EARTO Paper:
Setting-up a European Strategy for Technology Infrastructures

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Introduction

Europe has high ambitions: boosting its economic competitiveness and prosperity while the global competition is fierce, achieving the twin transition to a green and digital industry and society, building Europe's resilience and technology sovereignty in key European ecosystems and value chains to meet the needs of EU citizens. The ability for Europe to fulfil such ambitions largely depends on Research, Development and Innovation (RD&I). Industry's capacity to co-create, uptake and scale-up technologies into new products, processes and services on the market is key to boost their productivity and competitiveness. In this context, companies need to strengthen their collaboration with RD&I actors and secure an easy access to state-of-the-art Technology Infrastructures (TIs).

Technology Infrastructures (including demonstrators, testbeds, piloting facilities, living labs, etc.) are the backbone of dynamic RD&I ecosystems and stable innovation-driven value chains. Their strategic importance has been recognised in the EC Staff Working Document on Technology Infrastructures. These physical and/or simulated users' environments are indeed essential for companies of all sizes. TIs enable them to collaborate with RD&I actors to develop technology and high value-added solutions. TIs offer support all the way to system-level testing of entire products, services or processes in controlled, safe and close-to-real conditions, including validation to end-user clients and investors. Industry depends on the availability of technology infrastructures for validation, prototyping and upscaling before they can enter the market with new solutions. However, TIs require a lot of resources and competences to build, manage, operate and maintain. They are usually very costly, and they require highly skilled technical staff. Therefore, most companies cannot afford to have their own.

Accordingly, Research and Technology Organisations (RTOs), often in collaboration with other RD&I stakeholders, have since long taken the role of supporting industrial value chains by hosting complex large-scale technology infrastructures and providing an open access to industry of all sizes. As such, TIs support technology development and co-creation from proof of concept and validation in labs to prototype demonstration in industrial environment, with the aim to ensure technology uptake with high socio-economic impact. TIs differ from Research Infrastructures (RIs) who focus on scientific discovery at very earlier stages. However, collaboration between TIs and RIs is fostered in many cases.

Today, there is a critical momentum for the EU together with Member States to be more ambitious and to jointly develop a European Strategy for Technology Infrastructures with relevant stakeholders (including both the providers and the users of such facilities), boosting technology co-creation, scale-up and diffusion across Europe, supporting the green and digital transition, and strengthening Europe's technology sovereignty. Such shared European vision and common definition and understanding of Technology Infrastructures is greatly needed. It will also be key to ensure that Europe has the necessary TIs to keep up with technology developments and answer upcoming investment needs for industry transition, while safeguarding their long-term sustainability.

EARTO hereby puts forward a set of recommendations to contribute to the set-up and efficient implementation of a new EU Strategy for Technology Infrastructures:

- **Recommendation 1: Prioritise technology infrastructures in new EU and national policies, including in the new European Research Area (ERA) strategy, and make the key role they have in EU RD&I ecosystems more visible at EU level,** by: (1) linking all existing policy initiatives to the new European Strategy for Technology Infrastructures, (2) setting-up a governance model to steer such strategy, (3) adopting a common definition for technology infrastructures at EU level and harmonising the existing EU mapping and repositories based on such definition.
- **Recommendation 2: Ensure the creation and long-term sustainability of the necessary technology infrastructures at EU level,** by: (1) increasing cooperation and coordination between Member States at EU level and fostering a strategic foresight dialogue between the EC, Member-States and technology infrastructures' users and providers, (2) developing new public-private financing models to leverage investments while ensuring the right regulatory framework at EU level, and (3) facilitating access to EU Instruments and synergies of funds at all levels.
- **Recommendation 3: Support pan-European access to technology infrastructures by companies of all sizes to leverage their innovation capabilities,** by: (1) boosting their use in EU projects and (2) supporting the creation of EU thematic networks of technology infrastructures.

EARTO remains at the disposal of the EU institutions to further discuss these recommendations and support the set-up of this new European Strategy for Technology Infrastructures.

1. Technology Infrastructures: Essential for technology Development and maturation and to Accelerate Industry's Uptake

Technology Infrastructures are essential to ensure Europe's technology sovereignty. At the heart of European innovation hubs and ecosystems, TIs play a decisive role to efficiently transfer key technologies from research laboratories to innovative companies. TIs are mostly hosted by non-profit organisations such as RTOs, often in collaboration with other research organisations, universities or companies themselves. RTOs manage a diverse landscape of facilities answering the wide range of industrial needs and delivering high socio-economic impact.

1.1 Need for High Long-Term Investments Throughout Technology Infrastructures' Lifecycle

Key enabling technologies (KETs) have been a priority for EU's industrial policy for many years. They are the essential technology building blocks which underpin Europe's global leadership in various industries, especially in high value added and technology-intensive products and services. The Covid-19 crisis has exposed certain vulnerabilities of the EU in specific sectors. The EC Staff Working Document on "Identifying Europe's Recovery Needs" states that Europe should now strive to strengthen its strategic autonomy in those sectors.

- Such sectors are highlighted in the New European Industrial Strategy Communication, and include strategic digital infrastructures, key enabling technologies, defence & space, critical raw materials, and medical products and pharmaceuticals.
- The EC Communication "Repair & Prepare for the Next Generation (Recovery Plan)" also highlights 14 European industrial ecosystems, including for instance Mobility/Transport, Renewable energy, Aerospace and Defence, Electronics, Digital, etc.
- In addition, the EC report on Strengthening Strategic Value Chains for a future-ready EU Industry identifies six new strategic value chains to build and maintain Europe's technological capacity and ensure its leadership at global level: Connected, clean and autonomous vehicles, Smart health, Low-CO2 emission industry, Hydrogen technologies and systems, Industrial Internet of Things, and Cybersecurity.

Ensuring Europe's technology sovereignty calls for strengthening those industrial value chains in Europe. One of RTOs' core missions is to support Europe's industrial base by developing and co-creating highly innovative key enabling technologies together with their public and private RD&I partners along strategic industrial value chains, where TIs are a crucial element. Most of the time hosted and managed by RTOs themselves or by technical universities, Technology Infrastructures are an essential element of those value chains. They play a crucial role in the development of innovative technologies and skills, which are key to boost European industry's competitiveness, and to address societal challenges. They will enable the maturation and scale-up of the technologies that are necessary to reach the objectives of the European Green Deal and the European Digital Agenda. They will also be essential for Europe to recover from the current crisis and strengthen Europe's resilience in the long run.

In addition to the development and maturation of technology, TIs also enable to bind and integrate various technologies together, connecting one technology to various applications used in different scientific and industrial contexts. RTOs and their Technology Infrastructures thereby support technology diffusion, finding applications in areas far removed from the original goal of the original research idea. In addition, to achieve the twin transition, making the connection between digital and deep tech is essential to change the way we design, produce, commercialise and generate value from products and related services.

1.2 Technology Infrastructures at the Heart of European Innovation Hubs

Technology Infrastructures are a central element of European innovation hubs[1]. Aiming at accelerating technology uptake and scale-up by large and small industry, TIs provide the necessary services to solve industry's challenges, turning innovative ideas into large volume production, or transforming disruptive technologies into market-ready products and services, and they do so in the most efficient and sustainable way.

Large companies may own production lines with control facilities: those are typically used for the company's own purpose and designed to analyse and develop existing solutions closer to market, rarely suitable for the development, maturation and testing of new technologies. When developing the readiness of a manufacturing process for a new technology together with the development of the product itself, it is necessary to enable scaling-up production amounts from single demonstrators to small series. This is

[1] EARTO, European Innovation Hubs: an ecosystem approach to accelerate the uptake of innovation in key enabling technologies, 2018

often possible only in dedicated technology infrastructures, which are most of the time beyond the investment capabilities and skills needed to operate them for one single industrial stakeholder, least of all for SMEs. Large companies of international scale, but also mid-caps and SMEs therefore rely on TIs' providers such as RTOs to offer access to their wide range of facilities. Such access enables to share, and therefore considerably lower, both the risks and the costs of RD&I investments for industry, while speeding up the implementation of new solutions. It fosters and leverages RD&I investments by industry, most of which would not take place if these companies did not have access to RTOs' TIs. This is key to boost industry's productivity and competitiveness with high impact for society.

Depending on the context, a single technology infrastructure can be used for a wide range of activities: from investigating completely new technologies, to piloting, but also spin-off incubation, testing changes in existing products, and validating emerging concepts, either in collaboration with single industry partners (large and small) or together with a consortium of several players.

With their central role in European innovation hubs and RD&I ecosystems, TIs connect technologies to non-technological disciplines and services, including feasibility and regulatory compliance. TIs ensure the connection between a broad range of stakeholders, supporting companies to find the right partners to reach their goals. They also incorporate the users' perspective while looking at solutions bridging commercial interests and societal needs, for instance with the direct involvement of users within "living labs" to improve the societal acceptance of innovation. TIs also provide professional training and coaching and strongly contribute to the training of professionals on-the-job at the front end of industry's technology needs.

1.3 RTOs' Skills and Expertise: Key to Manage Technology Infrastructures

The management of technology infrastructures requires a set of skills to be able to operate them across the TRL scale. RTOs possess those skills:

- **Close connection both to the academic research world and the close-to-market industrial world thanks to their open innovation business model**, which gives them an optimal position to align technology development and maturation with concrete market needs. RTOs' close connection to industry indeed provides first-hand information on industry's needs and a long-term market vision, and thus the ability to create innovative concepts of industrial relevance in the long run.
- **Expertise for horizon scanning and technology foresight and assessment**, which is essential in today's fast-paced markets to make sure that TIs remain at the cutting edge of technology. This includes the identification of emerging technologies worth investing in from economic and societal points of view, the activities that are needed to introduce new technologies to the market, or the measures required to speed-up innovation. Such expertise is also used by policy makers at all levels to take knowledge-based decisions on RD&I policy[2].
- **Highly skilled and specialised human capital and know-how**, without which it would not be possible to create bridges between the many different disciplines and knowledge necessary to solve complex societal and industrial challenges. TIs require such specialised and highly skilled staff to maximise their potential utility.

Thanks to this strong expertise, the services provided by TIs are tailored and adapted to the target group. This specific and personalised support is particularly important for SMEs and can take many forms, from understanding their business-model and investigating their bottlenecks and challenges, to facilitating technology uptake.

1.4 A Diverse Landscape Supporting a Wide Range of Industrial Needs

The European technology infrastructures' landscape is diverse, ranging from state-of-the-art large-scale facilities such as full-scale test environments and cleanrooms, to networks of imaging technologies and resources such as datasets and computing systems.

Technology Infrastructures can be physical or virtual, and sometimes a combination of both. Linked to this, physical technology infrastructures may be located at a single location, or distributed across various sites (sometimes in different countries). All are usually accessed through a single-entry point, either in person, remotely, or via digital mechanisms.

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[2] e.g. RTOs' experience and capabilities for technology foresight and horizon scanning are also used at EU level, e.g. feeding into the [EC report on Future technology for prosperity]

Technology Infrastructures are rarely single domain-led, and many are focused across more than one technological or economic sector. Most infrastructures are designed from their outset to serve multiple sectors with applications across the economy.

Technology Infrastructures can have different dimensions:

- **National/European/International dimension**: only capability of its kind at national or even European/global level, even though other similar capabilities may exist in other countries. These technology infrastructures have a European/international reputation, with strong international draw and a diversified outreached capacity, targeting national, European or international users. They are often large-scale infrastructures, very costly to build, maintain and operate.
- **Regional/local dimension**: capability replicated in the country at a regional level, embedded in the local/regional ecosystem and answering the needs of local/regional customers (often SMEs). It is likely to be the only one in the Region and linked to that Region's Smart Specialisation Strategy (RIS3). They are often small to mid-scale facilities.

Technology Infrastructures can typically have two main purposes (sometimes combining them both):

- **Co-creation, development and maturation of upcoming, "breakthrough" and highly innovative key enabling technologies with the potential of creating new markets:** these technology infrastructures mostly target collaboration with companies with high innovation capacity (large industry but also high-tech SMEs and start-ups).
- **Transfer to and effective uptake of existing commercially available technology by the market, often in different domains, also called "broad roll-out" of technology**: these technology infrastructures particularly target SMEs with lower RD&I capacity, supporting them to incrementally integrate innovation into their products, resolving large profit & loss problems, modernising their production processes, etc.

Such typology is an attempt at generalising a complex and diverse landscape and it can of course lead to oversimplifications in several cases. In fact, many TIs can fall in-between categories and/or include different aspects which makes them difficult to put in one category or the other. In general, all types of technology infrastructures are essential to the well-functioning of efficient European RD&I ecosystems.

1.5 Technology Infrastructures: Delivering High Socio-Economic Impact

RTOs have a high impact in Europe, both from a science and technological perspective but also in social and economic terms[3]. An important part of such impact can be attributed to RTOs' technology infrastructures, which are an essential element to RTOs' technology transfer and co-creation capacity.

The 2018 EARTO Economic Footprint Study[4] includes 3 case studies analysing the economic effect (direct, indirect and induced) of RTOs' investments in specific technology infrastructure projects in 2015-2016. It shows that regardless of the size of the initial investment, investing in technology infrastructures always has a considerable impact, as shown in the examples below:

- **CEA's Jules Horowitz research Reactor (JHR)** is an international infrastructure project conducted by CEA in collaboration with industry partners, the European Commission, and research institutes from 7 different countries. This nuclear reactor is a unique experimenting tool to test material behaviour under irradiation in Europe. **In 2016 only, €66 million investment by CEA in the JHR infrastructure led to 1,240 jobs, €140 million revenue, €63 million value added, and €28 million fiscal and parafiscal return to the French government.** Similar effects were generated by CEA's €66.8 million investments in 2015. Given that this project started in 2002 and should be finalised in 2020, the total effects of the entire project are a multiple of these figures.
- **Imec's clean room** is a state-of-the-art technology infrastructure enabling to develop ultra-small chips with the latest industrial standards. To obtain a totally vibration-free and dust-free environment of extreme precision and accuracy, crucial for nanotechnology, the structure rests on 831 concrete piles, placed 18 metres deep in the ground. **In 2016 only, €20 million investment by imec in this new cleanroom led to 420 jobs, €46 million revenue, €20 million value added, and €8.2 million fiscal and parafiscal return to the Flemish government.** Imec's new clean room comprises a total investment of more than €1 billion: 10% for the building and 90% for the equipment. It includes investments both from the Flemish Government and from more than 90 industrial partners from the semiconductor industry.
- **In 2016, DTI invested in the creation of unique technology facilities**, including the purchase of an ion accelerator to develop new surface coatings which will open up entirely new industrial perspectives. DTI also invested to **upgrade some of its existing facilities** for advanced packaging

[3] See an overview of such impact studies in EARTO Recommendations for European RD&I policy post-2020
[4] See EARTO Economic Footprint Study - Impact of 9 RTOs in 2015-2016

development, making them one of the most modern in Europe. In 2016 only, a €2 million investment by DTI in these infrastructure projects led to **37 jobs, €4.2 million revenue, €1.8 million value added, and €0.8 million fiscal and parafiscal return to the Danish government.** Similar effects were generated by DTI's €2 million investments in 2015.

The considerable impact of TIs as demonstrated by the figures above is not even covering the full picture. Indeed, as detailed in the report's methodology, the approach taken is quite conservative and is only able to capture limited aspects of those TIs' impact. In addition, it is also worth noting that a substantial share of the impact of technology infrastructures includes non-economic aspects, such as the increase of citizens' well-being, environmental protection, national security, improved health and social cohesion, amongst others.

2. Barriers & Challenges Hampering the Creation and Long-Term Sustainability of Technology Infrastructures in Europe

Despite their key role in European RD&I ecosystems, technology infrastructures face many barriers and challenges which can prevent them from fully delivering on their potential. This include the insecurity of their long-term sustainability and/or the possibilities to create the new facilities needed to fill gaps and keep up with new technology developments and industrial needs.

2.1 Lifecycle of a Technology Infrastructure: High and Long-Term Investments Needed

Even though the duration of the different stages can substantially vary, the lifecycle of a technology infrastructure tends to follow a quite typical path as shown in Figure 1 below, which includes (1) a planning and construction phase, (2) an operation phase, and (3) an upgrade or repurposing phase, before eventual decommissioning. The succession between the different stages is not always linear and can be a fluid process with some stages running in parallel or overlapping. However, technology infrastructures are typically operational for many years and in development for some time before that.

Stable support and a long-term investment plan are vital to enable the full benefits for industry users, public and private co-funders, and to achieve greater socio-economic impact. However, many technology infrastructures today need to operate in complex funding landscapes, drawing on multiple streams of varying duration over the course of their lifecycle, often with short-term political priorities, which puts their long-term sustainability at risk.

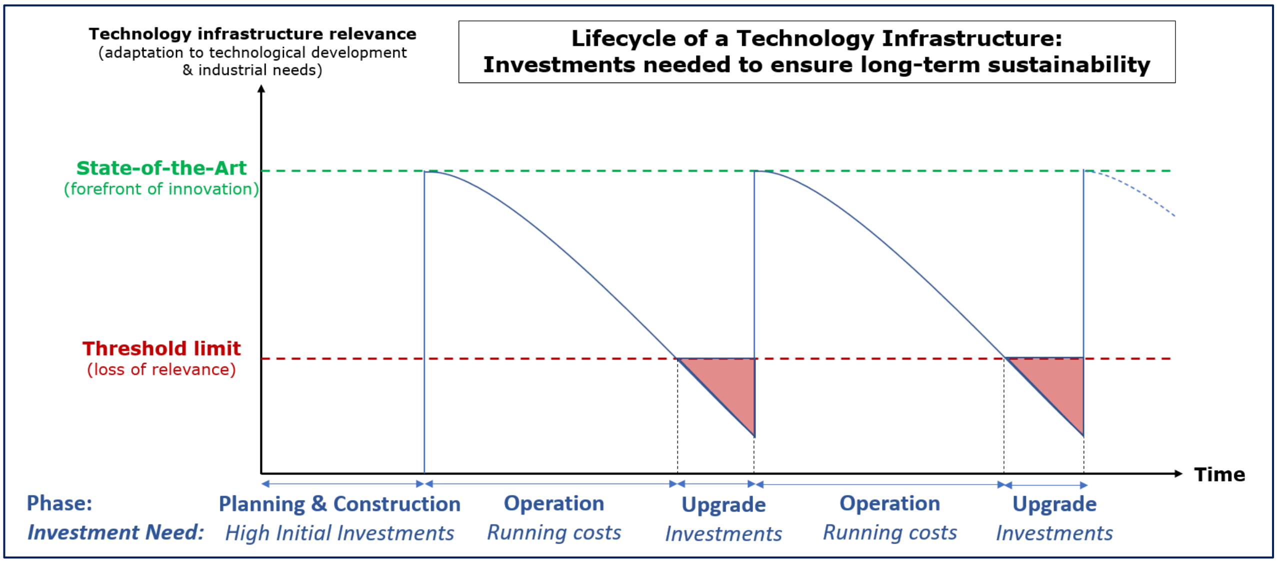

Figure 1: Lifecycle of a Technology Infrastructure: Investments needed to ensure long-term sustainability

Planning & Construction: High Initial Investments Required

Setting-up a new technology infrastructure requires high up-front investments, which are not affordable by individual companies on their own, even less so for SMEs. They are therefore at least partially publicly funded and managed by non-profit organisations such as RTOs or technical universities. Public funding enables to lower the risk and the cost for companies, which often co-invest in the technology infrastructure, giving rise to a mixed model of public (regional/national/EU) and private funding. It is also important to note that, from experience, public funding to TIs through loans is not sufficient: most public research organisations like RTOs cannot legally take loans, and in any case the financial constraints linked to loan-based financing would have a disruptive impact on the business models of such infrastructures.

A handful of public schemes exist at national level in some EU countries to secure initial capital investment for the construction of technology infrastructures, but they remain limited in scale, topics and country coverage, and they most of the time lack long-term perspective. Besides, due to the scale and costs of such facilities, some of these TIs can only be set-up through international collaborations and long-term strategic planning, and there is a lack of suitable instrument available for that in the cross-regional, pan-European setting. In addition, funding for the early-stage planning and investigation of new infrastructures, such as identifying the needs, building the case and technical design, scoping activity and feasibility studies, defining the governance and financial model and the legal status is often not available. New solutions are needed at national & EU levels to close the critical financing gap and the initial costs for the setting-up of technology infrastructures.

Operation: Covering the Running Costs of Technology Infrastructure at their Real Value

The use of technology infrastructures generates operational costs, which can be quite high. Depending on the size and type of TI, their use in projects will generate different types of operational costs, including for dedicated support staff. In addition, utility costs can also be quite high for certain types of technology infrastructures (e.g. electricity, heating, cooling, waste management, etc.). Other operational costs also add up such as those of base materials (often bought in bulk), consumables (e.g. chemicals, animals, etc.), premises (e.g. rental cost), maintenance, cleaning, security, depreciation of the equipment, etc.

Technology Infrastructures can be used in various projects in parallel, including through competitive publicly funded projects at regional, national or EU level, or through direct collaboration with industrial partners. Depending on the type of contract, operational costs can be covered by a diverse range of sources. Such operational costs are therefore quite impossible to allocate without allocation keys and relevant cost drivers. The use of cost allocation mechanisms based on the usual cost accounting practices of the organisation managing the technology infrastructure are therefore essential[5]. Besides, no technology infrastructure can run at 100% capacity for 100% of the time. Many can only run when operational staff are present, while others require blocks of downtime for maintenance, or to run non-output processes in the background. This needs to be taken into account when allocating eligible operational technology infrastructure costs to projects.

The uncertainty of funding is one of the main challenges faced by TIs during their operation phase. Such operational costs (which include both direct and indirect costs) are indeed rarely covered at their full real value in publicly funded projects, which means that technology infrastructures' providers need to cover part of these costs themselves, and they can be quite high. In addition, this uncertainty of funding also impacts high-skill personnel recruitment and retention, essential to run the technology infrastructure on a day-to-day basis.

Upgrade: Securing Long-Term Investments to Ensure Sustainability

Technology Infrastructures require long-term investments to ensure their sustainability in the long run. This is essential for them to keep up with the state-of-the-art, adapt to changing industrial and users' needs and technological developments, remain competitive while substitute infrastructures are created elsewhere in the world, and stay at the forefront of innovation.

Many technology infrastructures have operational lifespans of many years, but as the speed of technology development increases, their lifespan tends to get shorter, especially in certain technology areas. Failing to upgrade the technology infrastructure in time can cause users' demand to critically decrease. A good trade-off needs to be found between making full use of a technology infrastructure in the short run and sustaining and maximising its potential in the long run.

Crucially, the long-term sustainability of technology infrastructures requires stable financial support and long-term investments. However, the uncertainty around public funding cycles makes it very difficult to ensure. Today's reality is that it is often complicated to plan over three years ahead. This has consequences for the planning of any upgrades or repurposing needed to keep up with the state-of-the-art.

Besides, TIs have sometimes been initially co-funded in view of particular goals/applications by the private partners concerned, while they could serve many other domains. A broader industry community could therefore be called upon to participate in the upgrades, however, it is usually very difficult to simultaneously raise funds from different communities that may have different interests and time constraints.

2.2 Gaps in Technology Infrastrucures' Landscape for Key European Ecosystems

Dedicated policies for Technology Infrastructures are currently lacking, while TIs are essential for the successful implementation of the EU's policies, including the Green Deal and Digital Strategies. Creating new technology infrastructures at the forefront of innovation is essential to offer capabilities for new technological challenges and to support new technology uptake by European companies, enabling them to transform and stay competitive in the global market. New technologies need to be developed, demonstrated and verified as quickly as possible to enable fast scaling-up of new products and services and solve industrial and societal challenges in due time.

As highlighted in the European Industrial Strategy, there is already a lack of appropriate technology infrastructures in certain areas in Europe: such gaps need to be filled to ensure Europe's technology sovereignty in key industrial ecosystems and attached strategic value chains. Building on the successful

[5] For more information see EARTO paper on Horizon Europe's Internal Invoices Scheme, 2020

examples of previous European alliances such as for Microelectronics, the set-up of new industrial alliances in key sectors such as Clean Hydrogen, Low Carbon Industries, Industrial Clouds and Platforms or Raw Materials will also most certainly require the use of state-of-the-art technology infrastructures.

There are also tensions between the establishment of new technology infrastructures against maintaining and upgrading the existing ones. Making such investment decisions is a critical part of managing any technology infrastructure portfolio and ensure the best value for public investment. However, the current lack of strategic oversight makes future planning difficult. A coordinated strategic approach at national and European levels is needed with a forward-looking approach to identify the priorities in the next decade. This requires a solid understanding of the current technology infrastructure landscape including the identification of the ones that need upgrading and those which are missing. Such strategic approach should be based on industry's and society's needs and technology infrastructures providers' anticipation of such needs, gaps and related opportunities. It also needs to be underpinned by a clear cycle of monitoring, review and performance evaluation, which, given the diversity of the landscape, needs to be planned early in the technology infrastructure lifecycle, so that they are adapted and fit for purpose. A coordinated approach at EU level for the creation of new cost-intensive technology infrastructures can also help to avoid unnecessary duplications, always to ensure the best value for public investment at European level.

2.3 Cross-Borders Access to Technology Infrastructures to All Users at EU Level

Cross-border collaboration is abundant when it comes to research projects, especially within the EU Framework Programmes. RTOs have gathered considerable experience from engaging in technology infrastructures' collaboration in European projects. However, providing cross-border access to technology infrastructures faces serious challenges, especially due to the lack of dedicated policies and investment mechanisms with a holistic and long-term perspective. A few ad-hoc network collaborations of technology infrastructures do exist today at European level[6], either based on strong relations between RTOs or strong industry users' demand. Returns on those experiences should be used to further spread and systematise such cross-border collaborations.

While technology infrastructures are key for companies to access technology and stay ahead of global competition, companies often lack knowledge about the possibilities for accessing them, especially across borders. Such lack of knowledge has a high search cost. This is mostly the case for SMEs with low innovation capacity and limited resources, for which the proximity of facilities as well as potential language barriers and contractual arrangements are of particular importance.

Ensuring cross-border access to technology infrastructures for companies of all sizes would also lead to an increase in the potential market size for such infrastructures, as they would then have access to a European-wide range of users. This would help achieve the necessary utilisation rates to justify the set-up of very large and cost intensive technology infrastructures, for which the natural national home market might not be enough. In addition, covering the high costs for the long-term sustainability of such infrastructures require to attract investments and cooperation partners, both nationally and at European level.

Connecting technology infrastructures together across borders and across sectors would also be very beneficial to increase knowledge transfer and capacity building, as well as to spread excellence and expertise in order to overcome the European innovation divide. Technology infrastructures clearly contribute to increase regional attractiveness for investments, companies and skills. TIs should therefore be one of the key targets of the revised European Research Area (ERA) strategy. However, the development of closed and more intense collaboration and networks is nowadays hampered by a lack of awareness of potential synergies that could be achieved, possible organisational lock-ins and a lack of commonly agreed best-practise models for organising cross-border collaboration between technology infrastructures.

2.4 Right Regulatory Framework to Support Investments in Technology Infrastructures

The current funding landscape requires to explore new public-private partnerships models to leverage investments when setting up technology infrastructures. However, this can give rise to potential issues linked to the application of EU state-aid rules for RD&I at national level. The main issue often arises from the margin for interpretation left to EU Member States, which leads to a fragmented application of such

[6] e.g. the H2020 AMICI project which creates a network of "Accelerator and Magnet European TIs, also demonstrating how TIs enable to provide the components necessary for the construction or upgrading of RIs.
the DTI Production and Material Hub, which connects RTOs together and aim at aims at providing companies an easier access to RTOs' experts and TIs across borders;
the European Research Fab for Microelectronics, which connects the state-of-the-art TIs from 3 RTOs (see Annex 1).

rules. Some Members States tend to be risk-averse and often have a too narrow interpretation of these rules, resulting in difficulties for RTOs. For instance, the increased administrative burden due to the application and strict interpretation of EU State Aid rules in some EU countries create important barriers to the creation and management of state-of-the-art technology infrastructures. This can result in important delays and loss of competitiveness vis-a-vis other global competitors, and limit industry's access to these technology infrastructures. Indeed, the main competitors of EU RD&I organisations, when it comes to building a large-scale technology infrastructure, clearly come from outside the EU and are not subject to such regulatory framework, giving them a clear competitive advantage. The State Aid rules should clarify that both RIs and TIs managed by non-profit organisations such as RTOs should not fall under the EU State Aid rules. This is essential to foster the smooth creation of new TIs, but also to ensure their openness to all private partners (incl. large and small companies) and a sound financial model to cover the running operational costs.

3. EARTO Recommendations to Set-up a European Strategy for Technology Infrastructures

There is a critical momentum for the EU together with Member States to be more ambitious and to jointly develop a European strategy for technology infrastructures with relevant stakeholders to boost technology co-creation, development, diffusion and scale-up across Europe. This is essential to support the green and digital transition and strengthen Europe's technology sovereignty. Such shared European vision is greatly needed to ensure that Europe has the necessary technology infrastructures to answer upcoming technology needs, while safeguarding their long-term sustainability. This strategic approach should be based on the industry needs in key EU industrial ecosystems and TI providers' anticipation of such needs, gaps and related opportunities. It should also link to regions' smart specialisation strategies. Boosting pan-European access to technology infrastructures would create an EU "single market" for Technology Infrastructures, which would help achieve the necessary utilisation rates to justify the set-up of very large and cost-intensive facilities and leverage private investments at European level. It would also help reduce discrepancies between Member States and regions, creating more opportunities for all to benefit from a European ecosystem of accessible and shared technology infrastructures.

Recommendation 1: Prioritise technology infrastructures in new EU and national policies, including in the new European Research Area (ERA) strategy, and make the key role they have in EU RD&I ecosystems more visible at EU level. This requires to:

1. **Link the existing policy initiatives addressing technology infrastructures at EU level to the new EU strategy and prioritise technology infrastructures in new EU and national policies, including in the new ERA strategy.** Even though the existing policies offer different types of support mechanisms (see points 3.2 and 3.3 below), connecting them into one strategy would contribute to an increased visibility of technology infrastructures in the policy landscape, while reinforcing synergies, reducing unnecessary duplication and overlap and make better use of the financial and human resources at hand in Europe. Technology infrastructures also need to be taken into consideration when deciding on RD&I strategies, programmes and funding priorities at all levels. A focus on technology infrastructures should be included as a key priority within the RD&I section of the European Semester, and recommendations to set-up national funding schemes to support the creation and upgrade of technology infrastructures should be recommended if those do not already exist in the Member State in areas of relevance. Support for the long-term sustainability of technology infrastructures should also be a clear target of the revised ERA strategy and clearly reflected in its new governance structure: a new ERA working group on technology infrastructures should be set up to this effect within ERAC, involving both national Research Ministries and Economic and Industry Affairs' Ministries. The European strategy for technology infrastructures should also be embedded into the overarching European Industrial Strategy.
2. **Jointly discuss the set-up of a governance model together between the European Commission (DG RTD, GROW and CNCT), Members States and technology infrastructures' providers and users**. The objective would be to provide strategic advice both for the coordination of investments and for the identification of relevant sources of funding, including through EU instruments such as the new Recovery & Resilience Facility linked to the European Semester, Important Projects of Common European Interest (IPCEI), Structural Funds, the Horizon Europe and the Digital Europe programmes, etc.
3. **Jointly develop and adopt a common definition and criteria for recognition for technology infrastructures at EU level and harmonise the existing EU repositories and mappings based on this definition.** There are currently many different concepts that could enter under the title Technology Infrastructures, which can create confusion for users to access TIs, for providers to manage and operate TIs and for policymakers to support TIs. The European Commission, Member States and technology infrastructures providers and users, should therefore jointly align on a common definition of technology infrastructures at EU level. This will be essential to identify technology infrastructures in Europe. Moreover, (1) harmonising the already existing repositories and mappings at EU level done by DGs GROW, RTD, CNECT, JRC and the EIT, (2) providing a single digital entry point for instance, and (3) organising a wide communication campaign via the new EU Strategy on TIs, would greatly improve their accessibility. This would help users to know what technology infrastructures already exist and policy makers to have a better understanding of the European technology infrastructures' landscape. It should cover technology infrastructures' locations as well as the services and facilities on offer (including technical capabilities and specifications, market-readiness levels supported, detailed features, terms of usage, etc.).

Recommendation 2: Ensure the creation and long-term sustainability of the necessary technology infrastructures at EU level. This requires to:

1. **Increase cooperation and coordination between Member States at European level to address the long-term sustainability of technology infrastructures and foster a strategic foresight dialogue between the EC, Member States and the providers and users of those infrastructures**. Strengthened cooperation would help coordinate national and regional programmes and policies for technology infrastructures, while ensuring that they match broader EU strategic objectives, including Horizon Europe partnerships & missions, Strategic Value Chains, Regional Smart Specialisation Strategies, the new European Industrial Strategy (including the creation of new industrial alliances), the EU Green Deal and Digital agendas, etc. Creating a strategic foresight dialogue between the EC, Member States and technology infrastructures' users and providers would also enable to identify industry's needs, and strategically fill possible gaps based on national positions and strength. This would foster the joint set-up and financing of new cross-border large-scale technology infrastructures to respond to emerging priorities. Th use of Important Projects of Common European Interest (IPCEI) can be further explored. In addition, strengthened coordination would help reducing any unnecessary duplication for the set-up of large-scale and cost intensive technology infrastructures.

2. **Develop new public-private financing models to leverage investments in technology infrastructures with a long-term vision and ensure the right regulatory framework at EU level to prevent any unwanted barriers that risk hampering the EU's innovation capacity**. Fostering public investments in technology infrastructures at all levels (regional, national, European) is crucially needed to lower the risk for industry to co-invest. Those public investments will then leverage additional investments from the private sector, which are now expected to be even lower than usual due to the Covid-19 crisis. To ensure TIs' sustainability, new business models need to be explored and developed. In addition, to make sure that those new public-private funding models can be implemented in practice, further integration between RD&I and competition policies is essential at EU level. For instance, the specificities of the RD&I sector should be clearly recognised in the revised EU state aid rules, including with regards to technology infrastructures. The interpretation of such rules at national level should also be monitored to ensure that risk-aversion mechanisms do not create unwanted barriers to the creation and co-funding of technology infrastructures between non-profit organisations and industry.

3. **Facilitate access to EU Instruments to support the creation and long-term sustainability of cross-border technology infrastructures, and improve synergies between European, national and regional funding schemes.** The next MFF 2021-2027 and Next Generation EU include several opportunities to support the creation of a pan-European network of TIs. For instance, the Digital Europe Programme Calls to create Testing and Experimentation Facilities are a step in the right direction and should especially target the creation of technology infrastructures with a long-term sustainability. Such model could be extended to other sectors than the digital one by being implemented via other EU funding programmes such as Horizon Europe. In addition, the new European Recovery & Resilience Facility should include an RD&I window with a dedicated support to technology infrastructures, to be addressed by Member States when setting out their reform and investment agenda for the next years. Dedicated support to the creation of new technology infrastructures and upgrade of existing ones should also be further fostered at regional level, for e.g. via the European Structural Funds, providing the necessary funding rates. The new Interreg Component 5 for Interregional Innovation Investments should also be focused on creating cross-border technology infrastructures. This would help address the innovation divide across regions in Europe.

Recommendation 3: Support pan-European access to technology infrastructures by companies of all sizes to leverage their innovation capabilities. This requires to:

1. **Boost the use of technology infrastructures in EU funded projects to foster technology co-creation, maturation and scale-up.** This will contribute to increase the impact of the EU Framework Programmes by fostering collaboration for technology development, while increasing the visibility of technology infrastructures at EU level which can then be further used by industry in subsequent projects. The use of TIs in specific collaborative projects, in particular in partnerships and missions, should be strengthened and covered by dedicated ex-ante criteria and Key Performance Indicators (KPIs), as a token of the projects' potential impact. In addition, to boost SMEs access to a broad portfolio of technology infrastructures across borders, learning from previous European (and National) voucher-schemes pilots, linking different technology infrastructures together, should be further improved and used more widely, such as H2020-I4MS

(e.g. ROBOTT-NET) or Interreg (e.g. HYPEREGIO B2B, SmartPilots). A minimum share of subcontracting to technology infrastructures for demonstration activities should also be included in the projects funded by the EIC Accelerator. In such European projects, appropriate funding mechanisms should be put in place to cover the use and real operational costs of technology infrastructures via the acceptance of unit costs and allocation keys (see EARTO paper on Horizon Europe's Internal Invoices' scheme). Dedicated practical support to SMEs to enable easier access to TIs could also be put in place at EU level (incl. support for language translation, contractual agreements, etc.).

2. **Foster the creation of structural thematic networks of technology infrastructures at EU level linked to smart specialisation strategies by providing dedicated support and funding for network and orchestration activities**. This could first be initialised by a pilot project including foresight studies and roadmaps, prior to be more widely extended. Creating more systematic links between technology infrastructures throughout Europe is indeed essential to increase knowledge transfer and capacity building across regions, as well as to spread excellence and expertise in order to overcome the European innovation divide. This will strengthen the creation of a dynamic, flexible and accessible ecosystem at EU level, enabling technology infrastructures' providers to offer local and regional industry better technology services, as well as advising on possibilities abroad which they cannot supply themselves. This will therefore contribute to incrementally moving towards a wider cross-border accessibility to technology infrastructures by companies of all sizes, regardless of their geographical location within Europe. Strengthened thematic networks and cooperation between technology infrastructures could also lead to the development of common framework for access conditions to technology infrastructures, which could help build trust and transparency among users and providers and create framework conditions to handle sensitive or confidential material.

EARTO remains at the disposal of the EU institutions to further discuss these recommendations and support the set-up of this new European Strategy for Technology Infrastructures.

RTOs - Research and Technology Organisations: *From the lab to your everyday life. RTOs innovate to improve your health and well-being, your safety and security, your mobility and connectivity. RTOs' technologies cover all scientific fields. Their work ranges from basic research to new products and services development. RTOs are non-profit organisations with public missions to support society. To do so, they closely cooperate with industries, large and small, as well as a wide array of public actors.*

EARTO - European Association of Research and Technology Organisations: *Founded in 1999, EARTO promotes RTOs and represents their interest in Europe. EARTO network counts over 350 RTOs in more than 20 countries. EARTO members represent 150.000 highly-skilled researchers and engineers managing a wide range of technology infrastructures.*

Annex 1: Examples of RTOs' Technology Infrastructures

The European Research Fab for Microelectronics connecting TIs from 3 European partners:

- **CEA (France):** **LETI's cleanrooms** consist in 8,500m^2 dedicated to state-of-the-art nanoelectronics covering the value chain from materials to device prototypes. Clean rooms are open 24-7 and are operated in such a way as to provide a high level of expertise and offer highly qualified Staff. With 500 research scientists, engineers and technicians, protocols are in place for treating innovation needs in all corresponding strategic European sectors, including High performance computing and Cyber-physical systems. So far, €500 million have been invested in clean rooms through public and private funds and annual operating and maintenance costs reach €60 million. The need to upgrade European world class infrastructures for critical electronic components and systems is essential for Europe to prepare the future and stay in the course (i.e. new generations of computing & Cyber physical Systems). To guarantee sustainability for both civilian and defense applications, which also relies on complementary European RTOs technology infrastructures, the CEA cleanrooms upgrade will require €200 million from 2018-2022.

- **Fraunhofer (Germany):** **Research Fab Microelectronics** is a unique platform combining all major publicly funded Institutes of Applied Research in microelectronics in Germany. When completed in 2020, FMD will have over 12,500m^2 of clean room facilities for new microelectronic devices prototyping, testing and pilot production. All current and new technologies to produce new semiconductor devices and smart systems will be establish at FMD and available for industrial users on the basis of collaborative projects. Several programs and funding schemes to assist start-ups are being put in place to supplement the existing support schemes for industrial applications and technology transfer. The FMD project is currently a nationally funded initiative of €350 million. Over 4,000 staff are currently employed at the institutes in FMD, 50% of which are scientists and engineers. Annual operational costs of FMD will be in the range of the initial investment. FMD will create +500 jobs in the FMD institutes and leverage at least a 5-fold number of jobs in the industrial sector. Semiconductor sales amounted to some €400 billion in 2017. They are expected to grow to €1 trillion by 2030.

- **Imec (Belgium):** **The FAB3 300mm Cleanroom facility** has been expanded in March 2016 and comprises of state-of-the-art tools supporting the research towards further scaling integrated circuit technology used to develop and produce ultra-small chips. The additional 4,000m2 cleanroom's structure consists of a 'waffle table', a 90-centimetre-thick concrete slab that is completely separated from the outer walls. The structure rests on 831 concrete piles, placed 18 metres deep in the ground to make it totally vibration-free. The waffle table is further perforated with 3,300 holes to allow for constant air circulation, so that the clean room would also remain perfectly dust-free. The new cleanroom comprises a total investment (building and equipment) of more than €1 billion of which €100 million has come from the Flemish Government and more than €900 million investments from more than 90 leading industry partners. Imec's state-of-the-art semiconductor 300mm research cleanroom now totals 7,200m2. Imec also has a 5,200m2 200mm cleanroom that houses a flexible platform to fabricate prototypes by using process steps that are not available off-the-shelf in a foundry. Also, various specialised labs are on-site. This unique infrastructure will allow imec to keep its global leading position as a nanoelectronics R&D centre serving the entire semiconductor ecosystem, including foundries, IDMs, fabless and fablite companies, equipment and material suppliers, etc.

DTI (Denmark): Centre for Industrial 3D-printing, upgraded in 2019 thanks to DTI's major investment and renovation effort, is a facility of more than 1,400 m2 in Aarhus. It now gathers all the processes around 3D printing production, which were developed over many years via, amongst others, FP7 and H2020 projects. The centre's focus is to demonstrate and develop the industrial potential of 3D printing in production in Denmark, and here, as the only place in the country, there are four metal printers. Danish companies can thus have items printed in metal and at the same time have access to test a full production line for the development and 3D printing of components and parts that can later be implemented directly in their own production. The centre is also the focal point of AM-LINE 4.0, which is a project supported by the Innovation Fund Denmark together with a number of leading Danish companies and universities from Denmark and abroad. With a total budget of DKK 88 million, AM-LINE 4.0 is the largest investment in Industrial 3D printing in Denmark ever, and the goal is to ensure that Danish industrial companies have the necessary knowledge and capacity to be able to utilise the great potential in 3D printing production.

EURAC Research (Italy): terraXcube is an innovative 1,240m^2 facility operational since mid-2019 that simulates the Earth's most extreme climate conditions to study their influence on humans, ecological processes and technologies. The lab combines hypobaric and altitude chamber technology with state-of-the-art environmental simulation. From extreme artic cold and Himalayan storms (max 9,000m altitude), to the scorching heat of a North African desert, terraXcube can reproduce many of the Earth's most extreme climate conditions. TerraXcube is focused on medical research, ecological research and product testing. TerraXcube comprises an initial investment of €7.8 million covered by the Province of Bolzano which disposes of a special funding programme for capacity building, for which terraXcube had been selected. Prior to its construction, the concept and technical specification of terraXcube had been realised and funded by Eurac Research directly. 10% of the total initial investment per year is foreseen for upgrade/upscale. The running/operational costs of the infrastructure are covered at 58% by Eurac Research basic funding, 26% by incomes from industry and training projects, and 16% by research projects with public funding (incl. EU projects).

EURECAT (Spain): Plastic Processing Pilot Plant is a leading international plant for novel plastic transformation technologies in Southern Europe. Plastic injection, along with other polymer moulding processes, continues to be the most important industrial process for the replication of pieces, thanks to the vast geometric freedom that it allows and its low costs of large production volumes. At both national and international levels, Eurecat is a well-known specialist of these processes, which have gradually evolved and adapted throughout the years, diversifying in different techniques such as: multi-component injection, gas assisted injection moulding (GAIM), injection compression moulding or In-Mould Decoration (IMD). Eurecat offers the industry experience and technical know-how for testing, manufacturing and the industrialisation of pre-series with the most innovative plastic processing technologies.

FORCE Technology (Denmark): **Test facility for large-scale mechanical test of large structures** at both complex and realistic loads. An important offset for the facility is supporting the wind turbine industry both in Denmark and aboard in validating the design of monopiles and jackets. Testing is a necessary element in cutting costs of the structure (e.g. material usage) and reducing related costs of erecting the structure at site. Other industrial sectors involving large scale structures such as bridge engineering and the Oil and Gas industry are also benefiting from the same services and value creation. The key industries in Denmark in need for large-scale mechanical and structural validation and testing services are wind industry (more than 85,000 full-time employees linked to the industry), buildings and large-scale infrastructure projects (almost 166,000 employees), and marine vessels and systems (approx. 40,000 direct employees). Furthermore, the facility attracts a broad range of customers from all over Europe. Such facility required a double figured million-euro investment.

INL (Spain-Portugal): The International Iberian Nanotechnology Laboratory is an international intergovernmental research organization (IGRO) with the mission to perform cutting-edge R&D in interdisciplinary nanotechnology and to function as an innovation integrator in multiple application domains. INL had been established in 2005 by a joint decision of the governments of Portugal and Spain. Operating since late 2010, following a total investment of €100 million, INL is part of the Portuguese Road Map of Research Infrastructures 2020 with 4 listed infrastructures: (1) Micro&NanoFabs@PT - a Network of Micro and Nano Fabrication Research Facilities in Portugal; (2) CRYOEM-PT - National Advanced Electron Microscopy Network for Health and Life Sciences; 3) AIR Centre - Atlantic International Research Centre; 4) PPBI - Portuguese Platform of BioImaging. The INL technology infrastructures provide a high-tech research environment for INL staff and users. INL campus extends over an area of 47,000 m2, with 26,000 m2 of buildings. This includes 7,500 m2 of individual and central laboratories, including high-accuracy laboratories, a cleanroom with an area of 1,000 m2, an auditorium and other public areas over 4,800 m2. At the beginning of 2020, there were 368 people of over 40 nationalities working at INL, 312 of them researchers.

JSI (Slovenia): **TRIGA MARK II research reactor** was established in 1966 and financed by the Ministry of Higher Education, Science and Technology of Slovenia and managed by Jožef Stefan Institute (JSI). The reactor has been playing important role in developing nuclear technology and safety culture in Slovenia. It is one of a few centres of modern technology in the country. It provides training courses about nuclear technologies and radiation protection. The reactor has been routinely used for national and international research projects, including with two national SMEs making radiation resistant electronics. All major investments are covered by the help of foreign sponsors (incl. the International Atomic Energy Agency, Germany and the USA). Actual costs include maintenance, material costs (including electricity, water, physical protection, etc) and technical staff.

LIST (Luxembourg): **N-CCL Technology Platform**: Established in 2016, the National Composite Centre Luxembourg aiming at accelerating industry-oriented RDI projects (TRL4-7) is hosted in Luxembourg Institute of Science and Technology (LIST). The Composite Manufacturing Platform, which is an integral part of the N-CCL, provides key research infrastructure and competency in composite materials, from polymer processing, structural composite manufacturing and welding as well as composite material analysis. More than €7,5 million have been co-invested by LIST (50%) and the Luxembourg's Ministry of Economy (50%) for cutting-edge equipment. The 600 m² of the NCC-L infrastructure is organised around three mains fields: (1) the polymers processing lab offers the ability to process gram-scale batches of material and to define a clear path to industrial scale production up to hundred kilograms batches; (2) the structural composite manufacturing lab supports the development of innovative material and process combinations, together with demonstrating their feasibility at (semi-)industrial scale; (3) the thermal analysis lab offers a large range of advanced techniques for determining the thermophysical properties of materials and characterizing their thermal behaviour. Such integrated infrastructure is operating synergistically with the Materials Research and Technology department of LIST to provide in a single hub all required competencies to turn advanced chemistry materials into relevant scale composite systems. Since its inception, the platform has served more than 70 customers, attracted 4 international projects and is currently central in the largest public-private research partnerships in Luxembourg (€ 50 million).

Łukasiewicz - ITEE (Poland): **Centre for Sustainable Technologies and Circular Economy** is aimed at supporting small and medium-sized enterprises in the field of innovative industrial technologies as well as technical and environmental safety. The Centre is equipped with unique, independently developed research systems and technological installations, which ensure effective and efficient execution of research and application tasks in the field of mechatronics and optomechatronics, advanced plasma technologies, passive building support, circular economy, technical safety and environmental protection. The formula of the Centre for Sustainable Technologies and Circular Economy is supplemented by the Prototype Centre, which enables the transformation of the developed model solutions to a higher TRL levels - up to a verified and tested prototype. The use of the most modern design and process technologies enables quick and effective development of new innovative products and their materialisation in a form of a fully functional, professionally designed and manufactured prototype. The Centers are co-financed from Regional Operational Programme of the Mazowieckie Voivodeship 2014-2020 (total budget – €16,8 million, including €11,7 million from ERDF).

RISE (Sweden): **AstaZero - Active Safety Test Area** is the world's first full-scale test environment for future road safety. A unique feature of the facility is the different traffic environments that make it possible to test advanced safety systems and their functions for all kinds of traffic and traffic situations. Asta Zero was inaugurated in 2014 and had an initial budget of SEK500 million (€48 million). Half of the financing was through public grants at EU (ERDF), National (Vinnova), and regional/local (Västra Götaland region and Borås City) levels, and the remaining half via bank loans guaranteed by five industrial partners (AB Volvo, Volvo Cars, Scania, Autoliv and Test Site Sweden). The SEK18 million National support by Vinnova was made via the Swedish Strategic Innovation programme for Vehicles (FFI) allowing SMEs, start-ups and universities to use the infrastructure. In volume, AstaZero is mainly used by larger companies, Swedish and international, even though SMEs and start-ups are increasingly using the facility. After four years of operations, AstaZero had a usage rate of 120% and had already benefited from an extension.

Tecnalia (Spain): [Harsh Lab 1.0]is an advanced floating platform moored 1 mile off Armintza's coast (Bay of Biscay, Spain) designed for the evaluation of materials and components against corrosion, ageing and fouling phenomena in real offshore environment. Harsh Lab allows the evaluation of standardised probes and components both in splash and immersion zones. It is focused on the extension of the lifecycle of the components and equipment in harsh environments. This offshore laboratory can handle up to 125 samples in atmospheric zone and 600 in splash/immersion. The development of HarshLab has been supported by the Basque Government and by the European Union through the Operative Program ERDF (European Regional Development Fund) of the Basque country 2014-2020.

VITO (Belgium): [Deep Geothermal Program] aims at extracting geothermal heat from the deep subsoil, which is very complex and comes with many uncertainties and risks. The VITO infrastructure aims to reduce these risks for industry, other energy users, and governments. VITO took the initiative to start the deep geothermal project in the frame of its sustainable energy technology program long before local authorities and industry showed their interest in this technology. To allow for a full demonstration of the capability of geothermal energy as a source for green energy in Belgium/Flanders, VITO has built a pilot installation for serving a small local heating network, consisting of three geothermal wells, a geothermal heat and electricity generation pilot installation & building, and a district heating network (± 2 km) for delivering heat. Early 2019, €46 million had been invested, approximately 85% coming from internal VITO funds and 15% from government subsidies. In June 2019, a first spin-off company Hita was founded based on the knowledge gained by the VITO technology infrastructure.

VTT (Finland): [Bioruukki Pilot Centre] is a 10.000 m2 unique innovation and demonstration platform for bio- and circular economy process concepts and businesses, officially inaugurated in 2015. Bioruukki supports solving technology and innovation challenges e.g. in low carbon energy solutions, efficient biomass refining, new biomass-based products, recycling and waste utilisation and sustainable chemicals. All the required expertise, modelling and piloting capability is under one roof. Bioruukki combines the expertise of more than 500 VTT specialists and works in partnership within an innovation ecosystem composed by companies, start-ups and researchers in the Otaniemi Technology Hub of Finland as well as internationally. Total capital investment costs of Bioruukki piloting centre were estimated to be €32 million by 2019. Financing comprises special grants from national government budgets (€13 million), VTT's own capital investments (€10 million), real estate owner (€9 million paid in-kind). Currently revenue from projects is ~€20 million/year and collaboration projects with industry make up around 30% of operation. Already early on, Bioruukki reported 137 customers, in 186 projects, from 14 countries. SME's share of contracts is 7-10% annually, comprising around 40-60 companies from 10 different countries.

Annex 2: Examples of Regional/National Support Schemes Supporting Technology Infrastructures

Denmark - [Green Labs Programme]: GreenLabs DK is a programme that supports the establishment of large-scale facilities for testing and demonstration of new climate and energy technologies. Commercial companies that need testing of their products or prototypes can use the world class facilities to obtain test results to certify their products. The programme primarily focuses on efficient energy use and renewable energy but can also support all technology types which can contribute making Denmark independent of fossil fuels. Green Labs DK fills a void in the Danish innovation chain. By establishing test facilities Green Labs DK enables the testing and demonstration of new energy technologies that small and medium-sized companies often do not have the economic latitude to facilitate themselves. This furthers utilisation and development of the industrial potential of benefit to growth and job creation in Denmark. Eight Green Labs have received support.

Germany - Industry 4.0 initiative: This initiative includes important elements of test bed activities such as the 'Labs Network Industry 4.0' programme, which allows SMEs to test their innovations in test beds. There are currently 54 so called test centres where users can test new technologies, innovations, and business models and review their economic feasibility prior to market launch. Moreover 72 institutes and research units of the Fraunhofer-Gesellschaft provide technology infrastructures for research, innovation, testing and certification in different scientific areas.

Norway - **Norwegian Catapult Programme**: The Norwegian Catapult Programme is a governmental scheme designed to assist the establishment and development of "catapult centres", with the purpose of accelerating the process from concept to market launch of the product. The purpose of the Catapult programme is to support innovative capability of small and medium sized enterprises in specific industry areas in Norway. The ambition is to create an infrastructure for innovation with 7-9 national Catapult centres within areas of the Norwegian industry sector with great economic potential. The programme is administered by The Industrial Development Corporation of Norway (SIVA) on behalf of the Norwegian Ministry of Trade, Industry and Fisheries, in partnership with Innovation Norway and The Research Council of Norway. The Catapult centres assist companies in developing prototypes, offer expertise and equipment for testing, visualisation and simulation to turn innovative ideas into new products and services in an effective manner at a lower risk. The Catapult centres provide expertise, contacts and facilities in various technological areas, and can assist companies to access new markets and captivate interest from other potential business partners.

Poland - R&D Infrastructure Programme: The government of Mazowieckie region has established in 2014-2020 a programme dedicated to support the extension or modernisation of R&D institutions. The goal of the programme is to focus on R&D facilities, which will be used in areas of smart specialisation of the region and will comply with specified identified needs of regional enterprises cooperating with R&D institutions. By now, 17 projects have been supported. Those projects are co-funded from ERDF (€100 million). The programme is administered by Mazovian Unit for EU Programmes Implementation (regional agency supervised by the Marshall Office of Mazowieckie Voivodeship).

Sweden - Smart Industry Programme: The Swedish government 2014-2018 has launched the Smart Industry programme with the aim to strengthen the development of Swedish industry to become a world leader in developing innovative and sustainable solutions. The programme shall support industry to be at the forefront of the digital transformation and adoption of sustainable production methods. Testbed Sweden is one of the four priorities of this programme, building on the idea that test and demonstration environments are essential to meet companies and public sector challenges and at the same time enhance the country's image as a competitive environment for research and development worth investing in. The Research Institutes of Sweden, RISE – the Swedish RTO – is managing over half of the country's testbeds and demonstration facilities which are open to industry, academia, SMEs and the public sector.

The Netherlands - Smart Industry: Building on the Dutch Smart Industry Action Agenda published in 2014, the Smart Industry Implementation Agenda is launched in 2018. The aim of the Implementation agenda is to get the Netherlands to a higher level as a modern industrial country by focusing on implementation and scaling up over the period 2018-2021. One of the 5 main strands of actions in this Implementation Agenda is the support of technology infrastructures through "Accelerating in Field Labs". Field Labs meet the need for physical and digital space for experimentation and accompanying facilities, allowing companies and knowledge institutions to develop, test and implement solutions. Field labs also enable skills development. A total of 45 field labs have been set-up between 2015 and 2020 covering domains such as 3D materials, flexible manufacturing, thermo-plastics, industrial robotics and data sharing inside the factory and in the value network. Each field lab has currently a turnover of € 250.000 to € 2 million annually, depending on whether they have a national, regional or international focus.