanding the project beyond engineering. Over the course of a year of weekly exchanges and lab visits in Genoa, Berlin, and Madrid, the team co-created a new interaction protocol grounded in material feedback and tactile dialogue, moving away from purely code-based instruction toward physical and intuitive communication.

The project investigates whether touch can become a shared language between humans and machines. It asks what would happen if robots were designed to respond to gestures and collisions instead of avoiding them, and whether such a design could foster empathy, anticipation, or trust. The research examines how the material qualities of softness, deformation, and resistance can shape our understanding of robotic behavior and our emotional connection to it.

At the core of *Soft Collision* is a deformable pneumatic membrane—a soft, skin-like surface that envelops a robotic arm. Embedded with flexible sensors and air channels, the membrane captures pressure, direction, and intensity of human touch, translating these inputs into the robot's motion. Rather than programming through abstract code, users can physically "teach" the robot by guiding it through direct manipulation. The robot acknowledges each gesture through subtle inflations and bursts of air, turning communication into a tangible, haptic exchange. The structure of the membrane follows the robot's six axes of motion, ensuring flexibility and safety during interaction. Two air chambers at its base emit short pulses as nonverbal

Top to bottom:

Photo: vog.photo

Photo: Michelle Mantel

Photo: Michelle Mantel

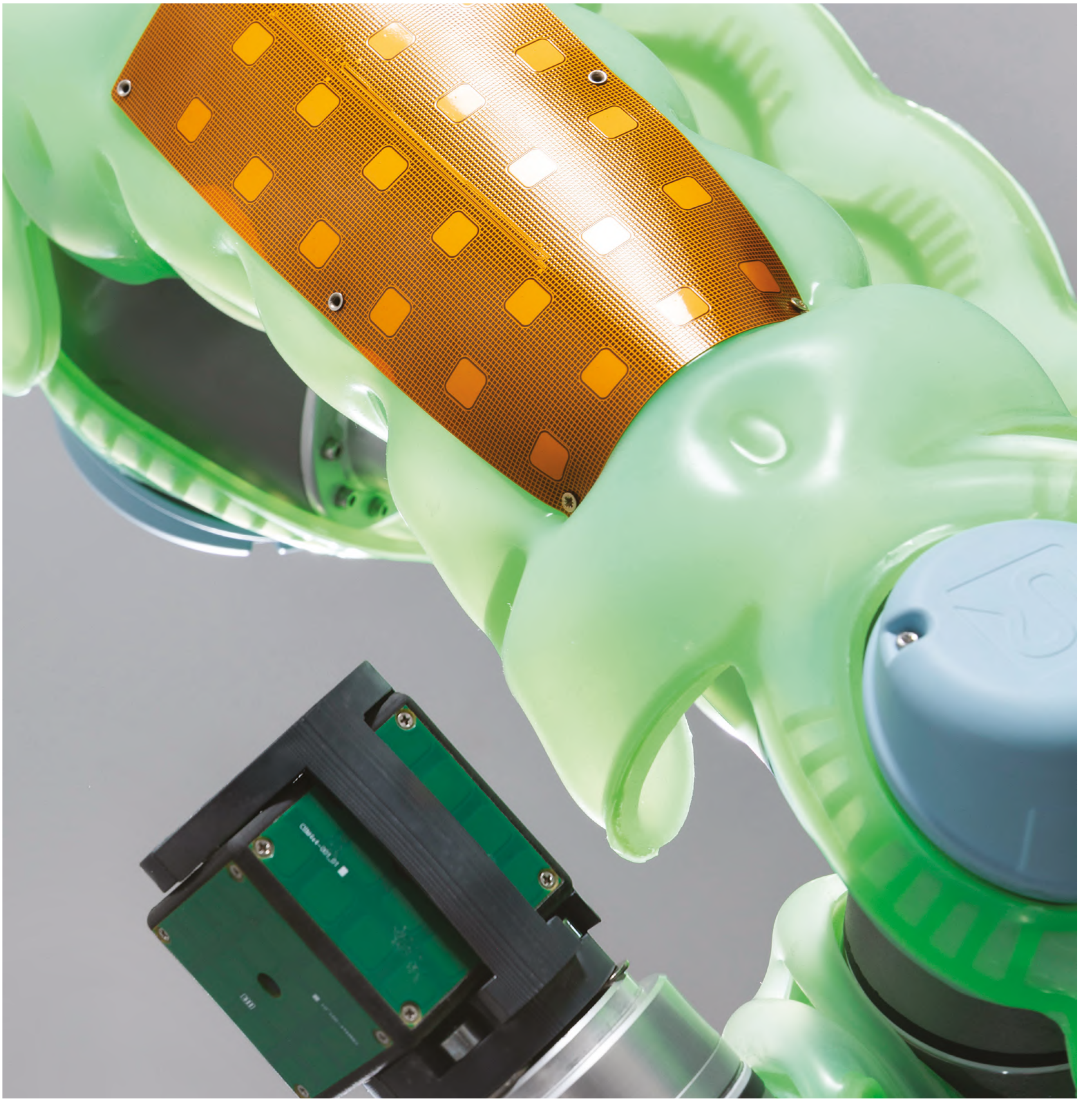
Photo: Michelle Mantel

feedback, while the morphology of the air channels enhances tactile affordance, allowing the human partner to intuitively anticipate the robot's movements. Drawing inspiration from natural organisms such as caterpillars, the design borrows organic principles of motion—softness, adaptability, and elasticity—to build a new vocabulary of robotic expression.

Within the broader STARTS ecosystem, *Soft Collision* exemplifies how artistic experimentation can expand industrial and scientific innovation by questioning its underlying assumptions. It challenges the idea that safety in robotics depends on separation, showing instead that closeness and sensory feedback can lead to new forms of trust and understanding. The project demonstrates how material design and artistic inquiry can enrich technical development, creating a framework where robots are no longer rigid tools but responsive collaborators.

Ultimately, *Soft Collision* reimagines human-robot interaction as a relationship based on sensitivity and reciprocity. This approach opens up practical and conceptual pathways toward safer, more adaptive, and intuitive robotic systems in manufacturing. The membrane's tactile responsiveness and real-time feedback mechanisms offer a new model for designing robots that can coexist with human workers in shared spaces, enabling fluid cooperation without the need for barriers or complex programming interfaces. By shifting from control and avoidance to presence and shared perception, the project opens a new horizon for coexistence between humans and machines in industrial contexts.

VOJEXT S+T+ARTS Art Residency 3: Social Robots
Residency lead by VOJEXT partners: Fondazione Istituto Italiano Di Tecnologica (IIT), Universdidad Politécnica de Madrid (UPM), Universidad Nebrija (UNNE) and Waag Futurelab
This project has received funding from the European Union's Horizon 2020 research and innovation program under the Grant Agreement no.952197
With support from: The Cluster of Excellence "Matters of Activity. Image Space Material" Berlin



SmartEnvelope

DAVID RICKARD (UK)

STARTS pillar
STARTS Technical Pilot (Better Factory, 2020-24)

SmartEnvelope reimagines one of the most familiar everyday objects—the postal envelope—by merging digital connectivity, sustainability, and design innovation. Developed within the framework of the Better Factory residency program by artist David Rickard, in collaboration with Plast-Farb, a Polish security-envelope manufacturer, and AND TECH, a technology provider, the project transforms the traditional envelope into an interactive, reusable communication tool. Each envelope carries a unique QR code linked to an online platform, allowing senders to connect their physical mail to individualized digital content. Once received, the envelope can be turned inside out to reveal a fresh surface and reused, extending its lifespan and reducing waste. Through this dual innovation—physical reinvention and digital extension—*SmartEnvelope* challenges the throwaway culture of postal systems and opens new possibilities for hybrid communication. The project's first application, the collaborative artwork *Fluid Borders*, used the envelopes to connect communities along the natural boundaries of the European Union, illustrating how a simple object can be reimagined as both a sustainable medium and a tool for social connection.


DAVID RICKAR
TUDIO
AND-TECH
Plast-farb

REFINE

NMASA DESIGN (SE)

STARTS pillar
STARTS Technical Pilot
(Better Factory, 2020–24)

Stakeholders involved
designers focused on material innovation, manufacturers of diving equipment, specialists in recycled marine plastics, and environmental researchers

Technology applied
plastic processing, material testing, injection molding, product prototyping, speculative design methodologies

Industry areas addressed
manufacturing, marine environmental protection, circular materials, sustainable product design

REFINE is a design and material research project that reconsiders how existing plastic-processing technologies can be applied within the scuba diving sector to reduce environmental impact and introduce more sustainable production practices. Developed by NMASA Design in collaboration with SEAC Sub and HEALIX, the project investigates how recycled plastics derived from marine waste can replace conventional raw materials used in fin manufacturing, while also addressing the broader ecological challenges associated with underwater sports.

The project began with a clear research question: Could plastics recovered from the sea—specifically discarded marine ropes—be transformed into a high-performance material suitable for industrial injection molding? Together with HEALIX, a specialist in converting ocean-bound plastics into high-quality pellets, the team ran extensive comparative tests on different waste-derived polymers. These tests evaluated mechanical strength, elasticity, durability, and production feasibility within SEAC's established manufacturing processes. Through several iterative prototyping rounds, *REFINE* identified MR04 PP-plastic, sourced from used fishing and mooring ropes collected from harbors and coastlines, as the optimal substitute for virgin plastic typically used in fin production.

This discovery led to the creation of an innovative fin made entirely from MR04 recycled plastic. The design process also explored how modifying the geometry of the fin itself could reduce material consumption while mitigating ecological disturbance underwater. Scientific studies indicate that a significant portion of accidental damage to coral reefs is caused by divers' fins, largely because divers have little tactile awareness of what their feet are touching underwater. This gap between protection for the diver and vulnerability for marine life raised questions about conventional fin design. In response, NMASA Design explored an alternative fin geometry that exposes more of the foot to increase underwater awareness. The shape uses less material and appears more delicate than standard fins, encouraging divers to move with greater caution and reducing the likelihood of unintentional contact with fragile organisms. By reconsidering efficiency, performance, and safety through an ecological lens, the project challenges established assumptions about what diving equipment should optimize for and why.

Photos: NMASA desgin, SEAC sub

The project moves beyond technical substitution by demonstrating how existing industrial tools can be redirected toward more responsible futures. Instead of treating recycled material as a simple alternative feedstock, *REFINE* shows how material choice, product geometry, and user behavior can be reconsidered together to shift the ethics of an entire practice. By working closely with manufacturers and environmental specialists, the team translates artistic inquiry into concrete change and proves that speculative thinking can coexist with pragmatic industrial implementation. The project challenges established expectations of efficiency and performance, proposing instead equipment that encourages attentiveness, restraint, and a more reciprocal relationship with the underwater world. In doing so, *REFINE* illustrates how current technologies can be pushed beyond familiar applications, opening space for alternative modes of making and diving that question prevailing norms and ultimately reimagine the practice.

Computational Compost

MARINA OTERO VERZIER (ES)

STARTS pillar
STARTS Prize (Honorary Mention, 2025)

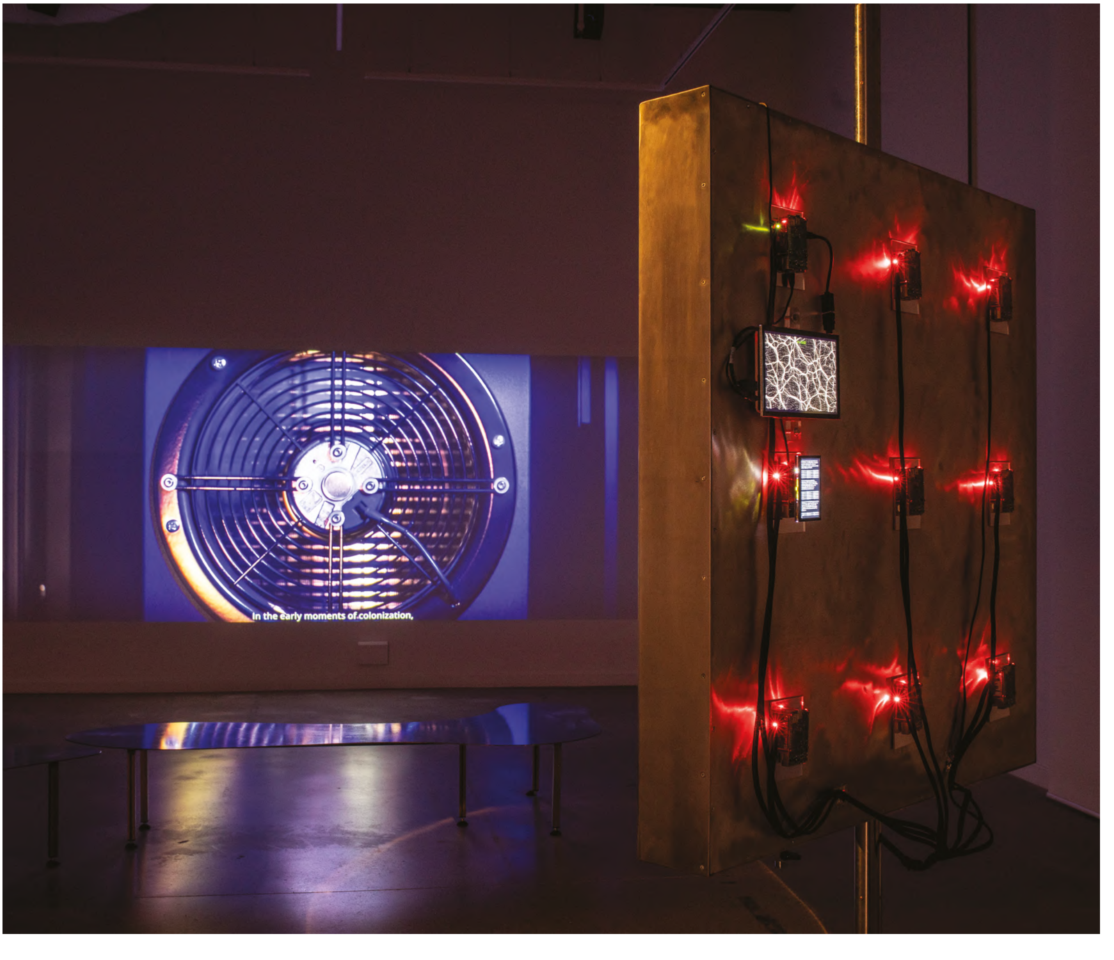
Computational Compost is an artistic research project that challenges the illusion of immaterial digital data. While often perceived as weightless and harmless, data is in fact supported by vast infrastructures that consume enormous amounts of energy, water, and raw materials, releasing heat and carbon dioxide into the atmosphere. Developed together with the Donostia International Physics Center (DIPC), the project responds to this hidden environmental impact by exploring how the energy demands of digital systems can be redirected to support ecological processes rather than harm them.

Its core research question asks whether computation—traditionally associated with extraction, heat, and depletion—can instead operate within the cycles of renewal and transformation that sustain life. The project presents a prototype that repurposes the heat produced by computers running simulations of the origin of the universe to power a vermicomposting machine. In this system, live worms and microorganisms use this waste heat to transform organic matter into fertile soil.

By combining scientific research, environmental design, and artistic experimentation, *Computational Compost* reimagines how technology can function within natural systems. It suggests a shift from extractive digital infrastructures toward models that use computational processes to support ecological balance and resource renewal.

Artistic direction, research and prototype design: Marina Otero Verzier
Project coordination, research, 3D direction: Claudia Paredes Intriago
Film direction: Locument (Francisco Lobo, Romea Muryń); Marina Otero Verzier
Prototype development: Claudia Paredes Intriago, Fernando Fernandez Sanchez, Pablo Saiz del Río
Production: Rocco Roncuzzi
In collaboration with the Donostia International Physics Center (DIPC)
Commissioned by Tabakalera

Photos: Mikel Blasco


In the early moments of colonization,

Film Seed Festival

HYPERCOMF (GR)

STARTS pillar
STARTS Regional Centers
(Repairing the Present, 2021–22)

Film Seed Festival is a smart-agriculture initiative that reimagines how technology, farming, and culture can coexist in rural communities. Central to the project is the Peanut Pod, an IoT-enabled unit that supports peanut cultivation through real-time monitoring of soil moisture, plant health, and local weather conditions. This data helps farmers manage resources efficiently and regenerate their land. Once the crop is harvested, the system shifts purpose: part of the peanut is pressed into oil and converted into biodiesel, powering a generator and projector stored inside the Pod. The field where the peanuts grew then becomes the site for the "Film Seed Festival", a fully crop-powered open-air cinema where farmers welcome their community, screen films, and offer roasted peanuts made from the harvest.

By reimagining existing agricultural technology as a cultural and social engine, *Film Seed Festival* explores new possibilities for rural innovation. The project blends regenerative farming, renewable energy, and community celebration, showing how technology can sustain both ecosystems and local traditions. It challenges conventional ideas about efficiency and production by giving farmers agency to transform their land into a space of gathering, creativity, and shared learning. Through this circular approach—where cultivation, energy generation, and cultural expression emerge from the same field—the project proposes alternative models for resilient rural futures. It demonstrates how rethinking technological use can strengthen local economies, reconnect producers and consumers, and build community-led solutions that integrate sustainability with everyday life.

Concept/Production: Hypercomf
Project Coordination: Eleni Michaelidi
Smart Agriculture Technology Provider: AGENSO – Agricultural and Environmental Solutions
Environmental Engineering Consulting : ACT4ENERGY – Democritus University of Thrace Spin-off – Vasileios Diamantis, Alexandros Eftaxias, Iliana Kolokotroni, Christos Michailidis
Peanut Crop Cultivators: Alexandros Androvik (Tinos Farm to Table), Paul Delatolas, Ioannis Koliopoulos, Omarr Mabchour, Harut Maragozyan, Paola Palavidi, Yiannis Pontis, Giorgis Stergiotis
Commissioned by: Onassis Stegi
Within the framework of: STARTS Regional Centers – Repairing the Present, a European Commission initiative

Photo: Harut_Marangozyan


STASI

Labyrinth Psychotica

JENNIFER KANARY (NL)

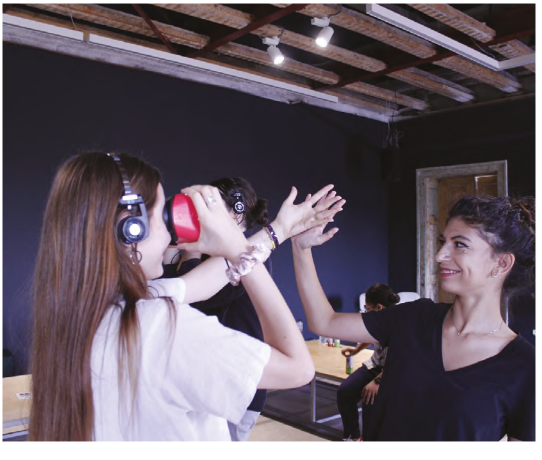
STARTS pillar
STARTS Prize (Honorary Mention, 2023)

Creation time
2005–ongoing

Stakeholders involved
mental health professionals, academic researchers, healthcare organizations, law enforcement agencies

Technology applied
VR, mixed-reality simulation, immersive media design, conceptual modeling, and psychosis experience mapping tools

Industry areas addressed
mental health, medical and professional training, education, human-computer interaction



Photos: Jennifer Kanary

Labyrinth Psychotica is an immersive, long-term artistic research project created by Jennifer Kanary in response to a deeply personal tragedy: the loss of her sister-in-law to suicide during a psychotic episode. Confronted with the painful realization that she had no real understanding of what her sister-in-law had experienced, Kanary posed a powerful guiding question: How can we use art and technology to communicate the subjective experience of psychosis—an experience that resists conventional language—in order to build empathy, transform mental health training, and reduce stigma?

This question led to nearly two decades of artistic experimentation, technological development, and interdisciplinary collaboration. *Labyrinth Psychotica* re-imagines Virtual Reality not as an entertainment medium but as a tool for radical empathy, a way to step, even briefly, into another person's reality. The flagship outcome of this research is the Anoiksis VR Psychosis Experience, a mixed-reality simulation that immerses the wearer in over 42 subjective phenomena typical of psychosis within approximately eight minutes. The experience is designed as an interactive, waking dream state in which users must navigate shifting voices, hallucinations, and thought patterns that reflect the internal logic of psychotic episodes. The simulation offers not a mere illustration but a visceral, affective journey into altered perception, aiming to unsettle and provoke reflection. It is based on the Anoiksis Theory, Kanary's original conceptual framework that reframes hallucinations and delusions not as signs of a broken brain but as a survival mechanism, and supported by the Anoiksis Map, a practical method to help hold space for psychosis and recognize early warning signs. This method, developed in close collaboration with mental health professionals, students, and people with lived experiences, has been tested as a tool not only for psychosis but for other psychiatric conditions such as depression or OCD, pointing to its potential for broader mental health practice.

The project's approach to impact is equally rigorous. In collaboration with organizations like TNO: Innovation for Life, the Dutch Police Academy, and academic hospitals, *Labyrinth Psychotica* has measured and refined the simulation's effectiveness as a training and educational tool. The aim is not only to educate mental health professionals but to cultivate empathy among family members, caregivers, and even law enforcement personnel who encounter people in crisis. By inviting users to doubt their own borders between real and unreal, the VR experience does not just simulate psychosis—it interrogates the cultural and clinical assumptions that surround it. By creating a shared experiential reference, the simulation offers the possibility of transforming relationships that are too often marked by fear, misunderstanding, and stigma.

As the result, *Labyrinth Psychotica* does not simply use technology to replicate reality but re-imagines its potential to communicate the incommunicable, inviting users to encounter the world as someone else might experience it. It challenges the dominant medical narratives that treat psychosis as purely pathological and instead proposes a more holistic, empathetic understanding that can inform prevention, early intervention, and compassionate care.

Thanks to: The Doen Foundation, The Creative Industry Funds, The Mondriaan Funds, Jolijn Friederichs, Tim Knoote, Teresa Feldman (EE), Sigrid Bannenberg, Pinar Temiz, Alec Kopyt (USSR), Laura Schuster, Konstantin Leonenko (UKR), Jeanette Groenendaal, Suleika Elfassi, Dora Grootman, Megan Mateer (USA), Jeroen Zwaal, Linda Maissan, Kasia Szmigiero (P), Xiomara Vado Soto, Renana Elran (ISR), Suzanne Meyer, Dr. Wouter Kusters, Dr. Karlijn Roex, Dr. Wim Veling, Alwin Verdonk, Josephine Bosma, Rokus Loopik, Dr. Anna Cornelia Beyer (UK), Sam Gerrits, Angèle De Jong, Lieselotte Nooyen, Christien Oudshoorn, Nina Boas, Iris Jousma, Anneke de Weerd, Fausto, Marie-Anne Soyez (D), Dr. Sabine Wildevuur, Dr. Tycho Hoogland, Marjelle van Hoorn, Selma Steenhuizen, Ewout Stumphius and Nikola Nikolov (BG). TNO, Dutch Police Academy Ossendrecht (Harold + Frans), AMC UMC Academic Hospital (Jacqueline + Franka + Ellen), Zaans Justitieel Centrum (Ingrid + Remco) and all the teachers and students of the University of Applied Sciences Amsterdam and St Joost Avans.


PICK ME PICK ME

INNOVATE RESPONSIBLY

Innovate Responsibly explores artistic practices that approach innovation as a socially embedded and ethically grounded process. The works in this cluster examine how societal systems—whether urban, ecological, cultural, or political—can be reshaped through collaborative inquiry, context-specific knowledge, and participatory engagement. Artists collaborate with various stakeholders, from local residents and decision-makers to care professionals, to understand how everyday structures function and to co-develop alternatives that are more equitable and supportive of collective well-being. This may involve digital tools, but also design methods, ecological practices, or shared cultural processes that help communities reflect on their environments and influence the conditions that shape their lives. Across these initiatives, the emphasis lies on agency, accessibility, and public responsibility. By involving diverse stakeholders in the formation of processes, the projects foster inclusive decision-making and encourage communities to take part in shaping social, environmental, and economic systems. Responsible innovation here means creating structures where people are not passive beneficiaries but active contributors—where technological progress supports inclusion, strengthens collective well-being, and helps societies imagine more equitable ways of living together. It refers to aligning practices—technological or otherwise—with principles of fairness and mutual care, demonstrating how creative approaches can contribute to such innovative processes.

Avatar Robot Café DAWN ver.β

ORY YOSHIFUJI, ORY LAB INC., OYAMATSU DESIGN STUDIO AND TASUKI INC. (JP)

STARTS pillar
STARTS Prize
(Honorary Mention, 2022)

Creation time
2018–ongoing

Stakeholders involved
engineers, designers, social innovators, people with disabilities as remote operators, care and rehabilitation specialists

Technology applied
telepresence and avatar robotics, eye-tracking interfaces, communication technology, human-centered design methods

Industry areas addressed
health tech, social inclusion, robotics and telecommunication, service and hospitality

The project *Avatar Robot Café DAWN ver.β* was developed by Ory Yoshifuji, who experienced prolonged periods of social isolation during his youth due to chronic illness. These early challenges inspired him to explore how technology could enable those who are physically unable to participate in society to regain agency and presence in the social sphere. The central question that guides the project is: How can we use avatar robotics to create inclusive opportunities for employment, communication, and social connection for people with severe physical disabilities or mobility restrictions?

The project combines technology, social innovation, and artistic experimentation. At the heart of it is the OriHime robot—an avatar robot equipped with a camera, microphone, and speaker that can be remotely operated via the internet. OriHime allows people who are bedridden, housebound, or physically limited to work and interact in public spaces without leaving their homes. These “pilots” serve customers in a café, engage in conversations, and become active agents in society. The experience is not only technically functional but deeply human. Through OriHime, users are seen, heard, and felt—as individuals with distinct personalities, not as their illnesses or disabilities.

The project’s outcomes extend across artistic, social, and technological domains. Artistically, it functions as a living social sculpture—an evolving, participatory installation where every robot movement reflects a human behind it. The robot’s design, inspired by Japanese mask traditions, draws attention to the cultural idea that identity and expression emerge through presence, regardless of physical form. The robot becomes a medium through which users reveal their humanity. As the project team notes, “Every robot sounds different, works differently, moves differently depending on the person”. This brings a performative, relational aesthetic to the work, where the art is the society being built—one where inclusion, connection, and dignity take center stage.

Photos: MIYOGRAPHY

Methodologically, the project embodies a co-creation model: Ory Lab develops its technology in close collaboration with users. This ensures the tools serve real needs and empower real lives. The café itself functions as a prototype for a scalable model—a place where technological research, business innovation, and lived experience intersect. With each deployment, feedback from pilots helps refine both the robot and the system around it. The process has resulted in practical outcomes (employment opportunities, income generation) as well as intangible ones (self-worth, hope, renewed purpose).

The project received a STARTS Prize Honorary Mention and aligns closely with the core values of the initiative: leveraging technology for societal good, integrating artistic and scientific inquiry, and developing sustainable, inclusive solutions. The OriHime robots are not powered by AI—precisely because it raises essential questions about presence, agency, and ethics in human-machine interaction. By rejecting automation and emphasizing human control, the project challenges dominant narratives about AI and robotics. Here, technology is not replacing people—it is restoring their ability to participate.

The project's key ambition is to reframe disability and dependence not as limitations, but as starting points for reimagining work, identity, and care in society. This vision is realized through an interdisciplinary approach that unites engineering, care ethics, design, art, and business. Its real-world impact is visible: pilots who had never worked before are now earning money, some have moved out of their parents' homes, others have reduced their reliance on disability subsidies. The psychological transformation—the sense of being needed, being useful, being present—is at the heart of the project's success. However, the project's relevance extends even beyond. The project provides a replicable business model that combines social entrepreneurship with scalable technology.

The recent opening of the first overseas branch—Bunshin Robot Café Øens Madhus in Aarhus, Denmark (April 2025)—demonstrates the project's international potential. With a package including proven outcomes, business models, and training tools, the team promotes a powerful replicable model. The ambition is not just to serve coffee via robots, but to serve connection, dignity, and a shared future.

Ory Lab Inc.
OYAMATSU Design Studio
TASUKI Inc.
Sponsored by:
NTT Corporation, Biogen Japan Ltd., Mitsui Fudosan Co., Ltd.; charity by crowdfunding "CAMPFIRE".


DAWN
ver.β
with TAILORED CAFE


スナック 織姫
Cafe Lounge
30

CLIMAVORE

COOKING SECTIONS (INT)

STARTS pillar
STARTS Prize
(Honorary Mention, 2023)

Creation time
2015–ongoing

Stakeholders involved
marine biologists, chefs, agronomists, soil scientists, farmers, engineers, architects, legal scholars, cultural institutions

Technology applied
agroecological and regenerative farming systems, digital mapping, site-specific environmental diagnostics, design, participatory and community-based environmental practices

Industry areas addressed
food and agriculture, climate adaptation, sustainable aquaculture, environmental law and governance

CLIMAVORE, created by the artist group Cooking Sections (Daniel Fernández Pascual and Alon Schwabe), is an evolving research platform that interrogates how to eat in the context of accelerating climate breakdown, such as drought, soil exhaustion, fertilizer runoff, wetland disappearance, or polluted seas. Through long-term, interdisciplinary collaborations and site-specific interventions, the project designs regenerative food infrastructures that are locally embedded, ecologically viable, and culturally transformative.

At the heart of the project lies the question: What does it mean to eat in a climate emergency? How must our food practices, legal frameworks, and cultural institutions transform to address rapidly shifting environmental realities? In response, *CLIMAVORE* operates on the principle that food is both a material and symbolic site through which climate adaptation can be negotiated and enacted. The project is structured around *CLIMAVORE* Stations—long-term hubs established in Skye and Raasay (Scotland), Istanbul (Turkey), and Sicilia and Puglia (Italy), regions that experience specific manifestations of the climate crisis. These stations, located in Scotland, Italy, Turkey, and beyond, act as testing grounds for adapting food systems and support local transitions in food systems through regenerative practices. Rather than offering isolated artistic gestures, each station is designed to embed itself in existing social and ecological systems. In the Scottish Highlands, the station supports a transition from industrial salmon farming to restorative aquaculture through apprenticeships, intertidal farming, and material reuse. In Southern Italy, it focuses on diversifying agriculture by cultivating drought-resistant seeds and developing legal frameworks for their protection. In Istanbul, the project revitalizes wetland ecologies and traditional herding practices, reinforcing the value of shared landscapes under threat from urban expansion.

CLIMAVORE is based on a deeply embedded, citizen-centered approach; rather than imposing top-down solutions, the project reflects critically on existing agricultural, cultural, and institutional processes, asking how these can be adapted to become more just, sustainable, and locally rooted. It fosters responsible innovation not through the introduction of new technologies alone, but by reconfiguring the socio-ecological relationships that underpin our foodscapes. From apprenticeships with young people in Scotland to seed exchange networks in

Top to bottom:

Cooking Sections, Çamuralem / Wallowland. Istanbul Art Biennial, 2022. Photo: Deniz Sabuncu / Aposto.

Cooking Sections, CLIMAVORE: On Tidal Zones. View of the intertidal table installation. Isles of Skye and Raasay. Photo: Colin Hattersley

Cooking Sections, CLIMAVORE: On Tidal Zones. View of the intertidal table installation. Isles of Skye and Raasay. Photo: Nick Middleton

Southern Italy and collaborations with herding communities in Istanbul, *CLIMAVORE* foregrounds participatory design and co-creation. The project engages citizens not only as end-users but as active agents in shaping regenerative alternatives, ensuring that interventions remain context-sensitive and accessible.

Across all locations, the project's methodology combines artistic experimentation with local knowledge systems, scientific expertise, and community co-production. Activities include performative meals, edible installations, microclimate-building prototypes, school-based training programs, seed nurseries, legal toolkits, and ecological monitoring. These artistic strategies function as more than aesthetic encounters—they act as prototypes for policy-making, regenerative agriculture, and socio-ecological repair. One of its most ambitious policy-oriented initiatives is the *CLIMAVORE* Assembly, launched in Rome in 2023, which brought together artists, farmers, seed custodians, activists, policymakers, and museum professionals to collectively imagine the future of food systems in the climate emergency. It positioned cultural institutions not merely as observers of climate change but as agents of transformation—spaces where public infrastructure, ecological knowledge, and food justice intersect. The Assembly also served as a platform to revise and expand the *Becoming CLIMAVORE* toolkit, a growing movement of museums and food providers adapting their menus and procurement systems to reflect local ecological realities.

Through the *Becoming CLIMAVORE* campaign, cultural and educational institutions—such as Tate and Serpentine in the UK—have removed ecologically harmful ingredients like farmed salmon from their menus and replaced them with regenerative alternatives such as seaweed, bivalves, and climate-resilient grains. These changes are not only symbolic but operational, serving as scalable models for how the food service sector can respond to region-specific environmental challenges. Each participating institution follows local "human-made seasons", aligning culinary practices with ecological rhythms rather than industrial norms.

CLIMAVORE is a powerful example of how artistic practice drives real change. It demonstrates how artistic interventions can pioneer systemic change by designing climate-resilient food futures and engaging multiple sectors. Through site-responsive methodologies and long-term collaborations, it not only raises awareness but creates replicable models for climate-resilient economies and promotes a cultural shift in how societies understand and enact sustainability.

Cooking Sections: Daniel Fernández Pascual and Alon Schwabe
Studio team: Rosa Whiteley, Remi Kuforiji
Director of Care: Dani Burrows
Director, CLIMAVORE Station Skye & Raasay: Shona Cameron
Director, Becoming CLIMAVORE: Kelly Tsipni-Kolaza

(Be)eTogether

MARIA CASTELLANOS AND ALBERTO VALVERDE (ES)

STARTS pillar
STARTS Technical Pilot
(Hungry EcoCities, 2022–26)

(Be)eTogether is a collaborative art-science project that creates a new way for humans to understand and care for bees using environmental sensing and data interpretation. Developed with Olaya Miel, an ecological beekeeping initiative in northern Spain, and BeeSage, a specialist in beekeeping technologies, the project combines multiple tools to monitor hive life. BeeSage's HiveScale and HiveNodes track weight, temperature, and humidity inside the hive; open-source outdoor sensors built by the artists measure air quality, UV radiation, and wind; AI-powered cameras observe bee traffic at the entrance; and contact microphones capture the hive's subtle vibrations, which carry signals unique to collective bee behavior. From this continuous flow of data, the artists created an interface that translates the hive's rhythms into light, sound, vibration, and airflow, allowing people to perceive when bees are active, resting, or responding to changes in their environment. Designed to follow, rather than interrupt, natural cycles, the system offers a gentle, non-intrusive way to connect with the daily life of the hive.

Thus, *(Be)eTogether* proposes an alternative approach to innovation—one grounded in care, reciprocity, and ecological awareness. The project demonstrates how design can strengthen social and environmental well-being by helping communities understand the pollinators on which food systems depend. It supports beekeepers in anticipating challenges, reduces stress on colonies, and encourages a shift from control to cohabitation. More broadly, the work shows how accessible, human-centered tools can empower people to engage with the technologies shaping their environments, rebuilding relationships between humans, non-humans, and ecosystems.

Conceptualization/Production/Technology: María Castellanos and Alberto Valverde in collaboration with Beesage
Funding: Winning Artists Hungry EcoCities: Paths to Progress Experiments, STARTS

Low Carbon Chinatown

LING TAN (UK/SG)

STARTS pillar
STARTS Prize (Nomination, 2024)

Low Carbon Chinatown is an interactive urban intervention and participatory platform that uses art, design, and data science to address the climate crisis through the lens of global agri-food systems. Created by artist and designer Ling Tan, the project reimagines how communities can take collective responsibility for sustainable food futures. Using Chinese diasporic food culture as its starting point, it engages cross-generational East and Southeast Asian (ESEA) communities in the UK and Europe to explore how everyday cooking and eating practices can reduce the carbon footprint of food production, sourcing, and consumption.

Developed with contributions from data scientists, architects, engineers, and food writers, the project combines research, workshops, and public engagement. Participants co-create low-carbon recipes that preserve cultural authenticity while adopting sustainable alternatives in ingredients and preparation. These are shared through AI-enabled digital platforms, media-savvy recipe videos, and public meal-as-performance events that transform dining into an act of environmental awareness and cultural celebration.

By merging data-driven insights with cultural knowledge and community participation, *Low Carbon Chinatown* exemplifies responsible innovation in practice. It demonstrates how technology can enhance well-being and social cohesion while addressing systemic environmental challenges. The project empowers citizens to become active contributors to climate action, offering a model for inclusive, ethical, and culturally grounded forms of sustainable innovation.

Low Carbon Chinatown is a project by Ling Tan, originally commissioned by Kakilang.

With support from: Arts Council England, Compass Festival, Manchester Museum, Barking Riverside, London Chinese Community Centre, Hackney Chinese Community Centre, Newham Chinese Association, Royal Docks

Low Carbon Chinatown Pop-Up
Photo: Luke O'Donovan


CORAL
CORAL
CHINESE ART AND FASHIONS
福
福
New World

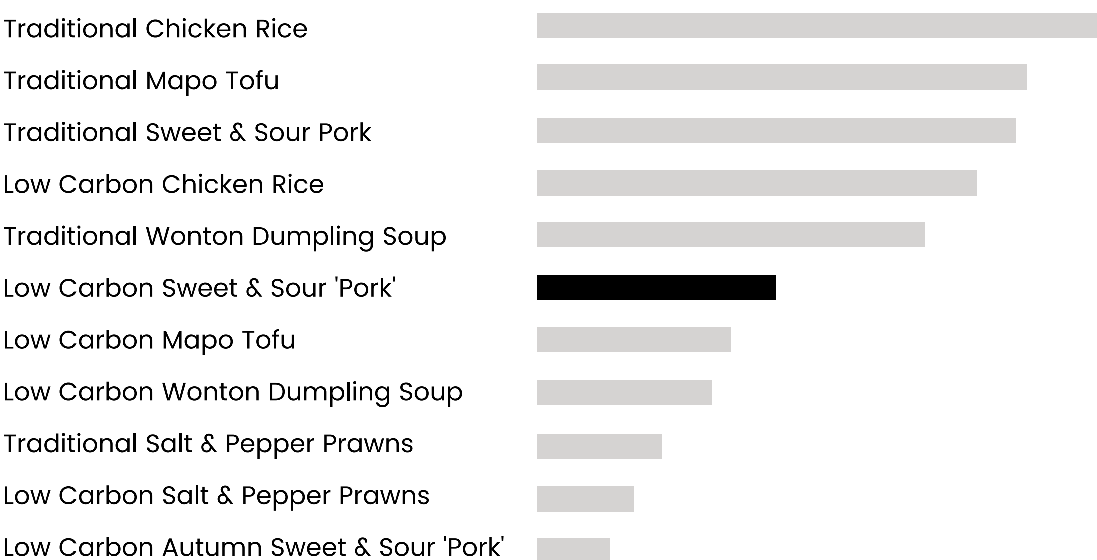
Low Carbon Sweet & Sour 'Pork' | 低碳咕噜'肉'

"I will use cauliflower instead, as pork has such a high carbon footprint, and usually when I make this, no one misses the pork."

– Collaborating food writer Uyen Luu

Recipe's Carbon Footprint Impact | 食谱的碳足迹影响

Carbon Footprint Per Serving Compared To Traditional Recipes | 与传统食谱相比，每份低碳食谱的碳足迹



Servings: 2–4 people

Key Ingredients | 关键成分

For the marinade

1 tablespoon light soy sauce

2 teaspoons caster (superfine) sugar

1 teaspoon sesame oil

1/2 teaspoon white pepper

1 teaspoon garlic powder

500 g (1 lb 2 oz) cauliflower florets (British grown)

For the sweet & sour sauce

2 tablespoons cider vinegar

Large bowl of very cold water (keep it in the fridge)

4 tablespoons caster or brown sugar

100 ml (3 1/2 fl oz/scant 1/2 cup) vegetable stock (make from half a stock cube)

3 tablespoons ketchup

10g fresh ginger, finely chopped

2 teaspoons tomato purée (paste)

2 tablespoons pineapple juice

1/2 teaspoon cornflour (cornstarch)

1 tablespoon light soy sauce

For the vegetables

2 free range eggs, beaten in a shallow bowl

100 g (3 1/2 oz/generous 3/4 cup) cornflour (cornstarch) plus more for dusting

cooking oil, for deep-frying

1 tablespoon cooking oil (go for UK produced rapeseed oil)

1 onion, sliced into eighths

2 garlic cloves, finely chopped

1/2 red (bell) pepper, sliced into 2 cm (3/4 in) wide strips

1/2 yellow (bell) pepper, sliced into 2 cm (3/4 in) wide strips

200g courgette (zucchini), cut into thin long strips (allotment grown)

100 g (3 1/2 oz) green beans, sliced (allotment grown)

small tin (about 225 g (8 oz)) of pineapple chunks (supermarket)

For the garnish

2 spring onions (scallions), sliced

Key Steps | 关键步骤

In a large bowl, mix all the marinade ingredients together and set aside.

Mix together all the ingredients for the sweet and sour sauce. Set aside.

Have 3 shallow bowls ready, one for the beaten egg, one for cornflour and one to place the coated cauliflower. Dip a cauliflower floret in the beaten egg, then dredge it with cornflour and tap off any excess flour, then place it in the third bowl and repeat with all the florets.

Bring an electric deep fat fryer to about 170°C (325°F/gas 3). Deep-fry the coated cauliflower for exactly 4 minutes until they turn golden then set to cool on a rack or paper towels. For a crispier affair, double fry, the second time for 2 minutes at 170°C (325°F/gas 3).

In a wok, over a high heat, add the cooking oil. Once it has melted, add the onions to char on the edges and then the garlic. Once the garlic starts to turn golden, throw in the red pepper, courgette and mangetout.

Quickly stir-fry and toss for about 2 minutes then add the pineapple chunks, cook for a further 2 minutes. Mix together then add the sweet and sour sauce. Toss and cook together until it becomes juicy, thick, saucy and glossy. Turn off the heat and add fold in the florets.

Garnish with spring onion. Serve immediately with steamed rice.

The low carbon recipe was developed as part of Low Carbon Chinatown by artist Ling Tan, in collaboration with data scientist Raphael Leung, food writer Uyen Luu, and East & Southeast Asian community members from Hackney.

To find out more about the project and explore other low carbon recipes, visit the project website.

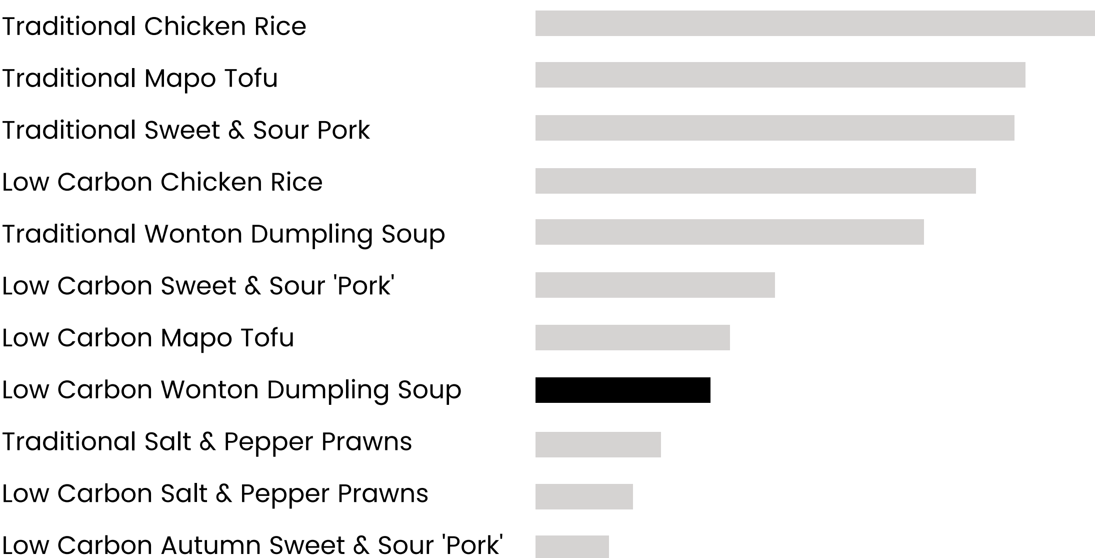
Low Carbon Wonton Dumpling Soup | 低碳馄饨汤

"Instead of usual pork and prawn, we use a vegan filling of tofu, leek and carrot. Tofu's a super versatile ingredient and takes on flavour like a sponge. Leek, when stir fried first, gives us savoury depth and aroma. Carrot gives us the sweetness and colour you would normally get from prawns."

– Collaborating food writer Shu Han Lee

Recipe's Carbon Footprint Impact | 食谱的碳足迹影响

Carbon Footprint Per Serving Compared To Traditional Recipes | 与传统食谱相比，每份低碳食谱的碳足迹



Servings: 8 (assuming 5 wontons each)

Key Ingredients | 关键成分

Pack of 40 wonton wrappers (200g)

For the filling

200g block of firm tofu

1 large carrot, peeled and grated (about 80g)

1 leek, washed and sliced (about 100g)

1 teaspoon grated ginger

1 tablespoon sunflower oil

3 tablespoons soy sauce

1 tablespoon sesame oil

1/4 tsp white pepper

For broth

1 L chicken stock (homemade, or use 2 Knorr stock pots and 1L water)

2 teaspoons soy sauce (or to taste, depending on saltiness of stock)

1/2 tsp sesame oil

Big dash of white pepper

1 spring onion, finely chopped

Key Steps | 关键步骤

Place firm tofu under a heavy dish for about 15 minutes, to help remove excess water.

Meanwhile, on an electric stove over medium high heat, fry the leek in sunflower oil until softened, about 5 minutes. Add 1 tablespoon of soy sauce and cook for another 2 minutes until most of the soy sauce has disappeared and been absorbed by the leek. The leek should reduce in volume and also become a bit sticky - helping you bring the filling together.

Drain the tofu and finely chop. Combine tofu with all the rest of the filling ingredients, stirring till well combined.

Dip your finger in water and wet the edge of a wonton wrapper. Place a tablespoon of filling in the middle. Fold the wrapper in half into a rectangle, pressing to seal the edges. Wet one corner then place the other corner on top, press to seal.

In a saucepan, bring the stock to a boil. Season with soy sauce, white paper and sesame oil.

In a separate saucepan, bring plenty of water to the boil, then lower the heat to a medium high. Gently put in the wontons in a single layer (you may need to cook them in batches). Move them around with a spoon to avoid sticking.

The wontons are done when they rise from the bottom and float on the surface, about 3 minutes.

Remove the wontons with a slotted spoon into bowls. Pour over the stock and garnish with the chopped spring onions.

The low carbon recipe was developed as part of Low Carbon Chinatown by artist Ling Tan, in collaboration with data scientist Raphael Leung, food writer Shu Han Lee, and East & Southeast Asian community members from Newham.

To find out more about the project and explore other low carbon recipes, visit the project website.

Ciutat Vella Land-use Plan

300.000 KM/S (ES)

STARTS pillar
STARTS Prize
(Grand Prize for Innovative Collaboration, 2019)

Creation time
2016–18

Stakeholders involved
city government, citizens, academia, data scientists, urban planners

Technology applied
big data, machine learning, AI-driven spatial analysis, participatory digital platforms

Industry areas addressed
urban planning, smart cities, civic participation, governance

The Ciutat Vella Land-use Plan represents a new model in data-driven and participatory urban planning. Developed by the Barcelona-based studio 300.000 km/s, the project uses large datasets—open data, big data, and qualitative insights from citizens—to design public policy that balances economic activity with the quality of urban life. Combining advanced spatial analysis, AI, and machine learning with civic participation, it redefines the regulatory framework for public establishments, food shops, and tourist services in Barcelona's historic center—one of Europe's most densely populated and socially sensitive urban areas. The project challenges traditional top-down planning methods to co-create a new regulatory framework that ensures coexistence between local life and tourism-driven economies.

The project emerged from the need to address the negative effects of urban over-commercialization—noise, overcrowding, waste, and rising vulnerability—through a model that combines research, collaboration, simulation, and regulation. The first phase, launched in 2016, produced a data atlas comprising 150 thematic maps that, for the first time, measured the connections between the city's structure, economic activity, and residents' health and wellbeing. Drawing from open-access municipal datasets and environmental sensors, this atlas applied AI-based spatial modeling to analyze the impacts of tourism and nightlife on local life, setting the foundation for evidence-based policymaking.

Beyond its technical innovation, the project places artistic and design thinking at its core. The interdisciplinary team at 300.000 km/s—made up of architects, artists, and data scientists—employs artistic methodologies of visualization and narrative framing to make complex urban data accessible and meaningful. Through data storytelling, aesthetic clarity, and performative mapping, the team transforms abstract datasets into shared civic knowledge. This artistic engagement enables citizens to see and understand the forces shaping their urban environment, fostering empathy, collective awareness, and agency.

Photos: Jorge Franganillo

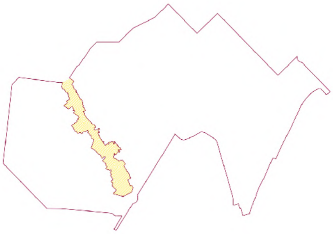
The second phase focused on co-creation through a large-scale participatory process facilitated by Decidim Barcelona,[1] the city's open-source digital democracy platform. Thousands of residents, business owners, and local organizations participated in workshops, interviews, and online consultations to co-author the plan, building a shared sense of ownership and civic responsibility. This process ensured that the resulting framework was both technically rigorous and socially legitimate—an uncommon balance in urban governance.

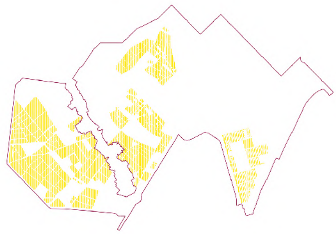
In the next phase, predictive simulation models were developed to anticipate the social and environmental consequences of new business activities, allowing for different scenarios to be tested and regulations to be adjusted accordingly. The final plan, approved in 2018, was implemented as a software tool that automates licensing and monitoring processes using transparent, data-based criteria. This system was actively used by the Barcelona City Council to manage urban activity, showing how civic technology can make public administration more fair, efficient, and trustworthy.

Officially approved in 2018, the plan stands as a milestone in European urban policy, merging artificial intelligence, artistic inquiry, and participatory democracy to uphold the city as a common good. Unlike corporate-led "smart city" models that concentrate power, *the Ciutat Vella Land-use Plan* shows how technology—when shaped by artistic thinking and ethical responsibility—can empower citizens instead of controlling them. Through data visualization, design thinking, and participatory processes, 300.000 km/s turns complex data into a tool for shared understanding and collective action. This approach represents a form of responsible innovation, where technology serves not only efficiency but also social well-being and inclusive governance. By involving citizens as co-creators and ensuring transparency in digital tools, the project demonstrates how art can help reshape political and economic systems from within. It reclaims technology as a democratic tool—one that rebuilds rather than disrupts, fostering sustainable, fair, and humane urban futures.

Primary authors: Mar Santamaria and Pablo Martínez (300.000 Km/s)
Legal and technical consultants: Graciela Chaia, Carlota Casanova and Daniel Lorenzo
Co-authors from Barcelona City Council: Gala Pin (city councilor); Jordi Rabassa, Santi Ibarra and Ferran Caymel (district councilors); Mònica Mateos (district manager); Josep M. Coll, Marc Pinedo and Ana Olalla (business licenses department); Yolanda Hernández, Tristan Llusà and Francesc Palau (lawyers); Barcelona City Council Planning Department
Participatory process: Raons Públiques SCCL
Preliminary studies: Universitat Autònoma de Barcelona (under the direction of Francesc Muñoz), Barcelona Public Health Agency, TAE and 300.000 Km/s

1. See https://www.decidim.barcelona.





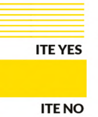
Single Zone

The district has a single regulation zone, except La Rambla and the harbour area.

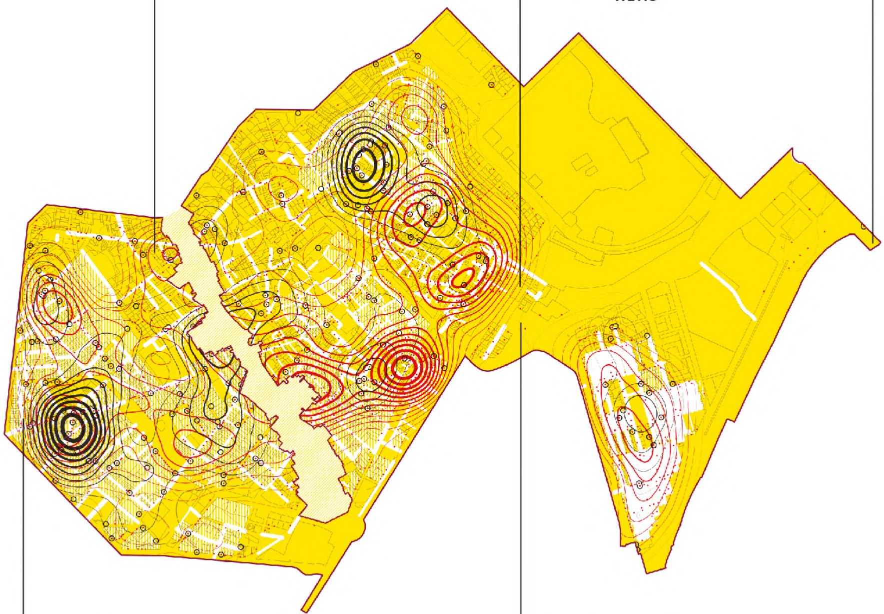
Road width

Restriction of auditoriums and supermarkets < 7m.

Vulnerability



In areas with extreme residential vulnerability a building quality certificate is required.



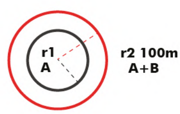
Day/Night

Auditoriums and concert halls
Music venues
Bars and restaurants
Gambling activities
Audiovisual
Food specialists
Small supermarkets
Meublés

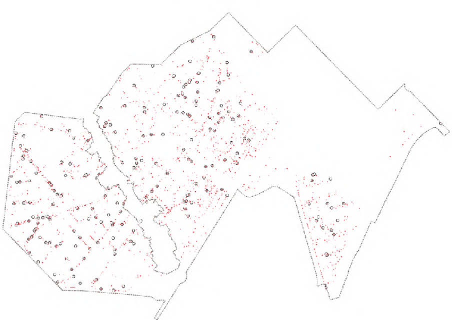
Theaters/cinemas
Sports
Cultural and social
Local products
Supermarkets
Personal mobility vehicles
Travel services

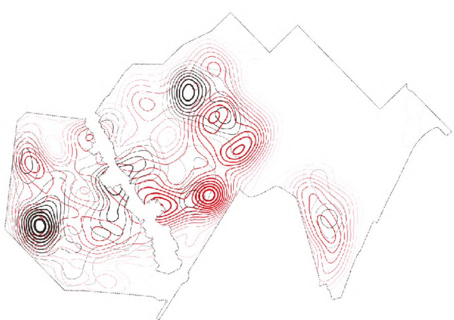
Double radius

Density of activities calculated in a double radius



Radius 1: same typology
Radius 2: nocturnal activities





Housing density

0 m2 housing/m2 land 15

69,6% premises are housing
7,6% premises are business
3,6% premises are offices

Population density

0 inhabitants/m2 of housing 0,005

774 inhab/Ha CVella (avg)
951 inhab/Ha Raval (máx)
622 inhab/Ha Bcn (avg)

2nd district with more unemployment rate
24% demand for social services

13.000 loss of population last 10 years
9,2% raise of rental prices (2013-15)

Quality of construction

0 Quality of construction indicator 9

4 m^2/m2 of land (avg)
4 floors (avg in residential buildings)
31% streets < 10 m wide
63% plots < 200 m2^2
150 m2 avg of business premises

Buildings before 1940
Buildings in poor conditions
Extreme residential vulnerability

Saturation of diurnal activities

0 m2 surface of premises 4.000

5 public establishment/Ha
20,98 public establishment/1.000 inhab.
28 public est. 50 m radious (max)

2.831 public establishment + hotel 2010
1.980 public establishment 2010

3.040 public establishment + hotel 2017
2.191 public establishment 2017

41,15 % bars and restaurants 2017

Saturation of nocturnal activities

0 m2 surface of premises 4.000

Demonstrated health impact due to noise of nocturnal activities.

Noise complaints related to **street cleaning and waste collection.**

Impact in the public space due to **overcrowding.**

Impact of logistics related to premises.

DïaloG

REFIK ANADOL (TR) AND MAURICE BENAYOUN (FR)

STARTS pillar
STARTS Technical Pilot (MindSpaces, 2019-21)

DïaloG is an interactive urban media art installation exploring themes of alterity, strangeness, and immigration through real-time interaction. Installed in a public space, it features two large, dynamic visual entities facing each other. These autonomous systems do not resemble known life forms and communicate through patterns of light, sound, and movement instead of spoken language. Equipped with sensors and data-processing algorithms, they react to environmental changes and the movements of passersby, translating this input into evolving visual and behavioral responses. As they attempt to interpret their surroundings and each other, they simulate the process of building understanding across differences.

The project reflects on how mutual understanding can emerge beyond linguistic and cultural divides, showing how technology can mediate empathy rather than isolation. As the two entities adapt and evolve, they mirror the relational dynamics of democratic societies, where communication, adaptation, and negotiation are constant. Beyond being an artwork, it operates as a participatory democracy tool—transforming urban space into an arena of social reflection. By inviting citizens to engage in a silent yet expressive conversation with these sentient forms, *DïaloG* nurtures awareness, responsibility, and inclusion. It exemplifies how artistic experimentation can drive responsible innovation, using technology to enhance civic dialogue, strengthen social cohesion, and inspire more empathetic and equitable public spaces.

Photo: Refik Anadol and Maurice Benayoun

The Wild Future Lab

KAIROS FUTURA (KE)

STARTS pillar
STARTS Prize Africa
(Grand Prize, 2025)

Stakeholders involved
designers, material researchers,
local artisans, farmers, textile specialists

Technology applied
open-source fabrication tools,
small-scale spinning and fiber-processing machines, wearable electronics,
digital storytelling systems

Industry areas addressed
sustainable fashion and textiles,
community manufacturing,
regenerative design, social innovation

The Wild Future Lab is a collective of artists, designers, scientists, and community leaders working together to address the urgent challenges of climate change and ecological loss. In their speculative worldbuilding and material research project they reimagine Nairobi in 2045 as a city transformed through ecological regeneration, local craft, and community-driven textile production. It explores how fashion and material design can support more resilient urban futures by relying on locally available resources rather than imported technologies or extractive global supply chains. *The Wild Future Lab* began by considering some urgent questions that many African cities face: How can designers respond to climate uncertainty with locally rooted solutions? What new relationships between humans and non-human species might flourish in post-extractive environments? Rather than producing a distant fantasy, the team developed tools, machines, and materials that could serve as practical foundations for rewilded, socially equitable futures.

To move beyond purely conceptual speculation, the collective combined traditional Kenyan craft knowledge with open-source technological development. Their research included systematic experiments in extracting and processing banana fiber, testing enzyme treatments, and mechanical methods to soften the material for garment use. They also conducted flax cultivation trials in Eldoret, built the tools needed to break and spin the fibers, and produced what may be the first linen thread created in Kenya since before World War II. These experiments serve not as exotic material showcases but as practical steps toward rebuilding resilient, local textile economies that have been eroded by decades of extractive global supply chains.

A key dimension of the project is its participatory methodology. A series of workshops with Nairobi-based designers used speculative scenarios of rewilded futures as a catalyst for creating functional garments and wearable technologies. Participants engaged in speculative scenario-making and practical experimentation, producing garments that

Top to bottom:

Photo: Ajax Axe

Photo: AdamsRop

TheWildFutureLab7 ©LeaOneko

respond to imagined ecosystems while grounded in real material pathways. As a result, they have developed climate-adaptive artefacts such as solar-charging jackets made from upcycled billboards and pollution-sensing eyewear built from locally sourced components. These workshops served as both creative laboratories and civic spaces, where designers collectively questioned how fashion might support ecological stewardship and urban resilience.

The project extends beyond studio-based work through a mobile lab, which travels across Nairobi to transform public spaces into temporary research hubs. Here, citizens engage directly with materials, tools, and future scenarios, contributing their own visions of rewilded urban life. The collective also created the Wild Future Tarot, a storytelling and decision-making tool that helps communities articulate hopes, fears, and priorities for ecological transition. These participatory methods ensure that future-making is not limited to experts but becomes a shared, accessible practice embedded in everyday life.

The Wild Future Lab ultimately presents fashion and design as forms of responsible innovation, demonstrating how new tools, wearable technologies, and community processes can emerge from local knowledge and collaborative experimentation. The project's strength lies in turning visionary storytelling into tangible prototypes, inclusive methods, and grounded infrastructures offering a realistic and regenerative pathway toward more equitable and ecologically resilient urban futures.

Concept and design: Kairos Futura
Kairos Futura: Abdul Rop, artist; Lincoln Mwangi, artist; Willie Nganga, scientist; Stoneface Bombaa, artist; Ajax Axe, artist; Coltrane McDowell, designer
Workshop facilitation: Kairos Futura team, New Order of Fashion, and Lea Oneko
Project development: Abdul Rop, Coltrane McDowell, Willy Ng'ang'a, Ajax Axe, Helen Milne
Project fashion designers: Mike Mwa, Maureen Shena, Stoneface Bombaa, Ajax Axe, Hisi Studios
Partners: New Order of Fashion Program
Support: Stimuleringsfonds
Textile production: Tosheka Textiles, Zaida Crafts
Design research: Abdul Rop, Willy Ng'ang'a, Ajax Axe, Lea Oneko, Coltrane McDowell

JACKET SPECIFICATIONS

TENT SPECIFICATIONS

KAIROS FUTURA

THE TENT JACKET

Into the E-Metropolis

AKWASI BEDIAKO AFRANE (GH),
CYRUS LOGNONNÉ KHALATBARI (CH)
AND ANWAR SADAT MOHAMMED (GH)

STARTS pillar
STARTS Residency (STARTS4Africa, 2023–24)

Into the E-Metropolis is a workshop-based initiative aimed at reshaping the narrative of Ghana's relationship with electronic waste, particularly at the Tantri area in Cape Coast, which is renowned for its large market. Contrary to the simplistic view of Ghana as a "computer graveyard", this project highlights the complex ecosystem of second-hand computer dealers, repairers, scrap-dealers, and metal casters.

By integrating traditional knowledge and techniques with contemporary technology and ecological concerns, the project collaborates with the artists and members of the scientific community to develop sustainable strategies that support and empower e-waste workers, many of whom face isolation and precarity due to a lack of shared infrastructure and knowledge. Through the lens of Afrofuturism, *Into the E-Metropolis* fosters meaningful discussions with these workers to collectively explore the past, present, and future of their knowledge and practices. Artists and workers are brought together through workshops and co-create a mobile makerspace hub with accessible toolkits and resources, as well artworks in augmented reality and 3D designed through the project.

Through community engagement and art-driven innovation, *Into the E-Metropolis* raises awareness about the important but often overlooked work of e-waste workers in both a dynamic and interactive way.

Photo: ASM STUDIOS

INVENT

Invent highlights projects that materialize new technological possibilities through hands-on experimentation with materials, fabrication methods, and applied innovation. Here, artistic inquiry becomes a driver for developing functional prototypes and production techniques that extend what can be built and how it can behave. The selected works range from smart textiles and responsive surfaces that rethink environmental interaction, to printable stone-based composites and granular jamming techniques that propose alternative construction logics. They include bio-based structures that are designed to decompose back into the soil, microbial energy systems for urban lighting, and compostable or regenerative designs that align fabrication with ecological cycles. Other projects focus on the tools and interfaces needed for artistic creation in digital and hybrid spaces, building new pathways for performance art and virtual production. Across these approaches, artists push fabrication into new domains by modifying industrial workflows, testing circular material streams, and combining craft with robotics or additive manufacturing. Together, these projects demonstrate how art-driven experimentation can yield tangible innovations that influence a variety of fields, from architecture and urban design to performance technologies, and sustainable manufacturing, expanding both the methods and the materials through which the built and digital worlds take shape.

Amsterdam's 3D Printed Steel Bridge

MX3D (NL) AND JORIS LAARMAN LAB (NL)

STARTS Pillar
STARTS Prize
(Grand Prize for Innovative Collaboration, 2018)

Creation time
2014–21

Stakeholders involved
designers and architects, engineers, robotic fabrication specialists, material scientists, construction experts, academic researchers, urban authorities.

Technology applied
3D printing, industrial robotics, advanced metallurgy, computational design, Wire Arc Addictive Manufacturing (WAAM)

Industry areas addressed
metallurgy, public sector, architecture, engineering, digital fabrication, industrial design, material research

The core research question driving *Amsterdam's 3D Printed Steel Bridge* is: How can robotic metal 3D printing be used to radically rethink the material, aesthetic, and structural possibilities of architecture and infrastructure? This inquiry unfolds at the intersection of design, engineering, and fabrication, proposing a fundamentally new approach to how we conceive, produce, and experience the built environment.

The core aim of the project is to reimagine construction materials and methods. The twelve-meter-long bridge, designed by Joris Laarman Lab and fabricated by Dutch design and technology studio MX3D, is the world's first fully functional 3D-printed steel bridge. Installed across a canal in Amsterdam's historic Red Light District, it demonstrates how additive manufacturing can unlock design freedoms that traditional construction methods cannot accommodate. As Tim Geurtjens, co-founder and CTO of MX3D, notes, 3D printing opens up a world of complex forms and geometries that were previously impossible, or prohibitively expensive, using standard fabrication techniques.

One of the key innovations of this project lies in its ability to reduce material waste and redundancy. Traditional steel or concrete structures often contain significant excess material for the sake of safety, as removing it would be too complex or costly. In contrast, the bridge's Wire Arc Additive Manufacturing (WAAM) process allows material to be deposited precisely where needed, following load paths and structural stress patterns with efficiency and elegance. The result is not only a more sustainable use of resources, but also an entirely new aesthetic language: curved, dynamic, and structurally expressive. The bridge curls in a subtle S-shape to connect two misaligned canal banks, with force lines and material thickness reflecting its engineering logic as well as its artistic vision.

This project serves as a compelling proof-of-concept for the future of architectural fabrication. It demonstrates

Top to bottom:

Photo: Adriaan de Groot

Photo: Joris Laarman Lab

that we are no longer bound by the limitations of mold-based or subtractive processes, and that large-scale metal structures can be directly printed using industrial robotics and computational design. The robotic arms used in this process are capable of printing in metal, plastic, concrete, and even fiber composites, thus they represent the next generation of adaptive fabrication tools, bringing flexibility and experimentation into the construction industry.

The bridge is also the result of a unique and open model of collaboration. Engineers, architects, material scientists, city officials, and academic researchers worked side by side to solve the technical and logistical challenges of deploying robotic 3D printing in a real urban setting. The project brought together expertise from industry leaders in metallurgy, construction, and robotics, alongside academic contributions from institutions like Arup and Imperial College London. While the bridge incorporates a sensor network that allows researchers to study its long-term performance, it is the material and design innovation, the realization of a digitally crafted steel structure at architectural scale, that defines its transformative power.

Rather than speculating on future scenarios, the bridge demonstrates in practical and public terms how artistic imagination and engineering experimentation can lead to a redefinition of what construction looks like and how it happens today. Its success is not only technical or functional; it is cultural, as it has opened a shared vision among engineers, designers, and citizens about what building with new materials can mean.

The project's relevance is particularly high for the architecture and construction industries, which are increasingly seeking low-waste, adaptive methods to meet the demands of sustainability and urban complexity. It is equally significant for designers and artists, for whom it showcases a new sculptural vocabulary rooted in algorithmic control and material logic. For academic researchers, it provides a real-world case study for exploring the structural behavior and lifecycle of additively manufactured metal components. While it remains a utilitarian piece of infrastructure, the bridge's greatest contribution is perhaps symbolic: it connects an ancient city to a future of making that is more precise, expressive, and materially intelligent.

By combining robotics, computational design, metallurgy, and data systems into a single urban object, the 3D-printed bridge not only expands the vocabulary of infrastructure, it shifts the paradigm. It opens up space for thinking about cities as responsive environments shaped by cross-disciplinary collaboration, aesthetic vision, and technological imagination.

This project is a collaboration by MX3D and Joris Laarman Lab.
Robotic 3D-printing, concept, innovative collaborations, execution: MX3D
Design, concept and bridge design: Joris Laarman Lab MX3D Team (current): Gijs van der Velden, Tim Geurtjens, Joris Laarman, Anita Star, Filippo Gilardi, Boyan Mihaylov, Kasper Siderus, Casey Hemingway, Thomas van Glabeke, Jean Francois Moulin, Barney Salsby, Rasmus Frankel, Diane Toxopeus, Cas Nieuwland, Daan Goedkoop, Teun van der Velden.
With the collaboration of: The Alan Turing Institute, Autodesk, ArcelorMittal, Arup, Lenovo, ABB, Airliquide, Gemeente Amsterdam, The Amsterdam Institute of Advanced Metropolitan Studies, Heijmans

Stone Printing

ISAAC MONTÉ (BE)

STARTS pillar
STARTS Technical Pilot (Better Factory, 2020–24)

Stone Printing is a new manufacturing approach developed by artist Isaac Monté that turns stone-based waste into a 3D-printable material. It began as a collaboration with Europack Bulgaria and OVISO Robotics in the framework of the Better Factory project to explore new applications for stone paper and increase production efficiency. Through a series of experiments, the project evolved into the world's first stone-paper 3D-printing system, boosting production capacity and generating both improved grow-tube designs and entirely new products. The artist uses a self-developed cutting-edge, eco-conscious material developed from $CaCO_3$, a byproduct of the limestone industry, and engineered an extrusion system designed for cold extrusion of biobased materials. This system seamlessly interfaces with several 3D printers and robotic arms offering versatility in print dimensions.

By reinventing how stone-derived materials can be processed and applied, *Stone Printing* expands the technological possibilities of digital fabrication. Instead of relying on conventional plastic-based filaments, the project proposes a circular and renewable alternative sourced from industrial waste streams. It introduces new workflows for extrusion, new material recipes, and new aesthetic possibilities that bridge craftsmanship with automation. The work demonstrates how artistic experimentation can lead to practical, scalable innovations, supporting sustainable manufacturing, reducing resource extraction, and opening space for bio-inspired material systems. Through this integration of design, engineering, and environmental thinking, *Stone Printing* offers a tangible model for how next-generation materials and production methods can reshape both industry and creative practice.

Isaac Monté
Oviso Robotics
V3DA
With the generous support of Creative Industries Fund NL

Top to bottom:

Photo: Beer van Hees

Photo: Beer van Hees

Photo: tom mesic

Ambient Weaving

YASUAKI KAKEHI LAB, UNIVERSITY OF TOKYO, HOSOO CO., LTD., AND ZOZO NEXT, INC. (JP)

STARTS pillar
STARTS Prize
(Honorary Mention, 2022)

Creation time
2020–21

Stakeholders involved
textile artisans, material scientists, interaction designers, environmental researchers

Technology applied
advanced fiber materials, environmental sensing technologies, data-responsive weaving systems, traditional Nishijin textile techniques

Industry areas addressed
material research, smart materials, textile innovation, environmental design and architecture, cultural heritage

The project *Ambient Weaving*, developed by Hosoo Co., Ltd. in collaboration with the Yasuaki Kakehi Laboratory at the University of Tokyo and ZOZO NEXT, Inc., is an ambitious exploration of how traditional textiles can be transformed into interactive media that reflect, respond to, and shape their surrounding environments. Presented first in 2021 and expanded through the 2023 exhibition *Ambient Weaving* II at Hosoo Gallery, the project reimagines the role of textiles in contemporary life, not only as decorative or functional surfaces, but as active and responsive participants in the formation of space.

The central research question guiding the project is: How can textiles become environmental interfaces, mediating the relationship between humans, nature, and space through technological and material innovation? In response, the team developed a series of prototypes that make environmental phenomena, such as changes in light, air, and atmosphere, visually perceptible through the structure and surface of woven textiles. These materials are neither static nor purely decorative; instead, they invite a reconsideration of what it means for space to be alive, ambient, and co-constructed by human and non-human forces.

The outcomes of the project are both artistic and technical. By combining traditional Nishijin weaving, a technique developed in Kyoto for over 1,200 years, with advanced fibers and sensing technologies, *Ambient Weaving* introduces a new class of materials that are at once rooted in craft and oriented toward the future. The 2023 exhibition featured a collection of such prototypes alongside Ori-An, a tearoom constructed from washi-based gauze woven using the Nishijin sha technique. In this structure, space is defined not by walls but by translucent, breathing surfaces that blur the boundary between interior and exterior, nature and culture. The juxtaposition of traditional aesthetics with interactive textiles proposes a contemporary language for spatial design, one that is tactile, poetic, and environmentally aware.

Beyond its material innovation, the project is a compelling example of STARTS's relevance, showing how the intersection of science, technology, and art can produce new forms of knowledge and perception.

Photos: hosoo

Ambient Weaving offers an experiential and conceptual redefinition of textiles as a medium of environmental communication, reconnecting the tactile intimacy of fabric with the distributed systems of sensing and information that define the Anthropocene. The project does not merely decorate space; it challenges how we experience it, calling attention to unseen environmental dynamics and turning them into a source of aesthetic and cultural reflection.

Ambient Weaving clearly aligns with the ambition to create novel tools, materials, and environments through interdisciplinary collaboration. It contributes to the invention of a new type of interface, one that is soft, flexible, and deeply embedded in everyday life. Unlike conventional screens or digital devices, these woven media invite slowness, attentiveness, and embodied engagement. The ambition is not only to invent new materials, but to reframe the role of design and technology in shaping how we dwell. By building upon ancient techniques and recontextualizing them through emerging technologies, the project invents a future that is continuous with the past, yet radically transformed by our contemporary concerns with ecology, perception, and responsiveness.

Hosoo Co., Ltd.: Masataka Hosoo, Hiroshi Kanaya, Kotaro Uchibe, Naotoku Yasuta
Yasuaki Kakehi Lab., The University of Tokyo: Yasuaki Kakehi, Yumi Nishihara, Hitomi Kuboki, Juri Fujii
ZOZO NEXT, Inc.: Satoshi Nakamaru, Kotaro Tajima
Exhibition Design: Kumiko Idaka, Rurihiko Hara, Takayuki Suo, Yugo Minomo

Rock Print

GRAMAZIO KOHLER RESEARCH, ETH ZURICH (CH), AND SELF-ASSEMBLY LAB, MIT (US)

STARTS pillar
STARTS Prize (Grand Prize for Innovative Collaboration, 2017)

Rock Print is an architectural investigation, conducted by Gramazio Kohler Research and the Self-Assembly Lab, into the constructive principle of the physical phenomena of jamming, where loose particles like gravel can shift from fluid to solid states. The project uses a custom 3D-printing process by combining robotic fabrication and granular jamming. A robotic arm lays a continuous network of tensile string while layers of granular material are poured, creating precisely jammed, load-bearing forms without any binding agents. When the string is pulled, the structure disassembles, returning materials to their original state.

This reversible, material-efficient system offers a radical alternative to conventional construction, replacing permanent binding with controlled aggregation and release. As robotics become more deeply integrated into construction, both on- and off-site, building processes are likely to shift toward greater automation and reduced manual labor. *Rock Print* embodies this transition, showing how digital fabrication and material intelligence can work together to redefine how structures are designed, assembled, and reused. This project not only proposes a truly sustainable construction method but also establishes a new design logic that transforms digital fabrication and self-organization into tools for shaping resilient and circular built environments.

Collaborators: Fabio Gramazio, Matthias Kohler, Skylar Tibbits, Andreas Thoma (project lead installation), Petrus Aejmelaeus-Lindström (project lead research), Volker Helm, Sara Falcone, Jared Laucks, Lina Kara'in, Michael Lyrenmann, Carrie McKnelly, George Varnavides, Stephane de Weck, Jan Willmann
Selected experts: Hans J. Herrmann and Falk K. Wittel (Institute for Building Materials, ETH Zurich), Heinrich Jaeger and Kieran Murphy (Chicago University)
Selected consultants: Walt + Galmarini AG
Supported by ETH Zurich, ETH Zurich Foundation Grant, MIT's Department of Architecture, the MIT International Design Center, MIT (MISTI) Grant, Pro Helvetia Swiss Arts Council, swissnex, MISAPOR Beton AG

Photo: Gramazio Kohler Research, ETH Zurich

GR-AI-N

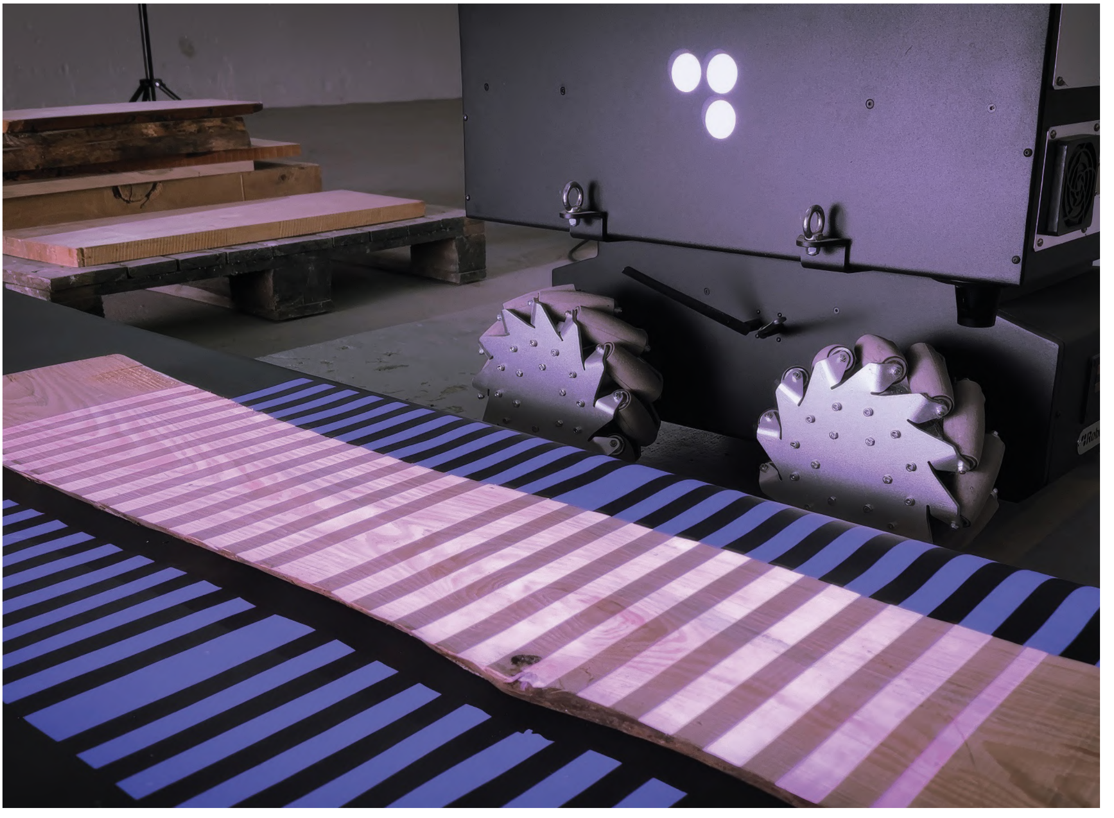
MARIELENA PAPANDREOU (GR)

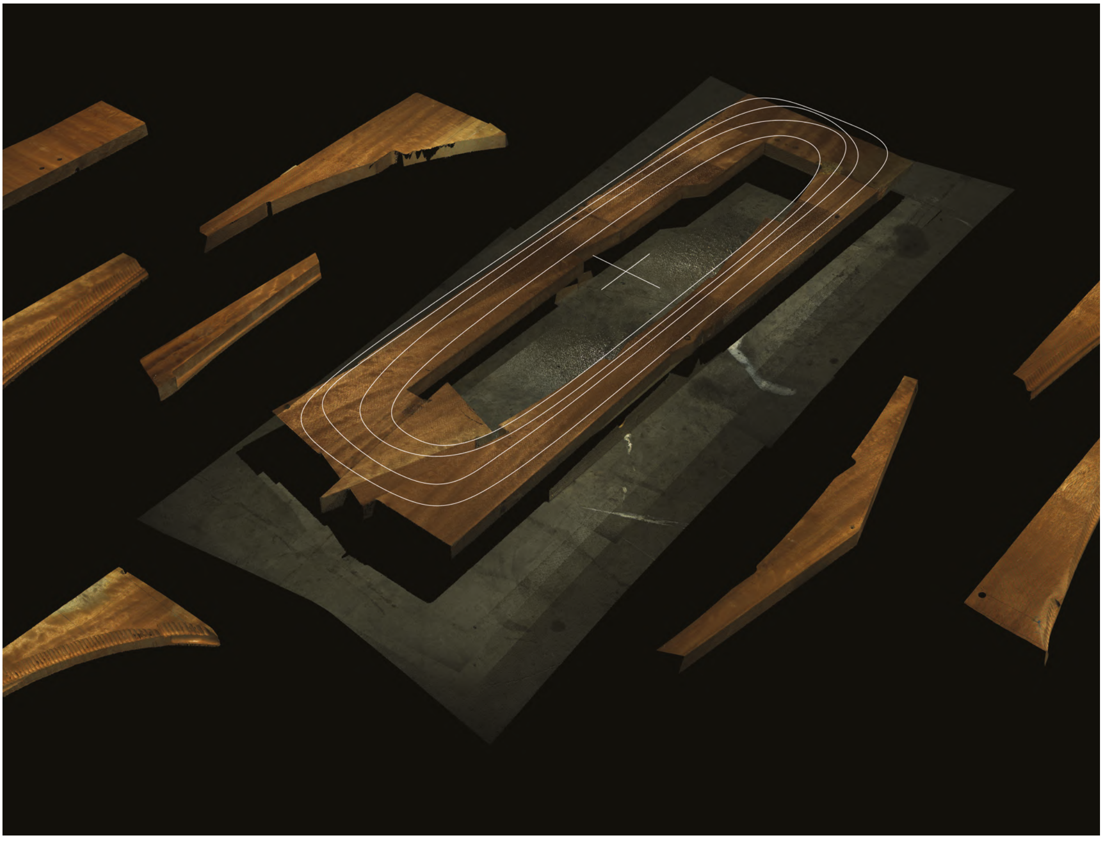
STARTS pillar
STARTS Technical Pilot (VOJEXT, 2020–23)

GR-AI-N is a robotic fabrication project that turns timber offcuts—which are normally thrown away—into wooden objects. Developed by the artist Marielena Papandreou in collaboration with Robothnik, the system combines computer vision, AI analysis, and robotic manipulation to evaluate discarded pieces of wood and integrate them into new, high-quality designs. A dual robotic end-effector equipped with vacuum grippers and a high-resolution depth camera scans each offcut, capturing its geometry, grain pattern, texture, and imperfections. AI tools then interpret this data to propose forms that follow the wood's natural contours rather than cutting against them. Instead of gluing large billets and carving them by hand, the workflow is based on assembling a 3D mosaic of irregular fragments, allowing robots to position, join, and finish them with minimal manual effort. The result is a production method that makes use of material that would otherwise be lost while extending the lifespan of carbon stored in the wood.

By creating a full digital-to-physical toolchain for processing timber waste, *GR-AI-N* advances material practices within sustainable manufacturing. Its approach positions robotics not as a substitute for craft but as a means to expand it for preserving grain continuity and improving efficiency. The project demonstrates how innovation in scanning, assembly, and AI-guided design can turn overlooked resources into valuable products. Thus, *GR-AI-N* offers a concrete example of material invention: a new workflow, a new application for industrial leftovers, and a new way to merge technological precision with ecological responsibility.

VOJEXT STARTS Art Residence 2: Robotics in Arts and Crafts received funding from the European Union's Horizon 2020 research and innovation program under Grant Agreement 952197
Residence led by VOJEXT PARTNERS: Robotnik and WAAG
Collaborative partner: Vincent Huyghe
With support from: TMDC, an open-access workshop in Barcelona, offered space and manufacturing facilities. IAAC, in a generous gesture, provided a UR10 for preliminary testing of the scanning workflow before the mobile platform's arrival in Barcelona





Geo-Llum

SAMIRA BENINI ALLAOUAT (IT/ES)

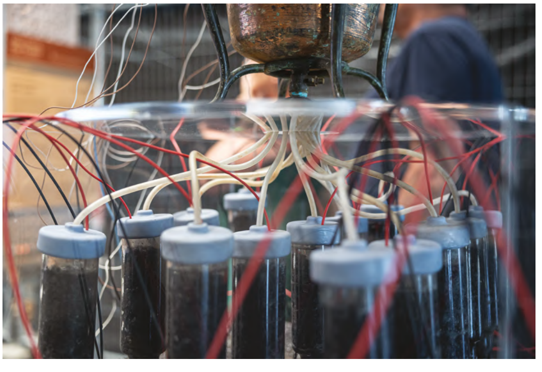
STARTS pillar
STARTS Regional Centers (Repairing the Present, 2021-22), STARTS Prize (Nomination, 2023)

Creation time
2021–22

Stakeholders involved
urban innovation hubs, environmental scientists, bioengineers, sustainable design researchers, circular economy experts

Technologies applied
bioelectrochemical systems, microbial fuel cells, bioremediation, 3D printing with biomaterials, circular design

Industry areas addressed
urban sustainability, bioenergy, public infrastructure



Geo-Llum is a prototype for a self-sustaining public lighting system powered by bacteria that generate electricity while purifying the soil. Developed by artist Samira Benini Allaouat during the STARTS Repairing the Present residency, which was hosted by CCCB (Centre de Cultura Contemporània de Barcelona), Sónar, and UPC (Universitat Politècnica de Catalunya), the project offers an imaginative, sustainable response to the challenge: How can we integrate microorganisms to design more sustainable cities?

The project was created with the support of Akasha Hub in collaboration with Green City Lab and Bioé Group (IMDEA Agua) led by biotechnologist Abraham Esteve Nuñez. *Geo-Llum* draws on advanced microbiological research to merge environmental remediation and energy generation. Central to the project are geobacters, anaerobic electroactive bacteria known for their ability to oxidize organic compounds and metals, including iron and uranium, while producing an electric current. These microorganisms thrive in oxygen-free soils and aquatic sediments and are used in bioremediation strategies to detoxify polluted environments such as industrial sites and rice fields.

Building on this potential, *Geo-Llum* transforms soil into a living electrical circuit. Its structure, made from recycled and biomaterial-based elements and partially 3D-printed, integrates a microbial fuel cell powered by this geobacter bacteria. As the bacteria generate electricity, they simultaneously clean the surrounding soil, enabling a lighting system that is both self-powered and regenerative. The prototype also includes rainwater collection features and a modular design that can adapt to different urban contexts, combining public lighting, soil decontamination, and renewable energy in a single system.

At the same time, *Geo-Llum* opens up a broader discussion about the intersection of the artificial and the natural in urban life, particularly in the context of lighting, essential for humans yet often disruptive for other species. By placing microorganisms at the core of urban design, the project advocates for a new kind of infrastructure where technology, ecology, and aesthetics coexist symbiotically. It was also included in Barcelona's first bioremediation pilot program at Hort del Clot, contributing to ongoing experiments in urban environmental recovery.

Top to bottom:

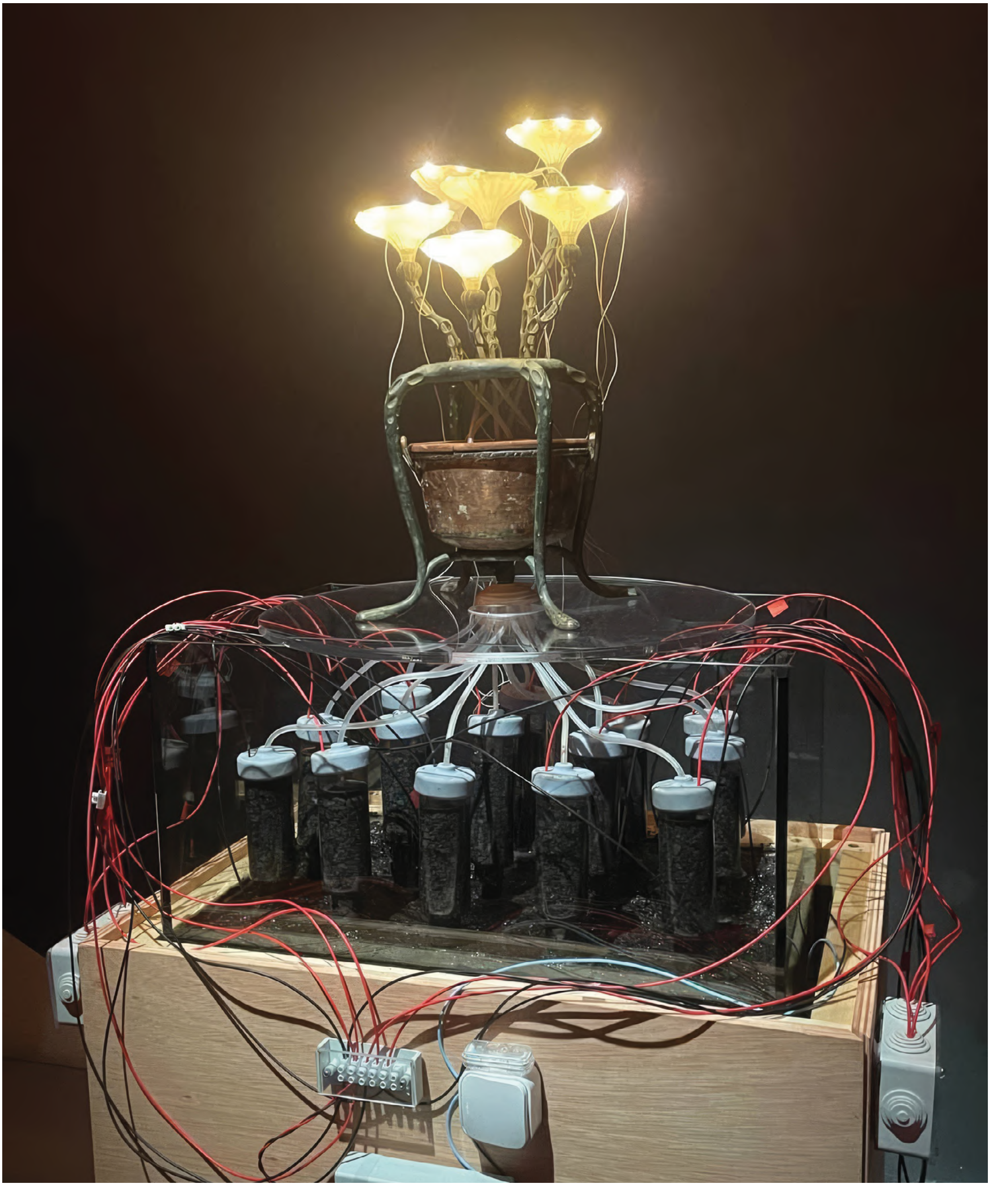
Photo: tom mesic

Photo: Courtesy of the artist / Samira Benini Allaouat

Photo: Courtesy of the artist / Samira Benini Allaouat

Geo-Llum demonstrates how artistic research can materialize into concrete innovations that unite sustainability, design, and applied science. By bridging art, biotechnology, and engineering, it proposes a living, bioelectrical infrastructure that not only produces light but also regenerates the environment that sustains it. Through microbial intelligence, renewable energy, and open, experimental fabrication, the project challenges conventional urban systems and imagines cities as collaborative ecosystems where technological progress evolves in harmony with natural processes rather than at their expense.

Credits
Derek Lovley
Abraham Esteve Nuñez/Bioe Group
Miguel Alegre
Akasha Hub
Green City Lab



Compostable Altar

BETIANA PAVÓN (AR)

STARTS pillar
STARTS Technical Pilot (Hungry EcoCities, 2022–26)

Compostable Altar is a biodesign experiment that resulted in an installation transforming agricultural by-products into a living, biodegradable structure. Developed by artist Betiana Pavón in collaboration with the agroecological farm Le Terre di Zoè in Calabria, the project uses local organic waste, such as fruit pulp and processing residues, to create a material for 3D printing. From it, the artist forms a large-scale altar designed to gradually decompose and return nutrients to the soil. Throughout the research process, sensors monitored pH, temperature, humidity, electrical conductivity, and nutrient cycles, generating data on how the soil responds to the altar's breakdown. This information informed an adaptive design workflow combining parametric modeling and AI predictions, turning decomposition into an active part of the artwork's form and behavior.

By turning waste streams into functional, regenerative material, *Compostable Altar* opens new possibilities for sustainable fabrication. The project demonstrates how bio-based matter can replace conventional construction materials and how digital fabrication can be aligned with ecological timescales. Its open-source methodology offers farmers and designers a replicable model for circular production where organic by-products become resources rather than waste. In combining environmental monitoring, biomaterial innovation, and regenerative agriculture, the project reimagines how we build, showing that design can support soil health, biodiversity, and community rituals. As a prototype for sustainable material culture within the agri-food system, *Compostable Altar* contributes to rethinking production, waste, and material culture, offering an alternative vision in which design becomes an act of care and regeneration.

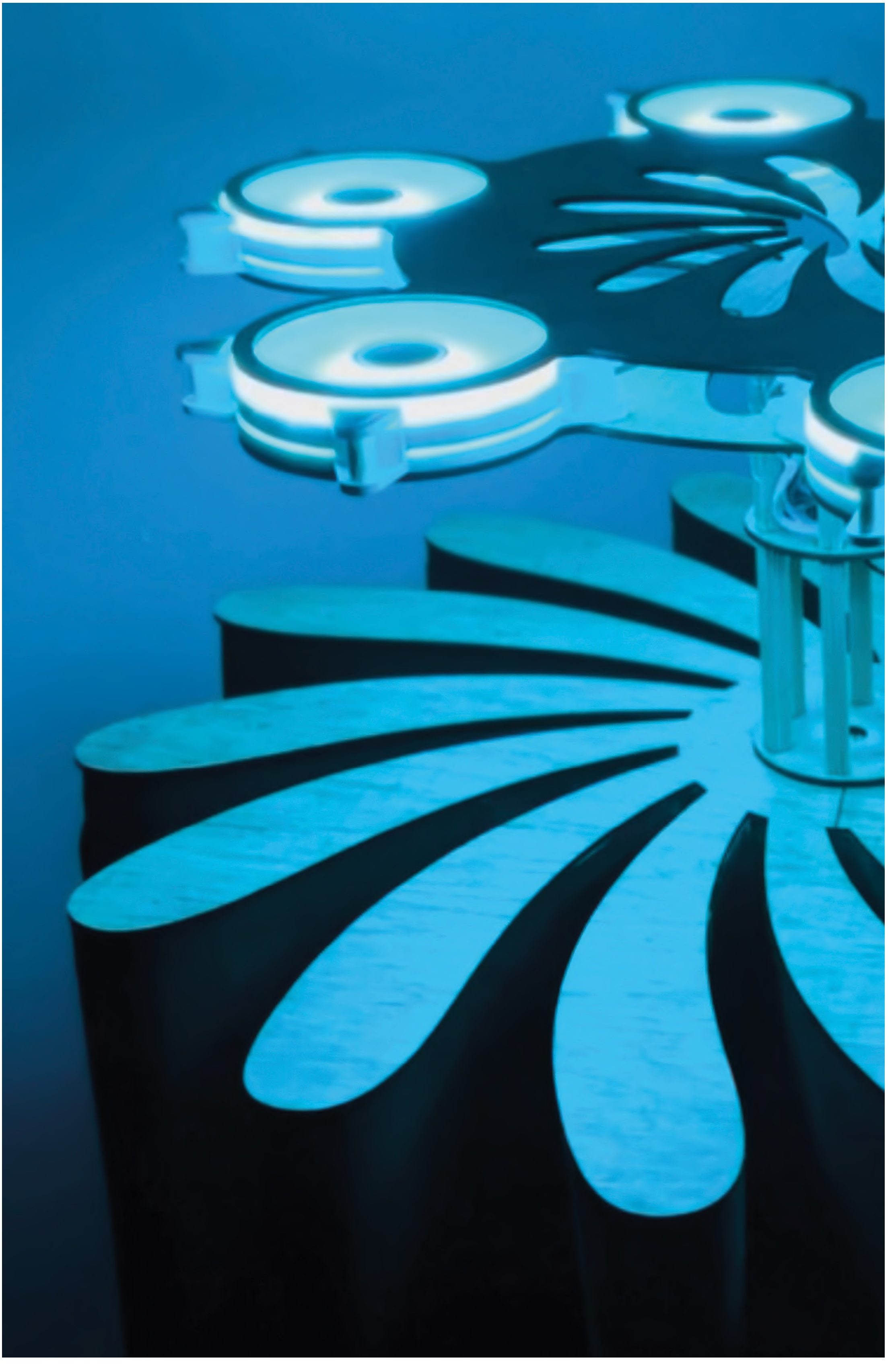
Re.Source Society

NICOLÁS ROTTA (ES)

STARTS pillar
STARTS Technical Pilot (Hungry EcoCities, 2022–26)

Re.Source Society is a research-driven design project by Nicolás Rotta that develops low-energy climatization systems and regenerative metabolic infrastructures for small-scale food production. The work began as a collaboration with InstaGreen to prototype climate-control solutions for indoor farms using minimal resources. Drawing from biomimicry and passive cooling strategies, Rotta developed methods that regulate temperature and humidity through terracotta components, optimized water cycles, and natural air exchange. In parallel, he designed a regenerative nutrient and energy system that integrates anaerobic digestion, aerobic composting, and hydroponics. Sensors and simulations—built in Grasshopper and Python—guided an iterative prototyping process in which organic waste was transformed into heat, biogas, warm water, food, and nutrient-rich humus, closing the nitrogen cycle and storing atmospheric carbon in soil.

By combining ecological engineering, low-tech principles, and digital design, *Re.Source Society* invents new models for urban metabolism. Instead of treating waste, heat, and nutrients as separate problems, the project merges them into a single circular system that supports both food production and energy generation. Its approach demonstrates how DIY fabrication, predictive modeling, and regenerative material flows can replace resource-intensive infrastructure with accessible, closed-loop alternatives. The project shows a pathway toward buildings and urban farms that heat themselves, grow food, recover nutrients, and produce renewable energy—all with minimal inputs. In doing so, *Re.Source Society* expands what sustainable fabrication can be, offering a blueprint for future systems that integrate biology, engineering, and design into resilient, self-regenerating environments.



MetaPhase

GIUSY CARUSO (BE) AND LWT3 (IT)

STARTS pillar
STARTS Prize (Honorary Mention, 2023)

Creation time
2021–ongoing

Stakeholders involved
performing artists, HCI engineers, music researchers, XR developers, data specialists

Technologies applied
surface electromyography (sEMG), motion tracking, XR/VR, Unity, wearable sensor technologies

Industry areas addressed
performing arts, human-computer interaction, phygital interfaces, creative data processing, digital fabrication for performance

MetaPhase is an experimental XR performance system that merges biometric sensing, motion tracking, and virtual embodiment to prototype new modes of human-machine interaction in hybrid spaces. Developed through a collaboration between pianist-researcher Giusy Caruso and the Italian innovation start-up LWT3, the project investigates how corporeal expressiveness can be captured, processed, and re-materialized as a responsive digital agent. At the center of the work is a wearable sensor prototype designed by LWT3, capable of acquiring surface electromyography (sEMG) signals together with optical motion data. These biometric streams feed into a Unity-built virtual environment in which the pianist encounters her virtual double, creating a performance space where musical identity is duplicated, altered, and recombined in real time.

The research examines how performative elements can be translated into XR conditions and how this shift changes both musical interaction and audience perception. To build the virtual counterpart, Caruso recorded the first piano part of Steve Reich's Piano Phase with corresponding muscular and motion data; these were synchronized to animate an embodied avatar whose behavior mirrors the nuance of her real performance. During the live event, the pianist performs the second part while wearing the biometric suit and VR headset, engaging in a phygital duet where phase shifts, posture adjustments, and head-nod cues become amplified to function clearly in virtual space.

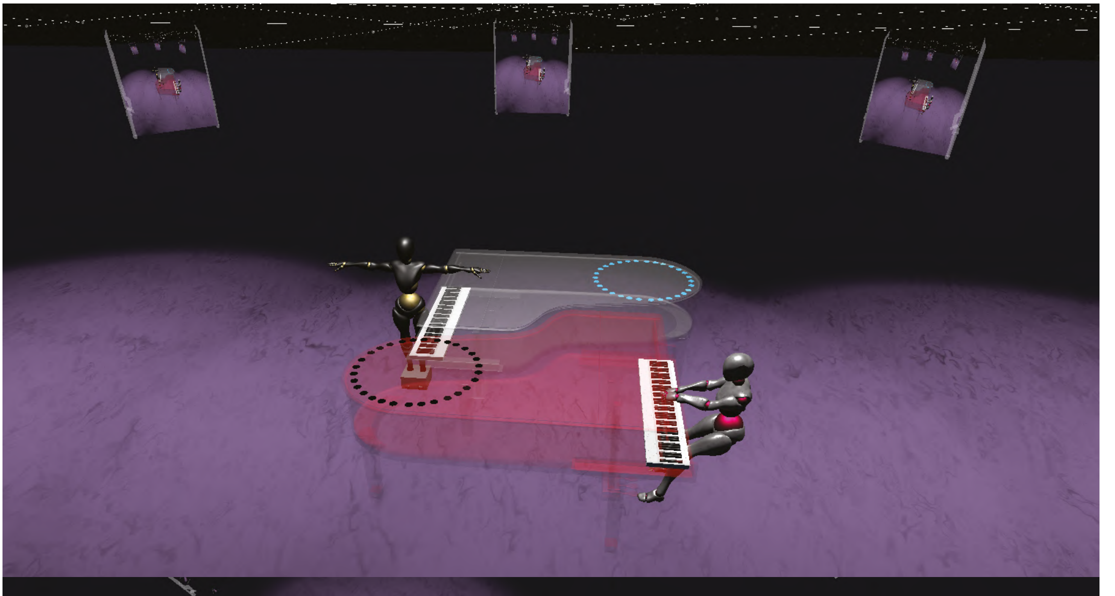
The audience experiences a hybrid environment that foregrounds the relationship between gesture and sound: they see both the physical pianist and the XR scene, and can later re-enter the recorded performance through VR headsets to explore alternative viewpoints or examine the underlying biometric metadata. This dual format expands the public's sensory and analytical access to musical expression as it has the remarkable ability to reveal embodied musicianship with unprecedented clarity.

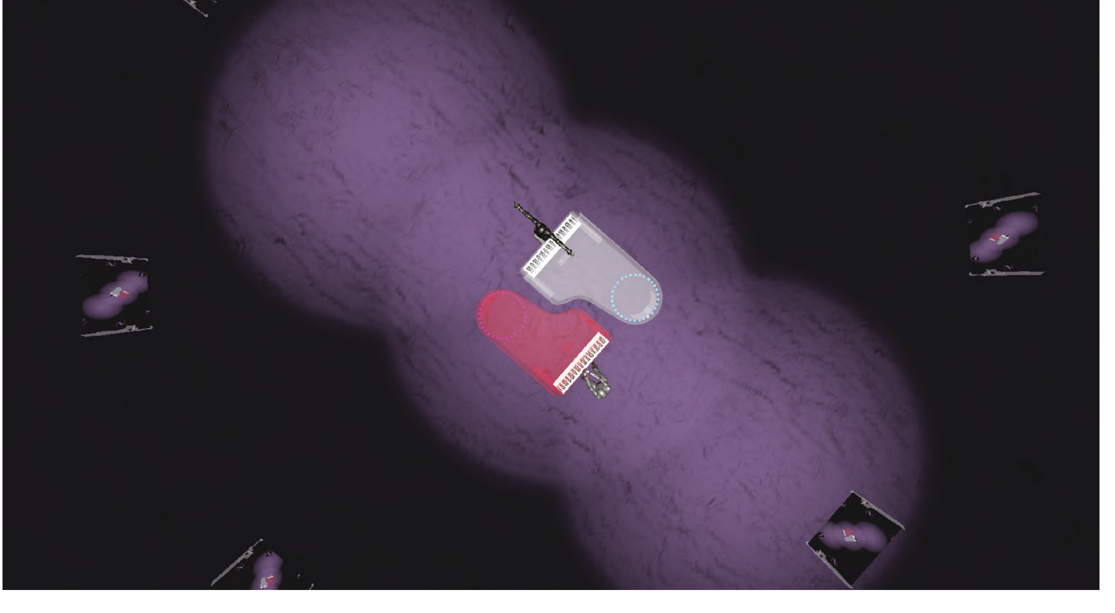
MetaPhase demonstrates how artistic experimentation can result in tangible tools and methods for applied innovation. By integrating a lightweight wearable, a motion-data workflow, and an adaptive XR environment, the project creates a functional prototype that connects physical gesture to digital behavior with high precision.

Its hands-on, cross-disciplinary development process embodies the spirit of innovation driven by artistic inquiry, demonstrating how creative exploration can open new pathways for the digital performance's methods.

Thus, the project advances the development of new products, methods, and future-oriented performance interfaces through iterative prototyping, material experimentation, and open technological processes. It expands how performers and audiences inhabit technologically mediated spaces and exemplifies an approach in which artistic excellence and technological innovation mutually reinforce each other, opening up new possibilities for how we experience music performance in the digital age.

Concept and pianist (Royal Conservatoire Antwerp, IPEM – University Ghent): Dr. Giusy Caruso
LWT3 Team:
Hardware and data engineer: Dr. Paolo Belluco
Designer and VR director: Samuele Polistina
VR developer: Andrea Randone
Fashion and product designer: Luigi Sossi
With support from: Royal Conservatory of Antwerp, IPEM – University Ghent, Yamaha Music Europe






YAMAHA
YAMAHA

EXPLAIN

Explain addresses projects in which artistic inquiry operates as a mode of knowledge production in its own right. In these cases, artists work alongside scientists, technologists, and researchers to construct new ways of understanding complex systems, treating artistic methods as epistemological tools that can stand alongside conventional scientific research. Rather than centering public mobilization around urgent socio-political issues, these projects work on the level of knowledge itself—how it is produced, structured, and shared across disciplines. Across the cluster, data visualization, predictive modeling, critical cartography, and hybrid installations uncover patterns that are otherwise difficult to perceive: oceanic transformations, the long genealogies of technological power, biological processes as the hidden architectures of breathing, the flows shaping financial systems, or microscopic changes in glacial bodies. By creating environments that invite close attention—through immersive simulations, material artefacts, large-scale mapping, or interactive installations—the projects enable audiences to grasp connections that remain abstract in scientific formats. In doing so, artists not only communicate existing research but also produce new forms of knowledge, contributing insights that complement and sometimes challenge established scientific perspectives. This cluster also demonstrates how artistic inquiry can expand science communication into a shared space of learning. Thus, the projects broaden access to scientific reasoning and enrich the shared vocabularies through which complex worlds become knowable.

Oceans in Transformation

TERRITORIAL AGENCY (INT), JOHN PALMESINO (IT)
AND ANN-SOFI RÖNNSKOG (FI)

STARTS pillar
STARTS Prize
(Grand Prize for Artistic Exploration, 2021)

Stakeholders involved
scientific institutions (ESA, NOAA,
and national research programs),
academic researchers, environmental NGOs

Technology applied
geospatial and remote-sensing
data integration, satellite imagery,
sonar mapping, AI-assisted data analysis,
hybrid visualization methods

Industry areas addressed
climate science and oceanography,
environmental policy, geospatial analysis,
sustainability education

The transformations that our planet has been undergoing for decades, and the current state of the climate catastrophe that these transformations have amounted to, are undeniable. So many different areas of human and non-human life have been affected that it is sometimes difficult to keep track. *Oceans in Transformation* is an attempt to zoom in on one particular area—the world's oceans—with the mission to sense, visualize, and understand the complex, multi-scalar transformations of these immense bodies of water under the intensifying pressures of the Anthropocene. How can art, science, and technology collaboratively develop new perceptual modes for encountering the ocean? How can fragmented, difficult-to-access oceanic data be recombined to tell new stories and foster collective understanding and action? What role can the ocean play as a "sensorium" in revealing the entangled dynamics of climate, culture, politics, and ecological violence? In this project, three years' worth of intensive intersectional research culminated in a detailed body of methodologies and a number of scientific as well as artistic outcomes. The groundwork was laid by the aggregation of data to be visualized—not an easy task given the multitude of sources. A huge amount of multi-temporal open-access geospatial and remote-sensing datasets, from institutions like ESA, NOAA, and other national programs, needed to be collected, organized, and integrated with each other as well as with two largely independent knowledge systems: Earth System Science (e.g., sea level rise, acidification, overfishing, etc.) and long-term World-systems Analysis (e.g., historical extractivism, migration, etc.).

The development of hybrid approaches to visualization that span scientific modeling, artistic storytelling, and political cartography was necessary to create the resulting visuals, carefully arranged in multimedia exhibitions that successfully synthesized the gathered remote sensing imagery, data visualizations, and spatial compositions into a dynamic, aesthetic, and conceptual installation. From these visuals, seven distinct "trajectories" (e.g. "North Sea to Red Sea", "Humboldt Current", etc.) emerge—conceptual, geographical,

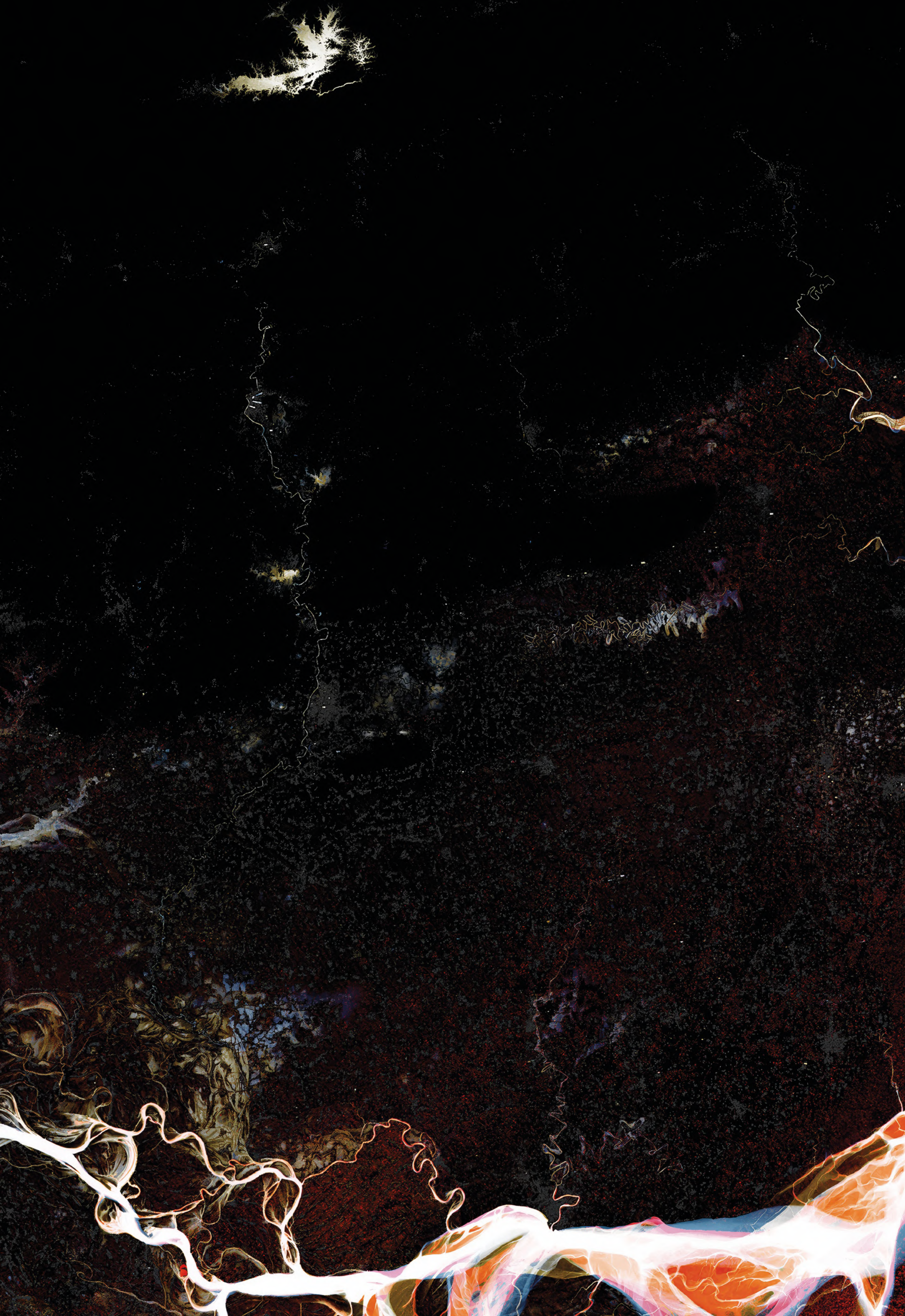
Photos:
Territorial Agency: Oceans in Transformation,
Ocean Space, Venice, Italy, 2021

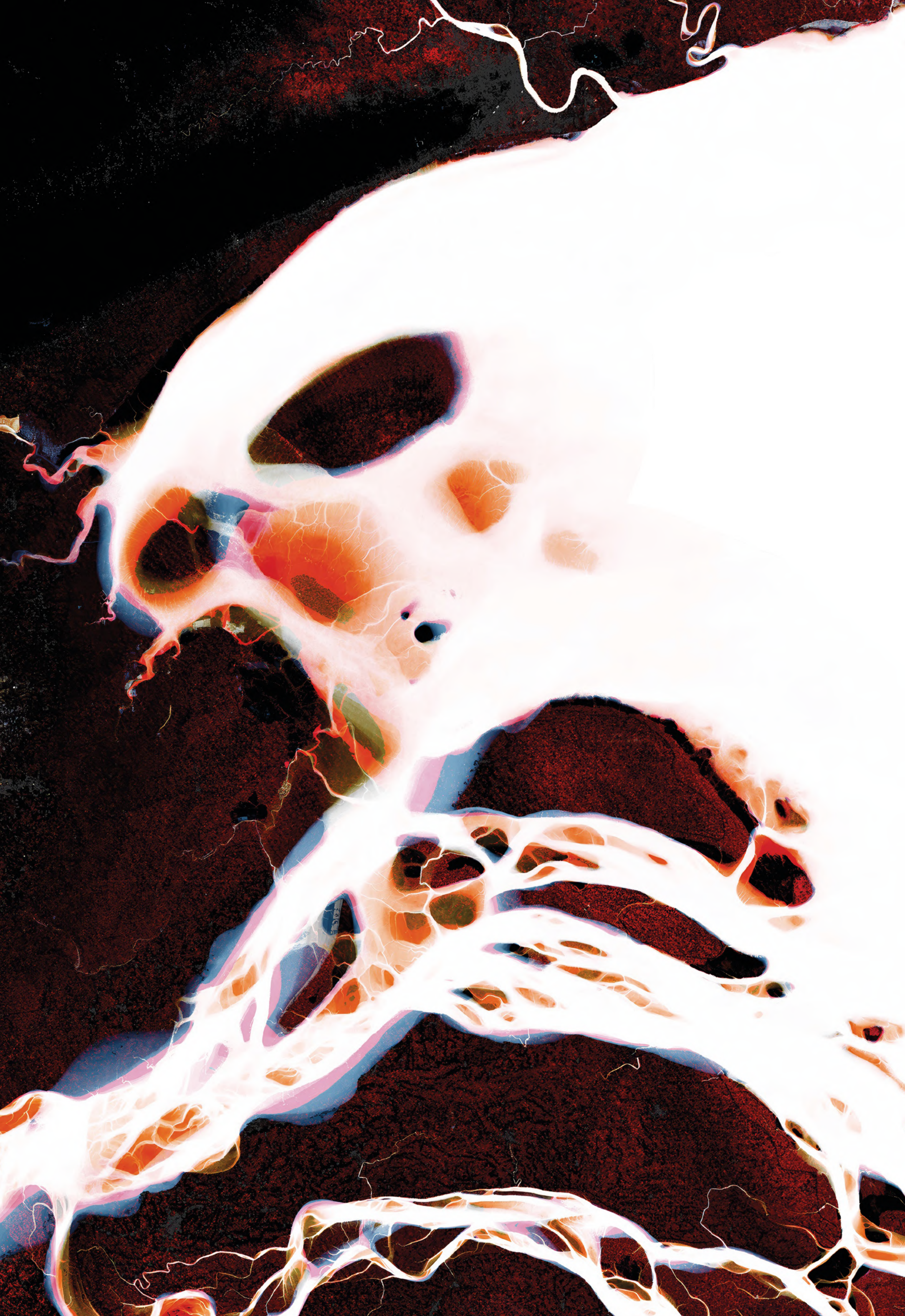
and narrative lines that visualize transformations in the ocean and re-map concrete maritime spaces as sites of violence, climate crisis, and colonial legacies. But the visual exhibition and its online archive are not the only ways to engage with the topic—a series of workshops and collaborative research formats compliment the work and invite policymakers, activists, and the general public to engage with the data and look for ways to take action.

The STARTS ethos is embodied on all levels, as scientific models of the earth are used alongside technological tools, such as satellite imagery, sonar, AI, and geospatial tools, in an artistic fashion—conceptualizing and translating scientific insights into visual, spatial, and narrative forms that resonate with diverse audiences through tangible, emotional experiences. Hidden patterns of extractivism, ecological violence, and global entanglements are revealed as the invisible processes of ocean transformation are made visible, sensible, and politically relevant. And while academia and the art world are left with a fascinating ledger of methodologies between data-driven art practice and art-driven innovation, environmental NGOs and policymakers are provided with shared imagery and conceptual tools that could inform marine policy, conservation strategies, and communication efforts while encouraging integrated thinking about human impact, sustainability, and ocean governance.

Oceans in Transformation shows how artistic and academic research can successfully coalesce to not only inform each other but also educate and emotionally and intellectually engage experts, policymakers, and a general audience—building ocean literacy and fostering empathy for complex marine issues. Through highlighting the trenches between our epistemological disciplines, emphasizing the amount of necessary in-depth research and artfully reiterating humanity's deep connection to maritime ecosystems, the project ultimately redefines our understanding of the depth of the ocean.

Oceans in Transformation is a research project by Territorial Agency—John Palmesino and Ann-Sofi Rönnskog, commissioned by TBA21–Academy.





The Glacier Trilogy

THERESA SCHUBERT (DE)

STARTS pillar
STARTS Residency (STARTS4Water, 2021–22), STARTS Prize (Nomination, 2023)

Founded by
STARTS4Water, an initiative by the European Commission within the Horizon 2020 Residency at Cittadellarte – Fondazione Pistoletto (IT)

Physical resources
Photo Archives of the Italian Glaciological Committee Turin (CGI) and Sella Foundation Biella \

Voice and singing: Joseph Schnurr
Simulation programming: Sage Jenson
Glass blowing: JoGa Glass Turin
AI consultation: Moises Horta Valenzuela
Ice core meltwater: EUROCOLD Lab, University di Milano-Bicocca
Digital resources: customized StyleGAN, EsreGAN, VQGAN models. TINITALY, a digital elevation model of Italy with a 10m cell size. Istituto Nazionale di Geofisica e Vulcanologia

The Glacier Trilogy is an immersive artwork investigating glaciers as the starting point of fluvial systems and the future of water in climate crisis. Combining field research in the Italian Alps with computational methods such as generative adversarial networks, atmospheric sensing, and real-time simulation, the project translates scientific knowledge into an experiential artistic environment. It examines glaciers as water reservoirs, geological archives, and fragile records of millennia-old organic and inorganic information. The project highlights not only the physical transformations occurring in these landscapes but also the scientific methods that allow us to read and interpret them.

By merging art, data, and environmental research, *The Glacier Trilogy* exemplifies how complex climate knowledge can be made accessible through artistic interpretation. Machine learning models trained on glacial data generate evolving synthetic landscapes that reveal patterns and conditions not visible in the physical world. Glass sculptures containing ice core meltwater act as small-scale archives, preserving ancient climatological and biological information. A panoramic simulation system responds in real time to visitor breath through measuring CO_2 levels with sensors, showing how human presence influences the formation and disappearance of ice. By blending predictive modeling, material memory, and interactive visualization, the project creates new ways of understanding glacial dynamics, making the invisible forces shaping our water future both tangible and experientially engaging for diverse audiences.

Top to bottom:

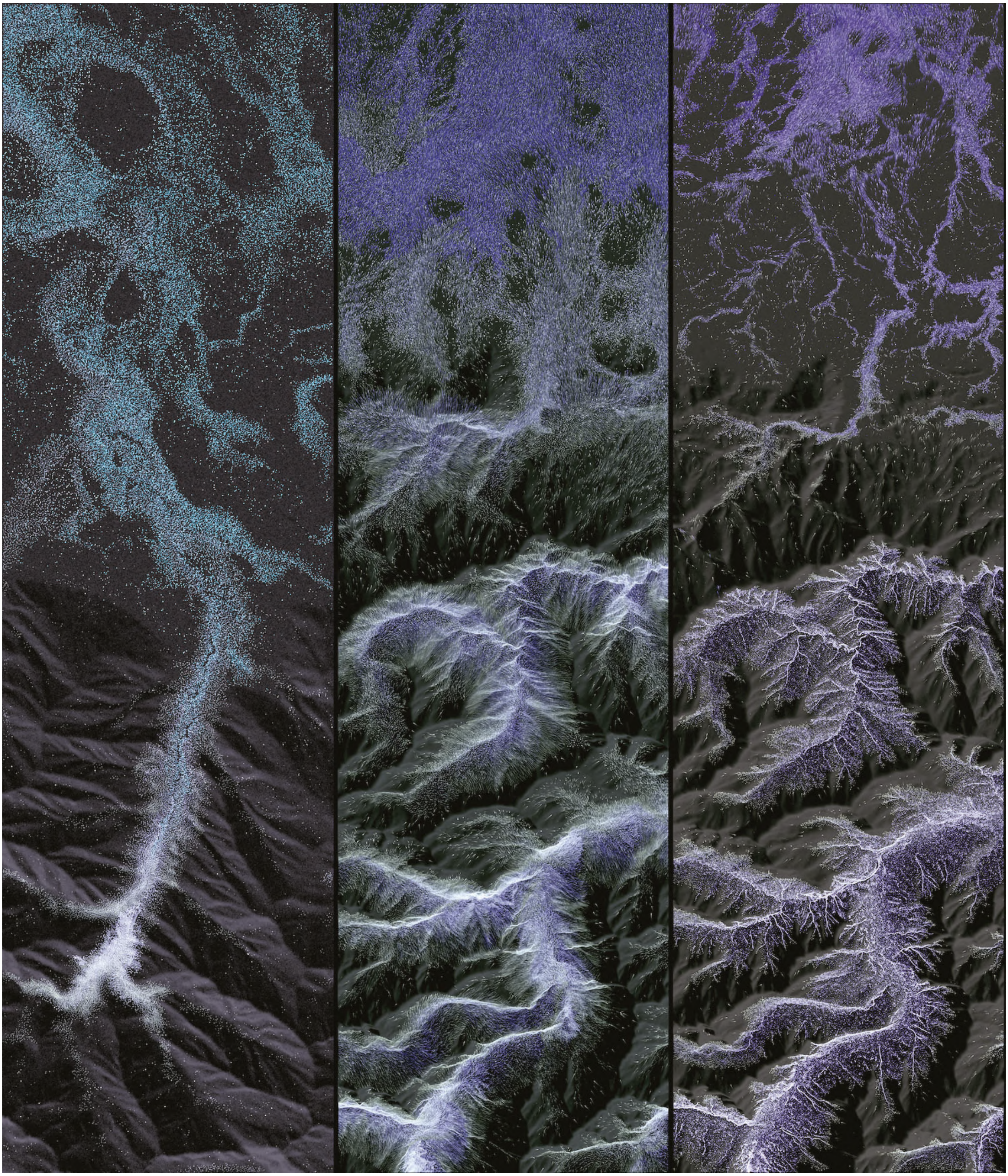
Installation view of the Glacier Trilogy Part 2 + 3 at "Melting Mountains" exhibition, Meinblau Gallery Berlin, 2024. Photo: Theresa Schubert / VG Bild-Kunst Bonn

Field trip to Aosta valley (IT). Observing recent recession of Lys Glacier (Monte Rosa Group). Photo: Theresa Schubert, 2022

Visiting the Comitato Glaciologico Italiano (CGI) at the University of Turin. Researching materials for neural network training. Photo: Theresa Schubert, 2022

Visiting the EuroCold lab at the University of Milano-Bicocca. Prof. Valter Maggi holding an icecore drilling in -34°C. Photo: Theresa Schubert, 2022

Visiting the Comitato Glaciologico Italiano (CGI) at the University of Turin. Researching materials for neural network training. Photo: Theresa Schubert, 2022



Top to bottom:

The Glacier Trilogy Part 3 – simulating glacial water systems. Particle evolvement over time, 2023. Photo collage: Theresa Schubert / VG Bild-Kunst Bonn / Sage Jenson

Installation view of the Glacier Trilogy Part 1 + 3 at "Intersecting Realities" exhibition, Timisoara 2023. Photo: Tudor Popa / Marginal

Installation view of the Glacier Trilogy Part 2 at "Faces of Water" exhibition, BOZAR Brussels, 2022. Photo: Claire Lessire

Breathing Architecture

FILIPPO NASSETTI (IT / UK)

STARTS pillar
STARTS Residency (AIR, 2023-24),
STARTS Prize (Honorary Mention, 2025)

Creation time
2023–24

Stakeholders involved
supercomputing centers, medical researchers, computational scientists

Technology applied
high performance computing (HPC), digital twins, computer fluid and particles dynamics (CFPD), simulation, visualization, 3D printing

Industry areas addressed
computational biology, medical research, healthcare innovation, scientific simulation and visualization, architecture

High Performance Computing (HPC) and Digital Twins are able to help humanity with many things: we can simulate a huge variety of processes on a multitude of scales—from molecular interactions to organ functions and even urban ecosystems—and we can draw conclusions and take action based upon the results. Modelling these processes and their intricate components is incredibly complex and scientists can sometimes reach the limits of their toolkits. Within STARTS AIR, two supercomputing centers embarked on a journey to find out how artistic perspectives can contribute to the understanding, modelling, and communication of such complex systems.

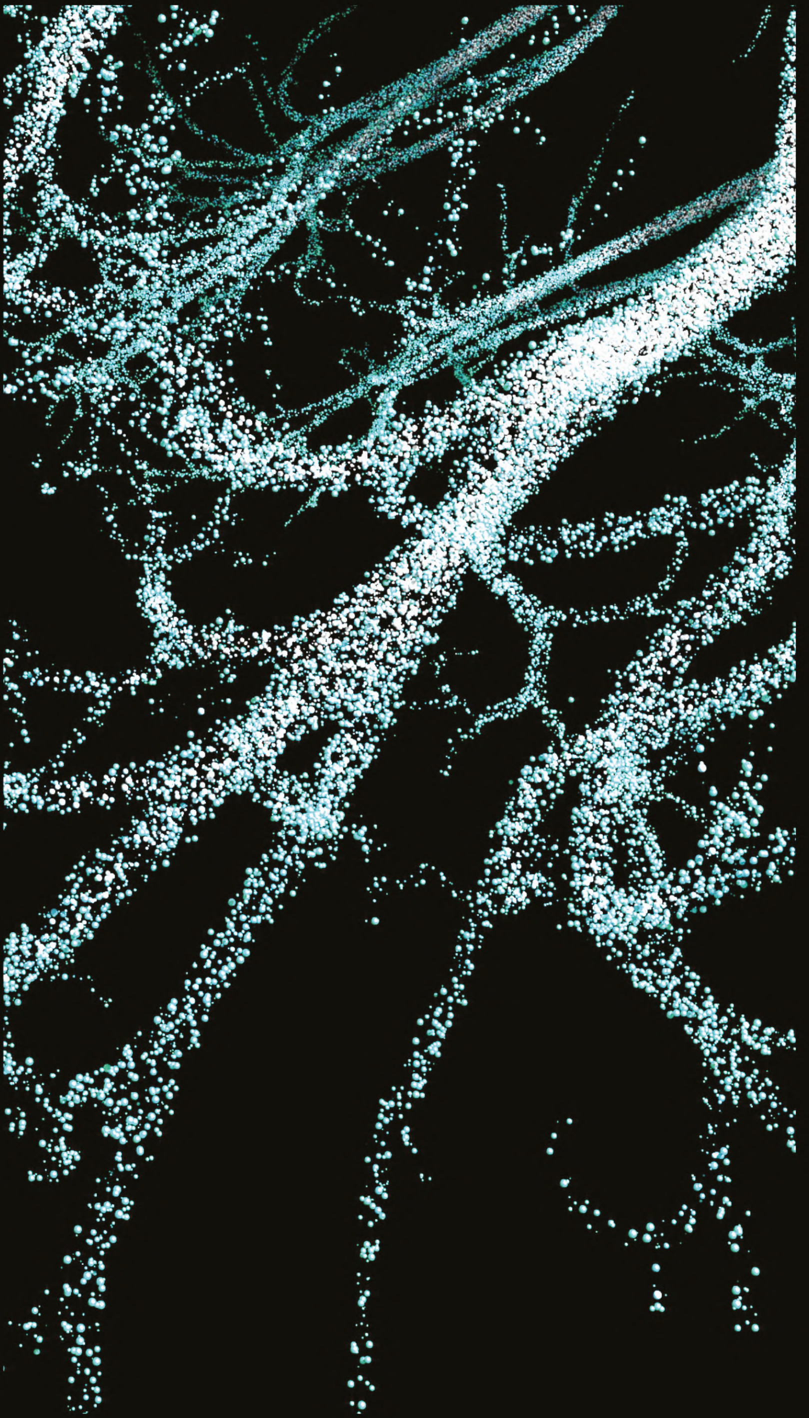
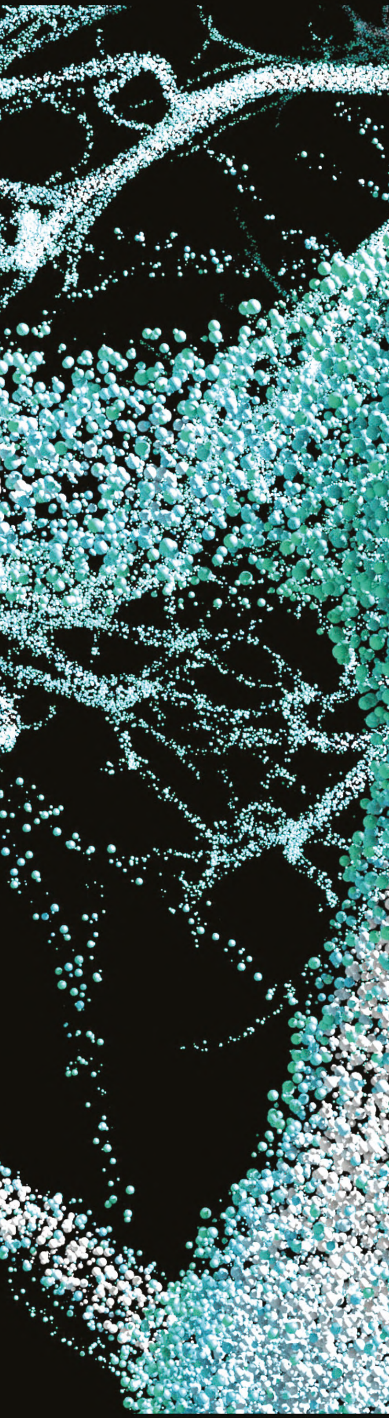
Breathing Architecture—the residency project of Filippo Nassetti and (primarily) the Barcelona Supercomputing Center—was an inquiry into the particulars of the human respiratory system: Can visual/spatial artistic approaches help simulate microscale respiratory structures? Can such simulations improve scientific understanding of internal body processes? Can artistic representations of internal anatomy create intuitive and immersive experiences for broader audiences? The answer to all of these questions turned out to be a resounding “yes”.

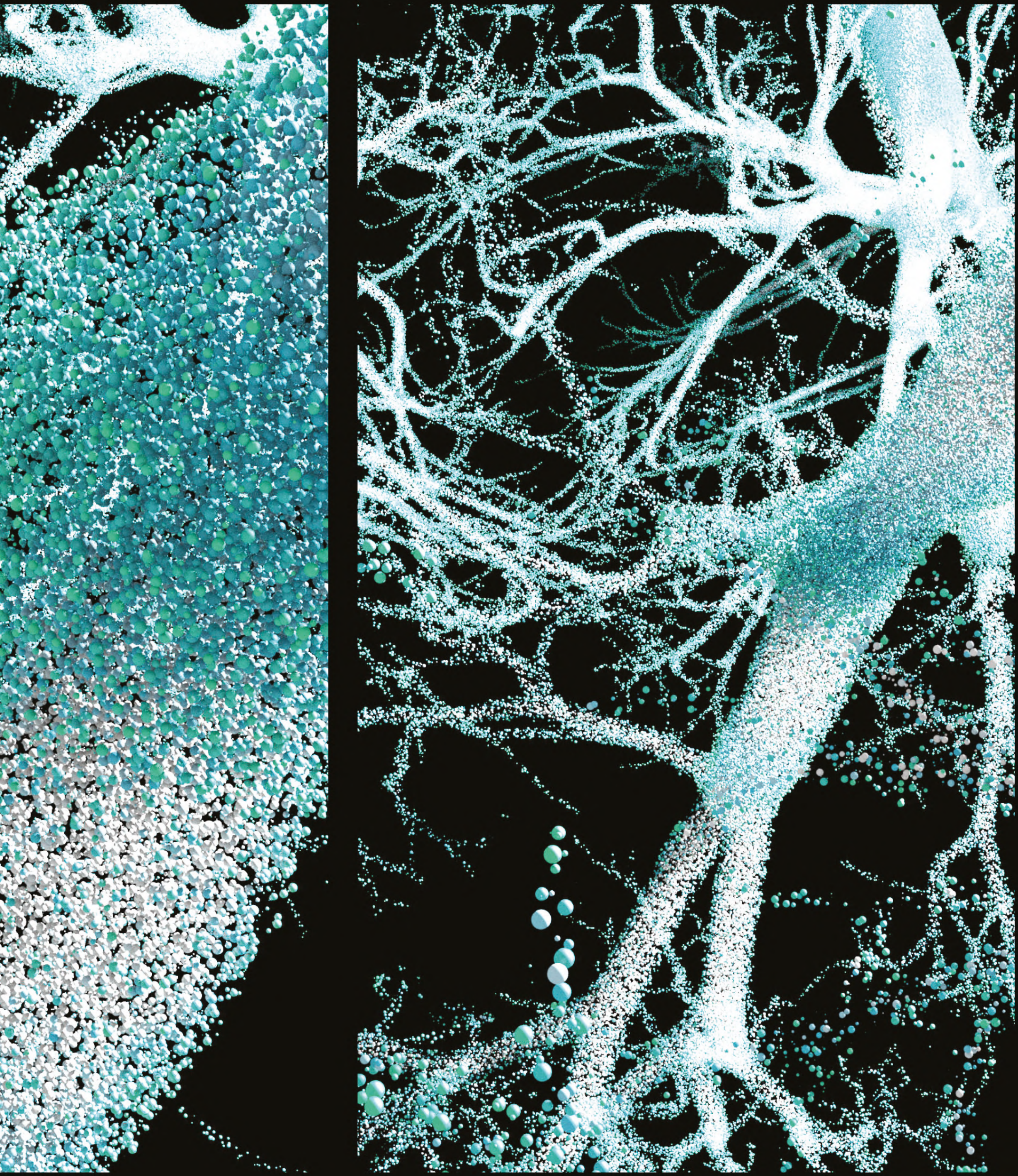
After exploring a multitude of ideas and visualizing the scientific datasets in an artistic manner, an unexpected similarity was discovered between the artist’s previous work on bone structures and a microscope image of alveolar lung tissue. Traditional medical imaging technologies were unable to capture the fine structures of this tissue, making it impossible to simulate their inner workings. By drawing on the unique blend of artistic spatial modelling and HPC, the team developed a new procedural method that generates synthetic, data-informed models of lung microstructures. These models can help simulate the progress of diseases, enabling more effective and personalized treatments. This innovative approach turned out to be incredibly promising for ongoing tuberculosis and Chronic Obstructive Pulmonary Disease (COPD) research and led to a joint scientific publication as well as a presentation at the 35th Parallel CFD International Conference in 2024.

The scientific relevance is obvious, but the rigorous process of research, prototyping, production, and dissemination also managed to produce novel methodological and artistic outputs. Data-driven workflows to convert scientific datasets into artistic visualizations and 3D-printed objects have been instrumental to the project's success story. These renderings, animations, and tactile objects not only translate abstract data into physical form but also invite audiences to perceive the human body in ways that are sensorially rich and emotionally resonant—fostering deeper understanding through aesthetics. Complex medical and computational data is thereby being humanized, **revealing** the hidden architecture of breathing and ultimately making it perceptible and relatable. The residency shows how promoting interdisciplinary communication between arts, medicine, science, and design can be key in supporting future applications in public health awareness and medical education.

These are the types of synergies STARTS is looking for and promoting. *Breathing Architecture* does not just model breathing—it breathes new life into how we create, understand, visualize, and share scientific knowledge. It successfully demonstrates how artistic insight and transdisciplinary collaboration can inform and improve technological and scientific processes, at the same time bringing the resulting science out of the lab and into the minds of the general public.

Filippo Nassetti within S+T+ARTS AIR Residencies program (Barcelona Supercomputing Center, In4Art, Fundación Épica La Fura Dels Baus, Media Solution Center Baden-Württemberg / High Performance Computing Centre Stuttgart, Pina/Heka, RCR Lab·A, Sony CSL).



Coexist

EMERGENCE DELFT (NL)

STARTS pillar
STARTS Prize (Honorary Mention, 2025)

Coexist is an immersive installation developed by Emergence Delft, a student-led interdisciplinary collective. Visitors move through a large-scale structure where beams of light pass through layers of polarizing filters, mirrors, and translucent materials. Depending on the viewer's position and movement, the light patterns continuously shift—revealing and hiding colors, shapes, and reflections. This ever-changing visual field translates quantum concepts such as superposition and measurement into perceptible form: just as particles exist in multiple states until observed, the installation shows how perception itself determines what becomes visible and knowable.

Rather than explaining science through theory, *Coexist* uses sensory experience to connect quantum logic with social life. It highlights how observation, context, and interpretation shape both knowledge and coexistence. By transforming scientific abstraction into an embodied encounter, the work invites reflection on complexity, uncertainty, and the shared realities we construct in a technologically mediated world.

Thanks to:
Emma Sanders, Ezra Sanders, Frederique Spruijt, Gijs van der Kerk, Haryn Jeon, Hugo de Jong, Ismail Music, Jor Frencken, Khruthika Kowkuntla, Loïs de Reus, Marcos Merino Francos, Nemo Anderson, Tom Hoevers, Valerie Schulpen, Wouter Schuit, Yasamin Zeinalizadeh
With support from: Quantum Delta NL, QuTech, TNO, Delft University of Technology

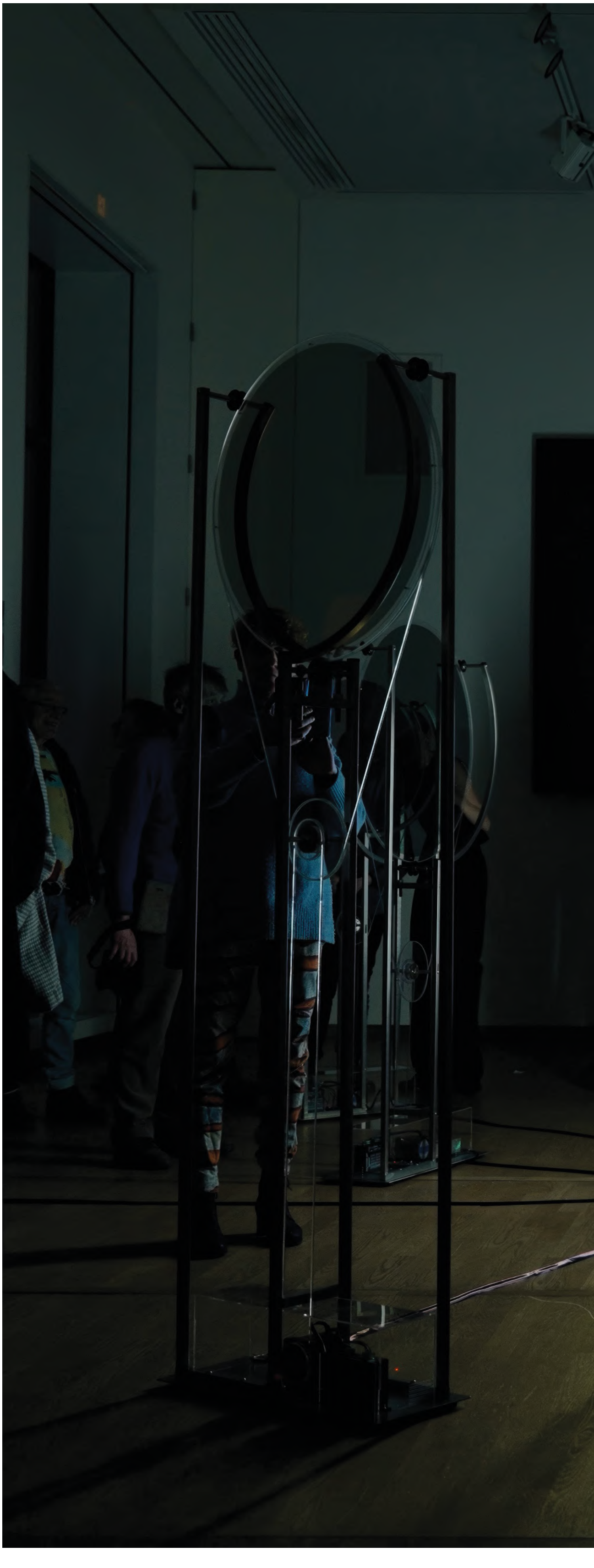
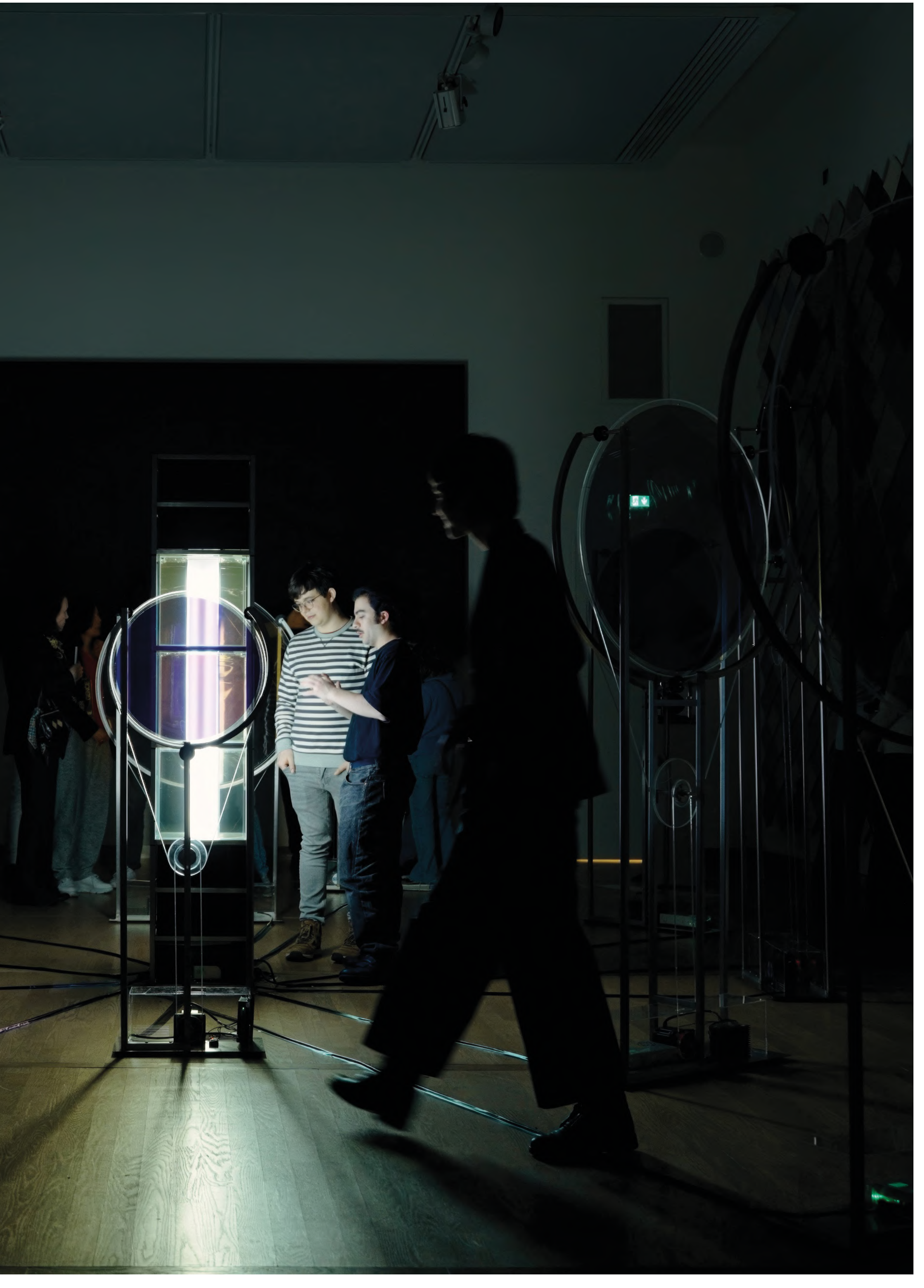


Photo: Emergence Delft



Vortex Harmonies

ARCANGELO CONSTANTINI (MX)

STARTS pillar
STARTS Residency (STARTS4Water II 2024-25)

Vortex Harmonies is a modular kinetic installation that consists of nine floating hyperbolic cones. Each of them houses a Tesla-inspired pump that generates a controlled micro-vortex. As water spirals through the curved geometry, the modules act as hydroacoustic instruments, emitting base frequencies and evolving harmonics shaped directly by the dynamics of the vortex. Light pulses respond to these vibrations, creating a multisensory field where sound, motion, and flow are tightly interconnected.

Developed in collaboration with Wetsus, the European Centre of Excellence for Sustainable Water Technology, the project builds upon scientific research into vortex dynamics and fluid energetics. Drawing on Viktor Schauberger's studies of spiraling flow and revitalization and Nikola Tesla's bladeless turbine principles, it examines how vortices influence oxygenation, energy distribution, and coherent flow structures. Embedded sensors record turbulence, flow speed, temperature, and acoustic signatures, while real-time analysis reveals how harmonic patterns evolve as the vortex strengthens or decays.

By translating fluid-dynamic behavior into audible and visible patterns, *Vortex Harmonies* offers an accessible framework for understanding complex natural processes. It demonstrates how scientific concepts—such as laminar-turbulent transitions, resonant flow structures, and vibrational energy transfer—can be experienced rather than abstractly described, allowing audiences to directly sense the hidden behaviors that shape the life and energy of water.

In collaboration with Diego Leido and Miguel Mendoza
Supported by Bolster Lab
Residency Support Network: Waterschap de Dommel, Wetsus, Waag Futurelab, Pythagoras Kepler System Society for Promotion of Natural Technology, Schauberger Natur Technik, Bright Spark, IPF


VAN ABBEMUSEUM

Critical Climate Machine

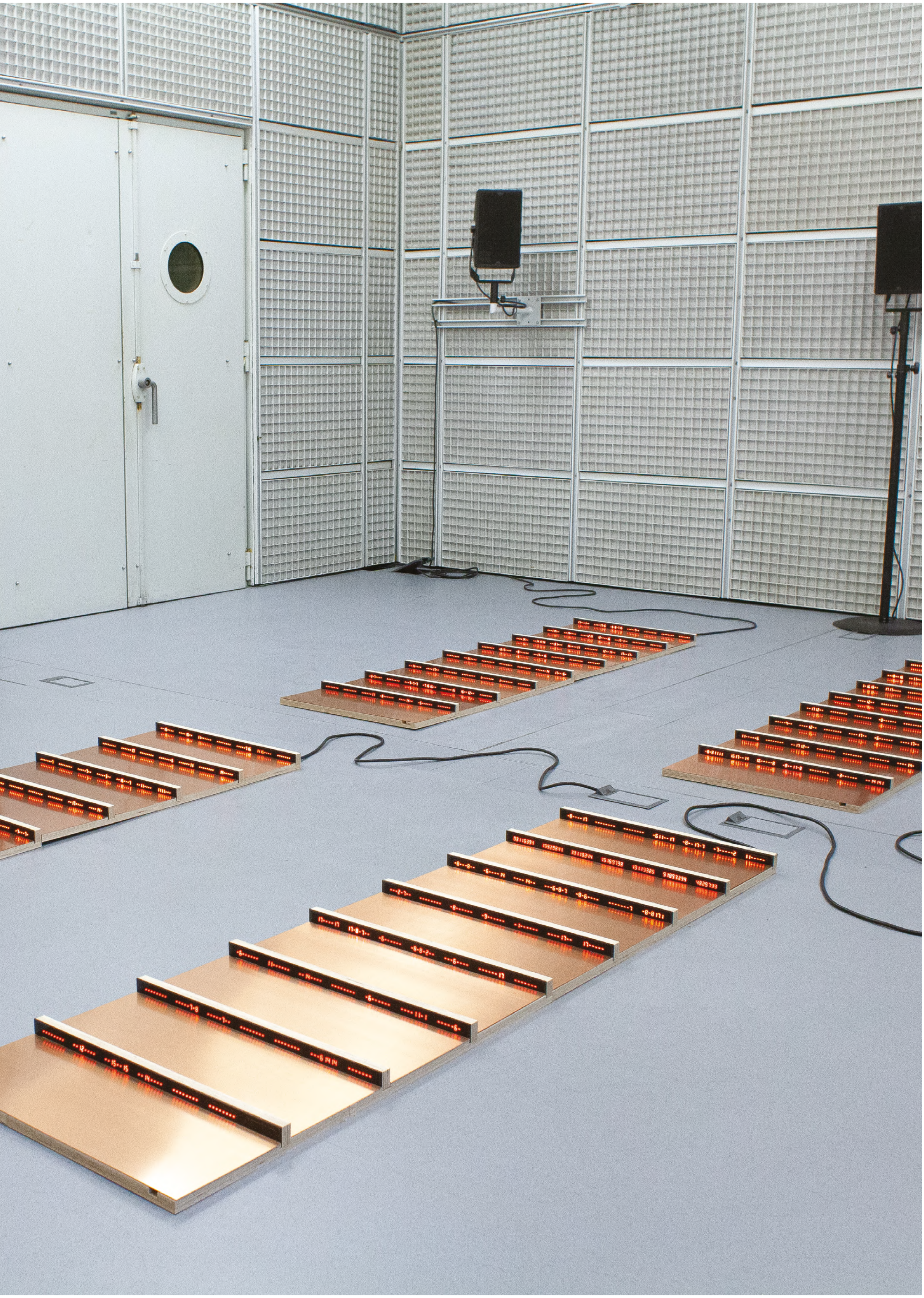
GAËTAN ROBILLARD (FR)

STARTS pillar
STARTS Residency (MediaFutures, 2020–23),
STARTS Prize (Nominaiton, 2023)

Critical Climate Machine is a research-based project that quantifies and reveals the mechanisms of misinformation on global warming. It consists of a data sculpture and a sound installation inside a walk-in space. Using natural language processing, the sculpture gathers false climate arguments from Twitter (X), compares them with reliable counterarguments, and transforms this process into a shifting landscape of "error codes" that visitors can navigate. A live visualization displays the thermal effects generated by the system's computation. Around it, constructed dialogues unfold between two AI-driven voices—one repeating misleading claims, the other correcting them. These dialogues draw on recordings from workshops in which participants used a specially designed card game to practice identifying and dismantling climate misinformation.

By merging cognitive science, data analysis, and artistic experimentation, *Critical Climate Machine* develops new ways of making the hidden mechanisms of climate misinformation visible and audible. It translates abstract processes—social-media discourse, algorithmic detection, thermal computation—into tangible forms that can be experienced and questioned by visitors. This convergence of art and scientific research opens alternative frameworks for communicating climate knowledge, revealing patterns that often remain buried in data streams and social media infrastructures. Through hybrid visualization, participatory elements, and critical approach to data ethics, the project offers an innovative model for turning complex scientific insights into accessible, engaging experiences that deepen public understanding of the climate information crisis.

Art and research: Gaëtan Robillard
Machine Learning algorithm: John Cook, Travis Coan, Constantine Boussalis, Mirjam O. Nanko
Musical research: Jérôme Nika
Sound design: Tony Houziaux
Computer music: Dionysios Papanikolaou
Art and education: Özlem Sulak
Engineering: Laurine Capdeville, Jolan Goulin
The Refutation Game: Gaëtan Robillard, Laurine Capdeville
Sound production: IRCAM Centre Pompidou



Calculating Empires: A Genealogy of Power and Technology, 1500–2025

KATE CRAWFORD (AU) AND VLADAN JOLER (RS)

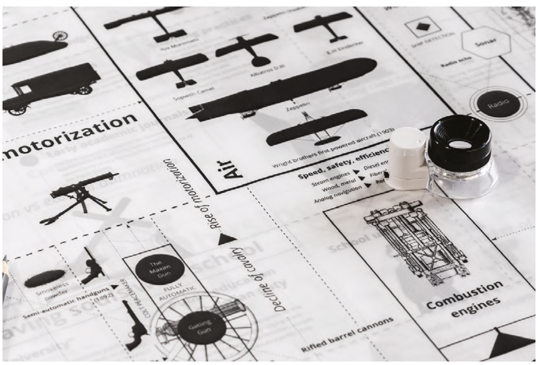
STARTS pillar
STARTS Prize
(Grand Prize for Artistic Exploration, 2024)

Creation time
2023–ongoing

Stakeholders involved
researchers, academic collaborators

Technology applied
critical cartography, large-scale data visualization, interactive web development

Industry areas addressed
AI and data ethics, media and cultural studies, education



Inspired by Donna Haraway's call to map the "informatics of domination", the artistic partnership between Kate Crawford and Vladan Joler took a quite literal approach and mapped the history of technology at large—from the printing press of the sixteenth century to the AI systems of today. Primarily, this project inquired into how technical and social structures have co-evolved over the past five centuries, and how they continue to shape contemporary forms of power, control, and technology. How are communication, computation, classification, and control historically linked? How can we visualize and understand the age-long trajectories of empire, militarization, and automation that underpin today's technology? In what ways are the practices of past empires echoed in current technological and industrial systems?

After four years of using a deliberately manual, research-driven methodology—resisting automation in favor of deep engagement—as well as the established method of critical cartography, the artists succeeded in creating a visual genealogy blending science and art, historical data visualization and artistic expression. *Calculating Empires* provides an extensive study of the entangled systems of knowledge and power during exhibitions—either as a 24-meter long diptych map installation or an immersive map room that physically engages users—as well as online, using an interactive website where users can zoom in and pan across the map, read detailed descriptions, and listen to an audio guide. This form of presentation not only aims to unwind inherited systems of control by making them legible to wider audiences but also serves as an educational tool encouraging critical thinking about contemporary socio-technical structures. The audience is invited to reflect but also contribute to the piece with their own annotations—thereby expanding the work to include a multitude of POVs.

Top to bottom

Exhibition view of Calculating Empires, Kate Crawford and Vladan Joler Osservatorio Fondazione Prada, Milan, Photo: Piercarlo Quecchia—DSL Studio

Calculating Empires (detail), Kate Crawford and Vladan Joler (2023), Courtesy of artists

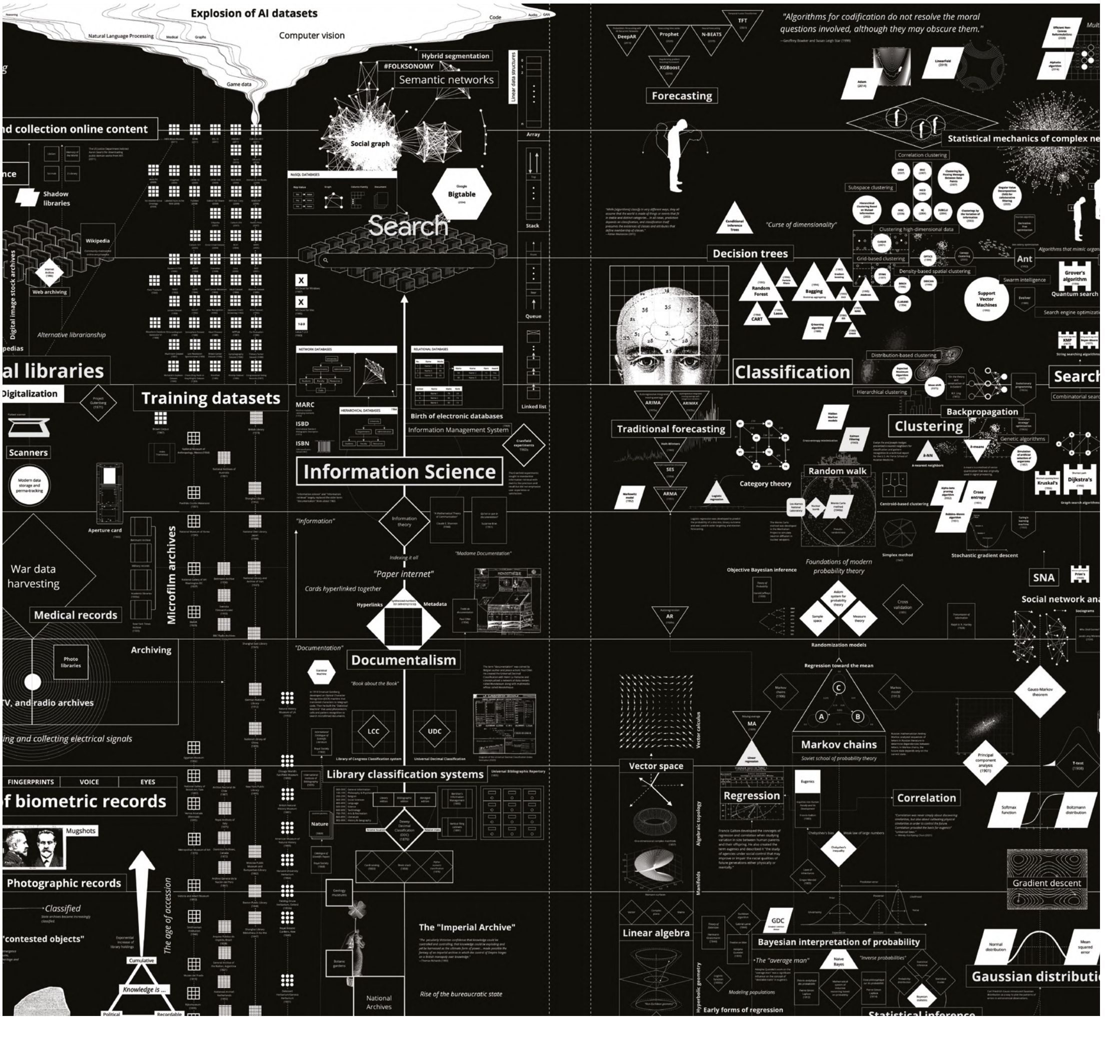
Exhibition view of Calculating Empires, Kate Crawford and Vladan Joler Osservatorio Fondazione Prada, Milan, Photo: Piercarlo Quecchia—DSL Studio

Calculating Empires is STARTS through and through: by critically examining the evolution of science and technology through an artistic lens the project creates an emotional and intellectual space for engagement—all enabled by an interdisciplinary collaboration. It represents and advocates for a holistic reflection on long-term historical forces, contributing to new forms of knowledge production and public discourse/understanding. Mediating between the disciplines of history, art, science, technology and political theory, the project reveals the hidden patterns of domination inherent to our daily lives—how scientific instruments, classification systems, and computation tools have evolved and co-produced social control.

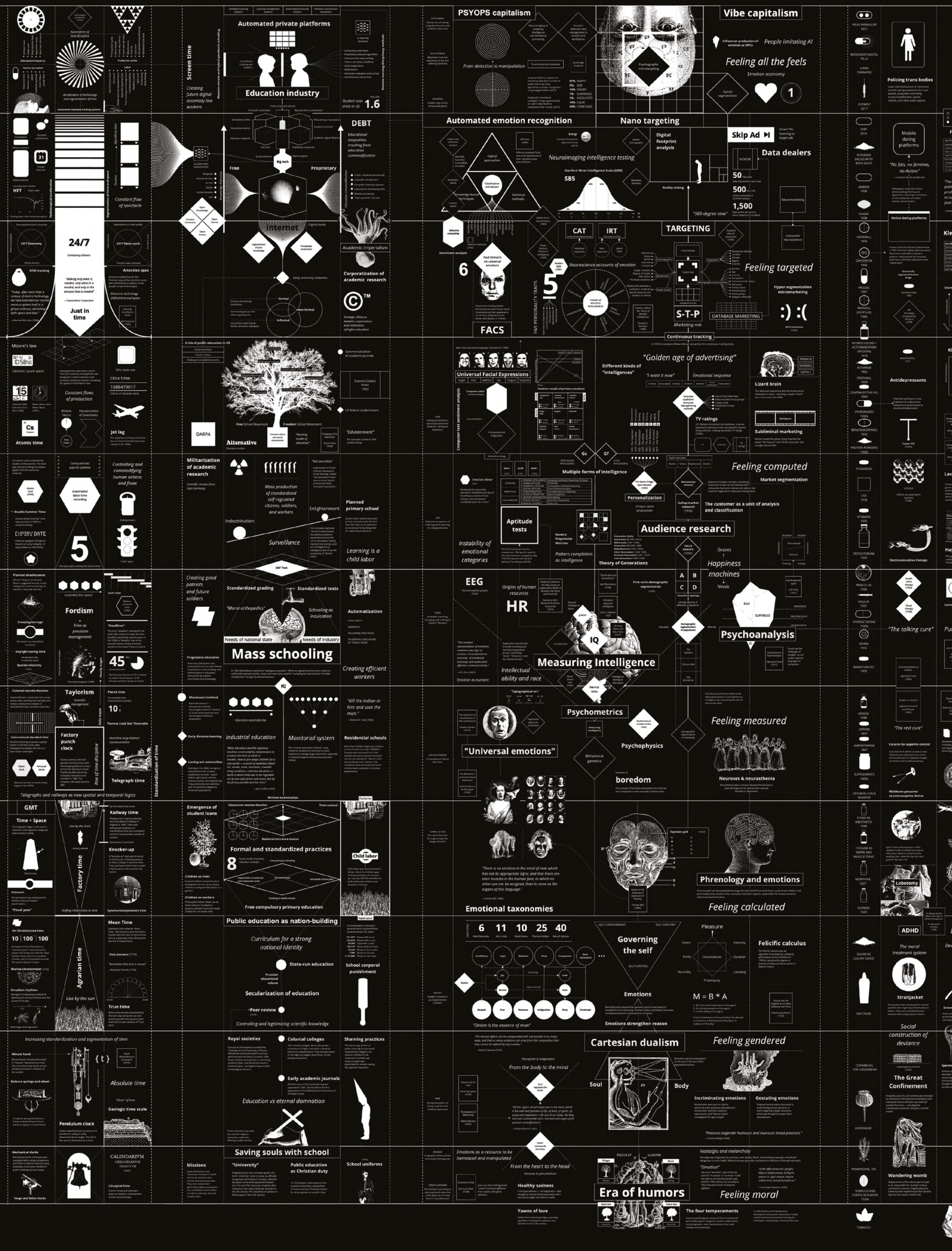
Academia as well as the art sector can learn from the visual research methodology used in the creation of this piece. The power of art to perform epistemological work challenges the boundaries between creative and academic practices—begging to be replicated and adapted more widely.

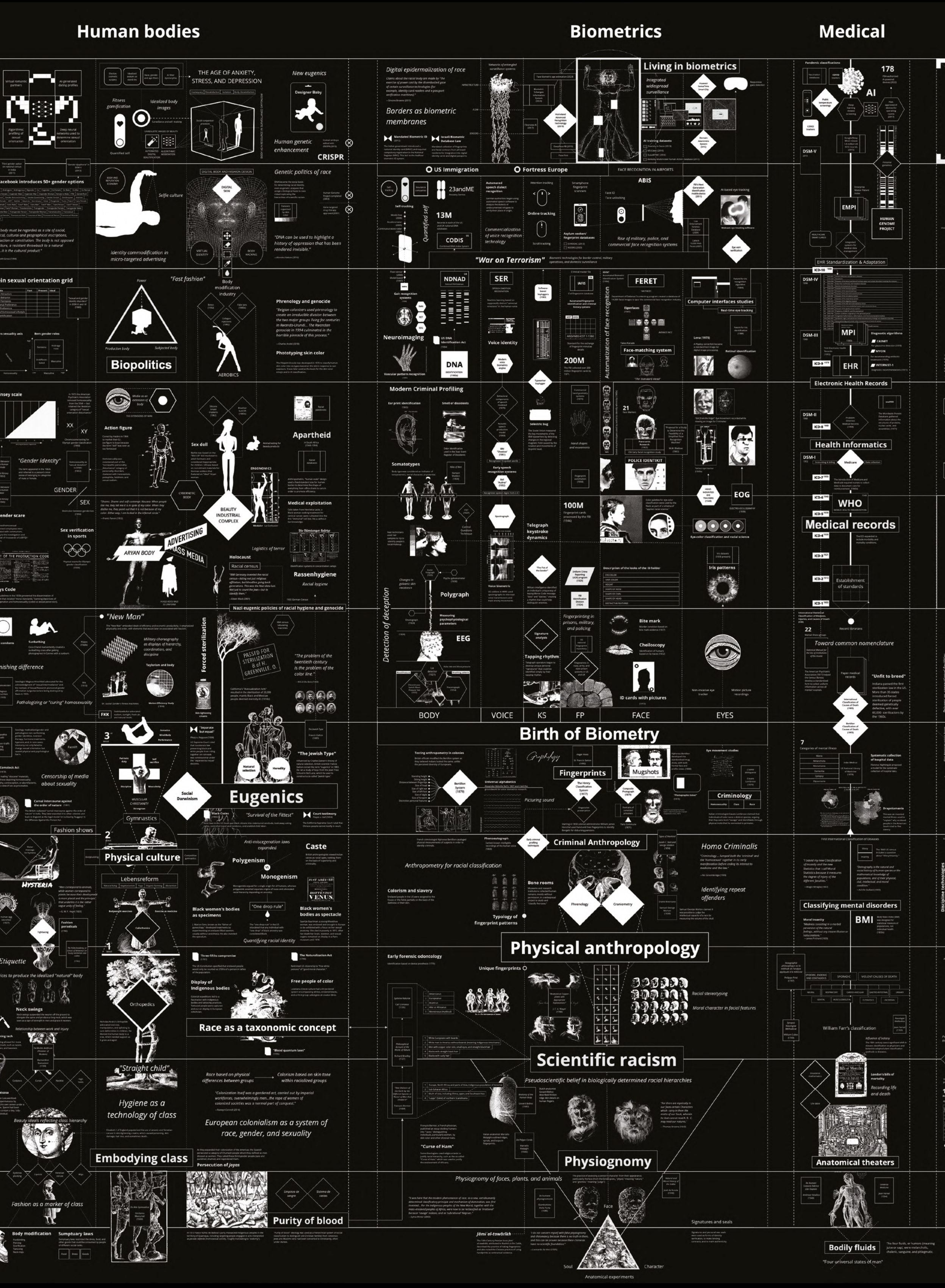
Science and industry are invited to use the map as a critical mirror to observe the blind spots in current tech narratives and reflect upon the historical significance of technology and corporate influence in the manifestation of imperial power structures. On the other hand, the general public can use this mirror to educate themselves on urgent but complex topics, such as AI, surveillance, militarization, and the overarching motif of colonialism, and use this shared knowledge to speak truth to power and insist on a better future for mankind. In the words of the STARTS Prize jury: "By seeing how past powers have calculated, we can begin to calculate the costs of contemporary empires"—and fight for a better tomorrow.

Artists: Kate Crawford and Vladan Joler (2023)
Research and design associate: Sarah Ciston
Research assistants: Francis Corry, Edward Kang, Will Orr, and Hamsini Sridharan
Project management: Hannah Franklin and Michael Weinberg
Website production: Olivia Solis Villaverde and Milutin Marinovic
With support from: The Sloan Foundation, as part of the Knowing Machines project, The Robert Bosch Academy, Fondazione Prada



Time Education Emotions and intelligence





Human bodies
Biometrics
Medical
THE AGE OF ANXIETY, STRESS, AND DEPRESSION
New eugenics
Designer Baby
Human genetic enhancement
CRISPR
Digital epidermalization of race
Borders as biometric membranes
Living in biometrics
AI
178
Facebook introduces 50+ gender options
Selfie culture
Genetic politics of race
US Immigration
Fortress Europe
ABIS
23andME
13M
CODIS
"War on Terrorism"
EMPI
HUMAN GENOME PROJECT
EHR Standardization & Adaptation
Identity commodification in micro-targeted advertising
"DNA can be used to highlight a history of oppression that has been rendered invisible."
"Fast fashion"
Body modification industry
Phrenology and genocide
Phototyping skin color
NDNAD
SER
FERET
Computer interfaces studies
Neuroimaging
DNA
200M
Face-matching system
MPI
EHR
Biopolitics
AEROBICS
Electronic Health Records
Modern Criminal Profiling
Apartheid
Action figure
"Gender identity"
GENDER
SEX
Somatotypes
Sex doll
BEAUTY INDUSTRIAL COMPLEX
ADVERTISING
MASS MEDIA
ARYAN BODY
Medical exploitation
Holocaust
Racial census
Rassenhygiene
Logistics of terror
Polygraph
Telegraph keystroke dynamics
100M
POLICE IDENTIKIT
EOG
Iris patterns
Health Informatics
WHO
Medical records
Establishment of standards
Nazi eugenic policies of racial hygiene and genocide
"New Man"
Forced sterilization
PASSED FOR STERILIZATION
"The problem of the twentieth century is the problem of the color line."
Detection of deception
EEG
Bite mark
Cheiloscopy
ID cards with pictures
Toward common nomenclature
"Unfit to breed"
BODY
VOICE
KS
FP
FACE
EYES
Birth of Biometry
"The Jewish Type"
Eugenics
Social Darwinism
"Survival of the Fittest"
Gymnastics
Fingerprints
Mugshots
Criminology
Fashion shows
Physical culture
Lebensreform
Caste
Polygenism
Monogenism
"One drop rule"
Criminal Anthropology
Homo Criminalis
Identifying repeat offenders
Anthropometry for racial classification
Colorism and slavery
Bone rooms
Phrenology
Craniometry
Typology of fingerprint patterns
Classifying mental disorders
BMI
Etiquette
Quantifying racial identity
Physical anthropology
Unique fingerprints
Racial stereotyping
Moral character in facial features
Orthopedics
Race as a taxonomic concept
William Farr's classification
Scientific racism
Pseudoscientific belief in biologically determined racial hierarchies
"Straight child"
Hygiene as a technology of class
European colonialism as a system of race, gender, and sexuality
Embodying class
Purity of blood
Physiognomy
Physiognomy of faces, plants, and animals
"Curse of Ham"
Anatomical theaters
Fashion as a marker of class
Body modification
Sumptuary laws
Face
Soul
Character
Anatomical experiments
Bodily fluids
"Four universal states of man"

Anatomy of an AI System: The Amazon Echo as an Anatomical Map of Human Labor, Data, and Planetary Resources

KATE CRAWFORD[1] AND VLADAN JOLER[2] (2018)

I

A cylinder sits in a room. It is impassive, smooth, simple and small. It stands 14.8cm high, with a single blue-green circular light that traces around its upper rim. It is silently attending. A woman walks into the room, carrying a sleeping child in her arms, and she addresses the cylinder.

“Alexa, turn on the hall lights”.

The cylinder springs into life. “OK”. The room lights up. The woman makes a faint nodding gesture, and carries the child upstairs.

This is an interaction with Amazon’s Echo device.[3] A brief command and a response is the most common form of engagement with this consumer voice-enabled AI device. But in this fleeting moment of interaction, a vast matrix of capacities is invoked: interlaced chains of resource extraction, human labor, and algorithmic processing across networks of mining, logistics, distribution, prediction, and optimization. The scale of this system is almost beyond human imagining. How can we begin to see it, to grasp its immensity and complexity as a connected form? We start with an outline: an exploded view of a planetary system across three stages of birth, life, and death, accompanied by an essay in 21 parts. Together, this becomes an anatomical map of a single AI system.

II

The scene of the woman talking to Alexa is drawn from a 2017 promotional video advertising the latest version of the Amazon Echo. The video begins, “Say hello to the all-new Echo” and explains that the Echo will connect to Alexa (the artificial intelligence agent) in order to “play music, call friends and family, control smart home devices, and more”. The device contains seven directional microphones, so the user can be heard at all times even when music is playing. The device comes in several styles, such as gunmetal grey or a basic beige, designed to either “blend in or stand out”. But even the shiny design options maintain a kind of blankness: nothing will alert the owner to the vast network that subtends and drives its interactive capacities. The promotional video simply states that the range of things you can ask Alexa to do is always expanding. “Because Alexa is in the cloud, she is always getting smarter and adding new features”.

1. Kate Crawford is a Distinguished Research Professor at New York University, a Principal Researcher at Microsoft Research New York, and the co-founder and co-director of the AI Now Institute at NYU.
2. Vladan Joler is a professor at the Academy of Arts at the University of Novi Sad and founder of SHARE Foundation. He is leading SHARE Lab, a research and data investigation lab for exploring different technical and social aspects of algorithmic transparency, digital labor exploitation, invisible infrastructures, and technological black boxes.
3. Amazon advertising campaign, “All-New Amazon Echo”, September 27, 2017, https://www.youtube.com/watch?v=IyvZ41X- jUjY.

How does this happen? Alexa is a disembodied voice that represents the human-AI interaction interface for an extraordinarily complex set of information processing layers. These layers are fed by constant tides: the flows of human voices being translated into text questions, which are used to query databases of potential answers, and the corresponding ebb of Alexa's replies. For each response that Alexa gives, its effectiveness is inferred by what happens next:

Is the same question uttered again? (Did the user feel heard?)

Was the question reworded? (Did the user feel the question was understood?)

Was there an action following the question? (Did the interaction result in a tracked response: a light turned on, a product purchased, a track played?)

With each interaction, Alexa is training to hear better, to interpret more precisely, to trigger actions that map to the user's commands more accurately, and to build a more complete model of their preferences, habits, and desires. What is required to make this possible? Put simply: each small moment of convenience—be it answering a question, turning on a light, or playing a song—requires a vast planetary network, fueled by the extraction of non-renewable materials, labor, and data. The scale of resources required is many magnitudes greater than the energy and labor it would take a human to operate a household appliance or flick a switch. A full accounting for these costs is almost impossible, but it is increasingly important that we grasp the scale and scope if we are to understand and govern the technical infrastructures that thread through our lives.

III

The Salar, the world's largest flat surface, is located in southwest Bolivia at an altitude of 3,656 meters above sea level. It is a high plateau, covered by a few meters of salt crust which are exceptionally rich in lithium, containing 50% to 70% of the world's lithium reserves.[4] The Salar, alongside the neighboring Atacama regions in Chile and Argentina, are major sites for lithium extraction. This soft, silvery metal is currently used to power mobile connected devices, as a crucial material used for the production of lithium-Ion batteries. It is known as "grey gold". Smartphone batteries, for example, usually have less than eight grams of this material.[5] Each Tesla car needs approximately seven kilograms of lithium for its battery pack.[6] All these batteries have a limited lifespan, and once consumed they are thrown away as waste. Amazon reminds users that they cannot open up and repair their Echo, because this will void the warranty. The Amazon Echo is wall-powered, and also has a mobile battery base. This also has a limited lifespan and then must be thrown away as waste.

According to the Aymara legends about the creation of Bolivia, the volcanic mountains of the Andean plateau were creations of tragedy.[7] Long ago, when the volcanos were alive and roaming the plains freely, Tunupa—the only female volcano—gave birth to a baby. Stricken by jealousy, the male volcanos stole her baby and banished it to a distant location. The gods punished the volcanos by pinning them all to the Earth. Grieving for the child that she could no longer reach, Tunupa wept deeply. Her tears and breast milk combined to create a giant salt lake: Salar de Uyuni. As Liam Young and Kate Davies observe, "your smart-phone runs on the tears and breast milk of a volcano. This landscape is connected to everywhere on the planet via the phones in our pockets; linked to each of us by invisible threads of commerce, science, politics and power".[8]

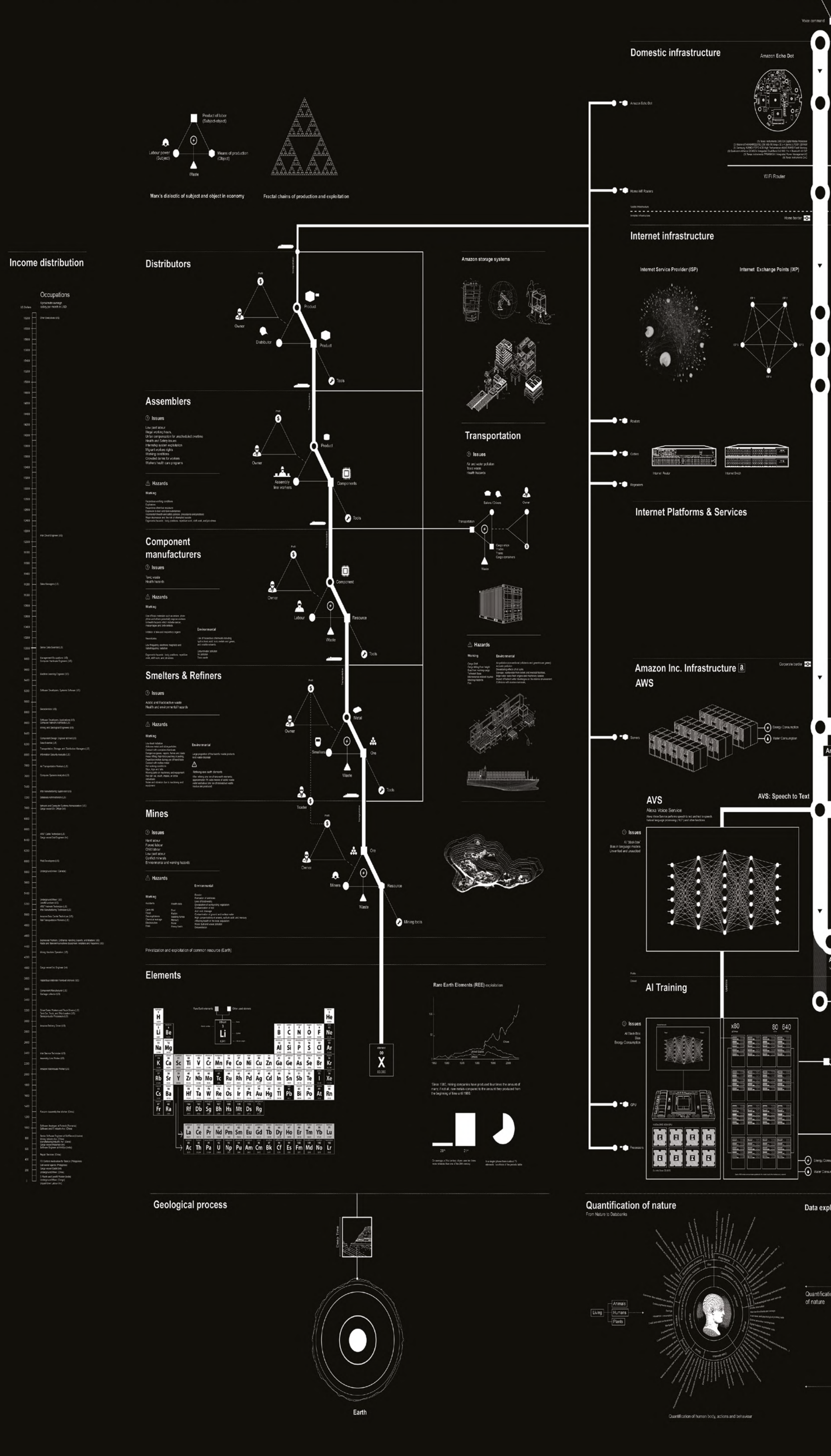
IV

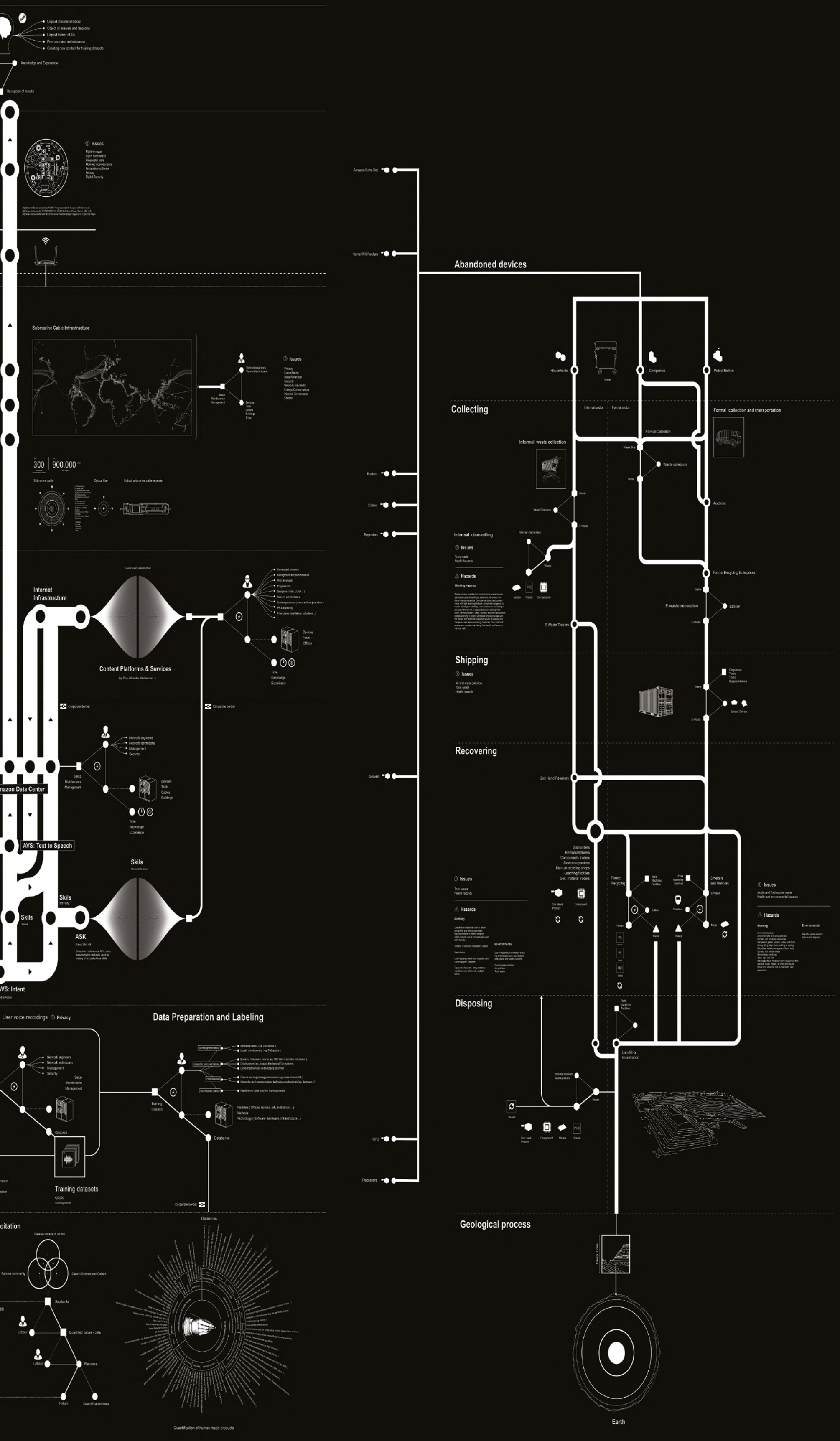
Our exploded view diagram combines and visualizes three central, extractive processes that are required to run a large-scale artificial intelligence system: material resources, human labor, and data. We consider these three elements across time—represented as a visual description of the birth, life, and death of a single Amazon Echo unit. It's necessary to move beyond a simple analysis of the relationship between an individual human, their data, and any single technology company in order to contend with the truly planetary scale of extraction. Vincent Mosco has shown how the ethereal metaphor of "the cloud" for offsite data management and processing is in complete contradiction with the physical realities of the extraction of minerals from the Earth's crust and dispossession of human populations that sustain its existence.[9] Sandro Mezzadra and Brett Nielson use the term "extractivism" to name the relationship between different forms of extractive operations in contemporary capitalism, which we see repeated in the context of the AI industry.[10] There are deep interconnections between the literal hollowing out of the materials of the earth and biosphere, and the data capture and monetization of human practices of communication and sociality in AI. Mezzadra and Nielson note that labor is central to this extractive relationship, which has repeated throughout history: from the way European imperialism used slave labor, to the forced work crews on rubber plantations in Malaya, to the Indigenous people of Bolivia being driven to extract

4. Emily Achtenberg, "Bolivia Bets on State-Run Lithium Industry", NACLA, November 15, 2010, https://nacla.org/news/boliv-ia-bets-state-run-lithium-industry.
5. Christine Negroni, "How to Determine the Power Rating of Your Gadget's Batteries", The New York Times, December 22, 2017, https://www.nytimes.com/2016/12/26/business/lithium-ion-battery-airline-safety.html.
6. Jessica Shankleman et al., "We're Going to Need More Lithium", Bloomberg, September 7, 2017, https://www.bloomberg. com/graphics/2017-lithium-battery-future/.
7. Nicola Clark and Simon Wallis, "Flamingos, Salt Lakes and Volcanoes: Hunting for Evidence of Past Climate Change on the High Altiplano of Bolivia", *Geology Today* 33, no. 3 (May 1, 2017): 104, https://doi.org/10.1111/gto.12186.
8. Kate Davies and Liam Young, *Tales from the Dark Side of the City: The Breastmilk of the Volcano Bolivia and the Atacama Desert Expedition* (London: Unknown Fields, 2016).
9. Vincent Mosco, *To the Cloud: Big Data in a Turbulent World* (Boulder: Paradigm, 2014).
10. Sandro Mezzadra and Brett Neilson, "On the Multiple Frontiers of Extraction: Excavating Contemporary Capitalism", *Cultural Studies* 31, no. 2–3 (May 4, 2017): 185, https://doi.org/10.1080/09502386.2017.1303425.

Anatomy of an AI system

An anatomical case study of the Amazon echo as a artificial intelligence system made of human labor





Abandoned devices
Collecting
Informal waste collection
Formal collection and transportation
Informal dismantling
Issues
Hazards
Shipping
Recovering
Disposing
Geological process
Earth
Submarine Cable Infrastructure
300
900.000
Internet Infrastructure
Content Platforms & Services
Amazon Data Center
AVS: Text to Speech
Skils
ASK
AVS: Intent
User voice recordings
Privacy
Data Preparation and Labeling
Training datasets
Quantification of human-made products

the silver that was used in the first global currency. Thinking about extraction requires thinking about labor, resources, and data together. This presents a challenge to critical and popular understandings of artificial intelligence: it is hard to “see” any of these processes individually, let alone collectively. Hence the need for a visualization that can bring these connected, but globally dispersed processes into a single map.

V

If you read our map from left to right, the story begins and ends with the Earth, and the geological processes of deep time. But read from top to bottom, we see the story as it begins and ends with a human. The top is the human agent, querying the Echo, and supplying Amazon with the valuable training data of verbal questions and responses that they can use to further refine their voice-enabled AI systems. At the bottom of the map is another kind of human resource: the history of human knowledge and capacity, which is also used to train and optimize artificial intelligence systems. This is a key difference between artificial intelligence systems and other forms of consumer technology: they rely on the ingestion, analysis, and optimization of vast amounts of human generated images, texts, and videos.

VI

When a human engages with an Echo, or another voice-enabled AI device, they are acting as much more than just an end-product consumer. It is difficult to place the human user of an AI system into a single category: rather, they deserve to be considered as a hybrid case. Just as the Greek chimera was a mythological animal that was part lion, goat, snake, and monster, the Echo user is simultaneously a consumer, a resource, a worker, and a product. This multiple identity recurs for human users in many technological systems. In the specific case of the Amazon Echo, the user has purchased a consumer device for which they receive a set of convenient affordances. But they are also a resource, as their voice commands are collected, analyzed, and retained for the purposes of building an ever-larger corpus of human voices and instructions. And they provide labor, as they continually perform the valuable service of contributing feedback mechanisms regarding the accuracy, usefulness, and overall quality of Alexa’s replies. They are, in essence, helping to train the neural networks within Amazon’s infrastructural stack.

VII

Anything beyond the limited physical and digital interfaces of the device itself is outside of the user’s control. It presents a sleek surface with no ability to open it, repair it, or change how it functions. The object itself is a very simple extrusion of plastic representing a collection of sensors—its real power and complexity lies somewhere else, far out of sight. The Echo is but an “ear” in the home: a disembodied listening agent that never shows its deep connections to remote systems. In 1673, the Jesuit polymath, Athanasius Kircher, invented the statua citofonica—the “talking statue”. Kircher was an extraordinary interdisciplinary scholar and inventor. In his lifetime he published forty major works across the fields of medicine, geology, comparative religion, and music. He invented the first magnetic clock, many early automatons, and the megaphone. His talking statue was a very early listening system: essentially a microphone made from a huge spiral tube, which could convey the conversations from a public square up through the tube, and then piped through the mouth of a statue kept within an aristocrat’s private chambers. As Kircher wrote:

“This statue must be located in a given place, in order to allow the end section of the spiral-shaped tube to precisely correspond to the opening of the mouth. In this manner it will be perfect, and capable to emit clearly any kind of sound: in fact the statue will be able to speak continuously, uttering in either a human or animal voice: it will laugh or sneer; it will seem to really cry or moan; sometimes with great astonishment it will strongly blow. If the opening of the spiral shaped tube is located in correspondence to an open public space, all human words pronounced, focused in the conduit, would be replayed through the mouth of the statue”.[11]

The listening system could eavesdrop on everyday conversations in the piazza, and relay them to the 17th century Italian oligarchs. Kircher’s talking statue was an early form of information extraction for the elites—people talking in the street would have no indication that their conversations were being funneled to those who would instrumentalize that knowledge for their own power, entertainment, and wealth. People inside the homes of aristocrats would have no idea how a magical statue was speaking and conveying all manner of information. The aim was to obscure how the system worked: an elegant statue was all they could see. Listening systems, even at this early stage, were about power, class, and secrecy. But the infrastructure for Kircher’s system was prohibitively expensive—available only to the very few. And so the question remains: What are the full resource implications of building such systems? This brings us to the materiality of the infrastructure that lies beneath.

VIII

In his book *A Geology of Media*, Jussi Parikka suggests that we try to think of media not from Marshall McLuhan’s point of view—in which media are extensions of

11. Lamberto Tronchin, “The ‘Phonurgia Nova’ of Athanasius Kircher: The Marvellous Sound World of 17th Century,” *Proceedings of Meetings on Acoustics 4*, no. 1 (June 29, 2008): 015002, https://doi.org/10.1121/1.2992053.

human senses[12]—but rather as an extension of Earth.[13] Media technologies should be understood in context of a geological process, from the creation and the transformation processes, to the movement of natural elements from which media are built. Reflecting upon media and technology as geological processes enables us to consider the profound depletion of non-renewable resources required to drive the technologies of the present moment. Each object in the extended network of an AI system, from network routers to batteries to microphones, is built using elements that required billions of years to be produced. Looking from the perspective of deep time, we are extracting Earth's history to serve a split second of technological time, in order to build devices that are often designed to be used for no more than a few years. For example, the Consumer Technology Association notes that the average smartphone lifespan is 4.7 years.[14] This obsolescence cycle fuels the purchase of more devices, drives up profits, and increases incentives for the use of unsustainable extraction practices. From a slow process of elemental development, these elements and materials go through an extraordinarily rapid period of excavation, smelting, mixing, and logistical transport—crossing thousands of kilometers in their transformation. Geological processes mark both the beginning and the end of this period, from the mining of ore to the deposition of material in an electronic waste dump. For that reason, our map starts and ends with the Earth's crust. However, all the transformations and movements we depict are only the barest anatomical outline: beneath these connections lie many more layers of fractal supply chains, and exploitation of human and natural resources, concentrations of corporate and geopolitical power, and continual energy consumption.

IX

Drawing out the connections between resources, labor, and data extraction brings us inevitably back to traditional frameworks of exploitation. But how is value being generated through these systems? A useful conceptual tool can be found in the work of Christian Fuchs and other authors examining and defining digital labor. The notion of digital labor, which was initially linked with different forms of nonmaterial labor, precedes the life of devices and complex systems such as artificial intelligence. Digital labor—the work of building and maintaining the stack of digital systems—is far from ephemeral or virtual, but is deeply embodied in different activities.[15] The scope is overwhelming: from indentured labor in mines for extracting the minerals that form the physical basis of information technologies; to the work of strictly controlled and sometimes dangerous hardware manufacturing and assembly processes in Chinese factories; to exploited outsourced cognitive workers in developing countries labeling AI training data sets; to the informal physical workers cleaning up toxic waste dumps. These processes create new accumulations of wealth and power, which are concentrated in a very thin social layer.

X

This triangle of value extraction and production represents one of the basic elements of our map, from birth in a geological process, through life as a consumer AI product, and ultimately to death in an electronics dump. Like in Fuchs's work, our triangles are not isolated, but linked to one another in the production process. They form a cyclic flow in which the product of work is transformed into a resource, which is transformed into a product, which is transformed into a resource, and so on. Each triangle represents one phase in the production process. Although this appears on the map as a linear path of transformation, a different visual metaphor better represents the complexity of current extractivism: the fractal structure known as the Sierpinski triangle.

A linear display does not enable us to show that each next step of production and exploitation contains previous phases. If we look at the production and exploitation system through a fractal visual structure, the smallest triangle would represent natural resources and means of labor, i.e. the miner as labor and ore as product. The next larger triangle encompasses the processing of metals, and the next would represent the process of manufacturing components and so on. The ultimate triangle in our map, the production of the Amazon Echo unit itself, includes all of these levels of exploitation—from the bottom to the very top of Amazon Inc., a role inhabited by Jeff Bezos as CEO of Amazon. Like a pharaoh of ancient Egypt, he stands at the top of the largest pyramid of AI value extraction.

XI

To return to the basic element of this visualization—a variation of Marx's triangle of production—each triangle creates a surplus of value for creating profits. If we look at the scale of average income for each activity in the production process of one device, which is shown on the left side of our map, we see the dramatic difference in income earned. According to research by Amnesty International, during the excavation of cobalt, which is also used for lithium batteries of multinational brands, workers are paid the equivalent of one US dollar per day for working in conditions hazardous to life and health, and were often subjected to violence, extortion and intimidation.[16] Amnesty has documented children as young as 7

12. Marshall McLuhan, *Understanding Media: The Extensions of Man* (New York: Signet Books, 1964).
13. Jussi Parikka, *A Geology of Media* (Minneapolis: University of Minnesota Press, 2015), vii–viii.
14. Chris Ely, "The Life Expectancy of Electronics", *Consumer Technology Association,* September 16, 2014, https://www.cta.tech/News/Blog/Articles/2014/September/The-Life-Expectancy-of-Electronics.aspx.
15. Christian Fuchs, *Digital Labor and Karl Marx* (London: Routledge, 2014).
16. Amnesty International, "This Is What We Die For: Human Rights Abuses in the Democratic Republic of the Congo Power the Global Trade in Cobalt", 2016, https://www.amnesty.org/en/documents/afr62/3183/2016/en. For an anthropological description of these mining processes, see Jeffrey W. Mantz, "Improvisational Economies: Coltan Production in the Eastern Congo", *Social Anthropology* 16, no. 1 (February 1, 2008): 34–50, https://doi.org/10.1111/j.1469-8676.2008.00035.x.

working in the mines. In contrast, Amazon CEO Jeff Bezos, at the top of our fractal pyramid, made an average of $275 million a day during the first five months of 2018, according to the Bloomberg Billionaires Index.[17] A child working in a mine in the Congo would need more than 700,000 years of non-stop work to earn the same amount as a single day of Bezos's income.

Many of the triangles shown on this map hide different stories of labor exploitation and inhumane working conditions. The ecological price of transformation of elements and income disparities is just one of the possible ways of representing a deep systemic inequality. We have both researched different forms of "black boxes" understood as algorithmic processes,[18] but this map points to another form of opacity: the very processes of creating, training and operating a device like an Amazon Echo is itself a kind of black box, very hard to examine and track in toto given the multiple layers of contractors, distributors, and downstream logistical partners around the world. As Mark Graham writes, "contemporary capitalism conceals the histories and geographies of most commodities from consumers. Consumers are usually only able to see commodities in the here and now of time and space, and rarely have any opportunities to gaze backwards through the chains of production in order to gain knowledge about the sites of production, transformation, and distribution".[19]

One illustration of the difficulty of investigating and tracking the contemporary production chain process is that it took Intel more than four years to understand its supply line well enough to ensure that no tantalum from the Congo was in its microprocessor products. As a semiconductor chip manufacturer, Intel supplies Apple with processors. In order to do so, Intel has its own multitiered supply chain of more than 19,000 suppliers in over 100 countries providing direct materials for their production processes, tools and machines for their factories, and logistics and packaging services.[20] That it took over four years for a leading technology company just to understand its own supply chain, reveals just how hard this process can be to grasp from the inside, let alone for external researchers, journalists, and academics. Dutch-based technology company Philips has also claimed that it was working to make its supply chain "conflict-free". Philips, for example, has tens of thousands of different suppliers, each of which provides different components for their manufacturing processes.[21] Those suppliers are themselves linked downstream to tens of thousands of component manufacturers that acquire materials from hundreds of refineries that buy ingredients from different smelters, which are supplied by unknown numbers of traders that deal directly with both legal and illegal mining operations. In *The Elements of Power*, David S. Abraham describes the invisible networks of rare metals traders in global electronics supply chains: "The network to get rare metals from the mine to your laptop travels through a murky network of traders, processors, and component manufacturers. Traders are the middlemen who do more than buy and sell rare metals: they help to regulate information and are the hidden link that helps in navigating the network between metals plants and the components in our laptops".[22] According to the computer manufacturing company Dell, complexities of the metal supply chain pose almost insurmountable challenges.[23] The mining of these minerals takes place long before a final product is assembled, making it exceedingly difficult to trace the minerals' origin. In addition, many of the minerals are smelted together with recycled metals, by which point it becomes all but impossible to trace the minerals to their source. So we see that the attempt to capture the full supply chain is a truly gargantuan task: revealing all the complexity of the 21st century global production of technology products.

XII

Supply chains are often layered on top of one another, in a sprawling network. Apple's supplier program reveals there are tens of thousands of individual components embedded in their devices, which are in turn supplied by hundreds of different companies. In order for each of those components to arrive on the final assembly line where it will be assembled by workers in Foxconn facilities, different components need to be physically transferred from more than 750 supplier sites across 30 different countries.[24] This becomes a complex structure of supply chains within supply chains, a zooming fractal of tens of thousands of suppliers, millions of kilometers of shipped materials, and hundreds of thousands of workers included within the process even before the product is assembled on the line.

Visualizing this process as one global, pancontinental network through which materials, components, and products flow, we see an analogy to the global information network. Where there is a single internet packet traveling to an Amazon Echo, here we can imagine a single cargo container.[25] The dizzying spectacle of

17. Julia Glum, "The Median Amazon Employee's Salary Is $28,000. Jeff Bezos Makes More Than That in 10 Seconds", *Time*, May 2, 2018, http://time.com/money/5262923/amazon-employee-median-salary-jeff-bezos/.
18. Frank Pasquale, *The Black Box Society: The Secret Algorithms That Control Money and Information* (Cambridge, MA: Harvard University Press, 2016).
19. Mark Graham and Håvard Haarstad, "Transparency and Development: Ethical Consumption through Web 2.0 and the Internet of Things", *Information Technologies & International Development* 7, no. 1 (March 10, 2011): 1.
20. Intel Corporation, "Intel's Efforts to Achieve a 'Conflict Free' Supply Chain", May 2018, https://www.intel. com/content/www/us/en/corporate-responsibility/conflict-minerals-white-paper.html.
21. Philips, "We Are Working to Make Our Supply Chain 'Conflict-Free'", 2018, https://www.philips.com/a-w/about/company/suppliers/supplier-sustainability/our-programs/conflict-minerals.html.
22. David S. Abraham, *The Elements of Power: Gadgets, Guns, and the Struggle for a Sustainable Future in the Rare Metal Age*, reprint edition (Yale University Press, 2017), 89.
23. Dell, "Responsible Minerals Sourcing", 2018, http://www.dell.com/learn/us/en/uscorp1/conflict-minerals?s=corp.
24. Apple, "Apple Supplier Responsibility 2018 Progress Report", 2018, https://www.apple.com/supplier-responsibility/pdf/Apple_SR_2018_Progress_Report.pdf.
25. Alexander Klose, *The Container Principle: How a Box Changes the Way We Think*, trans. Charles Marcum II (Cambridge, MA: The MIT Press, 2015).

global logistics and production will not be possible without the invention of this simple, standardized metal object. Standardized cargo containers allowed the explosion of the modern shipping industry, which made it possible to model the planet as a massive, single factory. In 2017, the capacity of container ships in seaborne trade reached nearly 250,000,000 deadweight tons of cargo, dominated by giant shipping companies like Maersk of Denmark, the Mediterranean Shipping Company of Switzerland, and France's CMA CGM Group, each owning hundreds of container vessels.[26] For these commercial ventures, cargo shipping is a relatively cheap way to traverse the vascular system of the global factory, yet it disguises much larger external costs.

In recent years, shipping boats produce 3.1% of global yearly CO2 emissions, more than the entire country of Germany.[27] In order to minimize their internal costs, most of the container shipping companies use very low grade fuel in enormous quantities, which leads to increased amounts of sulphur in the air, among other toxic substances. It has been estimated that one container ship can emit as much pollution as 50 million cars, and 60,000 deaths worldwide are attributed indirectly to cargo ship industry pollution related issues annually.[28] Even industry-friendly sources like the World Shipping Council admit that thousands of containers are lost each year, on the ocean floor or drifting loose.[29] Some carry toxic substances which leak into the oceans. Typically, workers spend 9 to 10 months in the sea, often with long working shifts and without access to external communications. Workers from the Philippines represent more than a third of the global shipping workforce.[30] The most severe costs of global logistics are borne by the atmosphere, the oceanic ecosystem and all it contains, and the lowest paid workers.

XIII

The increasing complexity and miniaturization of our technology depends on the process that strangely echoes the hopes of early medieval alchemy. Where medieval alchemists aimed to transform base metals into "noble" ones, researchers today use rare earth metals to enhance the performance of other minerals. There are 17 rare earth elements, which are embedded in laptops and smartphones, making them smaller and lighter. They play a role in color displays, loudspeakers, camera lenses, GPS systems, rechargeable batteries, hard drives, and many other components. They are key elements in communication systems from fiber optic cables, signal amplification in mobile communication towers, to satellites and GPS technology. But the precise configuration and use of these minerals is hard to ascertain. In the same way that medieval alchemists hid their research behind cyphers and cryptic symbolism, contemporary processes for using minerals in devices are protected behind NDAs and trade secrets. The unique electronic, optical, and magnetic characteristics of rare earth elements cannot be matched by any other metals or synthetic substitutes discovered to date. While they are called "rare earth metals", some are relatively abundant in the Earth's crust, but extraction is costly and highly polluting. David Abraham describes the mining of dysprosium and Terbium used in a variety of high-tech devices in Jiangxi, China. He writes, "Only 0.2 percent of the mined clay contains the valuable rare earth elements. This means that 99.8 percent of earth removed in rare earth mining is discarded as waste called 'tailings' that are dumped back into the hills and streams", creating new pollutants like ammonium. In order to refine one ton of rare earth elements, "the Chinese Society of Rare Earths estimates that the process produces 75,000 liters of acidic water and one ton of radioactive residue".

Furthermore, mining and refining activities consume vast amounts of water and generate large quantities of CO2 emissions. In 2009, China produced 95% of the world's supply of these elements, and it has been estimated that the single mine known as Bayan Obo contains 70% of the world's reserves.[31]

XIV

A satellite picture of the tiny Indonesian island of Bangka tells a story about human and environmental toll of the semiconductor production. On this tiny island, mostly "informal" miners are on make-shift pontoons, using bamboo poles to scrape the seabed, and then diving underwater to suck tin from the surface through giant, vacuum-like tubes. As a *Guardian* investigation reports "tin mining is a lucrative but destructive trade that has scarred the island's landscape, bulldozed its farms and forests, killed off its fish stocks and coral reefs, and dented tourism to its pretty palm-lined beaches. The damage is best seen from the air, as pockets of lush forest huddle amid huge swaths of barren orange earth. Where not dominated by mines, this is pockmarked with graves, many holding the bodies of miners who have died over the centuries digging for tin".[32] Two small islands, Bangka and Belitung, produce 90% of Indonesia's tin, and Indonesia

26. United Nations, "Review of Maritime Transport 2017", 2017, http://unctad.org/en/PublicationsLibrary/rmt2017_en.pdf.
27. Zoë Schlanger, "If Shipping Were a Country, It Would Be the Sixth-Biggest Greenhouse Gas Emitter", *Quartz*, April 17, 2018.
28. John Vidal, "Health Risks of Shipping Pollution Have Been 'Underestimated'", *The Guardian*, April 9, 2009, http://www.theguardian.com/environment/2009/apr/09/shipping-pollution.
29. World Shipping Council, "Containers Lost At Sea – 2017 Update", July 10, 2017, http://www.worldshipping.org/industry-is- sues/safety/Containers_Lost_at_Sea_-_2017_Update_FINAL_July_10.pdf.
30. Rose George, *Ninety Percent of Everything: Inside Shipping, the Invisible Industry That Puts Clothes on Your Back, Gas in Your Car, and Food on Your Plate* (New York: Metropolitan Books, 2013), 22. Similar to our habit to neglect materiality of internet infrastructure and information technology, the shipping industry is rarely represented in popular culture. Rose George calls this condition, "sea blindness" (4).
31. Chris Lo, "The False Monopoly: China and the Rare Earths Trade", *Mining Technology*, August 19, 2015, https://www.mining-technology.com/features/featurethe-false-monopoly-china-and-the-rare-earths-trade-4646712/.
32. Kate Hodal, "Death Metal: Tin Mining in Indonesia", *The Guardian*, November 23, 2012, http://www.theguardian.com/environment/2012/nov/23/tin-mining-indonesia-bangka.

is the world's second-largest exporter of the metal. Indonesia's national tin corporation, PT Timah, supplies companies such as Samsung directly, as well as solder makers Chernan and Shenmao, which in turn supply Sony, LG, and Foxconn.[33]

XV

At Amazon distribution centers, vast collections of products are arrayed in a computational order across millions of shelves. The position of every item in this space is precisely determined by complex mathematical functions that process information about orders and create relationships between products. The aim is to optimize the movements of the robots and humans that collaborate in these warehouses. With the help from an electronic bracelet, the human worker is directed though warehouses the size of airplane hangars, filled with objects arranged in an opaque algorithmic order.[34]

Hidden among the thousands of other publicly available patents owned by Amazon, US patent number 9,280,157 represents an extraordinary illustration of worker alienation, a stark moment in the relationship between humans and machines.[35] It depicts a metal cage intended for the worker, equipped with different cybernetic add-ons, that can be moved through a warehouse by the same motorized system that shifts shelves filled with merchandise. Here, the worker becomes a part of a machinic ballet, held upright in a cage which dictates and constrains their movement.
As we have seen time and time again in the research for our map, dystopian futures are built upon the unevenly distributed dystopian regimes of the past and present, scattered through an array of production chains for modern technical devices. The vanishingly few at the top of the fractal pyramid of value extraction live in extraordinary wealth and comfort. But the majority of the pyramids are made from the dark tunnels of mines, radioactive waste lakes, discarded shipping containers, and corporate factory dormitories.

XVI

At the end of 19th century, a particular Southeast Asian tree called palaquium gutta became the center of a technological boom. These trees, found mainly in Malaysia, produce a milky white natural latex called gutta percha. After English scientist Michael Faraday published a study in *The Philosophical Magazine* in 1848 about the use of this material as an electrical insulator, gutta percha rapidly became the darling of the engineering world. It was seen as the solution to the problem of insulating telegraphic cables in order that they could withstand the conditions of the ocean floor. As the global submarine business grew, so did demand for palaquium gutta tree trunks. The historian John Tully describes how local Malay, Chinese, and Dayak workers were paid little for the dangerous works of felling the trees and slowly collecting the latex.[36] The latex was processed then sold through Singapore's trade markets into the British market, where it was transformed into, among other things, lengths upon lengths of submarine cable sheaths.

A mature palaquium gutta could yield around 300 grams of latex. But in 1857, the first transatlantic cable was around 3,000 km long and weighed 2,000 tons—requiring around 250 tons of gutta percha. To produce just one ton of this material required around 900,000 tree trunks. The jungles of Malaysia and Singapore were stripped, and by the early 1880s the palaquium gutta had vanished. In a last-ditch effort to save their supply chain, the British passed a ban in 1883 to halt harvesting the latex, but the tree was already extinct.[37]

The Victorian environmental disaster of gutta percha, from the early origins of the global information society, shows how the relationships between technology and its materiality, environments, and different forms of exploitation are imbricated. Just as Victorians precipitated ecological disaster for their early cables, so do rare earth mining and global supply chains further imperil the delicate ecological balance of our era. From the material used to build the technology enabling contemporary networked society, to the energy needed for transmitting, analyzing, and storing the data flowing through the massive infrastructure, to the materiality of infrastructure: these deep connections and costs are more significant, and have a far longer history than is usually represented in the corporate imaginaries of AI.[38]

XVII

Large-scale AI systems consume enormous amounts of energy. Yet the material details of those costs remain vague in the social imagination. It remains difficult to get precise details about the amount of energy consumed by cloud computing services. A Greenpeace report states: "One of the single biggest obstacles to sector transparency is Amazon Web Services (AWS). The world's biggest cloud computer company remains almost completely non-transparent about the energy footprint of its massive operations. Among the global cloud providers, only AWS still refuses to make public basic details on the energy performance and environmental impact associated with its operations".[39]

33. Cam Simpson, "The Deadly Tin Inside Your Smartphone", *Bloomberg*, August 24, 2012, https://www.bloomberg.com/news/articles/2012-08-23/the-deadly-tin-inside-your-smartphone.
34. Marcus Wohlsen, "A Rare Peek Inside Amazon's Massive Wish-Fulfilling Machine", *Wired*, June 16, 2014, https://www.wired.com/2014/06/inside-amazon-warehouse/.
35. Peter R. Wurman et al., "System and Method for Transporting Personnel Within an Active Workspace", US 9,280,157 B2, Reno, NV, filed September 4, 2013, and issued March 8, 2016, http://pdfpiw.uspto.gov/.piw?Docid=09280157.
36. John Tully, "A Victorian Ecological Disaster: Imperialism, *the Telegraph*, and Gutta-Percha", Journal of World History 20, no. 4 (December 23, 2009): 559–79, https://doi.org/10.1353/jwh.0.0088.
37. Ibid., 574.
38. See Nicole Starosielski, *The Undersea Network* (Durham: Duke University Press Books, 2015).
39. Gary Cook, *Clicking Clean: Who Is Winning the Race to Build a Green Internet?* (Washington, DC: Greenpeace, 2017), 30, https://storage.googleapis.com/p4-production-content/international/wp-content/uploads/2017/01/35f0ac1a-click-clean2016-hires.pdf.

As human agents, we are visible in almost every interaction with technological platforms. We are always being tracked, quantified, analyzed, and commodified. But in contrast to user visibility, the precise details about the phases of birth, life, and death of networked devices are obscured. With emerging devices like the Echo relying on a centralized AI infrastructure far from view, even more of the detail falls into the shadows.

While consumers become accustomed to a small hardware device in their living rooms, or a phone app, or a semi-autonomous car, the real work is being done within machine learning systems that are generally remote from the user and utterly invisible to her. In many cases, transparency wouldn't help much—without forms of real choice, and corporate accountability, mere transparency won't shift the weight of the current power asymmetries.[40]

The outputs of machine learning systems are predominantly unaccountable and ungoverned, while the inputs are enigmatic. To the casual observer, it looks like it has never been easier to build AI or machine learning-based systems than it is today. Availability of open-source tools for doing so in combination with rentable computation power through cloud superpowers such as Amazon (AWS), Microsoft (Azure), or Google (Google Cloud) is giving rise to a false idea of the "democratization" of AI. While "off the shelf" machine learning tools, like TensorFlow, are becoming more accessible from the point of view of setting up your own system, the underlying logics of those systems, and the datasets for training them are accessible to and controlled by very few entities. In the dynamic of dataset collection through platforms like Facebook, users are feeding and training the neural networks with behavioral data, voice, tagged pictures and videos, or medical data. In an era of extractivism, the real value of that data is controlled and exploited by the very few at the top of the pyramid.

XVIII

When massive data sets are used to train AI systems, the individual images and videos involved are commonly tagged and labeled.[41] There is much to be said about how this labeling process abrogates and crystallizes meaning, and further, how this process is driven by clickworkers being paid fractions of a cent for this digital piecework.

In 1770, Hungarian inventor Wolfgang von Kempelen constructed a chess-playing machine known as the Mechanical Turk. His goal, in part, was to impress Empress Maria Theresa of Austria. This device was capable of playing chess against a human opponent and had spectacular success winning most of the games played during its demonstrations around Europe and the Americas for almost nine decades. But the Mechanical Turk was an illusion that allowed a human chess master to hide inside the machine and operate it. Some 160 years later, Amazon.com branded its micropayment based crowdsourcing platform with the same name. According to Ayhan Aytes, Amazon's initial motivation to build Mechanical Turk emerged after the failure of its artificial intelligence programs in the task of finding duplicate product pages on its retail website.[42] After a series of futile and expensive attempts, the project engineers turned to humans to work behind computers within a streamlined web-based system.[43] Amazon Mechanical Turk digital workshop emulates artificial intelligence systems by checking, assessing, and correcting machine learning processes with human brainpower. With Amazon Mechanical Turk, it may seem to users that an application is using advanced artificial intelligence to accomplish tasks. But it is closer to a form of "artificial artificial intelligence", driven by a remote, dispersed and poorly paid clickworker workforce that helps a client achieve their business objectives. As observed by Aytes, "in both cases [both the Mechanical Turk from 1770 and the contemporary version of Amazon's service] the performance of the workers who animate the artifice is obscured by the spectacle of the machine".[44]

This kind of invisible, hidden labor, outsourced or crowdsourced, hidden behind interfaces and camouflaged within algorithmic processes is now commonplace, particularly in the process of tagging and labeling thousands of hours of digital archives for the sake of feeding the neural networks. Sometimes this labor is entirely unpaid, as in the case of Google's reCAPTCHA. In a paradox that many of us have experienced, in order to prove that you are not an artificial agent, you are forced to train Google's image recognition AI system for free, by selecting multiple boxes that contain street numbers, or cars, or houses.

As we see repeated throughout the system, contemporary forms of artificial intelligence are not so artificial after all. We can speak of the hard physical labor of mine workers, and the repetitive factory labor on the assembly line, of the cybernetic labor in distribution centers and the cognitive sweatshops full of outsourced programmers around the world, of the low paid crowdsourced labor of Mechanical Turk workers, or the unpaid immaterial work of users. At every level contemporary technology is deeply rooted in and running on the exploitation of human bodies.

40. Mike Ananny and Kate Crawford, "Seeing without knowing: Limitations of the transparency ideal and its application to algorithmic accountability", *New Media & Society* 20, no. 3 (2018): 973–89.
41. Olga Russakovsky et al., "ImageNet Large Scale Visual Recognition Challenge", *International Journal of Computer Vision* 115, no. 3 (December 1, 2015): 216, https://doi.org/10.1007/s11263-015-0816-y.
42. Ayhan Aytes, "Return of the Crowds: Mechanical Turk and Neoliberal States of Exception", in *Digital Labor: The Internet as Playground and Factory*, ed. Trebor Scholz (London: Routledge, 2012), 80.
43. Jason Pontin, "Artificial Intelligence, With Help From the Humans", *The New York Times*, March 25, 2007, https://www.nytimes.com/2007/03/25/business/yourmoney/25Stream.html.
44. Aytes, "Return of the Crowds", 81.

XIX

In his one-paragraph short story "On Exactitude in Science", Jorge Luis Borges presents us with an imagined empire in which cartographic science became so developed and precise that it needed a map on the same scale as the empire itself.[45]

"In that Empire, the Art of Cartography attained such Perfection that the map of a single Province occupied the entirety of a City, and the map of the Empire, the entirety of a Province. In time, those Unconscionable Maps no longer satisfied, and the Cartographers Guilds struck a Map of the Empire whose size was that of the Empire, and which coincided point for point with it. The following Generations, who were not so fond of the Study of Cartography as their Forebears had been, saw that that vast map was Useless, and not without some Pitilessness was it, that they delivered it up to the Inclemencies of Sun and Winters. In the Deserts of the West, still today, there are Tattered Ruins of that Map, inhabited by Animals and Beggars; in all the Land there is no other Relic of the Disciplines of Geography".

Current machine learning approaches are characterized by an aspiration to map the world, a full quantification of visual, auditory, and recognition regimes of reality. From cosmological models for the universe to the world of human emotions as interpreted through the tiniest muscle movements in the human face, everything becomes an object of quantification. Jean-François Lyotard introduced the phrase "affinity to infinity" to describe how contemporary art, techno-science, and capitalism share the same aspiration to push boundaries towards a potentially infinite horizon.[46] The second half of the 19th century, with its focus on the construction of infrastructure and the uneven transition to industrialized society, generated enormous wealth for the small number of industrial magnates that monopolized exploitation of natural resources and production processes.

The new infinite horizon is data extraction, machine learning, and reorganizing information through artificial intelligence systems of combined human and machinic processing. The territories are dominated by a few global mega-companies, which are creating new infrastructures and mechanisms for the accumulation of capital and exploitation of human and planetary resources.

Such unrestrained thirst for new resources and fields of cognitive exploitation has driven a search for ever deeper layers of data that can be used to quantify the human psyche, conscious and unconscious, private and public, idiosyncratic and general. In this way, we have seen the emergence of multiple cognitive economies from the attention economy,[47] the surveillance economy, the reputation economy,[48] and the emotion economy, as well as the quantification and commodification of trust and evidence through cryptocurrencies.

Increasingly, the process of quantification is reaching into the human affective, cognitive, and physical worlds. Training sets exist for emotion detection, for family resemblance, for tracking an individual as they age, and for human actions like sitting down, waving, raising a glass, or crying. Every form of biodata—including forensic, biometric, sociometric, and psychometric—are being captured and logged into databases for AI training. That quantification often runs on very limited foundations: datasets like AVA which primarily shows women in the "playing with children" action category, and men in the "kicking a person" category. The training sets for AI systems claim to be reaching into the fine-grained nature of everyday life, but they repeat the most stereotypical and restricted social patterns, re-inscribing a normative vision of the human past and projecting it into the human future.

XX

"The 'enclosure' of biodiversity and knowledge is the final step in a series of enclosures that began with the rise of colonialism. Land and forests were the first resources to be 'enclosed' and converted from commons to commodities. Later on, water resources were 'enclosed' through dams, ground-water mining and privatization schemes. Now it is the turn of biodiversity and knowledge to be 'enclosed' through intellectual property rights (IPRs)", Vandana Shiva explains.[49] In Shiva's words, "the destruction of commons was essential for the industrial revolution, to provide a supply of natural resources for raw material to industry. A life-support system can be shared, it cannot be owned as private property or exploited for private profit. The commons, therefore, had to be privatized, and people's sustenance base in these commons had to be appropriated, to feed the engine of industrial progress and capital accumulation".[50]

While Shiva is referring to enclosure of nature by intellectual property rights, the same process is now occurring with machine learning—an intensification of quantified nature. The new gold rush in the context of artificial intelligence is to enclose different fields of human knowing, feeling, and action, in order to capture and privatize those fields. When in November 2015 DeepMind Technologies Ltd. got access to the health

45. Jorge Luis Borges, "On Exactitude in Science", in *Collected Fictions*, trans. Andrew Hurley (New York: Penguin, 1999), 325.
46. Jean Francois Lyotard, "Presenting the Unpresentable: The Sublime", *Artforum*, April 1982.
47. Yves Citton, *The Ecology of Attention* (Cambridge, UK: Polity, 2017).
48. Shoshana Zuboff, "Big Other: Surveillance Capitalism and the Prospects of an Information Civilization", *Journal of Information Technology* 30, no. 1 (March 1, 2015): 75–89, https://doi.org/10.1057/jit.2015.5.
49. Vandana Shiva, *The Enclosure and Recovery of The Commons: Biodiversity, Indigenous Knowledge, and Intellectual Property Rights* (New Delhi: Research Foundation for Science, Technology, and Ecology, 1997).
50. Vandana Shiva, *Protect or Plunder: Understanding Intellectual Property Rights* (New York: Zed Books, 2001).

records of 1.6 million identifiable patients of Royal Free hospital, we witnessed a particular form of privatization: the extraction of knowledge value.[51] A dataset may still be publicly owned, but the meta-value of the data—the model created by it—is privately owned. While there are many good reasons to seek to improve public health, there is a real risk if it comes at the cost of a stealth privatization of public medical services. That is a future where expert local human labor in the public system is augmented and sometimes replaced with centralized, privately-owned corporate AI systems, that are using public data to generate enormous wealth for the very few.

XXI

At this moment in the 21st century, we see a new form of extractivism that is well underway: one that reaches into the furthest corners of the biosphere and the deepest layers of human cognitive and affective being. Many of the assumptions about human life made by machine learning systems are narrow, normative, and laden with error. Yet they are inscribing and building those assumptions into a new world, and will increasingly play a role in how opportunities, wealth, and knowledge are distributed.

The stack that is required to interact with an Amazon Echo goes well beyond the multi-layered "technical stack" of data modeling, hardware, servers, and networks. The full stack reaches much further into capital, labor, and nature, and demands an enormous amount of each. The true costs of these systems—social, environmental, economic, and political—remain hidden and may stay that way for some time.

We offer up this map and essay as a way to begin seeing across a wider range of system extractions. The scale required to build artificial intelligence systems is too complex, too obscured by intellectual property law, and too mired in logistical complexity to fully comprehend in the moment. Yet you draw on it every time you issue a simple voice command to a small cylinder in your living room: "Alexa, what time is it?".
And so the cycle continues.

51. Alex Hern, "Royal Free Breached UK Data Law in 1.6m Patient Deal with Google's DeepMind", *The Guardian*, July 3, 2017.

The Waterworks of Money

CARLIJN KINGMA (NL)

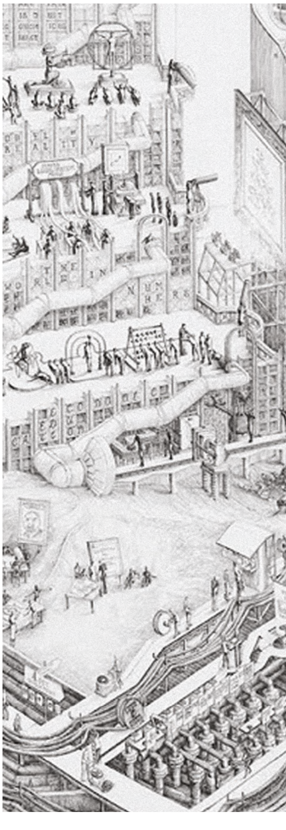
STARTS pillar
STARTS Prize (Honorary Mention, 2024)

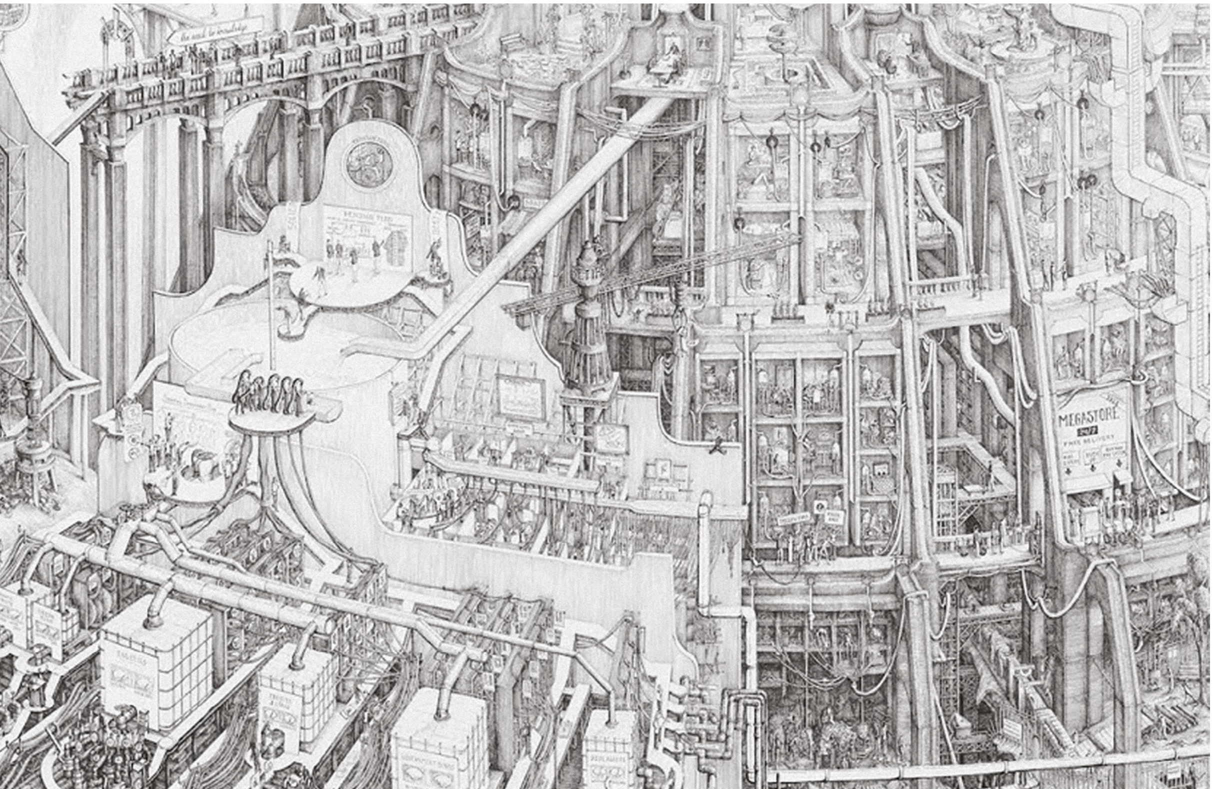
The Waterworks of Money is a collaborative art-research project that visualizes the flow of money through society using the metaphor of an irrigation network. Led by cartographer Carlijn Kingma, with investigative journalist Thomas Bollen and finance researcher Martijn van der Linden, the team translates complex financial mechanisms—money creation, capital accumulation, institutional control—into architectural maps, narratives, and animations. The visuals show where the "water" of capital pools, where it dries up, and where it is channeled to benefit a few.

What makes this work especially powerful is its interdisciplinary nature. Over two years, the team interviewed over 100 experts: central bankers, pension fund managers, regulators, academics, and activists. Kingma spent more than 2,300 hours drafting maps from this input, while Bollen and van der Linden shaped the story logic, scenarios, and policy reflections. Exhibitions, videos, and publications emerged from these interactions.

By turning abstract financial dynamics into a visual, spatial, and narrative form, *The Waterworks of Money* makes hidden power visible. It invites audiences to engage with systemic issues—inequality, policy choices, reform—through an accessible language of imagery and metaphor. In doing so, it shows how art, when paired with rigorous research, can open new ways of seeing economic systems that usually remain opaque.

Drawings: Carlijn Kingma
Stories: Thomas Bollen, Carlijn Kingma, and Martijn Jeroen van der Linden
Animations: Studio Tiepes
English translation: Erica Moore
Audio recordings: Studio Oorbit
Photos: Studio Oppa
With support from: The Hague University and investigative journalism platform Follow The Money; Stimuleringsfonds Creatieve Industrie, Stichting Brave New Works, and the Interledger Foundation. The project received support from the Rabobank through an artist-in-residence.




MEGASTORE
FREE DELIVERY

RAISE AWARENESS

Raise Awareness focuses on artistic practices that critically investigate the technological, political, and ecological conditions shaping contemporary life by revealing biases, opaque infrastructures, and mechanisms of power that often remain unseen. These projects aim to make complex social and ecological realities accessible in ways that allow broad audiences to engage meaningfully. Across the cluster, artists address topics such as algorithmic decision-making, surveillance practices, geopolitical conflicts, environmental degradation, and the hidden infrastructures of global food and waste systems. Their approaches range from immersive installations and data-driven visualizations to interactive games and participatory platforms that support citizen learning and dialogue, and the final form of presentation is intended to be engaging and attractive to the audience. Through these diverse forms of public-facing inquiry, the artists make hidden structures visible and foster digital and environmental literacy. They invite viewers to question dominant narratives, recognize systemic inequities, and reflect on their own position within technological and environmental systems. Thus, these projects ultimately create conditions in which informed public discourse and collective action can emerge.

Antarctic Resolution

GIULIA FOSCARI (IT) AND UNLESS (IT)

STARTS pillar
STARTS Prize
(Grand Prize for Innovative Collaboration, 2022)

Creation dates
2021–23

Stakeholders involved
NGO, academia, architects, scientists (climate and glaciology), policy experts, designers, and cultural institutions

Technology applied
data visualization, cartography, open-access digital publishing, immersive installation design, wearable technology

Industry areas addressed
environmental science, architecture and spatial design, policy and governance, civic advocacy, public education

Launched 200 years after the first recorded human landing on the continent, *Antarctic Resolution* is a transnational and multidisciplinary project initiated by architect Giulia Foscari and the non-profit agency UNLESS. As the first terrestrial Global Commons with no Indigenous population, Antarctica occupies a paradoxical place in the global imagination—widely romanticized yet geopolitically contested and ecologically threatened. The central research question that drives this expansive effort is: How can interdisciplinary collaboration and artistic research reshape public and policy-maker awareness of Antarctica as a critical Global Commons, and mobilize action to protect its fragile ecosystem in the face of climate crisis and geopolitical tension?

The project addresses this challenge through a remarkable constellation of initiatives that combine data visualization, artistic practice, environmental science, and policy engagement. At its core lies a 1000-page encyclopedic volume, *Antarctic Resolution*, published by Lars Müller Publishers and authored by over 150 leading polar experts across disciplines. This monumental work brings together scientific research, geopolitical analysis, and architectural design to construct a comprehensive high-resolution image of the continent—contrasting the fragmented view offered by big data platforms. The publication is now available as an open-access resource, underscoring the project's commitment to knowledge democratization.

Beyond the book, *Antarctic Resolution* has been presented in internationally recognized cultural venues, including the Venice Architecture Biennale and the Thyssen-Bornemisza Museum in Madrid. These exhibitions—featuring immersive installations, archival materials, and the "Antarctic Suit" co-developed with D-Air Lab—transform the project's research into accessible, tangible experiences.

The impact of the project is not limited to cultural discourse. UNLESS launched the campaign "Speak Up for Antarctica Now" during the 44th Antarctic Treaty Consultative Meeting in Berlin, inviting citizens to publicly demand accountability from the 29 nations responsible for shaping the governance of the continent. This initiative illustrates the project's approach to civic engagement—not through traditional citizen

Top to bottom:

Speak Up for Antarctica Now.
Courtesy: UNLESS Photo: Louis De Belle

Antarctic Resolution. Exhibition at the Venice Biennale
Courtesy: UNLESS Photo: Delfino Sisto Legnani

science, but through citizen-involved practices that foster emotional connection and political awareness. Following the STARTS Prize award, UNLESS has expanded its advocacy by drafting two *Antarctic resolutions*: one proposing a redefinition of the Antarctic masterplan to prioritize shared international scientific bases; the other calling for a transnational Antarctic Data Space, resisting national data embargoes in favor of transparency and environmental accountability. Along with it, the project intervenes in international processes with concrete proposals and a clear vision for cooperative, ethically driven Antarctic stewardship. Another outcome that the project development led to is the foundation of the Polar Lab, the transnational academic platform.

The project translates complex environmental, political, and scientific realities into engaging, provocative narratives that reach diverse audiences. It challenges dominant structures of knowledge, critiques extractive geopolitical ambitions, and invites global citizens to assume their role as stewards of the planet. By making environmental data both intelligible and emotionally resonant, the project fosters public literacy and catalyzes action—demonstrating the power of artistic practice not only to inform but to transform.

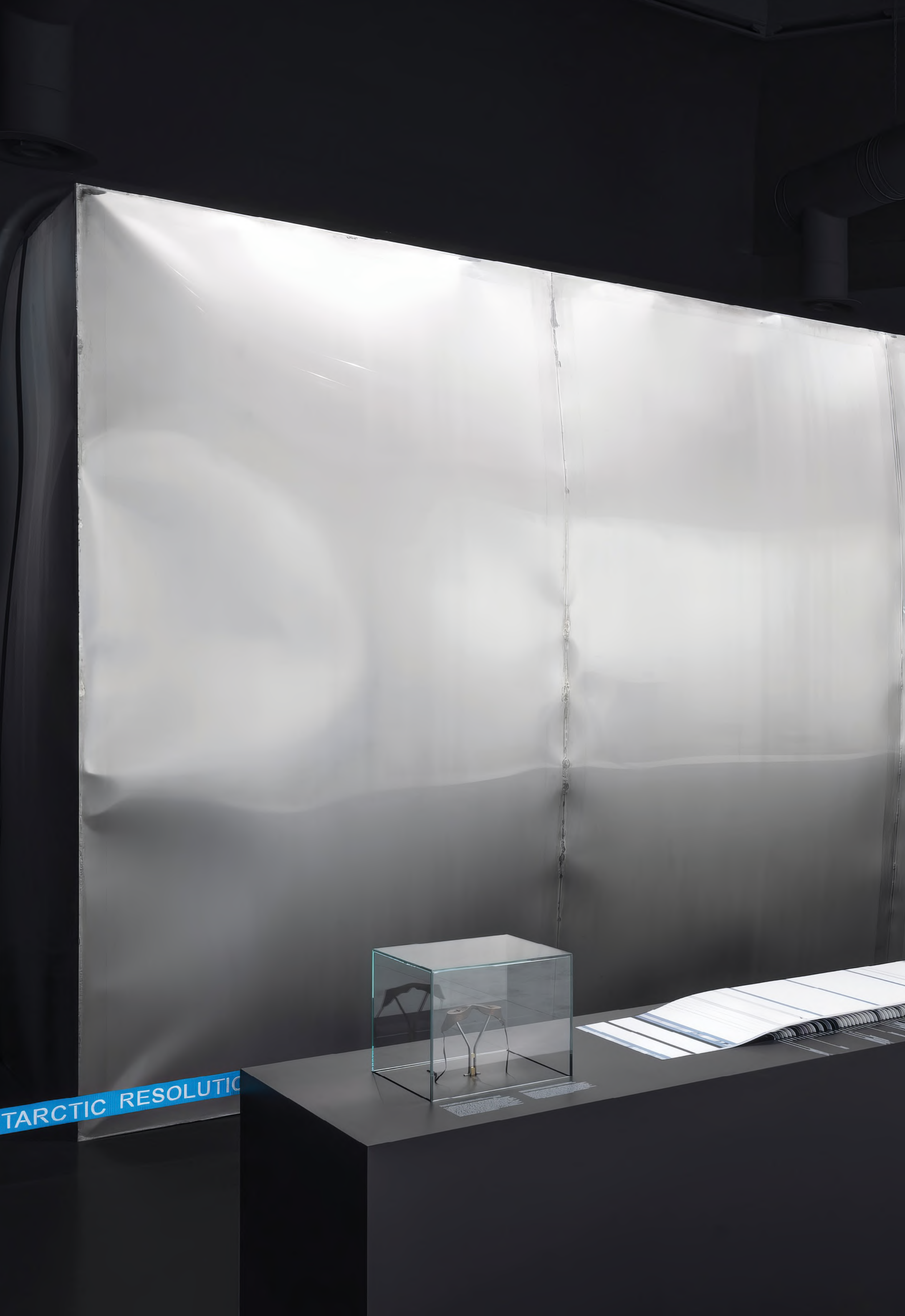
Giulia Foscari & UNLESS

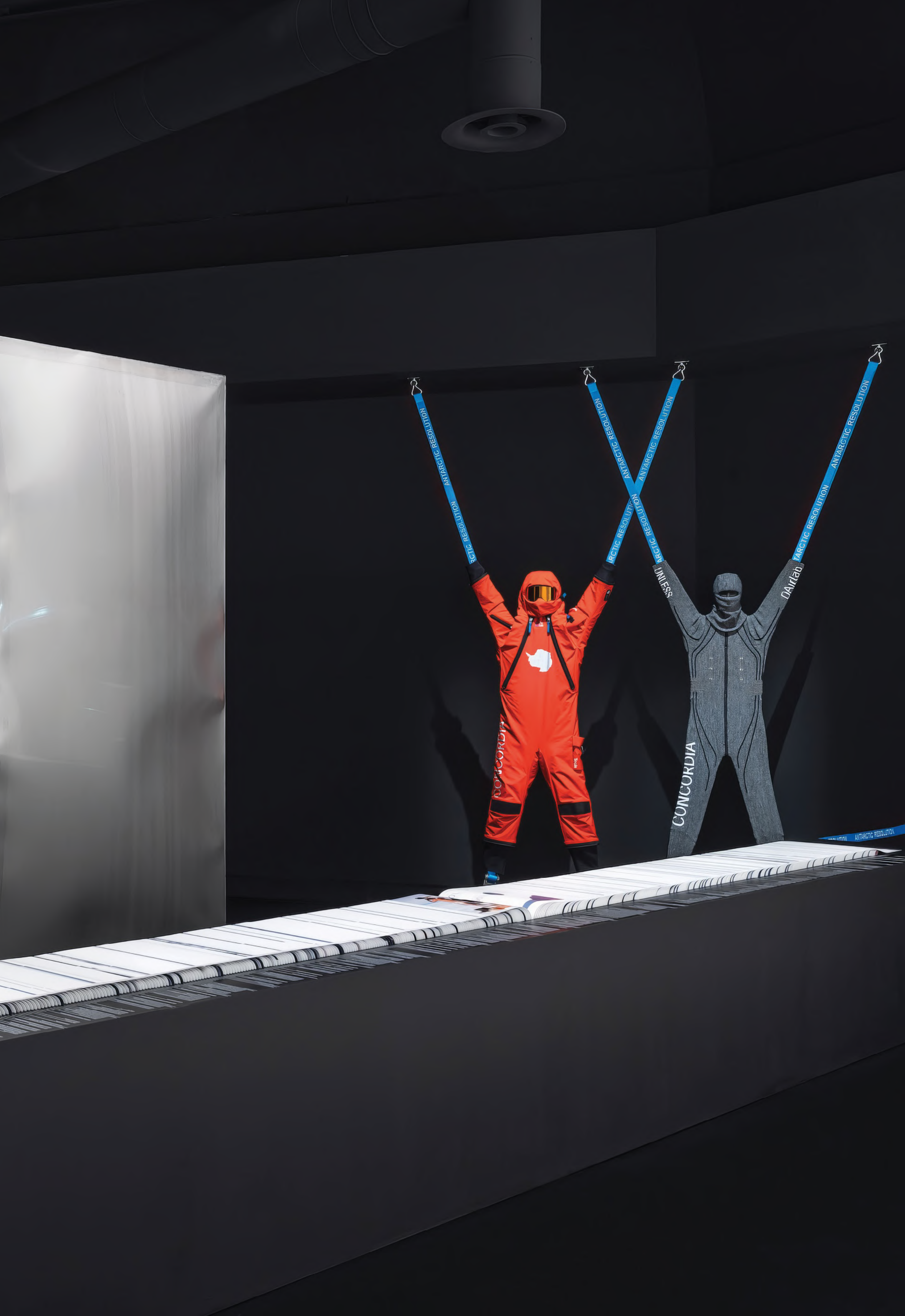
Antarctic Resolution (2019). Publication
Editor: Giulia Foscari / UNLESS
Authors: 150 interdisciplinary specialists (full list in project URL)
Data/Images: 82 organizations & archives, 27 artists (full list in project URL)
Cartography/Infographics: UNLESS, The Polar Lab, Pomo
Architectural Drawings: UNLESS, The Polar Lab
Publisher: Lars Müller Publishers

Antarctic Resolution. Exhibition in Venice, Italy
Exhibitor: Giulia Foscari / UNLESS
Featured: Arcangelo Sassolino; David Vaughan; D-Air Lab
Collaborators: Lars Müller Publishers, Scott Polar Research Institute

#SpeakUpForAntarcticaNow. Campaign in Berlin, Germany
Concept: UNLESS with Carlo Barbante, Alan D. Hemmings, James N. Barnes
Graphic design: Studio Vedet and HaugHaug.
Photographers: Shaun O'Boyle, Sebastian Copeland, Andrea Izzotti, Spencer Lowell, James Morris, Paolo Pellegrin, Emil Shulthess, John Weller, Norbert Wu
Partner organizations for the rally: Antarctic Southern Ocean Coalition, Deutsche Umwelthilfe, Fridays for Future, Greenpeace, Pew Bertarelli Ocean Legacy, Scientists for Future
Partners: Only One, TBA21 on St_age

With support from: D-Air Lab; Fondazione Giuseppe e Pericle Lavazza; Furthermore: a program of the J. M. Kaplan Fund; Graham Foundation for Advanced Studies in the Fine Arts; Thyssen Bornemisza Art Contemporary TBA21; Ursula Stein.


TARCTIC RESOLUTIO


ANTARCTIC RESOLUTION
CONCORDIA
UNLESS

Antarctic Resolution

GIULIA FOSCARI (IT)

Accounting for approximately 10% of the land mass of Planet Earth,[1] Antarctica—first theorised by the ancient Greeks yet only "discovered" after the Industrial Revolution—is a realm we collectively neglect. Far from being a pristine natural landscape, the continent is a contested territory which conceals not only resources that might prove irresistible in a world with ever-increasing population growth but also scientific data crucial to inform future environmental policies. The kilometres-thick stratum of ice that has accumulated on its bedrock for millions of years, equivalent to around 70% of the freshwater on our planet,[2] represents both an indispensable resource for human survival and the greatest menace to global coastal settlements threatened by the rise in sea levels induced by anthropogenic global warming.

Antarctic Resolution advocates the urgent removal of the goggles of Heroic Age explorers[3] and the rejection of the pixelated view of Antarctica offered to us by Big Data companies.[4] In their place it urges the construction of a high-resolution image focusing on the continent's unique geography, experimental governance system, contemporary geopolitical significance, unparalleled scientific potential, and extreme inhabitation model. Looking beyond what is visible, *Antarctic Resolution* also aims to unveil the intricate web of growing economic and strategic interests, tensions, and international rivalries that are deliberately enveloped in total darkness, as is the continent for six months per year.

Only a concerted effort by a transnational network of multidisciplinary polar experts could construct an image sufficiently focused to properly address the urgent issues concealed in 26 quadrillion tons of ice.[5] No single discipline can synthesise the complexity of the natural and political forces at play in what is unquestionably a Global Commons, i.e. an open-access site, like the high seas, the deep seabed, the atmosphere, and Outer Space, whose governance should equitably benefit humankind at large.

With this in mind, on the eve of the 200th anniversary of the first recorded sighting of Antarctica,[6] UNLESS[7] has invited over 200 specialists from the fields of aeronautics, anthropology, architecture, biology, chemistry, climate change, economics, engineering, geoscience, glaciology, history, law, literature, logistics, medicine, physics, political science, science, sociology, technology, and the visual arts to actively engage in dynamic dialogues, theoretical seminars, and radical workshops,[8] in an attempt to jointly close a paradoxical knowledge gap of the only continent devoted, on paper at least, purely to research.

Presented here in the form of single pixels, data to be analysed, and ideas to be built upon, the collaborative project offers no presumption of completeness and no authoritative finale. Alongside the authored texts, a vast portfolio including visualisations[9] produced by UNLESS and its Polar Lab[10] testifies to architecture's disciplinary aptitude for visualising phenomena that pertain to the realms of geopolitics, science, and sociology and to the designer's responsibility to critically analyse the contemporary condition and redirect collective behaviours. With subjects ranging in scale from neutrinos[11] and microscopic diatoms[12] to the cosmos, and in timescales from past glacial-era atmospheric concentrations to projected post-human conditions, the

1. Planet Earth was first immortalised in its entirety on the 7th of December 1972 by Harrison Schmitt aboard the command module of Apollo 17. Known as NASA Image AS17-148-22727, the photograph is the first to capture the illuminated globe. Contrary to all previous lunar missions, during which the celestial bodies of the Earth and the Moon were obscured by complementary shadows, the trajectory of Apollo 17 allowed humankind to see the so called "Blue Marble" from afar. Prophetically, the crew's line of sight fell onto Africa and Antarctica, putting the latter centre stage.
2. See Tabatha Thompson and Ed Campion, "Joint NASA Study Reveals Leaks in Antarctic 'Plumbing System'", NASA press release, 15 February 2007, nasa.gov [online].
3. The wooden snow googles with cross-shaped eye slits, like those worn by Captain Robert Falcon Scott during the National Antarctic Expedition in 1901–1904, offered a limited field of vision to explorers who ventured into the unforgiving environment of Antarctica during the Heroic Age (1897–1922).
4. The ultimate metaphor for the collective neglect of Antarctica is the pixelated and fragmented view of the southernmost continent offered by Google Earth, which is reminiscent of the "blank spaces" on imperial maps.
5. See Peter Fretwell, *Antarctic Atlas: New Maps and Graphics That Tell the Story of a Continent* (London: Particular Books, 2020).
6. The first official sightings were recorded on the 27th of January 1820 by Admiral Fabian Gottlieb von Bellingshausen, on the 30th of January 1820 by Edward Bransfield, and on the 17th of November 1820 by Captain Nathaniel Brown Palmer. The first to land on the continent is believed to have been John Davis, on the 17th of February 1821.
7. UNLESS is a non-profit agency for change devoted to interdisciplinary research on extreme environments.
8. The workshops and seminars were held at the Architectural Association School of Architecture in London, at the Scott Polar Research Institute and the United Kingdom Antarctic Heritage Trust in Cambridge (United Kingdom), at the Pontifical Catholic University of Chile in Santiago (Chile), at the University of Hong Kong (Hong Kong), and at Ness in Buenos Aires (Argentina).
9. All the visualisations produced by UNLESS and the Polar Lab rely on primary sources that were often unveiled during deep dives into deserted archives and long conversations with Antarctic specialists. Evidence of these data-mining efforts is offered in the appendix, where all the sources are duly recorded. The ever-changing trajectory of the Convergence circumpolar current, the pulsating ice pack (which almost doubles the overall surface area of ice during the winter months), and the shifting Magnetic and Geomagnetic South Poles offer examples of the impossibility and inadequacy of trying to dominate the southernmost continent.
10. Launched by UNLESS, the Polar Lab is an experimental, transnational academic platform that brings together architecture students from universities around the globe with interdisciplinary Antarctic experts. With research hubs in Argentina, Brazil, Chile, Hong Kong, and the United Kingdom—directed respectively by Florencia Rodriguez, Sol Camacho, Arturo Lyon, Juan Du, Francesco Bandarin, and myself—the Polar Lab has brought to light unique Antarctic narratives concealed in regional archives and produced the "Antarctic Atlas" presented in the following pages.
11. Scientifically studied within the 1,000,000,000-cubicmetre block of ice of the IceCube Neutrino Observatory located at the South Pole, the almost massless and chargeless subatomic particles known as neutrinos encapsulate information on supernova explosions, cosmic rays, and the universe.

publication aspires to broadcast knowledge of the continent and the Southern Ocean that surrounds it (which together constitute the “Antarctic” as a region), provoke change, and ultimately mobilise younger generations to undertake a true Antarctic resolution.

Equally significant to the content presented here are the blanks. I assume responsibility for any omission, which is hopefully excusable in the context of a work that attempts to examine a continent twice the size of Australia and a maritime area of tens of millions of square kilometres; any perceived scarcity of mention of certain nations and their accomplishments should not be interpreted as an editorial decision nor as a lack of effort. More problematic, though, is the blank page or, better put, the programmed “white-out”[14] of exploitable Antarctic resources.

Antarctica’s governance model relies on the Antarctic Treaty, an international Cold War-era agreement signed in 1959[15] as a legacy of the International Geophysical Year to promote the demilitarisation and denuclearisation of Antarctica and ensure that “international cooperation in scientific investigation” conducted in the continent would lead to the free exchange of “scientific observations and results”.[16] Six decades after the agreement came into force, allowing for the progressive building of what is now called the Antarctic Treaty System, commercial and strategic interests in the vast untapped reserves of natural resources, in the marine species found in abundance in the Southern Ocean,[17] in Antarctic bioprospecting,[18] in polar tourism,[19] and in unperturbed access to global satellite navigation systems[20] are exerting new pressures on the already fragile Antarctic system of governance.

In this contemporary scenario, it appears as if scholars are no longer granted the cultural freedom to share their discoveries on Antarctic natural resources in the way that they were up until the signing of the Protocol on Environmental Protection,[21] and their subjection to the rules of conduct enforced by national programmes is expressed in an eloquent silence. With the Antarctic Environmental Protocol—and thus the provisions that ban mining and resource exploitation—subject to review as of 2048, this black hole, which is no less haunting than the ozone hole that looms over Antarctica, preludes conflicts that will be difficult to govern and, if unresolved, potentially catastrophic to our ecosystem.

The paradoxes induced by the current science-centred governance model are accompanied by a legislative vacuum, by the unwillingness of the Consultative Parties to the Antarctic Treaty (who manage the continent “in the interest of all mankind”[22]—in other words, on behalf of the remaining 85% of nations) to formulate a pertinent legal framework for the southern-most continent. The normative void born out of the treaty’s deferral of national claims, and the consequent absence of sanctions, limits the enforcement of regulations on all operations in Antarctica, including the building sector, which is not regulated by binding building standards either for new constructions or for the preservation of its historical artefacts. Consequently, the continent’s intrinsic value—i.e. the moral standing of Antarctica’s astonishing natural world, wilderness, and wonders, and the rights accorded to them—is challenged, just like anywhere else on our planet, not only by the manifest risks posed by global warming but also by environmental pressures and harmful interference arising from human activity.

Humans who devote their lives to science so that “the world may have a little more knowledge, that it may build on what it knows instead of what it thinks”[23] inhabit this un-normed geography in scientific research

12. Coccolithophores are microscopic marine diatoms which are gravely affected by the excessive acidification of the warming Southern Ocean, the world’s largest carbon sink. On its own, this body of water is responsible for the absorption of 40% of anthropogenic carbon dioxide and for activating the global oceanic circulation. The altered pH value of the oceanic water inhibits the calcification process of organisms such as the coccolithophores, endangering the entire marine ecosystem and aggravating biodiversity loss.
13. Antarctica is the largest planetary archive—an archive in which it is the very substance of the ice that contains what is most evanescent in life: air and time. Ice cores drilled on the Antarctic Plateau allow palaeoclimatologists to extract scientific values on historic temperature fluctuations and reconstruct trends in atmospheric greenhouse-gas concentrations from past ice ages and “warm” interglacial eras. As shown on the following page and expanded upon in an article in The Economist dated 21st of September 2019, “in interglacials the carbon-dioxide level is 1.45 times higher than it is in the depths of an ice age. Today’s level is 1.45 times higher than that of a typical interglacial”. While relativising the infinitesimal history of humankind within deep time and heightening our awareness of the assured extinction of our own species, such time capsules of our planet’s climate history are the foundation on which future sustainable environmental policies must, as a matter of urgency, be constructed, to reduce worldwide carbon-dioxide production.
14. “White-out” is a term commonly used to identify an atmospheric phenomenon whereby the refraction of light onto the totalising whiteness of the Antarctic landscape blurs the horizon line, obliterates shadows, and overwhelms the human visual capacity by hindering depth detection. Alongside this disorienting weather-centric definition, “white-outs” can also refer to the conscious act of blanking out information. The use of the term in this context is nonbinary and alludes to both definitions.
15. The Antarctic Treaty was signed on the 1st of December 1959 by the twelve nations that had been active during the International Geophysical Year: namely, Argentina, Australia, Belgium, Chile, France, Japan, New Zealand, Norway, South Africa, the Soviet Union, the United Kingdom, and the United States of America. To date the number of signatories has risen to include fifty-two states, twenty-eight of which are Consultative Parties and retain the right to vote on Antarctic affairs.
16. The Antarctic Treaty, opened for signature on the 1st of December 1959.
17. The marine species include krill, small crustaceans best known as representatives of the dominant animal species on Earth. Krill are overexploited by national fishing enterprises, which vehemently object to the creation of much-needed Marine Protected Areas (MPAs).
18. Bioprospecting, which entails the systematic search for products and genetic information derived from bioresources, leverages the commercial value of unique biological compounds, predominantly for pharmaceutical applications.
19. According to data documented by the International Association of Antarctica Tour Operators’ (IAATO) official website, retrieved on the 3rd of March 2021, Antarctic tourism has been growing exponentially over the decades, reaching the unprecedented number of 74,401 tourists in the austral summer season of 2019–2020.
20. While the Antarctic Treaty states, in its first article, that “Antarctica shall be used for peaceful purposes only”, scholars argue that Antarctic satellite receiving stations have tacit dual civil-military capabilities which would enable new hybrid warfare strategies that surpass the traditional kinetic forms of warfare implied in the Treaty itself.
21. Geoscientific discoveries on Antarctic natural resources were freely accessible until the signing of the utopic Protocol on Environmental Protection in 1991, when assumptions on natural resources were still based purely on “geological association”, i.e. on memories of Antarctica’s continental drift some 160 million years ago, from lands rich in oil, gas, coal, platinum-group metals, iron, uranium, copper, and chromium (Doaa Abdel-Motaal, “Antarctic Resources and the Protocol for Environmental Protection”, see pp. 136–37). Such transparency on Antarctic resources led Shell Oil BP to celebrate the 1957–1958 Commonwealth Transantarctic Expedition by producing a game that enacted “an exciting race to the South Pole by land, sea and air”, whereby fuel depots (represented by red dots in the photograph above) are connected to the coastline via a road to the South Pole, and a “crash caus[ing] fuel loss” would force players to “wait 3 throws for more BP”.
22. The Antarctic Treaty, opened for signature on the 1st of December 1959.
23. Apsley Cherry-Garrard, *The Worst Journey in the World* (London: Constable, 1922).


4,337
scientists and staff deployed in summer
1,105
scientists and staff deployed in winter
McMurdo 1000/163
Amundsen-Scott South Pole 150/49
Marambio 165/70
Rothera 120/22
Casey 99/20
Davis 91/17
Dumont d'Urville 90/24
Esperanza 90/63
SANAE IV 80/10
Mawson 53/15
Halley VI 52/13
O'Higgins 52/25
Mirny 50/25
Progress 50/25
Druzhnaya IV 50/0
Bharati 46/23
Carvajal 46/0
Maitri 45/25
Troll 45/7
Palmer 44/13
Henryk Arctowski 40/16
Ferraz 40/15
Orcadas 35/17
Gabriel de Castilla 33/0
Pedro Vicente Maldonado 32/22
Vernadsky 30/12
Machu Picchu 15/30
Prat 30/8
Vostok 30/15
Yelcho 28/0
Juan Carlos I 27/0
Kunlun 26/0
Petrel 26/0
Princess Elisabeth 22/0
St. Kliment Ohridski 20/16
Belgrano II 20/0
Taishan 20/20
Johann Gregor Mendel 20/0
Camara 20/0
San Martín 19/21
Decepción 18/3
Primavera 18/0
Dallmann 16/2
Molodezhnaya 15/0
Gabriel González Videla 15/0
Aboa 13/0
Wasa 13/0
Matienzo 12/10
Brown 12/0
Int. Field Camp Peninsula Byers 12/0
Melchior 12/0
Mountain Evening/ Vechernyaya 11/0
Dirck Gerritsz Laboratory 10/0
Leningradskaya 10/0
Russkaya 10/0
Oazis 10/0
Artigas 9/8
Dr. Guillermo Mann 8/0
Signy 8/0
Risopatron 6/0
Kohnnen 6/0
Ruperto Elichiribehety 4/0
The transient population of the only continent that has no indigenous peoples and no other long-term residents fluctuates in number in a way that is inversely proportional to the seasonal surface rhythms, whereby sea ice doubles the Antarctic surface in winter. As visualised in the diagram above, over 4,000 scientists and supporting staff are typically deployed in Antarctica during the summer months, while the number reduces drastically to approximately 1,000 during the austral winter. The visualisation reflects population data by station and by year as published in the COMNAP (Council of Managers of National Antarctic Programs) 2017 Antarctic Station Catalogue.


Sensory Deprivation and the Role
Extreme Habitation. Antarctica's
Communication
The Medicinal Role of Reading in the Heroic Age
Interior Urbanism at the Pole. Framheim vs. Cape Evans
Inhabitation in the Extreme. The Winter-Over Syndrome
Extreme Habitation. Compressed Spaces and Dilated Times
SURVIVING IN THE CRYOSPHERE
The Antarctic through the Lens of Eliot
Cosmic Rays and Neutrino Astronomy
IceCube Neutrino
The Balloon-Borne Large Aperture

stations that shield them from the harsh, deserted environment, which has recorded temperatures of -89.2°C and wind speeds of 259 kilometres per hour.[24] The stations themselves (whose combined surface area equals that of the Pentagon[25]) reveal an under-theorised, accelerated history of architecture from primordial huts[26] to hyper-technological mobile architectures reminiscent of provocative 1960s projections of utopian cities.[27] With national iconography morphing into façades proudly projecting national identities against the white backdrop, embassy-like stations act as political devices, reinforcing national agendas on the territory and resisting true forms of international cooperation.[28]

Within these bases, the transient population of the only continent that has neither Indigenous peoples nor other long-term resident populations lives in confinement, experiencing an isolation far greater than the one imposed on astronauts living in the International Space Station. Beyond the walls of their huts and stations, a white, iconoclast landscape—predominantly lifeless yet "living"[29]—stands in contrast to the world these people left behind. The distorted day cycle with its weeks-long sunset, the sensory deprivation, and the unexpected high-density cohabitation which obliterates privacy challenge the well-being of Antarctic inhabitants, who are scrupulously selected for their innate physical and mental stability. While the arts historically played a "medicinal role",[30] allowing for intellectual escape in simulated lives, today digital technologies and virtual realities[31] alleviate the frequent overwintering syndromes. Acting as a prototyping ground for extreme inhabitation, Antarctica—the ultimate "Space analogue"[32]—may prove essential for cosmic endeavours which contemplate (as yet unearned[33]) life beyond Planet Earth.

While we attempt to optimise extreme inhabitation strategies, Antarctica rejects and literally ejects the structures we build on its ice. The relentless movement of glaciers towards the ocean as they calve,[34] carrying with them all the captive evidence of humanity in the form of polluted frozen air bubbles or buildings, is a prelude to a future in which disembodied technologies[35] and forms of surveillance will allow for the reduction of the anthropic footprint on the continent in favour of automated unmanned scientific research.
The current imbalance between ice loss through melting and iceberg formation via snowfall—which occurs six times faster than forty years ago, with ice melting at a rate of 6,300 tons per second[36]—is provoking an alarming global rise in sea levels and calls for immediate action.

The conviction with which polar experts, practitioners, and thinkers have joined forces to author this book is evidence that the specialist community recognises the need to act together, driven by the determination that, at the very least, the knowledge of Antarctica ought to be shared as a Global Commons.

Learning from Antarctica's spirit of cooperation, built upon the total reliance on one another to survive, *Antarctic Resolution* aspires to launch a platform, an agency for change, in which planetary citizens can engage in a coordinated and unanimous effort—independent of nation—to shape the future of Antarctica, and, in turn, of our "Spaceship Earth".[37]

The essay was originally published at *Antarctic Resolution* (edited by Giulia Foscari / Unless, Lars Müller Publishers, 2021). Courtesy of Lars Müller Publishers.

24. The fragility of humankind and its uncertain survival within the unforgiving Antarctic environment is epitomised by the photograph taken during the 1911–1914 Australasian Antarctic Expedition by Frank Hurley. Upon his return from taking scientific measurements during a blizzard, meteorologist Cecil Madigan found himself wearing a so-called ice mask.
25. Council of Managers of National Antarctic Programs, *Antarctic Station Catalogue* (Christchurch: COMNAP, 2017), comnap.aq [online].
26. Astonishingly, the first hut ever built on the continent—constructed at Cape Adare by Carsten Egeberg Borchgrevink and his party during the British Antarctic Southern Cross Expedition (1898–1900)—is still standing.
27. While architecture on all other continents could be understood as the final act of a gradual metamorphosis of the landscape, in the absence of matter and raw materials, all Antarctic buildings (including the radical station by Hugh Broughton Architects, which builds upon Archigram's "Walking City" project) consist of an assembly of imported prefabricated elements.
28. See Alan D. Hemmings, "International Antarctic Stations", see pp. 582–83.
29. Ursula K. Le Guin, "Sur: A Summary Report of the Yelcho Expedition to the Antarctic, 1909–1910", *The New Yorker*, 1 February 1982.
30. Elizabeth Leane, "The Medicinal Role of Reading in the Heroic Age", see p. 356.
31. Admittedly not yet exploited to the fullest within polar architectures.
32. Scott Parazynski, "Inhabiting Space", see pp. 580–81.
33. Neri Oxman in conversation with Paola Antonelli, "Design Emergency", Instagram live interview, 29th of January 2021.
34. Calving is a natural phenomenon whereby sections of glaciers floating on the ocean break off and fall into the water. Charged with symbolic value as markers of the retreating cryosphere and rising global sea levels, it is hard to imagine that calving glaciers could conceal even greater evidence of humanity's impact on Planet Earth. Yet, as proven by the photograph of Halley I Station's cross section taken by the crew of the *Polarsirkel* shown on the previous page, temporary apparitions of an archaeology of debris are not unusual on the Antarctic Barrier.
35. As explored in Elena Glasberg, *Antarctica as Cultural Critique: The Gendered Politics of Scientific Exploration and Climate Change* (New York: Palgrave Macmillan, 2012).
36. David Vaughan, research data shared with UNLESS, 2020.
37. Richard Buckminster Fuller, *Operating Manual for Spaceship Earth* (1969; repr. Zurich: Lars Müller Publishers, 2008).

Antarctic Resolution. Exhibition at the Venice Biennale. Detail.
Courtesy of UNLESS ©Delfino Sisto Legnani

TRACEWASTE

SUSI GUTSCHE (AT)

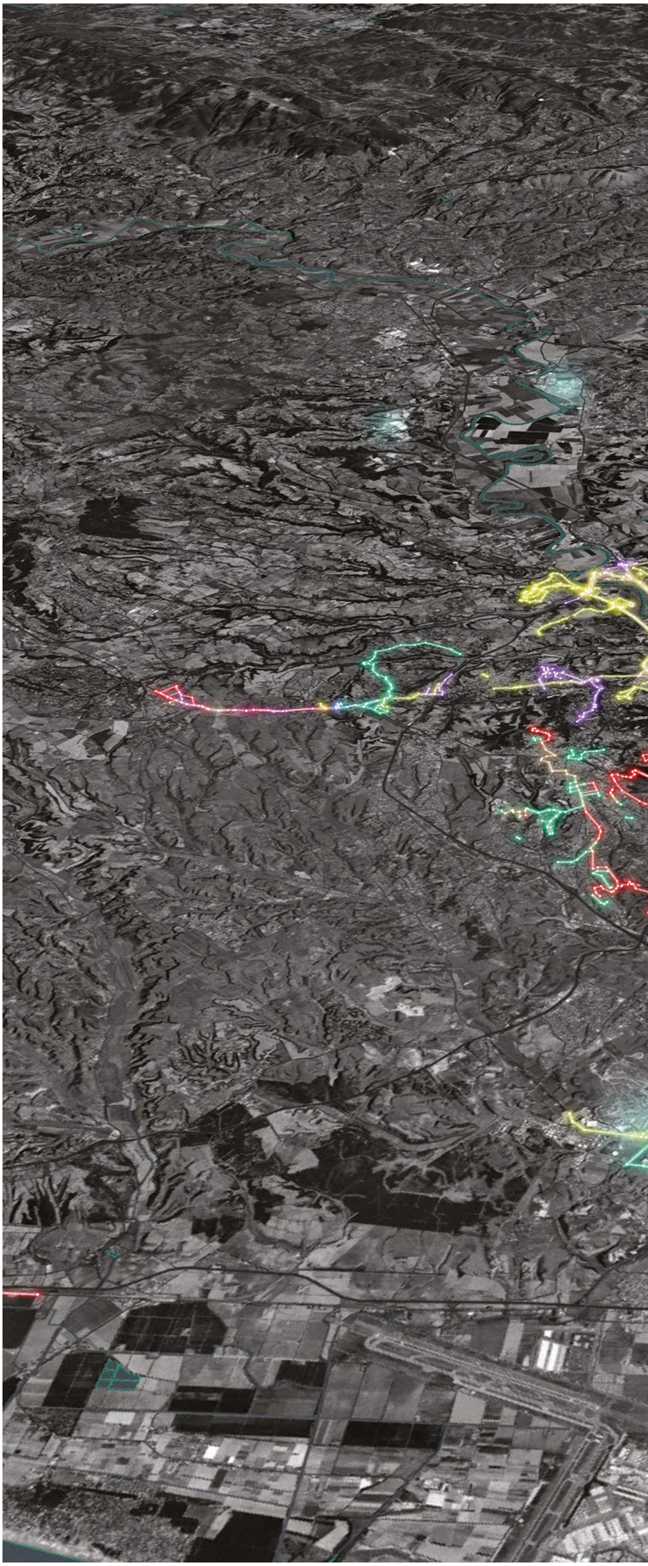
STARTS pillar
STARTS Regional Centers
(Repairing the Present, 2021-22)

TRACEWASTE is an artistic research project that explores how waste moves through complex global systems and what these movements reveal about urban life. It asks how we can better understand and rethink our relationship to waste in a world where the traces of human activity have become increasingly visible and impossible to ignore.

Responding to this challenge, the artists conducted large-scale experiments tracking discarded objects—from plastics to textiles—using Internet of Things (IoT) devices connected through a low-power wide area network. By monitoring waste collection vehicles and discarded items across Italy, they gathered data on routes, durations, distances, and emissions. This research took shape as an interactive audiovisual installation shaped like an "island of waste", combining sound, light, and real tracking data to challenge everyday perceptions of disposal and consumption. *TRACEWASTE* encourages public reflection on the scale and impact of global waste systems. By merging artistic practice with citizen-based research, the project triggers discussion about today's global era of trash, raises awareness of how waste shapes urban life, and encourages collective reflection on responsibility, sustainability, and the material consequences of everyday habits.

Assistance, design: Dimitrije Andrijević
Sound design: Sebastian Scholz
Coding: Max Pellert
Technology partnership: Paul Pinault
Supported by SONY CSL: Vittorio Loreto, Alessandro Londei, Bernardo Monechi, Matteo Bruno & MAXXI Foundation: Chiara Bertini and Alessio Rosati in the framework of the artist residency "Big Data and the City"

The project has received funding in the framework of the European S+T+ARTS initiative under grant agreement LC01641664.



Animation Screenshot ©TRACEWASTE, Susi Gutsche, mapbox


TRACEWASTE | © Mapbox © Open

All the Tyres from Iceland

MICHAEL PINSKY (UK)

STARTS pillar
STARTS Residency (STARTS4Water II, 2024–25)

All the Tyres from Iceland is a sculptural and film-based installation by the artist Michael Pinsky, created during his STARTS4Water II residency in collaboration with the Port of Amsterdam. The work explores the international trade in waste materials, focusing on the journey of discarded tyres shipped from Iceland to Granuband, a tyre recycling company based in the Port of Amsterdam. It reveals the hidden logistics, industrial infrastructures, and economic systems that shape the global circulation of waste. Before these tyres enter the recycling stream, Pinsky temporarily diverts them to form large-scale sculptural forms—stacked, suspended, or partially submerged—each kept in its original state yet recontextualized in public space. Their titles reference their “negative value”, underscoring the paradox that waste costs money to discard while simultaneously possessing material potential. The film follows the passage of the tyres through Amsterdam, linking everyday urban life with the port’s complex material flows.

By exposing the vast networks that manage what societies throw away, *All the Tyres from Iceland* critically examines the promises of circularity and the often-invisible environmental costs of global trade. The project makes abstract systems legible by turning an industrial waste stream into an aesthetic, spatial, and political encounter. Through artistic intervention and collaboration with industrial partners it raises public awareness of how value is constructed, how reuse is negotiated, and how ports function as sites where sustainability narratives meet economic realities. The work encourages viewers to question assumptions about waste, resource use, and responsibility within the wider context of global material circulation.

Construction: Leoke Weldingworks
Video production: Leandra Hoffmann r3mediacontent
Exhibition cultural partner: Stichting NDSM-werf
With material and logistic support by: Granuband

Photo: Lucas Evers, Waag Futurelab

AI War Cloud Database

SARAH CISTON (US)

STARTS pillar
STARTS Prize
(Grand Prize for Artistic Exploration, 2025)

Creation time
2024–ongoing

Stakeholders involved
artists, researchers, technologists, critical AI theorists

Technology applied
interactive visualization, open-source intelligence, network graph systems, critical code studies

Industry areas addressed
military AI, commercial AI, surveillance, algorithmic accountability, ethics

What responsibilities do users and makers have in choosing AI tools when their development can also lead to deadly outcomes at massive scales? *AI War Cloud Database* by Sarah Ciston poses this urgent question through an artistic and investigative approach.

The project catalogues artificial intelligence systems used to make automated decisions in warfare, and maps where similar technologies operate in civilian life—embedded in smartphones, social media platforms, and data infrastructures. Presented as both an interactive online database and a tangible installation, *AI War Cloud Database* reveals how the architectures of machine learning circulate between commercial and military domains, exposing the "techno-imperial boomerang" perpetuated by contemporary AI development. Built on a continuously expanding archive, *AI War Cloud Database* collects data on key stakeholders, technologies, and their interconnections. The database already includes more than 50 examples from the past 25 years, from early predictive targeting software to advanced AI tools used by various militaries and corporations. Among these are cases where commercial technologies flow in the opposite direction: law enforcement and military agencies gain access to civilian data networks and consumer surveillance tools. Partnerships that allow agencies such as the Immigration and Customs Enforcement (ICE) or defense contractors to use footage from Ring Doorbell cameras and other privately owned smart devices reveal how domestic tools become resources for surveillance and control. Thus, the project situates such technologies within a web of relationships that cross industries, borders, and time, showing how decision-making systems built for everyday security merge with those designed for geopolitical power. The result is a living map that makes visible the infrastructures shaping both digital life and armed conflict.

Through concrete examples such as Palantir's data-driven operations or the Lavender targeting system, the project also demonstrates how vast quantities of data are processed to make life-and-death decisions at unprecedented speed. These technologies

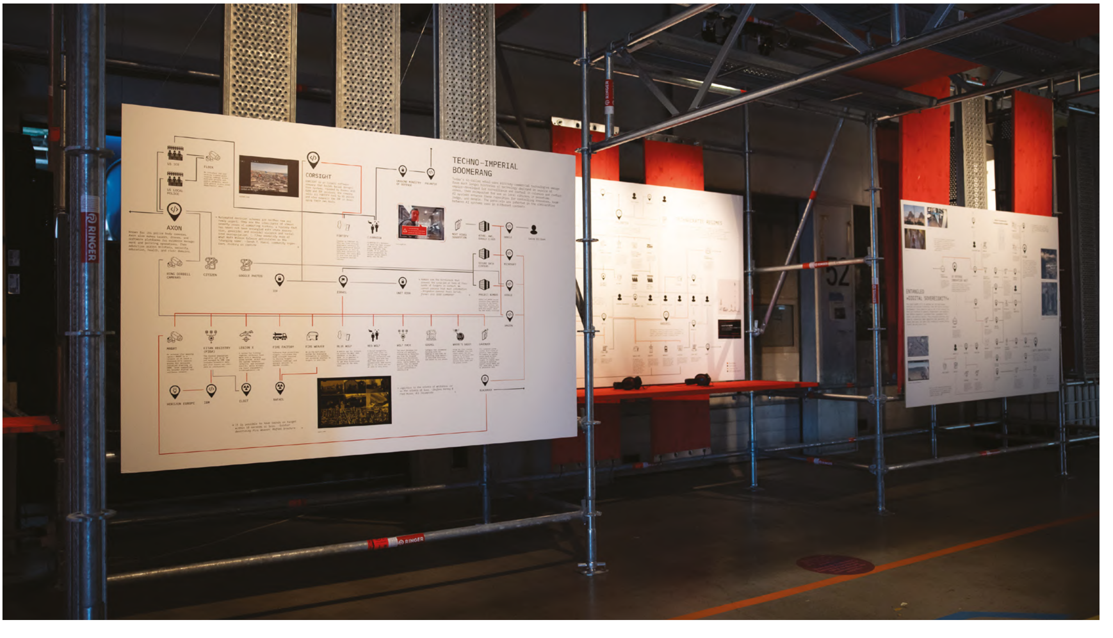
Photo: tom mesic

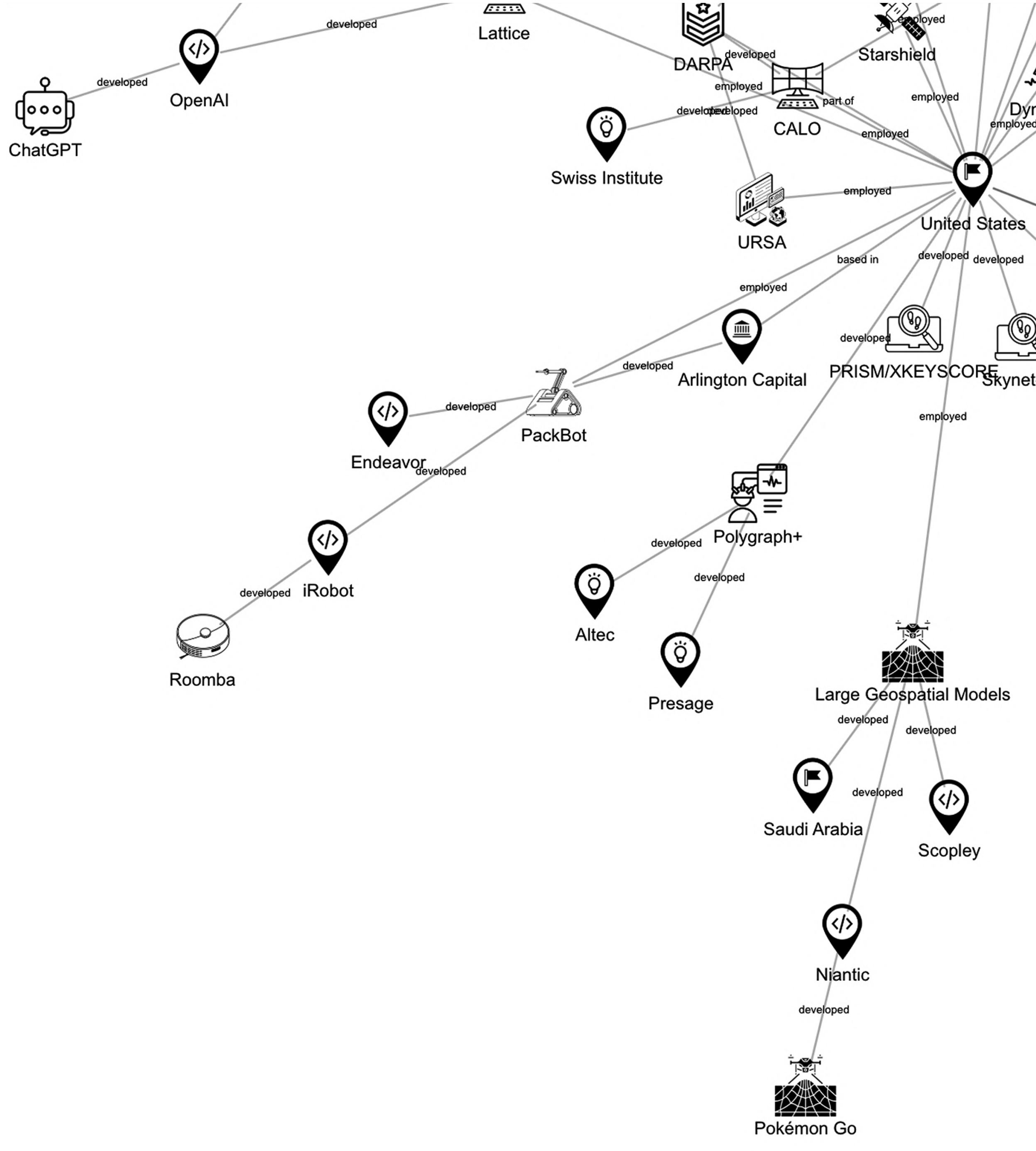
are often tested on vulnerable populations in conflict zones before being integrated into domestic surveillance and policing systems. At the same time, the project exposes the growing involvement of the tech industry in the defense sector, as startups and global corporations become de facto military suppliers. Platforms and algorithms originally built for commerce or efficiency are redefined as instruments of control, blurring the boundaries between consumer technology and warfare.

Still in the early stages of development, *AI War Cloud Database* exemplifies how artistic inquiry can intervene in one of the most urgent debates of our time: the social and political stakes of AI development. By transforming investigative data into an interactive experience, Ciston offers a model for collaboration between art, research, and technology. The work demonstrates the potential of artistic research to unpack complex technological systems and to encourage public understanding, dialogue, and participation in shaping their future development.

As artificial intelligence becomes central to both everyday life and modern warfare, *AI War Cloud Database* offers a vital and timely reflection on how these systems operate and what they cost. It is not a comprehensive index nor a solution but rather an act of witnessing and an appeal for accountability. The project began as a personal response to the normalization of AI-enabled violence and has evolved into a collective platform for awareness and intervention. By exposing the shared infrastructures of harm and convenience, *AI War Cloud Database* reminds us that every algorithm carries consequences, and that understanding these hidden systems is the first step toward reclaiming agency over them.[1]

Design, programming, research, writing: Sarah Ciston
Research sources and image credits on project website.
With thanks to Claire Carroll, Kate Crawford, Ariana Dongus, Vladan Joler, Pedro Oliveira, Miller Puckette, Corbinian Ruckerbauer, Nataša Vukajlovic, Ben Wagner and the AI Futures Lab, Thorsten Wetzling, Cambridge Digital Humanities, and the Center for Advanced Internet Studies for discussions and support contributing to the work.





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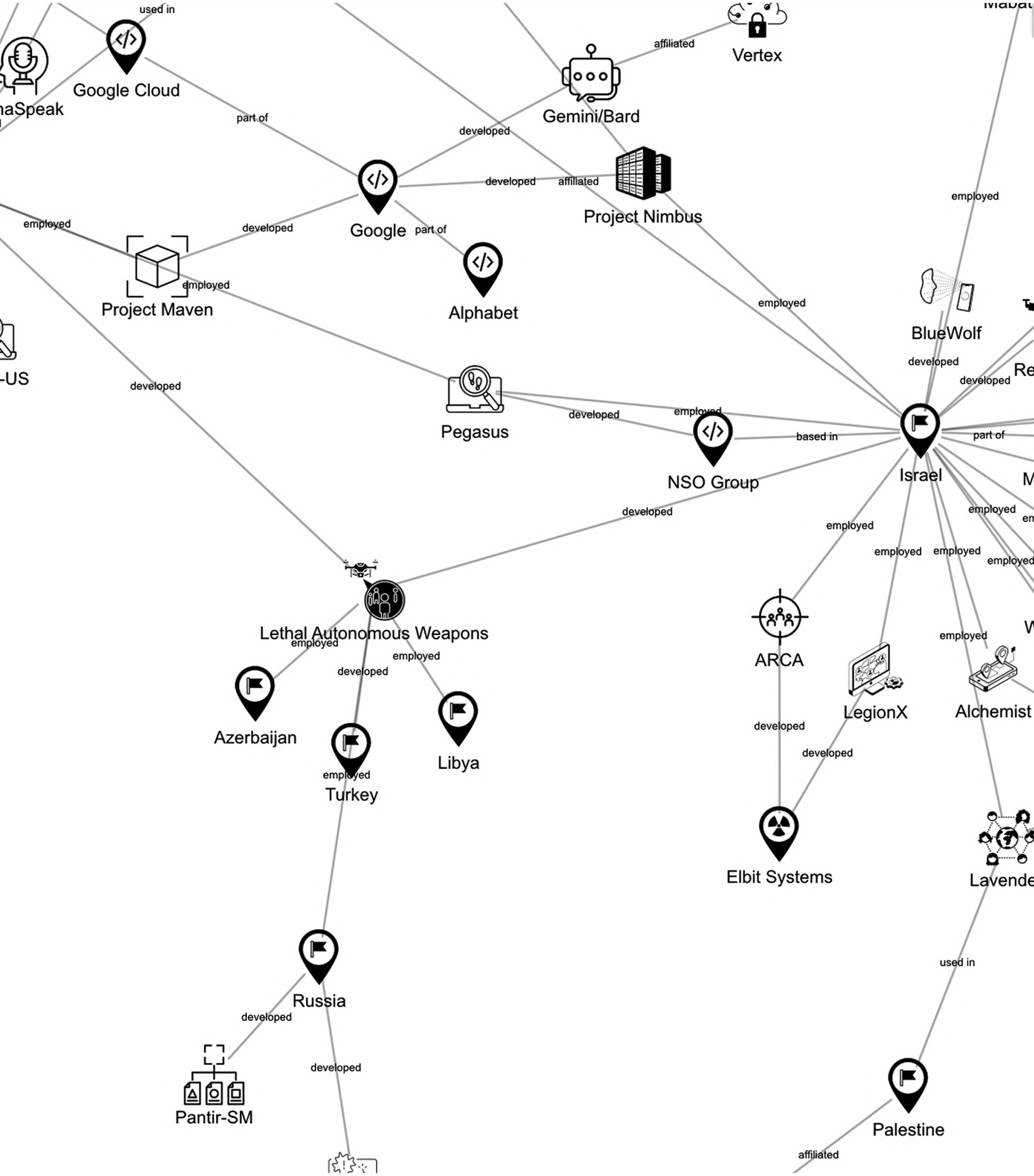
Pokémon Go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NSO Group
based in
Israel
Lethal Autonomous Weapons
Azerbaijan
Turkey
Libya
ARCA
LegionX
Alchemist
Elbit Systems
Russia
Pantir-SM
Palestine

Invisible Voice

MARK FARID (UK)

STARTS pillar
STARTS Residency (MediaFutures, 2020–23),
STARTS Regional Centers (STARTS in the City, 2023–24)

Invisible Voice is a digital arts and research project that aims to reshape societal narratives and empower individuals to make informed decisions about the companies they use. Initially developed within MediaFutures as a browser plugin, the project was later expanded during the STARTS in the City residency into a mobile app and a public installation. The browser extension displays clear summaries of a company's ownership, affiliations, political leanings, environmental practices, labor conditions, and more—drawing from 37 open-access datasets. The app extends this function into physical space: by scanning products, logos, or barcodes, users instantly receive accessible information on materials, ingredients, packaging, and corporate behavior. The installation identifies visible brands on passersby and reveals related news and visual counter-advertisements, supported by an interactive network map of corporate links.

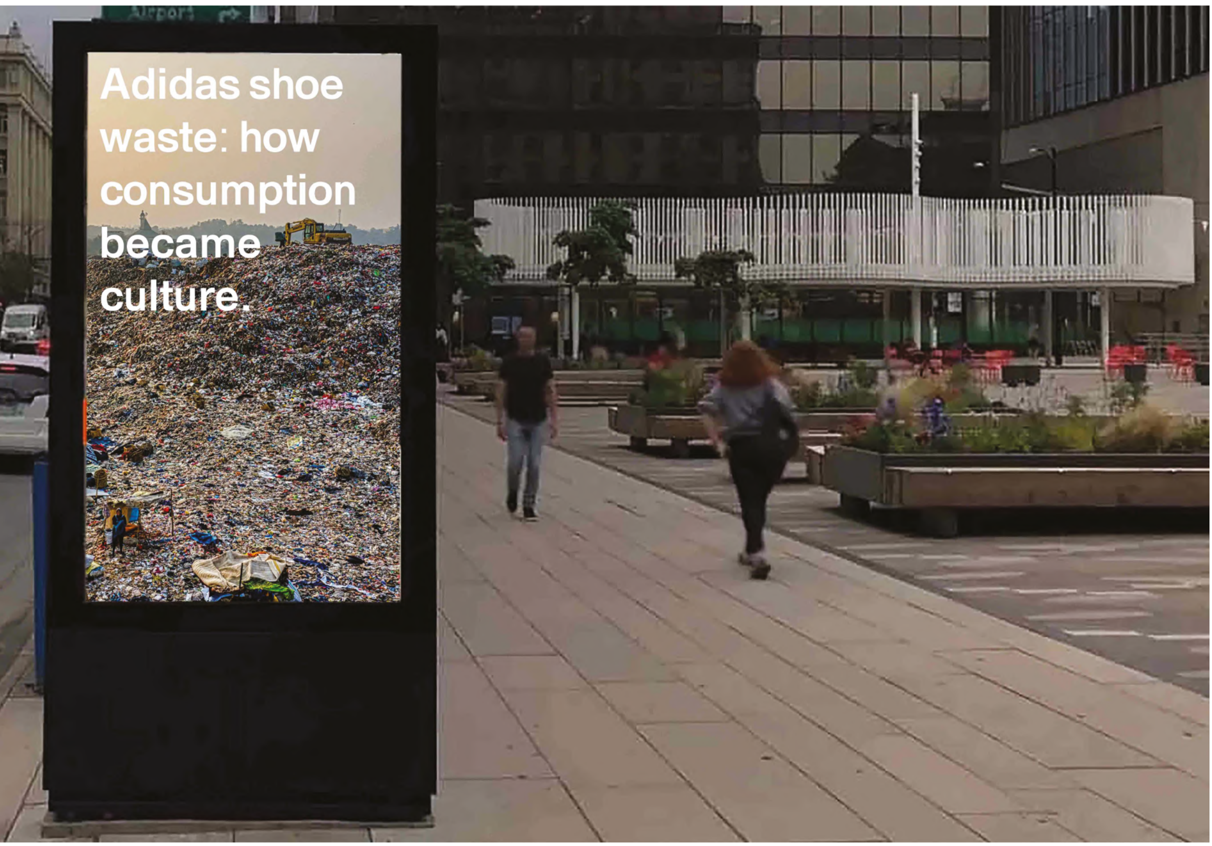
By translating complex economic and political systems into engaging, easy-to-understand formats, *Invisible Voice* exposes biases, opaque structures, and unethical practices that often remain unseen. Through playful interaction, it strengthens digital literacy, encourages critical thinking, and helps the users to make informed choices aligned with their values. Rather than merely informing, it provokes conversation and empowers individuals to question their relationship with technology, consumer culture, and power structures.

Lead developer: Orange
UX and UI: Tom Shearing

Invisible Voice is created by Mark Farid and developed by Orange. It is co-commissioned by HacTe and MediaFutures with support from the University of the Arts London, Universitat Oberta de Catalunya, and GuestRoomMaribor.

This project has been developed in the context of the STARTS in the City project. STARTS in the City has received funding from the European Commission's Directorate-General for Communications Networks, Content, and Technology under Grant Agreement LC-01984766.

Photo: Mark Farid


Adidas shoe waste: how consumption became culture.

Council of Foods

NONHUMAN NONSENSE (SE)

STARTS pillar
STARTS Technical Pilot (Hungry EcoCities, 2022–26)

The Council of Foods is an interactive digital platform that uses AI-generated food avatars to open accessible conversations about the complexities of the global food system. Developed as a browser-based environment, it creates a dedicated space where users can explore food system challenges in dialogue with ten diverse “council members”, each representing different production methods, environmental impacts, and ethical standpoints. By combining curated topics with real-time interaction, the platform functions as a personalized learning tool: users can ask questions, debate, take notes, and generate reports that support ongoing decision-making. Tested in real contexts by SMEs such as Logiqs and BeeSage, the system demonstrates technological readiness for tailored, scenario-based learning and can be easily expanded with new food characters or thematic modules.

By presenting food items as AI-driven discussion partners, the project makes the eco-social consequences of food production and consumption clearer and more accessible. These interactive dialogues help reveal systemic issues that are often hidden by marketing, pricing, or fragmented information. This approach is especially valuable given the significant knowledge gaps that persist around food system complexities—gaps that can hinder effective policymaking. Through an engaging, conversational format, *The Council of Foods* supports critical awareness, strengthens informed decision-making, and provides policymakers and citizens with a more transparent entry point into understanding how food systems are shaped and governed.

Photo: Council of Food © Nonhuman Nonsense 2024

How (not) to get hit by a self-driving car

TOMO KIHARA (JP) AND DANIEL COPPEN (UK)

STARTS pillar
STARTS Prize (Honorary Mention, 2024)

How (got) to get hit by a self-driving car is an interactive game installation that invites people to explore how artificial intelligence sees the world. In this playful yet thought-provoking game, players try to cross a virtual street without being detected by the vision system of a self-driving car. On a large screen, they see themselves through the “eyes” of the AI, which assigns each person a confidence score showing how certain it is that they are a pedestrian. To win, players must move, hide, or disguise themselves so that the system fails to recognize them—revealing both the creativity of human behavior and the limitations of machine perception.

Each successful round exposes gaps and biases of the AI model, from its failure to detect children or wheelchair users to their dependence on narrow, geographically limited training data. After playing, participants can choose whether to share their anonymized data to help improve the AI or delete it, raising questions about data ownership, privacy, and responsibility.

By turning a complex technology into a playful public experience, *How (got) to get hit by a self-driving car* helps people see and question the systems shaping our cities. It opens up space for discussion about how AI works, who it serves, and how we can make it fairer and safer for everyone.

Music: Plot Generica
Support: Saki Maruyama (Playfool)
Photography: Luke O’Donovan, Playable City Bristol July 2023; Daniel Coppen
Videography:
Jon Aitken, Playable City Bristol July 2023
Jack Offord, Playable City Bristol July 2023
Jacob Gibbins, Playable City Bristol July 2023
Daniel Coppen, Playfool
Commissioned by: Playable City Sandbox 2023 supported by MyWorld

Photo: Luke O’Donovan


53%
PEDESTRIAN

Cloud Studies

FORENSIC ARCHITECTURE (UK)

STARTS pillar
STARTS Prize
(Honorary Mention, 2021)

Creation time
2016–22

Stakeholders involved
architects, filmmakers, software developers, journalists, scientists, lawyers, activists

Technology applied
spatial analysis, digital modeling, machine learning, fluid dynamics simulation, remote sensing

Industry areas addressed
human rights, environmental justice, data transparency, open-source research

Cloud Studies is a large-scale video installation and research project by Forensic Architecture, a London-based agency that investigates human rights violations through architectural and spatial analysis. The work examines how the atmosphere has become a field of conflict and control, as state and corporate powers weaponize the air itself—deploying gases, smoke, and chemical agents to suppress bodies and devastate ecosystems so they are no longer inhabitable.

The project brings together eight investigations conducted between 2016 and 2020, each focused on a different kind of toxic cloud and its political, social, and environmental consequences. These range from white phosphorus over Gaza and chlorine attacks in Syria to herbicide spraying in Colombia, tear gas in Hong Kong and Chile, methane emissions in Argentina, and large-scale forest fires in Indonesia. Together, the case studies reveal how contemporary violence unfolds not only across territories and borders but within the air, an element that knows no boundaries, connecting all living beings through the act of breathing.

The outcome is a multi-channel installation in which the narrative moves between testimonies and scientific reconstructions, combining poetic voiceovers, maps, and animations to build a new visual vocabulary for environmental violence. The work invites viewers to consider how the atmosphere—once imagined as a natural commons—has become a site of domination and resistance. Toxic clouds are both material and symbolic: they mark the contamination of air by industry and warfare, but also reflect the fog of misinformation that obscures accountability. By following these clouds, *Cloud Studies* uncovers connections between climate collapse and authoritarian violence.

At its core, *Cloud Studies* exemplifies Forensic Architecture's investigative methodology, where artistic practice and scientific research merge into a form of public inquiry. The growing availability of open-source material—images, videos, and data gathered by citizens—has created the need for new analytical methods. Forensic Architecture has been a pioneer in developing such approaches, using what it calls investigative aesthetics to identify traces of violence in fragmented online evidence from conflict zones and sites of human rights violations. The team employs spatial

Top to bottom:

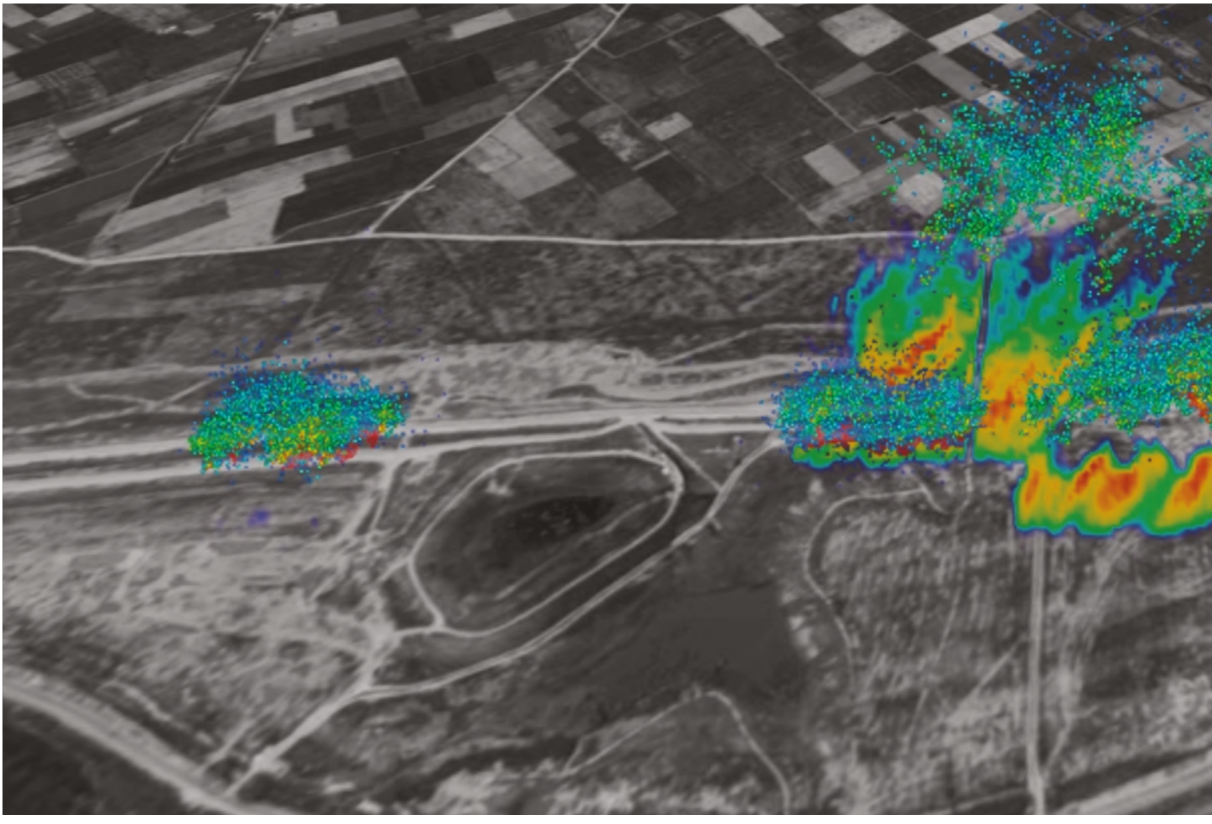
Cloud Studies, 2020, Palais de Tokyo. Photo: Forensic Architecture

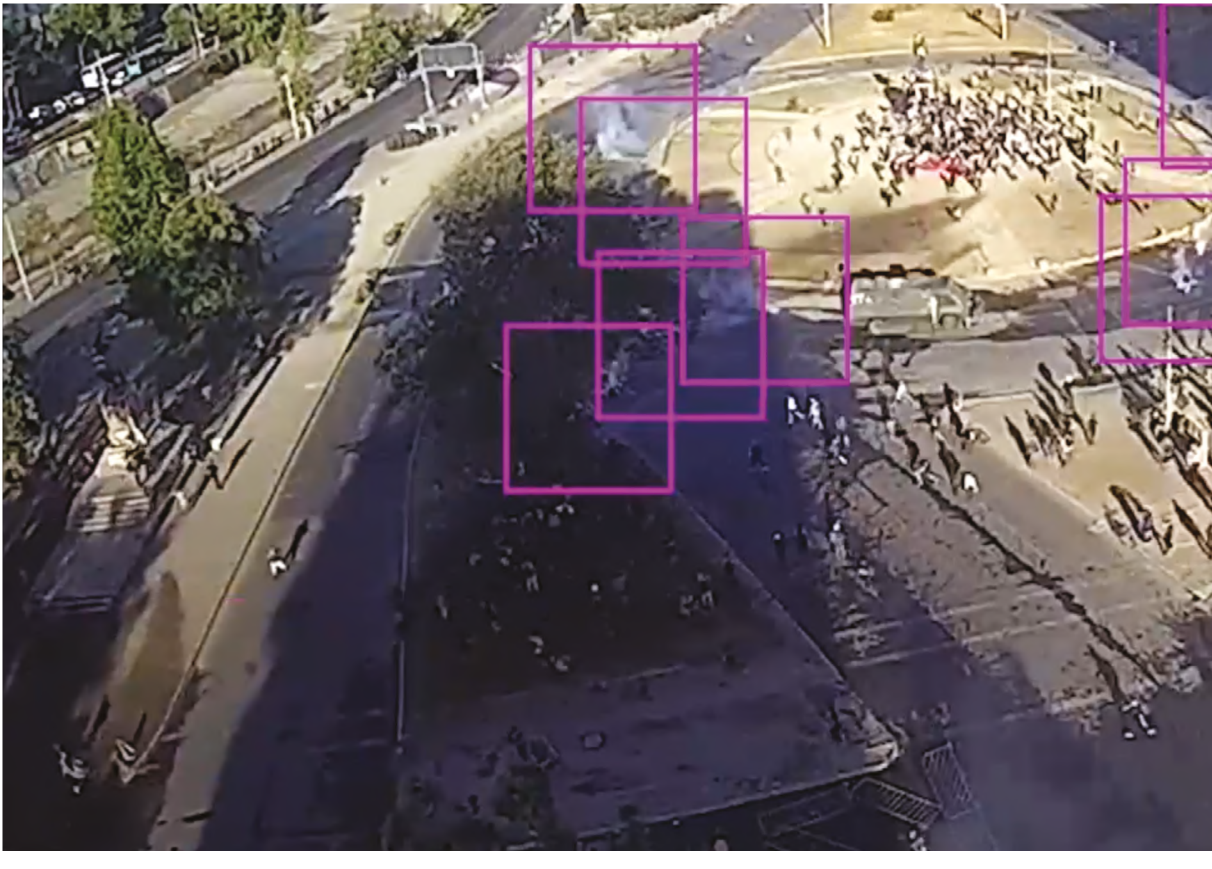
Photos: Forensic Architecture

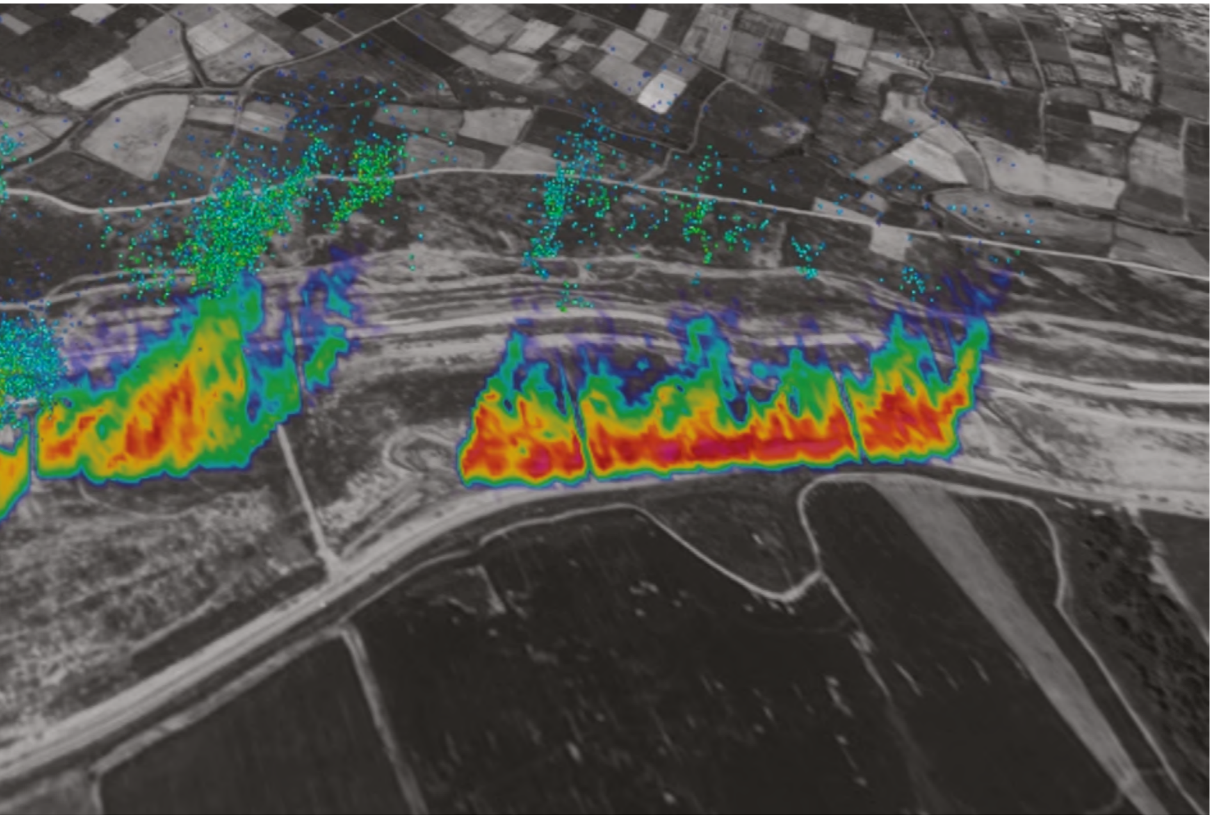
modeling, satellite imagery, fluid dynamics simulations, and machine learning to reconstruct the movement of airborne substances and link digital data with testimonies and environmental records. Each investigation is the result of collaboration between artists, architects, coders, scientists, journalists, and local communities. Through this hybrid practice, aesthetic tools become instruments of analysis and accountability, translating data into public truth.

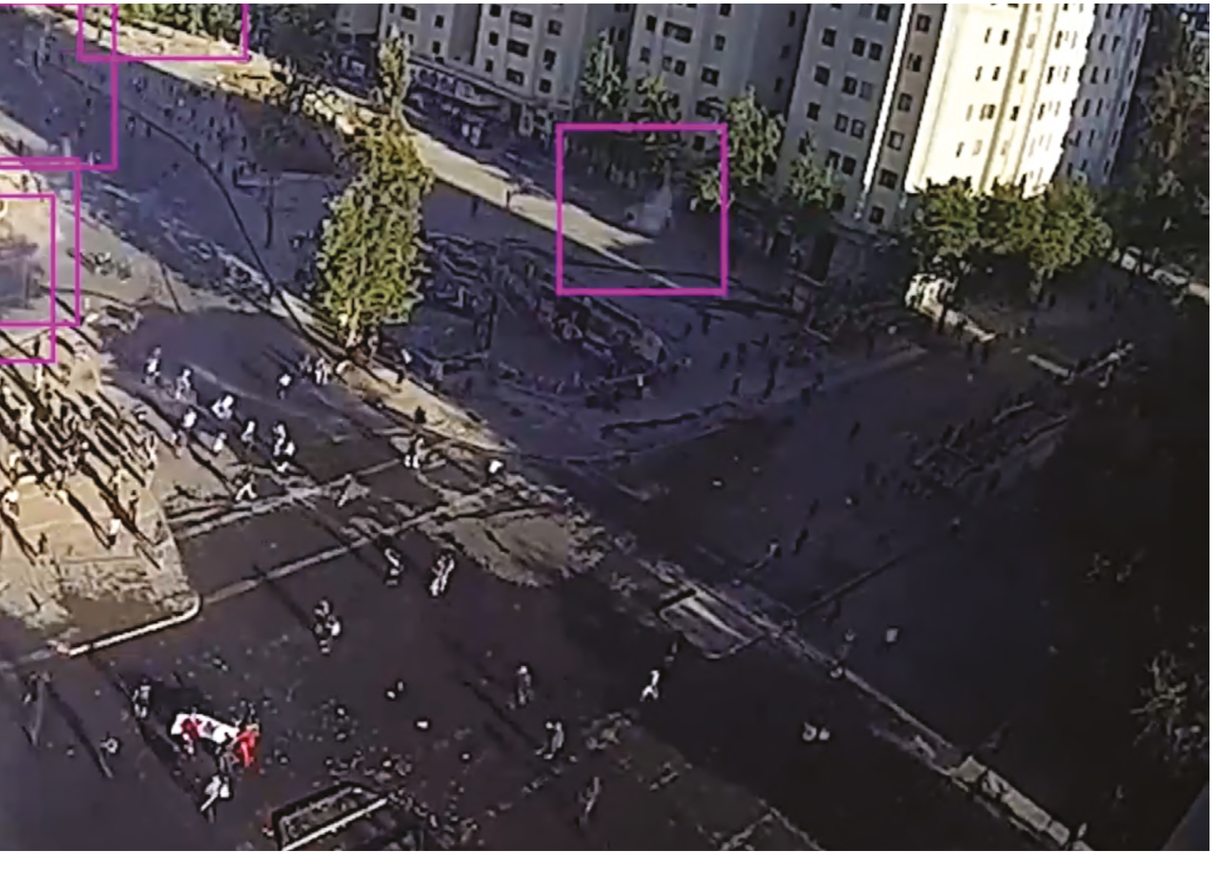
Cloud Studies makes investigation itself a shared act of witnessing. By combining scientific analysis with poetic narration, it redefines the tools of art and research as instruments of resistance against the obfuscation of truth. The work exposes the air as both a medium of life and a battlefield—an element through which power is exercised but also one that connects all living beings in a common breath. In doing so, it raises awareness of how violence and pollution are intertwined, how our atmospheres reflect our political realities, and how making the invisible visible is a first step toward accountability and change.

Credits
Forensic Architecture Team:
Principal Investigator: Eyal Weizman
Researcher in Charge: Samaneh Moafi
Team: Robert Trafford, Martyna Marciniak, Lola Conte, Lachlan Kermode, Mark Nieto, Leigh Brown, Sarah Nankivell, Christina Varvia, Amy Cheung, Shourideh C. Molavi
Originally commissioned by ZKM Centre for Art and Media in Karlsruhe









Vocal Values

JONATHAN CHAIM REUS (US/NL)

STARTS pillar
STARTS Residency (AIR, 2022–23)

Vocal Values is an artistic-research initiative that examines how voice becomes data in the age of AI, raising public awareness about the social, ethical, and political stakes of emerging voice technologies. It grows out of *Dadasets*, an ongoing interdisciplinary music project by Jonathan Reus that began during his STARTS AIR residency. As the result of collaborative work with Wiebke Toussaint, In4Art, and a community of vocalists, technologists, legal scholars, and AI ethicists, the artistic inquiry into datasets revealed the absence of safeguards around vocal information and the need for new ethical frameworks. As such, the project addresses a critical gap in EU policy: neither the AI Act nor the Data Act provide clear protections for voice data, despite its status as one of the most intimate biometric identifiers.

At the initiative's core is the *Vocal Values* Principles, a living manifesto co-created through workshops at Mozilla Festival, The Hmm, and various public events. Hosted at vocalvalues.org, it proposes starting points for transparent, traceable, and human-centered voice-technology development. As AI systems expand into voice cloning, synthesis, and emotion recognition, the project raises urgent questions about dataset origins, attribution, consent, and compensation. By framing voice as identity—not mere computational input—*Vocal Values* exposes how AI can reveal sensitive biometric, cultural, and emotional information while operating beyond public understanding. Thus, the project makes visible the infrastructures and power dynamics behind voice-based AI, empowering citizens, policymakers, and creators to engage critically with technologies that increasingly shape how our voices are represented in digital systems.

PART 3

FUTURE PRACTICE

EXPANDING

What began as a European initiative has grown into a global movement. STARTS, rooted in the EU's vision for responsible and human-centered innovation, has expanded beyond Europe. These new contexts bring fresh perspectives, diverse knowledge systems, and situated approaches that enrich the original framework. The following essays trace this geographical and conceptual expansion, illustrating how local realities and intercultural dialogue strengthen the STARTS model—and how even greater potential lies in extending its approach to innovation through artistic involvement going forward.

S+T+ARTS Beyond Europe: Innovation from Africa and South America

AURÉLIE DELATER

Since its launch in 2015, the STARTS program has been a catalyst for innovation at the intersection of technology and culture within Europe, creating a unique ecosystem in the continent. In 2022, recognizing the potential for a broader impact to be entailed in its policy framework, DG CNECT issued for the first time an open call for a STARTS project to be implemented in Africa[1], followed by a second one in 2024, expanding to South America, opening up new avenues for collaboration.

The internationalization of the STARTS program is driven by a vision to promote a more inclusive and environmentally conscious model of digital innovation. Europe's approach emphasizes the integration of social and ecological priorities together with critical thinking about technology's impact. By grounding digital innovation in the rich cultural and artistic heritage of Africa and South America, STARTS aims to facilitate a socially inclusive and environmentally friendly approach to technological development, following the recommendations of the Science, Technology and Innovation Strategy for Africa 2024 (STISA-2024).[2]

1. This open call was entitled "Promote worldwide a European way to digital innovation rooted in culture".
2. This strategic document of the African Union highlights the importance of innovation and technology for Africa's economic and social development. It emphasizes the need for increased cooperation and integration among African states to foster an entrepreneurial culture and embed research infrastructures within local and global innovation systems.

Expanding to new continents, the STARTS mindset remains the same in its holistic approach: supporting artistic residencies through open calls, fostering transdisciplinary projects, implementing educational activities, awarding prizes, producing events, and strengthening an interconnected ecosystem at local and global levels. But running STARTS projects in new regions is not just about transferring methodologies implemented in Europe, it implies new collaborations marked by interculturality that require a post-colonial approach (Sarr, 2016), as well as adapted methodologies grounded in local contexts.

The expansion of STARTS to Africa takes place within a complex geopolitical and historical context, marked by decades of asymmetrical relations. To renew this political framework (European Commission, 2020), initiatives led by European cultural organizations, like STARTS4Africa, STARTS Afropean Intelligence, and STARTS Buen-TEK, place their emphasis on building platforms for mutual learning and knowledge exchange with their peers abroad. Based on concepts that emerged in Africa (Afrofuturism[3], Afropolitanism[4]) and South America (Buen Vivir[5] and Lo-TEK[6]), they provide valuable insights into the importance of cultural heritage, ancestral knowledge, and community engagement in driving innovation. These projects demonstrate that technological advancements must be grounded in local contexts and realities to be truly effective. By incorporating these notions, STARTS initiatives show how technology can address pressing social and environmental challenges in a culturally sensitive and sustainable manner.

Ecological awareness and the exploration of more-than-human worlds have become central to contemporary artistic and technological practices, especially as communities worldwide confront the urgent realities of climate change, resource depletion, and habitat destruction. These themes challenge anthropocentric perspectives, advocating instead for a holistic understanding of sustainability that recognizes the interdependence of humans, nature, and technology. By fostering interdisciplinary collaboration and public engagement, artists in Africa and South America are leveraging projection mapping, soundscapes, and interactive installations to explore these interdependencies. For example, *The Wild Future Lab* by the collective Kairos Futura, winners of the STARTS Prize Africa in 2025, envisions Nairobi in 2045 as a metropolis transformed by regenerative and biomimetic design. The project reimagines abandoned greenhouses and forgotten infrastructure as spaces reclaimed by native flora and fauna, integrating locally made materials, adaptive textiles, and ecological storytelling. Another topic that is of common interest globally, and explored in Africa and South America within the framework of STARTS, is urban transformation. Artists collaborate with local communities to reimagine cities as spaces of equity, resilience, and cultural expression. The challenges of urbanization—mobility, sustainability, and social cohesion—demand innovative, context-sensitive solutions that prioritize the needs and aspirations of those who inhabit these spaces. *The Affogbolo's Home* by Pierre-Christophe Gam reimagines Abuja in 2063 through WebVR, augmented reality, and photo-collage, centering a fictional Nigerian family's home as a vessel for exploring alternative urban futures. Here, community dreams and cultural memory take precedence over traditional development plans, offering a vision of the city shaped by spiritual resilience, ecological wisdom, and collective imagination. In Brazil, *Direito à sombra* ("Right to get shadow") examines the impact of extreme sun exposure on urban life and public health in Fortaleza. Who gets access to shade? Can shade be a form of climate justice? This project uses data, AI, and community knowledge to address these questions through data mapping and the creation of a cooling center prototype built from local materials and adaptable to other cities.

Cultural heritage and storytelling lie at the heart of many STARTS projects in Africa and South America, where artists harness technologies such as artificial intelligence (AI), augmented reality (AR), virtual reality (VR), and digital media to create immersive experiences that preserve and revitalize traditions. By weaving together traditional music, visual art, and folklore, these initiatives transform cultural memory into dynamic, accessible narratives—bridging past and present while inviting broader audiences to engage with diverse cultural expressions. *The Daladala-Verse* by Aurelio Mofuga uses immersive storytelling technologies like AR and VR to capture and preserve the cultural significance of Tanzania's public buses, known as "Daladalas". This type of artistic intervention demonstrates how technology can serve as a tool for both preservation and renewal, ensuring that cultural heritage remains vibrant and relevant for future generations. A central theme in these projects is the role of ancestral knowledge, often transmitted orally or through practice. Artists leverage digital archives, multimedia recordings, and interactive platforms to document and revive Indigenous wisdom, creating innovative solutions that are rooted in tradition. In the Democratic Republic of

3. Afrofuturism is a cultural, artistic, and intellectual movement that reimagines the future, past, and present of the African diaspora through the lens of science fiction, technology, and speculative fiction. It merges African mythologies, histories, and cosmologies with futuristic and technological themes to critique contemporary social realities—such as racism, colonialism, and oppression—while envisioning liberatory futures. Popularized by Mark Dery (1994), and developed by authors such as Octavia Butler (1993), Alondra Nelson (2002), and Ytasha L. Womack (2013), among others.
4. Afropolitanism is a political and philosophical framework that critiques and reimagines the political, economic, and social structures of Africa and its diaspora. It combines Afrofuturist speculative imagination with political theory to address contemporary and historical injustices, such as neocolonialism, racial capitalism, and state violence. Popularized by Séloua Luste Boulbina (2015), Achille Mbembe (2016 and 2017), Felwine Sarr (2016 and 2018), among others.
5. A Spanish term, meaning "good living" or "living well". For activist-intellectual Catherine Walsh (2010), a professor at Ecuador's Universidad Andina Simón Bolivar, Buen Vivir "denotes, organises and constructs a system of knowledge and living based on the communion of humans and nature and on the spatial-temporal-harmonious totality of existence".
6. Julia Watson (2019) explores Traditional Ecological Knowledge (TEK) and how Indigenous cultures around the world have developed sustainable solutions to address environmental challenges. The theory advanced by Lo-TEK is applied by many movements across the world, such as *Inteligencias colectivas*, a place from which to discover and promote local knowledge and material practices from every corner of the planet that highlights and maps initiatives using ancestral technologies.

Congo, *TERRITOIRE TISSÉ: Art Royal Kuba entre tradition et (R)évolution* ("WOVEN TERRITORY: Royal Kuba Art between Tradition and (R)evolution") uses AI to trace the various journeys of the scattered NDOP statues—a cultural heritage fragmented by colonial spoliation. By combining traditional Kuba tapestry techniques with virtual reality, the project reconstructs the statues' historical trajectories, inviting viewers to interact with them and contribute to the restoration of Kuba cultural memory. *Territory, Sound, and Shared Memory* by Peruvian artist Jimmy Carrillos illustrates the effects of climate change on ecosystems, memory, language, and culture. Through participatory fieldwork in Amazonia and sound cataloguing, the project combines traditional ecological knowledge with scientific data to create a living archive of a transforming ecosystem. Beyond preservation, these projects illustrate how technology can be a medium informed by local wisdom, fostering a dialogue between tradition and modernity.

Intertwined with cultural heritage and ancestral knowledge, the theme of decolonization is important in discussions of STARTS in Africa and South America. The STARTS Prize Africa 2024 winner, *Balot NFT* by the Cercle d'Art des Travailleurs de Plantation Congolaise (CATPC), paints a profound picture of the ongoing impact of colonization on African communities. Themes of restitution, loss of sacred lands, ancestral cultures, and spiritual objects are addressed, in a perspective that positions the arts not just as creative expressions but as crucial platforms for knowledge production and the critique of prevailing paradigms.

In South America, a focus on exploring the topic of technology and obsolescence can be observed, echoing the Buen-TEK concepts, to critically examine the materiality of computation, the phenomenon of planned obsolescence, and the temporalities of technology. By delving into the lifecycle of technological devices and their environmental impacts, this topic encourages a reflective approach to technological consumption and innovation. It challenges the notion of disposability and advocates sustainable practices in technology design and usage. Through artistic dispositive and interdisciplinary collaborations, it aims to expose the hidden layers of technological systems and inspire alternative models of technological development that prioritize longevity, sustainability, and ethical considerations.

In Africa, responding to the focus of STARTS Afropean Intelligence, the topic of cultural inclusivity and representation in AI is particularly explored. As AI continues to permeate various aspects of our lives, the need for cultural diversity and representation in its development and deployment has become increasingly apparent. This is especially important in the African context, since current AI technologies often reflect biases present in the data upon which they are trained, which predominantly comes from Western contexts. This lack of diversity leads to AI systems that do not adequately represent or serve non-Western cultures. *Untangler: Worlds Reimagined* by Nigerian artist Peace Olatunji addresses the issue of biased and stereotypical representations of Africa generated by text-to-video models like OpenAI's "Sora". By using diverse and culturally relevant data, it seeks to create images and videos that accurately reflect the richness and diversity of African cultures, moving away from current stereotypes.

The implementation of STARTS beyond Europe demonstrates that while the way artists engage with science, technology, and local communities remains methodologically consistent, the realities and priorities differ across continents. Although ecological concerns and reflections on urbanization are equally present in Africa and South America just as in Europe, questions related to cultural heritage, ancestral knowledge, and a more critical approach to technology take center stage. The social, economic, and ecological contexts of each region give rise to projects that are more deeply rooted in humanity, celebrating cultural richness and the relationship between societies, nature, and all living species. Through these endeavors, STARTS highlights the potential of technology—not as a neutral tool, but as a medium informed by local wisdom and cultural context. The fusion of ancestral knowledge and modern innovation creates a dialogue between past and present, and with European perspectives, enriching both technological development and cultural preservation. In doing so, these projects offer a model for responsible innovation, one that prioritizes ecological stewardship, community empowerment, and the celebration of life in all its forms.

While these observations are based on a limited sample of 39 residencies and projects awarded by the STARTS Prize, it is inspiring for Europe to see how African and South American artists seek to preserve and celebrate their identities—those that have shaped their history and continue to mold ever-evolving societies. Considering the experiences of all stakeholders, we can affirm that working with STARTS on other continents presents challenges but is, above all, a unique learning experience, opening minds and perspectives in many ways.

This type of program allows the EU to position itself as a leader in responsible innovation, in contrast to purely technocentric models like those of Silicon Valley. These initiatives also fuel European policies, such as the Green Deal or the strategy for cultural and creative industries, by integrating expertise from Africa and South America (e.g., in circular economy or biomimetic design).

Nourished by these learnings, STARTS can serve on a global scale as a soft power lever, demonstrating that Europe supports innovation rooted in human rights and diversity. This strengthens the EU's credibility in forums like the UN or the WTO, where technology regulation is a critical issue.

In a geopolitical context marked by technological competition, STARTS illustrates how art and culture can act as tools of scientific diplomacy, building bridges between civil societies and easing postcolonial tensions. By valuing ancestral knowledge and local innovation, the program offers a counter-model to the extractivist dynamics often associated with “tech for good”.

While STARTS remains an experimental laboratory, its internationalization reveals a broader truth: the most relevant innovation emerges where art, science, and community intersect on equal footing. For the EU, this means continuing to rethink funding mechanisms and partnerships, not as unilateral aid but as a mutually transformative exchange. As food for thought we can state that collaborative projects outside Europe should emphasize a more bottom-up approach, valuing adaptation to local contexts, flexibility, long-term commitments, and equitable partnerships with local institutions.

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“We should say Abya Yala”[1]:

Finding a Common Ground

ELISA CUESTA FERNÁNDEZ (TBA21) and
MARÍA MONTERO SIERRA (TBA21)

As the first South American-European STARTS consortium, laying the groundwork for ethical and reciprocal collaboration across continents, contexts, and cosmovisions, several responsibilities were clear to us:

> “In contexts where colonialism is both past and present, the real common ground to build is the ongoing conscious effort to cease all forms of violence so that honest listening becomes possible”.
>
> Karen Palacio, CCAD-UNC (399 m ASL, Espinal, 31° 25’6.89” S, 64° 11’16.68” W).

> “Working in a pluriversal and intercultural terrain requires an ethic of attention and presence, grounded in the understanding of difference as a driving force for creation”.
>
> Ramon Martins, Pivô (64.87 m ASL, Atlantic Forest-Mata Atlântica, 12° 58’49.13” S, 38° 30’29.03” W).

We commit to these responsibilities by activating conscious forms of acknowledging, listening to, and making visible other ways of doing that allow us to learn from each other and advance mutually nurturing interdisciplinary artistic practices. We wanted to practice working together remotely, to disregard national borders, and to connect through multiple languages. We needed to de-center to be able to recalibrate. We called this round trip “grounding”. Buen-TEK, the proposed umbrella theme of the project, became our roadmap.

> “Buen Vivir is a concept that comes from the Andean indigenous thought Sumak Kawsay (in Quechua) and Suma Qamaña (in Aymara language), which consists of the search for more balanced relationships in ecosystems and between all beings, human and non-human, as a path to a common well-being”.
>
> Alexander Correa and Lina Mejia, Platohedro (1518.99 m ASL, Northwestern Andean Mountain Forests, 6° 14’37.75” N, 75° 33’27.02” W).

1. This was a comment made during a consortium meeting by Tere Badia (HacTe, 223 m ASL, Mediterranean Forests, 41° 25’ 21.00” N, 2° 7’ 6.99” E). *Abya Yala* is a Kuna term used to identify the Latin American region: “This debate opened the way for greater recognition of the identity and collective rights of the Indigenous peoples of Latin America (or *Abya Yala,* the Kuna term with which Indigenous peoples have come to identify the region), including the right to political participation” (Beling et al., 2021).

The six cultural, scientific, and research European partner institutions intentionally borrowed the South American term *Sumak Kawasay*. Its pointed consideration for local and vernacular knowledge (Lo-TEK[2]), practiced by the communities respectfully living in the lands that belonged to their ancestors and that will be passed on to the next generations, became particularly relevant when exploring further ecosystems. We chose Buen-TEK as our framework and brought it back to our eleven South American partner organizations (who we call twins) as an invitation to collectively frame our activities and conversations.

Buen Vivir accompanied South American political and emancipatory processes led by Indigenous peoples and social and labor movements at the turn of the twenty-first century, disputing colonial legacies and modern development paradigms, particularly in the Andean-Amazonian region. Today, it continues to carry powerful and precious learnings. The search for alternative ways of doing in favor of "life in harmony" responds to ongoing extractive practices where climate awareness is unavoidable. We wish to identify ecological and material ecosystems and learn from the technologies developed by those who attune to environmental cycles at a slow pace. As we rekindle this concept, we consciously consider its current implications and our responsibilities in this process.

Having proposed this term, we soon learned that the diversity of ecosystems and communities across which we were trying to build a common ground would challenge a unique definition of "-TEK". Spanning from over 3,000 meters above sea level, from the Andean highlands to the Amazon river basin, from research labs and universities in densely populated cities to community-run centers in the Patagonian Steppe, and from the Atlantic to the Pacific shores of the continent, local knowledge, technologies, and ways of doing embody different epistemologies. Rather than labeling tech as high or low, we now ask:

> What is the appropriate technology for this moment and in this place?
>
> (Sol Bucalo, Barcelona Supercomputing Center [BSC] [87.21 m ASL, Mediterranean Forests, 41° 23'22.68" N, 2° 6'56.68" E]; Arjon Dunnewind, IMPAKT [5.5 m ASL, Temperate Broadleaf and Mixed Forests, 52° 5'18.29" N, 5° 7'23.10" E]; Christophe De Jaeger, GLUON [20.35 m ASL, Temperate Broadleaf and Mixed Forests, 50° 50'51.91" N, 4° 20'19.49" E]; Denise Lanzieri, Sony CSL – Rome [48.21 m ASL, Mediterranean Forests, 41° 53'45.19" N, 12° 29'20.08" E]).

We also ask: How do we ensure we are not instrumentalizing this knowledge?

> "From the very beginning, we have been inspired by the lichen, a unique organism that emerges from the symbiosis between different species, which collaborate and evolve together to adapt and survive in extreme conditions. Within this framework, local technologies emerge as a fundamental element, as they offer solutions tailored to the specific needs and contexts of each community. These technologies not only foster innovation but also promote a deep respect for the environment, allowing communities to develop sustainable and effective strategies".
>
> Colectiva Liquenlab (8.42 m ASL, Magellanic Subpolar Forests, 53° 9'43.33" S, 70° 53'59.24" W).
>
> "The association between gambiarra[3] and Buen-TEK offers insight into the structural condition of artistic and scientific practices in Brazil. In this context, gambiarra operates as a situated technology, mobilizing creativity in the face of ongoing instability. I see gambiarra as an adaptive human intelligence, an expression of a way of inhabiting the world amid collapse. It shares with Buen-TEK a reappropriation of technique, interdependence, and collective strength in the face of scarcity".
>
> Fabiane M. Borges, LACO-USP (10.55 m ASL, Bahia Coastal Forests, 23° 29'58.97" S, 45° 7'7.72" W).
>
> "The potential lies in building from trust, transparency, and above all, from practice: co-creating tools that respond to our realities, not ones imposed by others. To ensure that Buen-TEK is not exploited, it is important not to forget that this knowledge is born from bodies, from territories, from memories. And if it doesn't care for life, then it isn't Buen-TEK".
>
> Jenny Campues, CICTA (3119.33 m ASL, Northern Andean Páramo, 0° 8'11.82" N, 78° 4'3.11" W).

To engage with these questions in Abya Yala, we first needed to de-center dominant narratives, established protocols, and fixed definitions. We had to prepare for ongoing transformation. Guided by our twins, we embraced epistemic discomfort and sustained negotiation as essential components of the process. The following text documents some of the hands-on

2. Lo-TEK (Local Traditional Ecological Knowledge) is a term coined by landscape designer and educator Julia Watson (2019), who studies sustainable traditional technologies by Indigenous peoples around the world to address environmental challenges.

3. "Gambiarra" is a Brazilian-Portuguese word that refers to an improvised, low-cost, often makeshift solution to a problem. It implies a creative, but not always elegant, workaround, often using whatever materials are at hand.

Top to bottom:

Performance OBLIVION by Javier Blanco, part of Moore's *clock ticks: your supercomputer is rotting* residency, organized by Barcelona Supercomputing Center with the support of Centro de Cómputo de Alto Desempeño de la Universidad de Córdoba (CCAD-UNC). Centro Cultural UNC, Argentina, November 7, 2025. Photo: Paula Fernández Vergara

Cariçara mariculturist Seu Gino during the "Workshop on Algaculture, Science, and Art" in collaboration with the Instituto de Pesca (APTA), part of the *Shifting Shores* residency, organized by TBA21 with the support of Pivô and the Oceanographic Institute of the University of São Paulo (LACO-IOUSP). Ubatuba, Sao Paulo, October 31, 2025. Photo: Melanie Matthieu

Workshop Digital Taxonomy of Palms in the Post-Tropics in collaboration with Fundacao Getulio Vargas University and Museu do Amanhã, during the *Post-natural and other ecologies* residency, hosted by Museu do Amanhã, co-commissioned by Gluon, developing project Bunker for a Tropical Pixel, by Tatyana Zambrano. Rio de Janeiro, Brazil, September 18, 2025. Photo: Mixel Sevla.

practices, consensual decisions, and emerging ideas that surfaced in response to these urgencies.

DE-CENTERING

> "We begin by recognizing asymmetries in power, priorities, and expectations. These differences won't disappear, but they can become sources of learning, tension, and richness".
>
> Jonathan Colin, Más Arte Más Acción (92.84 m ASL, Guiana Shield-Amazon Rainforest, 3° 51'55" N, 67° 55'26" W).

From the outset, de-centering was not a rhetorical gesture, but a methodological imperative. Working across distinct cultural, political, and epistemological contexts required us to question the foundations of how collaborative projects are typically structured, particularly within EU-funded consortia. This involved not only recognizing asymmetries, which are technical and also historical and emotional (Jenny Campues, CICTA), but actively creating spaces where they could be named, discussed, and re-negotiated. We paused to listen.

HANDS-ON: VOICE UP

We started by gently subverting the already familiar STARTS methodology through one of the project's work packages, "Building Narrative and Sustainability", to embed a fully encompassing (un)learning effort that would respond to the diverse collection of voices and the evolving nature of the project. The editorial board reflected the balance of representatives from Indigenous, rural communities and cultural, academic, and scientific institutions, and it established a multilingual approach to guarantee the presence of at least the three main languages spoken in the consortium, and reasserted a commitment to a non-extractive, inclusive equity group practice.

> "Multiplicity takes time. It emerges through discomfort, trust, and ongoing reflection. We need tools for this: pooling collective funds for the unexpected, sharing beyond financial means, and building grounded, unconventional platforms for exchange. Collaboration is not a destination, but a continuous practice of unlearning, reimagining, and challenging power imbalances—together".
>
> Jonathan Colin, Más Arte Más Acción (92.84 m ASL, Guiana Shield-Amazon Rainforest, 3° 51'55" N, 67° 55'26" W).

HANDS-ON: SYNCHRONIZED REFLECTION AND COLLECTIVE WRITING

In the early stages of the project, interculturality, community engagement, technological plurality, and linguistic diversity were some of the realms that sparked productive friction. Inspired by this, we initiated an exercise of synchronized reflection and collective writing, and invited all partners and twins to reflect and articulate their positions in regard to these terms.

> "It is not merely about including diverse groups under the label of 'community', but about redefining knowledge production and power relations within it. Not by extracting data from communities but by collaboratively generating visibility and agency. This is a deeply political and ethical role—one where listening, dialogue, and co-production replace top-down action".
>
> Lara Furtado, UNIFOR (21.66 m ASL, Caatinga, 3° 46'7.59" S, 38° 28'41.02" W).

HANDS-ON: ETHICAL FRAMEWORK OF COMMUNITY ENGAGEMENT

Involving communities was vital to us. The difficulties in arriving at a common definition of who the "communities" were, and the different imaginaries and lived experiences in each case, encouraged the creation of an ethical framework of community engagement, a collaboratively written tool

> "[...] aimed at proposing alternative ways of thinking about credit, profit, and collaboration dynamics in artistic and academic practices, including gender and social class realities as intersectional factors, and a framework for navigating the creative act of proposing non-extractive and truly situated methodologies".
>
> Karen Palacio, CCAD-UNC (399 m ASL, Espinal, 31° 25'6.89" S, 64° 11'16.68" W).

HANDS-ON: SITUATED PRACTICES

This way of working allowed for a redefinition of the residency model, not around a single artistic theme or medium but around contextually grounded inquiries posed by each twin organization in dialogue with local communities. Representatives of these communities were involved in the selection committees, along with evaluating the proposals and eventually choosing the artists who would engage in the residency program. Having such regional experts accompany the artistic research, as well as running a series of workshops designed to pull wisdom from the local communities involved, reflected the continued efforts to advance situated knowledge.

In all these examples, the attention given to the multiplicity of life forms in each ecosystem nurtures possible ways of doing "-TEK", which is facilitated by the transgenerational observation of local communities. We take onboard these principles and constantly ask ourselves "where", "who", and "whom".

Top to bottom:

Josefa Nolta, the trans-local expert supporting the residency of Jimmy Carillo, and artisan women of the Santa Teresita community at the Cashibocha lagoon, near Pucallpa, Peru. Jimmy Carillo stayed for several weeks at the “Casa Sanango” Residency, close to this Shipibo-Konibo community of Santa Teresita, as part of his residency organized by Alta Tecnología Andina (Lima) and IMPAKT (Utrecht). Photo: Gabriela Nolasco.

Scientist Karen Benalcázar taking water samples in the Andes highlands during the *Turminta* residency, organized by HacTe with the support of CICTA. La Chimba, Ecuador, October 2025. Photo: Jenny Campues

Yuca brava is a poisonous tuber, saturated with cyanide, and it is the basis of the diet of Amazonian human communities. Here we see the Sebucan, a device that is used to extract the toxic from the Yuca Brava. The Yuca Brave is the central focus of artist aniara rodado in her residency in Colombia, organized by Mas Arte Mas Action (Bogota) and IMPAKT (Utrecht).
Photo: aniara rodado

RECALIBRATING THROUGH PRACTICE

If de-centering allowed us to shift the axis where knowledge and authority are located, recalibrating was the process of willfully reorienting our intellectual, methodological, and operational tools toward these new coordinates. It required ongoing co-creation and decision-making to ground the project plans within local specificities, while simultaneously building a common body of knowledge. At the core of this recalibration is Buen-TEK, not as a closed concept, but as a provocation and organizing principle, whose terms are yet to be defined.

> "Building a community of learning and practice involves translating the project's shared principles into situated methodologies, and conversely, allowing situated knowledge to challenge such principles".
>
> Miriam Calabrese, TBA21 (650.43 m ASL, Mediterranean Forests, 45° 26'13.69" N, 12° 20'41.61" W); Fernando Cucchietti and Paula Fernández Vergara, Barcelona Supercomputing Center (87.21 m ASL, Mediterranean Forests, 41° 23'22.68" N, 2° 6'56.68" E).

HANDS-ON: MULTILINGUAL APPROACH

Budgets speak loudly. The project proposal did not initially allocate resources for translation or interpretation. This clear oversight for a project rooted in intercultural collaboration was pointed out by the twins early on. The consortium responded by pooling funds from partner institutions to create a shared translation pot for supporting multilingual online sessions and translating texts, enabling knowledge to circulate in Spanish, Portuguese, and English. It was a logistical fix, with the potential to become a signature feature of this particular STARTS Buen-TEK program. And yet, Abya Yala is home to many other languages, whose sonorities will potentially slip through the project's work packages and deliverables.

HANDS-ON: FROM A COMMON BIBLIOGRAPHY TO A COLLECTIVE SYLLOGE

We molded, questioned, and pushed the boundaries of the core concept of Buen-TEK by considering our points of reference together. To grasp this dual principle of *Buen Vivir* and Lo-TEK, partners, twins, and regional experts contributed annotated recommendations of key texts, practices, media, or references, reflecting on their relevance to their specific context and locale. The abundance of interdisciplinarities, regions, communities, and experiences provided us with an extensive and expansive bibliography—an eye-opening one that continues to grow.

Authors, thinkers, and activists, such as Tránsito Amaguaña, Gloria E. Anzaldúa, Antônio Bispo dos Santos, Marisol de la Cadena, Arturo Escobar, Arturo Jauretche, Ailton Krenak, Daniel Munduruku, Josefa Nolte, Silvia Rivera Cusicanqui, and Paulo Tavares, as well as essential concepts like Earth Beings, *gambiarra*, ancestral future, *contracolonização*, alternative-to-development, pluriverse, and *Kaleuche* are opening up new pathways, connecting fields of research and disparate conceptions of how to live in the world, and have all contributed to shaping the narrative of the project. Together, we are producing a collective sylloge as a means not solely of communicating the project and presenting the artistic practices, but also of deepening the understanding of questions of sustainability, ways of making, and responses to today's crisis, and sharing a vision for how to live together.

HANDS-ON: PEER-TO-PEER LEARNING PROGRAM

To promote knowledge exchange among resident artists, translocal experts, and the network of partners and twins, and to connect an active web of practitioners spread across regions, disciplines, and languages, we co-designed a peer-to-peer learning program. We invited duos of artists and regional experts—paired not by territorial proximity but by potential affinity—to engage in a series of curated online group sessions, each following the artist's proposed dynamic. With this program, we aim to create a space for trial and error, where unexpected conversations occur, and where the multiplicity of knowledge within this diverse learning community can cross-pollinate amongst the various practices shaping the residencies.

HANDS-ON: SOUNDSCAPES

A more textured sonic experience offers a different kind of access to the project—more intimate, affective, and sensorial—embedding the sounds of local ecosystems. For this reason, and with the aim to reflect upon the learning exchanges and to share them publicly, we are developing a multilingual podcast series, involving the ten resident artists and the translocal experts. Soils, seeds, bacteria, plants, and animals will emerge to formalize a new map of interconnectivity and exchanges.

WE PRACTICE EARTH-BEINGS

We are not only learning how to be together among communities spread across vast regions, but also about what coexistence means in a more-than-human world. Various tools, platforms, renewed protocols, and group learning programs have already been established to aid these efforts, which also means that they are now ready to be adapted and developed. demonstrating multiple examples of vernacular and situated knowledge. We will be practicing together as Earth Beings.[4]

4. The concept of "Earth Beings" was developed by Davis Marisol de la Cadena (2000), a professor of anthropology at the University of California.

NOTE FROM THE EDITORS

The words in this text were written by multiple hands, typing across languages and ecosystems in a coordinated effort, with the aim of accounting for plurality in concept as well as in practice. The quotes included have been developed by the consortium twins in response to a series of prompts inspired by the sites of friction and contestation derived from the implementation of the project itself in its early stages. The consortium partners also engaged with these prompts in a workshop during an on-site consortium meeting, which preceded the launch of the residencies. The ideas discussed were then collected and integrated into this text.

On the Formatting

Although it is still early to reflect on the spatial dimensions of Buen-TEK, this collective effort of both thinking and writing already offers some hints of what these will be like. For every contributor we have chosen to include a few geobiological contextual references, such as elevation above sea level (m ASL), notes about the kind of ecosystem they are in, and the GMS geographic coordinates where the consortium organizations are located. We hope this non-linear arrangement of information will account for the diversity of contexts that are present in the making of this project, and hopefully may inspire an emergent cartography of Buen-TEK.

Editorial Board: Elisa Cuesta Fernández, María Montero Sierra, Hygor Piaget, and Pedro Soler.

Contributors: Tere Badia, Fabiane M. Borges, Sol Bucalo, Miriam Calabrese, Jenny Campues, Jonathan Colin, Alexander Correa, Fernando Cucchietti, Christophe De Jaeger, Arjon Dunnewind, Paula Fernández Vergara, Lara Furtado, Denise Lanzieri, Colectiva Liquenlab, Ramon Martins, Lina Mejia, Karen Palacio, Anna Pinotti.

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Moving Forward: S+T+ARTS as Europe’s Innovation Paradigm

VERONIKA LIEBL (ARS ELECTRONICA)

A BOLD BEGINNING! A SYSTEMIC FUTURE?

Europe cannot afford to treat STARTS as an experiment. What began a decade ago as an initiative of the European Commission has grown into one of the most distinctive and successful innovation programs the continent could have hoped for. STARTS is no longer just a platform for residencies or prizes. It has become the new paradigm of working and learning, a model of transdisciplinary innovation that directly addresses the systemic crises that Europe faces: the climate emergency, digital sovereignty, trust in democracy, and the inclusion of diverse communities.

If Europe wants to remain competitive and resilient in a world shaped by global technological powerhouses, not only must it invest in science and technology but also cultivate the type of cultural intelligence and imaginative capacity necessary to shape innovation in human-centric, democratic, and sustainable ways. This is exactly what STARTS delivers. The question is no longer whether STARTS has proven its value. The question is whether Europe has the courage to consolidate this model, embed it structurally, and claim it as a defining element of its innovation DNA.

WHY CONSOLIDATION AND SYNERGIES MATTER

Over the past ten years, STARTS has built a remarkable ecosystem. It has supported over 300 residencies in universities, research laboratories, and industries; it has created regional centers across Europe that connect local ecosystems; it has trained thousands of students and professionals through STARTS Academies; it has attracted more than 14,000 submissions to the STARTS Prize, turning it into one of the largest showcases of transdisciplinary innovation worldwide. The STARTS Lighthouses have addressed grand challenges in water, food, textiles, and circularity, mobilizing a broad consortium of artists, scientists, and companies around systemic problems.

These achievements are not isolated. They form a unique knowledge base and community that no other continent has built with comparable breadth. Yet the very richness of this ecosystem risks fragmentation if left without strategic consolidation. Different strands of STARTS—residencies, prizes, academies, regional centers—currently operate under project-based funding cycles. While this has yielded an extraordinary variety of activities, it has also created duplication, uneven visibility, and difficulties in sustaining momentum.

The next chapter of STARTS, therefore, must be about consolidation and synergies. Consolidation does not mean uniformity; it means weaving the diverse strands of STARTS into permanent infrastructures and servicing other European research and innovation communities with the unique methodologies, practices, and cultural intelligence that only STARTS has developed. Synergies mean ensuring that what happens in regional centers feeds into European policy debates, that residencies connect to academic curricula, that prizes shape research agendas, and that the knowledge generated in STARTS is harvested for broader societal use. Only by consolidating can STARTS become not just a set of projects but a structural infrastructure for Europe's innovation future.

STARTS AS AN INFRASTRUCTURE OF INNOVATION

STARTS should be understood as more than just a funding program. It has already taken on the characteristics of an infrastructure of innovation, comparable to the way Europe has invested in technical research infrastructures. Whereas those infrastructures provide the physical and technological backbone of science, STARTS provides the cultural and imaginative backbone of innovation.

As an infrastructure, STARTS plays two roles. It is a laboratory, where experimentation happens in residencies, joint research projects, and artistic interventions in scientific domains. And it is a platform, where results are disseminated through the Prize, through exhibitions, through policy dialogues, and through its growing international networks. This dual function—lab and platform—makes STARTS uniquely powerful. It ensures that experimentation is not locked inside labs but flows outward into society, industry, education, and policy.
By consolidating STARTS as a recognized European infrastructure, the EU would anchor a distinctive model of innovation: one that combines technological excellence with societal legitimacy, and one that links local ecosystems to European and global networks.

DIGITAL SOVEREIGNTY AND THE EUROSTACK AGENDA

Nowhere is the necessity of STARTS clearer than in the field of digital sovereignty. Europe has recognized that its reliance on non-European digital infrastructures threatens not only competitiveness but also democracy and cultural autonomy. The recent **EuroStack initiative** illustrates this strategic shift: a program designed to create European digital commons, strengthen HPC and AI infrastructures, and promote "Buy European" awareness among citizens.

Yet digital sovereignty is not just a question of hardware or software. It is a question of citizen literacy, cultural legitimacy, and democratic agency. This is precisely where STARTS plays a decisive role. Artists within STARTS projects have long worked on algorithmic transparency, AI literacy, and participatory data governance. They have created installations that demystify machine learning, workshops that allow communities to experiment with data, and performances that provoke debate about surveillance, identity, and trust.

These contributions are not decorative. They are the conditions of possibility for digital sovereignty. Without cultural engagement and citizen awareness, "Buy European" will remain a slogan. With STARTS, it can become a movement: a shared understanding that Europe's digital infrastructures are not just technologically excellent but socially grounded, ethically accountable, and culturally resonant.

This is why STARTS must be seen as a strategic partner in EuroStack, EuroHPC, and AI Factories. It ensures that Europe's digital future is not only built in Europe but also believed in by Europeans.

POLICY ALIGNMENT AND EMBEDDING INTO EUROPEAN FRAMEWORKS

Consolidating STARTS also means embedding it more deeply into existing European programs. Each major EU policy area offers opportunities for synergies where STARTS can add demonstrable value.

Horizon Europe. In Cluster 2 (Culture, Creativity, Inclusive Society), STARTS provides tested methodologies for transdisciplinary collaboration that enhance mission-oriented innovation. In Cluster 4 (Digital, Industry, Space), STARTS projects ensure that AI, robotics, and industrial transformation are developed with human-centric perspectives and creative imaginaries. The Missions, especially those on climate adaptation and soil health, can draw on STARTS's experience in engaging citizens and reframing systemic challenges. The New European Bauhaus has already drawn inspiration from STARTS in connecting sustainability with culture and creativity.

Creative Europe. The upcoming AgoraEU program will focus on strengthening democratic participation and cultural ecosystems. STARTS can feed directly into Agora with projects that build trust, civic literacy, and cultural debate around technology. The combination of arts, science, and civic participation is exactly what Agora seeks to institutionalize and that STARTS has practiced for more than ten years.

AI strategies and EuroHPC. STARTS has already advanced pioneering work on AI literacy, ethical foresight, and artistic explorations of machine learning. By linking these experiences to the AI Factories and EuroHPC initiatives, Europe can ensure that its cutting-edge computing infrastructures are matched with cutting-edge societal engagement and public trust grounded in cultural relevance.

Erasmus+ and education. STARTS Academies have shown how curricula can integrate art, science, and technology. Embedding these models into Erasmus+ would help disseminate them widely across Europe's education systems.

EIT Culture & Creativity. The EIT Culture & Creativity partnership has the mandate to mobilize innovation in the cultural and creative industries. To avoid duplication, it must build on the knowledge base and community STARTS has created, rather than reinventing such structures. STARTS offers expertise and networks that can help the EIT Culture & Creativity partnership succeed in fostering entrepreneurial ecosystems for culture and creativity.

By embedding STARTS across these frameworks, Europe maximizes synergies, prevents duplication, and ensures that transdisciplinary innovation becomes a structural element of European policy.

STARTS AS A GLOBAL REFERENCE

The impact of STARTS is not limited to Europe. It has already become a global reference for transdisciplinary collaboration. The STARTS Prize has attracted submissions from over 100 countries. STARTS projects have been showcased in South America, Africa, and Asia. The model has inspired ministries and universities beyond Europe to develop similar programs. The African and South American collaborations, documented in STARTS reports, illustrate that this approach resonates deeply in regions that are engaging with questions of Indigenous knowledge, cultural diversity, and sustainable development.

Europe has thus created something unique: a globally recognized framework for art-science-technology collaboration. The next step is to build on this position, strengthening STARTS not only as a European infrastructure but as a European export of cultural leadership. Just as Erasmus became a symbol of Europe's role in education, STARTS can become a symbol of Europe's role in human-centered innovation.

ENABLING STRUCTURES AND PRACTICES FOR SUSTAINABILITY

For STARTS to thrive as a form of infrastructure, it requires sustained structures and adaptive practices. The experience of Ars Electronica, Waag Futurelab, and other European organizations is instructive here. Over decades, Ars Electronica, for example, has developed a permanent lab (the Futurelab), large-scale public platforms (the Ars Electronica Festival), and long-term educational partnerships. It has shown that art-science collaboration can not only provide inspiration but also monetization, generating value for industry while preserving critical independence. Across Europe, similar structures are emerging, and there are attempts to institutionalize some of them, turning them into legal entities, as in the very promising model of HacTe in Barcelona. What these examples reveal is that sustainability depends on three major factors:

- **Infrastructure:** Residencies and projects must be embedded in semi-permanent labs and institutions, not only in temporary open calls for projects.
- **Mediators:** Cross-disciplinary collaboration needs professional facilitators who can guide the collaborators with less experience in cross-sectorial collaboration on how to manage friction, (re-)spark curiosity, and ensure continuity.
- **Institutional embedding:** Universities and cultural organizations are the natural allies for developing transdisciplinary research and education. It is of utmost importance that we strengthen these alliances—through institutional embedding, the creation of shared research lab structures, or dedicated project-based funding that ensures continuity and depth.

By consolidating these structures across Europe, STARTS can ensure that its practices are not episodic but systemic.

STRUCTURED EXCHANGE WITH ACADEMIA AND SKILLS DEVELOPMENT

Another crucial step is building structured exchange with the academic sector. STARTS has shown the power of embedding artists in research laboratories and curricula. But this experience needs to be connected systematically with wider skills initiatives.

Europe has already recognized the importance of transdisciplinary skills through initiatives and projects like the Pact for Skills, CYANOTYPES, and Creative Skills Week. These initiatives explore new models of education both for and from the creative and cultural industries. But they also need the practical experience of STARTS projects—the lessons on what works, what frictions arise, how disciplines can be bridged—in order to create a holistic knowledge foundation for Europe's skills agenda.

This is all the more urgent given the global consensus that creative thinking is a core skill for the future. The World Economic Forum's Core Skills for 2030 identifies creative thinking, alongside analytical thinking, system thinking, resilience, and technology literacy, as the most important competences for the next decade. Europe's workforce effectiveness will depend on these skills. STARTS, with its track record in directly cultivating these capacities, must therefore be recognized as a strategic contributor to Europe's skills policies.

To consolidate this contribution, Europe should invest in the development of a European curriculum for innovation catalysts and facilitators: professionals who can navigate transdisciplinary collaboration and connect sectors. And STARTS is a highly experienced provider to contribute to such a curriculum.

CLOSING REFLECTIONS AND CALL TO ACTION

Europe has, through STARTS, discovered something extraordinary: an innovation model that is not only effective but profoundly European. It draws on the continent's DNA: the belief that culture and technology must go hand in hand, that democracy and science belong together, that imagination is as essential as efficiency.

This model matters for two reasons. First, it provides critical input into technological development itself, ensuring that Europe's industrial systems are shaped with cultural intelligence and societal legitimacy. Second, it creates new imaginaries for citizens—stories, experiences, and visions that help people see themselves as agents of transformation in the face of global crises.

The task ahead is clear. Europe must consolidate STARTS as a permanent infrastructure of innovation. It must increasingly embed STARTS methodologies into programs such as Horizon, Creative Europe, New European Bauhaus, EIT Culture & Creativity, and Erasmus. It must give STARTS a role in digital initiatives such as EuroStack, EuroHPC, or AI Factories to ensure digital sovereignty is culturally grounded. It must align itself with skills agendas to prepare Europe's workforce for the future. And it must sustain its role as a global reference for transdisciplinary collaboration.

If successful, STARTS will stand as a model of how Europe innovates: not by speed alone, not by technology alone, but by cultivating ecosystems of care, critique, creativity, and collaboration. This is a Europe true to its DNA: an innovation paradigm that is as imaginative as it is inclusive, as ambitious as it is humane.

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SCIENCE+TECHNOLOGY+ARTS: Lessons Learned from a Decade of European Transdisciplinary Innovation

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SCIENCE+TECHNOLOGY+ARTS: Lessons Learned from a Decade of European Transdisciplinary Innovation reflects on the legacy of the S+T+ARTS Initiative, a pioneering European program that, since 2016, has redefined how art, science, and technology intersect to drive innovation and societal change. Bringing together voices from across the S+T+ARTS ecosystem, the book summarizes the learnings of a decade of practice and offers insights for policymakers, cultural practitioners, educators, and innovators dedicated to the development of transdisciplinary programs in Europe and beyond.

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