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ERA Monitoring 2023

Report on methods to improve the Scoreboard and the Dashboard

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ERA Monitoring 2023 – Report on methods to improve the Scoreboard and the Dashboard

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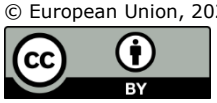

EUROPEAN COMMISSION

ERA Monitoring 2023

Report on methods to improve the Scoreboard and the Dashboard

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as part of 'Development of the ERA Scoreboard, the ERA Dashboard and the Regular Reports' project for the European Commission, Directorate-General for Research and Innovation under Framework Contract N° 2018/RTD/A2/OP/PP-07001-2018 Lot 2 (EDAR)

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Abbreviations

AC	Horizon Europe Associated Country
AI	Artificial Intelligence
ARRA	Agreement on Reforming Research Assessment
BERD	Business enterprise expenditure on R&D
CIS	Community Innovation Survey
COARA	Coalition for Advancing Research Assessment
CORDIS	Community Research and Development Information Service
DB	ERA Dashboard
DG RTD	Directorate-General for Research and Innovation
EARMA	European Association of Research Managers and Administrators
EC	European Commission
EEA	European Environment Agency
EOSC	European Open Science Cloud
EPO	European Patent Office
ERA	European Research Area
ERC	European Research Council
ESFRI	European Strategy Forum on Research Infrastructures
FTE	Full-time equivalent

GBARD	Government budget allocations for R&D
GEP	Gender Equality Plan
GERD	Gross domestic expenditure on R&D
HEI	Higher education institution
HRST	Human Resources in Science & Technology
IPC	International patent classification
JRC	Joint Research Centre
KTO	Knowledge transfer office
MS	EU Member State
PCT	Patent Cooperation Treaty
PRO	Public research organization
R&D	Research and development
R&I	Research and innovation
REA	European Research Executive Agency
RPO	Research performing organisation
SB	ERA Scoreboard
SET	Strategic Energy Technology
STEM	Science, technology, engineering, and mathematics
STIP	Science, technology, and innovation (STI) policy

Country codes

EU Member States (EU-27)

AT	Austria	**IE**	Ireland
BE	Belgium	**IT**	Italy
BG	Bulgaria	**LT**	Lithuania
CY	Cyprus	**LU**	Luxembourg
CZ	Czechia	**LV**	Latvia
DE	Germany	**MT**	Malta
DK	Denmark	**NL**	Netherlands
EE	Estonia	**PL**	Poland
EL	Greece	**PT**	Portugal
ES	Spain	**RO**	Romania
FI	Finland	**SE**	Sweden
FR	France	**SI**	Slovenia
HR	Croatia	**SK**	Slovakia
HU	Hungary		

Horizon Europe Associated Countries covered in the 2023 ERA monitoring cycle

AM	Armenia	**ME**	Montenegro
GE	Georgia	**NO**	Norway
IS	Iceland	**RS**	Serbia
IL	Israel	**TR**	Türkiye

EXECUTIVE SUMMARY

This report forms part of the 'Development of the ERA Scoreboard, the ERA Dashboard and the Regular Reports' project for the European Commission, Directorate-General for Research and Innovation (DG RTD). It presents the **challenges of the 2023 ERA monitoring indicators** and identifies potential **improvements to the ERA Scoreboard (SB) and Dashboard (DB) for 2024**. The ERA SB is designed to monitor progress towards the ERA objectives at the Union level, while ERA DB is a more detailed exercise for monitoring progress towards the ERA objectives at the level of Member States (MS) and those eight Horizon Europe Associated Countries (AC) that the ERA DB covered in the 2023 ERA monitoring cycle[1].

As initially planned, the ERA SB consists of 18 indicators, whereas the ERA DB is a broader monitoring exercise that covers 56 indicators. However, the final number of indicators used in the 2023 ERA monitoring cycle is lower due to data limitations: three indicators are missing in the SB and 18 in the DB. The report investigates the main challenges faced and presents possible improvements going forward.

The methods used in this report include desk research, feedback from ERA stakeholders, and the ERA monitoring study team who reported the issues faced during the implementation of the project. To discuss and collect feedback on the challenges and proposed improvements to the ERA SB and DB, an **online workshop** was held on 23 January 2024 with 71 participants (see workshop summary note in Annex 2). To support the event, an **online survey** was launched to collect initial feedback before the workshop and then continued afterwards. 17 responses were received between December 2023 and February 2024. In addition, **an interview** was held with a representative of Eurostat to discuss the challenges in more detail.

There were three key challenges faced during the 2023 ERA monitoring cycle:

1. **Indicators for which no data is available**. As ERA Priority Area 1 had the highest number of initially planned indicators (i.e., 29), it is the Area with the highest number of missing indicators (i.e., eight). ERA Priority Area 2 has six missing indicators (out of planned 17) and ERA Priority Area 3 has five missing indicators (out of planned six). ERA Priority Area 4 does not have this limitation (as it also had the lowest number of initially planned indicators, i.e., two).

2. **Indicators for which some data is missing or inconsistent**. This challenge mainly concerns the geographical scope limitations for indicators. In addition, the report identifies some methodological limitations for some specific indicators. Nevertheless, the indicators listed within section 2.2. are still applied in ERA SB and DB for the countries with available data after acknowledging this limitation.

3. **Limited reflection of ERA sub-priorities**. This concerns indicators that were flagged by stakeholders as not fully representative of specific ERA objectives, and the general lack of indicators that are needed to analyse each ERA sub-priority[2].

[1] Armenia, Georgia, Iceland, Israel, Montenegro, Norway, Serbia, and Türkiye.
[2] In this report, the term 'ERA sub-priority' is used equally to the term 'Pact for R&I priority area for joint action'.

To address the first challenge the use of alternative indicators or data sources is explored. For the second challenge, the report presents solutions such as additional data sources, country data requests, and using data projections. However, these solutions have their own downsides related to comparability, transparency, and resource issues.

For the third challenge, the report identifies additional indicators that could better reflect the objectives and priority areas for joint actions of the Pact for R&I (ERA sub-priorities). Nevertheless, some sub-priorities still lack adequate indicators due to the absence of relevant and reliable data sources, and thus they may need new surveys to collect new data.

1. INTRODUCTION

The Pact for Research & Innovation (R&I)[3] requests the Commission to prepare an **ERA Scoreboard (SB)**, which monitors progress towards the ERA objectives at the Union level, and a more detailed **Dashboard (DB)** monitoring progress towards the ERA objectives that accommodates the different circumstances of Member States and Horizon Europe Associated Countries. The set of indicators was initially outlined during the preparatory work by CSES[4] and an analytical report was developed by six experts[5].

It was recommended that the ERA SB covers 18 indicators, including two general indicators measuring progress in the European R&I system, and 16 specific indicators, one for each Pact for R&I priority area for joint actions. The ERA DB is a broader monitoring exercise that covers 56 initial indicators to better reflect the specifics of ERA priorities.

Based on the defined indicators, sources of information and databases (such as Eurostat, OECD, UN Women in Science database and others) have been assessed for the coverage they could provide to the indicators. However, depending on the indicator, not all data is always available for each Member State or Associated Country. Due to completely **unavailable data**, three[6] out of 18 predefined ERA SB indicators could not be applied.

In the case of the ERA DB, out of the 56 predefined indicators, data was unavailable for 18 of them[7]. Moreover, some indicators have limited **geographical coverage** or some methodological limitations, and more indicators may be needed in general to better **reflect ERA priorities**. The aim is to have suggestions for 3-4 indicators with data available per priority area for joint actions in the Pact for R&I.

The work for the report followed the following key steps. The first step was to map the limitations of the current ERA indicator framework based on the desk research and feedback received from various ERA stakeholders and the study team implementing the 2023 ERA SB and DB. The second step was to review existing relevant monitoring exercises and their possible links to ERA in order to propose additional/alternative indicators to better reflect the progress made in achieving ERA objectives. Then, the possible improvements to the currently used indicators were explored based on the detected limitations and reviewed potential suggestions for solutions to the missing indicators challenge.

The fifth step aimed to gather insights and validate the proposals during an online workshop and report on the suggested improvements. To discuss and collect feedback on the challenges and proposed improvements to the ERA SB and DB, an **online workshop** was held on 23 January 2024 with 71 participants (see workshop summary note in Annex 2). To support the event, an **online survey** was launched to collect initial feedback before the workshop and then continued after it. 17 responses were received between December 2023

[3] Council of the European Union, Future governance of the European Research Area (ERA) - Council conclusions (adopted on 26/11/2021), 14308/21, Brussels, 2021, https://data.consilium.europa.eu/doc/document/ST-14308-2021-INIT/en/pdf

[4] CSES, Data gathering and analysis of policy developments and reforms: Study to evaluate the ERA policy framework/ERA monitoring mechanism, RTD/2020/SC/013, European Commission, doi/10.2777/17689

[5] Amanatidou, E., H. Hollanders, J. Kolar, B. Mahieu, C. Nauwelaers, and M. Guasp Teschendorff, Design of the new ERA Monitoring System – Analytical Report, European Commission, 2022.

[6] SB#15 and #16 are also among the 18 ERA DB indicators that are missing.

[7] One of them is repeated to times: DB#36/43; in addition, two of them are also in the ERA SB: #15 and #16. Moreover, one indicator (DB#31) might need to be dropped in the future ERA monitoring due to the data not being updated for several years (it was not counted in the number of missing indicators).

and February 2024. In addition, an interview was held with a representative of Eurostat to discuss the challenges in more detail.

This report presents the methodological challenges of the indicator framework used for the 2023 ERA monitoring cycle and suggests potential improvements to the ERA Scoreboard and Dashboard for 2024. It will contribute to further developing a robust set of indicators to be applied in future ERA monitoring exercises and should provide guidance on the possible methodological choices. The report is structured based on three key identified challenges and potential solutions to them:

- Indicators for which no data is available (section 2.1).
- Indicators for which some data is missing or inconsistent (section 2.2).
- Limited reflection of ERA sub-priorities (section 2.3).

2. ERA MONITORING 2023: KEY CHALLENGES AND SOLUTIONS

2.1. Challenge 1: No available data

The main challenge with 19 indicators[8] is the absence of data necessary for the assessment. This challenge applies to indicators where data is not available across all countries covered, be it ERA DB or SB. While in principle the selection of indicators focused on those for which data should be publicly available, the practical application of these indicators finally revealed problems in data availability for a number of them.

In addition, seven indicators were already expected to require collecting new data through surveys even before the actual monitoring started. However, these surveys have not been initiated. Data unavailability therefore is a **key challenge,** and the current work takes it up to propose how this challenge could be mitigated for the next monitoring cycles.

In the case of the **ERA SB**, data for three out of the 18 indicators are completely unavailable (indicators #4, #15, #16). As for the **ERA DB**, 18 out of 56 predefined indicators cannot be included due to the same problem: seven of these indicators were initially discussed in the context of collecting related data through new surveys; the remaining 11 indicators have been dropped due to the unavailability of the necessary information in the existing data sources (two of them are also in the ERA SB: #15 and #16).[9]

In this section, missing indicators and their alternatives are discussed in groups based on the associated ERA Priority Area. As ERA Priority Area 1 had the highest number of initially planned indicators (i.e., 29), it is the Area with the highest number of missing indicators (i.e., eight). ERA Priority Area 2 has six missing indicators (out of planned 17) and ERA Priority Area 3 has five missing indicators (out of planned six). ERA Priority Area 4 does not have

[8] One of such indicators (DB#36/43) was included in the list of Dashboard indicators two times. In addition, one indicator (DB#31) might need to be dropped in the future ERA monitoring due to the data not being updated for several years (it was not counted in the number of missing indicators).
[9] In addition, one indicator (DB#31) might need to be dropped in the future ERA monitoring due to the data not being updated for several years (it was not counted in the number of missing indicators).

this limitation (as it also had the lowest number of initially planned indicators, i.e., two). All the newly suggested possible alternative proxies for the missing indicators are summarised in Annex 1 together with all applied indicators in 2023 ERA monitoring.

2.1.1. ERA Priority Area 1

ERA Priority Area 1: Deepening a truly functioning internal market for knowledge - Table 1 lists missing indicators connected to this Priority Area. The table indicates the data sources which were initially envisioned during the preparatory work by CSES[10] and an analytical report by six experts[11]. There are eight indicators for which data was unavailable. In addition, one indicator (DB#31) might need to be dropped in the future ERA monitoring due to the data not being updated for several years (it was not counted in the number of missing indicators). The proposed solutions for these missing indicators are discussed in the following.

Table 1. Indicators for which no data is available (ERA Priority Area 1)

No.	Title	ERA Pact sub-priority	Initially envisioned data source
DB#6	*Percentage of the metadata related to publicly funded research datasets which are defined as Open Data that are discoverable through EOSC federated infrastructure*	Open Science	EOSC
DB#7	*Share of investments in the EOSC as a percentage of total public R&D and/or per 1,000 researchers*	Open Science	EOSC
SB#4	*Share of national public R&D expenditure committed to joint programmes and initiatives, research infrastructures and European Partnerships*	Research infrastructures	EC/MS
DB#10	*Share of higher education institutions or public/private research institutions with a Gender Equality Plan (GEP)*	Gender, equality, equal opportunities for all and inclusiveness	EC/MS
DB#21	*Number of spin-offs created by HEIs or public/private research organisations*	Knowledge valorisation	New survey
DB#24	*Commercialisation of technology and other research results through licensing (HEIs or public/private research organisations)*	Knowledge valorisation	New survey
DB#29	*ERC grants by total R&D expenditure*	Scientific leadership	ERC
DB#31	*European and international co-patenting in EPO applications at national and EU level*	Global engagement	Eurostat (data available only until 2013)
DB#32	*EU co-patenting at the EPO according to applicants'/ inventors' country of residence by international patent classification (IPC)*	Global engagement	Eurostat

[10] CSES, Data gathering and analysis of policy developments and reforms: Study to evaluate the ERA policy framework/ERA monitoring mechanism, RTD/2020/SC/013, European Commission, doi/10.2777/17689
[11] Amanatidou, E., H. Hollanders, J. Kolar, B. Mahieu, C. Nauwelaers, and M. Guasp Teschendorff, Design of the new ERA Monitoring System – Analytical Report, European Commission, 2022.

The first unavailable indicator under the Open Science sub-priority is the ***Percentage of the metadata related to publicly funded research datasets which are defined as Open Data that are discoverable through EOSC federated infrastructure*** (DB#6). The initially envisioned source was EOSC, however, the required data was unavailable during the implementation of the 2023 ERA DB. Possible alternative indicators are:

- Number of open-access research datasets by country / Ratio between open-access research datasets and open-access publications (source: OpenAIRE). Limitations: additional human resources are needed to calculate the indicators manually.

- Number of repositories by country (source: EOSC Observatory). Limitations: as noted by EOSC, the Survey on National Contributions to EOSC used for this indicator is in its initial stage, which means that some of the data may not yet be stable. In addition, data is only available for 2022 and covers 14 countries[12]. However, it is planned that the survey will be improved in future iterations. An alternative source for data on repositories could be re3data (source: re3data). This data may be less extensive than that provided by the EOSC Observatory, but it also provides detailed information on the characteristics of repositories.

The second missing indicator connected to Open Science is the ***Share of investments in the EOSC as a percentage of total public R&D and/or per 1,000 researchers*** (DB#7). The expected data from EOSC was not available in the end. An alternative indicator could be:

- Country investments in EOSC and Open Science in ranges of investment (source: EOSC Observatory). Limitations: as noted by EOSC, the Survey on National Contributions to EOSC used for this indicator is in its initial stage, which means that some of the data may not yet be stable. In addition, data is presented in ranges of investment[13] rather than the total amount of investment, and the indicator covers 25 countries[14]. It is planned that the survey will be improved in future iterations. In case it is possible to obtain the exact number of total investments in each country in the future, a denominator of total public R&D and/or per 1,000 researchers (based on Eurostat data) could be considered in this indicator, keeping it close to the originally envisaged one.

Regarding Research infrastructures, data on the ***Share of national public R&D expenditure committed to joint programmes and initiatives, research infrastructures and European Partnerships*** (SB#4) is not available. An alternative could be:

- Government budget allocations for R&D (GBARD) allocated to Europe-wide transnational, as well as bilateral or multilateral, public R&D programmes per FTE

[12] AT; BA; CY; DE; DK; ES; FR; GE; GR; IE; IT; LT; LU; LV; UA.
[13] Five ranges of investment: < 1 M; 1 - 5 M; 5 - 10 M; 10 – 20; > 20 M. Total amount of financial investments in EOSC and Open Science in 2021 (in millions of Euros) is available only in aggregated (countries combined) presentation.
[14] 25 countries: AT; BA; BG; CY; CZ; DE; DK; EE; ES; FI; FR; GE; GR; IE; LT; LU; LV; NL; NO; PL; RS; SI; SK; TR; UA.

researcher (source: Eurostat; already used as SB#18 and DB#34/56 indicators[15]). The idea of using this proxy to replace the missing indicator is generally supported by stakeholders. However, as discussed during the workshop, there are some concerns about the consistency of the collected data (see section 2.2.2. for more details). Therefore, the need for clearer definitions was raised to help distinguish the differences between the subcategories of this indicator.

The data on the ***Share of higher education institutions or public/private research institutions with a Gender Equality Plan (GEP)*** (DB#10) is currently not collected systematically in any database. Data on applicants for Horizon Europe funds (with a requirement to have a GEP) could be exploited. However, there are more higher education institutions (HEIs) with GEPs than those which apply to Horizon Europe, and they would not be captured by such an approach. Other alternatives:

- The proportion of research organisations (HEIs/PROs) that take actions or measures towards gender equality (source: She Figures). Limitations: currently data is available for only one year (2020) and 23 EU Member States and 6 non-EU countries are covered[16].

- During the workshop it was noted that the European Commission (DG RTD) is currently working towards making data on GEPs available in the future.

The Knowledge valorisation indicator ***Number of spin-offs created by HEIs or public/private research organisations*** (DB#21) is not available as the data was envisioned to be collected through a new survey by the Commission. However, it has not been created yet[17]. Nonetheless, it has been highlighted by workshop participants that such data is of great importance for the ERA. Therefore, despite the associated burdens, a new survey is highly desirable. Some alternative indicators could be:

- Number of spin-offs created by KTOs per million population (source: ASTP KT annual survey; currently 2014-2020 financial years). Limitations: limited and inconsistent number of covered countries[18]; uneven representation of the countries (administrative data and survey responses combined); comparability issues due to inconsistent data, and data disaggregated by country and year may not be publicly available.

- Using an alternative database like Crunchbase could also work as a short-term solution. However, the spin-offs created by higher education institutions or public/private research organisations are not exclusively presented in a separate category. Therefore, manual identification of spin-offs via selected criteria would be needed. This would require additional human resources and access to the database to extract the data and manually calculate the indicator.

[15] The rationale of including this indicator under yet another sub-priority would be its focus on funding for international activities. While it is not a perfect measure, it may still serve as a proxy providing additional information about a country's propensity to spend on international R&D.
[16] EU Member States (23): AT; BA; BG; CY; CZ; DE; DK; EE; EL; ES; FI; FR; HR; HU; IE; IT; LT; LU; MT; NL; PL; PT; SE. Non-EU countries (6): BA; CH; IL; IS; NO; TR.
[17] In general, while introducing new surveys (or updating existing ones) is a possible option, it always comes with an increase in administrative burden and associated costs.
[18] 32 countries covered with uneven representation: AT; BE; CH; CZ; DE; DK; EE; ES; FI; FR; GR; HR; HU; IE; IS; IT; LT; LU; LV; MT; NL; NO; PL; PT; RO; RS; RU; SE; SI; SK; TR; UK.

Another indicator under the Knowledge valorisation sub-priority is the ***Commercialisation of technology and other research results through licensing (HEIs or public/private research organisations)*** (DB#24). A new survey is required to collect this specific data, and the workshop participants highlighted the importance of such data despite the associated data collection burdens. An alternative indicator could be:

- Patents by technology – Patent grants at EPO (source: OECD). However, data for patents reflects different aspects than licensing and therefore captures a related but different concept.

In terms of Scientific leadership sub-priority, the data on ***ERC grants by total R&D expenditure*** (DB#29) at a country level and disaggregated by years cannot be directly accessed, but it would be possible to manually calculate the indicator, because the ERC project database includes data on the ERC grant size provided for each project, the year of grant provision, the coordinating institution and its country. However, data on ERC grant size may need to be split by year under the assumption of equal annual spending per project, which may lead to some discrepancies between the calculated and actual annual numbers. Alternatively, such indicator could consider the sum of grants received by a country each year. This would eliminate the need to make assumptions abbot distribution within projects' lifecycles. In addition, data extraction and calculations would require additional human resources, until at least an automated algorithm is developed.

Concerning the indicator ***European and international co-patenting in EPO applications at the national and EU level*** (DB#31), besides missing data for several Associated Countries (see Table 4 in section 2.2.) a more severe problem is the temporal data availability, i.e., the data for this indicator is available only until 2013 and Eurostat is no longer updating it. Therefore, due to such a significant limitation, this indicator could be also considered unavailable, especially, in future iterations of the monitoring cycle.

Concerning the ***EU co-patenting at the EPO according to applicants'/ inventors' country of residence by international patent classification (IPC)*** (DB#32), the data available in Eurostat (EU-28 value) is not disaggregated at the desired level (by country) to be included in the ERA Dashboard. Overall, such data on patents could be accessed with the collaboration of PATSAT, although it would require resources to extract data and create the indicators. Alternatively, other proxies for these indicators could be explored as well:

- Share of patents with foreign co-inventors (source: OECD). Currently, such OECD data is available from 1999 to 2021, it presents the disaggregation by patents office (EPO, PCT, USPTO) and the inventor's/partner's country. Data covers all EU Member States and most of the Associated Countries included in this study (all except ME and RS).

- More data on patents is being developed by DG RTD through one of its current projects – "Quantitative evidence to EU R&I policy" (RTD/2022/OP/0005). Within the scope of this project, the following indicators are envisioned in the tender specifications: (1) Total number of patent applications to the EPO; (2) Total number of patent applications filed under PCT; (3) Total number of patent grants at the EPO; (4) Share of EPO applications that are part of a PCT application; (5); Top 1% most cited EPO applications; (6) Specialisation index; (7) Share of female inventors on EPO patents; (8) Share of female inventors on EPO PCT patents. However, these indicators do not capture the international co-patenting aspect by themselves, and additional work would be needed - this could possibly be included in the future.

2.1.2. ERA Priority Area 2

Under **ERA Priority Area 2: Taking up together the green transition and digital transformation and other challenges with impact on society, and increasing society's participation in the ERA**, Table 2 below lists missing indicators connected to this Priority Area. In sum, there are six[19] indicators, which were not included in the ERA DB due to missing data. In most cases, such specific data is novel and is not yet collected systematically within any survey. The proposed solutions are discussed in the following.

Table 2. Indicators for which no data is available (ERA Priority Area 2)

No.	Title	ERA Pact sub-priority	Initially envisioned data source
DB#36/43	*R&I investments in green transition as a share of total GERD*	Challenge-based ERA actions / Synergies with sectorial policies and industrial policy	New survey
DB#44	*R&I investments in digital transition as a share of total GERD*	Synergies with sectorial policies and industrial policy	New survey
DB#45	*Number of people attending relevant events at the national level (differentiation also for students and young people) as a share of millions of the population*	An active citizen and societal engagement in R&I in all its dimensions	New survey
DB#46	*Share of investments in Citizen Science as a percentage of total public R&D and/or per 1,000 researchers*	An active citizen and societal engagement in R&I in all its dimensions	EOSC
DB#47	*Share of funding for science communication/ public engagement in Universities and PROs*	An active citizen and societal engagement in R&I in all its dimensions	New survey

The data on the ***R&I investments in green transition as a share of total GERD*** (DB#36/43) is not available as such, and a new survey would be needed to collect it. However, this would require significant human resources and create an administrative burden. Nevertheless, in case the collection of such data is initiated, there must be clarity of what "green transition" exactly means in the context of R&I investments. This would ensure correspondence with the ERA needs and cross-country comparability of the data.

Regarding alternative approaches to identifying proxies for the green transition, the existing indicators are broader than just R&D and are mostly limited to a specific sector or funding programme:

- One alternative could be based on the analysis of Horizon Europe project topics, but it would cover only a limited number of R&I investments in the green transition (i.e. only those that relate to the Horizon Europe programme). Such analysis would

[19] Indicator "R&I investments in green transition as a share of total GERD" is present in the ERA DB two times as DB#36/43.

require newly collecting and processing data to create an indicator, which would lead to additional costs, especially, initially, when setting up the system.

- Some workshop participants suggested using a proxy on green patents, for example, "OECD Patents on environment technologies" (DB#38 indicator under Challenge-based ERA actions). This would capture the R&I outputs but not the inputs, thus, deviating from the originally envisaged indicator.

- Another proxy could be "Green bond issuance as a percentage of total bond issuance" (source: EEA). The data is currently available for 2014-2022 for all EU Member States. Limitations: data are compiled by commercial data providers; the continuity of this indicator is uncertain, and the scope is broader than just R&I.

Another related indicator, ***R&I investments in digital transition as a share of total GERD*** (DB#44), also required the creation of a new survey to collect such data which is associated with the challenges mentioned above. In this case, it is important to clearly define what "digital transition" means in the context of R&I investments. Alternative indicators would be broader than just R&D and likely limited to a specific sector or cover the take-up of digital products/services. Another alternative could be created through the analysis of Horizon Europe project topics (similarly to the suggestion described under the indicator for green transition), but it would cover only a limited number of R&I investments in the digital transition. In addition, such analysis would require to manually collect and process data to create an indicator.

Regarding sub-priority "An active citizen and societal engagement in R&I in all its dimensions", the ***Number of people attending relevant events at the national level (differentiation also for students and young people) as a share of million of the population*** (DB#45) was also initially envisioned to be calculated based on the data collected through a new survey. No adequate alternative indicator was found during the research. Alternative indicators could be connected to individual citizen science campaigns, but comparability would likely be low, due to the scope being too narrow, difficulties in data collection, and cross-country comparability (e.g. a country's participation is limited, participants not systematically recorded).

In terms of the ***Share of investments in Citizen Science as a percentage of total public R&D and/or per 1,000 researchers*** (DB#46), the needed data is not available at the EOSC Observatory (i.e. the initially envisioned source). As no alternative data sources that provide a good proxy for this indicator were found, a new survey at the national level would be needed to approximate such data. The Joint Research Centre (JRC) has carried out an inventory of citizen science activities limited to environmental policies. While its scope is narrower, this could serve as an example of an exercise to collect data at least on the number of citizen science activities.

Lastly, concerning the ***Share of funding for science communication/public engagement in Universities and PROs*** (DB#47), a new survey is likewise needed to collect such data. No adequate alternative indicator was found due to the lack of a cross-institutional/cross-country registry for science communication.

2.1.3. ERA Priority Area 3

Under **ERA Priority Area 3: Enhancing access to research and innovation excellence across the Union and enhancing interconnections between innovation ecosystems across the Union**, Table 3 lists missing indicators connected to this Priority Area. There are

five indicators which turned out to be unavailable due to completely missing data. The proposed solutions are discussed in the following.

Table 3. Indicators for which no data is available (ERA Priority Area 3)

No.	Title	ERA Pact sub-priority	Initially envisioned data source
DB#50	*Value of participation in Horizon Europe in millions of EUR in a given year divided by the countries' GDP*	More investments and reforms in countries and regions with lower R&I performance	REA
SB#15/ DB#51	*Share of Seal of Excellence rewards that received funding from other sources*	Synergies between Union, national and regional funding programmes	Horizon Dashboard
DB#52	*Number of early career research managers participating in training programmes, staff exchanges, and networks as a share of the total number of researchers*	Increased collaborative links & excellence-based integration of research-performing organisations	EARMA
DB#53	*Number of more experienced research managers participating in training, in order to lead out the research management teams as a share of total number of researchers*	Increased collaborative links & excellence-based integration of research-performing organisations	EARMA / Eurostat
SB#16/ DB#54	*Number of collaboration networks of RPOs in Widening countries[20] with other EU countries*	Increased collaborative links & excellence-based integration of research-performing organisations	CORDIS

Data on the ***Value of participation in Horizon Europe in millions of EUR in a given year divided by the countries' GDP*** (DB#50) is unavailable, as data is provided cumulatively, not disaggregated by year. Equal division across years of a project's implementation period could provide an approximation, but it would not be robust. Alternatives could be:

- The sum of Horizon Europe grants received by country in a given year per 1,000 R&D personnel (in FTEs) (source: CORDIS, Eurostat). While it would measure success at a particular point in time, this data would be more robust and comparable across years and countries without the need for assumptions on funding distribution within projects' lifecycles.

- Number of participations in Horizon Europe measured in terms of 1,000 R&D personnel (in FTEs) (source: FFG's EU Performance Monitor and R&D personnel from Eurostat). Limitation: data available in a cumulative way (years combined) – disaggregating data needs either additional input from programme management or making assumptions about the annual distribution of participation.

In terms of the ***Share of Seal of Excellence rewards that received funding from other sources*** (SB#15/ DB#51), there is no such accessible data on the Horizon Dashboard. It was discussed during the workshop that this indicator was included in the initial list as the data

[20] Widening countries: BG, HR, CY, CZ, EE, GR, HU, LV, LT, MT, PL, PT, RO, SK, SI.

was expected to be available in the future, and it was suggested to engage once again with other projects running in DG RTD to check the availability of the data for these indicators. However, according to some stakeholders, there were already attempts to collect this data, but it can be only partial and patchy as it depends on the responsiveness of individual MS. Therefore, an alternative indicator could be considered:

- Number of Seal of Excellence projects published on the InvestEU Portal that have received funding (source: InvestEU Portal where part of the displayed projects seeking funding have received the Seal of Excellence). This indicator would require an agreement on accessing InvestEU Portal data and a further investigation of the indicator's suitability. In addition, not all Seal of Excellence projects are tracked on this portal.

Concerning the ***Number of early career research managers participating in training programmes, staff exchanges, and networks as a share of the total number of researchers*** (DB#52), such information is not available in EARMA. Some survey respondents pointed out that the formulation of this indicator might be too vague and there is a risk of having the value of 100%. Therefore, it is suggested to specify the relevant training programmes, staff exchanges, and networks.

Concerning potential proxies for this indicator, the upcoming European Higher Education Sector Observatory could be used in the future. This new project will combine EU data tools (e.g., ETER, U-Multirank, Erasmus+ database) and present useful indicators and benchmarks related to Higher Education. The Commission's future RICO Observatory, which will be set up with the support of the OECD, could be potentially useful too as it will monitor the mobility of researchers. On the other hand, an alternative suggested indicator is more focused on international mobility:

- Share of researchers who agree that international mobility is regarded as a positive factor for career progression in their home institution (source: MORE surveys, CP4.4). Limitation: it is not certain that the MORE surveys will be continued in the future. Therefore, this may not provide a long-term solution, and the mentioned upcoming sources should be considered.

The data on the ***Number of more experienced research managers participating in training, in order to lead out the research management teams as a share of total number of researchers*** (DB#53) is missing from the initially envisioned source (EARMA or Eurostat). As above, survey respondents noted that the formulation of this indicator might be too vague and risks having a value of 100%. Therefore, it is suggested to specify the training programmes mentioned in the indicator.

The upcoming European Higher Education Sector Observatory and RICO Observatory could be used in the future as they will include monitoring indicators related to Higher Education and researchers. One suggested alternative indicator focuses on the perceived effects of transferable skills:

- Share of leading researchers who agree that transferable skills are regarded as a positive factor for career progression in their home institution (source: MORE surveys, CP4.5). Limitation: it is not certain that the MORE surveys will be continued in the future. Therefore, this may not provide a long-term solution, and the mentioned upcoming sources should be considered.

The ***Number of collaboration networks of RPOs in Widening countries[21] with other EU countries*** (SB#16/ DB#54) is not available from the initially envisioned data source – CORDIS. It was discussed during the workshop that this indicator was included in the initial list as the data was expected to be available in the future, and it was suggested to engage once again with other projects running in DG RTD to check the availability of the data for this indicator. To calculate the number of collaboration networks, there is a need to access the detailed microdata on the Horizon programmes. However, this requires additional resources. In addition, if the needed data from CORDIS becomes available in the future, stakeholders suggest specifying the networks referred to in the title of the indicator (i.e., networks within the Horizon programme). Suggested alternative indicators:

- The average number of partners from non-widening countries per institution from a Widening country participating in the Horizon programme each year (source: CORDIS).

- Some workshop participants suggested using a bibliometric proxy – co-publishing – as there could be an assumption that such collaboration of researchers from Widening and other EU countries in the publications reflects the general level of research collaboration. Currently there is no existing indicator that disaggregates the countries of co-publishers. A similar approach could also be taken when using a proxy of international co-patenting. For example, the previously mentioned data on the Share of patents with foreign co-inventors (source: OECD) can be disaggregated by the country of foreign partners (co-inventors). Thus, it is possible to calculate the share of patents registered by a Widening country together with partners from other EU countries.

2.1.4. ERA Priority Area 4

For **ERA Priority Area 4: Advancing concerted research and innovation investments and reforms**, all initially planned 2023 ERA monitoring indicators have available data. However, there is a general lack of indicators to reflect the objectives of this Priority Area. This challenge is discussed in section 2.3. Challenge 3: Reflection of ERA priorities.

2.2. Challenge 2: Missing or inconsistent data

2.2.1. Limited geographical scope

The second common challenge mainly concerns the geographical coverage limitations for indicators. For example, in some of the indicators, alternative data sources (e.g., UNESCO) are used in addition to the main source (e.g., Eurostat) to include Horizon Europe Associated Countries (AC)[22]. However, in numerous cases, it was not possible to include some specific countries (see Table 4 below).

Overall, there are two main solutions for indicators with missing data for some specific countries. First, the missing data could be requested from national statistical offices by interacting individually with them. Alternatively, data projections (imputation) could be used in case of missing data.

[21] Widening countries: BG, HR, CY, CZ, EE, GR, HU, LV, LT, MT, PL, PT, RO, SK, SI.
[22] Associated Countries covered in this study: AM, GE, IS, IL, ME, NO, RS, TR.

Requesting data from different national statistic offices would raise the problem of data comparability between countries. It may not be guaranteed that the same definitions and data collection methods are used when collecting such individual data. This would require sharing strict definitions and guidelines for collecting (or constructing) such data. While the Frascati manual and the complementary EU guidelines should reduce the potential comparability issues for indicators on R&D, most indicators measure other aspects of ERA progress and therefore need other guidance. In addition, similarly to survey implementation, such individual data collection in general requires additional resources. Moreover, individually contacting countries for missing data might not always be feasible because the availability of such data depends on existing national statistical systems.

Regarding the second main solution (data projections – imputation), there are two groups of arguments. During the workshop discussions, some participants supported the idea of imputing the missing data, while others objected to it. On the one hand, in the case of ERA monitoring, such data projections could have a satisfactory quality as the quality of imputation could be tested by fake-imputing known data and comparing to actual data in order to see to what extent the imputation approach is reliable. However, there are some concerns that there could be political disagreements about using the projections instead of reporting the data gaps.

Table 4. Indicators with a limited geographical scope

No.	Title	Used sources	Member States (MS)/ Associated Countries (AC) with no data
SB#2/ DB#3	*Researchers (in full-time equivalent) per million inhabitants*	Eurostat, UNESCO	AC: AM, IL
SB#3/ DB#5	*Share of publications available in open access*	DG RTD	AC: AM, GE
DB#8	*Share of national public R&D expenditure committed to European research infrastructures*	ESFRI	MS: AT, CY, CZ, DK, EE, FI, HR, IE, LT, LU, SE AC: AM, GE, IL, RS, TR
DB#9	*Number of European research infrastructures in which a Member State or an Associated Country participates (financially contributes to operations)*	ESFRI	AC: AM, GE, ME
SB#5/ DB#11	*Share of women in grade A positions in higher education institutes*	Women in Science	MS: CZ, EE AC: AM, GE, ME, RS
DB#12	*Proportion of papers with mixed gender authorship, 2000-2020*	Scopus, NamSor (Science-Metrix dataset)	AC: AM, GE, IL
DB#13	*Proportion of women in authorships of the top 10% most cited publications*	Scopus, NamSor (Science-Metrix dataset)	AC: AM, GE, IL
DB#14	*Women in Digital Index*	DESI	AC: AM, GE, IL, IS, ME, NO, RS, TR
DB#15	*Proportion of women among doctoral graduates by narrow fields of STEM*	Eurostat	AC: AM, GE, IL, IS, ME

No.	Title	Used sources	Member States (MS)/ Associated Countries (AC) with no data
DB#16	*Share of foreign doctorate students as a percentage of all doctorate students*	Eurostat	AC: AM, GE, IL, ME
SB#6/ DB#18	*Job-to-job mobility of Human Resources in Science & Technology*	Eurostat	MS: IE AC: AM, GE, IL
DB#19	*Share of public-private co-publications*	Science-Metrix, Eurostat	AC: AM, GE, IL, IS, ME, NO, RS, TR
DB#22	*Number of PCT patent application divided by GDP in million euros*	OECD, Eurostat	AC: AM, GE, ME, RS
SB#7/ DB#23	*Share of innovating firms collaborating with HEI/PRO out of all innovative firms*	Eurostat	AC: AM, GE, IL, ME
DB#25	*Business enterprise researchers as % of total national researchers*	OECD	MS: HR, CY, MT, RO AC: AM, GE, IL, ME, RS
DB#26	*Business enterprise researchers in full-time equivalent per thousand employees in industry*	OECD	MS: BG, HR, MT, RO AC: AM, GE, IL, ME, RS
SB#8/ DB#27	*Scientific publications among the top-10% most cited publications worldwide as a percentage of all publications*	Scopus (Science-Metrix dataset)	AC: AM, GE
DB#31	*European and international co-patenting in EPO applications at national and EU level*	Eurostat	AC: AM, GE, ME, RS
SB#10/ DB#35/42	*Environmentally related government R&D budget as percentage of total government R&D*	OECD	MS: BG, CY, HR, MT AC: AM, GE, IS, ME, RS
DB#37	*National public and private investments as suggested in the SET Plan progress report 2021.*	SETIS	AC: AM, GE, IL, IS, ME, NO, RS, TR
SB#11/ DB#39	*Share of researchers receiving transferable skills training*	MORE survey	MS: CY AC: AM, GE, IL, ME, RS, TR
DB#40	*Innovative enterprises that co-operated on R&D and other innovation activities with universities and higher education institutions*	Eurostat	AC: AM, GE, IL, IS, ME, RS
SB#12/ DB#41	*Direct government support and Indirect government support through R&D tax incentives as a percentage of GDP*	OECD, Eurostat	AC: AM, GE, ME, RS
DB#48	*Trust in Science*	Eurobarometer	AC: AM, GE, IL
SB#17/ DB#55	*Share of public R&D expenditures financed by the private sector*	Eurostat	AC: AM, GE
SB#18/ DB#34/56	*Government budget allocations for R&D (GBARD) allocated to Europe-wide transnational, as well as bilateral*	Eurostat	MS: FR AC: AM, GE, IL, ME, TR

No.	Title	Used sources	Member States (MS)/ Associated Countries (AC) with no data
	or multilateral, public R&D programmes per FTE researcher		

In addition to the general solutions discussed above, some specific indicators can be addressed separately using alternative sources/indicators.

In terms of the ***Share of national public R&D expenditure committed to European research infrastructures*** (DB#8)[23], as there are many countries not covered by this ESFRI data, it may be necessary to rely on the "Number of European research infrastructures in which a MS or an AC participates" (financially contributes to operations) (DB#9).

Concerning the ***Business enterprise researchers as % of total national researchers*** (DB#25) and ***Business enterprise researchers in full-time equivalent per thousand employees in industry*** (DB#26), as only OECD data was used for these indicators, data from Eurostat could be added as it covers most of the countries not covered by OECD data.

In relation to DB#25, Eurostat the indicator "Total researchers by sectors of performance - head count" (tsc00003) would allow including the missing four EU MS (i.e., HR, CY, MT, RO) and two AC (i.e., ME, RS).

In terms of DB#26, an alternative Eurostat indicator "Share of R&D personnel and researchers in total active population and employment by sector of performance" (rd_p_perslf) allows measuring business enterprise researchers in full-time equivalent as a share of total employment. Using this indicator would allow including the missing four EU MS (i.e., BG, HR, MT, RO) and two AC (i.e., ME, RS).

2.2.2. Methodological limitations

Another issue concerns data consistency, which creates some complications in comparisons between the years. Overall, ERA monitoring reports would continue relying on the latest available data while acknowledging the possible limitations. Table 5 below outlines the methodological limitations of specific indicators.

Table 5. Indicators with methodological limitations

No.	Title	Limitation
DB#9	*Number of European research infrastructures in which an MS or an AC participates (financially contributes to operations).*	We cannot be certain that the data is comparable for 2016, 2018 and 2021: different ESFRI reports[24] use slightly different terminology to classify the countries.

[23] Instead of the "Share of national public R&D expenditure committed to joint programmes and initiatives, research infrastructures and European Partnerships" (initially planned indicator) the Dashboard report includes the "Share of national public R&D expenditure committed to European research infrastructures" based on the provided data by ESFRI.
[24] ESFRI reports: 2016, 2018, 2021. New guide for report from 2019.

No.	Title	Limitation
SB#11/ DB#39	*Share of researchers receiving transferable skills training*	MORE survey measures the extent of formal and information training received by PhD students and graduates. However, not all researchers in the business enterprise sector are PhD students or holders. In addition, it is not certain that the MORE surveys will be continued in the future.
SB#18/ DB#34/56	*Government budget allocations for R&D (GBARD) allocated to Europe-wide transnational, as well as bilateral or multilateral, public R&D programmes per FTE researcher*	There are some concerns about the consistency of the collected data. Some stakeholders have noted that national statistical offices might not know what exact data is needed for this indicator (what the differences are between its subcategories[25]). Therefore, during the workshop discussions the need for clearer definitions was raised to help distinguish the differences between the subcategories of this indicator.

For the ***Number of European research infrastructures in which an MS or an AC participates (financially contributes to operations)*** (DB#9), it can be stated that despite some uncertainties about the consistency of this data, the difference is not significant. Thus, the indicator should be kept while acknowledging the limitations.

Regarding the ***Share of researchers receiving transferable skills training*** (SB#11/ DB#39), it is suggested to rephrase the indicator to "Share of researchers with a PhD (or in the process of acquiring PhD) receiving transferable skills training" in order to reflect the original indicator in MORE surveys. In case the MORE surveys are not continued in the future, the upcoming European Higher Education Sector Observatory and RICO Observatory could be used in the future as they will include monitoring indicators related to Higher Education and researchers.

Another indicator with some methodological limitations is the ***Government budget allocations for R&D (GBARD) allocated to Europe-wide transnational, as well as bilateral or multilateral, public R&D programmes per FTE researcher*** (SB#18/ DB#34/56). To ensure the consistency of collected data from national statistical offices, it is recommended to further elaborate the discussions between the EC and the countries on the definitions used in this indicator. Nevertheless, if data is collected following the Frascati manual and the complementary EU guidelines, the consistency issues should be minimal.

2.3. Challenge 3: Reflection of ERA priorities

The last type of ERA monitoring challenge is about the connection between the indicator and monitored ERA Action/sub-priority. This concerns not only some indicators that were flagged by stakeholders as not fully representative of specific ERA objectives (see sub-section 2.3.1.) but also the general lack of indicators that are needed to reflect each ERA sub-priority (see sub-section 2.3.2.).

[25] The indicator contains three subcategories for transnationally coordinated R&D: (1) Transnational public R&D performers located in Europe with their dedicated R&D facilities; (2) Europe-wide transnational public R&D programmes; (3) Bilateral or multilateral public R&D programmes established between Member State governments (and with candidate countries and EFTA countries).

2.3.1. Issues with specific indicators

It can be a challenge to assign a specific indicator directly to a specific ERA Action. In other words, some indicators could be potentially altered or substituted to better relate to the measured progress of MS/AC in achieving ERA's goals (see Table 6 below for the list).

Table 6. Indicators which do not fully reflect ERA priorities

No.	Title	ERA Pact sub-priority	Limitation
SB#13	*Research on social innovation per million population*	An active citizen and societal engagement in R&I in all its dimensions	Based on the collected feedback from stakeholders, this indicator may be not reflective of the goal of ERA Action 14 (Bring Science closer to citizens) nor its sub-actions as research per se might not lead to increased citizen participation in science activities.
SB#6/ DB#18	*Job-to-job mobility of Human Resources in Science & Technology*	Researchers' careers and mobility	According to stakeholders, this indicator might not fully reflect ERA Action 4 (Promote attractive research careers, talent circulation and mobility). In addition, a survey respondent noted that the definition of Human Resources in Science & Technology (HRST) includes professionals such as scientists and engineers, technicians and associates professionals with tertiary education which is a very large collective compared to the researchers' population. Therefore, it might be confusing to use indicators on HRST when monitoring ERA progress. Overall, job-to-job mobility is higher in countries with high rates of precarious and temporary jobs and may not imply anything regarding the circulation of knowledge, especially for younger cohorts. Job-to-job mobility could simply show the specifics of a vibrant labour market, which also raises the issue of comparability between countries.
DB#25 DB#26	*Business enterprise researchers as % of total national researchers* *Business enterprise researchers in full-time equivalent per thousand employees in industry*	Knowledge valorisation	The two indicators related to business enterprise researchers under the Knowledge valorisation sub-priority have been criticised by stakeholders. This focus on business enterprise researchers might imply that public sector researchers are less important in knowledge valorisation. This is misleading as all researchers are initially trained at higher education institutions despite their final position. What is important here, according to some stakeholders, are such aspects as funding or gender balance. Therefore, the DB#25 and #26 indicators might be more related to sub-priority "Researchers' careers and mobility".
SB#8/ DB#27	*Number of scientific publications among the top-10% most cited publications worldwide as a percentage of all publications*	Scientific leadership	It was discussed during the workshop that top-cited publications do not necessarily reflect a higher quality of research and that qualitative indicators could be better suited for this. Overall, research quality is a multidimensional concept, and its different components (such as impact, novelty, and reliability) could be measured by more sophisticated indicators. Citation metrics are rather a proxy of the scientific impact and relevance of articles and not of the quality of research publications. The indicator was also criticized

No.	Title	ERA Pact sub-priority	Limitation
			for being only about publications and not covering other aspects of research outputs as discussed in ARRA[26] such as data, software, models, methods, theories, etc.
DB#28	*Academic Freedom Index*	Scientific leadership	In relation to ERA Action 6 (Protect academic freedom in Europe), the indicator has some shortcomings (i.e., it relies on expert surveys, and does not differentiate between fields of science).
SB#12/ DB#41	*Direct government support and Indirect government support through R&D tax incentives as a percentage of GDP*	Synergies with sectorial policies and industrial policy	This indicator is aimed at indicating the directionality of R&I. However, the indicator does not have this directionality component notably with regard to the use of tax incentives, as they are not disaggregated by field of science or industry.

First, for ***Research on social innovation per million population*** (SB#13), the general solution would be to focus on indicators capturing citizen and youth participation in relevant events and competitions or campaigns. However, no feasible potential solution has been found, especially such that would allow comparability across countries.

Regarding ***Job-to-job mobility of Human Resources in Science & Technology*** (SB#6/ DB#18), data on precarity and policy initiatives to make research careers more attractive could be more relevant:

- An immediate solution would be to replace this indicator in the SB with the DB indicators, for example, the "Share of foreign doctorate students as a percentage of all doctorate students" (DB#16) or "New doctorate graduates per 1,000 inhabitants aged 25-34" (DB#17). However, some workshop participants highlighted that this indicator plays an important role in the national ERA action plans (e.g., in Germany), thus, it should not be eliminated. Instead, additional indicators could be included to increase the reflection of the entire ERA Priority Area and the specific ERA Action.

- One possible alternative indicator is the "Number of policy initiatives on research careers in the STIP Compass". (source: STIP Compass). Limitations: difficult to disaggregate by year and compare between countries; limited geographical scope and data is not complete for all countries. Therefore, it was discussed during the workshop that such an indicator is not really suitable. Identification of policy initiatives directly related to ERA could be facilitated by using text-mining or AI tools.

- Additionally, the "Share of researchers satisfied with career-related aspects" (source: MORE survey WC5.4) could be considered. Limitations: survey-based indicator which leads to comparability issues. Also, the data is infrequent (2012, 2016 and 2019) as well as it is not certain that MORE surveys will be continued in the future.

[26] Agreement on Reforming Research Assessment, signed by the Commission and by the European Research Council. https://coara.eu/app/uploads/2022/09/2022_07_19_rra_agreement_final.pdf

- Another possible proxy is the "Proportion of researchers in HES working under 'precarious' contracts" (source: She Figures). Limitations: this indicator is also based on MORE surveys, which leads to the issues discussed above.

For the ***Business enterprise researchers as percentage of total national researchers*** (DB#25) and the ***Business enterprise researchers in full-time equivalent per thousand employees in industry*** (DB#26), it is suggested to also include respective indicators from the perspective of the public sector, in order to remove the discussed implications and focus on just private sector researchers. Additional indicators that could help capture the valorisation of knowledge created in public research organisations could relate to patents. While they may not exactly allow assessing the extent to which this knowledge was then taken up, it could serve as a proxy.

The indicator ***Number of scientific publications among the top-10% most cited publications worldwide as a percentage of all publications*** (SB#8/DB#27) is still a good proxy for the efficiency of the research system, as the top most-cited publications are likely to be of higher quality. However, it should be interpreted more carefully. Therefore, instead of replacing the indicator, additional indicators are needed as it is not sufficient alone to reflect the efficiency and quality of the research system. In addition, more qualitative indicators are needed to better understand the efficiency and quality of the research system.

- During the workshop discussions it was suggested to use university rankings. For example, an indicator could measure the average ranking score of top 10 universities by country and year (source: QS World University Rankings). However, as the university rankings are based on a range of indicators, the top publications are also considered. Furthermore, not all indicators considered in the university rankings would be relevant (e.g. on study infrastructure), and this measure would not capture research-performing entities other than universities.

- It was proposed to closely follow the Coalition for Advancing Research Assessment (COARA), which is working on indicators for research assessment. For example, the COARA Boost project, launched in October 2023, is aimed at developing indicators for monitoring and reforming research assessment practices based on qualitative judgment rather than just simplified quantitative proxies.

For the ***Academic Freedom Index*** (DB#28), an additional indicator could measure the autonomy of Higher Education Institutions (HEIs). During the workshop discussion it was suggested that higher levels of autonomy can be associated with better performance and quality of HEIs. For example, the European University Association regularly develops a scoreboard that analyses higher education autonomy. In addition, other relevant data could potentially be also included in the new Observatory of Higher Education mentioned previously.

With regards to ***Direct government support and Indirect government support through R&D tax incentives as a percentage of GDP*** (to SB#12/ DB#41), indicators on GBARD by socio-economic objectives could be used additionally. Moreover, the "Share of innovating firms collaborating with HEI/PRO out of all innovative firms" (SB#7/ DB#23) could be considered as a proxy for concerted efforts between the public and private sectors and thus included under ERA sub-priority "Synergies with sectorial policies and industrial policy".

In general, measuring ERA Priority Area 4 is challenging. For example, progress toward actual reforms and their implementation cannot be measured quantitatively or qualitatively. While investments are important, it must be acknowledged that they provide only one side of

the phenomenon. Possibly, changes in the structure of funding or sources of funding or the ratio between competitive and block funding may indicate structural changes in the R&I systems. While this would not allow assessing the quality of change, it would indicate structural developments.

2.3.2. Newly suggested indicators

Besides some specific indicators discussed above, more indicators in general are needed to better reflect the ERA priorities. The overall aim should be to have 3-4 indicators (depending on the complexity of the area) with data available per priority area for joint actions in the Pact for R&I (i.e., ERA sub-priority). For example, the ERA sub-priorities "Synergies between Union, national and regional funding programmes" and “Increased collaborative links & excellence-based integration of research-performing organisations” under ERA Priority Area 3 currently have no available indicators in the 2023 monitoring cycle.

In addition, many other sub-priorities have only 1-2 indicators. In the cases where the already used and newly suggested indicators still only allow a limited reflection of ERA sub-priorities, capacities to include new indicators based on new or revised surveys should be explored.

Therefore, Table 1 below lists the proposed new indicators to be considered for use in the next monitoring cycle. This also includes the indicators presented as an alternative in the previous sections of this report[27]. In addition, the number of applied indicators in the 2023 ERA monitoring cycle is provided in brackets under each sub-priority in order to indicate the indicators' coverage. To give a general overview of indicators coverage of each sub-priority, Table 8 in Annex 1 maps all currently applied indicators together with the newly suggested indicators.

Table 7. Proposed new indicators

No.	Indicator	Source	ERA Pact sub-priority (No. of applied indicators)
ERA Priority Area 1: Deepening a truly functioning internal market for knowledge			
1	*Number of open-access research datasets by country*	OpenAIRE	Open Science (1)
2	*Number of repositories by country*	EOSC Observatory or re3data.org	
3	*Country investments in EOSC and Open Science in ranges of investment*	EOSC Observatory	
4	*Share of researchers who received training in open science approaches*	MORE surveys, OS2	
5	*GBARD (EUR) allocated to Europewide transnational, bilateral or multilateral, public R&D programmes per FTE researcher in the public sector*[28]	Eurostat	Research infrastructures (2)

[27] Some indicators could further be broken down to reflect the different sub-priorities. For example, some stakeholders suggest that gender equality may be relevant to consider in the contextualisation of some of the indicators (e.g. indicators related to researchers could be disaggregated by gender).
[28] This SB#18/DB#34/56 indicator is suggested as an alternative to the missing Scoreboard indicator (SB#4).

No.	Indicator	Source	ERA Pact sub-priority (No. of applied indicators)
6	*Women to men ratio of inventorships*	She Figures	Gender equality, equal opportunities for all and inclusiveness (5)
7	*Proportion of women among doctoral graduates*	Eurostat	
8	*Proportion of research organisations (HEIs/PROs) that take actions or measures towards gender equality*	She Figures	
9	*Share of researchers satisfied with career-related aspects*	MORE survey (WC5.4)	Researchers' careers and mobility (3)
10	*Proportion of researchers in HEIs working under 'precarious' contracts*	She Figures	
11	*Patents by universities and public research organisations*	EPO	Knowledge valorisation (6)
12	*Patents by technology – Patent grants at EPO*	OECD	
13	*Number of spin-offs created by KTOs per million population*	ASTP KT annual survey	
14	*Average ranking score of top 10 universities by country and year*	QS World University Rankings	Scientific leadership (2)
15	*Sum of ERC grants received by country in a given year per 1,000 R&D personnel (in FTEs)*	ERC, Eurostat	
16	*Share of patents with foreign co-inventors*	OECD	Global engagement (2)
ERA Priority Area 2: Taking up together the green transition and digital transformation and other challenges with impact on society, and increasing society's participation in the ERA			
-	*No new indicators proposed*	NA	Challenge-based ERA actions (5)
17	*Purchased or licensed-in patents or other IPRs from public research organisations, universities or higher education institutions*	Eurostat CIS	Synergies with Education and the European Skills Agenda (2)
18	*Green bond issuance as a percentage of total bond issuance*	EEA	Synergies with sectorial policies and industrial policy (2)
19	*Number of citizen science activities by country*	New survey needed. No currently available source, but JRC inventory could serve as an example	An active citizen and societal engagement in R&I in all its dimensions (2)
ERA Priority Area 3: Enhancing access to research and innovation excellence across the Union and enhancing interconnections between innovation ecosystems across the Union			
20	*Number of participations in Horizon Europe measured in terms of 1,000 R&D personnel (in FTEs)*	Eurostat, FFG's EU Performance Monitor	More investments and reforms in countries and
21	*Summary Innovation Index*	European Innovation Scoreboard	

No.	Indicator	Source	ERA Pact sub-priority (No. of applied indicators)
22	*Sum of Horizon Europe grants received by country in a given year per 1,000 R&D personnel (in FTEs)*	CORDIS, Eurostat	regions with lower R&I performance (1)
23	*Share of enterprises using public funds from different governance levels (local or regional, national, and EU) for R&I activities*	Eurostat CIS	Synergies between Union, national and regional funding programmes (0)
24	*Number of Seal of Excellence projects published on the InvestEU Portal that have received funding*	InvestEU Portal	
25	*Share of researchers who agree that international mobility is regarded as a positive factor for career progression in their home institution*	MORE surveys (CP4.4)	Increased collaborative links & excellence-based integration of research-performing organisations (0)
26	*Share of leading researchers who agree that transferable skills are regarded as a positive factor for career progression in their home institution*	MORE surveys, (CP4.5)	
27	*Share of Horizon Europe funding received by research organisations from countries with lower R&I performance*	Horizon dashboard	
28	*Average number of partners from non-widening countries per institution from a Widening country participating in the Horizon programme each year*	CORDIS	
29	*Share of enterprises that cooperated with RPOs located in other countries*	Eurostat CIS	
30	*Share of patents registered by a Widening country*[29] *together with partners from other EU countries*	OECD	
31	For further indicators, assessment for indicators to be made available through the European Higher Education Sector Observatory and RICO Observatory	European Higher Education Sector Observatory and RICO Observatory	
ERA Priority Area 4: Advancing concerted research and innovation investments and reforms[30]			
32	*Number of policy initiatives on horizontal policy coordination*	STIP Compass / ERA policy platform	Coordination of R&I investments (1)
-	*No new indicators proposed*	NA	Support to prioritise and secure long-term R&I investments and policy reforms (1)

[29] Widening countries: BG, HR, CY, CZ, EE, GR, HU, LV, LT, MT, PL, PT, RO, SK, SI.
[30] In light of the comments on the challenges to measuring the progress of ERA within the ERA Priority Area 4, we do not suggest significant new indicators. As discussed in the report text, instead, the indicators could measure the structure of funding sources, etc., to track changes, but it would not imply progress as such.

3. Conclusions and recommendations

This report has addressed the challenges of the 2023 ERA monitoring cycle and potential improvements to the ERA Scoreboard (SB) and ERA Dashboard (DB) indicators for 2024. It was based on the desk research and the feedback collected from ERA stakeholders and the study team which had reported the issues faced during the implementation of the 2023 ERA Scoreboard and ERA Dashboard. The report has discussed three key identified challenges: (1) indicators for which no data is available; (2) indicators for which some data is missing or inconsistent; and (3) limited reflection of ERA priorities.

In terms of the first challenge where there is no available data, 19 indicators could not be included in the ERA SB and DB due to this issue. For seven indicators[31] data was initially envisioned to be collected via new surveys by the Commission. However, the creation of surveys was not initiated in order to avoid additional burden. For the remaining 12 indicators, the initially envisioned data from a specific database was not available at the end.[32] Therefore, possible alternative indicators or data sources were suggested for each unavailable indicator, based on the existing databases or projects.

The second challenge is about indicators with missing data for some countries or inconsistent data due to some methodological limitations. The possible solutions are to use available additional data sources, individually ask countries to provide the missing data, or use data projections. However, these solutions have some drawbacks, such as comparability, transparency, and resource issues.

Lastly, the report analysed the relevance of the indicators for the priority areas for joint action within Pact for R&I (ERA sub-priorities) and the general coverage of each ERA sub-priority. Additional indicators were proposed, which could help better capture the objectives of the Pact for R&I. However, some ERA sub-priorities still have few available indicators due to the lack of relevant and reliable data sources, and thus they are not well captured by the ERA monitoring system. Therefore, new surveys may be needed to collect new data for some areas.

Based on the findings within this report, recommendations are presented below:

1. To improve the data availability and quality for the ERA monitoring indicators, it is important that the ERA monitoring exercise can benefit from:

    - Close collaboration with data providers such as EOSC, Eurostat, and the OECD, to ensure timely and consistent data collection and dissemination for the indicators that rely on their sources.

    - New surveys or existing surveys with revised questionnaires to collect data for the indicators that require the collection of new primary data collection that is currently not collected otherwise (e.g. related to spin-offs, licensing, and green/digital transition).

[31] One of such indicators (DB#36/43) was included in the list of Dashboard indicators two times.
[32] In addition, one indicator (DB#31) might need to be dropped in the future ERA monitoring due to the data not being updated for several years (it was not counted in the number of missing indicators).

- Access to microdata from databases such as PATSTAT or Crunchbase to construct indicators that are not available at the aggregate level (e.g. those related to co-patenting or ERC grants).

- Contacts with national statistical offices from countries with missing data for some of the presented indicators, helping to reduce the geographical scope limitations.

- Inclusion of relevant indicators from the new monitoring exercises, such as the European Higher Education Sector Observatory and the Research and Innovation Careers Observatory.

2. To enhance the relevance and coverage of the ERA monitoring indicators, the Commission should:

    - Continue to review the indicator framework and assess their alignment with the ERA sub-priorities, and any methodological limitations (e.g., relating to research infrastructures, job-to-job mobility, and trust in science).

    - Adopt new indicators in the light of the experience of the 2023 ERA monitoring cycle in order to capture the ERA sub-priorities that are currently not well-covered.

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5. Annexes

5.1. List of already applied and proposed new ERA monitoring indicators

Table 8. List of already applied and proposed new indicators

No. in 2023 monitoring cycle	Indicator	Source	ERA Pact sub-priority
General indicators			
SB#1/ DB#1	*Gross Domestic Expenditure on R&D (GERD) as a percentage of GDP*	Eurostat	
DB#2	*Government Budget Allocations for R&D (GBARD) as share of GDP*	Eurostat	
SB#2/ DB#3	*Researchers (in full-time equivalent) per million inhabitants*	Eurostat	
DB#4	*Business Enterprise expenditure on R&D (BERD) as a percentage of GDP*	Eurostat	
ERA Priority Area 1: Deepening a truly functioning internal market for knowledge			
SB#3/ DB#5	*Share of publications available in open access*[33]	OpenAIRE	Open Science
Newly suggested	*Number of open-access research datasets by country*	OpenAIRE	
Newly suggested	*Number of repositories by country*	EOSC Observatory or re3data.org	
Newly suggested	*Country investments in EOSC and Open Science in ranges of investment*	EOSC Observatory	
Newly suggested	*Share of researchers who received training in open science approaches*	MORE surveys, OS2	
DB#8	*Share of national public R&D expenditure committed to European research infrastructures*[34]	ESFRI	Research infrastructures
DB#9	*Number of European research infrastructures in which a Member State or an Associated Country participates*	ESFRI	

[e] Open access scientific publications with digital object identifier (DOI) as % of total scientific publications with (DOI)

[34] Instead of the "Share of national public R&D expenditure committed to joint programmes and initiatives, research infrastructures and European Partnerships" (initially planned indicator) the Dashboard report includes the "Share of national public R&D expenditure committed to European research infrastructures" based on the provided data by ESFRI.

No. in 2023 monitoring cycle	Indicator	Source	ERA Pact sub-priority
Newly suggested[35]	*GBARD (EUR) allocated to Europewide transnational, bilateral or multilateral, public R&D programmes per FTE researcher in the public sector*	Eurostat	
SB#5/ DB#11	*Share of women in grade A positions in higher education institutes*	Women in Science	Gender equality, equal opportunities for all and inclusiveness
DB#12	*Proportion of papers with mixed gender authorship, 2000-2020*	Scopus, NamSor (Science-Metrix dataset)	
DB#13	*Proportion of women in authorships of the top 10% most cited publications, 2000-2018*	Scopus, NamSor (Science-Metrix dataset)	
DB#14	*Women in Digital Index*	DESI	
DB#15	*Proportion of women among doctoral graduates by narrow fields of Science, Technology, Engineering and Mathematics (STEM)*	Eurostat	
Newly suggested	*Proportion of women among doctoral graduates*	Eurostat	
Newly suggested	*Women to men ratio of inventorships*	She Figures	
Newly suggested	*Proportion of research organisations (HEIs/PROs) that take actions or measures towards gender equality*	She Figures	
DB#16	*Share of foreign doctorate students as a percentage of all doctorate students*	Eurostat	Researchers' careers and mobility
DB#17	*New doctorate graduates per 1,000 inhabitants aged 25-34*	Eurostat	
Newly suggested	*Share of researchers satisfied with career-related aspects*	MORE survey (WC5.4)	
Newly suggested	*Proportion of researchers in HEIs working under 'precarious' contracts*	She Figures	
SB#6/ DB#18	*Job-to-job mobility of Human Resources in Science & Technology*	Eurostat	
DB#19	*Share of public-private co-publications per million population*	Science-Metrix, Eurostat	Knowledge valorisation
DB#21	*Best practice examples and methodologies for knowledge valorisation (qualitative indicator)*	Qualitative indicator	
DB#22	*Number of PCT patent applications divided by GDP in million euros*	OECD, Eurostat	
SB#7/ DB#23	*Share of innovating firms collaborating with HEI/PRO out of all innovative firms*	Eurostat	

[35] This SB#18/DB#34/56 indicator is suggested as an alternative to the missing Scoreboard indicator (SB#4).

No. in 2023 monitoring cycle	Indicator	Source	ERA Pact sub-priority
DB#25	*Business enterprise researchers as percentage of total national researchers*	OECD	
DB#26	*Business enterprise researchers in full-time equivalent per thousand employees in industry*	OECD	
Newly suggested	*Number of spin-offs created by KTOs per million population*	ASTP KT annual survey	
Newly suggested	*Patents by technology – Patent grants at EPO*	OECD	
Newly suggested	*Patents by universities and public research organisations*	EPO	
SB#8/ DB#27	*Number of scientific publications among the top-10% most cited publications worldwide as a percentage of all publications*	Scopus (Science-Metrix dataset)	Scientific leadership
DB#28	*Academic Freedom Index*	Vdem	
Newly suggested	*Average ranking score of top 10 universities by country and year*	QS World University Rankings	
Newly suggested	*Sum of ERC grants received by country in a given year measured in terms of 1,000 R&D personnel (in FTEs)*	ERC, Eurostat	
SB#9/ DB#30	*International co-publications with non-EU partners per 1,000 researchers (in full-time equivalent) in the public sector*	Scopus, Eurostat	Global engage-ment
DB#31	*European and international co-patenting in EPO applications at national and EU level*	Eurostat	
Newly suggested	*Share of patents with foreign co-inventors*	OECD	
ERA Priority Area 2: Taking up together the green transition and digital transformation and other challenges with impact on society, and increasing society's participation in the ERA			
DB#33	*Government budget allocations for R&D (GBARD) according to NABS as share of total GBARD*	Eurostat	Challenge-based ERA actions
SB#10/ DB#35/42	*Environmentally related government R&D budget as percentage of total government R&D*	OECD	
DB#37	*National public and private investments as suggested in the SET Plan progress report 2021*	SETIS	
DB#38	*OECD Patents on environment technologies*	OECD	
SB#11/ DB#39	*Share of researchers receiving transferable skills training*	MORE surveys	Synergies with Education and the European Skills Agenda
DB#40	*Share of products and/or processes by innovative firms cooperating with higher education institutions or public/private research institutions*	Eurostat	

No. in 2023 monitoring cycle	Indicator	Source	ERA Pact sub-priority
Newly suggested	*Purchased or licensed-in patents or other IPRs from public research organisations, universities or higher education institutions*	Eurostat CIS	
SB#12/ DB#41	*Direct government support and Indirect government support through R&D tax incentives as a percentage of GDP*	OECD, Eurostat	Synergies with sectorial policies and industrial policy
DB#35/42	*Environmentally related government R&D budget as percentage of total government R&D*	OECD	
Newly suggested	*Green bond issuance as a percentage of total bond issuance*	EEA	
SB#13	*Research on social innovation (publications on 'social innovation' or 'social entrepreneurship')*	OpenAIRE	An active citizen and societal engagement in R&I in all its dimensions
DB#48	*Trust in Science*	Eurobarometer	
Newly suggested	*Number of citizen science activities per million inhabitants by country*	New survey needed.[36] No currently available source, but JRC inventory could serve as an example	
ERA Priority Area 3: Enhancing access to research and innovation excellence across the Union and enhancing interconnections between innovation ecosystems across the Union			
SB#14/ DB#49	*Increase in total R&D expenditure in widening countries expressed as a percentage of GDP*	Eurostat	More investments and reforms in countries and regions with lower R&I performance
Newly suggested	*Number of participations in Horizon Europe measured in terms of 1,000 R&D personnel (in FTEs)*	Eurostat, FFG's EU Performance Monitor	
Newly suggested	*Summary Innovation Index*	European Innovation Scoreboard	
Newly suggested	*Sum of Horizon Europe grants received by country in a given year measured in terms of 1,000 R&D personnel (in FTEs)*	CORDIS, Eurostat	
Newly suggested	*Share of enterprises using public funds from different governance levels (local or regional, national, and EU) for R&I activities*	Eurostat CIS	Synergies between Union, national and regional funding programmes
Newly suggested	*Number of Seal of Excellence projects published on the InvestEU Portal that have received funding per 1,000 R&D personnel (in FTEs)*	InvestEU Portal, Eurostat	

[36] The survey could target academic institutions and research funding organizations, asking to identify them any such activities that they ran. Another venue to distribute the survey would be through citizen science mailing lists, following the approach used in an earlier study (see JRC inventory).

No. in 2023 monitoring cycle	Indicator	Source	ERA Pact sub-priority
Newly suggested	*Share of researchers who agree that international mobility is regarded as a positive factor for career progression in their home institution*	MORE surveys (CP4.4)	Increased collaborative links & excellence-based integration of research-performing organisations
Newly suggested	*Share of leading researchers who agree that transferable skills are regarded as a positive factor for career progression in their home institution*	MORE surveys, (CP4.5)	
Newly suggested	*Share of Horizon Europe funding received by research organisations from countries with lower R&I performance*	Horizon dashboard	
Newly suggested	*Average number of partners from non-widening countries per institution from a Widening country participating in the Horizon programme each year*	CORDIS	
Newly suggested	*Share of enterprises that cooperated with RPOs located in other countries*	Eurostat CIS	
Newly suggested	*Share of patents registered by a Widening country together with partners from other EU countries*	OECD	
Newly suggested	*For further indicators, assessment for indicators to be made available through the European Higher Education Sector Observatory and RICO Observatory*	European Higher Education Sector Observatory and RICO Observatory	
ERA Priority Area 4: Advancing concerted research and innovation investments and reforms[37]			
SB#17/ DB#55	*Share of public R&D expenditures financed by the private sector*	Eurostat	Coordination of R&I investments
Newly suggested	*Number of policy initiatives on horizontal policy coordination*	STIP Compass / ERA policy platform	
SB#18/ DB#34/56	*Government budget allocations for R&D (GBARD) allocated to Europe-wide transnational, as well as bilateral or multilateral, public R&D programmes per FTE researcher*	Eurostat	Support to prioritise and secure long-term R&I investments and policy reforms

5.2. Workshop summary note

The aim of the online workshop on 23 January 2024 was to discuss and collect feedback on the challenges and proposed improvements to the 2023 European Research Area (ERA) Scoreboard (SB) and Dashboard (DB), and to contribute to establishing a robust set of

[37] In light of the comments on the challenges to measuring the progress of ERA within the ERA Priority Area 4, we do not suggest significant new indicators. As discussed in the report text, instead, the indicators could measure the structure of funding sources, etc., to track changes, but it would not imply progress as such.

indicators (with available data) to be applied to the 2024 SB and DB. There were 71 workshop participants (see list in section 5.2.4.). The following sections provide an overview of the workshop summarising the discussions.

5.2.1. Introduction

The workshop was started by the moderator from DG RTD, who introduced the goal of the workshop and the main issues with ERA monitoring indicators to be discussed. Before starting the discussion, the contractors from Visionary Analytics briefly presented the context of the study, delved deeper into the introduced three main issues with indicators, and proposed the main questions for discussion:

- We have listed the indicators for which data is not available and proposed some possible solutions. Are the proposed solutions viable? What alternatives would you see?

- Indicators with some missing/inconsistent data. Some of the indicators are limited for some countries or may lack comparability over time. How could these limitations be minimised? Are alternative indicators needed?

- Does the current indicators' coverage of ERA Priority Areas well reflect the progress made? Are they sufficient to monitor each ERA Priority Area? Do you suggest alternative indicators to address the identified gaps?

5.2.2. Summary of discussions

5.2.2.1. ERA Scoreboard and Dashboard Indicators: No Available Data

The study team presented in more detail the first key issue with ERA monitoring indicators – no available data for some indicators. The ERA Scoreboard has three (out of 18) indicators for which data is not available, while the ERA Dashboard has 18 (out of 56) such indicators.

Three generic solutions were mentioned: (1) new surveys to collect the data; (2) dropping indicators; and (3) identifying alternative indicators with (some) similarity to the original ones. More detailed proposals for each such missing indicator were presented in the background note, which was shared before the workshop.

Therefore, some key questions were raised: **Are the proposed solutions viable? What alternatives would you see?**

After the presentation of the study team, one expert who contributed to the creation of the initial list of ERA monitoring indicators explained why currently for some indicators no data is available. For some indicators, it was assumed that they would need further development by the Commission and the Member States in the future through launching new surveys or adding questions to existing surveys. The challenges and burden of creating surveys were also anticipated. However, if the option of creating new surveys is not feasible or desirable, alternative indicators could be suggested.

During this first session of the workshop, the following points were raised:

- The ***Share of national public R&D expenditure committed to joint programmes and initiatives, research infrastructures and European Partnerships*** (SB#4) is extremely important as it would show national contributions and commitment to ERA. The idea of using an alternative Eurostat indicator *Government budget allocations for R&D (GBARD) allocated to Europe-wide transnational,* as well as *bilateral or multilateral, public R&D programmes per FTE researcher* (SB#18, DB#34/56) is generally supported as it is a good practical solution.

  However, there could be some issues in the definition of this Eurostat indicator as some national statistical offices might not know what exact data is needed for this indicator. We need clearer definitions so that the data would be comparable between countries. Overall, it is a difficult indicator, and Member States might need support in collecting this data. In addition, using the indicator could incentivise the national statistical offices to collect such data according to common definitions.

- Concerning the ***Percentage of the metadata related to publicly funded research datasets which are defined as Open Data that are discoverable through EOSC federated infrastructure*** (DB#6), it could be possible to extract the necessary data from EOSC and calculate the needed percentage manually. However, the technical challenge might require many additional human resources.

- In terms of the ***Share of investment in European research infrastructures as a percentage of GDP*** (DB#8), it has been expressed that the suggested alternative is acceptable – the *Number of European research infrastructures in which an MS or an AC participates (financially contributes to operations)* (DB#9). However, the DB#8 indicator should still be pursued as it would provide valuable information.

- As for the indicator ***Share of higher education institutions or public/private research institutions with a Gender Equality Plan (GEP)*** (DB#10), DG RTD is working towards making such data available in the future. In addition, there are some relevant projects (e.g., the Inspire project), thus there should be quite some data for this in the future.

- In terms of the ***Number of spin-offs created by HEIs or public/private research organisations*** (DB#21), two solutions are possible: (1) using an alternative database like Crunchbase (short-term solution); (2) creating a new survey (longer-term solution). However, there are many issues connected to creating a new survey, such as data comparability and lack of geographical scope. Nevertheless, it has been highlighted by participants that such data is of great importance for the ERA. Therefore, despite the associated burdens, a new survey (which would also include methodological clarification so that these indicators are understood correctly) is highly desirable. Whereas the alternative indicators suggested in the background note may have a slightly different focus and content.

- For the ***Commercialisation of technology and other research results through licensing (HEIs or public/private research organisations)*** (DB#24), the ITEA survey could potentially be used. In addition, it is not suggested to turn to data for patents as it is different from licensing. Overall, similarly to the previous indicator (DB#21), participants highlight that it is important to have such data despite the associated burdens.

- As for the ***EU co-patenting at the EPO according to applicants'/ inventors' country of residence by international patent classification (IPC)*** (DB#32), it could use PATSTAT data. For example, data from PATSTAT is used in **She Figures** reports as

statistics on inventorships. Thus, using the same data source is important for assuring comparability and consistency at the European level.

- It was suggested that the indicator of ***R&I investments in green transition as a share of total GERD*** (DB#36/43) could be replaced by the share of green patents.

- In terms of the ***Share of Seal of Excellence rewards that received funding from other sources*** (SB#15/ DB#51) and *the* ***Number of collaboration networks of RPOs in Widening countries with other EU countries*** (SB#16/ DB#54), it has been revealed that these indicators were included in the initial list as the data was expected to become available on the Horizon Dashboard. Therefore, it should be encouraged to engage once again with other projects running in DG RTD to check the availability of the data for these indicators.

  What is needed is accessing detailed microdata on Horizon and constructing the indicator. However, this requires additional resources. On the other hand, the ***Number of collaboration networks of RPOs in Widening countries with other EU countries*** (SB#16/ DB#54) could be changed to the data on co-publishing: there could be an assumption that researchers from different countries collaborating in the publications correspond to an overall number of collaboration networks.

- Discussing the indicators ***Number of early career research managers participating in training programmes, staff exchanges, and networks as a share of the total number of researchers*** (DB#52) and the ***Number of more experienced research managers participating in training, in order to lead out the research management teams as a share of total number of researchers*** (DB#53), which were initially envisioned to be based on EARMA's data, the suggested alternatives based on MORE surveys are not a good option as there is no certainty that the survey will be continued. However, the new Observatory of Higher Education (HE) could be used in the future. It is a new project (by DG EAC), which will merge the data on Higher Education. In addition, the Commission's future RICO Observatory, which will be set up with the support of the OECD, could be potentially useful too as it monitors the mobility of researchers.

5.2.2.2. ERA Scoreboard and Dashboard Indicators: Some Missing/Inconsistent Data

The study team presented the second key issue for the quantitative ERA monitoring, concerning indicators with some missing or inconsistent data. 26 indicators throughout the ERA Scoreboard and Dashboard do not include data for specific countries. This mostly concerns Horizon Europe Associated Countries (AM, GE, ME, IL, others), however, for some indicators, data is also missing for Member States (BG, HR, MT, others).

In such cases, two possible solutions are proposed: (1) using alternative data sources for those countries, where possible; (2) retaining indicators but acknowledging their shortcomings for specific countries.

Two indicators with specific methodological limitations were presented as well: data comparability for European research infrastructures (DB#9); and lack of data on specifically transferable skills training for researchers (SB#11/ DB#39). In these cases, two solutions are proposed: (1) in the case of DB#9, keep using the data acknowledging the limitations; (2) rephrase the indicator (SB#11/ DB#39) so that its name would correspond to the available data.

Consequently, the main questions for discussion were presented: **Should the indicators be kept in the ERA Scoreboard and Dashboard given their limitations? How could the limitations be minimised?**

In general, it was highlighted that this indicator problem is much simpler than the one discussed in the previous session. That is because in this case there is plenty of available information which could be used to fill the gaps (missing data for some countries). This mainly concerns the eight Horizon Europe Associated Countries covered by the 2023 monitoring cycle, which are not well covered by international sources (e.g., Eurostat and OECD) or EC reports (e.g., Women in Digital Index or SET Plan progress report).

This issue will be even more pertinent when all Horizon Europe Associated Countries will be considered. Therefore, the main challenge here is accessing the relevant national data. In the meantime, it is important to include such indicators in the ERA SB and DB despite some missing data. This could consequently persuade countries to start collecting such data as they would seek to be included in the monitoring.

Overall, two main solutions were discussed for indicators with missing data for some specific countries. The first solution is **persuading countries to provide the missing data**. This could be done by interacting with national statistical offices and it would require sharing strict definitions and guidelines for collecting (or constructing) such data. The second solution is to **use data projections** (imputation) in case of missing data. However, when using this solution there could be a lack of transparency about missing data.

Regarding the first discussed solution (persuading countries to provide the missing data), it was proposed to issue official requests or simply email letters to such countries asking (reminding) to provide data. Alternatively, the already compiled data could be sent to the responsible persons in such countries for the revision and confirmation of the data. On the other hand, if data is taken from individual national offices, the problem of data comparability between countries arises. It could be challenging to ensure that the same definitions and data

collection methods are used in such cases. Moreover, such individual data collection requires many additional resources.

On the second discussed solution (using data projections) opinions were divided. Some participants support the idea of imputing the missing data, while others object to it. In the case of ERA monitoring, such data projections could have a satisfactory quality as the quality of imputation could be tested by comparing to the numerous countries which have available data.

However, concerns were raised about using data projections as there could be political disagreements about using the projections instead of being transparent and showing the data gaps. This could urge the countries with the missing data to take action. Nevertheless, in case it is chosen to use data projections, an option to show original data should be ensured as it has been done in the Women in Science database.

Some specific indicators with missing or inconsistent data were discussed in more detail:

- In terms of the ***Business enterprise researchers as % of total national researchers*** (DB#25) and ***Business enterprise researchers in full-time equivalent per thousand employees in industry*** (DB#26), GERD statistics and the number of researchers could be used instead, as this data should be available for all countries. On the other hand, as the OECD data was used for these indicators, the Eurostat database should be checked to complement the data initially found during the study.

- The ***Share of researchers receiving transferable skills training*** (SB#11/ DB#39) was briefly commented. This indicator uses MORE survey data, which measures the share of researchers with PhD (or in the process of acquiring PhD) and not the overall share of researchers. Therefore, rephrasing the title of the indicator could be an immediate solution. However, as there are signs that the MORE survey might not be continued in the future, this indicator should be investigated in more detail.

- For the ***Number of European research infrastructures in which an MS or an AC participates (financially contributes to operations)*** (DB#9), it has been agreed to keep using the data acknowledging the limitations (potential differences in country classification). Although there is some uncertainty in terms of the consistency of used definitions in different ESFRI reports, the difference is most likely very small.

5.2.2.3. ERA Scoreboard and Dashboard Indicators: Reflection of ERA Priority Areas

The study team presented the third and last key issue within ERA monitoring indicators, which concerns the reflection of ERA Priority Areas. In cases where some indicators are not as relevant to the ERA Priority Area (or sub-priority), one possible solution is adopting new indicators to replace the problematic ones. To better reflect ERA Priority Areas, additional indicators need to be included.

However, the challenge is to find indicators that are relevant and have sufficient data. Therefore, the main questions for discussion were raised: **Are the current indicators**

sufficient to monitor ERA Priority Area X? What is currently not covered in ERA Priority Area X? What indicators could cover these gaps?

The discussion mainly concerned indicators under **ERA Priority 1: Deepening a truly functioning internal market for knowledge**. The issues covered were:

- There is some concern that the applied and suggested indicators for ERA Action 1 (Open Science) are not sufficient to fully reflect the Action. Therefore, it was suggested to closely cooperate with EOSC to seek additional information to resolve the existing issues with the indicators or to propose additional indicators.

- In terms of gender equality, inspiration for indicators could be taken from the recently launched project called Inspire (also mentioned above). For example, the ratio of internationally mobile women could be considered in ERA. Another missing aspect among the current ERA indicators is gender-based violence, which should be also addressed in the future. There is a recent European Science Foundation project on this topic – UniSAFE. Its survey covers 15 Member States and 42.000 staff.

- The indicator ***Job-to-job mobility of Human Resources in Science & Technology*** (SB#6/ DB#18) was discussed in depth. There is some doubt that this indicator reflects the objective of ERA Action 4 (Promote attractive research careers, talent circulation and mobility). The issue is that there are two types of mobility – intersectoral (e.g., from academia to business) and geographical (across the countries). In addition, there is a high level of precarity in research careers and the proposed alternative indicators (based on STIP Compass data) are not entirely suitable. Overall, job-to-job mobility could also simply show the specifics of a vibrant labour market. Consequently, the issue of comparability between countries arises.

  Another more immediate and simple solution would be to replace this indicator in the SB with the DB indicators, for example, the *Share of foreign doctorate students as a percentage of all doctorate students* (DB#16) or *New doctorate graduates per 1,000 inhabitants aged 25-34* (DB#17). However, some participants highlighted that this indicator plays an important role in the national ERA action plans (e.g., in Germany), thus, it should not be eliminated. Instead, additional indicators could be included to increase the reflection of the entire ERA Priority Area and the specific ERA Action.

  In addition, data on precarity could be used as suggested in the background note. However, as the MORE survey might be discontinued, some other indicators should be used. For example, She Figures uses a proxy from Eurostat instead – the *Proportion of researchers in HEIs working under 'precarious' contracts (by sex)*. Even if some countries do not collect data on precarity, the application of such indicators could incentivise countries to develop a solution.

- In terms of the ***Business enterprise researchers as % of total national researchers*** (DB#25) and ***Business enterprise researchers in full-time equivalent per thousand employees in industry*** (DB#26), these indicators might be more related to sub-priority "Researchers' careers and mobility". As these indicators are currently connected to "Knowledge Valorisation", it might create the wrong impression that private-sector researchers add more value to science than public-sector researchers.

- As for the ***Number of scientific publications among the top-10% most cited publications worldwide as a percentage of all publications*** (SB#8/ DB#27), it was noted that this indicator is quantitative and does not capture the qualitative aspects of research leadership. It was argued that highly cited publications do not necessarily reflect higher quality or impact of research and that qualitative indicators could be better suited for assessing the quality of research. The indicator was also criticized for being only about publications, and not covering other aspects of research.

  Nevertheless, despite the drawbacks, it is still a relatively good proxy, and should be kept. Therefore, additional indicators are needed as it is not sufficient alone to reflect the efficiency and quality of the research system. Such additional indicators could be included in the Dashboard, which is more flexible than the Scoreboard as regards the total number of indicators.

  It was suggested that the ranking of universities could be used instead. However, the top publications are also considered when compiling the ranking.

  Another suggestion was to follow up on the COARA coalition, which is working on indicators for research assessment. It was also agreed that bibliometric analysis has some limitations. However, it should not be discarded, but rather interpreted carefully.

  Finally, it was emphasized that research quality is a multidimensional concept and that different components of good research, such as impact, novelty, and reliability, could be measured by more sophisticated indicators. It was also emphasised that the policy context should be taken into account when measuring the dimensions of the science and innovation system, and that policy measures directly related to ERA should be identified (e.g., by using AI tools).

- For the ***Academic Freedom Index*** (DB#28), an alternative/additional indicator could measure the autonomy of Higher Education Institutions (HEIs) as some studies argue that higher education performance is better if there is more autonomy. This data could be potentially related to the new Observatory of Higher Education referred to in the first session of the workshop. In addition, the European University Association is looking into Higher Education autonomy.

In addition, other ERA Priority Areas have been briefly discussed. For ERA Priority Area 2, it has been suggested that a more detailed technological breakdown into various indicators could be used. This would help to see more specific reasons why some countries are lagging behind (e.g., green energy, solar energy, nuclear energy).

Concerning ERA Priority Area 4, the suggested indicator Number of policy initiatives on horizontal policy coordination, has some limitations due to the shortcomings of the STIP Compass. In the context of ERA, the STIP compass does not provide specific information and the data on relevant policies is not always fully available. Therefore, new AI tools could be used to analyse text and identify relevant national policies.

5.2.3. Wrap-up

The workshop was concluded by a DG RTD representative:

- It was highlighted that as both ERA SB and DB were created from scratch, it is normal to face challenges. That is why it is important to stay open for discussions and frequently scrutinise the indicator framework. The ultimate aim must be to improve the quality of the Scoreboard and Dashboard in the next monitoring cycle.

- The importance of keeping a certain level of continuity with the indicator set was stressed. A good mix of existing indicators that worked, and possibly new indicators, should be sought.

- Creating new indicators and collecting additional data is time and resource-consuming and might be developed together with national administrations. However, there are a lot of projects going on and techniques (including new AI tools) applicable that the ERA monitoring could benefit from and that would allow efficient processing of vast amounts of data.

- Lastly, the need for ERA monitoring to stay credible was accentuated. This means that the "right" indicators must be used – they should reflect ERA sub-priorities as closely as possible.

After the wrap-up of the discussion, the next steps were presented:

- Participants were encouraged to visit the new ERA Platform accessible here. This platform will facilitate access to relevant information regarding ERA. It includes the ERA (Scoreboard) Performance Indicators.

- All the feedback received during and after the workshop will be reflected in the report on methods to improve the analytical framework of the ERA SB and DB. After the report, another discussion might be needed on a technical level, but also possibly with the ERA Forum.

5.2.4. Anonymised list of participants

No.	Stakeholder group	Represented entity
1	ERA Forum representative	Ministry of Education and Research of Norway
2	ERA Forum representative	Ministry of Education and Science Republic of Latvia
3	ERA Forum representative	EARTO
4	ERA Forum representative	Malta Council for Science and Technology
5	ERA Forum representative	ANI - Portuguese National Innovation Agency
6	ERA Forum representative	Austria Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology
7	ERA Forum representative	Ministry of Education and Research of Estonia
8	ERA Forum representative	Ministry of Science, Innovation and Universities of Spain
9	ERA Forum representative	YERUN - Young European Research Universities Network

No.	Stakeholder group	Represented entity
10	ERA Forum representative	EU-Bureau of the German Federal Ministry of Education and Research at DLR Project Management Agency
11	ERA Forum representative	DLR Project Management Agency (Germany)
12	ERA Forum representative	Ministry of Education, Youth and Sports of Czechia
13	ERA Forum representative	National Research, Development and Innovation Office of Hungary
14	ERA Forum representative	DFHERIS (Ireland)
15	ERA Forum representative	The Israeli Council for the advancement of women in Science and Technology
16	ERA Forum representative	Ministry of Education, Culture and Science (Netherlands)
17	ERA Forum representative	Ministry of Higher Education, Science and Innovation of Slovenia
18	ERA Forum representative	National Information Processing Institute (Poland)
19	ERA Forum representative	Deputy Ministry of Research, Innovation and Digital Policy (Cyprus)
20	ERA Forum representative	COR (Finland)
21	ERA Forum representative	German Federal Ministry for Education and Research
22	ERA Forum representative	Ministry of Education and Science of Georgia
23	ERA Forum representative	Wallonia-Brussels Federation
24	ERA platform contact	Foundation for Science and Technology, Portugal
25	ERA Action Owner	European Commission
26	ERA Action Owner	Ministry of Education, Science and Culture (Netherlands)
27	ERA Action Owner	EOSC Association
28	ERA Action Owner	FCT - Portugal
29	ERA Action Owner	RTD.D4.001 (Gender Sector)
30	ERA Action Owner	National Research, Development and Innovation Office (NRDIO) of Hungary
31	ERA Action Owner	Gender Sector - Unit D4
32	ERA Action Owner	German Ministry of Education and Research
33	ERA Action Owner	European Commission DG RTD Unit E2 Valorisation policy and IPR
34	ERA Action Owner	European Commission - RTD.A.4
35	ERA Action 5 subgroup member	Higher Education Authority, Ireland
36	ERA action 5 subgroup representative	EASSH
37	ERA Action-PRT FCT team	FCT-Foundation for Science and Technology (Portugal)
38	Commission services and units (other than ERA Action Owner)	DG RTD

No.	Stakeholder group	Represented entity
39	Commission services and units (other than ERA Action Owner)	European Commission, DG RTD, Unit A.2
40	Commission services and units (other than ERA Action Owner)	European Commission - DG R&I
41	Commission services and units (other than ERA Action Owner)	European Commission - DG RTD
42	Commission services and units (other than ERA Action Owner)	DG R&I
43	R&I stakeholder (invited expert)	OST
44	Consortium partner, Invited expert	Maastricht University
45	Policy Officer, NCP ERA Monitoring	Austrian Federal Ministry of Education, Science and Research
46	R&I statistician	BELSPO (Belgian Science Policy Office)
47	R&I stakeholder	EARTO
48	R&I stakeholder	Malta Council for Science & Technology
49	R&I stakeholder	Institute for Advanced Studies
50	R&I stakeholder	Łukasiewicz Centre - Łukasiewicz Research Network
51	R&I stakeholder	Independent researcher
52	R&I stakeholder	Fraunhofer-Gesellschaft
53	R&I stakeholder	Fraunhofer-Gesellschaft
54	R&I stakeholder	Technology Agency of the Czech Republic
55	R&I stakeholder	G6 - CSIC - Spanish National Research Council
56	R&I stakeholder	TNO
57	R&I stakeholder	Rathenau Instituut
58	National administration for research policy	Belgian science policy office
59	National Contact Point Gender Equality in R&I	Slovak Centre of Scientific and Technical Information
60	National Contact Point Gender Equality in R&I	Slovak Centre of Scientific and Technical Information
61	Public administration	National Research Development and Innovation Office Hungary
62	Group unknown as participant did not register for the workshop in advance	DG RTD
63	Group unknown as participant did not register for the workshop in advance	DG RTD
64	Group unknown as participant did not register for the workshop in advance	DG RTD
65	Group unknown as participant did not register for the workshop in advance	DG RTD

No.	Stakeholder group	Represented entity
66	Group unknown as participant did not register for the workshop in advance	ESFRI
67	Group unknown as participant did not register for the workshop in advance	FFG – Austrian Research Promotion Agency
68	ERA study team	Ecorys
69	ERA study team	Visionary Analytics
70	ERA study team	Visionary Analytics
71	ERA study team	Visionary Analytics

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This report presents the methodological challenges of the indicator framework used for the 2023 ERA monitoring cycle and suggests potential improvements to the ERA Scoreboard and Dashboard for 2024.

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