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Pioneers of Advanced Technologies

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3D Pioneers
Challenge
Pushing Boundaries

Opening

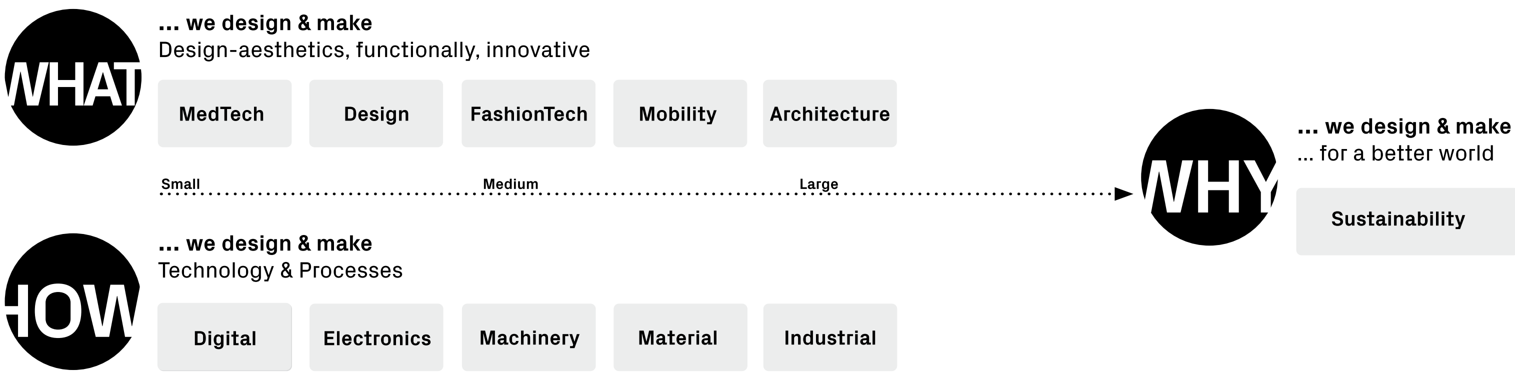
by Simone and Christoph Völcker

Welcome to the world of Additive Manufacturing and Advanced Technologies.

This book takes you through the categories of the 3D Pioneers Challenge, which derive from the central questions: **"WHAT, HOW, WHY ... we design and make."** It showcases the diversity of the 3DPC platform, the wide spectrum of Additive and Advanced Technologies, and the opportunities they create across a wide range of industries.

Each chapter begins with an **Introduction**[1] to the topic area, outlining the scope and relevance of the category while providing an overview of the 3DPC verticals. The **Perspectives** that follow are contributed by the competition's jurors – longtime collaborators and experts in their disciplines. Their insights place the categories and projects in a broader context and reveal the role of Additive Manufacturing.

These innovations are brought to life through selected **Project** examples from finalists and winners spanning 2016 to 2025. The contributions provide insights into the mindsets of the pioneers – from students and research institutions to start-ups and industrial companies. They reflect the cultural and professional diversity that shapes the character of 3DPC.



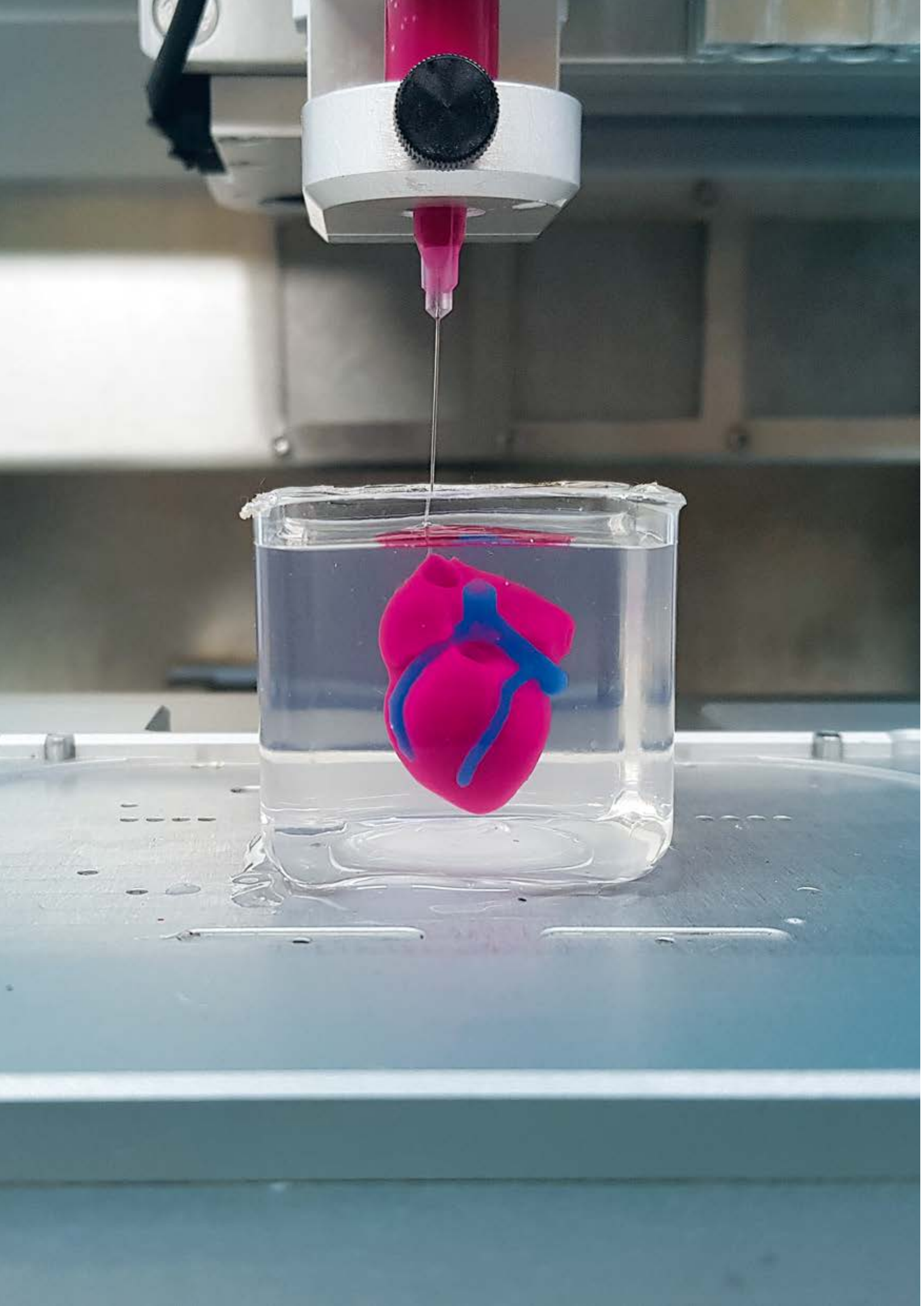
*Dieses Buch führt Sie durch die Verticals der 3D Pioneers Challenge, die sich aus der zentralen Fragestellung ableiten: **„WHAT, HOW, WHY ... we design and make"**. Diese Vielfalt der 3DPC-Plattform zeigt die enorme Bandbreite additiver und fortschrittlicher Technologien und die Potenziale, die sich daraus für unterschiedlichste Branchen eröffnen.*

*Jedes Kapitel beginnt mit einer **Einführung**[1] ins Themenfeld, die den Rahmen und die Bedeutung der jeweiligen Kategorie vermittelt und damit einen Überblick über die Verticals der 3DPC bietet.*

*Mit den **Perspektiven** setzen die Juroren des Wettbewerbs – langjährige Wegbegleiter und Branchengrößen ihrer jeweiligen Disziplinen – die Kategorien und Projekte in einen größeren Kontext und zeigen, welche Rolle additive Fertigungsverfahren in ihnen einnehmen.*

*Die Vielfalt der Innovationen wird sinnbildlich anhand ausgewählter **Projektbeispiele** veranschaulicht von Finalist:innen und Gewinner:innen aus den Jahren 2016–2025. Die Beiträge geben Einblicke in die Denkweisen der Pioniere – von Studierenden über Forschungseinrichtungen und Start-ups bis hin zu Industrieunternehmen. Sie spiegeln die kulturelle und fachliche Breite wider, die den Charakter der 3DPC prägt.*

Bottom left: Verticals 3D Pioneers Challenge



MedTech

Advanced Technologies can improve the medical sector for the care of patients, human or animal. The spectrum in this field is broad and includes a diverse range of innovations – from products such as prostheses, orthoses, or implants to bioprinting and 4D medicine that changes through specific indicators, as well as educational improvements up to clinical process support.

MedTech focuses on the advantages created where Advanced Technologies directly interface the human body. It also embraces the exploration of how MedTech can be further developed through metal 3D printing, human based biomaterials and material gradients.

Left page: Cardiac tissue printing, Dvir Lab

Perspective on MedTech

by Andreas Velten

Personalized, precise, and pioneering: The role of AM in modern medicine

Additive Manufacturing (AM) is virtually predestined for use in the healthcare sector. Many medical devices are produced as one-off pieces and must be customized to individual patients. The integration of various manufacturing techniques, particularly with the increasing influence of AM, is already enhancing patient care – often delivering cost savings and higher quality outcomes.

In pharmacology, printed, patient-specific drug formulations are already possible. In medical research, new types of tissue scaffolds can be 3D printed, which helps reduce reliance on animal testing and allows for more standardized testing protocols.

Dentistry, in particular, has leveraged AM over recent years, with developments pointing in a promising direction toward more cost-effective, rapid, and high-quality care.

Realistic anatomical models created via additive manufacturing are increasingly used in medical training. These models can replace human cadavers and provide standardized conditions that enable reproducible results in both foundational and advanced education.

As more materials receive regulatory approval, new possibilities continue to emerge – especially as global networking increasingly facilitates international collaboration.

> **“Medicine is the primary and ideal application field for Additive Manufacturing – in the next decade AM could become routine in clinical practice!”**

The 3D Pioneers Challenge plays a crucial role in promoting innovation. Each year, contributions from around the globe inspire new ways of thinking and drive technological advancement.

Orthotics, epitheses, patient-specific implants, tissue structures, and even simplified organ models are already being redefined through additive manufacturing.

Given the industry’s recent momentum, the outlook for the next decade is promising: Fully functional prostheses and custom implants – including organ replacements – could soon become routine in clinical practice.
The range of treatment options is set to expand significantly as Additive Manufacturing evolves from a niche technology into a foundational pillar of modern medicine.

Vita

Born in 1966, Andreas Velten trained as a dental technician and earned his master craftsman certificate in 1995. From 1994 to 2003, he served as CEO of Velten Dental Zentrum GmbH, followed by a decade as CEO of Velten Kunststofftechnik GmbH (2003–2013). Since 2013, he has been CEO of IFA3D Medical Solutions GmbH and CTO of the Institute for Anaplastology Velten & Hering OHG.

Velten has been a jury member of the 3D Pioneers Challenge (3DPC) since 2015 and has served as a board member for medical affairs at the German 3D-Printing Association since 2016. He is also a member of the International Society for Prosthetic and Epithetic Surgery (I.A.S.P.E.) and the American Anaplastology Association (AAA).

FashionTech

The fusion of human and machine becomes tangible in the FashionTech sector. The merging of design, fashion and new technologies makes it possible to turn visions into reality by developing not only material innovations but also new production processes.

This sector covers a wide range of explorations – including inspiration from lifestyle and art – which can influence applications such as workwear, personal safety wear and wearables that support the interaction with belongings, comfort, safety, and surroundings. Not to forget it offers concepts that rethink the actual fashion industry in regards to its overproduction and the throwaway society towards sustainable solutions.

Left page: Caress of the Gaze, Behnaz Farahi

Liberty and CC0 collection

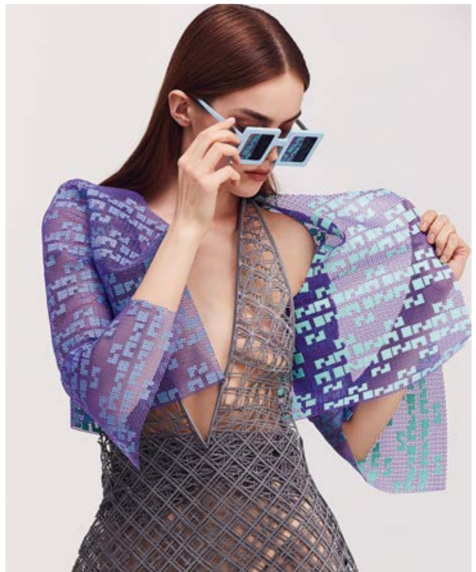
Designer: Danit Peleg
Company: 3D Printed Fashion Lab
Partners: Collaboration with nounsDAO for CC0 collection
Country: PORTUGAL

The fashion designer Danit Peleg unveiled the world's first fully 3D-printed fashion collection "Liberty Leading the People," in 2015, including shoes and accessories by using her at-home 3D printer. The collection, named after Eugène Delacroix's iconic painting, proved that 3D printing could move beyond prototyping into scalable, on-demand production of soft, wearable, customised, and low-waste apparel. The breakthrough earned Peleg international acclaim: Forbes named her one of Europe's Top 50 Women in Tech, and she was included on the BBC's 100 Most Inspiring and Influential Women list.

In 2024, Peleg marked a decade of innovation with a new collection funded by Nouns DAO, the community-run treasury behind the CC0 "Nouns" NFT series. Each garment was printed using a different 3D-printing technology, including FDM, PolyJet, SLS, SLA, and Multi Jet Fusion. The digital version of the collection was featured at Metaverse Fashion Week, the physical collection – alongside holographic twins – premiered at NFT Paris and NFT NYC. Today, Danit and her team are developing a new service that transforms fashion production waste into soft, wearable 3D-printed textiles – materials that can be used to create new fashion products, advancing a more circular and sustainable future for the industry.

Die Modedesignerin Danit Peleg präsentierte 2015 mit „Liberty Leading the People" die weltweit erste vollständig 3D-gedruckte Modekollektion – inklusive Schuhen und Accessoires – hergestellt mit einem 3D-Drucker für den Heimgebrauch. Die Kollektion, benannt nach dem Gemälde von Eugène Delacroix zeigte, dass 3D-Druck nicht nur für Prototypen, sondern auch für die skalierbare, tragbare, individuell anpassbare und ressourcenschonende Modeproduktion geeignet ist. Der Durchbruch brachte ihr internationale Anerkennung: Forbes zählte sie zu Europas Top 50 Women in Tech, die BBC zu den 100 einflussreichsten Frauen.

2024 feierte Peleg zehn Jahre Innovation mit einer neuen Kollektion, unterstützt von Nouns DAO, der Community hinter der CC0-NFT-Serie Nouns. Jedes Kleidungsstück wurde mit einer anderen 3D-Drucktechnologie gefertigt, u. a. FDM, PolyJet und SLS. Die digitale Version erschien auf der Metaverse Fashion Week, die physische – mit holografischen Zwillingen – auf der NFT Paris und der NFT NYC. Aktuell entwickelt Peleg einen Service, der Modeabfälle in tragbare 3D-gedruckte Textilien verwandelt – für eine nachhaltigere, zirkuläre Modezukunft.



Material: Flexible TPU Filament
Process: Fused Deposition Modeling (FDM), Polyjet and Multi Jet Fusion (MJF)

Left page: World's first 3D-printed fashion collection "Liberty"

Top: CCO collection features five unique looks

Left: Minimizing waste and democratizing design

Bottom: Presented on the Times Square, New York

Jet Suit Gravity

Institution: Gravity Industries
Team: Richard Browning, Sam Rogers and Alex Wilson
Country: GREAT BRITAIN

Gravity Industries, founded in 2017 by Richard Browning, is a British company pioneering personal flight with its Jet Suit. Powered by seven micro jet engines generating 1050 horsepower, allows vertical takeoff and landing, and has achieved speeds of 85 mph. Browning, a former Royal Marine reservist, initially invented the suit to push the boundaries of human flight, earning the nickname "real-life Iron Man." Gravity has performed over 400 live demonstrations in more than 40 countries, and collaborates with military forces, emergency services, and search-and-rescue teams. Recognized as one of TIME's Best Inventions of 2018, the Jet Suit has attracted global interest from defence organizations and technology enthusiasts. The company has performed the first Jet Suit Race, and is expanding its applications in defence, emergency response, and extreme sports. With continuous advancements, Gravity is shaping the future of human flight, merging cutting-edge engineering with human capability.

Das 2017 von Richard Browning gegründete britische Unternehmen Gravity Industries leistet mit seinem bahnbrechenden Jet Suit Pionierarbeit für den eigenständigen Flug des Menschen. Angetrieben von sieben Mikro-Jet-Triebwerken mit insgesamt 1.050 PS ermöglicht der Anzug vertikale Starts und Landungen sowie Fluggeschwindigkeiten von bis zu 85 mph. Browning, ehemaliger Reservist der Royal Marines, entwickelte den Jet Suit zunächst, um die Grenzen des Fliegens neu auszuloten – was ihm den Spitznamen „echter Iron Man" einbrachte. Mittlerweile hat Gravity über 400 Live-Demonstrationen in mehr als 40 Ländern durchgeführt und arbeitet mit Militär, Rettungsdiensten, Such- und Bergungsteams zusammen. 2018 wurde der Jet Suit vom TIME Magazine als eine der besten Erfindungen des Jahres ausgezeichnet und begeistert seither Verteidigungsorganisationen und Technologiebegeisterte. Das Unternehmen organisierte das weltweit erste Jet-Suit-Rennen und erschließt stetig neue Einsatzfelder – etwa in der Verteidigung, bei Notfalleinsätzen oder im Extremsport. Gravity vereint modernste Technik mit menschlichen Fähigkeiten und setzt hiermit neue Maßstäbe für die Zukunft.

Material: Polypropylene
Process: Selective Laser Sintering (SLS)

Left page: Gravity Jet Suit defense
Top left: Human flight becomes reality
Top right: Jet Suit backpack
Top right below: Rescue mission in the mountains

Architecture

Advanced Technologies can affect architectural innovation at numerous scales! It can happen in every part and detail, as well as 3D printing complete buildings – from the interior to the façade, all the way up to the way digital construction is being imagined.

This vertical highlights how some of the latest technologies, material innovations and tools like computational design or robotics are being used to disrupt the architectural design-build process, and how it can support topics like the digital side of construction.

Left page: TECLA, the eco-sustainable 3D-printed habitat by WASP

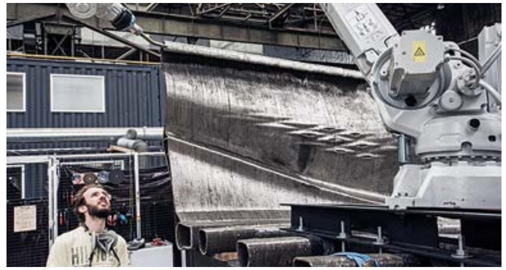
3D-Printed Bridge

Company: MX3D BV
Team: MX3D, Arup, Autodesk, ArcelorMittal, ABB, Heijmans, Lenovo, Airliquide, AMS Institute, TU Delft, Joris Laarman Lab, Gemeente Amsterdam among others
Country: THE NETHERLANDS

What began as a visionary moonshot project became reality in 2018 with the world's first 3D-printed stainless steel pedestrian bridge in the heart of Amsterdam – designed by Joris Laarman Lab and built by MX3D's robots. It serves as a metaphorical link between historic Amsterdam and a new age of technological possibilities. The project was initiated in 2015, when MX3D proposed to print a metal bridge using its own technology, employing off-the-shelf welding robots to build up metal structures layer by layer.

Together with their partners, MX3D developed a network of sensors that collected real-time data, fed it into live models, and supported a Digital Twin – enabling the bridge to be planned based on this information. Using generative design and topology optimization, MX3D achieved both material efficiency and formal freedom. The bridge finally spans over 11 meters and is constructed from 8mm-thick stainless steel tubes. Its s-curve geometry follows the misalignment of the canal banks. It was finally installed and opened to the public in Amsterdam in 2021.

Was als visionäres Zukunftsprojekt begann, wurde 2018 mit der weltweit ersten 3D-gedruckten Fußgängerbrücke aus Edelstahl im Herzen Amsterdams Wirklichkeit – entworfen vom Joris Laarman Lab und gedruckt mit den MX3D Robotern. Die Brücke steht für die metaphorische Verbindung zwischen dem historischen Amsterdam und einem neuen Zeitalter technologischer Möglichkeiten.



Bereits 2015 initialisierte MX3D das Projekt, eine Metallbrücke mit ihrer eigenen Technologie zu drucken, bei der handelsübliche Schweißroboter zum schichtweisen Aufbau der Metallstruktur eingesetzt werden. Gemeinsam mit den Kooperationspartnern entwickelte MX3D ein ganzes Netzwerk an Sensoren, die Echtzeitdaten aufnahmen. Diese wurden in einen digitalen Zwilling übersetzt, anhand dessen die genaue Planung und Umsetzung der Brücke realisiert wurde. Mittels generativem Design und Topologie-Optimierung erzielte MX3D sowohl Materialeffizienz als auch gestalterische Freiheit. Die Brücke überspannt 11 Meter und besteht aus 8 mm starken Edelstahlrohren. Ihre s-förmige Geometrie schmiegt sich an die Ufer der Grachten an. 2021 wurde sie in Amsterdam installiert und der Öffentlichkeit zugänglich gemacht.

Material: Stainless Steel, 308
Process: Wire Arc Additive Manufacturing (WAAM)

Left page: Queen Máxima opens bridge construction

Top: Gijs van der Velden in the MX3D construction halls

Middle: WAAM in progress

Right: Digital tools can generate a new design language for architectural objects – pushing the boundaries and connecting them

Backstage Pass

Behind the scenes and beyond – preparations, jury sessions, exhibitions, trade fair booths, award ceremonies, even virtual moments during the COVID years, gala evenings, panel talks and after-show Gimlet parties. Following snapshots capture the spirit, energy, and people who have shaped the 3D Pioneers Challenge.

A special highlight: The iconic 3DPC Trophy (designed by Ross Lovegrove, Hyperganic and Materialise) awarded to the main winners since 2020. And a glimpse of images of how the spirit of innovation traveled the world every year on its global roadshow, bringing the innovations and their stories to audiences worldwide.

Photo credits A-D: See Appendix

Digital

Digital is everywhere – but how can it be meaningfully applied to physical production?

Digital data forms the foundation of many manufacturing processes today: Additive Technologies rely on them, and Extended Reality (XR) opens up new ways to understand, collaborate, and communicate around design. Digital twins and simulation data can influence a product's life cycle even before physical production begins.

This chapter explores how digital technologies like Artificial Intelligence (AI), algorithms, or XR can enhance design and production. Especially noteworthy are the concepts of the "digital thread" and smart use of data throughout all phases, from design to production and use.

Left page: Dual metal aerospike created with PicoGK through algorithmic design

Material

The development of materials is a basic column and promises to be a main driver for innovations in Advanced Technologies.

The use of well-known industrial materials is challenging for the 3D-printing processes but just as much a part of this vertical as the development of new alloys, matrices and processes or the processing of meta-, nano- or biomaterials. The focus is on how specific material choices contribute to improved functionality or performance and where material developments open up new opportunities. Regarding regulations and standards, new material developments either meet current existing or may require the creation of new standards to find their way into industrial use. Especially in this category, a look at sustainability is of great added value. There is great potential to include and push the topic of sustainability, not only for the transparency in material passport for a circular economy.

Left page: 4,500 3D-printed ceramic shingles clad the walls and roof of the cabin

Protomycokion

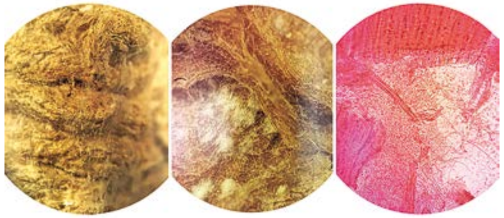
Institution: Lund University
Team: Ana Goidea, David Andréen
Country: SWEDEN

Protomycokion demonstrates the potential of 3D printing with biomaterials in a “new paradigm of manufacturing”: working with nature and biology both as inspiration and as the actual driver of transformation. This Bio-FDM process involves 3D printing with living fungi that bind wood particles after extrusion through their biological growth. In this way, the mycelium grows within the wood composite and fibers it anew while it reaches for nutrients.

Fungi are the archetype of the circular economy: They are the most important decomposers in our world, transforming waste into new organisms. Here, fungi become “agents of transformation,” bringing us closer to a more sustainable material culture. The complex geometries of 3D printing allow oxygen to flow through the structure due to their large surface area, which promotes fungal growth. As a result, more efficient materials can be produced than was previously possible.

Protomycokion demonstriert das Potenzial des 3D-Drucks mit Biomaterialien in einem „new paradigm of manufacturing“: die Arbeit mit der Natur und der Biologie sowohl als Inspiration als auch als eigentlicher Motor der Transformation. Bei diesem Bio-FDM-Verfahren wird mit lebenden Pilzen 3D-gedruckt, die durch ihr biologisches Wachstum nach der Extrusion Holzpartikel binden. Auf diese Weise wächst das Myzel innerhalb des Holzverbunds und fasert ihn neu, während es nach Nährstoffen greift.

Pilze sind der Archetyp der Kreislaufwirtschaft: Sie sind die wichtigsten Zersetzer unserer Welt, die Abfälle in neue Organismen umwandeln. Hier werden Pilze zu „Agents of Transformation“, bringen uns einer nachhaltigeren Materialkultur näher. Die komplexen Geometrien des 3D-Drucks ermöglichen durch die große Oberfläche der Pilze eine Durchströmung der Struktur mit Sauerstoff, was das Pilzwachstum fördert. Dadurch können leistungsfähigere Materialien produziert werden, als es bisher möglich war.



Material: Mycelium inoculum, sawdust, water, clay, cellulose fiber, xanthan gum
Process: Bio-FDM 3D printing, biofabrication

Left page: Ana Goida with the Protomycokion pillar

Top: Fungi as “agents of transformation”

Right top & bottom: Complex geometries promote fungal growth

Industrial

The creative innovations with long-term appeal, as well as operational projects that drive the implementation of Additive Technologies in the established manufacturing industry are part of this vertical. Such as realistic applications in the industry and best practices that are already in progress or aiming to make it happen.

Cutting-edge processes, materials and procedures are creating ground-breaking applications in Additive Manufacturing and thus offering chances for the economy, industry and sustainability, for a responsible production.

Left page: WAAM Reinforced Pressure Vessel with complex metal design

3DTI

Company: What The Future
Founder: Janne Kyttanen and Eduard Zanen
Country: THE NETHERLANDS

What the Future is redefining the manufacturing landscape with 3DTI – a breakthrough technology that combines 3D printing, thermoforming, and injection into a single, seamless process. By replacing traditional CNC-milled tooling with 3D-printed molds, 3DTI enables rapid design iteration, same-day production, and unprecedented agility in manufacturing.

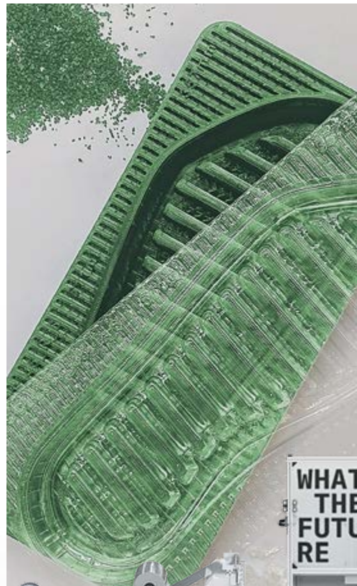
3DTI is transformative for the footwear industry, enabling brands to bring products to market faster and to manufacture closer to the customer, using planet-friendly materials. This innovation supports scalable, sustainable mass production – significantly reducing costs and supply chain risk and complexity.

What The Future Food utilises the same technology to power the production of frozen confections on-demand, in any quantity, shape and flavour. 3DTI enables the production of custom food products with the immense scale of mass manufacturing and the intricate detail of hand production, at a fraction of the complexity and cost.

What the Future definiert die Fertigungsindustrie mit 3DTI neu. Die bahnbrechende Technologie vereint 3D-Druck, thermoplastische Formgebung und Spritzguss in einem einzigen, nahtlosen Prozess. Herkömmliche CNC-gefräste Werkzeuge werden dabei durch 3D-gedruckte Formen ersetzt, wodurch schnelle Design-Iterationen, Produktion am selben Tag und eine beispiellose Flexibilität in der Fertigung ermöglicht werden.

3DTI revolutioniert damit die Schuhindustrie – Marken können ihre Produkte schneller auf den Markt bringen sowie näher am Kunden fertigen und dabei umweltfreundliche Materialien verwenden. Diese Innovation unterstützt eine skalierbare, nachhaltige Massenproduktion, die die Kosten, das Risiko und die Komplexität der Lieferkette erheblich reduziert.

What The Future Food nutzt dieselbe Technologie, um tiefgefrorene Süßspeisen, wie Eiscreme, in jeder beliebigen Menge, Form und Geschmacksrichtung direkt nach Bedarf zu produzieren. 3DTI ermöglicht die Herstellung individuell gestalteter Lebensmittel in großer Stückzahl – mit der feinen Detailgenauigkeit handwerklicher Produktion, aber bei deutlich geringerer Komplexität und zu einem Bruchteil der Kosten.



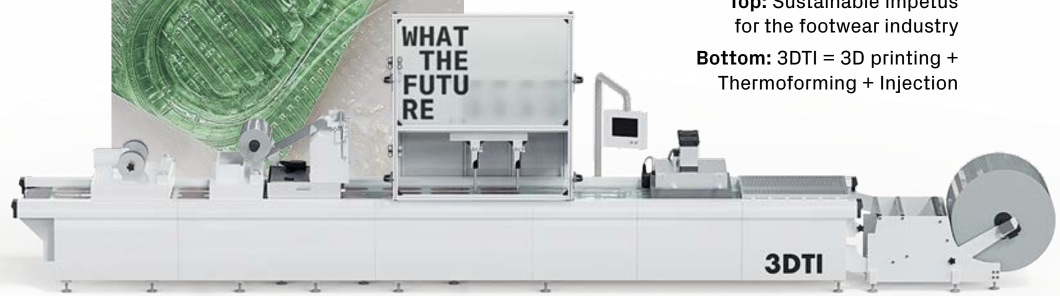
Material: Low-cost ABS molds, recycled PET films
Process: 3D printing, Thermoforming, and Injection (3DTI)

Left page: A vast variety can be produced on demand, also the 3DPC strawberry ice-pops

Left: No need for traditional CNC-milled tooling

Top: Sustainable impetus for the footwear industry

Bottom: 3DTI = 3D printing + Thermoforming + Injection



Sustainability

This overarching category addresses the aspects of enabling "A Better World." and is of basic importance for manufacturing not only with Advanced Technologies. Always with the view to sustainability, which can be perceived as a multilayered megatrend that includes the ecological, economical, and social significance of our actions.

Key topics like climate change, energy demand, and nutrition are faced with a demand for innovations in Clean Tech, Circular Economy, Zero Waste, or Agriculture, amongst others. In terms of responsible manufacturing, topics like rethinking production, product cycles, upcycling, recycling, materiality, marketing concepts, and many more focus subjects do apply. Concepts such as the Material Passport and the Digital Product Pass play a crucial role in enhancing transparency and traceability throughout product lifecycles, supporting circularity and sustainability goals. As an essential point to allow sustainability, the demand for technical innovations is not only necessary but actively being implemented. Advanced Technologies do have the power to enable solutions to these challenges and to drive future-proof responsible manufacturing.

Left page: Design of Coral Reef Seed Units by Emerging Objects

Steakholder Foods

Company: Steakholder Foods®
CO-Founder and CEO: Arik Kaufman
Country: ISRAEL

Steakholder Foods is a pioneering company at the forefront of food innovation, specializing in 3D-printing machinery and premium plant-based premixes. With a mission to revolutionize meat production, the company provides advanced manufacturing solutions that create delicious alternatives to traditional meat, fish, and seafood. Their cutting-edge technology includes the HD144 printer, designed for crafting fish and seafood substitutes, and the MX200 printer, tailored for producing meat alternatives. Complementing these innovations are their high-quality plant-based premixes, which serve as the foundation for a new generation of sustainable, flavorful protein products.

Steakholder Foods began its journey five years ago as a cultured meat company, pioneering advancements in cellular agriculture. In parallel, they developed proprietary 3D-printing technologies capable of producing complex textures and whole-cut formats, setting a new standard for alternative protein innovation. While cultivated meat continues to progress toward scalability and cost-efficiency, they have strategically shifted their focus to plant-based solutions. This transition has enabled to introduce a new generation of premium plant-based products that deliver an elevated sensory experience and align with evolving market demands.

Steakholder Foods ist ein Vorreiter in der Lebensmittelinnovation, spezialisiert auf 3D-Drucktechnologie und hochwertige pflanzliche Rezepturen. Mit dem Ziel, die Fleischproduktion grundlegend zu verändern, entwickelt das Unternehmen fortschrittliche Lösungen für köstliche Alternativen zu Fleisch, Fisch und Meeresfrüchten. Zum Portfolio gehören der HD144-Drucker für Fisch- und Meeresfrüchte-Ersatz sowie der MX200-Drucker für pflanzliche Fleischalternativen. Ergänzt wird dies durch eigens entwickelte Grundmaterial-Rezepturen – die Basis einer neuen Generation nachhaltiger und geschmackvoller Proteinprodukte.

Steakholder Foods begann seine Reise vor fünf Jahren als Unternehmen für kultiviertes Fleisch und erzielte seither Fortschritte in der zellbasierten Landwirtschaft. Parallel entstand eine eigene 3D-Drucktechnologie, die komplexe Texturen und ganze Fleischstücke herstellen kann und damit neue Maßstäbe in der Produktion alternativer Proteine setzt. Da kultiviertes Fleisch wirtschaftlich noch nicht skalierbar ist, richtet sich der Fokus inzwischen auf pflanzenbasierte Lösungen. Diese ermöglichen Premiumprodukte mit intensivem Genusserlebnis, die den Bedürfnissen eines sich wandelnden Marktes entsprechen.

Material: Plant-based premixes: custom paste blends mimicking meat and seafood texture and taste
Process: Drop Location in Space technology (DLS™) and Fused Paste Layering technology (FPL™)

Left page: SH™ – Beef Marbled Steak
Top: SH™ – White Fish Fillet
Middle: How it started: with cultivated meat (MeaTech)
Right: Meat Printer MX200 and Fish Printer HD144

Impulse

by the Pioneer of the Decade

2025 marks a decade of the *3D Pioneers Challenge* – ten years of trailblazing innovation by pioneers shaping the future. In the anniversary edition 2025, the 85-member jury awarded the Pioneer of the Decade title across verticals, focusing on the questions: Where has the journey taken these pioneers over the past ten years? Where were they then – and where are they now? What impact are they making today on the 3D-printing sector or the manufacturing industry? What impulses are they giving to shape the future? And beyond that – who are the people behind the pioneering work? It was an extraordinary lineup of participants – a true "Who's Who" of the scene – and the winner was given the opportunity to actively contribute to this book: *pushing boundaries* , offering insights, and sharing their perspective on how Advanced Technologies are set to change… everything.

On the following pages, now taking the stage, the *Pioneer of the Decade* – The Tal Dvir Lab, Tel Aviv, Israel:

"By enabling the fabrication of intricate, dynamic tissues, 3D bioprinting is reshaping regenerative medicine. Continued innovation and cross-disciplinary efforts are paving the way for effective, personalized treatments."

"Over the past decade, Additive Manufacturing has transformed a wide array of industries – from aerospace and automotive engineering to architecture and consumer products. Yet, in the realm of regenerative medicine, and especially in 3D bioprinting of tissues, the challenges are fundamentally different. Instead of plastics or metals, we work with living cells, bioactive molecules, and complex microenvironments. Rather than producing static objects, we are striving to engineer dynamic, living tissues.

This distinction is profound. In conventional 3D printing, materials tend to behave quite predictably. They do not engage in complex communication with their environment, nor do they multiply or evolve. Bioprinting, on the other hand, operates under biological constraints. Cells are inherently fragile and metabolically dynamic, requiring their surrounding materials to serve more than just a structural role. These environments must support cell adhesion, growth, and migration, while also enabling the diffusion of nutrients, the elimination of waste, and sustained cellular function over extended durations – introducing the critical fourth dimension: time. Creating tissues that fulfill these requirements ranks among the most intricate and ambitious challenges in modern science.

At the Dvir Laboratory for Tissue Engineering and Regenerative Medicine at Tel Aviv University, we treat biological complexity as a guiding force, driving us to develop technologies that are shaped by, and responsive to, the intricacies of living systems.

Outlook

by Simone and Christoph Völcker

In the following, we combine more than 25 years of experience in 3D printing and a decade of the 3D Pioneers Challenge to share a personal outlook for the next ten years. We start with a view on the current state of Additive Technologies and the development of the 3D-printing industry.

Status quo

The book *pushing boundaries* already illustrates, through a small selection of curated projects, the impressive diversity of Additive Technologies and their applications. Since its invention in the 1980s (Chuck Hull, USA), 3D printing has made its way from research labs to the maker community and even private households. In the 2010s, it underwent a decisive leap forward with metal printing and is now firmly established in industry under the name Additive Manufacturing (AM). Thanks to advances in mechanical engineering, material innovation in plastics and metals, and integration into established processes, it is now possible to produce objects "on demand" in specific areas.

AM is aiming high – literally – and plays a role in the race for space exploration: from rocket science to electronics capable of producing spare parts in zero gravity, to robots autonomously printing architectural structures on the moon. On Earth, too, we now see bridges and even entire buildings being printed. Product design has reached previously unimaginable levels of freedom, serving as a prime example of how new technologies can find their transfer into industry. In fashion, 3D printing brings forward democratization and is questioning the fast pace of the industry through sustainable, circular concepts. Combined with electronics, clothing becomes a "second skin" that actively interacts with its environment.

The automotive sector continues to push AM applications: from prototypes to series production parts, all the way to sustainable reductions of their warehousing and transport. Some of the most groundbreaking innovations can be found in medical technology, where achievements such as printing stem cells put human needs at the center.

Im Folgenden bündeln wir unsere Erfahrungen aus über 25 Jahren 3D-Druck und einem Jahrzehnt 3D Pioneers Challenge, um eine persönliche Einschätzung für die kommenden zehn Jahre zu geben. Wir beginnen mit einem Blick auf den Status quo Additiver Technologien und die Entwicklung der 3D-Druck-Industrie.

Status quo

Das vorliegende Buch pushing boundaries *zeigt bereits anhand einer kleinen Auswahl an kuratierten Projekten die beeindruckende Vielfalt additiver Technologien und derer Einsatzgebiete auf. Der 3D-Druck, der seinen Weg seit seiner Erfindung in den 1980er-Jahren (Chuck Hull, USA) von der Forschung über die Makerszene bis in die Privathaushalte geschafft hat, hat in den 2010ern eine entscheidende Weiterentwicklung für den Metalldruck erfahren und ist heutzutage für den industriellen Einsatz als Additive Manufacturing bekannt. Nicht nur die technologischen Errungenschaften im Maschinenbau oder den Materialinnovationen im Kunststoff- wie auch im Metallbereich, sondern auch die Einbindung in etablierte Prozesse ermöglichen es mittlerweile in spezifischen Bereichen, Objekte „on demand" zu produzieren.*

AM möchte hoch hinaus und findet seinen Einsatz im Wettlauf zur Erkundung des Weltraums: von sprichwörtlicher „rocket science" über Elektronik, die in Zero-Gravitation Ersatzteile produzieren kann, bis hin zu autonom hergestellten Architekturobjekten mittels Robotern auf dem Mond. Doch auch auf der Erde entstehen längst Brücken und ganze Gebäude im 3D-Druck. Das Produktdesign erlangt bisher unvorstellbare Freiheitsgrade und dient als Paradebeispiel des Transfers neuer Technologien in die Industrie. In der Modebranche wirkt 3D-Druck als Impulsgeber für Demokratisierung und stellt durch nachhaltige, zirkuläre Konzepte die Schnelllebigkeit von Fashion infrage. Kombiniert mit Elektronik wird Mode zur „zweiten Haut", die aktiv mit ihrer Umwelt interagiert.

Industriezweige wie der Automobilsektor treiben den Einsatz von AM-Applikationen konsequent voran: von Prototypen über Serienteile bis hin zur nachhaltigen Reduzierung von Lagerbeständen und Transportwegen. Die wohl imposantesten Innovationen findet man in der Medizintechnik, mit bahnbrechenden Errungenschaften wie dem Drucken von Stammzellen, die den Menschen in den Mittelpunkt rücken.

Glossary | *Glossar*

The glossary has been compiled with great care. However, no guarantee can be given for its complete accuracy, comprehensiveness, or currency. It focuses on terms used in the book and is intended to help for a better understanding.

Das Glossar wurde mit größter Sorgfalt erstellt. Dennoch kann keine Gewähr für Richtigkeit, Vollständigkeit oder Aktualität übernommen werden. Es beschränkt sich auf wesentliche Begriffe des Buches und soll der besseren Verständlichkeit dienen.

3D Inkjet Printing | ***3D-Tintenstrahldruck***
A printing technology that sprays tiny droplets of material to form an object. *Drucktechnologie, bei der winzige Materialtröpfchen versprüht werden, um ein Objekt zu formen.*

3D molding | ***3D-Formgebung***
A manufacturing process where three-dimensional objects are created by pouring or compressing material into hollow molds. *Fertigungsverfahren, bei dem dreidimensionale Formen durch Gießen oder Pressen von Materialien in spezielle Hohlformen hergestellt werden.*

3D-printed molds/tools |
3D-gedruckte Formen/Werkzeuge
Molds/tools fabricated using 3D printing for use in traditional processes, such as injection molding or casting. *Mit 3D-Druck hergestellte Formen bzw. Werkzeuge zur Verwendung in traditionellen Verfahren, wie Spritzguss oder Gießen.*

3D printing | ***3D-Druck***
A manufacturing process where material is placed layer by layer to create three-dimensional objects. *Ein Fertigungsverfahren, bei dem dreidimensionale Objekte durch das schichtweise Auftragen von Material hergestellt werden.*

4D printing | ***4D-Druck***
Extension of 3D-printing technology where the printed objects reversibly change shape due to environmental influences (e.g. temperature, humidity). *Erweiterung der 3D-Druck-Technologie, bei der die gedruckten Objekte ihre Form durch Umwelteinflüsse (z. B. Temperatur, Luftfeuchtigkeit) reversibel verändern.*

Acrylonitrile Butadiene Styrene (ABS) |
Acrylnitril-Butadien-Styrol
A durable, lightweight plastic material commonly used for housings, toys and 3D printing. *Ein leichter, robuster Kunststoff, der häufig für Gehäuse, Spielzeug oder 3D-Druck verwendet wird.*

Additive Manufacturing | ***Additive Fertigung***
Standard-compliant Term for 3D printing, mainly used in industrial context. *Normgerechter Begriff für 3D-Druck, oft im industriellen Umfeld genutzt.*

Aerosol Jet | ***Aerosol Jet***
A high-precision printing process in which a fine mist of material is applied onto a surface without contact – ideal for producing electronics, sensors or fine structures. *Hochpräzises Druckverfahren, bei dem ein feiner Materialnebel kontaktlos auf eine Oberfläche aufgetragen wird – ideal für die Herstellung von Elektronik, Sensoren oder feinen Strukturen.*

Algorithms | ***Algorithmen***
Clearly defined step-by-step instructions or rules that solve problems or automate tasks, often used in computer programs and digital processes. *Eindeutig beschriebene Folge von Anweisungen oder Regeln, die Probleme lösen oder Aufgaben automatisieren, oft in Computerprogrammen genutzt.*

Artificial intelligence (AI) | ***Künstliche Intelligenz (KI)***
Computer systems that perform tasks classically requiring human intelligence, such as pattern recognition and decision-making. *Rechnergestützte Systeme, welche Aufgaben übernehmen, die klassischerweise menschliche Intelligenz erfordern, z. B. Mustererkennung.*

Atomic Layer Deposition (ALD) |
Atomlagenabscheidung
Conventional process to create thin, uniform layers of material through the moistening of surfaces with various gases and their chemical reaction with each other, often used in electronics manufacturing. *Konventionelles Verfahren zur Herstellung dünner, gleichmäßiger Schichten eines Materials, durch die Benetzung von Oberflächen mit verschiedenen Gasen und deren Reaktion miteinander, häufig in der Elektronikfertigung eingesetzt.*

Bioinks | ***Bio-Tinten***
Special inks for 3D bioprinting that contain living cells. *Spezielle Tinten für den 3D-Bioprinting-Prozess, die lebende Zellen enthalten.*

Biopolymer | ***Biopolymer***
Biodegradable polymers made from renewable resources, often used as sustainable printing materials. *Biologisch abbaubare Polymere aus nachwachsenden Rohstoffen, häufig als nachhaltige Druckmaterialien genutzt.*

Bioresorbable prosthesis | ***Bioresorbierbare Prothese***
Implant that fully degrades in the body after some time, ideal for temporary applications like bone reconstruction. *Implantat, das der Körper nach einiger Zeit vollständig abbaut, ideal für temporäre Anwendungen wie Knochenrekonstruktion.*

Bound filament | ***Gebundenes Filament***
Solid filament containing not only plastic but also metal or ceramic powder in a binder. *Festes Filament, das nicht nur Kunststoff, sondern auch Metall- oder Keramikpulver in einem Bindemittel enthält.*

BPA-free | ***BPA-frei***
Materials which are free from Bisphenol-A, a harmful chemical. *Materialien ohne den schädlichen Stoff Bisphenol-A.*

Brain-Computer Interface (BCI) |
Gehirn-Computer- Schnittstelle
Interface that allows direct control of external devices via brain signals. *Technologie zur direkten Steuerung von externen Geräten durch Gehirnströme.*

Carbon dioxide equivalents CO_2e |
Kohlendioxid-Äquivalente
Standard unit to express the climate impact of greenhouse gases relative to CO_2. *Maßeinheit, die die Klimawirkung von Treibhausgasen im Verhältnis zu CO_2 angibt.*

Cardiac tissue engineering | ***Herzgewebezüchtung***
Lab creation of functional heart tissue using stem cells and 3D printing to repair or replace damaged heart parts. *Herstellung funktionalen Herzgewebes im Labor mit Stammzellen und 3D-Druck zur Reparatur geschädigter Herzareale.*

Cellular agriculture | ***Zelluläre Landwirtschaft***
Uses cell cultures instead of keeping animals to produce animal-based products like meat, milk, leather. *Zelluläre Landwirtschaft nutzt Zellkulturen statt herkömmlicher Tierhaltung zur Herstellung tierischer Produkte wie Fleisch, Milch, Leder.*

Cellulosic materials | ***Zellulose-basierte Materialien***
Natural materials made from cellulose, like wood or plant fibers, e.g. Cellulose-polyketone biocomposite | *Naturbasierte Materialien aus Zellulose, z. B. Holz oder Pflanzenfasern, u.a. Cellulose-Polyketon-Verbundstoff.*

Circular economy | ***Kreislaufwirtschaft***
Economic system focused on reuse, recycling, and sustainable resource management. *Wirtschaftssystem, fokussiert auf Wiederverwendung, Recycling und Ressourcenschonung.*

CNC-Milling (Computerized Numerical Control) |
CNC-Fräsen
Computer-controlled milling process using rotating cutting tools for precise object shaping. *Computergesteuertes Fräsen zur präzisen Bearbeitung von Objekten durch rotierende Schneidwerkzeuge.*

Computed Axial Lithography (CAL) |
Axiale Lithographie
Volumetric 3D-printing technique creating objects through targeted illumination in liquid photopolymers. *Volumetrisches Verfahren, das Objekte durch gezielte Belichtung in flüssigen Photopolymeren herstellt.*

Computer vision | ***Maschinelles Sehen***
Technology enabling computers to "see", analyze, and interpret images and videos, similar to human vision. *Technologie, die es Computern ermöglicht, Bilder und Videos, ähnlich dem menschlichen Sehvermögen, zu erkennen und zu analysieren.*

Convergence | ***Konvergenz***
It refers to the merging of different technologies, systems, or ideas – the purposeful unification and integration of diverse developments. *Das Zusammenwachsen verschiedener Technologien, Systeme oder Ideen – also das gezielte Vereinen und Zusammenführen unterschiedlicher Entwicklungen.*

DeepDye | ***DeepDye***
Color treatment for 3D-printed plastics using deeply penetrating dyes. *Farbbehandlung für 3D-gedruckte Kunststoffe mit tief eindringenden Farbstoffen.*

Design Automation | ***Design-Automatisierung***
Automation of design processes, often using algorithms or AI. *Automatisierung von Entwurfsprozessen, häufig mithilfe von Algorithmen oder KI.*

Digital blueprints | ***Digitale Baupläne***
Digital design files used as templates for manufacturing, 3D printing, or technical implementation. *Digitale Konstruktionspläne, die als Vorlage für Fertigung, 3D-Druck oder technische Umsetzung dienen.*

Digital fabrication | ***Digitale Fertigung***
Automated production using computers and machines as well as integrated software and hardware processes for directly converting digital designs into physical objects. *Automatisierte Produktion mithilfe von Computern und Maschinen sowie integrierte Software- und Hardware-Prozesse zur direkten Umwandlung digitaler Designs in physische Objekte.*

Digital Fabrication Environment |
Digitale Fertigungsumgebung
Integrated software and hardware processes for directly converting digital designs into physical objects. *Integrierte Software- und Hardware-Prozesse zur direkten Umsetzung dig. Designs in physische Objekte.*

Digital Light Processing (DLP) |
Digitale Lichtprojektion
3D-printing process projecting digital pictures using UV light to cure layers of photosensitive materials. *3D-Druckverfahren, digitale Bilder unter Verwendung von UV-Licht projiziert, um lichtempfindliche Materialien schichtweise auszuhärten.*

Digital realm | ***Digitaler Raum***
All virtual spaces where digital information is being exchanged or processed. *Gesamtheit aller virtuellen Umgebungen oder Netzwerke, in denen digitale Informationen verarbeitet werden.*

Digital Rights Management (DRM) |
Digitale Rechteverwaltung
Technology that enables secure licensing and transfer of digital design data for decentralized manufacturing. *Technologie, die sicheres Lizenzieren und Übertragen digitaler Konstruktionsdaten für dezentrale Fertigung ermöglicht.*

Digital Transformation | ***Digitale Transformation***
Transformation of business processes and value creation through digital technologies. *Umwandlung von Geschäftsprozessen und Wertschöpfung durch digitale Technologien.*

A decade of innovation: From the first heart printed from stem cells to the first additively manufactured metal bridge, all the way to the jet suit that makes the dream of personal flight a reality. For ten years, the international competition of the **3D Pioneers Challenge** has accompanied some of the most exciting milestones in Additive Manufacturing and **Advanced Technologies**. This book shows how these technologies are transforming industries: Architecture and Design, Fashion and Mobility, as well as Medical Technology, Digitalization, and Sustainability. International experts share insights from their perspectives, while the initiators Simone and Christoph Völcker bring together these developments and provide a forward-looking outlook toward the year 2035 and beyond. It paints a picture of what the manufacturing world of tomorrow will look like – and who will shape it. The book provides impulses for research, business, and politics – with a clear focus on sustainability, value creation, and societal transformation.

A book for everyone who wants to understand how innovation emerges, how it transforms cultures and markets – and how to become part of this movement. In the true spirit of **pushing boundaries**.

*Eine Dekade voller Innovationen: vom ersten gedruckten Herz aus Stammzellen über die erste additiv hergestellte Metallbrücke bis hin zum Jet Suit, der den Traum vom persönlichen Fliegen Wirklichkeit werden lässt. Der internationale Wettbewerb **3D Pioneers Challenge** begleitet seit zehn Jahren die spannendsten Meilensteine von Additiver Fertigung und **Advanced Technologies**. Das Buch zeigt, wie diese Technologien Branchen verändern: Architektur und Design, Fashion und Mobilität ebenso wie Medizintechnik, Digitalisierung oder Nachhaltigkeit. Internationale Expert:innen beleuchten die Chancen aus ihrer Perspektive, während die Initiatoren Simone und Christoph Völcker die Entwicklungen bündeln und einen Ausblick auf das Jahr 2035 und darüber hinaus geben. Es entsteht ein Bild davon, wie die produzierende Welt von morgen aussieht – und wer sie gestaltet. Das Buch setzt Impulse in Forschung, Wirtschaft und Politik – mit einem klaren Blick auf Nachhaltigkeit, Wertschöpfung und gesellschaftliche Transformation.*

*Ein Buch für alle, die verstehen wollen, wie Innovation entsteht, wie sie Kulturen und Märkte verändert – und wie man selbst Teil dieser Bewegung werden kann. Ganz im Sinne von **pushing boundaries**.*

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