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DELIVERABLE REPORT

WP18 JA8 – Bridging academic and industrial research

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Market Analysis Report

Due date

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NATURE

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1 INTRODUCTION

This report is a deliverable of Task 18.1 dedicated to the Market Analysis as part of WP18 “Bridging academic and industrial research”.

The main potential industrial users of NEP and related services, including of NFFA infrastructure beyond the NEP project, are entities from the two main cohorts: SMEs or large/multinational companies. The primary motivation for becoming a user of NEP is likely to be different between these two cohorts. SMEs may lack the resources to either acquire advanced instrumentation or obtain access to advanced facilities via commercial/contract services. The challenges of limited resources may be particularly relevant for start-ups. In contrast, large or multinational companies are likely to have substantial in-house resources and equipment as well as the financial ability to contract specialty services from external commercial providers. Nevertheless, for advanced research and development (R&D) activities of large companies, NEP is able to provide access to **unique facilities** and leading-edge **expertise** that are not commercially available. Accordingly, the access to infrastructure offered via NEP is not primarily in direct competition with services offered by existing analytical or fabrication companies. Rather, the preliminary and proof-of-concept R&D activities enabled by infrastructure access via NEP will be able to support the subsequent development, scale-up, and commercialization of new or improved processes, materials, or products.

The primary domains of expertise of NEP partners are nanoscience and nanotechnology, i.e., the facilities and expertise offered by NEP are inherently interdisciplinary. This interdisciplinarity naturally extends into the industrial applications of nanotechnology, which, rather than being concentrated in one or two industries, span a broad range of sectors, including materials and chemical synthesis/engineering, electronics and photonics (including the associated advanced technologies, such as superconductivity, spintronics, or quantum technology), energy (including photovoltaics, batteries, electrodes, catalysts for energy conversion, thermoelectrics, etc.), and pharmaceutics and biotechnologies.

A comprehensive analysis of all the above industrial sectors would extend well beyond the scope and resources of this project. Accordingly, the desk research addressed two representative cross-sections of the communities that can provide users for NEP facilities, services, and expertise: semiconductors and nanomaterials.

To collect primary information, a survey has been circulated among potential industrial users of NEP infrastructure, with questions designed to understand their needs in terms of services and to gain insights into their expectations. The collected information will enable NEP to optimize outreach channels in order to target industrial communities more appropriately in Task 18.2.

The results from the desk research and the survey are analyzed in light of the objectives of the Task 18.1, WP18, and NEP project and recommendations are provided in the final section of this report.

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2 DESK RESEARCH

2.1 Semiconductors

The semiconductor industry in Europe and Horizon Europe Associated Countries is self-organized into communities of transnational or national nature. In this section, representative communities are considered: Silicon Europe Alliance as well as national Semiconductor Industries in the UK, Israel, and Switzerland.

2.1.1 Silicon Europe Alliance

https://www.silicon-europe.eu/home/

The **Silicon Europe Alliance** is an Electronics-Based-Systems meta cluster, representing more than 2000 companies and research institutions that employ more than 400,000 people across Europe. Among these are ground-breaking research organizations, innovative SMEs, and global players, such as Arm, ASML, ASM International, Atos, AT&S, Bosch, Cisco, Epcos, Thales DIS, Globalfoundries, HPE, Infineon, Intel, Nexperia, NXP Semiconductors, Orange, Philips, SAP, Schneider Electric, STMicroelectronics, T-Systems, and Thales.

Figure 1 Silicon Europe Alliance Cluster Partners (from silicon-europe.eu)

As a meta cluster, the Silicon Europe Alliance unites (**Figure 1**) the following **Cluster Partners**:

- DSP Valley (Belgium)
- GAIA (Spain)

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- High Tech NL (Netherlands)
- Mesap (Italy)
- MIDAS (Ireland)
- Minalogic (France)
- Mobile Heights (Sweden)
- SCS Cluster (France)
- Silicon Alps (Austria)
- Silicon Saxony (Germany)
- TICE.PT (Portugal)

Micro- and nanoelectronics industry is contributing 30 bn EUR to European GDP (according to the Silicon Europe Joint Action Plan 2016–2018).

Figure 2 Technologies and application markets of the Alliance members (from silicon-europe.eu)

The Alliance members are leaders in digital technologies (**Figure 2**) including Micro- and Nanoelectronics, Cyber Security, Photonics, Robotics, and Internet of Things (IoT). These areas of expertise support the four main fields of applications:

- Smart Mobility
- Smart Living
- Smart Health
- Smart Industry

2.1.2 Semiconductor Industry in the UK

The UK semiconductor industry is not represented by a cluster in the Silicon Europe Alliance, but some of the major semiconductor companies operating in the UK, e.g., Arm or Nexperia, are members in the Alliance. As a national semiconductor industry with a substantial footprint, the UK ecosystem provides a good example of the common trends in the sector.

The physical infrastructure of semiconductor companies in the UK includes 19 fabs that produce silicon and/or compound semiconductors (indicated as Si and CS in **Figure 3**, respectively), which are distributed all around the country. These fabs do not have the most advanced, in terms of feature size, capabilities for processing silicon chips, but rather tend to focus on specialized applications, such as sensors, power, photonics, etc. (**Figure 3**)

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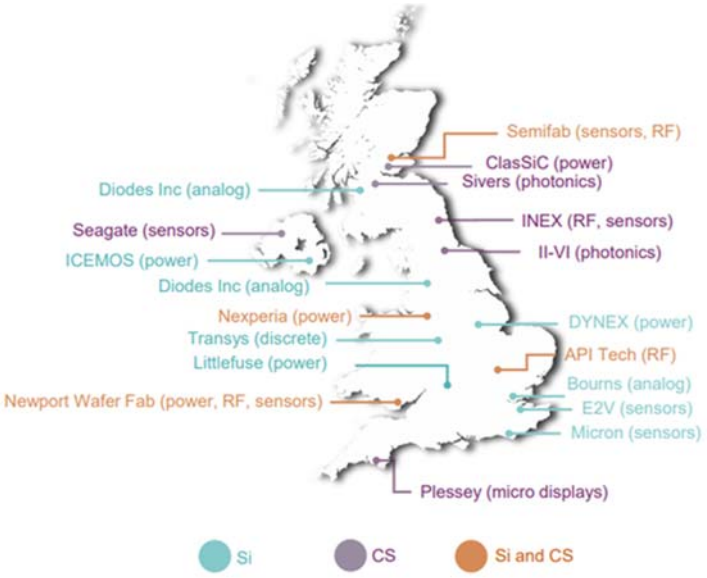

Figure 3 Semiconductor fabs in the UK (Source: CSA Catapult)

A well-organized national cluster in the UK is dedicated to compound semiconductors, supported by the government investments and including research and manufacturing partners.

Compound Semiconductor Applications (CSA) Catapult[1] was established to help the UK become a global leader in compound semiconductors through collaboration (**Figure 4**) with both large companies, and start-ups to develop and commercialize new applications utilizing this technology.

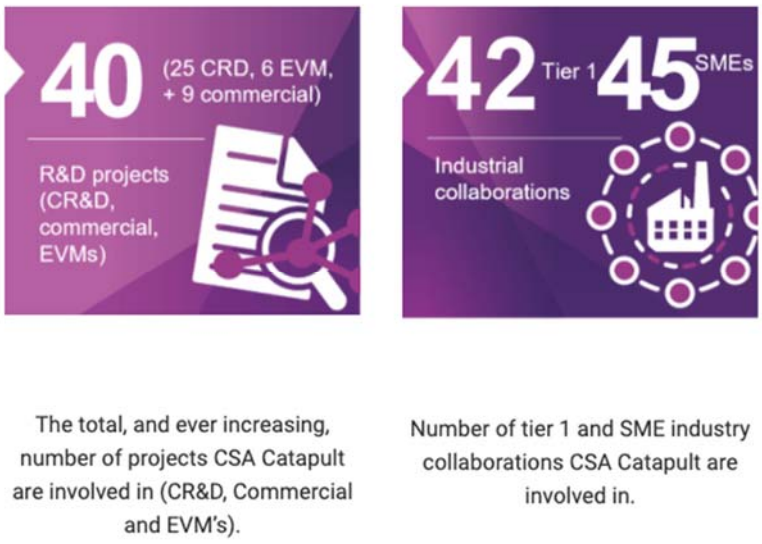

Figure 4 Examples of industrial activities of CSA Catapult (from csa.catapult.org.uk)

CSA Catapult is part of the **Compound Semiconductor Cluster** in Wales,[2] started in 2015 with a £75 million investment from Cardiff University. In 2020, the cluster received a £44 million investment and support from the U.K. government. The cluster expects to create 3000 jobs and establish an innovation village.

[1] https://csa.catapult.org.uk/
[2] https://tradeandinvest.wales/tech/compound-semiconductors

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The Compound Semiconductor Cluster includes:

- Compound Semiconductor Applications Catapult
- Institute for Compound Semiconductor Technology[3]
- Compound Semiconductor Centre[4]
- Future Compound Semiconductor Manufacturing Hub[5]

The **Newport Wafer Fab** in Wales is reported to have >50% global market share in compound semiconductor technology for chips used in smartphones, Wi-Fi, satellite communication systems, robotics, and efficient LEDs. The fab is at the center of an ongoing controversy surrounding its potential sale to a Chinese-owned company and a competing bid by a UK-based consortium, after the UK government raised national security concerns. This is a good example of the current volatility in the semiconductor industry, where supply-chain problems and increasing market demands are creating financial and political tensions at both national and international levels.

2.1.3 Semiconductor Industry in Israel

Many Israeli high-tech companies are based in the region referred to as **Silicon Wadi**, including Zoran Corporation, Aladdin Knowledge Systems, Mellanox, NICE Systems, Horizon Semiconductors, RAD Data Communications, RADWIN, Radware, Tadiran Telecom, Radvision, Check Point Software Technologies, Amdocs, Elbit, Israel Aerospace Industries and the solar thermal equipment designer and manufacturer Solel.

The semiconductor ecosystem in Israel is a good example of a mixture of companies that develop semiconductor devices without having in-house fabrication facilities and major companies that have large-scale production in their own fabs (Intel and Tower Semiconductor). Thousands of start-ups are created per year in the high-tech sector in Israel, about $200–300 million in capital is raised per year in communications sector.

2.1.4 Semiconductor Industry in Switzerland

Switzerland is another example of a semiconductor ecosystem that features a mixture of major companies and an active start-up scene. There does not appear to be a national semiconductor cluster in Switzerland.

There are several large semiconductor companies in Switzerland: STMicroelectronics (Europe's largest semiconductor chip maker based on revenue, $10B in 2020), Alpes Lasers S.A. (Infrared lasers), EM Microelectronic (ultra-low power, low voltage integrated circuits).

Many of the semiconductor start-ups in Switzerland were created as spin-offs from ETHZ and EPFL, with at least about 20 semiconductors start-ups having attracted $1–10 million investments.

[3] https://www.cardiff.ac.uk/institute-compound-semiconductors
[4] http://www.compoundsemiconductorcentre.com/
[5] https://compoundsemiconductorhub.org/

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2.2 Nanomaterials

Companies producing or importing nanoparticles as well as companies that are incorporating nanoparticles in their products (including as nanocomposites) represent a major potential market for nanocharacterization services. This market is driven by the EU regulations of nanomaterials, compliance with which requires significant amount of physicochemical characterization data to support the dossiers and applications for relevant regulatory agencies.

The diversity of industrial applications of nanoparticles, however, also means that these potential users are spread over many different industrial sectors and typically are not self-organized on the basis of using nanoparticles (in contrast to the example of semiconductor industry discussed in Section 2.1). Therefore, the companies using nanoparticles are a very diverse group that is hard-to-target via large clusters, associations, or other collective entities.

The difficulty of reaching out to the companies that need nanocharacterization services is highlighted by the experience from previous dedicated efforts.

The **Joint Research Centre Report** was published in 2014[6] following the review of the Recommendation (2011/696/EU) of the European Commission (EC) on the definition of the term 'nanomaterial'. A major activity in the development of this report was the collection (in 2013) of input from a broad range of stakeholders, who were contacted directly by JRC. While the development of the regulatory framework for nanomaterials was of clear importance for the stakeholders and the request for feedback came from a well-recognized authoritative source, the overall response rate to the circulated survey was approximately 25% (out of 255 invitations), with 67% of those responses provided by companies.

In an effort more focused in terms of the subject matter, EU **Nanomedicine Characterization Laboratory** (EU-NCL) project received 34 applications during 4 years of open calls (up to 2019), 19 of those applications were from SMEs.

Clearly, a significant outreach effort will be necessary to reach a broader community of companies using nanoparticles, especially the SMEs. In typical clusters or other collective entities, identifiable as potential targets for such outreach, there is a mixture of large companies and SMEs represented in a group of 10–30 companies. Four examples of different types of entities that could be useful for reaching out to the users of nanoparticles are presented below.

2.2.1 Nanotechnology Industries Association (NIA)

https://nanotechia.org/members

NIA is actively promoting the importance of characterization of nanomaterials and has worked with member companies to facilitate the associated collection of data. Among NIA members are about 30 companies, mixture of large companies and SMEs.

2.2.2 European Technology Platform Nanomedicine (ETPN)

https://etp-nanomedicine.eu/members/list-of-etpn-members/

ETPN is an initiative led by industry since 2005 and set up together with the European Commission, to address the application of nanotechnology in healthcare. ETPN member companies are interested

[6] Towards a review of the EC Recommendation for a definition of the term "nanomaterial"
Part 1: Compilation of information concerning the experience with the definition. Rauscher et al. JRC Scientific and Policy Reports (2014), Luxembourg: Publications Office of the European Union, doi:10.2788/36237

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in characterization of nanomedicine materials, which often involve the types of advanced characterization techniques offered by NEP.

2.2.3 ECETOC

https://www.ecetoc.org/ecetoc-membership/member-companies/

ECETOC is a Center for Chemical Safety Assessment, with members that are the leading companies with interests in the manufacture and use of chemicals, biomaterials, and pharmaceuticals, including nanomaterials.

2.2.4 Cluster Nanotechnology (Bavaria)

https://nanoinitiative-bayern.de/gb/cluster-nanotechnology/networks

Activities focus on SMEs, primarily support networking among SMEs and between SMEs and universities, colleges, or research institutes. The topics include the design and synthesis of nano and hybrid materials, the development of processing technologies, the establishment of analytics and quality control (including opportunity and risk assessment).

3 SURVEY

The survey was designed to collect information about the needs in terms of services and about expectations of potential industrial users of NEP. Invitations to fill out the survey online have been circulated via direct email messages to pre-existing contacts. The responses were collected anonymously, with no contact or other identifiable information requested from the participants. The answers were requested in the multiple-choice format, with additional free-text response fields available, where appropriate. The offered choices were based on the objectives of the survey, the characteristics of the target audience, and the services offered by NEP.

3.1 Survey Questions

The following questions were presented to the survey participants.

- What is the nature of your company?
  ☐ SME or start-up
  ☐ Large company
  ☐ Other, please specify below
- In what country is your company located/registered?
- In which sector(s) is your company operating?
  ☐ Micro- and Nanoelectronics
  ☐ Nanomaterials
  ☐ Sensors
  ☐ Energy
  ☐ Quantum technology
  ☐ Biotechnology
  ☐ Pharmaceutics
  ☐ Chemical synthesis
  ☐ Other, please specify below

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- Are you interested in services provided by NFFA research infrastructure for your R&D activities?
- Which services would be of interest/relevance for your R&D and business activities?
  ☐ Fabrication of nanoscale devices
  ☐ Deposition or growth of nanostructured materials or films/multilayers
  ☐ Functionalization of nanomaterials
  ☐ Advanced structural and morphological characterisation of nanomaterials or nanodevices
  ☐ Advanced electronic, chemical, or magnetic characterisation of nanomaterials or nanodevices
  ☐ Simulation of nanomaterials with computational tools
  ☐ Other, please specify below
- Would you be willing and able to pay for the access to these services?
- What approximate fraction of the budget in your company is dedicated to R&D expenses?
  ☐ 1%
  ☐ 3%
  ☐ 5%
  ☐ 10%
  ☐ >10%
  ☐ Prefer not to answer
- Does your company participate as a partner in EU-funded projects?
  ☐ No
  ☐ Infrequently (please provide an example or two below)
  ☐ Regularly (please provide an example or two below)
- Does your company collaborate on R&D with external entities?
  ☐ No
  ☐ Yes (please provide a brief explanation below, e.g., universities, regional technology clusters)
- How does your company choose external R&D collaborators or services?
  ☐ Marketing online
  ☐ Marketing at events
  ☐ Information/recommendations from colleagues or networks
  ☐ Personal contacts
  ☐ Based on research publications or presentations
  ☐ Other, please specify below

3.2 Survey Results

Survey respondents included four SMEs from Portugal, Germany, Italy, and Finland, for which the responses are summarized below.

The most common sectors of operation were **Micro- and Nanoelectronics** and **Sensors** (3 out of 4), followed by **Energy** (2 out of 4). Sectors of operation selected by only one company each were **Nanomaterials**, **Biotechnology**, and **Aerospace**.

All the companies were interested in services provided by NFFA research infrastructure. Two companies have subsequently expressed interest in preparing an access application with NEP.

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The most popular NEP services of interest were related to preparing or producing materials: **Fabrication of nanoscale devices** (3 out of 4), **Deposition or growth of nanostructured materials or films / multilayers** (2 out of 4), and **Functionalization of nanomaterials** (1 out of 4). One company selected **Advanced structural and morphological characterisation of nanomaterials or nanodevices** and **Simulation of nanomaterials with computational tools**.

Only one SME is willing or able to pay for the services of interest.

All the SMEs reported spending >10% of their budget on R&D.

A full range of answers was provided regarding the participation in EU-funded projects. One negative answer, and one "Infrequently" answer (in the primary sector of operation). Of the two "Regularly" answers, one company reported participation primarily via third-party agreements, while another reported the use of the H2020 SME Instrument and participating/coordinating research proposals.

All the companies reported collaborating with external entities, listing primarily universities and research centers as partners, apart from one company that also collaborates with industrial partners.

The most popular means of choosing R&D partners were **Information / recommendations from colleagues or networks** and **Personal contacts** (4 out of 4), followed by **Based on research publications or presentations** (2 out of 4). **Marketing at events** and **Marketing online** were chosen by only one company.

4 ANALYSIS AND RECOMENDATIONS

4.1 Market Size

Based on the numbers from the desk research (Section 2), the potential market for advanced nanocharacterization, nanofabrication, and other services related to nanoscience and nanotechnology is large, in terms of both the operating budgets and numbers of companies.

There is an important caveat, however, regarding the distribution of the operating budgets among the companies, whereby the majority of the billions of EUR per year turn-over is concentrated among a few large, typically multinational, corporations. This distribution is not entirely unexpected, as a limited turn-over is part of the definition of an SME. Realistic estimates of the market, therefore, have to rely on considering the fraction of the operating budget available at the smaller companies for external services, for many of which it means a fraction of 1–10 million EUR per year. With the cost of service provision by most of the NEP partners being >500 EUR per day, a realistic estimate would be that a typical technology SME may be able to afford to pay for one or two projects per year. While current NEP operation indicates that providing service to a sufficiently large number of companies would be feasible, the marketing efforts of acquiring such a large number of companies as paying users will be considerably more challenging.

A notable indication from the survey is that many SMEs may not be able to afford paying for advanced services. While R&D expenditures may be a large fraction of their budgets, those expenditures are likely dominated by payroll expenses, i.e., not easily redirected to paying for external services.

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Securing substantial projects from large companies poses a different challenge, as such model implies long-term R&D activities, which are difficult to arrange in a systematic and continuous fashion; there is also a strong competition from specialized technology centers that have traditional connections to specific industrial sectors.

4.2 Market Segmentation

The advanced nature of the services and expertise provided by NEP partners suggest that the initial marketing efforts are most optimally directed at industrial sectors in which R&D personnel are familiar with the offered techniques and methodologies. In such sectors, including the representative semiconductor (Section 2.1) and nanomaterial (Section 2.2) examples discussed in this report, the potential users are more likely to be aware of why the advanced services would be beneficial and valuable for their R&D work.

Conversely, while NEP is planning to make a dedicated effort to expand the user community to research fields that are not traditional users of the techniques offered by NEP, establishing such connections with the research community will provide only the initial step towards the broader acceptance in the associated industrial sectors. This effort represents a good long-term strategy for developing a new community of users, e.g., as students are hired by the companies or senior researchers create spin-offs. But in the near term, marketing advanced services to managers in a company who are not specialists (and possibly do not have the relevant technical background) will be extremely challenging. To help overcome that challenge, NEP can make an effort in earning word-of-mouth referrals and successfully completing marketable use cases in the targeted non-traditional user communities.

NEP offers both fabrication and characterization services that may be of interest to industrial users. The survey responses from SMEs indicated more interest in the former. This is an important issue to follow up in WP18, because academic researchers tend to be interested in both kinds of services. It is possible, for example, that industrial users include the necessary characterization in their R&D plans and are less interested in exploratory measurements by additional or complementary techniques. Therefore, the objectives of characterization and choices of techniques will be an important area to explore when helping industrial users to prepare their applications in NEP.

The original assumption that NEP services would be of interest to those SMEs that have significant R&D activities has been supported by the survey responses. Intriguingly, the participation of SMEs in EU-funded projects does not appear to be an important factor in determining their interest in advanced services. In other words, for some SMEs, their application for access via NEP may be their first substantial interaction with an EU-funded project. This will be another important issue to follow up in WP18, because it potentially broadens the target audience of SMEs, since only a fraction of them regularly participate in EU-funded projects.

4.3 Competitive Landscape

There are three main categories of entities that are operating in markets that partially overlap with the market targeted by NEP.

1. Commercial analytical companies. They typically will operate cost-effectively in routine and standardized services, including high throughput in terms of sample volume and the ability to offer ISO-compliant certificates of analysis. In these primary areas, NEP is not likely to be competitive with such companies. In cases where advanced expertise is required to establish or validate a new analytical procedure, NEP services may be cost-competitive with

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commercial actors, because such services are offered only by the companies that have a similar level of in-house expertise and charge for the advanced services accordingly.

2. Providers that are “local” to the user. Many universities and technology centers offer their services via open-access schemes, which may be attractive for local users in terms of both physical proximity and having pre-existing connections, i.e., advantages that NEP partners do not always have. The pricing may also be more attractive, although the prices for commercial users tend to be based on real costs and overheads, i.e., not subsidized. The user interface developed during NEP operation can be an important advantage in competition with the local providers, which may not always have resources for managing user requests at the level expected by the industrial users.
3. Large-scale facilities. As access at large-scale facilities tends to be oversubscribed, the special conditions for access as part of NEP user projects may not be maintained beyond the duration of NEP project. Excellence-based or paid access tends to be provided under comparable conditions at different synchrotrons, neutron sources, and other large-scale scale facilities.

For SMEs, the survey supports the original assumption that the main alternative to NEP services are the “local” providers (option 2 in the above list), as SMEs, particularly spin-offs, often have personal connections to local universities or research centers. How far an average SME might look for service providers is one of the questions that could be worth following up.

4.4 Recommendations

4.4.1 Continued Market Analysis

The results from this initial market analysis provided useful insights for the subsequent work in WP18 and inputs for the long-term sustainability planning. It will be useful to continue the market analysis activities throughout the project implementation, building on this report.

- The online survey has proven to be both practical and useful. It can be continued, with possible minor revisions, but in the same overall multiple-choice format and keeping the length short.
- Consider providing a link to the survey in the feedback from users upon their project completion.
- As NEP builds a GDPR-compliant contact list of industrial users as part of the efforts in WP17 “Communication and dissemination”, the online survey could be circulated more broadly to that community.
- A version of the survey could be adapted for academic users, to better understand any salient differences between the interests and expectations of the academic and industrial communities, as the former tend to dominate in the current NEP operation.

Three specific issues that would be interesting to follow up from the initial indications summarized in Section 4.2: (1) interest of industrial users in fabrication vs characterization services, (2) the correlation between interest of industrial users in NEP services and previous participation in EU-funded projects, and (3) whether SMEs are motivated to look for advanced services from providers that are not local to them or do not have a pre-existing connection.

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4.4.2 Outreach Strategies

In coordination with WP17 “Communication and dissemination”, the outreach strategies suggested as the most effective by the survey results will be emphasized. The strong preference for word-of-mouth recommendations and personal contacts evident in the current survey is in agreement with the previous experience and observations in other infrastructure-access projects. Pursuing these outreach strategies requires a strong involvement of the individual providers, in addition to the centralized efforts in WP17. Likewise, it is encouraging that research publications and presentations are also effective for engaging R&D-intensive SMEs, as publications and presentations by NEP users and partners will continually address this communication channel.

Explicit marketing efforts at events and on online platforms may need to be more specifically customized to the targeted audience, particularly of industrial users.

While large self-organized clusters, such as the Silicon Europe Alliance (Section 2.1.1), can provide an efficient mechanism for marketing to a large audience, such clusters typically do recognize the value of their contact lists and do not make them freely available for outside parties, particularly for providers of paid services. Cooperation with large clusters will require formal communications and agreements at the level of the NEP coordinator.

Conversely, smaller collective entities, such as the ones involved with nanomaterials (Section 2.2), will require more effort to contact individually, but are more likely to circulate information that is considered to be beneficial for the members.

4.4.3 Competitive Advantages of NEP

Considering the target communities and the competitive landscape, the primary advantage of NEP is the user interface that has been developed to take into account the interdisciplinary nature of nanoscience and nanotechnology and the resulting importance of internal coordination for providing the best combination of diverse backgrounds and complementary expertise of NEP partners. Without a strong user interface, the technical advantages may never reach the users.

Another advantage of NEP is the range and depth of the capabilities and expertise offered to the users, which is unmatched by any individual provider or by other infrastructure-access entities operating in the nanoscience and nanotechnology area.

Finally, a competitive advantage that NEP needs to establish with industrial users is the reputation of a reliable and trustworthy R&D partner. Large companies and SMEs alike always have concerns about the protection of their own intellectual property and about the fair exploitation of any new intellectual property created in projects with external parties. Creating and communicating industry-friendly policies will be important for establishing this competitive advantage of NEP.

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