



BIOASSEMBLER

Integrating bio-inspired assembly
into semiconductor manufacturing
technology for biosensors

BIOASSEMBLER

evaluation of the Dissemination, Exploitation and Communication actions

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1. Executive summary

This deliverable presents the final assessment and evaluation of the dissemination, exploitation and communication (DEC) actions implemented throughout the 42 months of the BIOASSEMBLER project. It consolidates and updates the analyses presented in the two previous assessment reports (Campos, Valente, 2023; Campos, Brito, 2024b) and integrates the recommendations provided by the external reviewer during the midterm evaluation, in M21. The report therefore offers a comprehensive overview of the project's DEC strategy, its evolution over time, and its overall impact.

BIOASSEMBLER targeted a diverse audience, including natural, exact and social science researchers, industrial stakeholders and market leaders in biotechnology, policymakers, artists and cultural professionals, and the public at large. During the first phase of the project (M1-M24), communication efforts focused on building and consolidating the project's identity and online presence. The website and social media channels were strengthened as key platforms to foster community engagement and disseminate project developments. As previously reported, LinkedIn demonstrated steady growth and increasing interaction rates, while Facebook showed slower but stable engagement. Website analytics confirmed a progressive increase in visits, driven by organic search, direct access, and cross-promotion via social media.

In the second phase of the project (M25-M42), and particularly during the final year, DEC activities concentrated on consolidating results and ensuring their visibility, accessibility and long-term impact. Beyond maintaining the website and social media presence, communication actions were primarily oriented toward supporting the conclusion of the artistic residency and the production and dissemination of the two art-science books, key legacy outputs of the project. These initiatives embodied BIOASSEMBLER's interdisciplinary approach and played a central role in broadening public engagement with biotechnology through creative and accessible formats.

The advanced training course, initially postponed in the second year due to low enrolment, was successfully held during the project's later phase (M32 and M33). This course represented a major dissemination and capacity-building milestone, bringing together participants from different disciplinary backgrounds and geographies, and reinforcing the project's educational and networking objectives.

Scientific dissemination remained a core priority across the 42 months. Project objectives, methodologies and results were communicated to academic and industrial audiences through participation in conferences, trade fairs, workshops and open-access publications. Public deliverables were systematically made available via the project website and promoted through social media, in alignment with open science principles and the revised DEC plan.

Exploitation activities, initiated in M13 in close collaboration with WP1 and Task 4.5, progressed steadily throughout the project. The creation of the External Advisory Board provided strategic guidance on exploitation pathways, including validation of the biosensors' market analysis and

feedback on the exploitation plan. These actions strengthened the project's innovation potential and clarified routes for post-project sustainability and uptake.

Importantly, the external review conducted in M21 played a decisive role in refining the DEC strategy. The incorporation of more concrete and measurable indicators enhanced the monitoring of impact and effectiveness across communication, dissemination and exploitation activities. The iterative process of evaluation, adjustment and implementation continued until the project's conclusion, ensuring responsiveness to emerging opportunities and challenges.

Overall, the final assessment indicates that BIOASSEMBLER successfully established a coherent and evolving DEC framework, increased its visibility among scientific, industrial and public audiences, fostered interdisciplinary dialogue through art-science collaboration, delivered targeted training activities, and laid solid foundations for the exploitation and sustainability of its key results beyond the project's lifetime.

2. The assessment and evaluation of the DEC Plan

The BIOASSEMBLER DEC Plan (Campos, Ferreira, Valente, 2023) was set to establish the main guidelines for the comprehensive and effective dissemination of the project's outputs and results to the identified target groups (scientists, market/industrial stakeholders, policymakers, and regulators: standardization bodies, civil society, public at large; educational communities; science communicators; end users). The goal was to promote "the future large-scale adoption of the novel technology, raising awareness of its opportunities and challenges, and contributing to a more informed society" (Campos, Ferreira, Valente, 2023; p. 7).

Different strategies and activities were combined to reach the public, including a regular online presence on social media platforms and the project website, participating in market, industry and scientific meetings, publishing in scientific journals, disseminating press releases, organizing an advanced training course, sponsoring an art-science/technology residency, and editing two books for non-specialist publics and educational actors.

The efforts put into the project communication and dissemination activities were monitored and calibrated according to a set of leading key performance indicators (KPIs) and draft target values (Table 1), in three time periods (M12, M24 and M42/end of the project). The progress and result of such efforts were also monitored based on expected achievements in the different dissemination phases (Table 2).

Table 1

KPIs for BIOASSEMBLER communication and dissemination activities (adapted from Campos, Ferreira, Valente, 2023).

KPI	Target value	Description	Achievements (M42*)
Website – average monthly single users	≥ 200	# of users accessing the project website	102 average monthly site visitors from M20
Facebook – followers	≥ 200	# of followers, # of interactions	40 followers, ~4500
LinkedIn – followers	≥ 600	# of followers, # of interactions	284 followers, 11.76 average engagement rate
Networking events	≥ 15	# of events attended by partners linked to existing initiatives	36
Press releases	≥ 30	# of media mentions	15
Artistic product	≥ 20, ≥ 2000	# of visitants for the live presentation, # of views for the virtual format	#53, 80
Visual dictionary	≥ 500, ≥ 200	# of readings, # of downloads for the online edition	--
Comic book	≥ 1000, ≥ 500	# of readings, # of downloads for the online edition	--
Presenting project results at national and international events	> 20	# of events hosting partners as speakers	22**

Stakeholder Workshop	> 200	# of representatives of market/industrial stakeholders, # of representatives of the scientific community	> 1000
Publishing results	> 20	# of scientific paper drafts prepared by partners, # report and brochures	6 scientific papers***, 1 Msc dissertation, 12 public reports

* The information was extracted in mid M42.

** Two presentations foreseen for M43 and M45.

*** One paper ready for submission.

Table 2

BIOASSEMBLER dissemination phases and KPI (adapted from Campos, Ferreira, Valente, 2023).

Phase	Timeline	Description	Achievements
Awareness	M1-12	By M12, BIOASSEMBLER is disseminated in at least 10 virtual and/or in-presence academic, educational, media-related or industry spaces/events	By M12, BIOASSEMBLER was disseminated in 10 academic and/or industry events
Scientific/technical dissemination phase	M12-42	By M30, BIOASSEMBLER is disseminated in at least 10 open-access publication and 10 industry events	By M42, BIOASSEMBLER was disseminated in 19 open-access publication and 8 industry events
Exploitation-focused	M24-42	By M30, a draft of the exploitation plan is ready	By M42, the exploration plan is ready

The first assessment and evaluation results were presented in Deliverable 2.2 (Campos, Valente, 2023) and led to targeted adaptations of the original DEC Plan. In addition to reinforcing the project's online presence and further aligning communication actions with the identified target audiences, this first evaluation prompted a strategic revision of the social media approach.

The BIOASSEMBLER Twitter/X account showed minimal growth (28 followers and an average of two interactions per publication). Moreover, changes in the platform's governance following its acquisition by Elon Musk contributed to a broader disengagement of scientists and other users from the network (Valero, 2023; Chang et al., 2023). In light of both the limited performance indicators and the evolving platform dynamics, it was decided to close the BIOASSEMBLER Twitter/X account and concentrate communication and dissemination efforts on LinkedIn and Facebook, which demonstrated greater potential for audience growth and engagement.

Following the mid-term evaluation (M21) and the recommendations provided by the external reviewer, further adjustments were incorporated and reported in Deliverable 2.3 (Campos, Brito, 2024b). These included the introduction of more concrete and measurable indicators to monitor impact and a more structured approach to reporting quantitative and qualitative outcomes.

The third and final assessment and evaluation results are presented in this deliverable. It consolidates the reflections, methodological refinements and strategic adjustments implemented across the three reporting periods, providing a comprehensive and integrated evaluation of the DEC activities carried out throughout the 42 months of the project.

3. The BIOASSEMBLER DEC Committee

The BIOASSEMBLER Dissemination, Exploitation and Communication (DEC) Committee was established by M6, with the main goal to overseeing, planning and organizing the multiple communication, dissemination and exploitation activities in the BIOASSEMBLER project.

Its composition changed during the second year of the project, when project member Mathias Reisbeck substituted Gerhard Jobst, from consortium partner Jobst (Table 3).

Table 3
Composition of the BIOASSEMBLER DEC Committee.

Partner	Member
VTT	Petri Saviranta - Project Coordinator
VTT	Emilia Barannik
VTT	Anna Spehar
UniVie	Mark Somoza
Jobst	Mathias Reisbeck
Abcalis	Laila Al-Halabi-Frenzel
CES	Rita Campos - DEC WP Coordinator

4. BIOASSEMBLER communication

4.1. Website

The BIOASSEMBLER website (<https://bioassembler.eu/>) was launched in M6 and was fully operational in M7. The News and Activities sections have been regularly updated, sharing information about actions or topics related to the project. The Team section was expanded to include the collaborator artists and to recognize the contribution of members that left the initial BIOASSEMBLER team.

The Outputs section was activated after the publication of the first open access scientific publication, in M16. This section now includes the artistic product developed with the BIOASSEMBLER artistic residency, five publish scientific articles (detailed in Table 8) and six public deliverables (D1.1; D4.3; D4.2; D4.1; D1.3; D2.1); other public deliverables will be published on the website and disseminated in the social media accounts after approval from the EC (following the final review, foreseen for M45).

The two art-based books will also be made available in this sections, as well as any scientific article related to the project published in the coming months.

After the expiration of the paid domain period, the website content will be transferred to the Centre for Social Studies (CES) domain, ensuring that all information remains publicly accessible beyond the project's duration.

Following the last evaluation (D2.2; Campos, Valente, 2023), the social media publication strategy was adjusted to generate more traffic to the project website: for most of the publications, only a teaser was used in the social media platforms that directed the readers to the new and full content on the website.

To gather the website statistics, we used Google Analytics. Since the platform only tracks data from the time its plugin is installed on the website (in M19), the statistics provided here cover the period from M20-M42.

During this time, there were a total of 2,400 active users visiting the BIOASSEMBLER website, defined as the number of people who engaged with the site. This translates to a monthly average of 109.1 users, a slight increase from the previous reporting period (M20-M24), during which time there were an average of 97.6 users (Campos and Brito, 2024b). These visitors are from at least 81 distinct countries, a significant geographical expansion from the previous reporting period during which time there were visitors from only 39 countries (Campos and Brito, 2024b).

The six countries contributing the highest number of visitors to the website were the United States (n=483), China (n=378), Portugal (n=316), Finland (n=275), Germany (n=213), and the Netherlands (n=164). These figures reflect both regions of leadership and innovation in biosensing and semiconductor technologies (U.S., China, Netherlands), and the home countries of BIOASSEMBLER consortium members (Portugal, Finland, Germany). Austria, home of one consortium partner, contributed the 8th highest number of visitors (n=42).

Of the 2,400 active users, 67% (n=1,566) arrived on the BIOASSEMBLER website via either a direct search (i.e. by typing the URL directly in their browser), or from an unidentifiable referrer (such as a link from a PDF document, or users browsing in "incognito" mode). 20% of visitors (n=477) arrived via a search result on Google Search, which points to the effective use of unpaid search engine optimization (SEO) strategies. 3% of site visits (n=65) came via LinkedIn, 2% (n=45) from Bing search engine, and another 1% each from the website of CES (Centre for Social Studies, University of Coimbra, n=35), and Facebook (n=29).

These figures suggest that the SEO and sharing of the website URLs are among the most effective strategies for driving visitors to the website. While social media generates its own forms of engagement (see section 4.2 below), and there are meaningful linkages between social media and

website visits, overall direct site visits and organic Google search results were the most productive avenues to bring visitors to the site.

The pages generating the highest level of engagement during this period (M20-M42) were as follows: BIOASSEMBLER's landing page (bioassembler.eu/): 1,559 views; Team page (bioassembler.eu/team): 395 views; Project page (bioassembler.eu/project): 348 views; Activities page (bioassembler.eu/activities): 299; News page (bioassembler.eu/news): 289 views; Outputs page (bioassembler.eu/outputs): 263 views; Objectives page (bioassembler.eu/objectives): 183 views.

As reported in the previous evaluation (Campos and Brito, 2024b), interest in the human dimensions of the project continue to drive and direct site visits.

It is notable that the Team, Project, Activities, and News pages outperformed the Outputs and Objective pages, highlighting the importance of science communication via short, engaging, and accessible texts that communicate the project work to a broad audience, and which do not require downloads to access relevant, human-centred information about science and technology innovation.

4.2. Social Media Accounts

BIOASSEMBLER LinkedIn, Facebook and Twitter accounts were set up by M2 and activated in M3. The first performance evaluation led to the closure of the BIOASSEMBLER Twitter/X account.

The BIOASSEMBLER Twitter/X account had a minimal growth rate, with 28 followers and an average of 2 interactions per publication. On the other hand, the changes undergone in the network's governance since its acquisition by Elon Musk have been pushing scientists (Valero, 2023) and other users (Chang et al., 2023) out. It was thus decided to close the BIOASSEMBLER Twitter/X account and concentrate the communication and dissemination efforts on LinkedIn and Facebook, which seem to have more potential for growing and engaging different audiences in the next two years of the project.

Since the activation of the social media accounts, at least one weekly publication was assured during the first two years and one monthly publication during the last 18 months, contributing to disseminating the project's main public activities and content considered relevant and linked with the project topics. The reduction in the number of regular publications was related to a period when most results were sensitive or subject to embargo, pending acceptance by the EC of deliverables submitted during this period.

Publications also addressed the commitment of BIOASSEMBLER in contributing to a transparent, trustworthy, and human-centred scientific activity, by sharing the progress and values endorsed by the project and identifying team members whenever possible or appropriate. Social media accounts will remain active beyond the end of the project to share all relevant results and open-access

publications available after M42. In the final days of the project, a special series of publications called “BIOASSEMBLER in review” will share the main milestones achieved during the 42 months of work.

Below, we present an analysis of the evolution and dynamics of the LinkedIn and the Facebook accounts since their creation (M2), considering the number of followers and interactions. We note that all statistics refer to the organic impact of both social media accounts and not to any paid publications. This distinction is important because these platforms, and Facebook in particular, are becoming increasingly commercial, with aggressive marketing strategies for paid content and growing limitations on access to page statistics for unpaid/non-commercial accounts.

4.2.2. LinkedIn

The BIOASSEMBLER LinkedIn (<https://www.linkedin.com/company/bioassembler>) has continued to grow. It has an established community of 285 followers, an increase of 36 followers from the previous evaluation (Campos and Brito, 2024b). The table below (Table 4) depicts BIOASSEMBLER followers by continent and country of origin.

Comparing with the values of the second evaluation (Campos and Brito, 2024b), alongside gradual growth in the overall number of followers, there has been a slight broadening of geographical breadth in Europe, the Americas, and Asia (1 new country in each region).

As concerns Africa, while the number of followers remained stable ($n=4$), the number of countries represented from the continent narrowed from four to two (both in North Africa). This geographical expansion likely reflects the participation of BIOASSEMBLER team members at scientific congresses, and the circulation of scientific publications. Weak connections to the African scientific community suggest areas of improvement for future research.

Table 4

BIOASSEMBLER followers on LinkedIn by continent and country of origin.

Europe	N=188	65,96 %
Portugal	115	40,35
Germany	23	8,07
Finland	12	4,21

Spain	7	2,46
The Netherlands	6	2,11
Belgium	3	1,05
United Kingdom	3	1,05
Ireland	3	1,05
Norway	3	1,05
Austria	3	1,05
Switzerland	2	1,70
Sweden	2	1,70
Denmark	2	1,70
France*	2	1,70
Czech Republic	1	0,35
Italy	1	0,35
America	N=28	9,82 %
USA	14	0,49
Brazil	8	2,81
Canada	2	0,70
Chile	1	0,35
Colombia	1	0,35
Venezuela	1	0,35
Peru	1	0,35
Asia	N=20	7,02 %
India	10	3,51
Turkey	2	0,70
Pakistan	2	0,70
South Korea	1	0,35
Iran	1	0,35

Japan	1	0,35
Oman	1	0,35
Saudi Arabi	1	0,35
China	1	0,35
Africa	N=4	1,40 %
Egypt	2	0,70
Morocco	2	0,70
Other**	N=45	15,79 %
Unknown geographic origin	45	15,79

*Includes the Reunion island.

** Followers with unknown geographic origin.

The analytical tools from the LinkedIn platform were used to characterize the BIOASSEMBLER community on this platform.

Most of the 505 page views, registered during M13-M24 (Campos, Brito, 2024b) were from visitors related to Higher Education (N= 137; 27.1%), IT Services and IT Consulting (N=68; 13.5%), Research (N= 60; 11.9%), Biotechnology Research (N= 50; 9.9%), and Business Consulting and Services (N= 17; 3.4%). Probably related to the reduction in publications, the number of page views dropped to 78 in the last 12-month period. The visitor's profile was similar: Biotechnology research (N= 16; 33%), Higher Education (N=12; 25%), Space research and technology (N= 12; 25%), Research (N= 8; 17%).

Engagement rates, which measure the number of Clicks, Likes, Comments, and Reposts divided by the number of impressions (views or clicks on the publication), have grown slightly over the past 12 months, as compared with the previous reporting period (Campos, Brito, 2024b).

Out of the 21 pieces of content published in the past year, 7 achieved an engagement rate higher than 20%. Of these, 3 had engagement rates above 40%. Another 7 posts had an engagement rate between 10% and 19%; and 7 had an engagement rate between 5% and 9%. No posts during this period performed below 5%. This indicates an average engagement rate of 11.76%; a slight increase from the previous average engagement rate of 11.43% (Campos, Brito, 2024b).

In the previous evaluation, higher engagement rates were related to the participation of BIOASSEMBLER members in dissemination events, with photographs and the identification of team members (Campos, Brito, 2024b). In the past 12 months, the posts with the highest engagement rates (above 40%) also included photographs, but were specifically related to group or team events with multiple participants.

The top two performing posts concerned the Advanced Course, “Deep Interdisciplinary in Biotechnological Research and Innovation”. The third highest performing post concerned the announcement of the 4th Consortium Meeting in Vienna (December 2025). These posts each included more than 3 photographs, and emphasized the human story behind the project. Inversely, the lowest performing posts did not feature full-size images, underscoring the centrality of visuals for engagement on this platform. In sum, the previous goal to “focus on content that brings visibility to the participation of project members” (Campos, Brito, 2024b) has proven to be effective. This experience will carry to future projects, and will continue to inform BIOASSEMBLER’s dissemination strategy for the release of the Comic Book and Visual Dictionary.

4.2.2. Facebook

The BIOASSEMBLER Facebook page (<https://www.facebook.com/profile.php?id=100087327157028>) has had very limited recognition. The number of followers and profiles liking the page increased in relation to the first two evaluation (Table 5), but remained lower than expected. Nevertheless, the number of views continuous to see an expressive growth, as well as the number of interactions (indicated as Likes in Table 4). The Meta Business Suite from Facebook was used to characterize the impact of BIOASSEMBLER presence on this platform.

Table 5

BIOASSEMBLER Facebook general statistics.

KPI	1 st Evaluation – M12*	2 nd Evaluation – M24**	3 rd Evaluation – M42
Followers	20	34	40
Likes	14	22	146
Views***	948	1900	4100

*In Campos, Valente, 2023; page 10.

**In Campos, Brito, 2024b; page 13.

***Number of views/reach of the page in the last three months prior to the 1st and 2nd evaluation, and in the last 18 months of the project.

As seen in the previous two evaluation (Campos, Valente, 2023; Campos, Brito, 2024b), the posts with more effective engagement are the ones that contain images, in particular the ones with several images, and focused on the human dimension of the scientific research. Thus, publications continued to prioritize the use of more than one image, and the information about the participation of BIOASSEMBLER team members in communication and dissemination actions.

In the last 18 months (M25-M42), publications about the Artistic Residency and the Advanced Course, “Deep Interdisciplinary in Biotechnological Research and Innovation”, had a higher impact (measured by the number of reactions by the public, the number of shares and the reach of the content). Publication related to the participation in scientific events and the consortium meetings also reach high impact. The top publications, the ones that stands out in terms of impact, were the ones announcing the public presentations of the performance resulting from the artistic residency.

The planned publication and dissemination of the BIOASSEMBLER visual dictionary and comic book should contribute to increased engagement and interaction on this social network after the project's completion.

4.3. Press Releases

Press releases were issued whenever relevant information about the project's progress and results could be made public.

To this end (M42), press releases describing BIOASSEMBLER main features have been mentioned in eight media outlets: four Portuguese regional press (Jornal de Proença, Diário de Coimbra, Campeão das Províncias and Rádio Regional do Centro), one German online, globally distributed magazine targeting the electronic industry (OPE Journal), one German platform that supports a network for life sciences (BioRegion), one Finnish general audience technology magazine (Tekniikan Maaailma), and one German specialist magazine for business and science in the Braunschweig region (Table 6).

Press releases announcing the BIOASSEMBLER Summer School were mentioned in one Portuguese regional press (Diário Online Região Sul), and in one academic agenda (CESAM-Centre for Environmental and Marine studies Agenda).

Table 6

Mentions of the BIOASSEMBLER press releases in different media outlets.

Country	Media	Link
Portugal	Campeão das Províncias	https://www.campeaoprovincias.pt/noticia/centro-de-estudos-sociais-da-uc-participa-em-investigacao-sobre-biossensores
Portugal	Rádio Regional do Centro	https://www.radioregionalcentro.pt/noticias/centro-de-estudos-sociais-da-uc-participa-em-investigacao-sobre-biossensores/
Portugal	Diário de Coimbra	Not available (see Figure 7 in Campos, Ferreira, Valente, 2023)
Portugal	Jornal de Proença	Not available (see Figure 7 in Campos, Ferreira, Valente, 2023)
Portugal	Diário Online Região Sul	https://regiao-sul.pt/educacao-e-ciencia/inscricoes-abertas-para-escola-de-verao-sobre-transformacao-sustentavel/658502
Portugal	CESAM Agenda	https://www.cesam-la.pt/en/calendar/ces-summer-school-critical-approaches-to-the-sustainable-transformation/
Germany	OPE Journal	https://ope-journal.com/news/vtt-bio-intelligent-micromanufacturing-paves-the-way-for-new-biosensors
Germany	BioRegion	Not available (see Figure 7 in Campos, Ferreira, Valente, 2023)
Finland	Tekniikan Maailma	https://tekniikanmaailma.fi/lehti/21b-2022/anturituotantoon-mallia-biologiasta/

Germany	VDI IQ Journal	https://www.vdi.de/fileadmin/pages/vdi_de/redakteure/vorort/bv/braunschweiger-bv/grafiken/iQ_Journal/iQ_2024/iQ_2_2024.pdf
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BIOASSEMBLER press releases were also featured in the project partner's institutional websites and social media accounts (Table 7).

Table 7

Mentions of the BIOASSEMBLER press releases in the consortium institutional websites.

Partner	Country	Link
		https://www.vttresearch.com/en/news-and-ideas/bio-intelligent-micromanufacturing-paves-way-new-biosensors-application-areas
VTT	Finland	https://www.linkedin.com/feed/update/urn:li:activity:7170353783707713538
		https://twitter.com/VTTFinland/status/1764588507731726415
Abcalis	Germany	https://abcalis.com/abcalis-vegan-antibodies-meet-mems/
Biomensio	Finland	https://biomensio.com/biomensio-to-develop-novel-cost-effective-methods-for-wafer-scale-biofunctionalisation-in-bioassembler-project/
CES	Portugal	https://www.ces.uc.pt/pt/agenda-noticias/destaques/2022/ces-participa-em-investigacao-que-visa-a-transformacao?fbclid=IwAR0JbuQW1kDR3k7DyWcqh_lcioCIPIL9ZgMMi3vSeOzNxapayi6Cb91xJoo

CES	Portugal	https://ces.uc.pt/en/agenda-noticias/agenda-de-eventos/2025/deep-interdisciplinarity-in-biotechnological/overview
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4.4. Art-based communication and engagement strategies

The collaboration between science and art plays a crucial role in translating complex scientific concepts, making science more accessible, engaging and emotionally resonant (Nature Editorial, 2021). Art-based approaches to science communication intentionally create emotional connections with scientific topics, recognising that understanding is not driven by information alone, but also by feelings, values and personal meaning. By appealing to people’s experiences and imagination, art can demystify intricate processes and bridge the gap between highly specialized research and broader audiences, thereby supporting public understanding and fostering trust in scientific knowledge and innovation (Lesen et al., 2016).

Moreover, art-science collaborations contribute to the creation of more inclusive and participatory forms of dialogue around research. They open spaces where different perspectives can coexist, encouraging reflection, discussion and critical engagement with the societal implications of science (Fraaije et al., 2022; Middleton et al., 2023). At the same time, such approaches do not only transform how science is communicated outwardly; they also invite scientists themselves to reconsider their work from alternative viewpoints. By engaging with artistic processes and interpretations, researchers are prompted to reflect on the ethical, social and human dimensions of their work, potentially gaining new insights into its meaning, impact and broader significance.

In BIOASSEMBLER, the collaboration between art and science is expected to contribute to the visibility and impact of biosensing development and innovations, promoting a broader societal engagement with biotechnology research (Fraaije et al., 2022; Middleton et al., 2023). Facilitating the dialogue between scientists and the public, the art-based strategies foreseen for the project communication - visual dictionary, artistic residency and comic book - can foster a more inclusive discussion of biotechnological advances and their societal implications.

4.4.1. Visual Dictionary

Among the strategies for linking science and society is the publication of an open-source visual dictionary of the project's concepts, processes, and impacts. It is expected that the final product will

contain 50 entries of short texts and illustrations. The content for the dictionary started to be created by M14. Six texts and four illustrations were produced by M24 (Campos, Brito, 2024b). As of M42, all 50 entries and 50 accompanying illustrations have been finalized; the translation for Portuguese was also finalized. BIOASSEMBLER team members wrote and/or revised the texts, and visual artist and concept and experience designer Inês Montalvão (@i.montalvao) created the illustrations inspired by the contents.

To bring the illustrations and text together in a well-designed and visually appealing output, BIOASSEMBLER engaged graphic designer and art director Joana Monteiro (<https://joanamonteiro.pt/>), who completed the final manuscript in M42. This project output will be made available on the BIOASSEMBLER website as a free e-book, in English and Portuguese. Additionally, as it is intended to be used as a science communication tool and teaching material, limited copies of the Portuguese edition have been printed and will be circulated to schools and other educational contexts for incorporation into classrooms activities and promote student's scientific literacy and critical thinking.

The selection of topics for the short texts followed a participatory strategy, where members of the consortium were invited to suggest a given concept or process to be included in the material. In addition, the selection of entries was informed by the social dialogues from the Task 6.5 (Connor et al., 2025) and from research conducted in Portuguese secondary schools (Campos and Brito, 2024a), ensuring alignment with the interests, questions and concerns identified among different stakeholder groups.

The title of the book was likewise chosen through a participatory process. Young people aged 15-25 were invited to indicate which proposed title they would be most likely to pick up and open. Based on the results of this survey, the BIOASSEMBLER Visual Dictionary was titled "Biotechnology in colour. An illustrated encyclopaedia on discoveries, ethics and science".

4.4.1.1. Evaluating the impact of the visual dictionary

A preliminary assessment of the first four entries and illustrations in M24 formed part of the Master's thesis of former BIOASSEMBLER's junior researcher Bianca Brito (Brito, 2024; Campos, Brito, 2024a). Survey responses indicated that a group of students from a Portuguese professional high school found the content engaging and interesting. For most respondents, the illustrations offered an attractive, engaging way for students to connect with the scientific content of the texts.

Constructive feedback for the inclusion of more examples and explanations was incorporated into the remaining entries. Additionally, aligned with the project's participatory communication approach, the suggestions provided by the group regarding topics they wish to see included in the dictionary was also considered during the development of the subsequent texts and illustrations.

This participatory communication approach has been critical for the creation of an impactful book. Although an analysis of the full impact of the book will take place after the termination of the BIOASSEMBLER project, the participatory approach allows for a degree of confidence in the success and uptake of the final output as it has already been tested.

4.4.2. Art-Science/Technology Residency

In M12, BIOASSEMBLER launched an open call seeking to commission an artistic production to communicate the processes and results of a new biosensor manufacturing technology being developed within the project. Seven applications were received and evaluated by the task leaders of WP2 – Dissemination, Exploitation and Communication, also team leaders from the institutions that hosted the artistic residency, VTT, Biomensio and CES. Three applicants were shortlisted for an online interview, aiming to discuss the applicant's previous work, motivation and ideas for the artistic product to be developed.

The selected artist was Andrea Inocência (<https://andreainocencia.wixsite.com/andreainocencia>), a Portuguese artist and researcher.

Andrea visited the three facilities during M22, having the opportunity to get to know more about the contributions of the Social Sciences and Humanities to the overall goal of the BIOASSEMBLER project, and about the different materials, resources, scientific and technological aspects of the work being done in the scope of the project. The first ideas for the artistic product were presented to WP2 task leader by M23.

Over the course of the artistic residency, Andrea Inocência developed a proposal to emphasize the experience of working in a laboratory, where the tasks performed by researchers are meticulous, persistent, and often not visible to those outside of the laboratory. In this performance, Inocência took the audience "behind the scenes" by displaying images taken in BIOASSEMBLER laboratories (with permission) on 64 discrete panels (a stand in for biosensing "chips" with acoustic microresonators) and invited participants to imagine what DNA would sound like, if they could hear it with the help of a resonator. One of the central poetic questions explored through the work was: *If acoustic resonance were audible, what would it sound like?*

The premiere of the artistic presentation, a contemporary live performance titled "BioAssemblage", took place in Coimbra, Portugal, in M28, at the Penedo da Saudade Cultural Centre (https://www.facebook.com/centroculturalpenedosaudade/?locale=pt_PT). The event was fully booked, with 35 attendees participating in person. It was also livestreamed on the Cultural Centre's Facebook page, reaching an additional 17 viewers online. The in-person audience included researchers working in technology-related fields and the arts, artists, and members of the general public, reflecting the project's interdisciplinary and outreach objectives.

Audience feedback collected after the premiere reflected a high level of engagement and curiosity. Several attendees approached the artist to ask how the residency had unfolded and what activities had been developed during that period. They expressed interest in learning more about the BIOASSEMBLER project, particularly about what biosensors are and how they are used in practice.

Regarding the performance itself, audience members reported that they greatly appreciated the experience, noting that it successfully conveyed the atmosphere of the laboratory environment and, in some cases, made them feel as if they had been transported into that setting. Particular reference was made to the projected images and drawings, which were highlighted as especially impactful elements of the presentation.

This feedback suggests that the performance effectively met its aims: enhancing the visibility and societal impact of scientific research and biosensor innovation, fostering dialogue between scientists and the public, and promoting broader social engagement with biotechnology through an art-based approach.

Andrea Inocêncio's *BioAssemblage* piece was performed live a second time in Espoo, Finland, in M34, in the lobby of VTT Technical Research Centre of Finland. Returning to one of the institutional contexts that had inspired the performance, the aim of this performance was to present the final results of the artistic residency to the scientific community and their guests.

Eleven people attended the presentation, including researchers and technical staff from VTT. The audience showed particular curiosity in seeing their laboratory environment reinterpreted through the artist's perspective. Several attendees expressed interest in how familiar instruments, routines and spatial dynamics had been translated into visual and performative elements. This encounter prompted informal discussions about how artistic interpretation can reveal overlooked dimensions of everyday scientific practice, encouraging researchers to reflect on their work from new and unexpected angles.

In addition to the two live performances and the livestreaming, a recording of the *BioAssemblage* performance was shared as part of the Advanced Training Course in M32, followed by a discussion with Andrea Inocêncio. This formed part of a session titled "Art, science, and science communication", and included a roundtable discussion with BIOASSEMBLER's two other artist-collaborators, Inês Montalvão and André Caetano, and Rita Campos (CES). This roundtable and live performance aimed to examine how artistic practices can bridge disciplinary divides, making complex scientific concepts more engaging and accessible to diverse audiences. It also explored how art can impact our perceptions and understanding of technology, including biosensing technologies.

The recording of the *BioAssemblage* performance is available to be streamed via the CES website (<https://saladeimprensa.ces.uc.pt/?col=canalces&id=48218>). The video was initially published on the official CES YouTube channel at M36, following the second live presentation. However, after the account was compromised and subsequently closed, the recording was re-uploaded to the CES website at M39. It is also accessible via the BIOASSEMBLER project website under the "Outputs"

section. CES website analytics show that this video has been streamed a total of 80 times since M39 to M42.

4.4.3. Comic Book

The creation of a comic book was a key component of the BIOASSEMBLER communication plan. The goal of this science communication output is to engage broad publics in the science of biosensing, as well as make visible the work, international networks, and collaboration required for European Union R&I projects such as Horizon Europe consortia.

A visually exciting and creative science communication, the comic book aims to explore BIOASSEMBLER's journey from the very beginning - starting with the opening of competitive funding calls and proposal preparation - through project implementation, experimentation and dissemination. It highlights not only the innovation behind multiplex antibody-based biosensors, but also the full research process: the long waiting periods, administrative procedures, experimental setbacks, iterative problem-solving, and the many technical and logistical challenges encountered along the way.

Importantly, the comic also wants to bring forward the human side of science, showcasing the international networks, teamwork and interpersonal dynamics that sustain collaborative research, as well as the dedication, uncertainty, resilience and shared achievements experienced by researchers. By presenting both the scientific and human dimensions of the project, the comic aims to foster a more realistic, transparent and relatable understanding of how contemporary scientific research unfolds.

After identifying and reaching out to several science communicators with appropriate experience at the intersection of comic book and science illustration from M27-M28, in M29 the decision was made to partner with André Caetano (andrecetano.com), a Portuguese illustrator whose work spans editorial illustration, comics, and visual storytelling and who specializes in science communication through comic illustration.

From M30-M35, CES team members drafted and/or revised the general script for the comic book. Through an iterative process, which entailed learning about comic books and the process of their creation, including André Caetano's method and experience, the decision was made to re-draft the script to better reach the main target audience: students aged 15-25.

The book is organized into four parts as follows: (1) the new biosensor is introduced as a prototype, being tested in a laboratory; (2) the action moves back in time to the moment of project inception, when the EC opened the call and the six partners that currently make up the consortium were writing the funding application, waiting for the results, and completing necessary bureaucratic tasks to finally kick-off the project in Finland; (3) a longer section then describes the three and a half years of work

carried out by the six partners, including depicting work in laboratories, database research, interviews, visits to partner laboratories, and consortium meetings in Coimbra and Vienna; (4) the final section describes possible applications of this biosensor, with a focus on forensic science and food quality monitoring, drawing on the insights from WP6, Task 6.5 (Connor et al., 2025).

In M35 and M37, the first and second part of the script, respectively, were finalized and shared with André Caetano. In mid M38, the full script was shared with the illustrator. Each draft underwent rigorous scientific revision by each of the six partners. This entailed both revising the script to align with the project and revising the scientific illustrations to appropriately depict the science and technology of the BIOASSEMBLER project, excepting proprietary and confidential information.

As with the Visual Dictionary, two editions of the comic book - titled “An illustrated journey through scientific discovery – The BIOASSEMBLER project” - are envisioned: the original English version and a Portuguese translation. Both editions will be made freely available as open-access e-books hosted on the BIOASSEMBLER website, ensuring broad and long-term accessibility. In addition, a limited print run of the Portuguese edition will be offered to local schools and other educational contexts, supporting direct engagement with secondary school and undergraduate students and teachers.

Dissemination and communication efforts for the Comic Book, as well as for the Visual Dictionary, will continue beyond the formal completion of the project. Planned activities include school presentations, press releases, and continued promotion through social media channels, reinforcing the project’s legacy and sustaining public engagement with biotechnology and biosensing research.

5. BIOASSEMBLER dissemination

The BIOASSEMBLER dissemination activities primarily target market/industrial stakeholders, policymakers, standardization bodies and the scientific community.

Following the dissemination plan presented in the DEC Plan (Campos, Ferreira, Valente, 2023), activities undertaken in the first year of the project aimed at promoting awareness about the project, thus prioritizing the generation of a community of interested stakeholders and suitable channels. However, given the opportunity to present the BIOASSEMBLER work in relevant scientific meetings with global projection, the second phase of the dissemination phase was initiated earlier than anticipated, in M3. This phase aims at disseminating the project and the generated knowledge mainly among scientific and industrial communities, ensuring the availability of research outputs to targeted audiences.

The last two and a half years of the project focused on scientific/technical dissemination, with team members actively seeking to present BIOASSEMBLER in scientific and industry events, and also publishing the first results in open access peer-review journals.

5.1. Scientific publications

By M42, six peer-reviewed articles related to the work undertaken within BIOASSEMBLER had been published. The Master's dissertation developed in the framework of the project was successfully defended, contributing to the project's scientific output and capacity-building objectives. In addition, one further scientific article has been completed and is ready for submission, extending the academic dissemination of BIOASSEMBLER's results beyond the project's lifetime.

The seven public deliverables submitted during the first 18 months of the project, and reviewed during the mid-term evaluation, have been made available on the project website under the "Outputs" section and promoted through the project's social media channels. Two additional public deliverables will be published following the final revision process with the European Commission (EC). At the conclusion of the project (M42), the publication and dissemination of all public deliverables are thus either completed or in their final stage of validation, ensuring open, transparent and sustained access to BIOASSEMBLER's outcomes.

Table 8 lists all BIOASSEMBLER scientific publications.

Table 8
BIOASSEMBLER scientific publication.

Full article – Title/Citation*	Link/DOI	Metrics
Das A, Santhosh S, Giridhar M, Behr J, Michel T, Schaudy E, Ibáñez-Redín G , Lietard J, Somoza MM (2023). Dipodal Silanes Greatly Stabilize Glass Surface Functionalization for DNA Microarray Synthesis and High-Throughput Biological Assays. <i>Analytical Chemistry</i> , 95(41), 15384-15393	10.1021/acs.analchem.3c03399	Article views: 4498 Altmetric Attention Score: 3 Citations: 19
Schaudy E, Ibáñez-Redín G , Parlar E, Somoza MM , Lietard J (2024). Nonaqueous Oxidation in DNA Microarray	10.1021/acs.analchem.3c04166	Article views: 2747

Synthesis Improves the Oligonucleotide Quality and Preserves Surface Integrity on Gold and Indium Tin Oxide Substrates. Analytical Chemistry, 96(6), 2378-2386		Altmetric Attention Score: 4 Citations: 9
Valente B, Pinto H, Pereira TS, Campos R (2024). Exploring Biosensors' Scientific Production and Research Patterns: A Bibliometric Analysis. Sensors, 24(10):3082		Article views: 5713 Altmetric Attention Score: 1 Citations: 7
Ibáñez-Redín G, Virkki M, Mäyrä A, Santhosh S, Behr J, Lietard J, Saviranta P, Somoza MM. Laser-directed photochemical synthesis of complex DNA microarrays and libraries.	Manuscript in preparation for submission to Angewandte Chemie, journal of the German Chemical Society (GDCh)	Not available
Working paper – Title/citation	Link/DOI	Metrics
Behr J, Michel T, [7 authors] Ibáñez-Redín G , [4 authors] Somoza MM (2024). An open-source advanced maskless synthesizer for light-directed chemical synthesis of large nucleic acid libraries and microarrays. ChemRxiv	10.26434/chemrxiv-2024-j4c90	Article views: 3090 Altmetric Attention Score: 2 Citations: 6
Conference paper – Title/Citation	Link/DOI	Metrics
Brito B, Campos R (2025) Abordagens artísticas e participativas na comunicação de ciência: primeiras reflexões sobre a percepção pública sobre biossensores [Artistic and participatory approaches in science communication: first reflections on public perception of biosensors].	https://doi.org/10.5281/zenodo.14643540	Not available (995 views of the whole document)

Proceedings of the SciComPt 2024 Conference, Zenodo.

Campos R, Brito B (2024a) The role of citizen science in public engagement with socio-scientific debates. In Vohland K et al. (eds) Change - The transformative power of citizen science. ARPHA Proceedings. In press.	https://doi.org/10.3897/ap.e126291	Article views: 1589 Altmetric Attention Score: 5 Citations: 1
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Master dissertation – Title/Citation	Link/DOI	Metrics
Brito B (2024). Comunicação de ciência pelo olhar da cultura: como abordagens participativas e baseadas em arte podem envolver públicos com a ciência? [Science communication through the lens of culture: how can participatory and arts-based approaches engage the public with science?] Master dissertation. University of Lisbon, Portugal.	http://hdl.handle.net/10400.5/97912	Document views: 50 Downloads: 61

Public deliverables – Title	Status**
D1.1 - Project Quality Management Plan	Published

D1.3 - Ethics Plan	Published
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D2.1 – Dissemination, Exploitation and Communication Plan	Published
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D2.4 - Evaluation of the dissemination, exploitation and communication actions	To be published
D4.1 - Chemistry for DNA on wafers	Published
D4.2 - Optimized zipcode sequences	Published
D4.3 - Illumination system for wafer-scale DNA synthesis	Published
D4.4 - Optimized full-wafer DNA zipcode synthesis	To be published
D5.2 - Antibodies	To be published
D5.4 - Report on the socioeconomic analysis of animal-to-recombinant transformation	To be published
D6.4 - Forecast on using Big data and AI with multiplexed silicon biosensors	To be published
D6.5 - Report: Socioeconomic Impact of Multiplexed Biosensors	To be published

*BIOASSEMBLER team member highlighted in bold when submitting with external colleagues.

**Published or to be published on the project website (following approval by the EC).

5.2. Scientific meetings and trade shows/industry events/stakeholder meetings

Over the grant period (M1-M42), BIOASSEMBLER team members participated in a total of 36 events, including conferences, tradeshow, workshops and laboratory courses (Table 9); 16 of which took place during the third and final year of the BIOASSEMBLER project. Two other participations are foreseen, one during the reporting period (M43; March 2026) and other after the expected final review with the EC (M45; May 2026).

The international dimension of these scientific communication efforts likely had a direct impact on the geographical diversification of visitors to the BIOASSEMBLER website from 39 to 81 countries between M24 and M42 (Section 4.1 above).

These activities also reflect the consortium's continued engagement with the international scientific and industrial community throughout and beyond the grant period.

Table 9

BIOASSEMBLER dissemination activities in scientific meetings and trade fairs.

Name	Type	Participation	Link
MEDICA and COMPAMED 2022	Trade fair	Gerhard Jobst, Jobst; presentation of biosensors and fluidic capabilities	https://www.compamed-tradefair.com/
Advanced Therapies Europe 2023	Trade fair/Conference	Gerhard Jobst, Michael Langemair, Jobst; presentation of biosensors and fluidic capabilities	https://advancedtherapies europe.phacilitate.com/
3D Cell Culture 2023: Models, Applications & Translation conference	Conference & exhibition	Nicola Altenhuber, Jobst; presentation of biosensors and fluidic capabilities	https://dechema.de/en/3DCC2023.html

3rd NEXT GEN ORGAN-ON-CHIP & ORGANOID WORKSHOP	Workshop	Michael Langemair, Jobst; presentation of biosensors and fluidic capabilities	https://www.csem.ch/en/events/next-gen-organ-on-chip-organoids-workshop/
Organ on a chip MasterClass – Oncology & Cancer Models	Workshop	Michael Langemair, Jobst; presentation of biosensors and fluidic capabilities	https://azar-innovations.com/organ-on-a-chip-masterclass-lectures-and-hands-on-lab-trainings/
2nd Microphysiological Systems World Summit	Conference & exhibition	Michael Langemair, Jobst; presentation of biosensors and fluidic capabilities	https://mpsworldsummit.com/
20th International Conference on Nanosciences and Nanotechnologies (NN23)	Conference	Petri Saviranta, VTT; oral communication - "BIOASSEMBLER - bioinspired assembly of binders on multiplex MEMS biosensors"	https://www.nanotextology.com/index.php/about-nn
Biosensors 2023	Conference	Anna Spehar, Biomensio/VTT; oral communication - "Mobile, multianalyte biosensing for actionable results at point-of-need"	https://www.elsevier.com/events/conferences/world-congress-on-biosensors
R&D Management Conference 2023	Conference	Bernardo Valente, Hugo Pinto, Tiago Santos Pereira, Rita Campos, CES; oral communication - "Markets and competencies of multiplex biosensors for a sustainable transformation:	https://eventos.upo.es/84186

		An exploratory bibliometric analysis"	
Triple Helix Conference 2023: Entrepreneurial and Engaged Universities for Sustainable Development	Conference	Bernardo Valente, Hugo Pinto, Tiago Santos Pereira, Rita Campos, CES; oral communication - "Entrepreneurial and engaged universities for sustainable development: linking education, research and innovation to achieve the SDGs & ESGs"	https://eventos.upo.es/84186
The 18th Munin Conference	Conference	Rita Campos, CES; oral communication - "The many paths for an open, participatory, and inclusive science"	https://site.uit.no/muninconf/
4S 2023 Honolulu Conference	Conference	Tiago Santos Pereira, CES; oral communication —“STS and STI Policy: do travelling STS concepts enact reflexivity in STI policymaking?”	https://4sonline.org/
ECSA 2024	Conference	Rita Campos, Bianca Brito, CES; oral communication - “The role of citizen science in addressing scientific controversies”	https://2024.ecsa.ngo/
SciComPt 2024	Conference	Bianca Brito, Rita Campos, CES; oral communication - “Abordagens artísticas e participativas na comunicação de ciência	https://scicom.pt/congresso2024/home

		[Artistic and participatory approaches to science communication]”	
Advanced Therapies Week	Trade fair/Conference	Michael Langemair, Jobst; presentation of biosensors and fluidic capabilities	https://advancedtherapiesweek.phacilitate.com/
Medical Technology UK	Trade fair/Conference	Michael Langemair, Jobst; presentation of biosensors and fluidic capabilities	
Microtec cluster conference	Conference	Michael Langemair, Gerhard Jobst, Jobst; presentation of biosensors and fluidic capabilities	microtec-suedwest.de
Triple Helix & ACEEU Conference 2024	Conference	Bernardo Valente, Hugo Pinto, Tiago Santos Pereira, Rita Campos, CES; oral communication - “Scientific partnerships and knowledge transfer on DNA recombinant”	https://triplehelixconferencebrazil.com/
XV Congreso Español de Sociología / XV Spanish Congress of Sociology	Conference	Bernardo Valente, Hugo Pinto, Tiago Santos Pereira, Rita Campos, CES; oral communication - “Explorando la base de conocimientos y el potencial científico de los biosensores: un análisis bibliométrico [Exploring the knowledge base and scientific potential of biosensors: a bibliometric analysis]”	https://congreso2024.fes-sociologia.com/

6th Conference of the European Sociological Association	Conference	Bernardo Valente, Hugo Pinto, Tiago Santos Pereira, Rita Campos, CES; oral communication - "Scientific partnerships and knowledge transfer on recombinant DNA"	https://www.europeansociology.org/conference/2024
Fachpresstag	Multi-press Conference	Mathias Reisbeck, Jobst; invited to give oral presentation of Jobst Technologies portfolio	https://fachpresstage.rbsonline.de/Fachpresstage2025
MicroTEC Cluster Conference	Conference	Michael Langemair, Gerhard Jobst, Jobst	microTEC - microTEC Clusterkonferenz 2025-Konferenzen
NOMATEN (H2020 857470) Centre of Excellence in Multifunctional Materials for Industrial and Medical Applications	Laboratory Course	Petri Saviranta, VTT; lecture - "Array-in-Well technology"	https://cordis.europa.eu/project/id/857470
MedTech Expo UK	Trade fair	Michael Langemair, Jobst; exhibition booth presenting biosensors and MEMS technology and applications	https://med-techexpo.com/
The World Congress on Biosensors 2025	Conference	Kristen Connor, Joana Sousa, Filipe Santos, Bernardo Valente, Hugo Pinto, Gustavo García-López, Tiago Santos Pereira, Bianca Brito, Rita Campos, CES; poster presentation - "Science meets society: the value of	https://lisbonvenues.pt/en/events/ccl-en/biosensors-2025-35th-anniversary-world-congress-on-biosensors/

		SSH in EU biosensor R&I and market research	
Compamed	Trade fair	Michael Langemair, Gerhard Jobst, Jobst; invited to give an oral presentation of Jobst Technologies portfolio	https://www.compamed-tradefair.com/vis/v1/en/exhprofiles/3pSD9jjhS5aSFcjdzBYnWw
PCST 2025 (Public Communication of Science and Technology)	Conference	Rita Campos, Bianca Brito, CES; oral communication - "The unfamiliarity of the familiar: how to communicate biotechnology-related science?"	https://www.abdn.ac.uk/events/conferences/pcst-2025/
IMCS, International Meeting on Chemical Sensors	Conference	Michael Langemair, Jobst; invited to give oral presentation of Jobst Technologies portfolio	https://imcs2025.com/
Termis EU, Tissue Engineering and Regenerative Medicine	Conference	Michael Langemair, Mathis Reisbeck, Jobst; exhibition booth presenting biosensors and MEMS technology + Workshop	https://eu2025.termis.org/partners-exhibitors/
Optics and Photonics Days 2025	Conference	Virkki Matti, VTT; poster presentation - "Laser scanner for photolithographic DNA synthesis in multiplexed biosensors"	https://www.photonics.fi/opd2025/
8th Cambridge Symposium on Nucleic Acids Chemistry	Conference	Gisela Ibanez, UniVie; oral communication - "Maskless laser lithography for DNA synthesis: towards large-	https://www.rsc.org/events/detail/77959/8th-cambridge-symposium-on-

		scale production of multiplexed biosensors”	nucleic-acids-chemistry-and-biology
2nd Annual Meeting on Digital Nucleic Acid Photolithography	Workshop	Gisela Ibanez, UniVie; oral communication - “Laser-directed photochemical synthesis of complex DNA microarrays: toward biosensor development”	https://www.leibniz-lsb.de/en/news-events/meetings
5th European Biosensor Symposium	Conference	Gisela Ibanez, UniVie; poster presentation - “Scalable photolithographic nucleic acid synthesis platform for multiplexed biosensor applications”	https://www.ebs2025.com/
Microbiotec’25	Conference	Kristen Connor, Joana Sousa, Filipe Santos, Gustavo García-López, Rita Campos, CES; oral communication - “Biosensors in practice: socioeconomic insights from forensics and food safety monitoring in Portugal”	https://mbtec25.org/nideia.com/program/
9th Annual Meeting of Political Economy	Conference	Kristen Connor, Joana Sousa, Filipe Santos, Gustavo García-López, Rita Campos, CES; oral communication - “From crime Scenes to aquaculture: social and political dimensions of emerging biosensor technologies in Portugal.”	

Advanced Therapies Week 2026, San Diego, CA; Cell and Gene Therapy	Conference	Michael Langemair, Jobst; exhibition booth presenting biosensors and MEMS technology and applications in the fields of personalized medicine	https://www.phacilitate.com/advanced-therapies-week/atw-sponsors-exhibitors
ECSA 2026*	Conference	Rita Campos, CES; oral communication - "Possibilities for citizen science in the design of Key-Value Indicators"	https://www.ecsa2026.ngo/
SciComPt 2026**	Conference	Rita Campos, CES; oral communication - "Cocriação artística e participação cidadã na comunicação sobre biotecnologia" [Artistic cocreation and citizen participation in science communication about biotechnology]	https://www.scicom.pt/congresso2026/home

*To be held on M43.

**Submitted.

5.3. Interdisciplinary advanced training course

The interdisciplinary Summer School "Critical Approaches to the sustainable transformation" was scheduled to take place in M23, at the University of Algarve, Campus de Gambelas, Portugal. Its main goal was to promote learning about the current challenges for sustainability transformation, PhD students and early career researchers to understand, articulate and discuss sustainable transformation's opportunities, benefits, challenges and impacts.

The School was organised around lecture sessions in the mornings, led by BIOASSEMBLER team members and guests; presentation of research and PhD projects and roundtable sessions led by participants in the afternoons; field visits to biotechnology and sustainable innovation labs and workspaces; and creative hands-on sessions. In addition to the members of the BIOASSEMBLER team, seven experts in the different scientific fields related to the development, use and impact of

biosensors that are in dialogue within the framework of the project were invited as keynote speakers and/or session facilitators.

A great effort was put in its interdisciplinary and transdisciplinary program, and in a widespread dissemination. But the number of registered participants was below the minimum number of participants required to create deep and meaningful discussions. As such, the decision was to postpone the School for a later date.

A new organizing committee met on M26 to reflect on possible causes for the low number of enrolments and to reformulate the course to attract more participants. A number of possible limitations were identified including: the dates (in the middle of July, when many students are already on vacation), the location (the Algarve, a congested and expensive tourist destination in the summer), the duration (the initial program schedule involved numerous long days of seminars and other classroom activities), and the topic (organized specifically around biosensors, which remains a relatively niche area). Based on this assessment, from M28 to M30 CES team members, in collaboration with the DEC Committee, designed a new advanced training course.

Taking into consideration all the above factors that contributed to low enrolment, including date, location, duration, and topic, the second iteration of the Advanced Course was well-enrolled and attended. Rather than focus exclusively on biosensors, the Advanced Course was organized around the topic of *interdisciplinarity* in *biotechnological* research and innovation, with reference to the BIOASSEMBLER project as an example. The new title reflected this shift: “Deep Interdisciplinarity in Biotechnological Research and Innovation: An advanced course for STEM and SSH PhD students, post-docs, and researchers”.

The main goal of this course was to invite participants from STEM and SSH backgrounds to analyse, discuss, and explore the actual practice of deep interdisciplinarity in biotechnology research, including discussing best practices, methods, challenges, and new approaches, drawing on the BIOASSEMBLER project as a case study and with reference to Horizon Europe’s SSH integration.

This hybrid Advanced Course was hosted by CES at the University of Coimbra (Portugal). It consisted of eight (8) hybrid sessions, six held across three days in M32 with two additional remote-only sessions in M33. There were 16 in-person and 10 remote participants for a total of 26 participants during the three days in M32. In M33, the Advanced Course remote sessions had a total of 33 participants across two sessions.

Four sessions were led by researchers in the social science, humanities, and arts (SSH). Four sessions were led by STEM researchers and industry experts, including specialists from within and beyond the BIOASSEMBLER consortium. In order to earn a certificate, participants were required to attend a minimum of five sessions, including two SSH-led and two STEM-led sessions. This requirement reflected the priorities of the course, which included questioning what it means to have deep and interdisciplinary collaborations between SSH and STEM experts, such as on Horizon Europe projects.

Each two-hour session was divided into presentations given by invited experts, followed by participant presentations in the second half.

Finally, while there is no quantitative measure to reflect the active engagement of participants during the course, the organizers agreed that the course attracted an unusually active, engaged, talkative, and open group of participants who were eager to share their research, experience, opinions, and make connections with each other. For example, while course organizers prepared a series of questions and conversation starters for each of the eight sessions, there was never a need to reference this document to stimulate debate or conversation.

One possible reason for the lively participation may have been the fact that all in-person participants were invited (and required) to give a brief presentation of their work as it related to one of the themes presented in the course. Another possible reason for the high levels of engagement could have been the deep interdisciplinary itself. Participants were invited and encouraged to reach across SSH-STEM epistemological divides and communicate their research and ideas in an accessible manner. Given the fact that few researchers shared the same academic background, common ground had to be forged through discussion rather than having been formed in advance as is the case with many academic courses, seminars, and conferences.

An online evaluation survey was sent to all participants in the days immediately following the Advanced Course, with the aim of collecting feedback on its organisation, content and overall impact. Four participants completed the survey.

Overall, respondents rated all assessed dimensions of the Advanced Course highly. These included the overall organisation, communication before and during the Course, technical conditions, scheduling and duration of sessions, thematic relevance, trainers' communication skills and subject mastery, the overall coherence of the programme, and its relevance to their academic work.

In addition to the quantitative ratings, qualitative responses were both positive and constructive. They provided valuable insights into participants' experiences and offered a deeper understanding of the Course's impact, particularly regarding its contribution to fostering interdisciplinary dialogue and critical reflection on biosensors and biotechnology research and innovation. The excerpts below illustrate some of these perspectives:

I think this course was a good learning experience. (P1)

The course fostered closeness between the various participants, from the business and academic sectors, moderating the discussion of the various topics with great skill. Everyone had the opportunity to express their points of view and ask questions. (P1)

I would recommend it, due to the importance of interdisciplinarity in the advancement of science and in the construction of more sustainable and ethical goods and services. (P1)

It was the first time I was involved with an art & science project and I was very enthusiastic of continuing to make this intersection through different ways (e.g. education). (P2)

Interchange and conviviality with other participants and organizers, themes and interdisciplinary of the program, the possibility of participants also share their projects and researchers, organization (P2)

It made me think about biosensors more critically (P3)

It has somewhat improved my understanding of R and I in biosensors; it was a good case study to choose and made me think about some social dimensions I had not considered about them before. (P3)

6. BIOASSEMBLER exploitation

Exploitation of BIOASSEMBLER's results and outcomes aims to promote broad uptake and replication of the results during the project's lifetime and beyond. This covers further research, increasing the potential for commercial exploitation, providing feedback to policy measures and exploring other possible uses for the novel biosensing technology.

The main lines for the exploitation plan are:

- The Point-of-Need Testing (PoNT) market analysis, with estimation of innovation trending and the Compound Annual Growth Rate (CAGR).
- The integration of biosensors with digital platforms analysis, including the developments in the point-of-care (POC) segment of the PoNT category.
- The distinctive features of the BIOASSEMBLER technology, with a focus on the innovative Mass-Sensitive Microarray (MSMA) technology.

Exploitation activities started in the beginning of the second year of the project (M13), with a preliminary analysis of the biosensors' market, in articulation with WP4 - DNA zipcoding (Valente et al., 2023). Understanding the existing and emerging markets are fundamental to identify plausible paths to commercialise the project results.

This section provides an overview of the various avenues for exploiting the outcomes of the BIOASSEMBLER project, including the use in future research and commercialization. It also discusses the exploitation potential of each of the core technologies developed in BIOASSEMBLER.

6.1 Photolithographic DNA synthesis technology

BIOASSEMBLER explored technological alternatives to translate photolithographic DNA synthesis from its established use in microarray fabrication to applications in multiplexed biosensing. This required the development of synthesis methodologies compatible with various materials and surface functionalization chemistries beyond conventional glass substrates, as well as light-exposure strategies suitable for large-scale fabrication.

A compact and portable maskless photolithography system based on a high-intensity laser was developed in the framework of the BIOASSEMBLER project.

In addition to meeting the project's technical requirements, the laser system enables controlled adjustment of key exposure parameters, including light intensity and irradiation time. This flexibility enabled us to gain insight into the photochemical mechanisms underlying DNA synthesis using well-established photolabile protecting groups. BIOASSEMBLER results demonstrate that photocleavage reactions can be completed with ultra-short exposure times in the millisecond range using high-intensity lasers, yielding full-length products of comparable quality to those obtained with conventional exposure systems.

These findings expand the potential of nucleic acid photolithography beyond microarrays. Laser-based optical systems are compact, portable, and significantly more cost-effective than legacy maskless array synthesizers, thereby increasing the accessibility of this technology. The approach can be adapted to alternative chemistries and extended to the synthesis of other nucleic acid analogues. This therefore anticipates applications in areas such as DNA data storage and multiplexed biosensors. Furthermore, the design of the laser-based exposure system facilitates its integration into customized fluidic platforms, opening the possibility for user-friendly systems enabling the on-demand synthesis of nucleic acid sequences and libraries. Such an integration is being pursued with Kilobaser, an Austrian company that manufactures personal, microfluidics-based nucleic acid synthesizers, and if successful, could lead to the commercialization of a portable multiplexed DNA synthesizer.

Some of the key findings of BIOASSEMBLER project in the field of DNA photolithographic technology are described in research papers that have been published or are currently in preparation (Table 8).

The optimization of the synthesis chemistry to ensure compatibility with conductive sensor surfaces was reported in the manuscript entitled *“Nonaqueous Oxidation in DNA Microarray Synthesis Improves the Oligonucleotide Quality and Preserves Surface Integrity on Gold and Indium Tin Oxide Substrates”*, published in *Analytical Chemistry* (DOI: doi.org/10.1021/acs.analchem.3c04166). In addition, a manuscript entitled *“Laser-directed photochemical synthesis of complex DNA microarrays and libraries”* is currently in preparation. This work describes the development of the laser exposure device and discusses key aspects of DNA photolithographic synthesis using short exposure times.

Further characterization of the impact of the laser exposure parameters on synthesis quality is planned, with the aim of defining optimized conditions for diverse potential applications.

Characterization studies using advanced technologies such as next-generation sequencing are currently ongoing and will also be published.

6.2 Self-assembly technology for sensor biofunctionalization

BIOASSEMBLER project has studied the feasibility of parallel self-assembly of bioreceptors on miniature sensor arrays in wafer-scale. The project has produced important insights into the process and its parameters in a realistic setting. Results indicate that self-assembly technology could be a viable approach also for other multiplexed miniaturized biosensor fabrication contexts, offering a powerful alternative to printing technologies.

Smart silicon biosensors could in principle be made much smaller if the size was not limited by the printing-based biofunctionalization step. Although some printing technologies achieve resolution down to 1 μm , they are not compatible with biomolecules and multiple parallel inks, or not scalable for high throughput production.

Results allow to envision a great potential for self-assembly technology as a general fabrication method for highly multiplexed microscale biosensor arrays.

We intend to follow up this project's results in an EIC Transition project to further explore the applicability of self-assembly technology for the manufacturing of various multiplexed sensor arrays. We will also focus on the industrial scalability of the process end-to-end, from the photolithographic step, through the bioreceptor assembly to the final biocompatible packaging of the multiplex chips.

6.3 Efficient site-directed coupling of single-stranded nucleic acids to (antibody) proteins

Conjugation of single-stranded DNA to proteins, especially antibodies, opens a variety of opportunities for diagnostic and therapeutic applications. In diagnostics, the DNA moiety enables antibody linking to innovative sensor elements, or barcoding and signal amplification (immuno-PCR).

For therapeutic applications, various conjugation technologies have become increasingly important. Antibody-drug-conjugates (ADCs) cover most of the current therapeutics research in the field of oncology and cancer treatment.

Key challenges include achieving site-directed conjugation and high conjugation efficiency. Both aspects were thoroughly evaluated within the BIOASSEMBLER project and showed performance comparable to current therapeutic standards. Nevertheless, freedom-to-operate and licensing options must be carefully considered. Among the coupling strategies evaluated in BIOASSEMBLER, the

SpyCatcher–SpyTag system proved to be particularly fast and robust. Although the technology is patented, licenses are available from Oxford University Innovation under reasonable terms.

6.4 Antibodies produced in BIOASSEMBLER

Abcalis has generated a series of new antibodies that are applicable as reagents for the IVD industry. These antibodies can be utilized for the development of new point of care tests for the important inflammation biomarkers C-reactive protein, Serum Amyloid A and Calprotectin.

These antibodies will be placed in Abcalis's product catalogue and will be available for commercial licensing for immunoassay test manufacturers. Furthermore, several antibody conjugates can be offered in these catalogues, increasing the potential customer market.

6.5 Fluidic packaging technology

Jobst developed new technological solutions for the manufacturing of small microchannel flow cells and their integration with sensor arrays on silicon chips. The developed solutions, such as the innovative gluing method developed in WP3 - MEMS, fluidics and integration, are readily applicable to other projects with Jobst's customers and collaborators.

6.6 Novel contact interface design for a disposable chip and a reader device

Biomensio developed an innovative adapter structure that will facilitate a one-step insertion of disposable sensor chips to reader devices equipped with embedded measurement and data analysis software. The sensors with fluidics are very small, < 5 cents coin and the proof-of-concept reading device of 1 kg weight is highly portable. Biomensio has - for other applications - developed hand-held devices for field testing, and they could eventually be adapted to this set up.

The result of BIOASSEMBLER project is biosensors with fluidics and adaptable biolayer, while the reader device contains fluidic interphase for sample and read out system. In the current setup, fluidically packaged sensors are manually wire-bonded to printed circuit boards. In future implementations, it is envisaged that the readout device will incorporate a permanent electrical interface to directly contact the sensor pads.

Owing to its compact size, the current setup is already easily portable to the measurement site (Tuppurainen, 2023). Further development could include additional miniaturisation and the integration of a battery-powered readout device, enabling point-of-need measurements in a wide range of settings, such as farms, fields, river sites, airports, or ambulances.

This result is exploitable not only for the acoustic sensor device but for any smart silicon-based multiplexed array chips that require integrated fluidic handling alongside electrical and data interfaces.

6.7 DNA-guided self-assembly technology for multiplex array chip fabrication

The DNA-guided self-assembly principle, although earlier demonstrated in different academic papers, has not previously been applied on a silicon-based sensor array. BIOASSEMBLER thus produced the first proof that this technology can be applied to a real manufacturing case. This methodology contains many qualitative improvements to earlier achievements, including: 1) fabrication of DNA zip codes by photolithographic synthesis, 2) dynamic self-assembly at the start of the assay, 3) Mix-and-match production of antibody-DNA conjugates and 4) high fidelity DNA hybridization to maximize the correct assembly and minimize cross-hybridization.

There are several advantages of wafer-scale biofunctionalization using on-surface DNA synthesis compared to traditional biofunctionalization of individual sensors using micro- or nanoplotters:

- Highly uniform biofunctionalization

Biofunctionalization of individual sensors is inherently prone to sensor-to-sensor variability caused by evaporation, sedimentation, and other processes that alter the composition of the functionalisation solution over time. Wafer-scale biofunctionalization ensures highly uniform surface chemistry across all sensors and enables true mass-production capability.

- High stability of DNA capture layers

Biosensors are most commonly functionalised with highly specific and sensitive antibodies. While effective, antibodies are biological macromolecules that gradually deteriorate, typically limiting sensor shelf life to approximately 12–24 months. In contrast, DNA is an exceptionally stable molecule and can be stored for very long periods without loss of functionality, enabling substantially extended shelf life.

- End-user-adaptable bioassays

Conventional biosensors are coated with target-specific receptors directly on the sensor surface, restricting their use to predefined applications. In this approach, sensors are functionalised with DNA strands that serve as universal anchoring sites. Any desired antibody or receptor protein can be conjugated to a complementary DNA strand using established chemistries and subsequently attached to the sensor surface in a specific and reliable manner. This enables flexible, user-defined multiplexing and broad applicability across environmental monitoring, food safety, pharmaceutical analysis, and diagnostic applications.

- Economies of scale

Biofunctionalization is typically one of the most expensive steps in biosensor manufacturing, as it relies on costly micro- or nanoplotting equipment operated in clean and highly controlled environments. Wafer-scale DNA biofunctionalization allows large numbers of uniformly coated, stable biosensors to be produced in parallel, significantly reducing per-device cost.

- Compatibility with fluidic packaging

Wafer-level processing facilitates early integration of fluidic structures, simplifying downstream packaging and improving reproducibility for biosensors that require precise and reliable fluidic interfacing.

6.8 Commercial potential of BIOASSEMBLER's manufacturing concept

During the BIOASSEMBLER project, the originally planned end-user and commercialisation partner, Biomensio, filed for bankruptcy and is therefore unable to continue with the commercial exploitation of the project results. Nevertheless, several innovations developed within BIOASSEMBLER retain significant commercial potential, and many of the technological advances are transferable to alternative sensing platforms.

The point-of-need diagnostic market is projected to grow at close to 10% annually towards 2029 (Figure 1).

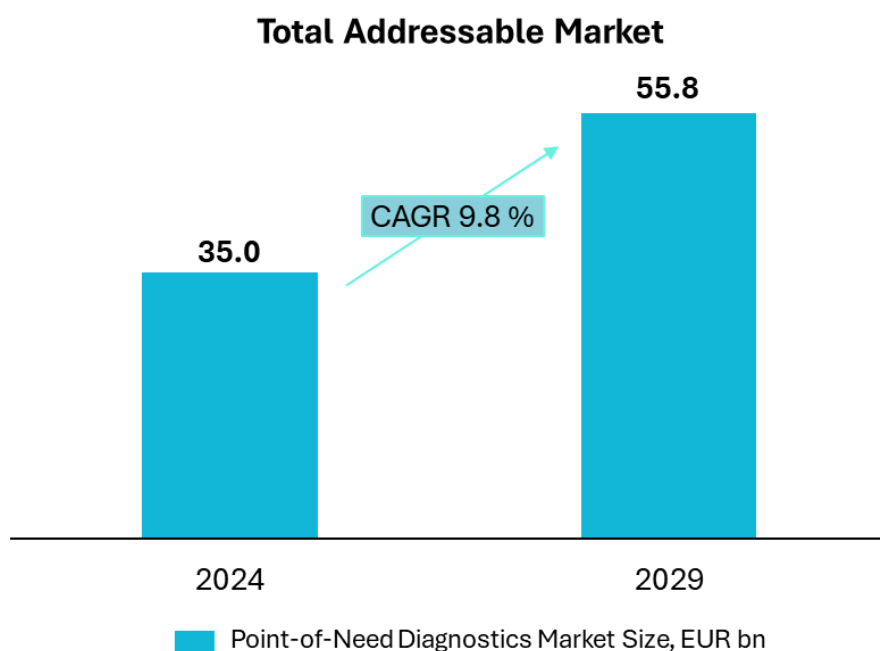


Figure 1 - Market size growth estimate of point-of-need devices (source: Biomensio)

The SARS-CoV-2 pandemic in 2020 resulted in substantial loss of life and severe economic disruption due to widespread societal shutdowns, but it also clearly demonstrated the critical need for reliable, rapidly manufacturable diagnostic testing devices. The technologies developed in BIOASSEMBLER directly address this need by enabling scalable production, robustness, and flexible assay adaptation.



Figure 2 - Market size estimates for different diagnostic areas (source: Biomensio)

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