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Transnational Access to Research Facilities: an EPOS service to promote multi-domain Solid Earth Sciences in Europe

Richard Wessels[*,1], Geertje ter Maat[1], Elisabetta Del Bello[2], Lucia Cacciola[2], Fabio Corbi[3], Gaetano Festa[4], Francesca Funiciello[5], George Kaviris[6], Otto Lange[7], Jörn Lauterjung[8], Ronald Pijnenburg[1], Giuseppe Puglisi[9], Danilo Reitano[9], Christian Rønnevik[10], Piergiorgio Scarlato[2], Letizia Spampinato[2]

(1) Utrecht University, Department of Earth Sciences, Princetonlaan 8a, 3584 CB, Utrecht, The Netherlands
(2) Istituto Nazionale di Geofisica e Vulcanologia, Via di Vigna Murata 605, Rome, Italy
(3) Istituto di Geologia Ambientale e Geoingegneria – CNR, P.le Aldo Moro 5, 00185, Rome, Italy
(4) Università degli Studi di Napoli Federico II, Dipartimento di Fisica, Via Cintia, 80126, Naples, Italy
(5) Università Roma Tre, Dipartimento di Scienze, Largo San Leonardo Murialdo 1, Rome, Italy
(6) National and Kapodistrian University of Athens, Department of Geology and Geoenvironment, Zografou, 157-84, Athens, Greece
(7) Utrecht University, University Library, Heidelberglaan 3, 3584 CS, Utrecht, The Netherlands
(8) GeoForschungsZentrum, Helmholtz-Zentrum Potsdam, Helmholtzstraße 6/7, 14467 Potsdam, Germany
(9) Istituto Nazionale di Geofisica e Vulcanologia, Sezione Catania, Osservatorio Etneo, Catania, Italy
(10) University of Bergen, Department of Earth Science, Allégaten 41, 5020, Bergen, Norway

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Abstract

Transnational access (TNA) allows cross-border, short-term and frequently free-of-charge access to world-class research facilities, to foster collaborations and exchanges of experience. Specifically, TNA aims to encourage open science and innovation and to increase the efficient and effective use of scientific infrastructure. Within EPOS, the European Plate Observing System, the Volcano Observatories and Multi-scale Laboratories communities have offered TNA to their high-quality research facilities through national and European funding. This experience has allowed the definition, design, and testing of procedures and activities needed to provide transnational access in the EPOS context.

In this paper, the EPOS community describes the main objectives for the provision of transnational access in the EPOS framework, based on previous experiences. It includes practical procedures for managing transnational access from a legal, governance, and financial perspective, and proposes logistical and technical solutions to effectively execute transnational access activities. In addition, it provides an outlook on the inclusion of new thematic communities within the TNA framework, and addresses the challenges of providing market-driven access to industry.

Keywords: EPOS; Transnational access; TNA; Solid Earth Sciences; Physical and remote access

1. Introduction

Transnational access (TNA) can broadly be defined as the process in which actors, such as researchers, are accessing services or organizations located in another country. The term transnational access has been in use for many decades [Sommeren and Tallberg, 2016] and an overview of the historical evolution of this term is described in Jönsson [2010]. Transnational access occurs in a broad range of contexts and actors, including governmental organizations (e.g., Jönsson and Tallberg, 2010), law [e.g., Krämer, 2012] and justice [e.g., Whytock, 2020], as well as scientific domains [e.g., Journeau et al., 2003; Fardis and Biskinis, 2015; Simell et al., 2019]. TNA to scientific Research Infrastructures (RIs) has gained significant traction through the European Commission Framework and H2020 programs [European Commission, 2018].

Research Infrastructures are crucial for meeting the three main strategic priorities of the European Commission (EC), namely Open science, Open innovation, and Open to the world [European Commission, 2016a]. The European Research Infrastructures aim at bringing together and opening up key national and regional facilities to all European researchers, from both academia and industry, ensuring their optimal use and joint development. In this framework, an increasing number of Research Infrastructure projects have offered access to their facilities: either transnational access, based on calls for proposals, or virtual access through online services. In particular, European Research Infrastructure projects relevant to the Environmental (e.g., ENVRI PLUS[1]), Earth Sciences (e.g., EUROVOLC[2], SERA[3]), Biological and Medical Sciences (e.g., iNEXT[4]), Energy (e.g., ECCSEL[5]), and Material and Physical Sciences (e.g., HEMERA[6]), have offered transnational access to various high-quality research facilities[7].

EPOS, the European Plate Observing System, is a multidisciplinary, distributed European Research Infrastructure Consortium (ERIC) that facilitates the integrated use of data, data products, and facilities, within the Solid Earth Sciences community in Europe [Cocco et al., 2022]. The EPOS community has particularly benefited from experience obtained within the Horizon 2020 infrastructure projects ENVRIPLUS and EUROVOLC, which allowed the definition, design, and testing of procedures and activities needed to provide transnational access. These experiences offered the research institutions the opportunity to expand their potential for contributing to the European research ecosystem, in terms of resources sharing, networking, and scientific collaboration. Moreover, the resulting scientific collaborations have allowed the exchange of scientific expertise and skills within and across different scientific domains, thus promoting new scientific developments.

In this paper, the EPOS community uses their previous experiences to define the main objectives for the provision of transnational access in the EPOS framework. It proposes practical procedures for managing the accesses from a legal, governance, and financial perspective, and proposes logistical and technical solutions to effectively execute transnational access activities.

2. Definitions

Within the context of EPOS, the following definitions are identified, which are based on the principles and guidelines formulated by the European Commission [2016b]:

– **Facilities**: Facilities, observatories, laboratories, stations, platforms, research vessels, equipment, resources and services that are used by the research communities to conduct research and foster innovation in their fields. They include, but are not limited to, major scientific equipment (or sets of instruments), knowledge-based resources such as collections, archives and scientific data, e-infrastructures, such as data and computing systems and communication networks and any other tools that are essential to achieve excellence in research and innovation.

1 https://cordis.europa.eu/project/id/654182

2 https://cordis.europa.eu/project/id/731070

3 https://cordis.europa.eu/project/id/730900

4 https://cordis.europa.eu/project/id/653706

5 https://cordis.europa.eu/project/id/675206

6 https://cordis.europa.eu/project/id/730970

7 https://ec.europa.eu/info/files/research-infrastructures-offering-free-access-eu-support_en

- **Users**: Individuals, teams and institutions from academia, business, industry and public services, which are engaged in the conception or creation of new knowledge, products, processes, methods and systems and also in the management of projects. Teams can include, but are not limited to, researchers, doctoral candidates, technical staff and students participating in research in the framework of their studies.
- **Providers**: The Research Infrastructures hosting, offering and granting access to their own Facilities to Users.
- **Access**: The legitimate and authorized physical and remote admission to, interactions with and use of Facilities and services offered by Providers to Users. Such Access can be granted, amongst others, to machine time, computing resources, software, data, data-communication services, trust and authentication services, sample preparation, archives, collections, set-up, execution and dismantling of experiments, education and training, expert support and analytical services.

Access is divided into Physical and Remote Access:
- **Physical Access**: Involves hands-on access of Users to the Facility (i.e., a physical visit) – access to limited resources for which competitive selection is needed.
- **Remote Access**: User does not visit the Facility physically – access to limited resources for which competitive selection is needed. This can involve remote operation or use of a Facility, or remote service by an operator at a Facility.

Within this context, two modes for Facility Access are identified within EPOS:
- **Excellence-driven Access**: Excellence-driven Access is exclusively dependent on the scientific excellence, originality, quality and technical, logistical, and ethical feasibility of an application that is evaluated through peer review conducted by internal or external experts. This Access mode enables collaborative research and technological development efforts across geographical and disciplinary boundaries.
- **Market-driven Access**: Market-driven Access applies when access is defined through an agreement between the User and the Facility that will lead to a fee for the Access, which may remain confidential.

3. Transnational access in EPOS

Transnational access (TNA) to research facilities allows cross-border short-term, frequently free-of-charge access to world-class facilities, to foster collaborations and exchanges of experience. Specifically, TNA aims to encourage open science and innovation and to increase the efficient and effective use of instrumentation.

In this chapter we provide the rationale for TNA provision in the context of EPOS, explore the lessons learned from the experience by the EPOS thematic communities at the European and national levels, elaborate on the EPOS TNA procedures, governance, and financial framework, and address the technical implications on operating TNA.

3.1 Rationale for TNA provision

Modern geosciences have developed and operate Research Infrastructures containing an increasingly larger number of scientific instruments, facilities and experimental environments. Often these facilities are highly specialized and, in many cases, unique worldwide.

A strong interaction and cooperation between Research Infrastructures, industry and public services, and users, helps build bridges between the public, commercial and Research Infrastructure worlds. This increases knowledge and technology transfer between these stakeholders and drives innovation. In addition to acting as a user, industry also plays an increasing role in the construction, operation and development of Research Infrastructures. TNA provision moreover promotes interaction with industry and public services, in order to maximize the return on investment in Research Infrastructures, foster competitiveness and increase efficiency in terms of use of the scarce resources available.

EPOS offers a large variety of high-level and highly specialized facilities, such as analogue modelling laboratories, high-pressure, high-temperature melt, rock physics and mineralogical experiments, volcano and near-fault observatories, deep boreholes, and instrument pools for field experiments and measurements. Transnational access to these facilities provides the opportunity to a researcher or a group of researchers to access Research Infra-

structure facilities in a country foreign to their own affiliation. The purpose of this access is to allow cross-border short-term access to world-class facilities to foster new science, collaborations and exchange of experience.

3.2 Lessons learned from previous experience in EPOS

The EPOS community is organized in ten Thematic Core Services (TCS), which represent sub-communities within the Solid Earth Sciences (e.g., seismology, volcanology, geodesy, laboratories, etc.). Each TCS has its own dedicated governance framework, including a consortium board, which is responsible for the data and services, legal, and financial framework of the TCS. The e-infrastructure aspect of EPOS is organized in the Integrated Core Services (ICS), which allows access to multidisciplinary data, data products, and services. The key element of the ICS in EPOS is a central hub (ICS-C) where users can discover and access data and data products. The EPOS European Research Infrastructure Consortium (ERIC) coordinates the legal framework aimed at operating EPOS and providing effective governance to the TCS and ICS[8]. For a more detailed description of EPOS and its various components, the reader is referred to the respective publications in this special issue [e.g., Cocco et al., 2022; Elger et al., 2022; Puglisi et al., 2022].

Within the context of EPOS, two TCS have already provided access to their facilities: the TCS Multi-scale Laboratories (MSL) and the TCS Volcano Observations (VO). In addition, the national program EPOS-NL has been using dedicated funding to provide free-of-charge physical and remote access to Dutch research facilities since early 2021 and will continue to do so in the coming years.

3.2.1 Experience from TCS MSL TNA calls

The TCS Multi-Scale Laboratories (MSL, Figure 1) developed and implemented TNA during three different call-for-proposals in 2017, 2018, and 2019, which served as a proof of concept for the EPOS TNA General Principles that were therein applied. The number of facilities involved in these TNA calls increased from five in the first year,

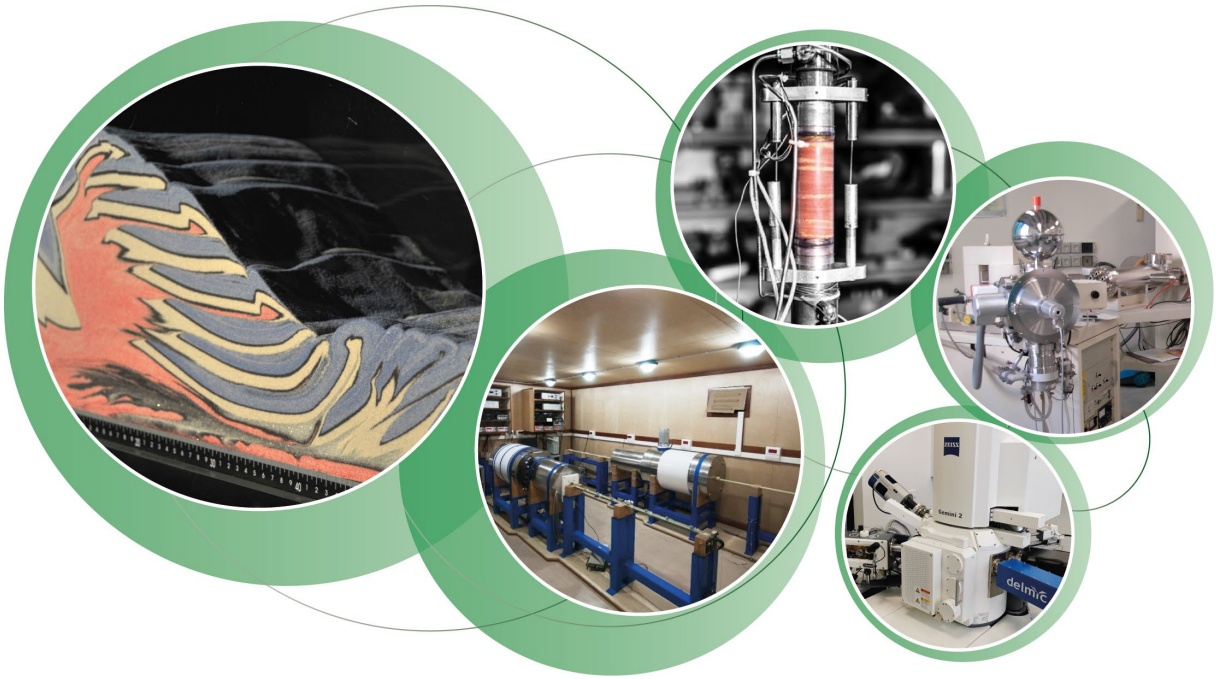

Figure 1. Selection of EPOS TCS Multi-scale laboratories facilities.

8 https://www.epos-eu.org/about-epos/what-we-do

to 22 in the second, and to 38 in the third year, which mirrors the success of the TNA program. Additional statistics can be found in Table 1.

Participating laboratories were encouraged to provide free-of-charge access, in order to be more attractive to users. The 22% of laboratories that could offer full financial support to users during the second MSL TNA call in 2018 received 46% of the applications. EPOS MSL employed user feedback forms to evaluate TNA procedures and processes, which also presented a clear correlation between financial support and application to specific facilities. Out of 18 feedback replies, 17 indicated that they would not have been able to carry out TNA without the available financial support. These statistics clearly indicate the need for and the importance of available funding to make TNA a success.

Statistics about length of the visits are also relevant for a funding organization, to assess possible access costs related to financial support, especially for accommodation. From the MSL TNA calls, 63% of granted projects had access periods up to 15 days, while only 20% needed 21 days or more for execution (Table 1). A milestone in the success of MSL TNA was the publication in 2019 of the first paper and dataset that resulted directly from access under the EPOS TNA framework (Boulton et al., 2019). This positively demonstrated the effectiveness of the EPOS data policy, which is aimed at making data collected under the TNA program openly accessible to the public.

During the three MSL TNA calls the functioning and implementation of TNA workflows were tested and refined, which are at the basis of TNA provision within EPOS ERIC.

3.2.2 Experience from the TCS VO TNA calls

The TCS Volcano Observatories (VO, Figure 2) has experience in TNA starting with the H2020 ENVRI PLUS[9] project (2015-2019), and subsequently in the H2020 EUROVOLC[10] project (2018-2021). During the ENVRI PLUS phase, the partners INGV and CNRS contributed to implement TNA at observatories on Mount Etna and Piton de la Fournaise volcanoes. In the EUROVOLC project the portfolio of providers and the list of proposed services expanded. This project has granted hands-on and remote access to research facilities in Italy, Iceland, French overseas territories, Spain and Portugal. During the first TNA call in 2018, 12 out of 28 submitted proposals were funded.

Figure 2. Selection of EPOS TCS Volcano Observatories facilities.

9 https://cordis.europa.eu/project/id/654182

10 https://cordis.europa.eu/project/id/731070

During the second call that started in 2019, 27 out of 42 submitted proposals were funded, which is an increase of 44% in terms of submitted proposals. Although the majority (75%) of the applications originated from EU-countries, a total of 25% of proposals were submitted from outside the EU, mostly from the Americas. The statistics for the EUROVOLC calls are summarized in Table 1.

The TNA call management was revised during the second call in response to lessons learned from the first call. Specifically, the evaluation and application procedures were simplified by the use of a web portal developed by INGV Catania, which handled these processes and allowed better promotion and clearer guidelines for proposal submission. Also, the procedure for the evaluation of the access proposals was revised in order to optimize the feedback from the TNA providers about the technical feasibility of the proposals and to improve their quality. These processes, including the web portal, are at the basis of the development of EPOS TNA.

3.2.3 Experience from a national program: EPOS-NL

EPOS-Netherlands (EPOS-NL[11]) is the Dutch research infrastructure for Solid Earth Sciences and contributes with data, facility access, coordination, and IT-resources to EPOS. Funded by the Dutch Research Council (NWO), EPOS-NL has been providing free-of-charge access to top Dutch research facilities since early 2021 and will continue to do so until at least 2025, and possibly beyond. Throughout 2021, EPOS-NL funded 24 out of 31 applications from both within and outside the EU. Successful applicants were granted access, plus associated technical and scientific support, to the rock physics, analogue tectonic modelling, and microscopy and tomography facilities at Utrecht University and Delft University of Technology. For additional statistics, see Table 1.

Due to Covid restrictions, access was frequently provided remotely, where successful applicants sent their samples to the Netherlands for analysis. It was generally experienced that such remote access was particularly effective in the case of short analyses (several hours), requiring high-end apparatus operated locally by an experienced staff member. Hence, access to the microscopy and tomography laboratories was in all cases provided remotely, which will remain a highly efficient mode of operation after Covid restrictions relax. On the other hand, where it came to longer, more laborious analyses or experiments (taking longer than one week), physical access was typically preferred. In such cases, training a visiting researcher was found to be more time-efficient and beneficial for the exchange of knowledge, compared to letting a staff member from the hosting facility execute the project. Physical access was typically preferred in the case of analogue tectonic modelling.

EPOS TNA STATISTICS											
Group	Year	Offered Facilities/ Instruments	No. of applications		Applicant's institute		Granted access type		Granted access days		
			Submitted	Granted	EU	non-EU	Physical	Remote	Min	Avg	Max
MSL	2017	5/15	7	6	50%	50%	66%	33%	5	16	35
MSL	2018	22/72	30	23	65%	35%	86%	14%	3	15	45
MSL	2019	38/211	33	28	52%	48%	82%	18%	2	11	30
VO	2018	25/45	28	12	82%	18%	100%	0%	5	10	24
VO	2019-2021	28/63	42	27	75%	25%	96%	4%	1	20	40
EPOS-NL	2021	5/16	31	24	68%	32%	87%	13%	1	5	30

Table 1. Overview of EPOS TNA statistics. Statistics relevant to the VO TNA from 2019 to 2021 refer to the same call that was launched in 2019 but extended until 2021 due to the Covid pandemic.

11 https://meetingorganizer.copernicus.org/EGU21/EGU21-2670.html

3.3 EPOS TNA governance and finance

The EPOS TNA governance involves a variety of stakeholders, each with their specific roles and relations. The financial model is based on the Horizon 2020 TNA regulations. The governance and financial structure as described here is specific for EPOS, but can be generically applied to other projects as well.

3.3.1 TNA governance and legal framework

The highest governing authority, represented by its executive committee, is EPOS ERIC. The ERIC is responsible for the validation of each TCS participating in TNA and acts as a potential funding agency (Figure 3).

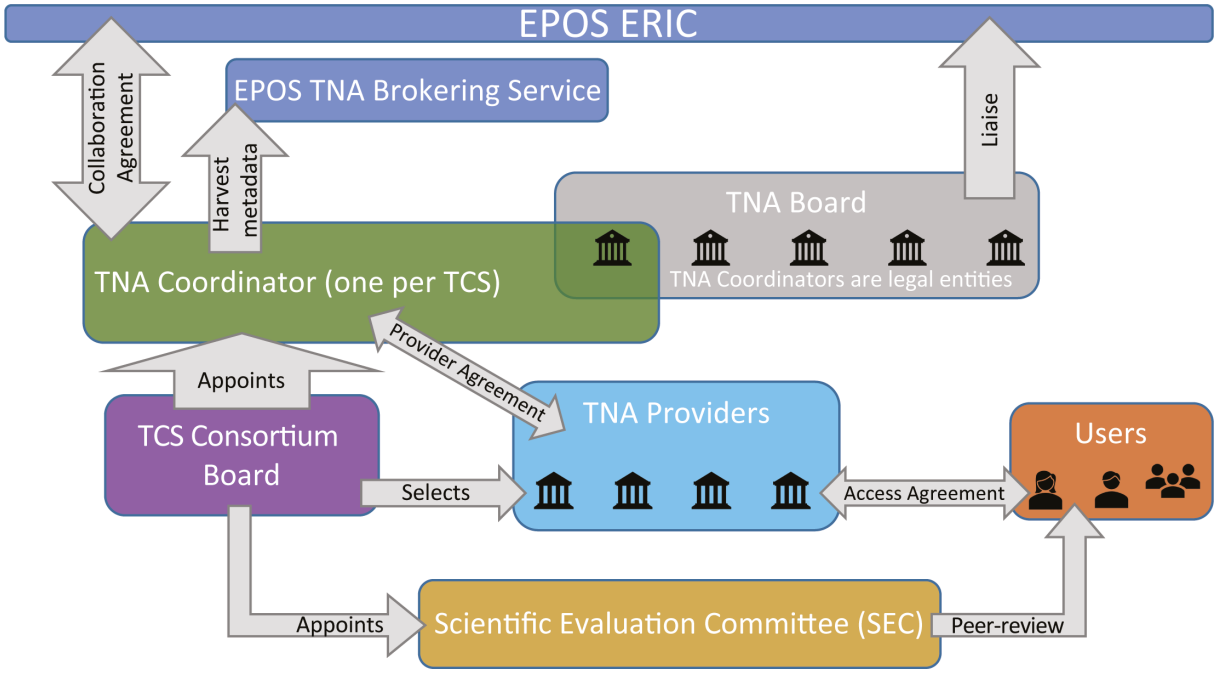

Figure 3. TNA stakeholders and governance structure.

The Consortium Board (CB) of each TCS is responsible for managing TNA within their thematic domain. The CB is responsible for the selection of TNA providers, the appointment of the Scientific Evaluation Committee (SEC), and the appointment of the TNA coordinator – i.e., the legal entity responsible for this specific TCS.

Across the different TCS, all TNA coordinators are organized in a Facility Access Board (FAB), which liaises with EPOS ERIC on topics concerning TNA.

The TNA coordinator signs a collaboration agreement with the ERIC in which the requirements and financial regulations for coordinating TNA are set out. The TNA coordinator is also responsible for collecting requirements from the TNA providers and the subsequent harvesting of TNA-related metadata by the EPOS TNA brokering service. In addition, the TNA coordinator signs a provider agreement with the individual TNA providers, in which the requirements and financial regulations for providing TNA are set out.

The TNA providers, in turn, sign an access agreement with each user in which the legal requirements and financial regulations for participating in TNA are specified, involving topics such as finances, reimbursement schemes, schedules, access rules, health and safety rules, compliance with data policy, and privacy policy. The privacy policy ensures that all parties involved comply with the General Data Protection Regulation (GDPR) and states which personal data is collected, how this is collected, where and for how long this is stored, who has access to the information and how the user can request to remove this data. The data policy is aimed at users and sets out the regulations for the licensing, use, sharing, and exploitation and open access to publications, data, data products

and digital tools resulting from EPOS TNA activities, in accordance with the *F*indable, *A*ccessible, *I*nteroperable, and Reusable (*FAIR*) principles [Wilkinson et al., 2016].

3.3.2 TNA financial framework

EPOS follows the Horizon 2020 financial regulations[12] to calculate the costs of access to a facility, which can be the *unit cost* method, the *actual costs* method, or a *combination of both*. Upon usage of the facility by users in the TNA context, the facility is reimbursed based on the before-mentioned methods.

TNA users can, if budget allows, be reimbursed for expenses such as travel, accommodation, and sustenance. The flux of reimbursements can follow two routes, scenario 1 and scenario 2, as indicated in Figure 4. The preferred route depends on the financial regulations of the different legal entities and countries involved. The necessary financial justifications follow the same route, but in opposite direction, towards the granting authority, which in Fig. 4 is depicted as EPOS ERIC.

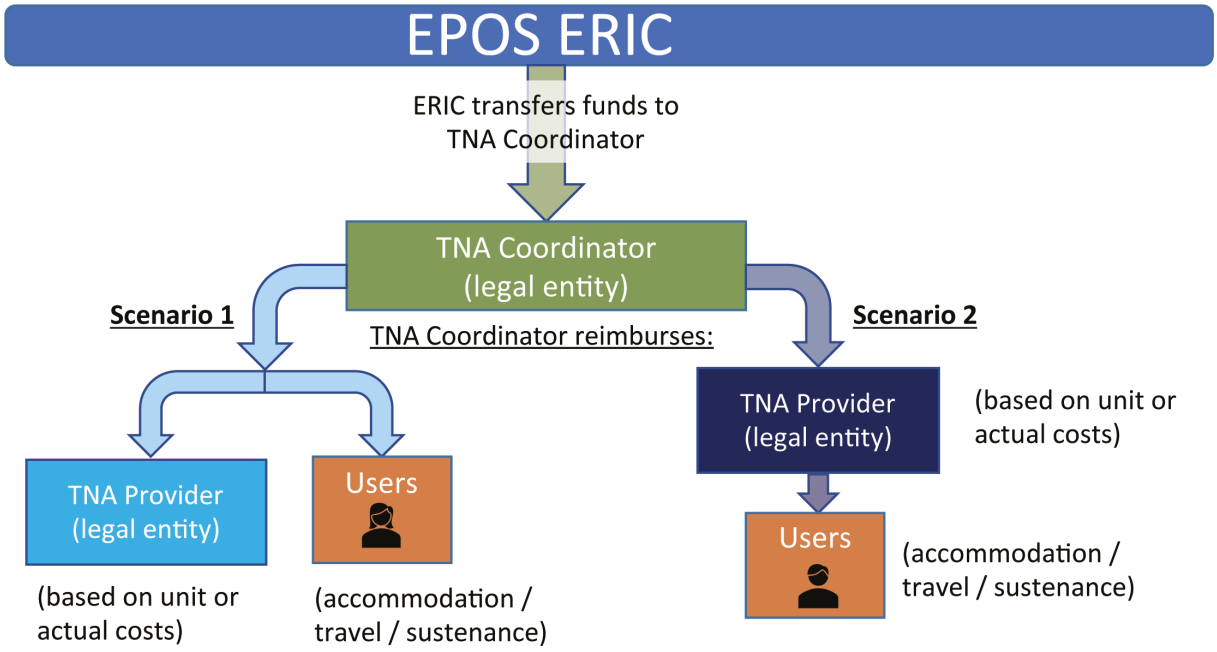

Figure 4. Reimbursement schema for TNA.

3.4 Technical aspects of TNA provision

The goal of EPOS is to fully incorporate TNA within its ecosystem. The wealth of heterogeneous data generated by EPOS TNA activities must be able to flow through the federated EPOS services into the EPOS data portal, thereby ensuring the FAIRness of that data. Facilities, instrumentation, and the services that are made available through EPOS TNA need to be stored in databases and be findable through the EPOS channels.

To achieve this interoperability, there is a need for a common metadata model describing both EPOS TNA and the EPOS data services. In addition, the EPOS TNA calls need to be advertised within the EPOS framework, which requires a dedicated TNA brokering service.

EPOS TNA consists of the following components: a coordination module and database that is kept at the level of each individual TCS, and a brokering service that showcases the EPOS TNA calls (Figure 5). This section address-

12 https://ec.europa.eu/research/participants/data/ref/h2020/other/legal/unit_costs/unit-costs_tna-infra_en.pdf

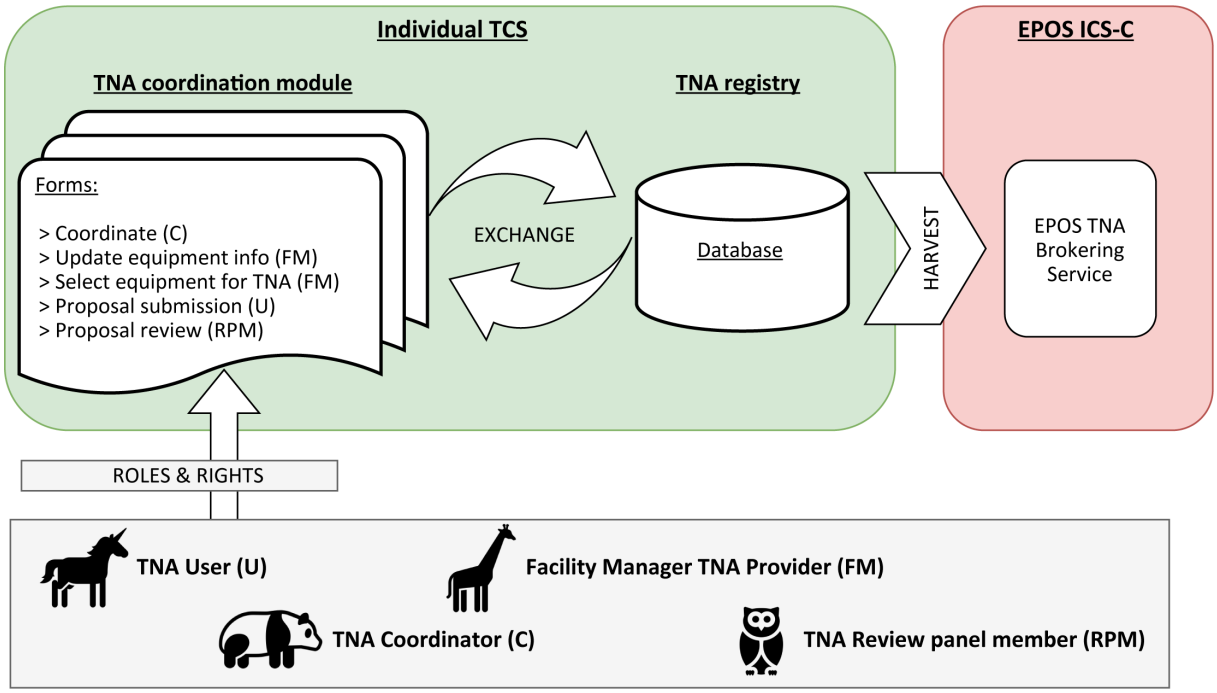

Figure 5. EPOS TNA components.

es the different elements that are needed to reach these goals, and provides an example of how this was accomplished within the EUROVOLC project.

3.4.1 EPOS TNA conceptual metadata model

Based on the experience from previous TNA calls, the TCS MSL and VO mapped-out the infrastructures and resources needed to operate TNA. After this mapping a first harmonization step was made, which resulted in the identification of commonly used terminology, thereby providing a minimum of metadata that needs to be collected for a successful TNA implementation. The identification of dependencies between these assets resulted in the creation of a conceptual metadata model. A total of eight classes were identified, being *Research Infrastructure*, *Facility*, *Equipment*, *Measurement*, *Sample*, *Research Data*, *Person*, and *TNA Call Information*.

This metadata model contains the minimum set of classes needed to describe a TNA call, the roles of persons involved in the TNA call, the participating infrastructures and equipment, the type of experiments that can be performed, the samples that can be acquired or analyzed, and the resulting data.

3.4.2 Harmonization with the EPOS-DCAT-AP model and CERIF catalogue

After identifying a conceptual metadata model for EPOS TNA, a harmonization step towards the common metadata model employed by EPOS was necessary. To enable semantic interoperability of information within its ecosystem, EPOS has created a metadata model built on the established W3C standard Data Catalog Vocabulary (DCAT) Application Profile (AP), termed EPOS-DCAT-AP, which is represented in the Resource Description Framework (RDF)/Turtle format [Bailo et al., 2020]. In addition, EPOS employs the Common European Research Information Format (CERIF) catalogue to store relations between research entities. The TNA conceptual model thus needed to be mapped onto the EPOS-DCAT-AP and CERIF models to be compliant with the EPOS ecosystem.

Most of the classes in the TNA metadata model matched with entities already available in the EPOS metadata model, such as Person, Facility, and Equipment, or otherwise required additional attributes. An example is the addition of the attribute roles that a Person can have within the TNA process. In other cases, the decision was made to repurpose existing or multipurpose entities in the EPOS-DCAT-AP, and extend these with additional attributes. An

example of this was the modification of the Service class in EPOS-DCAT-AP with temporal and spatial attributes, to handle the complexities of the TNA Call Information class.

This mapping of classes from the TNA conceptual metadata model onto the EPOS-DCAT-AP and CERIF models ensures that TNA information can be seamlessly incorporated within the EPOS framework.

3.4.3 EUROVOLC TNA portal and database

Information about the facilities and personnel participating in TNA varies on a per-call basis, which is therefore governed and stored by the individual TCS. Prior to the completion of the harmonized TNA metadata model, each TCS employed their own register structure to store this information. In addition, each TCS employed their own portal for announcing and handling TNA calls. Below is an example of the EUROVOLC TNA application portal and database. Lessons learned from the EUROVOLC experience are being implemented by all TCS for future TNA calls.

With the experience from the first EUROVOLC TNA call in 2018, a software tool was implemented during the second call (2019) to manage and disseminate TNA information. A dedicated TNA portal was developed within the VO-TCS Gateway i) to facilitate discovery of information related to facilities offered through the call, ii) to manage the proposal submission phase, through the implementation of a TNA submission form and the development of a searchable relational database containing the relevant metadata, iii) to aid the proposal evaluation phase, and (iv) to enable statistical analysis of call-related information.

The front-end of this software tool was a webpage that consisted of four main sections: 1) the discovery page of TNA calls; 2) the user registration/access page for completing and revising the TNA proposal submission form; 3) a submission guide and general information on how to use the portal, and 4) the F.A.Q. section, dedicated to the most frequently asked questions.

3.4.4 The EPOS TNA brokering service

Although the actual detailed management of a TNA application is executed at the TCS level, information about EPOS TNA possibilities has to be available at the ICS-C for end-users (Fig. 5). This information is to be offered through a so-called TNA Brokering Service, which was designed to provide a cross-TCS catalogue of the TNA possibilities offered by EPOS that underpin the various basic thematic services. This service will contain a graphical user interface that is embedded within the EPOS data portal, through which users can discover TNA-related services based on spatial and temporal constraints. More specific details can be found at the TCS level, thus a URL link to the TCS TNA pages is also required.

This brokerage service will collect and expose relevant TNA-related information (e.g., structured metadata on facilities and equipment, and temporal and spatial information) by harvesting the TCS TNA databases, and providing redirection to applicable TNA services for interested users. As such, users can search for relevant equipment and facilities through the EPOS ICS-C and simultaneously obtain direct access to the relevant TNA information at the TCS level.

3.5 EPOS TNA procedures

The EPOS TNA procedures describe the processes and interactions related to TNA. These procedures are based on the principles of non-discrimination and transparency, inspired to provide equal opportunities and encouraging the access to new users. They build on previous TNA experience in EPOS and on recommendations in the European Charter for Access to Research Infrastructures [European Commission, 2016b] and ENVRI PLUS D10.1[13] and D10.2[14] deliverables.

13 https://www.envriplus.eu/wp-content/uploads/2015/08/D10.1.pdf

14 https://www.envriplus.eu/wp-content/uploads/2015/08/D10.2.pdf

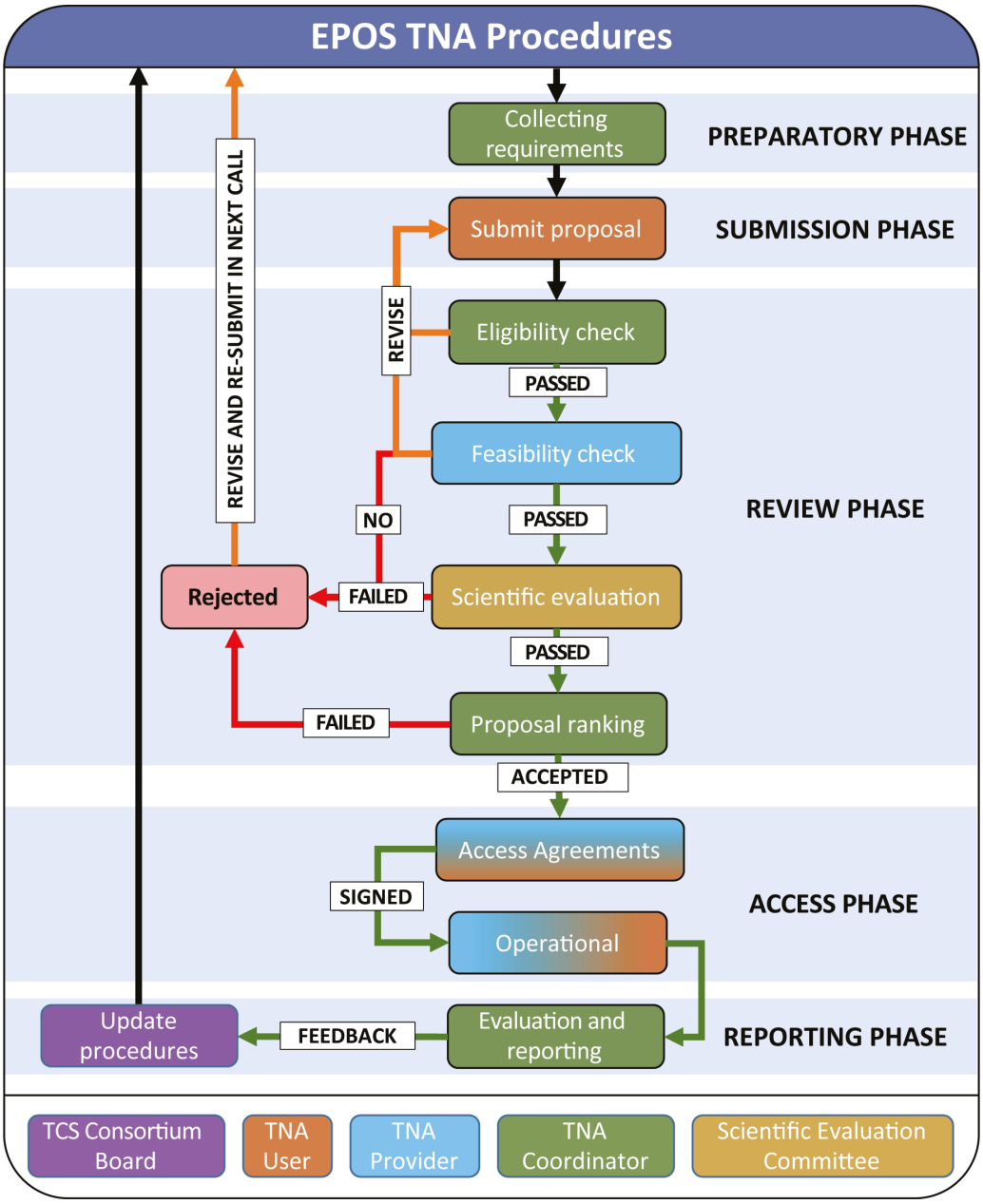

Figure 6. Access procedures for EPOS TNA.

The EPOS TNA procedures are organized in a workflow that consists of at least: a) preparatory phase, b) proposal submission phase, c) review phase, d) access phase, and e) reporting phase. This workflow is described in detail below and shown in Figure 6.

During the call preparation phase, the TNA coordinator collects requirements from the TNA providers regarding the mode(s) of access, units of access, and available facilities for the specific call period. TNA legal documents are also drafted in this period. The collected information is published through the TNA brokering system and available on the dedicated call website.

In the proposal submission phase, users create a scientific proposal that is submitted through an online application. Interaction with the requested facility is advised at this time to discuss the technical and logistical feasibility of the project.

During the evaluation phase, submitted proposals are first subjected to a check that verifies the eligibility of a user and their application, based on admissibility, legal, and ethical criteria. The TNA coordinator is responsible for this check, but the verification may take place through self-assessment by the applicants acknowledging the criteria to which their application must adhere. Subsequently, the feasibility of the proposal is checked based on lo-

gistical, technical, and risk criteria. This check is managed by the TNA provider and may result in an exchange with the applicant before the proposal is deemed feasible. The Excellence-driven access mode adopted by EPOS TNA requires scientific peer-review of the proposals by a selected panel of experts, whose composition and functioning are based on principles of transparency, fairness and impartiality. The proposal will be reviewed using a predefined scoring system with criteria based on scientific excellence, originality and quality. Additional evaluation criteria can be tailored to a specific TNA call by the respective TCS. The outcome of the scientific review is a ranked list of all submitted proposals. The minimum threshold for acceptance can be adjusted to match the availability of resources in a call (e.g., budget, availability of instruments). If needed, the coordinator can agree with the facilities to re-distribute successful proposals.

The accepted projects are executed during the access phase. For physical access projects, the user receives the necessary safety training provided by the TNA facility. For remote access projects, the user is informed about regulations regarding the remote use of the facility and services where necessary. The access agreements between the user and the facility are signed before the beginning of the access period.

The reporting phase for each TNA call consists of the following components; i) setting the feedback requirements, ii) collecting feedback from the users, facilities, and scientific review panel, iii) reporting call statistics and feedback to the relevant governing authorities, and iv) updating of TNA procedures, when necessary.

4. Future perspectives

The EPOS TNA landscape is continuously evolving. Lessons learned from previous TNA calls, changes in funder requirements, the identification of new potential user groups, as well as scientific communities that are not yet providing TNA, all require refining and updating of the EPOS TNA processes. In addition, the experiences gained under EPOS can be used to obtain dedicated TNA funding through community- or country-specific funding calls. This last section addresses some of the challenges and opportunities that EPOS TNA currently faces. These include, but are not limited to, i) connecting new thematic communities within the scope of TNA, exemplified by the TCS Near-Fault Observatories (NFO) and candidate-TCS Tsunami, and ii) opportunities for Market-driven access to users from industry.

4.1 Connecting new thematic communities – the NFO and Tsunami example

The successful implementation of TNA by the EPOS TCS Volcano Observatories and the EPOS TCS Multi-scale Laboratories has drawn interest from other thematic communities within, or soon to be included within, EPOS. The goal is to provide TNA to as broad an Earth Sciences community as possible. To this end, thematic communities interested in providing TNA need to adhere to the rules, regulations, and technical requirements as outlined by EPOS ERIC. After approval these communities can then provide TNA in the EPOS context. One of the challenges lies in the different temporal and spatial scales that each thematic community studies, and the associated complexities in experimental setups, which subsequently need to be included within the EPOS TNA framework.

The EPOS Near-Fault Observatories (NFO) consists of multidisciplinary research infrastructures aimed at monitoring chemical and physical processes occurring on faults, investigating the deformation processes and the mechanical behavior of the observed geological structures, and detecting the precursory phase of large seismic events [Chiaraluce et al., 2022]. The facilities range from multi-instrument networks of seismological stations, GNSS stations, and fiber optics, such as the Corinth Rift Lab (CRL)[15], to integrated facilities linked to seismic networks for real-time testing, such as CREW[16].

The candidate TCS Tsunami is concerned with simulating and investigating the processes and consequences of tsunamis. Examples of facilities within the Tsunami community include the Fast Flow Facility[17] flume tank (Figure 7) with auxiliary equipment operated by HR Wallingford, aimed at studying the characteristics of a tsuna-

15 https://nfo.crlab.eu/

16 http://lccepos.fisica.unina.it

17 https://www.hrwallingford.com/facilities/tsunami-simulator

mi wave, and the Cantabria Coastal and Offshore Basin (CCOB[18]) and Wave-Current-Tsunami Flume (CoCoTsu[19]) hydraulic facilities, integrating physical modelling with numerical simulations.

A major challenge is to harmonize and integrate the heterogeneous facilities within EPOS, whilst maintaining the unique elements that each facility offers, and presenting them to the user communities. Integrated physical and numerical facilities also provide an opportunity to test access to high-performance computing installations that represent a limited resource for which access is based on a competitive selection of research proposals.

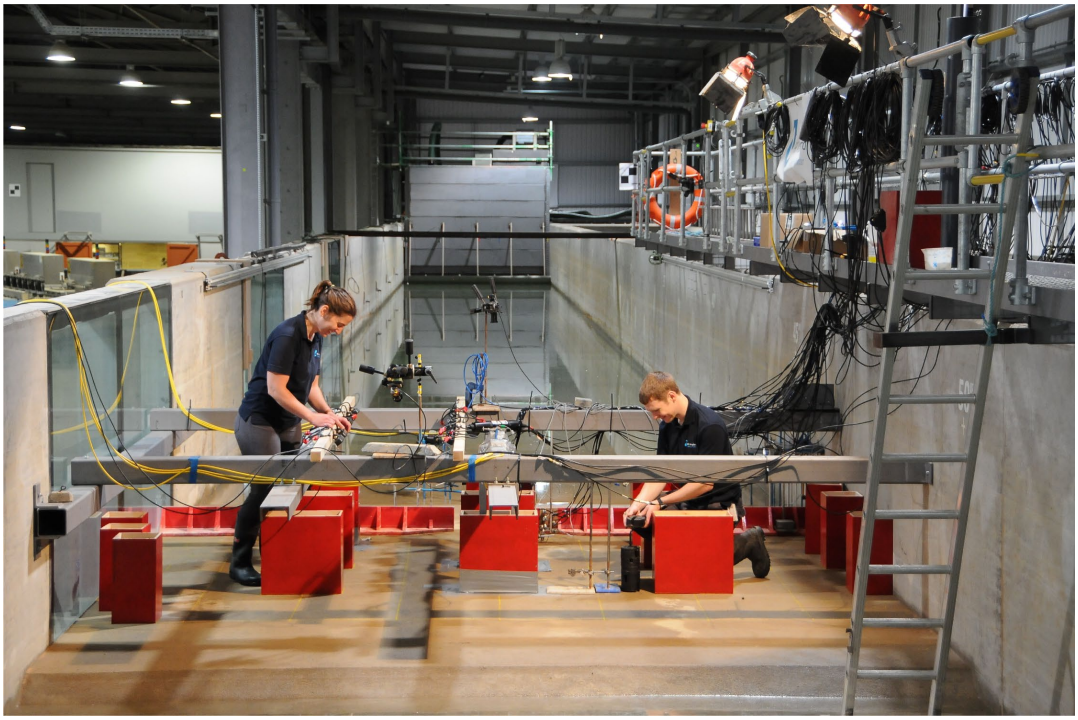

Figure 7. Fast Flow Facility flume tank at HR Wallingford.

4.2 Market-driven access to industry

Increasing the interaction and cooperation between the EPOS facilities, academic and industrial users, and public services, helps build bridges between these stakeholders and enhance their socio-economic impact. In addition, such dedicated initiatives will help increase the technology and knowledge transfer between academia and public and industrial services, thereby driving innovation.

To support these efforts, EPOS is not only exploring the opportunity for allowing users from private sector and industry access the research infrastructures, but also for allowing academic users access to facilities offered by industry. The development of a framework for a cooperative TNA with the private sector is already part of the EPOS ERIC roadmap, and will also be included in the EPOS TNA policy in the future.

Challenges related to this include i) establishing a regulatory concept to handle such partnerships, including a financial model, especially since access fees are anticipated to be involved, ii) understanding how the research output of this mode of TNA with the private sector aligns with the EPOS data policy and the principles of FAIR open-science, including the licensing of data, data products, and software, and iii) assessing the needs and interests of key industrial sectors to promote EPOS as a TNA facilitator.

EPOS is currently addressing this challenging topic and anticipates to be able to provide TNA in cooperation with the private sector in the near future.

18 https://ihcantabria.com/en/instalaciones-experimentales/laboratorio-de-hidraulica-costas-y-offshore/

19 https://www.ictsmarhis.com/en/coco-tsu

5. Conclusions

Transnational access (TNA) allows cross-border short-term access to world-class research facilities, fosters collaborations and the exchange of experiences. Within EPOS, the Volcano Observatories and Multi-scale Laboratories communities have used national and European funding to offer TNA to their high-quality research facilities. This funding has proven vital to lower costs, or even provide free-of-charge access to researchers, who would otherwise not have been in the position to visit these facilities and utilize their services.

The EPOS TNA governance structure, which includes legal, financial, and operational stakeholders, has been responsible for the establishment of transparent and non-discriminatory TNA principles designed to provide equal opportunities to its users. The streamlined execution of these procedures has enabled a steady growth of participating facilities and submitted applications since the first call launched in 2017. The TNA legal framework has ensured that the rights and obligations of the participating parties are well documented. The TNA data policy has guaranteed the FAIR publication of research results, in turn providing maximum impact to the scientific community, while the privacy policy has guaranteed compliance with GDPR standards to safeguard the privacy of the researchers involved.

Harmonization of the metadata and the creation of a common metadata model capable of describing both EPOS TNA and the EPOS data services has proven pivotal to achieving the interoperability needed to integrate TNA within the EPOS ecosystem, while ensuring the FAIRness of the produced data. The provision of physical or remote access to research facilities under the excellence-driven access mode has been well-established within the EPOS framework and will be further expanded to include other EPOS thematic communities within the coming years, specifically the Near-Fault Observatories (NFO) and the candidate TCS Tsunami. The provision of market-driven access to industry, however, still remains a challenge, especially concerning the financial and regulatory aspects and the FAIR publication of obtained results. These challenges are currently being met and we anticipate providing TNA for the private sector in the near future.

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***CORRESPONDING AUTHOR: Richard WESSELS**,
Utrecht University, Department of Earth Sciences, Princetonlaan 8a,
3584 CB, Utrecht, The Netherlands,
email: r.j.f.wessels@uu.nl