INNOVATIE NU

April 2025
14

TECHNOLOGY WITH A HUMAN TOUCH

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FOR ADVANCED MANUFACTURING

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Dear reader,

Technology has always shaped the way we live, work, and connect. But beyond its capabilities to enhance efficiency and productivity, its true power lies in its ability to improve lives, bridge inequalities, and respond to pressing humanitarian challenges. In this edition of InnovatieNU, ***Technology with a Human Touch***, we explore the ways in which engineering and innovation are making a tangible impact on society.

From disaster relief to medical rehabilitation, technology is increasingly developed with resilience, accessibility, and inclusivity at its core. Engineers, researchers, and communities worldwide are collaborating to create solutions that address urgent humanitarian needs. Whether through medical devices, advanced manufacturing, or sustainable infrastructure, these innovations are transforming emergency response, healthcare, and resource accessibility.

At the same time, our approach to technology is evolving. Open-source collaboration, ethical considerations, and human-centred design have become integral to developing and implementing new solutions. As these principles guide future innovations, they promise a future where technology is not just about progress, but about people.

Recognising this shift, the University of Twente is actively preparing the next generation of engineers to tackle these challenges head-on. In line with this vision, the University of Twente is launching a new Master's in Humanitarian Engineering in late 2025. This programme will equip future engineers with the skills to design and implement sustainable solutions for global challenges.

It is clear that technology has the potential to shape a more just and resilient world. This serves as encouragement for us all to consider how innovation can be harnessed to make a meaningful difference in shaping a more equitable and resilient world.

IAN GIBSON

Director
Fraunhofer Innovation Platform for Advanced Manufacturing at the University of Twente

ESTEFANÍA MORÁS JIMÉNEZ

Research Engineer
Fraunhofer Innovation Platform for Advanced Manufacturing at the University of Twente

UNIVERSITY OF TWENTE. | FRAUNHOFER INNOVATION PLATFORM FOR ADVANCED MANUFACTURING

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InnovatieNU Team

Editor-in-chief
Ian Gibson

Managing Editor
Estefanía Morás Jiménez

Design
Ale Sarmiento Casas
Estefanía Morás Jiménez

Distribution
Annemiek Rouchou-Bloemenkamp

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University of Twente

Contact details
Fraunhofer Innovation Platform for
Advanced Manufacturing at the University of Twente
Hengelosestraat 701
7521 PA Enschede
The Netherlands

T: +31 (0)53 489 1818
E: **media-fip@utwente.nl**

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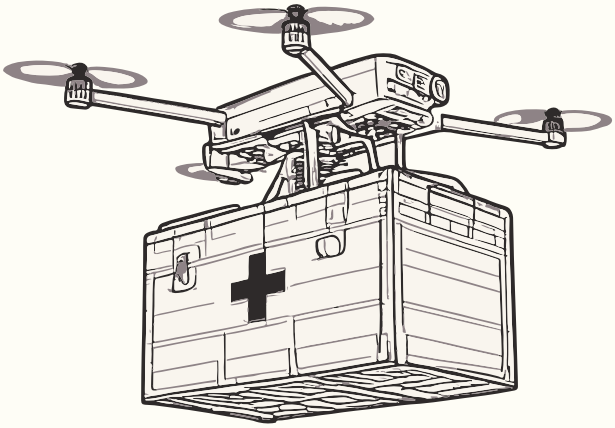
TRANSFORMING HUMANITARIAN EFFORTS *IN CONFLICT ZONES WITH* ADVANCED MANUFACTURING TECHNOLOGIES

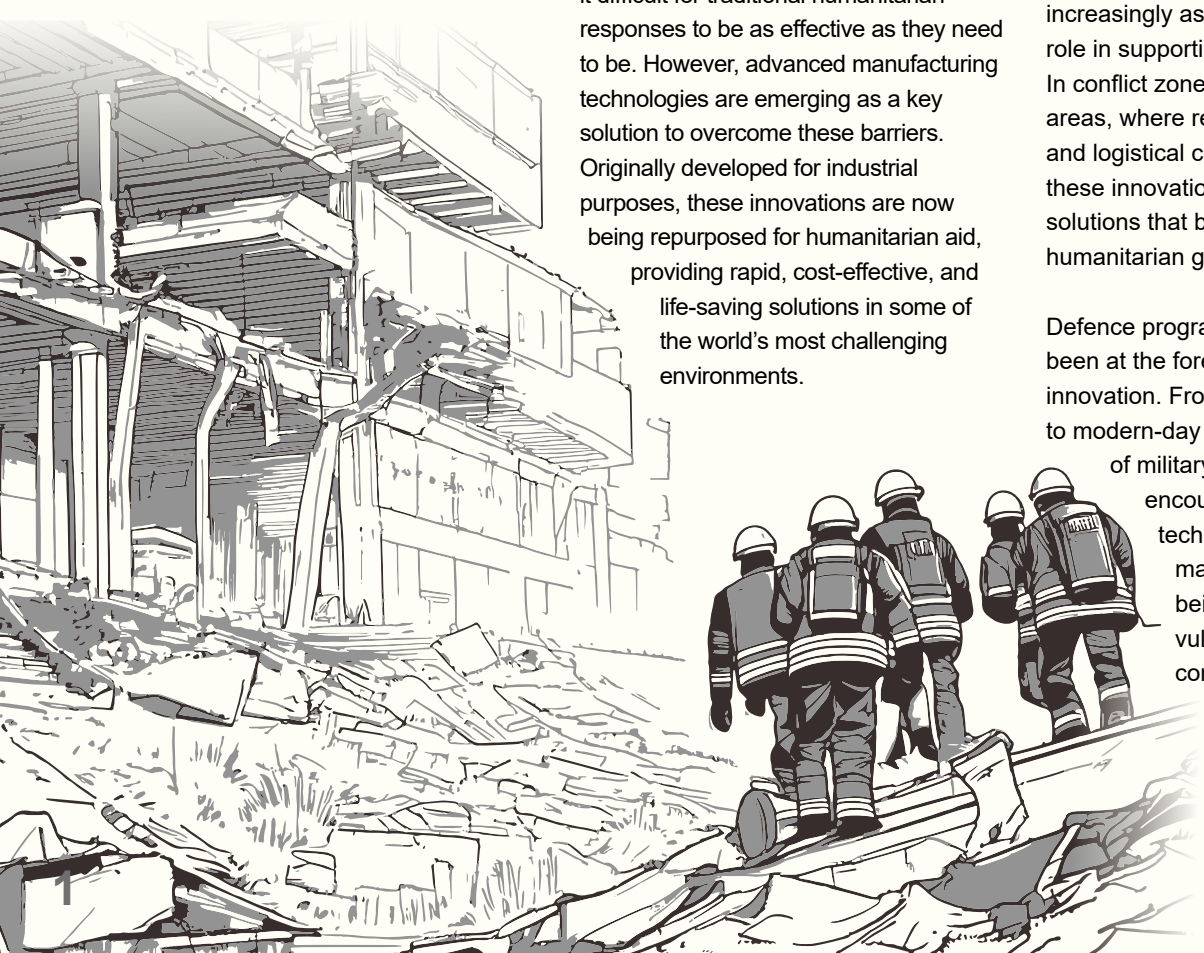


Humanitarian aid efforts in conflict zones or disaster areas are often faced with numerous challenges: limited resources, damaged infrastructure, and disrupted supply chains. The scale of these issues makes it difficult for traditional humanitarian responses to be as effective as they need to be. However, advanced manufacturing technologies are emerging as a key solution to overcome these barriers. Originally developed for industrial purposes, these innovations are now being repurposed for humanitarian aid, providing rapid, cost-effective, and life-saving solutions in some of the world's most challenging environments.

Bridging Defence and Humanitarian Goals

Advanced manufacturing technologies, once perceived as tools primarily for industrial applications, have increasingly assumed a dual-purpose role in supporting humanitarian efforts. In conflict zones and disaster-stricken areas, where resources are scarce and logistical challenges are immense, these innovations provide lifesaving solutions that bridge defence and humanitarian goals.

Defence programmes have long been at the forefront of technological innovation. From early radar systems to modern-day drones, the pursuit of military advancement has encouraged significant technological breakthroughs many of which are now being adapted to support vulnerable populations in conflict and disaster zones.



For instance, innovations in portable energy solutions and autonomous vehicles, initially designed to enhance operational efficiency for military forces, are now also being used for humanitarian purposes.

An example is the use of unmanned aerial vehicles (UAVs) or drones. While traditionally associated with reconnaissance and surveillance missions, drones are increasingly used for delivering medical supplies to inaccessible regions, monitoring displaced populations, and even assessing damage in post-conflict settings. The dual-purpose nature of these technologies underscores how investments in defence can be leveraged to address pressing humanitarian challenges.

Transforming Emergency and Disaster Response

When disaster strikes, whether natural or man-made, the speed and effectiveness of the response can mean the difference between life and death. Advanced manufacturing technologies, particularly those focusing on rapid production and deployment, are set to revolutionize emergency responses in conflict areas.

3D printing, for example, has emerged as a critical tool in creating customised and on-demand medical supplies. In scenarios where traditional supply chains are disrupted, 3D printers can produce prosthetics, surgical tools, and protective equipment locally, bypassing logistical bottlenecks. One example of 3D printing technology being used to produce prosthetic limbs for individuals injured by the violence occurred during the Syrian conflict. This not only provided medical support but also restored a sense of dignity and mobility to the victims [1,2].

Robotics also plays a significant role in disaster relief efforts. A key example of this technology in action was during the Fukushima Daiichi nuclear disaster in 2011. Following the catastrophic earthquake and tsunami that led to the meltdown of the nuclear plant, robots were deployed to access highly radioactive areas that were too dangerous for human workers. The “PackBot”, a ground-based robot, and aerial drones were used to inspect reactor buildings and assess radiation levels, enabling response teams to gather critical information without putting human lives at risk. These robots helped monitor situations in real-time, allowing for more informed decision-making and facilitating the subsequent recovery efforts. The use of robots in this disaster highlights their ability to operate in extreme conditions and their role in ensuring safety during complex emergency responses [3,4].

Moreover, mobile infrastructure solutions such as inflatable field hospitals, portable water purification units, and modular shelters offer scalable responses to emergencies. These solutions, enabled by advanced manufacturing processes, ensure that support can reach affected populations promptly and efficiently. The ability to adapt these technologies for humanitarian purposes demonstrates their transformative potential in addressing the unique challenges of conflict zones.

Supporting Vulnerable and Isolated Regions

One of the most profound impacts of advanced manufacturing technologies lies in their ability to support vulnerable and isolated regions, particularly those that are underserved or cut off due to conflict. Portable manufacturing units, for instance, enable local production of essential goods such as food, medicine, and construction items. These compact units, often designed to operate in extreme environments, provide a lifeline for communities in urgent need.

Energy-efficient systems are another area where advanced manufacturing excels. Solar-powered generators, developed with cutting-edge materials and processes, offer sustainable energy solutions for communities without access to traditional power grids.

Drones, once a staple of defence strategies, have become indispensable in providing technical support to isolated regions. From delivering vaccines to monitoring agricultural conditions, drones are proving to be a game-changer. For example, UNICEF used drones to deliver medical supplies in emergencies, such as in Malawi. The use of drones ensures that life-saving supplies can reach their destination quickly, even in places where traditional road transport is not feasible. The successful deployment of drones for emergency deliveries demonstrates how these technologies can dramatically improve medical accessibility in conflict zones and underserved regions[5].

The role of defence programmes in funding and deploying these solutions cannot be emphasised enough. Many of these technologies originate from defence research and development budgets, and their transition to humanitarian applications is often facilitated through partnerships with private industries and non-governmental organisations. This symbiotic relationship ensures that innovations designed for defence can also uplift communities in need, transforming lives in the process.

Driving Collaboration for Global Impact

To maximise the impact of advanced manufacturing technologies on humanitarian efforts, collaboration is key. Partnerships between defence programmes, industries, and humanitarian organisations are essential for developing, scaling, and deploying dual-purpose technologies. Shared investments in research and development can amplify the reach of these innovations. For example, public-private partnerships have been instrumental in advancing vaccine distribution technologies, such as ultra-cold storage units and automated dispensing systems. These systems, developed with contributions from defence budgets, played an important role in the global rollout of COVID-19 vaccines, including in conflict-affected areas.

The success of such collaborations highlights the need for policies and initiatives that prioritise equitable access to these advancements. Defence programmes, usually equipped with significant resources, can lead the charge by ensuring that humanitarian applications are considered during the development phase of new technologies. Governments and international bodies must also work together to establish frameworks that facilitate the sharing of these innovations across borders.

> **One of the most profound impacts of advanced manufacturing technologies lies in their ability to support vulnerable and isolated regions, particularly those that are underserved or cut off due to conflict.**

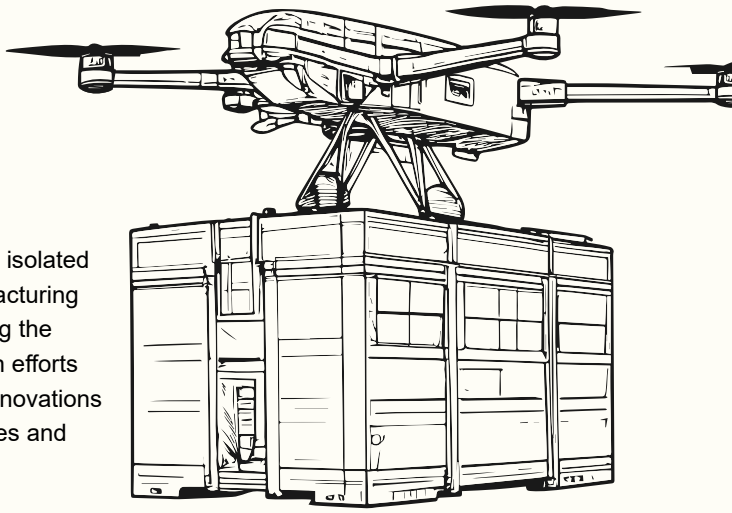
A promising initiative is the establishment of dual-use technology hubs, where defence and humanitarian stakeholders collaborate on projects that address both security and social needs. These hubs can serve as incubators for ideas that align with global priorities, developing innovation that can benefit all humanity. A growing initiative for dual-use technologies can be found in the form of collaborative spaces where both military and humanitarian sectors co-develop and refine technologies.

One example of such a programme is the Defence and Security Accelerator (DASA) in the UK, which funds and supports dual-use technologies that benefit both military and civilian sectors, including humanitarian needs. DASA has been involved in developing solutions such as the "Whole-Body Training Model," originally designed to improve military trauma team training, now being adapted for civilian use to enhance disaster medical response. Another DASA-backed initiative focuses on innovations to reduce ambulance cleaning times, which improves the speed and efficiency of emergency services, benefiting both military and civilian sectors. These projects demonstrate how DASA's collaborative approach fosters technologies that address both security and humanitarian needs [6,7].

Innovating for Humanity

From bridging defence and humanitarian goals to transforming emergency responses and supporting isolated regions, advanced manufacturing technologies are reshaping the landscape of humanitarian efforts in conflict zones. These innovations hold the power to save lives and rebuild communities.

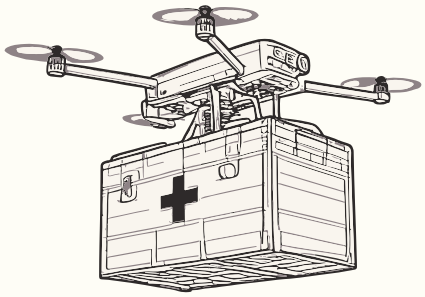
However, realising their full potential requires concerted efforts from all stakeholders. By developing collaboration between defence programmes, industries, and humanitarian organisations, and by pushing through policies that prioritise equitable access, we can ensure that these technologies are used for the greater good. ■



Author:

Ian Gibson
Director of Fraunhofer Innovation Platform for Advanced Manufacturing

Professor of Design Engineering
Dept. of Design, Production & Management, University of Twente



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LESSONS FROM IMPLEMENTING

HUMANITARIAN ENGINEERING

Good failures in humanitarian engineering offer valuable lessons for marketers and business leaders, especially in the advanced manufacturing sector. These lessons highlight the importance of cultural understanding, adaptability, and viewing failures as opportunities for innovation and growth. Humanitarian engineering is the application of engineering to improving the well-being of marginalised and disadvantaged communities. In the context of advanced manufacturing, this involves designing processes or products that meet basic human needs—such as access to clean water, infrastructure, or healthcare—while prioritising sustainability and cultural relevance. By understanding these challenges, leaders can cultivate sensitivity, flexibility, and a forward-thinking mindset that transforms failures into stepping stones for innovation.

Adapting to Local Markets

One common cause of good failures in humanitarian engineering projects is the lack of consideration for the unique characteristics of the communities and context they aim to serve. Similarly, businesses can fail when they apply a one-size-fits-all approach across different markets. Understanding local, cultural, environmental, and economic factors is essential for creating successful products and services.

For example, in Europe's advanced manufacturing sector, regulatory frameworks and environmental standards vary significantly between countries and industries. Manufacturers in the Netherlands may face stricter sustainability regulations compared to other regions, requiring customised solutions to address these challenges. Failure to adapt can impede product success. To mitigate such risks, businesses can utilise ethnographic research, partner with local experts, and engage with communities to gather direct feedback.

Tailoring marketing efforts is equally important. Adapting messaging to reflect local language, values, and customs strengthens a brand's connection to its target market. Just as humanitarian engineering projects involving local leaders are more likely to succeed, businesses that collaborate closely with local stakeholders can build greater trust and loyalty.

Turning Failures into Opportunities for Innovation

Failure should not be viewed as the end, but as a chance to learn and improve. A “good fail” mindset allows organisations to analyse their mistakes and develop innovative solutions that better meet the needs of their customers.

In advanced manufacturing, iterative design provides an ideal framework for harnessing good failures. For instance, if a water filtration system underperforms, teams can refine the technology to better align with user needs. This iterative approach mirrors how businesses can use customer feedback to improve underwhelming products. Humanitarian organisations leveraging 3D printing technology, such as the creation of low-cost prosthetics or water quality sensors, demonstrate how advanced manufacturing can address immediate needs through rapid innovation.

Marketers, too, can adopt this perspective by using data analytics to assess campaign outcomes, identify shortcomings, and refine strategies. Just as humanitarian engineering views setbacks as learning opportunities, businesses can frame failures as catalysts for future growth.

The Role of Collaboration in Sustainable Success

Successful humanitarian projects often succeed due to good collaboration amongst various stakeholders, which could include local communities, NGOs, and interdisciplinary teams. The advanced manufacturing sector can benefit greatly from this collaborative attitude, especially when addressing complex global challenges.

For instance, businesses in the manufacturing sector could partner with local universities or research centres to develop cutting-edge solutions. By working with trusted organisations, companies gain valuable insights into regional challenges, and can also build relationships that enhance their credibility and market acceptance. Corporate Social Responsibility (CSR) initiatives can benefit from similar partnerships.

Rather than imposing top-down solutions, businesses can collaborate with local organisations to co-create sustainable, mutually beneficial solutions.

When businesses build relationships with respected local organisation, they not only gain credibility but also tap into networks that can drive growth and innovation. In humanitarian efforts, collaboration with community leaders often leads to more effective and sustainable interventions, a principle that businesses can adopt for a competitive advantage.

Key Takeaways for Marketers and Business Leaders

The lessons drawn from humanitarian engineering are directly applicable to business in the advanced manufacturing sector. By embracing good failures as learning opportunities, marketers and business leaders can develop strategies that are culturally sensitive, adaptable and collaborative strategies suited to increasingly interconnected but also diverse European market. ■

RESPONSIBLE INDUSTRY 5.0

LEADERSHIP AND ORGANIZATIONAL CULTURE IN MANUFACTURING

Resilient by design

The rapid expansion of data-driven technologies in manufacturing offers new paradoxes to address pressing economic, environmental, and social challenges. While large enterprises often lead in implementing data-driven decision-making, small and medium-sized enterprises (SMEs) struggle to impact the full potential of data due to limited resources, expertise, and readiness. The transition toward Industry 5.0 introduces a shift by emphasizing not only economic and technological advancements but also social and environmental impact, integrating human-centric approaches into manufacturing.

Implications for responsible Industry 5.0

Industry 5.0 builds upon the foundations of Industry 4.0 but extends its focus beyond automation and efficiency to include human collaboration, sustainability, and social well-being. Scholars emphasize that while Industry 4.0 prioritized smart technologies such as IoT, AI, and data analytics, Industry 5.0 advocates for a balanced integration of human intelligence and machine capabilities. The European Commission has identified Industry 5.0 as a framework to ensure that digital and technological advancements contribute to resilience, sustainability, and inclusivity.

A key aspect of Industry 5.0 is its potential for social impact. By embedding resilience, accessibility, and equity within data-driven manufacturing, organizations can enhance supply chain robustness, support disaster recovery, and create inclusive work environments. However, achieving these objectives requires not only technological readiness but also a cultural transformation within organizations that prioritizes digital leadership and data-driven decision-making.

Critical enablers drive data-driven culture and decision-making and relate to leadership empowerment, organizational capabilities, data literacy, and employee beliefs. First, **leadership** plays a pivotal role in fostering a culture of data-driven readiness. Leaders who champion data utilization, encourage experimentation, and align data-driven strategies with broader organizational goals create an environment where employees feel empowered to leverage data in their decision-making. Second, a data-driven culture is reinforced by an organization's ability to establish **governance mechanisms,** develop infrastructure, and institutionalize best practices for data use. Such organizational capabilities can synergistically enhance digital transformation success, thereby

improving firm performance. Third, employees must possess the **skills and knowledge** to interpret and apply data effectively. Training programs, upskilling initiatives, and a commitment to continuous learning help SMEs bridge the gap between data availability and meaningful application. Fourth, organizational culture is shaped by **employees' attitudes** toward data-driven practices. When employees recognize the value of data in improving workflows, enhancing productivity, and addressing social challenges, they are more likely to adopt data-driven behaviors. Administrative and technical barriers, such as siloed data structures and resistance to change, were found to impact the relationship between data-driven culture and decision-making.

I. Resilience and economic impact

A well-developed data-driven culture enhances an organization's ability to respond to disruptions. By integrating predictive analytics and real-time data processing, SMEs can improve supply chain resilience, anticipate risks, and ensure continuity during crises such as natural disasters or pandemics. Moreover, data-sharing ecosystems can facilitate humanitarian efforts by optimizing logistics for emergency relief operations and ensuring equitable distribution of resources.

II. Equitable and inclusive workplaces

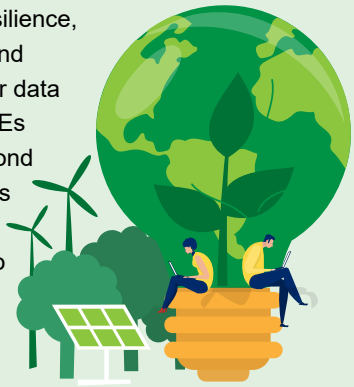
Industry 5.0 emphasizes the human aspect of digital transformation, advocating for workplaces that are accessible, diverse, and inclusive. A strong data-driven culture can help SMEs implement fair hiring practices, monitor workplace equity, and personalize employee development programs. Digital leadership plays a crucial role in fostering an inclusive culture where all employees, regardless of background or skill level, can benefit from data-driven advancements.

III. Sustainable manufacturing practices

Organizational culture that values data-driven insights can support SMEs in adopting sustainable practices. By leveraging data analytics, companies can optimize resource utilization, reduce waste, and align manufacturing processes with circular economy principles. This contributes to the environmental pillar of responsible Industry 5.0, ensuring that digital transformation supports long-term sustainability goals.

The path forward for SMEs

For SMEs to fully realize the benefits of responsible Industry 5.0, fostering a strong data-driven culture is essential. This requires committed digital leadership, targeted investments in data literacy, and a shift in organizational mindsets toward embracing data for decision-making. By embedding resilience, accessibility, and equity into their data strategies, SMEs can move beyond economic gains and contribute meaningfully to humanitarian and societal challenges.



In the future, we should further explore applications of data-driven culture in SMEs, examining how different socio-economic and regulatory contexts influence the adoption of responsible Industry 5.0 practices. Additionally, industry collaborations and policy interventions can support SMEs in overcoming barriers to digital transformation, ensuring that technological advancements translate into tangible benefits for society at large. ■

Author:

Dr. Pauline Weritz
Assistant Professor,
University of Twente

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Pauline Weritz is an assistant professor for responsible digital transformation and leadership within the BMS faculty at UT. She completed her Ph.D. (cum laude) at Ramon Llull University in Spain and has been a visiting researcher at Boston College. With her background in Psychology and Management, Pauline's research focuses on the interface of Organizational Behavior and Information Systems. Her work has been published in journals such as the European Journal of Information Systems, Information Systems Journal, and Business Strategy and the Environment.

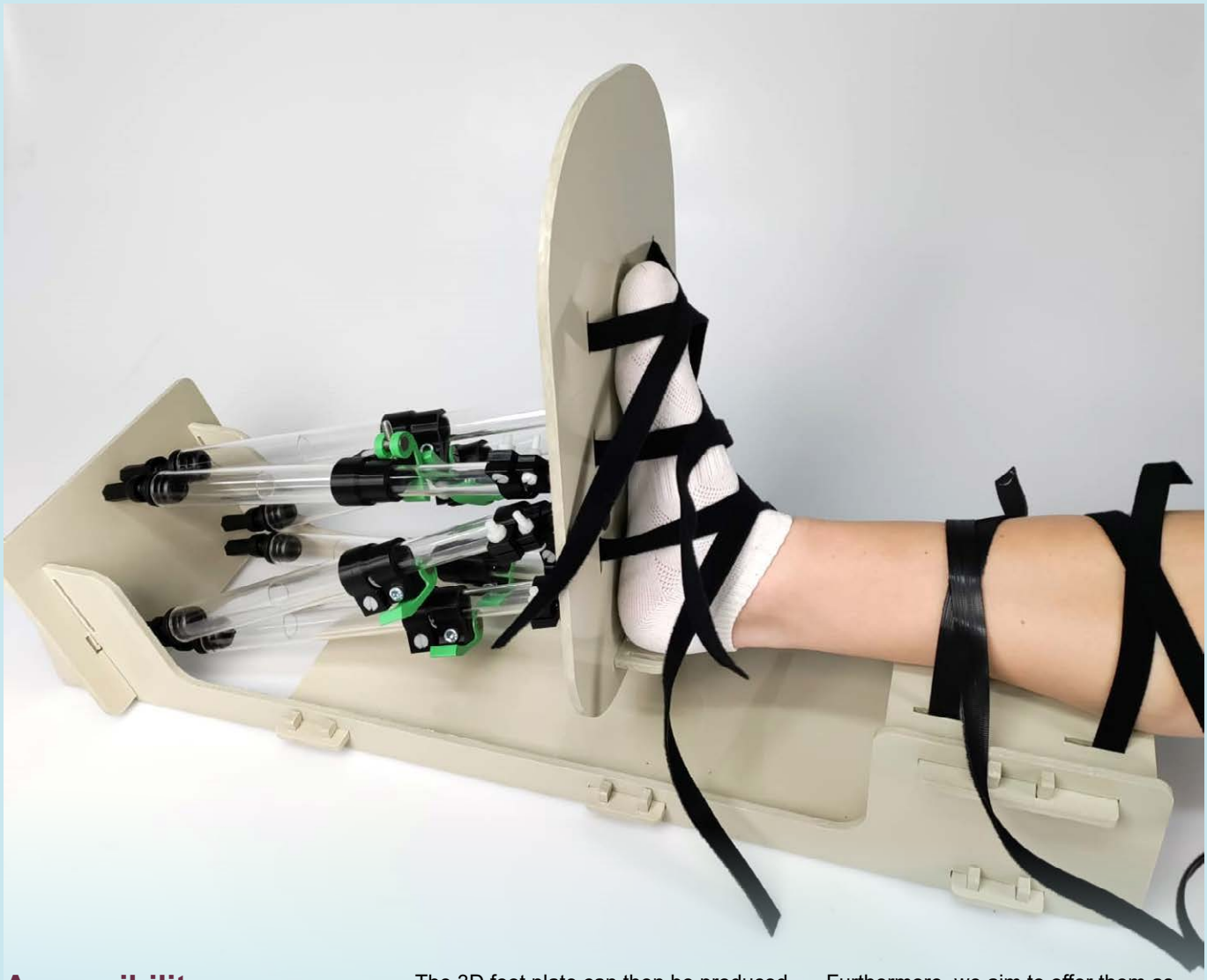
UT'S FIRST MEDICAL DEVICE REGULATION (MDR) COMPLIANT OPEN-SOURCE MEDICAL DEVICE (OSMD)

Medical devices can take a long time to finally enter the market to allow the intended users being medical professionals and/or patients to benefit from their functionality. The process covers a mixture of complying to the Medical Device Regulation to ensure safety and clinical benefit of the medical device and developing a business case including reimbursement and sales strategy. The latter is not a straightforward task as the users are most often not the buyers of the medical device.

Medical Device Innovation

With the stricter Medical Device Regulation, an extra hurdle is put to new medical devices developed for small patient populations or rare medical cases to enter the market. Due to the increased development costs for these cases, it is difficult to generate a sustainable business case as the low sales volumes do not offer return on investment. As a result, such innovative medical devices will not reach the intended users that could benefit from it. Within the chair Biomedical Device Design & Production at the University of Twente, we investigate alternative routes to offer these medical devices as open-source medical device with complementary medical device regulation documentation (including tests to show the compliance). This would allow the intended users to manufacture and assemble these devices at cost price and lower the burden of documentation and hopefully contribute to the introduction of these novel medical devices to assist clinical practice.

An example of a commercially non-viable medical device is a 3D foot plate, which is an assistive device for medical imaging of complex hindfoot pathology, classified as Medical Device Class I. The 3D foot plate allows the patients' foot to be positioned relative to the lower leg with this mimicking clinical stress test while recording CT-images. From the CT-images quantitative data can be derived that are indicative of the pathology, or that assess the quality of a certain surgical procedure. This request for detailed quantitative data has been posed by expert foot and ankle surgeons from the Academic University Medical Centre and Maastricht University Medical Centre. Due to its relevant application for the small patient population with complex hindfoot pathology which are primarily seen in academic medical centers, no business case can be made.



Accessibility

To ensure that clinicians and indirectly patients can benefit from the 3D foot plate, we redesigned the original version using the design for assembly method to an IKEA-style prototype, that can be manufactured using laser cutting, 3D printing, off-the-shelf components and basic hand tools for assembly. This is to ensure low manufacturing costs and minimize risks. Subsequently, we set up the full Medical Device Regulation documentation using templates from the University of Twente including a risk analysis, mitigating strategies, evaluation tests, an IKEA-style manual, and the technical dossier files. The entire package of bill of materials, technical drawings and the Medical Device Regulation documentation of the 3D foot plate will be offered on an open-source platform as an open-source medical device.

The 3D foot plate can then be produced against cost price, and the Medical Device Regulation documentation can be downloaded and adjusted to fit in the quality management system of the academic medical center that aims to use the medical device. In the end, by offering this medical device without business case via an open-source hardware platform, patients with complex problems in the hindfoot can benefit by improved diagnosis and treatment. The 3D foot plate is our first open-source medical device. The chair Biomedical Device Design & Production continues to gather additional cases and further develop a design strategy for these Medical Device Class I devices.

Furthermore, we aim to offer them as open-source to stimulate this alternative route and contribute to improving healthcare. The target users are not only based in the Netherlands, but due to their accessibility, open-source hardware platforms offer the possibility for collaborations in low- and middle-income settings, which contributes to the impact of this initiative. ■

Authors:

Gabriëlle Tuijthof
Chair of Biomedical Device Design & Production, University of Twente

Eliane Masih
University of Twente MSc Graduate

CIRCULAR MANUFACTURING SYSTEMS PROGRAM (CMSP)

Powered by: **RegioDeal Twente**

The Fraunhofer Innovation Platform for Advanced Manufacturing at the University of Twente (FIP-AM@UT), in collaboration with the regional government and industry partners, has launched the Circular Manufacturing Systems Program (CMSP) to advance sustainable, automated, and efficient production processes. The program strengthens the high-tech manufacturing sector in the eastern Netherlands by promoting circularity across various industries, including energy storage and broader industrial applications.

CMSP focuses on optimising manufacturing through automation, material recovery, and modular product design, fostering collaboration between regional and international partners to drive sustainability and waste reduction. By integrating digital tools and innovative production techniques, the programme enhances efficiency, traceability, and resource management.

A key aspect of CMSP is industrial collaboration. Participating companies gain access to cutting-edge research, technological advancements, and cross-sector knowledge exchange.

Through demonstrators, pilot projects, and training initiatives, FIP-AM@UT ensures that innovations developed within the program are widely adopted, strengthening the region's manufacturing competitiveness and sustainability.

Supported by the RegioDeal Twente, with funding from the Province of Overijssel and the Dutch State, CMSP aims to position Twente as a European hub for advanced manufacturing. The programme stimulates economic growth, attracts talent, and encourages investment in sustainable technologies.

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01_ BattInnovate

with STERN Technologies

The BattInnovate project, in partnership with STERN Technologies, aims to advance **battery module technology for electric motorbikes.** It focuses on optimising energy transfer, automating assembly, and developing circular repurposing strategies to extend battery lifecycles. Key objectives include enhancing cell-to-collector connections to reduce resistance and improve performance, alongside developing durable, high-performance battery cells. The project will pilot an automated Flexible Assembly Line to boost efficiency and quality. Additionally, it will explore repurposing strategies, using a Digital Product Passport (DPP) to track battery health and enable second-life applications. From a sustainability perspective, BattInnovate aligns with the seventh sustainable development goal (SDG) of the United Nations **(Affordable and Clean Energy)** by improving energy storage for sustainable mobility. By minimising waste and enabling circularity, it supports climate goals and a low-carbon economy. The DPP system ensures efficient reuse and recycling, reducing dependency on raw materials. The project also drives **industrial innovation (SDG 9)** by enhancing battery manufacturing through scalable, sustainable processes.

02_ ReLAB

with Riwald Recycling

The ReLAB project, a collaboration between the University of Twente (FIP-AM@UT) and Riwald Recycling B.V., focuses on **reconditioning decommissioned lead-acid batteries (LABs) for low-cost energy storage.** By implementing standardised testing protocols, the project will assess battery state of health and refurbishment potential, establishing a scalable reconditioning framework that includes reconditioning techniques, safety guidelines, and cost-effective improvements. ReLAB directly supports global sustainability efforts related to targeting **UN SDG 7 (Affordable and Clean Energy) and SDG 9 (Industry, Innovation, and Infrastructure)** by helping provide cost-efficient energy storage, extending battery lifecycles, and providing alternatives to achieve industrial energy efficiency. By reducing battery waste and promoting circularity, the project minimises environmental impact, and supports a low-carbon economy. Its outcomes will ensure affordable, scalable, and sustainable second-life battery solutions, contributing to a more resource-efficient energy landscape.

03_ ExtraCycles

with Benchmark Electronics

The ExtraCycles project, in cooperation with Benchmark Electronics in Almelo, focuses on **developing tools and methods to advance circularity principles in battery-related production technologies.** This is achieved through lifecycle interventions during production, maintenance, and disassembly. Firstly, by applying eco-design principles during battery assembly to prevent production errors that lead to waste generation. Secondly, development of tool concepts for battery systems testing to extend their remaining useful life with timely maintenance. Lastly, development of battery pack casing concepts to promote refurbishment and remanufacturing in battery packs in order to extend the lifecycle of battery cells. ExtraCycles aligns with sustainability efforts via **UN SDG 12 (Responsible Consumption and Production)** by reducing waste generation through prevention, reduction, recycling and reuse in battery production, use, and disassembly.

04_ MoCoSo

with Beckhoff and IMS

The MoCoSo project, a collaboration between the University of Twente (FIP-AM@UT), Integrated Mechanization Solutions B.V. (IMS) and Beckhoff B.V., focuses on **developing modular machine software for reuse of assembly equipment.** By developing a software structure for reuse, the project aims to extend the lifespan of materials and production equipment to help prevent hardware waste and avoid additional greenhouse gas emissions from producing new components and equipment. By leveraging the modular components embedded in the latest production equipment, such as cameras, robotic arms, and transportation modules, MoCoSo aims to develop an efficient approach for software module reuse. The results from MoCoSo contribute to global efforts on **UN SDG 12 (Responsible Consumption and Production)** through the collaboration with manufacturers to implement sustainable strategies that extend their products' lifecycle, reduce hardware waste, and integrate a circular approach to production equipment.

MANUFACTURING BEYOND EFFICIENCY

PROVIDING SAFE WATER TO COMMUNITIES

Access to safe water remains a critical challenge in many parts of the world, but innovative engineering solutions are making a difference. Efficient manufacturing is helping communities secure this essential resource in a way that is reliable, affordable, and sustainable. One example of this is the work of Susteq, a Dutch company based in Enschede, which develops prepaid water ATMs that improve water access for communities in need.

In many parts of Africa, households do not have direct access to piped water, making communal water collection an essential part of daily life. Susteq's prepaid water ATM system provides a convenient, affordable, and reliable solution to this challenge. The system allows users to prepay for water through a local provider, whether a utility, municipality, or private enterprise.

The payment is then stored on an RFID token, which users simply tap against the dispenser to retrieve a measured amount of safe water. To ensure accessibility, payments can be made through cash, mobile money, or other digital methods, accommodating different financial situations.

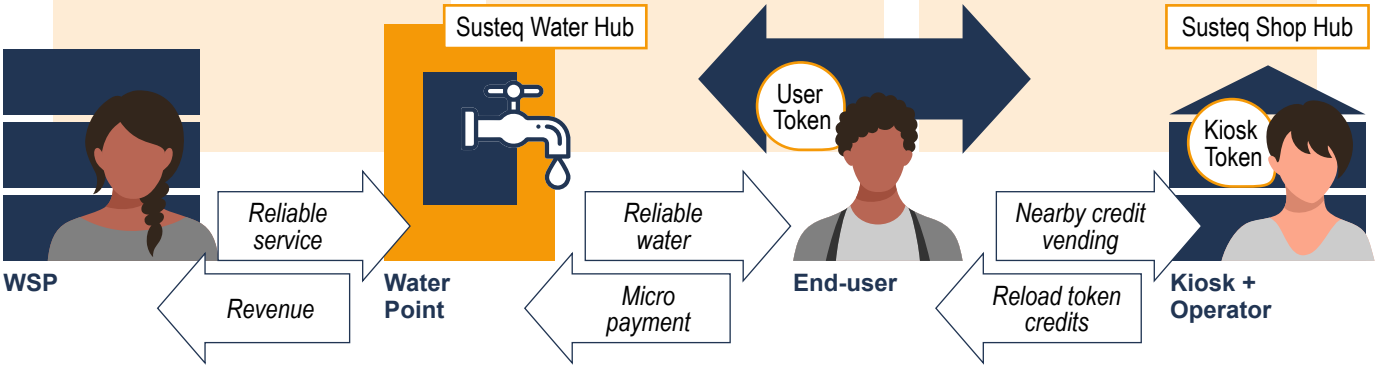
Unlike traditional water kiosks, Susteq's system is operational 24/7, allowing people to access water whenever they need it. Because the system increases water point usage and revenue stability, it helps maintain low, predictable water prices while ensuring long-term financial sustainability for service providers. Furthermore, real-time data monitoring enables authorities to track water usage, detect issues early, and perform proactive maintenance, improving uptime and overall efficiency.

SUSTEQ
safe water for all

Revenue for water service
WSP (water service providers) receives revenue, allowing them to provide reliable water service to the water point.

Micro-payment for water
End-users pay small amounts for access to reliable water via credits on an NFC token.

Pre-paid water credits
A nearby kiosk operator sells pre-paid water credits to end-users. Mobile payment options are also available.



Founded in 2013, Susteq believes that everyone has the right to safe and reliable water. Their solution is a solar-powered prepaid water ATM, installed at communal water points to ensure fair water distribution. The system operates on very little power (on average 2W), functions even without a mobile network, and includes a digital monitoring dashboard for local authorities and service providers.

The hardware is designed to withstand tough conditions and can dispense different amounts of water, from small household needs to large supplies for water trucks. It also features a pro-poor pricing model, allowing low-income users to receive free or discounted water. Susteq's ISO 9001-certified system is developed in the Netherlands and manufactured in Europe, demonstrating how quality engineering can make a lasting impact in underserved regions.

Susteq's system has been installed in 12 African countries, including Kenya, Tanzania, and Rwanda. Every day, more than 250,000 people receive over 1.2 million litres of safe water through 1,500 active units. The impact of this is far-reaching. Reliable access to water reduces health risks, helps children stay in school rather than spending hours collecting water, and strengthens local economies by making water supply more efficient.

By reducing non-revenue water loss, the system ensures that utilities can reinvest in infrastructure improvements. This approach allows communities to expand access and enhance water quality without relying on external aid.

Humanitarian Engineering: A Collaborative Approach

Ensuring long-term success in such projects requires more than just technology—it calls for thoughtful design, local engagement, and a deep understanding of social and economic factors.

The Humanitarian Engineering Research Group, at the University of Twente develops sustainable and inclusive engineering solutions for underserved regions. Their work combines technology with social responsibility, ensuring that engineering projects address both immediate and long-term community needs.

Last year, the Humanitarian Engineering Research group collaborated with Susteq on a student challenge related to SDG 6 (Clean Water and Sanitation), titled:

SUSTAIN YOUR FLOW

Master Students of the course Introduction to Humanitarian Engineering coordinated by Dr. Alberto Martinetti and Nikola Nizamis were tasked with finding affordable solutions to the question:

> *How can utilities supply their communities with safe, affordable, and reliable water?*
>
> *How can a prepaid communal water dispenser, such as the Susteq solution, be best applied to achieve this?*

The results were inspiring, highlighting the potential of students to think creatively when tackling real-world societal challenges. This collaboration demonstrated how partnerships between universities and companies can lead to practical solutions for urgent global issues.

The Humanitarian Engineering Research Group at the University of Twente operates within the Department of Design, Production, and Management (DPM), focusing on three transdisciplinary domains:

Humanitarian Engineering Design

Developing sustainable technological interventions for resource-limited contexts.

Design for Social Justice and Equity

Creating inclusive solutions through stakeholder engagement, responsible technology adoption, and systems thinking.

Educational Design for Vulnerable Communities

Using community-based and challenge-based learning to empower local populations.

By focusing on these areas, the research group ensures that engineering solutions are socially responsible, practical, and adaptable to different communities' needs.

The collaboration between Susteq and the Humanitarian Engineering Research Group highlights how engineering and technology can solve humanitarian challenges. Their work supports **Sustainable Development Goal (SDG) 6: Clean Water and Sanitation,** showing that practical innovations, when designed with social responsibility in mind, can make a lasting difference.

By focusing on these areas, the research group ensures that engineering solutions are socially responsible, practical, and adaptable to different communities' needs.

The Key to Susteq's Success

Susteq's success is built on advanced manufacturing techniques that allow for efficient production, long-term durability, and cost-effective scaling.

The manufacturing process includes:

- Smart material selection to withstand extreme environments
- Automation to ensure consistent quality and efficiency
- IoT-enabled monitoring for predictive maintenance and system optimisation

These techniques help keep costs low, reliability high, and maintenance easy, which is crucial for long-term water accessibility in remote regions.
As technology continues to evolve, incorporating AI, automation, and smart monitoring into water infrastructure will improve efficiency, reduce costs, and expand access. With continued collaboration and innovation, engineering will remain a key tool in addressing global water challenges.

Susteq's engineering-driven solutions are transforming safe water accessibility in underserved regions. By combining advanced manufacturing, smart technology, and social responsibility, the company sets an example of how engineering can change lives. With continued research, collaboration, and innovation, solutions like these will play an important role in solving global water challenges for future generations.

About Susteq

Susteq is a social enterprise dedicated to making safe water accessible and affordable for all. Based in Enschede, the Netherlands, Susteq develops prepaid water ATM systems that allow local water suppliers to deliver water efficiently and sustainably. The company's focus is on smart water distribution, ensuring that even the most remote and economically disadvantaged communities have access to safe drinking water.

With over 1,500 units installed across 12 African countries, Susteq's technology currently supplies more than 250,000 people per day with over 1.2 million litres of safe drinking water. Their innovative prepaid system allows customers to access water through an easy-to-use payment model, preventing water wastage and ensuring fair distribution.

By working with governments, NGOs, and local water authorities, Susteq provides long-term technical support and expertise to help communities build and maintain their own sustainable water networks.
As they continue to expand, Susteq remains committed to ensuring that safe drinking water is not a privilege but a universal right.

3D PRINTING FOR IMPLANTS IN HOSPITALS

3D printing technology is now an integral part of modern medical care, especially in hospitals. Many medical institutions have set up dedicated 3D laboratories to explore its diverse applications. One of its most impactful uses is in surgery, where it enables virtual planning and digital preparation of procedures. A key application is the creation of sawing jigs, which enhance the precision and efficiency of bone cutting—an essential step in preparing joint prostheses and implants. Additionally, 3D printing is increasingly being used to manufacture custom implants for a wide range of medical needs.

Application of 3D Printing Technology in Surgery

The most common application of 3D printing in operating theatres is the production of saw guides. These guides can significantly shorten the duration of complex oncological surgeries—sometimes by as much as 25%. By streamlining bone defect reconstruction, they contribute to better surgical outcomes. Additionally, 3D-printed moulds enable the creation of implants during surgery using bone cement, further supporting bone defect repair.

Use of 3D Printed Implants

Although still relatively uncommon, 3D-printed implants are becoming more widespread. Notable examples include skull implants for reconstruction after trauma or tumor removal, as well as jaw and spinal implants.

In some cases, 3D printing is also used to create plates secured with screws to stabilize fractures. In rare instances, even joint prostheses are produced using this technology.

Materials for 3D Printed Implants

A variety of materials are used for 3D-printed implants, with titanium and PEEK (polyetheretherketone) being the most common. Both are biocompatible, meaning they are well-tolerated by the body, reducing the risk of rejection. Additionally, these materials promote osteointegration, allowing bone tissue to grow into the implant and form a strong bond with the surrounding bone.

Other materials include zirconia, which is primarily used for dental crowns and, occasionally, joint prostheses. Bioresorbable polymers are also used to print temporary medical devices, such as screws and pins that naturally dissolve in the body after the bone heals.

Benefits of 3D Printing for Implants

A significant advantage of 3D printing in implant production is its ability to create highly precise, personalised implants tailored to individual patients. This customisation ensures a better fit, promotes faster healing, and enhances post-surgical functionality. Additionally, 3D printing often shortens the production time for patient-specific implants compared to traditional manufacturing methods. In many cases, it is also more cost-effective to print a custom implant rather than modify an entire production process to create a single patient-specific piece.

Regulations and Challenges in Clinical Practice

For 3D-printed implants to be used in clinical practice, they must comply with strict regulatory and quality standards. As a result, clinical studies are often required before an implant can be approved for patient use. Currently, large-scale production of 3D-printed implants in hospitals in the Netherlands remains unfeasible due to the complexity, high costs, and stringent quality requirements.

While advancements in 3D printing have accelerated implant production, a significant gap remains between the availability of custom-printed implants and the convenience of off-the-shelf alternatives. Moreover, custom-made 3D implants remain more expensive than mass-produced ones, limiting their widespread adoption.

Complexity of Bone Defects and the Role of 3D Printing

In cases involving complex anatomical structures, determining the exact size and shape of a bone defect before surgery can be difficult. This uncertainty makes it challenging to 3D-print an implant in advance, as the precise specifications often become clear only during the operation.

Future Developments: Bioprinting

A promising advancement in 3D printing is bioprinting, a technique that uses living cells to create implants for clinical applications. These cells, often derived from patient stem cells, can be transformed into specialized bone cells that seamlessly integrate with the body.

While bioprinting is still in its early stages, it holds great potential for developing fully biocompatible implants that naturally merge with human tissue.

Currently, ceramic implants are already being 3D-printed to gradually fuse with the body's bone tissue, marking an important step toward future biological implants.

Conclusion

The use of 3D printing technology in bone repair represents a groundbreaking advancement in healthcare. Its precision, customisation, and efficiency provide significant benefits for both patients and medical professionals. While challenges such as cost and regulatory approval remain, ongoing innovations continue to expand the potential applications of 3D printing. In the near future, 3D-printed implants are expected to become a standard component of medical treatment, improving patients' quality of life worldwide.

Author:

Dr. Feddo van der Beek
ENT Surgeon at MST &
Researcher Medical Technologies

"[3D printing] customisation ensures a better fit, promotes faster healing, and enhances post-surgical functionality.

PARTICIPATORY DESIGN OF OPEN-SOURCE TECHNOLOGY FOR COLLABORATIVE URBAN PLANNING

OGITO-noise used during the NAP workshop in Bochum.

Noise pollution is a growing environmental problem in urban and industrial areas, affecting residents' wellbeing, quality of life, and environmental health. Noise exposure can have long-term consequences including hearing loss, increased hyperactivity in children, and even hypertension. The European Union has implemented a directive to address this situation in cities and diminish the harmful effects of noise pollution. A new approach to this problem is being carried out by the Faculty of Geo-Information Science and Earth Observation at the University of Twente through OGITO: Open Geo-Spatial Interactive Tool. Considering noise pollution affects multiple stakeholders, the researchers have embraced a collaborative approach in two ways: by involving the users in the design process of the tool itself and by supporting stakeholders' input for decision-making in urban planning.

OGITO

Addressing urban challenges, such as noise pollution, demands the collaboration of different backgrounds and perspectives to gain a better understanding of the situation around the city. In recent years, maptables are more frequently being used to support collaborative processes in the spatial planning domain. These devices display geospatial content (e.g. specific city maps) in a digestible format for lay persons to interact with the content via the touch screen. Maptables allow to present the highly-technical content as easy-to-use materials that promote communication and understanding among stakeholders and researchers. However, software modifications are usually necessary to improve user usability of existent open-source software solutions.

The aforementioned limitations are addressed in the design of OGITO, Open Geo-spatial Interactive TOol, through co-designed modifications to the digital interface. This tool provides a map-based visualisation of the area under discussion in accordance with an ISO usability framework. Creating an intuitive and usable maptable interface is essential for data collection, if users cannot understand how to use the tool then they are limited to the information they can provide to urban planners and researchers.

Designing OGITO with users

The research group integrated a Human-Centred Design methodology with Agile development software methods. This combination aims to strengthen stakeholder participation

during the design process, an essential step for interactive tools. Users can get involved at different stages of the design process depending on the input necessary at any given stage. The combination of both approaches resulted in six different goals for stakeholder involvement during OGITO's design process:

1. **Understand and define the context of use**
2. **Define user requirements**
3. **Generate design solutions**
4. **Evaluate design solutions**
5. **Evaluate under controlled conditions**
6. **Evaluate during workshop with users**

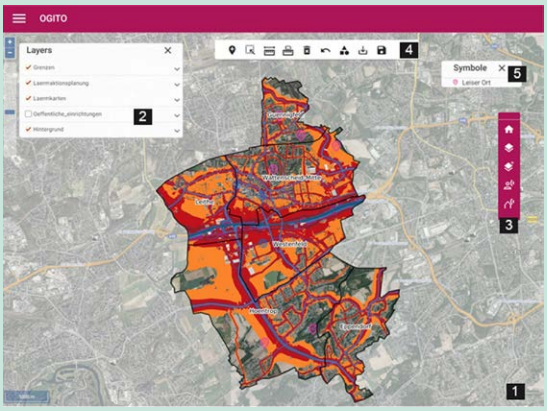
To collect the necessary feedback, researchers organised focus groups, face-to-face meetings, and workshops with different stakeholder groups depending on the goal at hand. The research had Sumatra, Indonesia as a case study to develop the first iteration of OGITO. Participants were local residents in Denai Lama and Kramat Gajah, spatial planning researchers, technical experts in geographic information systems (GIS), and application developers. Stakeholder feedback, filled with unique perspectives and insights, has been essential for the development of the final version of OGITO.

Involving other voices in the process led to the creation of a lightweight application with a simplified interface which provides the necessary functionality to satisfy both users and stakeholders. The usability of the maptable further considers those who have not used a maptable before as these users could use OGITO without assistance during community mapping workshops.

Noise action planning with OGITO users

Stakeholder involvement, during the research phase of a project, can highly benefit the project as the different experts can join the discussion and share their day to day experience with noise exposure and management. Researchers further tested OGITO to support noise action planning (NAP) in Bochum, Germany as a case study of the interactive tool in use for collaborative planning. During the workshop with current stakeholders, OGITO-noise was used to collect participants' perspectives of the acoustic environment in different areas of the city and supported the discussion of potential interventions for noise reduction.

The use of maptables during spatial and urban planning allows participants to interact with spatial information about the city in a different way. Through the embedded tools in OGITO-noise, users can identify noisy areas, noise sources (e.g. roads, factory), mark relevant roads, highlight the difference between day-evening-night noise levels, and visualise the estimated population exposed to noisy roads. The digital nature of this tool allows for future integration of map data sets, CAD files, and 3D-view integration.



OGITO-noise interface.

The results from the research indicate that an HCD+Agile approach is meaningful for developing usable and useful planning support tools such as maptables. Interactive tools such as OGITO have the potential to include a diverse group of experiences by bringing together citizens, environmental professionals, city planners, NGOs, politicians, local transport companies, municipality departments, and researchers into the spatial planning discussion. The research project exploits the benefits of spatial visualisation capabilities and digital technologies to create an interactive tool designed with citizens for citizens. ■

Workshop participants at Kramat Gajah and Denai Lama.

a) Kramat Gajah b) Denai Lama

Author:

Dr. Rosa Aguilar Bolivar
Assistant Professor for Dept. of Geo-information Processing, University of Twente

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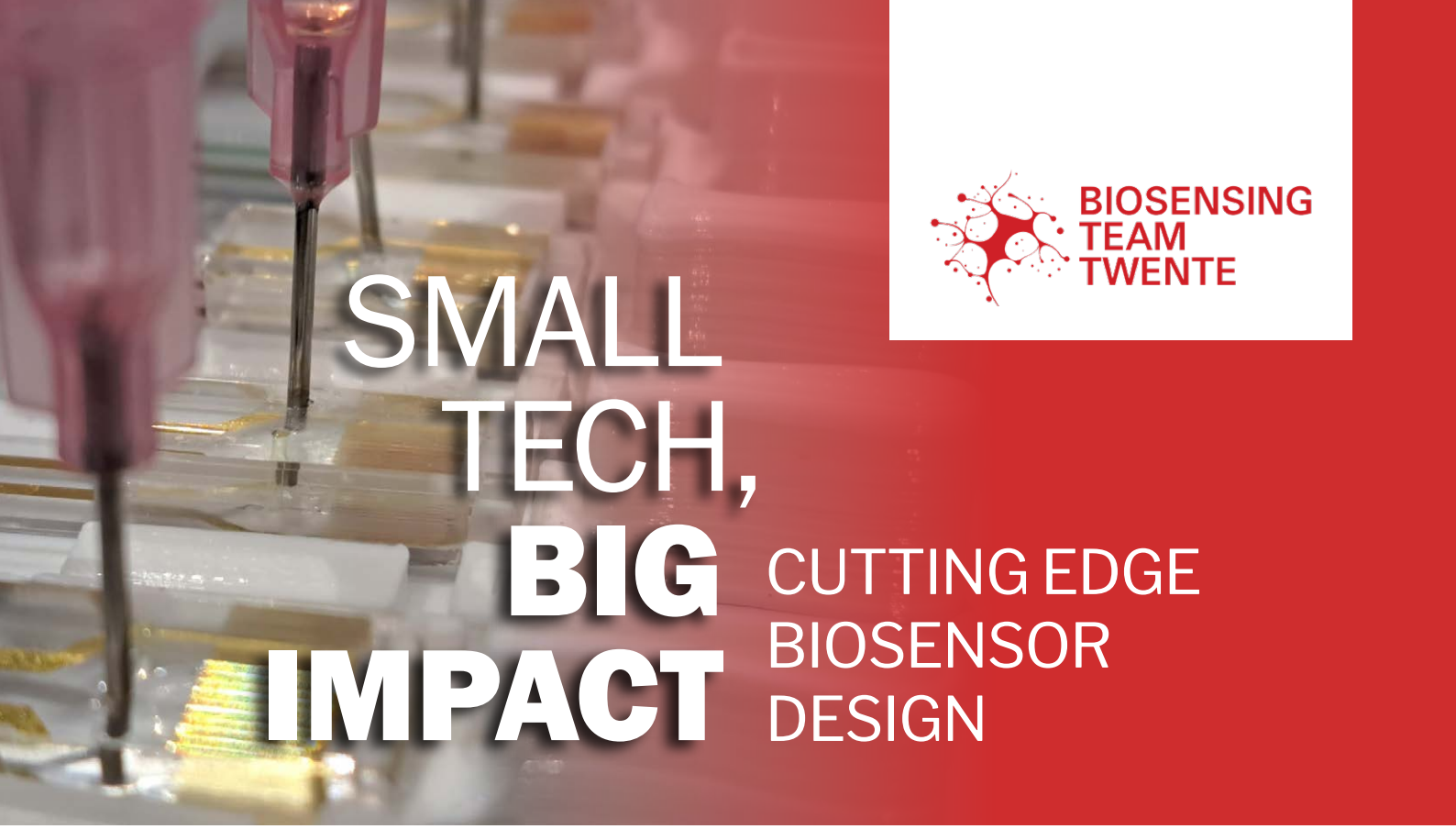


BIOSENSING TEAM TWENTE

SMALL TECH, BIG IMPACT

CUTTING EDGE BIOSENSOR DESIGN

Diana Andreoli
Chair,
Biosensing Team Twente

Caterina Cattabriga
Communication Manager,
Biosensing Team Twente

Jan Pieter de Rie
Technical Manager,
Biosensing Team Twente

In a world where technology and biology increasingly intersect, biosensors are emerging as game-changers in healthcare, diagnostics, and beyond. These sophisticated devices can detect and analyse biological data in real-time, unlocking insights into everything from glucose levels to early diagnosis. At the forefront of biosensor innovation is Biosensing Team, a student team transforming how we monitor and understand the human body. In this interview, the team shares the journey behind developing biosensor technology, its potential to revolutionize healthcare, and the challenges of competing at international student competition SensUs. Discover how they are bridging science and technology to shape a smarter, healthier future.

Can you introduce the Biosensing Team Twente and describe what challenges are you focused on?

Diana: The Biosensing Team Twente is a student team that combines innovation, education, and research to address real-world healthcare challenges. Our mission revolves around three core objectives. First, we aim to raise awareness about healthcare problems that require urgent attention but may not yet have widespread solutions. Second, we strive to develop simple, cost-effective devices to address these challenges. Finally, we provide a platform for students to gain experience in biomedical research, allowing them to develop their skills in a collaborative, startup-like environment.

Caterina: One of the most exciting parts of our work is our participation in the international SensUs competition, which brings teams from across the globe together to solve a clinical problem. This year, our challenge is Acute Kidney Injury, a condition that is both life-threatening and difficult to detect in its early stages. We're tasked with developing a biosensor that can detect specific biomarkers in the blood related to this condition. The process is long and intense, requiring at least eight months of research and development, but it's incredibly rewarding. This competition really pushes us to think critically and come up with innovative solutions to solve pressing healthcare problems.

BIOSENSORS

What are biosensors and who can benefit from improving these medical products?

Jan Pieter: Biosensors are highly specialized devices that combine biological components with technological systems to detect and measure specific substances. The basic structure of a biosensor includes three key components: a biological recognition element, like antibodies or enzymes, which identifies the target analyte; a transducer, which converts this interaction into a measurable signal; and a signal processor, which amplifies and interprets the data. These devices have become indispensable tools in healthcare and beyond because of their ability to provide real-time, accurate, and reliable information.

Diana: The potential applications of biosensors are vast, and so are the benefits. In healthcare, for example, biosensors help patients by enabling early diagnosis of diseases, better management of chronic conditions, and even non-invasive monitoring. Imagine being able to measure blood glucose or hormone levels with a simple wearable device—this is the kind of innovation biosensors make possible. It could change how we approach managing health on a day-to-day basis. Healthcare providers also benefit, as biosensors streamline diagnostics, support precision medicine, allowing doctors and nurses to focus more on patient care.

What materials and techniques are involved in developing a biosensor?

Diana: Developing a biosensor is an intricate process that combines cutting-edge materials with advanced techniques. The biological recognition element is the heart of the biosensor and can include components like enzymes, antibodies, nucleic acids, or even whole cells. These biological elements are chosen for their ability to bind specifically to the target analyte and are immobilized on a support structure. The transducer plays a critical role in converting the biological interaction into a measurable signal. The type of transducer and the materials used depend on the signal type—for example, semiconductors for electrical signals, optical fibers for light-based signals, or piezoelectric materials for mechanical signals. Nanomaterials, such as gold nanoparticles, graphene, or carbon nanotubes, are increasingly being used because they enhance the sensitivity and reduce the size of the device.

Jan Pieter: Beyond materials, techniques like photolithography, 3D printing, and microfluidics allow us to fabricate biosensors with high precision. Microfluidics is especially valuable because it enables the handling of tiny sample volumes, making biosensors more efficient and portable. Surface modification techniques, like plasma treatments, improve biocompatibility and stability, ensuring that the biosensor can function effectively under various conditions. Finally, machine learning and data analytics are used to interpret complex data, further enhancing the device's accuracy and usability.

What are some of the technical challenges of biosensor development the industry and healthcare are facing?

Jan Pieter: One of the most significant challenges is achieving the high sensitivity and specificity needed to detect target analytes accurately. Biological samples like blood or saliva are incredibly complex, with many substances that can interfere with the detection of the target analyte. To make sure we get accurate results, we need to filter out any "noise" from these interfering substances. This requires significant research and fine-tuning. Another major issue is the stability of the biological recognition element. Components like enzymes or antibodies can degrade over time, losing their activity due to environmental factors like temperature, pH changes, or prolonged storage. Ensuring the biosensor remains reliable over its intended lifespan is a persistent challenge. Miniaturization and integration add another layer of complexity. Portable and wearable biosensors are in high demand, but shrinking components like transducers and signal processors without compromising their performance is no easy feat. Manufacturing scalability is another hurdle; what works in the lab doesn't always translate smoothly to mass production.

Diana: Finally, cost remains a significant barrier. Many advanced materials and fabrication techniques are expensive, making the final product less accessible. Integrating biosensors with existing health technologies, like electronic health records or wearables, also requires sophisticated software, secure data transfer, and seamless interoperability—all of which can drive up costs.

> **We're continuing to test and iterate on designs to ensure that our biosensor can deliver accurate, reliable results over extended periods without manual intervention.**

COMPETITION

What are the steps involved in developing a functional biosensor for the SensUs competition?

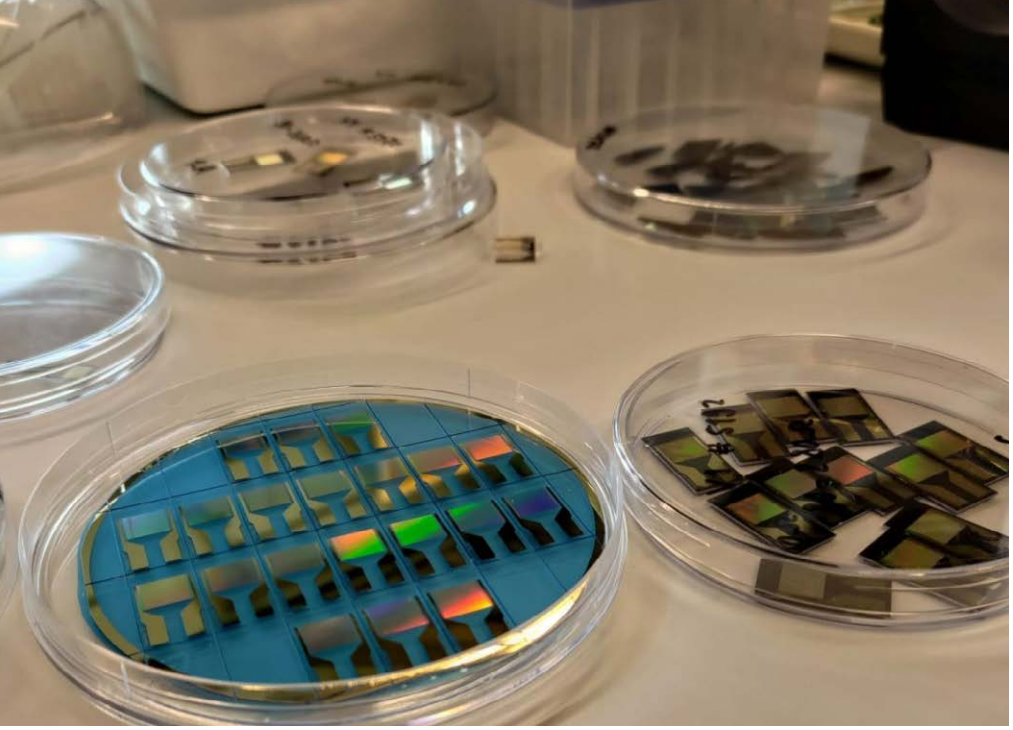
Jan Pieter: Developing a biosensor for the SensUs competition involves a well-defined but challenging series of steps. The process begins with thorough research on the clinical problem and the biomarker associated with it. This stage is crucial because understanding the underlying biology and the specific requirements for detection shapes the entire development process. Next, we evaluate various sensing techniques to determine the most suitable method for detecting the biomarker. Once we've selected the sensing approach, we move on to surface functionalization. This involves preparing the sensor surface to ensure it interacts effectively with the target analyte. Techniques like Quartz Crystal Microbalance with dissipation monitoring (QCM-D) are used to test and optimize this step.

Following this, we create the biosensor chip and design the full experimental setup. Calibration comes next, ensuring that the device can provide accurate and reproducible measurements. The final step is assembling all components into a fully functional biosensor, rigorously testing it, and preparing for the presentation at the competition.

What are the most significant technical challenges you've faced in developing your biosensor, and how have you addressed them?

Diana: One of the biggest technical challenges we've faced is ensuring continuity during measurements. When working with biosensors that rely on chips where multiple samples flow through, maintaining accuracy over time can be tricky. This is especially true when transitioning between samples or measurements. Any residue left behind by a previous sample or an additional cleaning substance can interfere with the next reading, potentially skewing results. This issue becomes even more critical when designing a wearable biosensor, where the goal is continuous or real-time monitoring in a practical, user-friendly form. Introducing a separate cleaning step or substance could complicate the design, increase cost, or make the device less portable and efficient.

Jan Pieter: To address this, we've explored materials and designs that minimize contamination and residue build-up. For instance, we've optimized the surface properties of the chip using advanced coatings that reduce adhesion of biological or chemical residues. These surface modifications help ensure that samples flow through smoothly without leaving behind substances that could interfere with subsequent measurements.



Biosensor research and development by BTT

Additionally, we've focused on refining the fluid dynamics within the chip. By improving the design of the flow channels, we've been able to reduce stagnation points where residues are more likely to accumulate. While these solutions have improved the performance, achieving full continuity during measurements is still a work in progress. We're continuing to test and iterate on designs to ensure that our biosensor can deliver accurate, reliable results over extended periods without manual intervention.

How are biosensors, such as yours, evaluated within a student competition structure?

Caterina: The SensUs competition evaluates biosensors on four separate criteria. First, there's an Innovation Award, which covers how the device looks, functions, and achieves its purpose. This criteria only assess the concept, especially evaluating how cutting-edge it is. The accuracy and functionality of the device are assessed during a Testing Event, where every team is given a number of samples and have to measure the biomarker's concentration in each of them. This award is critical—our biosensor must reliably detect the target analyte under specified conditions. In addition to technical performance, the Translation potential of the device is evaluated. To do this, we're required to present a business case outlining a 10-year plan for bringing the device to market. This includes exploring its feasibility, potential impact, and commercial viability. Lastly, there's a Public Inspiration vote, where we engage with the public to showcase our work and gain support. Social media and public outreach play a big role here!

After the competition, what are the next steps for your biosensor?

Diana: The future of the biosensor depends on the competition's theme and its outcomes. Sometimes, the problem is extended into the next year with added challenges, like making the device wearable. If that doesn't happen, the biosensor typically becomes the intellectual property of the team. In some cases, past ideas have evolved into PhD research projects, but they could even lead to the creation of startups. This flexibility allows us to explore various paths for continuing the work we've started during the competition.

THE TEAM

How many people are part of the team and how do they collaborate to achieve the team's goals?

Diana: Our team is organized into two primary components: the core group and the board, each playing a critical role in achieving our goals. The core group focuses on the technical aspects of the project, particularly the development of the biosensor. This involves extensive research, experimentation, and innovation to design and build a functional, competitive device. The board, on the other hand, ensures the administrative and organizational side of the team runs smoothly. They manage everything from finances and scheduling to communication with external stakeholders, making sure we stay on track and have the resources we need to succeed.

Caterina: Within the core group, we've divided responsibilities into specialized sub-teams, each focusing on a key area of the biosensor's development. For example, the chemistry team works on surface functionalization and biomarker interactions, while the chip and device design team focuses on creating the physical structure and integrating the necessary components. The experiments and analysis team handles testing, calibration, and data collection to ensure our biosensor performs as expected. Beyond the technical side, we also have a business case team, which prepares a comprehensive plan for how the device could be brought to market, addressing both feasibility and long-term impact. Lastly, the social media team helps us connect with the wider community, sharing our progress and generating excitement about our work, which is crucial for competitions where public support can make a difference.

Diana: The board complements these efforts by taking care of the "behind-the-scenes" work that keeps the team operational. Each board member has a defined role. The chair oversees everything and ensures cohesion between the core group and the board. The secretary manages planning, meeting agendas, and documentation, ensuring efficient communication and organization. The treasurer is responsible for budgeting and financial management, making sure we allocate resources wisely. Other key roles on the board include external relations, who build and maintain partnerships with sponsors and other stakeholders, and internal relations, who ensure seamless communication between team members, supervisors, and competition organizers. A Technical Manager is responsible for overseeing the lab work, ordering materials, and basically guide the team whenever they are in need. We also have a communication manager who handles publicity, social media campaigns, and public relations, which are vital for building our team's reputation and visibility.

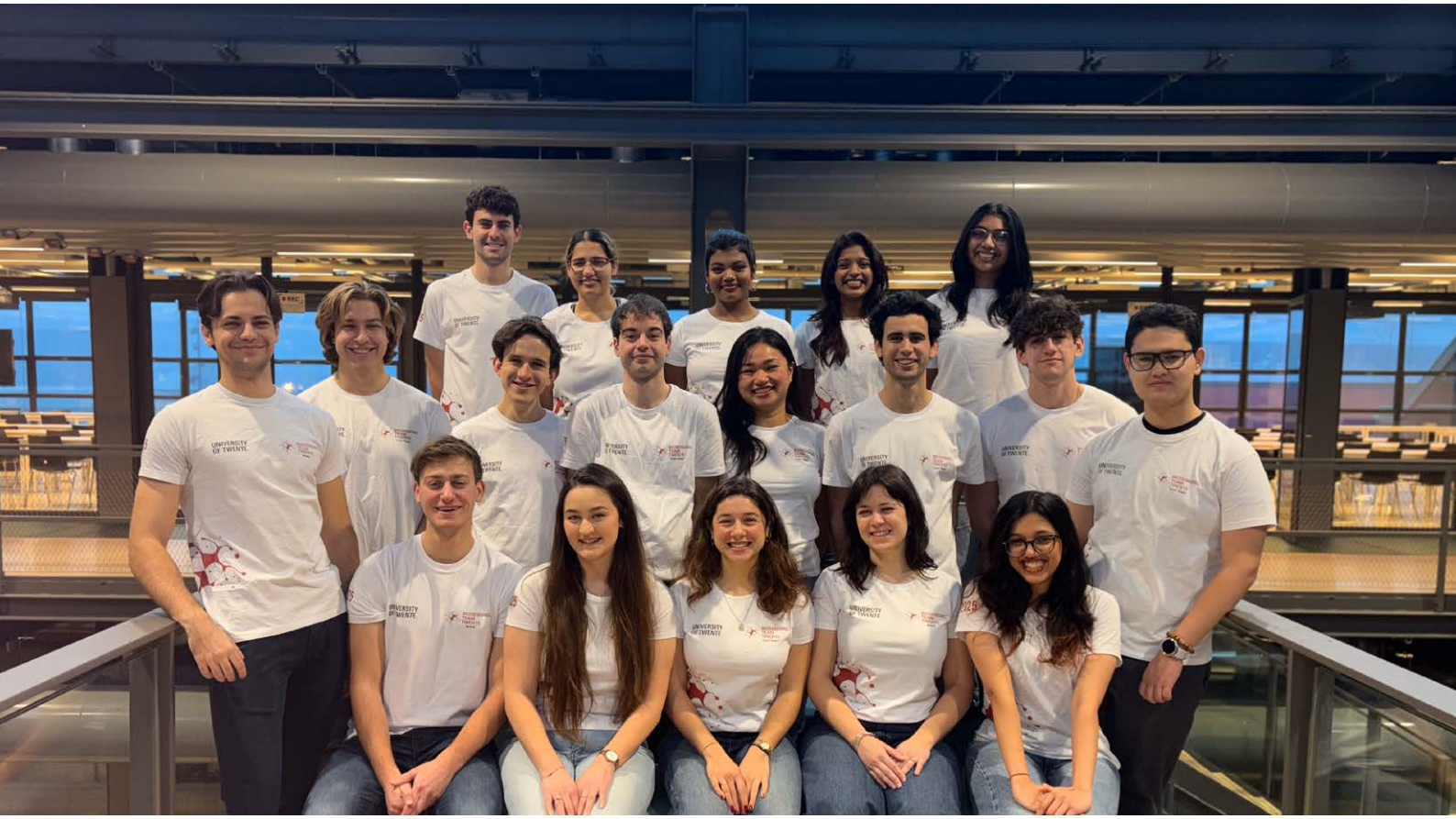
Caterina: In a team as big as ours it is necessary to ensure seamless collaboration between the core group and the board. This is achieved with regular meetings and clear communication. We hold regular check-ins to update each other on progress, identify roadblocks, and align our strategies. This ensures that everyone is on the same page and working toward a common goal. By having this structured approach, we've created a system where each member's contributions—whether technical, managerial, or creative—are valued and integrated into the overall mission.

What are some of the most valuable lessons the team has learned from working in a multidisciplinary team?

Diana: One of the most important lessons we've learned is the immense value of diversity. Having team members from different fields of expertise and varied academic or cultural backgrounds enriches our approach to problem-solving. For example, someone with a chemistry background might view a challenge differently from an engineer or a business expert, and bringing those perspectives together often leads to innovative solutions that none of us could have developed alone. This diversity also teaches us to be open-minded and adaptable because we must consider viewpoints and methodologies outside our own expertise.

Caterina: Collaboration has also taught us that no contribution is too small or insignificant. Whether it's a technical insight from the chemistry team, an innovative idea for social media outreach, or a creative solution for a business case, every team member's input plays a vital role in our project's overall success. We've learned the importance of clear communication and mutual respect, which are essential when working with such a wide range of disciplines. It's not just about dividing tasks but ensuring that everyone's efforts align with our shared goals.

Biosensing Team Twente 2024/2025



> **One of the most important lessons we've learned is the immense value of diversity. Having team members from different fields of expertise and varied academic or cultural backgrounds enriches our approach to problem-solving.**

Diana: Another key takeaway is the importance of patience and adaptability when merging different working styles. Each discipline comes with its own way of thinking and approaching problems, and learning to navigate those differences while maintaining productivity has been a challenge—but also a rewarding experience. We've become better at resolving conflicts constructively and finding common ground, which ultimately strengthens the team dynamic.

How do you see the future of the Biosensing Team Twente?

Diana: We're excited for the future! In the short term, we aim to solidify our presence within the university network, increase our visibility, and strengthen the support system for our members. By engaging more actively with university activities, we hope to attract more talent and resources to ensure the longevity and growth of the team.

Caterina: Looking further ahead, our aspiration is to expand our scope beyond the SensUs competition. While the competition has been a fantastic platform for developing biosensors, we want to diversify our projects and tackle different challenges in the biosensing field simultaneously. This might include launching our own initiatives, exploring collaborations with other academic institutions, and even hosting competitions to inspire other student teams. Ultimately, we hope the team can contribute to advancements in healthcare, making diagnostics and monitoring more accessible, affordable, and effective for people worldwide.

Diana: By fostering collaborations with academic and industry leaders, we aim to remain at the forefront of biosensing innovation. We also hope to create a legacy where students continue to explore their potential, gain hands-on experience, and make a meaningful impact, both in healthcare and beyond. ■

BIOSENSING TEAM TWENTE

Would you like to know more?

info@biosensingteamtwente.nl

biosensingteamtwente.nl

Biosensing Team Twente

@biosensingteamtwente

@biosensingteamtwente

FREEHABILITATION

A NEW WAY TO HEAL AT HOME

Physiotherapy is crucial for ensuring physical mobility after situations such as a stroke or surgery. Physiotherapy aims for patients to regain movement, reduce muscle atrophy, and encourage brain plasticity through active physical exercises at a clinic along the physiotherapist. After some time, the patients are given the responsibility of doing their exercises at home to further continue their recovery process. In the case of hand and wrist therapy, the recommended 30 minutes of daily exercise is necessary to keep the arm-wrist functional, while it can feel boring and difficult to be consistent at. Inconsistency in doing the exercises, in turn, slows down their recovery process or even reverses the mobility gained.

But what if brushing your teeth or drinking your morning coffee could help you get better?

With these patients in mind, a multidisciplinary group of researchers at the University of Twente had an innovative idea to support their recovery process. Researchers Juliet Haarman, Kostas Nizamis, Emiel Harmsen and Armağan Karahanoğlu have been delving into the use of everyday objects as tools for recovery and transforming regular household objects into tools for smart hand-training.

Designing for wellbeing

The process of developing technologies can gain valuable insights and data from collaborating across societal groups. The development process, especially for the healthcare sector, can benefit from the expertise of stakeholders by learning from patients' experiences and the lessons learned from healthcare professionals to create a well-rounded intervention. The Freehabilitation consortium embraced this collaborative approach and partnered with Roessingh Research and Development, Roessingh Rehabilitation Centre, Hankamp Rehab, ZGT, and Saxion University to work along with patients and physiotherapists.

The group began, back in 2019, with a focus on developing wearable robotics to support hand-training. This type of rehabilitation is recommended for stroke patients who need to maintain or regain wrist movement. Stroke patients may face additional challenges during their recovery process, thus it is important to create an easy-to-adopt training practice. Shortly after their start with the project, researchers identified that using patients' everyday objects made the physiotherapy session easier to follow and adopt.

Practicing around the house

The research team explored common household items - and based on the input from patients and experts - a toothbrush, a placemat, a cooking spatula, a computer mouse and a coffee cup resulted in potential objects to work as exercise tools. The goal for these tools is to be helpful for the patient's recovery, not to generate additional frustration. These familiar objects can then be adapted to practice specific movements depending on the patient's needs.

A collaborative design practice enables researchers to learn from other's experiences, collect their feedback, and include the final user in the design process. Researchers started gaining feedback since the initial testing of these tools, thus allowing them to make improvements according to the needs of patients and health professionals. With the gained insights the group modified materials and the way of interacting with the tools to create a more pleasant and fruitful physiotherapy practice.

Time to recover at home

The next step for the project is to carry out four-week trials with stroke patients at home. Over this time, researchers will track how often the patients use the tools and for how long. First, they need to validate that these new tools are being used by the patients, if they adopt them then testing can focus on their health impact compared to traditional exercises.

Future plans for the project include to extend the range of tools available to incorporate other household objects, allowing physiotherapists to fit the objects to the recommended routine. the exercises into their daily life through these tools could make their recovery process easier and more pleasant.

New ways to heal

Engaging recovering stroke patients in at-home physiotherapy has proven challenging to achieve through traditional approaches. Freehabilitation aims to engage with patients during their daily routine in a way that does not require them to allocate additional time for doing their exercises. By seamlessly embedding the exercises into their daily activities, patients will increase their training time throughout the day.

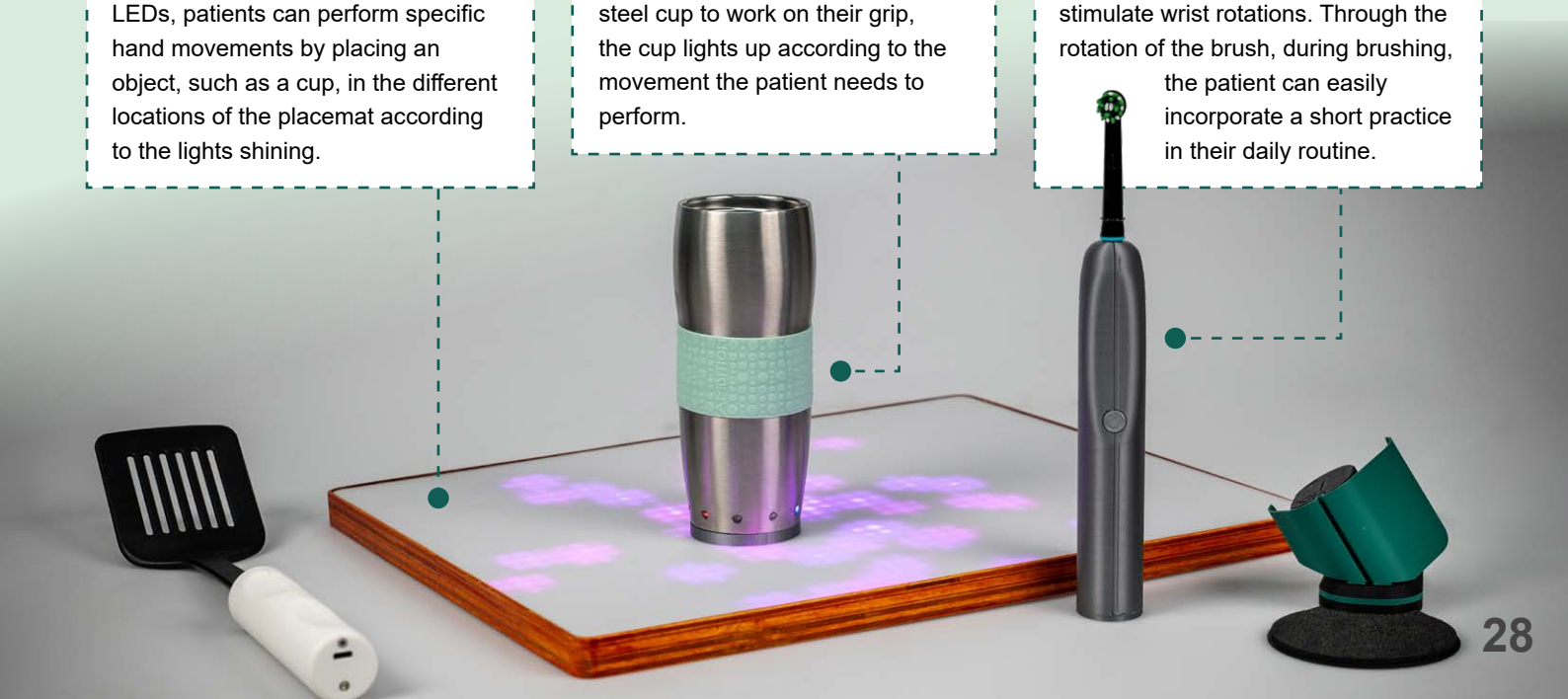
The Freehabilitation group is working to bring this innovative idea into reality and support stroke patients to have a less challenging road to recovery. These tools have the potential to reinvent physiotherapy through their unique approach to the recovery experience. Learning from patients and clinicians to design such tools can greatly benefit the healthcare community around the world. ■

Do you want to learn more about Freehabilitation?
Reach out to Juliet Haarman via j.a.m.haarman@utwente.nl

PLACEMAT FOR YOUR HAND
In the placemat integrated with LEDs, patients can perform specific hand movements by placing an object, such as a cup, in the different locations of the placemat according to the lights shining.

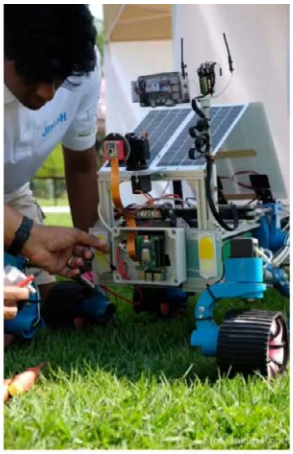
COFFEE CUP FOR YOUR GRIP
Patients can squeeze a stainless steel cup to work on their grip, the cup lights up according to the movement the patient needs to perform.

TOOTHBRUSH FOR YOUR WRIST
The team redesigned a toothbrush to stimulate wrist rotations. Through the rotation of the brush, during brushing, the patient can easily incorporate a short practice in their daily routine.



IGNITING INNOVATION

STUDENT ROBOTICS COMPETITIONS AS CATALYSTS FOR YOUNG TALENT



Cars4Mars
African Rover Challenge

In a world increasingly driven by technology, innovation is no longer a luxury but a necessity. For young minds passionate about engineering, coding, and artificial intelligence, student robotics competitions have emerged as a powerful platform for the engineers of tomorrow. Cars4Mars, an African-based initiative, has created a platform for high school, college, and university students to design and build a Mars rover prototype.

Building Community and a Robot

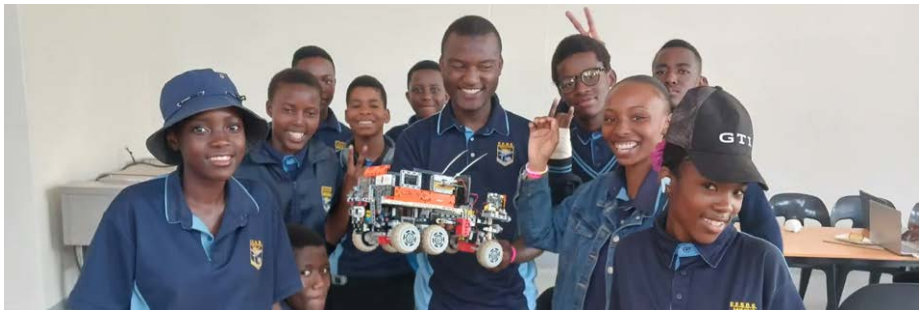
The Cars4Mars competition inspires students from different countries to become the next generation of African innovators. The competition motivates students to reach out to professors, experts, and engineers for technical guidance and mentorship. During its first edition, the competition started with 66 student teams ready to embark on the robotics challenge and turn their design into a reality. The students from 11 African countries brought their unique perspectives and approaches to robotics as each team had a unique robot design. This type of environment enables the youth to challenge themselves, overcome technical barriers, and learn not only from mentors and judges but also from each other.

In order to create a functional prototype, teams will explore different disciplines as they engineer, design, manufacture, program, and operate their robot. The Cars4Mars competition presents the opportunity for students to get hands-on experience in STEM (Science, Technology, Engineering and Mathematics), developing critical thinking, teamwork, and problem-solving skills that are essential for success in today's job market. These competitions foster creativity and resilience, as teams must iterate their designs, troubleshoot errors, and refine their strategies under tight deadlines.

After 7 months of work, teams have to present and test the capabilities of their manufactured rover to qualify for the final competition round. At this phase, the young participants get feedback from the competition judges and experts on the space industry. Such opportunities are key to discover a future career in STEM and get inspired with the possibilities of robotics in other industries.

The Final Test

Beyond technical skills, these competitions nurture leadership, confidence, and communication abilities. During the final, teams and their robots will come together in Johannesburg, South Africa to put their designs to the test. The first edition had 12 teams ready to wirelessly drive their rover through a special obstacle course built from red sand. The 2025 competition includes additional challenges that require AI & autonomous capabilities involving object recognition and classification (e.g. computer vision algorithm), further developing the skills that these future engineers will need to enter both industry and research fields.



Young people won't study science, technologies, engineering and mathematics (STEM), if no one tells them that such a field exists. There are many girls here, and because they're introduced to this here, any one of them can become a robotics engineer. – Basia Nasiorowska

Workforce of the Future

Technology-related fields have many opportunities to support societal challenges. Inspiring young talent to explore these areas is crucial for their future careers as they can develop critical and innovative thinking from an early age. Competitions, such as Cars4Mars, prepare students for situations they will face over the coming years such as project planning, problem solving, and multidisciplinary working.

Moreover, it fosters innovation as the participants can become the next generation of inventors, scientists, and engineers that will impact their communities and countries through their work.

The Next Rovers

The 2025 edition of Cars4Mars is underway and teams around the world are starting to plan their approach to the African Rover Challenge. Over the next months they will prepare their robot to compete against in this year's obstacle course called Mars Yard.

As these young innovators come together to compete, they are not just building robots—they are shaping the future of Africa's tech ecosystem. Their journey is one of collaboration, resilience, and ambition, proving that with the right support, Africa's youth can lead the global stage in robotics and beyond. ■

Cars4Mars
African Rover Challenge

Follow the Cars4Mars 2025 competition

cars4mars.co.za

Cars4Mars - African Rover Challenge

@Cars4Mars

@cars4mars_africanrover

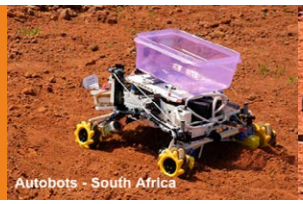
Basia - Cars4Mars African Rover Challenge

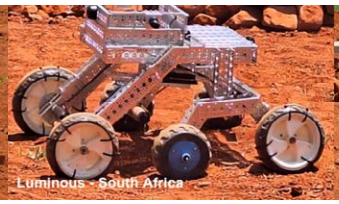
2025 Competition Dates

Launch Stage Final (Online)	09 August 2025
Mars Stage Final (In-person)	20 September 2025

Interested to join as a team?

Contact Ms Basia Nasiorowska – basia@cars4mars.co.za





BUILDING HOPE
ONE LAYER AT A TIME

In the face of global challenges, cutting-edge technologies are providing an alternative pathway for communities to help others around the world. Additive manufacturing (AM), also referred to as 3D printing, is revolutionising humanitarian aid by enabling a quick production of goods such as arm braces, low-cost prosthetics, and support tools for medical staff. As a technology that has entered many households around the Netherlands, a big community is ready to start printing to help those in need. Through non-profit organisations, as e-NABLE Nederland and MAKERS4ALL, the community can be organised to provide the best support possible to those in need. Thus, unleashing the power of AM for the good of all.

Beyond the Borders

e-NABLE Nederland is a Dutch foundation working to facilitate access to 3D-printed hands or arms, at a low cost, for those wanting to gain or improve grip function caused by an upper limb difference. Through their network of volunteers, and individual collaboration with every person, prostheses are customised in size and colours, printed, and assembled with the beneficiary. Their impact reaches not only children and adults in the Netherlands, but also the Dutch speaking part of Belgium, and since 1,5 years also the Tigray area in Ethiopia through the collaboration with DEKNA foundation.

MAKERS4ALL is a foundation that came to action during the COVID-19 pandemic to support healthcare workers by 3D-printing frames for face shields and clips for face masks. These small, yet impactful, printed parts helped people all over the country by reducing their exposure to the virus as they were dealing with medical supply shortages. Due to the development and availability of 3D printers nowadays, the MAKERS4ALL network printed over 100.000 items during the starting years of the pandemic.

Top. Child with arm prosthetic through e-NABLE Nederland.
Middle. Wrist braces being used in Ukraine.
Bottom. Face shield printed and delivered during COVID pandemic.

Finger and wrist braces from e-NABLE and MAKERS4ALL.

In recent years, both foundations have supplied printed items for crisis relief in Ukraine. The community has been printing light-weight designs that can be easily adapted for finger and wrist braces, additionally they have printed parts for making tourniquets. The efforts from both organisations, along with the extensive community, have showcased the impact of 3D printing for humanitarian support by delivering 8.500 braces for wounded Ukrainians.

Barriers to overcome

Advances in additive manufacturing have made this technology accessible for non-industrial consumers through affordable equipment, user-friendly software, and easy access to material; specially for FDM (fused deposition modelling) printers. These advances have benefitted users from hobbyists to engineers as newer printer models allow for faster printing with better quality. This allows the 3D printing community, involved in e-NABLE Nederland and MAKERS4ALL, to deliver more printed items during crisis situations. These organisations have faced various challenges and over the years some lessons have been learned about 3D printing and building a network:

One poor print will break their trust

It is important to clearly communicate the expected print quality with every volunteer as they may have different printers, materials, and parameters for working. Reducing the amount of faulty prints will contribute, besides a better use of resources, to only deliver parts of the best quality. Any faulty prints will affect the medical staff's perception of the reliability of 3D printed components and in a crisis context with high numbers of injuries, printed parts need to be of the best quality from the start or you don't get a second opportunity.

With different materials there is a different number of volunteers

To ensure good quality components that will perform as desired, different materials may need to be used for producing the range of products. Unfortunately, every volunteer has different abilities in which materials he or she is able to print which can limit how many parts could actually be printed. Having to print components in PLA raised no issues, when a piece required to be printed using PETG the number of volunteers available would drastically reduce, and numbers would be even lower for any other material.

Top. Doctor in Ukraine testing the delivered braces and tourniquet components.
Bottom. Shipment of braces for Ukraine support.

> **Building a community of volunteers is as important as having faster printers available. Being able to put AM technology into action at people's home has brought multiple benefits, one of them is having a big community to reach out for support.**

Faster printing does not secure a bigger outreach

Finding the right collaborators is essential to deliver the goods to where they are needed. For Ukraine, delivering the braces was achieved through small foundations who were already working in specific areas within the country, thus reaching a limited number of injured people. Big foundations, with bigger outreach, are hesitant on embracing 3D printed components that have not been thoroughly tested or approved by healthcare organisations. Therefore limiting the impact of printed goods during times of crisis even when resources are available.

Delivering help needs an additional community

For e-NABLE's work in Tigray, providing the prosthesis further relies on the community support from those already traveling between the Netherlands and Ethiopia. These unique volunteers support with collecting measurements or taking the printed parts with them to deliver at the hospital. Without this extended network, it would not be possible to deliver as many prostheses to the kids and adults in need living in Tigray.

Volunteers' motivation is not constant

Having been closely impacted by the COVID pandemic, volunteers were eager to help those around them and the struggling medical staff throughout the country. For other projects, it is essential to emphasise on the importance of the volunteers' efforts and the impact their participation can have, despite how distant the crisis is located.

Conclusion

Building a community of volunteers is as important as having faster printers available. Being able to put AM technology into action at people's home has brought multiple benefits, one of them is having a big community to reach out for support, as seen through the work by e-NABLE Nederland and MAKERS4ALL. These organisations look forward to the next advancements in 3D printing to help more children and adults with prostheses and continuing to support humanitarian efforts where needed. ■

Child with customised e-NABLE prosthetic.