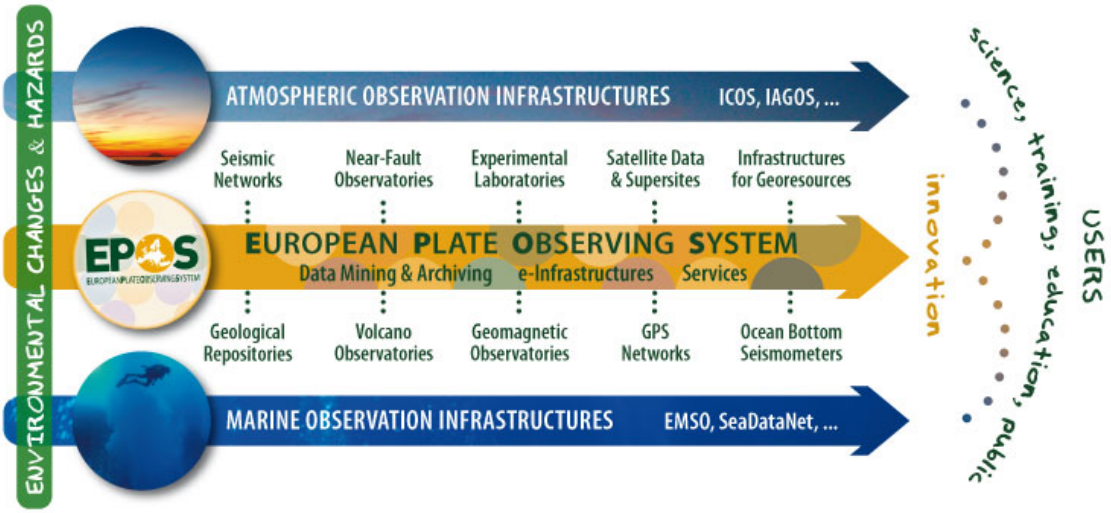


Figure 1. EPOS inter-disciplinary and cross-disciplinary landscape. *The range of communities participating in EPOS measures its multidisciplinary breath and potential impact on the whole Earth Science community and beyond.*

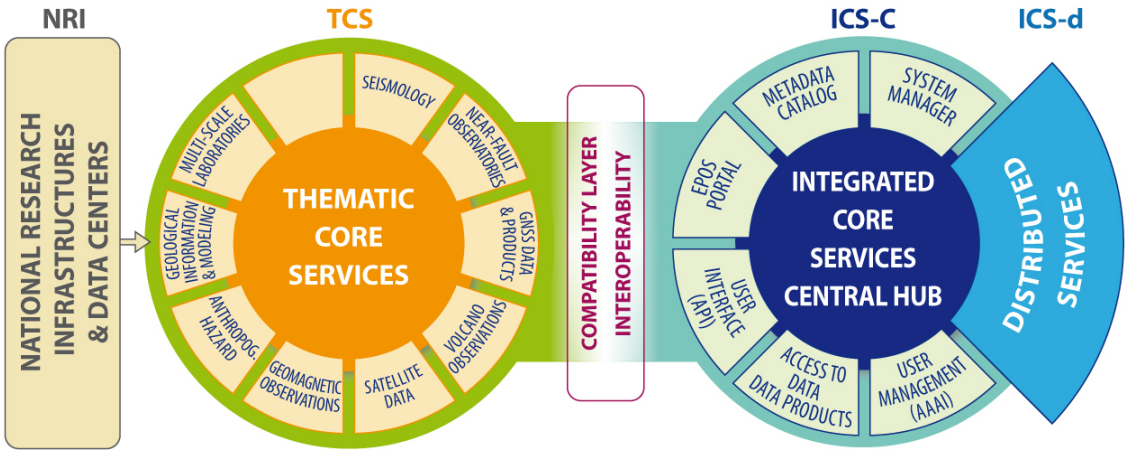


Figure 2. EPOS Functional Architecture: *the technical/scientific backbone of the whole enterprise. It is composed of three connected technical and organizational elements: National Research Infrastructures (**NRI**), Thematic Core Services (**TCS**), Integrated Core Services (**ICS**). The existing RIs generate data and information and are responsible for the operation of instrumentation in each country. These RIs are integrated into the TCS, which represent dedicated services (data archiving and mining, access to data products) for each specific community. The distinct TCS combine to create the ICS consisting of a variety of multidisciplinary services that will allow the access to data, data products, processing and visualization tools, and computational codes and resources for different stakeholders, not limited to the scientific community. The compatibility layer is the interface where all aspects of communication and exchange of information are implemented. The function of this layer is to get the resources requested by the users and translate it into a common format that can be managed by the system.*

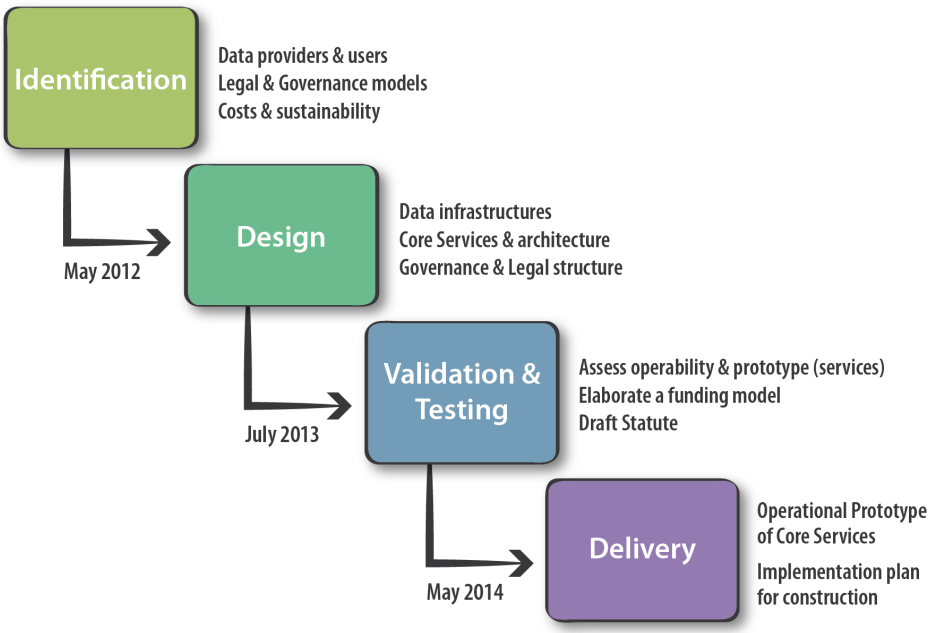


Figure 3. EPOS Roadmap towards construction. *The first stage of the roadmap, the "Identification", allowed to fulfil the EPOS mission; in the second stage, the "Design", EPOS PP has accomplished the required goals according to recommended specifications; the third stage, "Validation & Testing" has ensured the operability of the designed infrastructure prototype; in the forth stage, "Delivery", EPOS PP produced the final deliverables, comprising prototypes and implementation plans. This final stage will form the basis for the EPOS Implement*

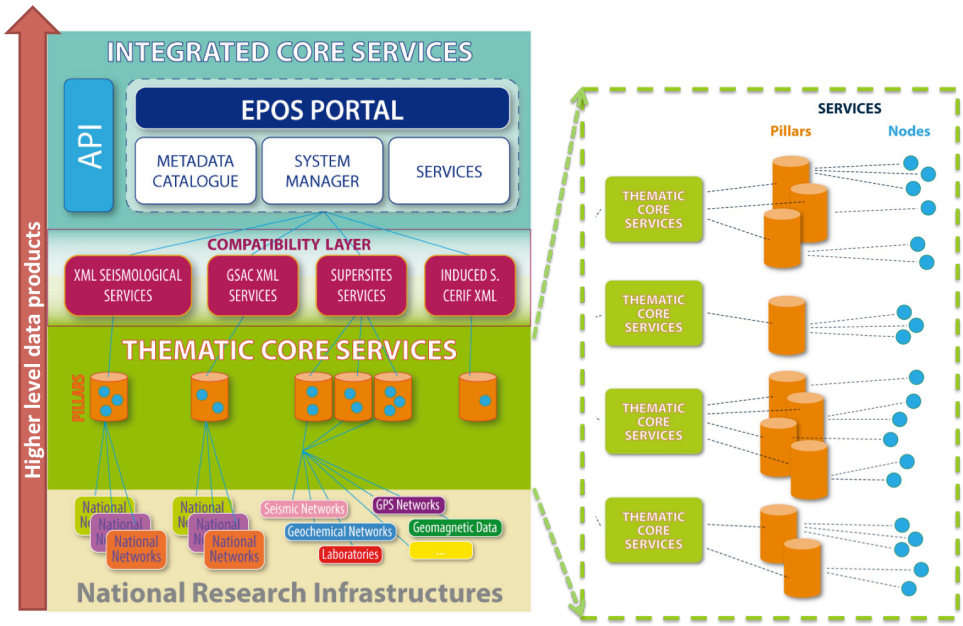


Figure 4. Scheme of the EPOS Functional Architecture*. The Functional architecture is made of three key elements: NRIs, TCS, ICS as defined in Figure 2 and sections above. Pillar, node, and services are defined as follow:* ***PILLAR,*** *the environment where different sets of data, products and services, directly related to a specific community, can be coordinated, managed and organized through distributed/single nodes.* ***NODE,*** *a distributed network of infrastructures or a single research infrastructure delivering data, products and/or services.* ***SERVICES,*** *IT solutions and tools for data management provided to the scientific community through multiple or individual nodes within a pillar.*

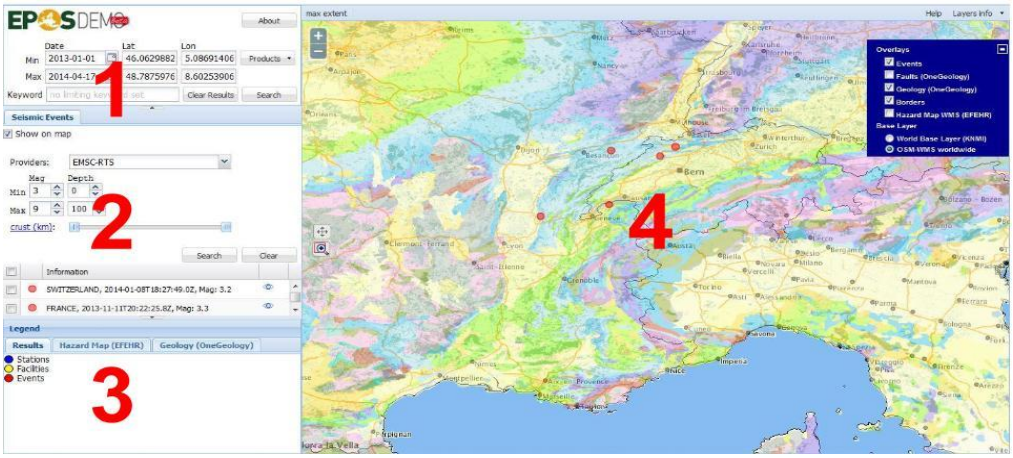


Figure 5. The Prototype web interface

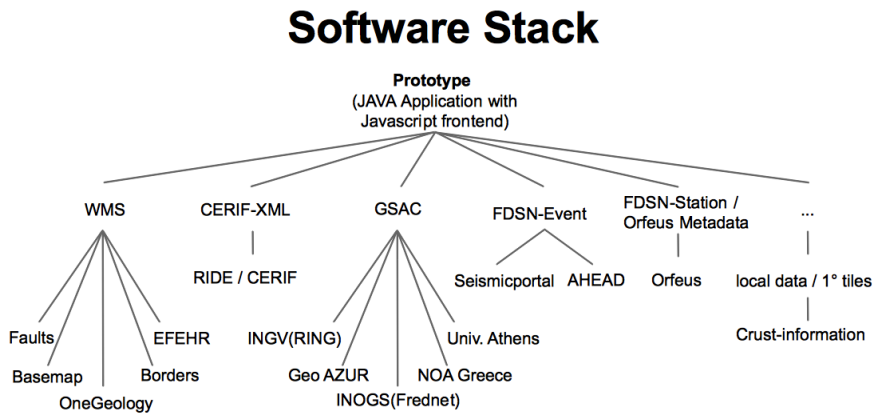


Figure 6. The prototype software stack.

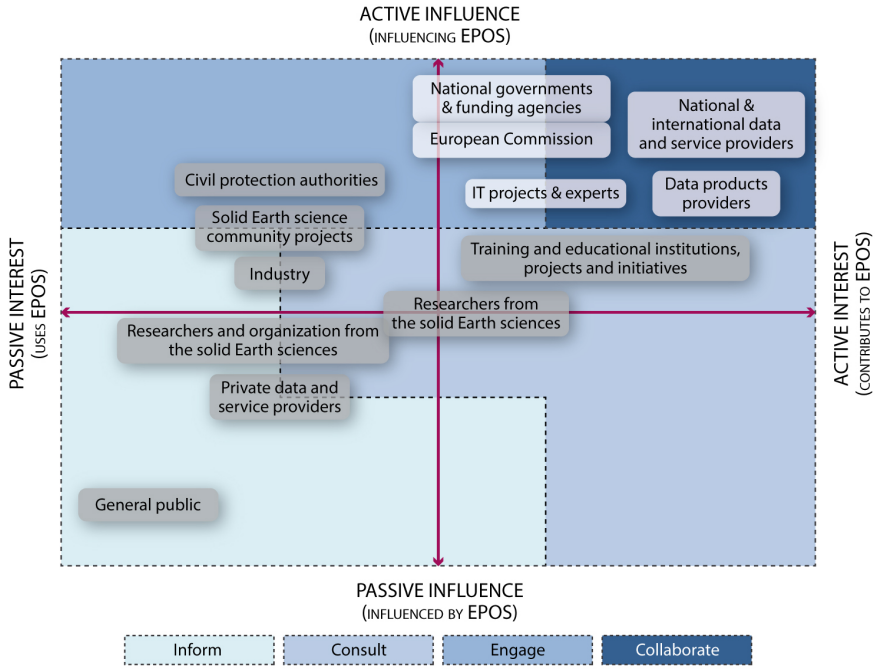


Figure 7. EPOS and Stakeholders. *The horizontal axis indicates the active (contributing to EPOS) and the passive (using EPOS) interest of stakeholders. The vertical axis shows the active (influencing EPOS) and passive (influenced by EPOS) influence of stakeholders. It is important to emphasize that all stakeholders in this figure are engaged with a different role in EPOS. The colour scale depicts different levels of engagement with EPOS from informing to collaborating.*

Table 1. Relationship between EPOS Architecture components and EPOS ERIC* during the implementation phase.

EPOS Implementation Phase 2015 – 2019		
Components	**Legal & Governance integration in the ERIC**	**Financial integration in the ERIC**
NRI	Maintain independent legal and governance status	Maintain independent financial status
TCS	Maintain independent legal and governance status, explore potential for integration in ERIC	Maintain independent financial status, explore potential for integration in ERIC
ECO+ICS-C	Fully integrated. Set-up and implement the legal subject and governance (ERIC)*	Dedicated financial plan with no discount for ERIC members financing ICS-d or TCS
ICS-d	Maintain independent legal and governance status, explore potential for integration in ERIC	Maintain independent financial status. Explore potential for integration in ERIC

***** The EPOS ERIC is expected to start to be operational by January 1st 2017

Table 2: EPOS Implementation Phase Critical Risks

Risks	Potential Impact	Mitigation
Technical Risks		
Failure to successfully implement TCS for EPOS integration	Poor provision of data, products and services to Thematic communities and to feed into multidisciplinary ICS, TCS	Monitor TCS implementation status by PDB; guarantee efficiency to SCB; perform progress assessment and reports; introduce dedicated user-feedback reports
Failure to ensure TCS/ICS interoperability	ICS failure, limited coverage, reduced impact of ICS	Monitor TCS implementation status by PDB; guarantee efficiency to SCB; perform progress assessment and reports
Failure to ensure data quality and standardisation	Unreliable data, products and services	TCS quality control and data standardisation plans must be reviewed and monitored
Financial Risks		
Underestimation of real implementation costs	EPOS RI too expensive; lack of financial sustainability; failure to secure sufficient funding to move to construction phase	Update and revise the business plan; revise the cost assessment and the funding model; expenditure check
Underestimation of the resources, including expertise and human resources, to build the new e-infrastructure	Modest progress in the implementation phase; failure in respecting the timeline of implementation phase	Guarantee the allocation of necessary human resources and available skills, efficient project management and realistic progress assessment toward operation
Strategic Risks		
Failure to engage governments and convince them to prioritize EPOS within national programmes	Lack of financial resources for M&O of implemented services; lack of in-kind contributions to EPOS RI	Monitor the interest of Governments through the involvement of BGR and the engagement of appropriate stakeholders
Failure to engage users and stakeholders to foster a full exploitation of services and products	The proposed infrastructure does not engage users, or meet their needs; reduced impact and uptake of both TCS and ICS	Revise and check Communication Plan; improve impact of dissemination; check impact assessment and science cases
Failure to demonstrate the EPOS impact on science	Failure to realise scientific potential and address scientific challenges	Update the EPOS science case; engage users to check the attractiveness of the EPOS RI for new science opportunities; improve communication
Failure to engage countries to support the wider EPOS mission	Limited ERIC membership necessitating increase of individual membership fees for ERIC, failure to realise pan-European coverage and recognition	Verify and strengthen the impact of harmonization with National Priorities; guarantee effective role to BNSR and BGR in the setting up of the legal governance and financial scheme for EPOS-ERIC
Spreading the available resources, and especially human resources, too thinly	Failure in maintaining the planned workflow and timeline	Guarantee efficient and appropriate management; check the on time delivering of achievements and information
Over-dependence on key individuals	Lack of community building, poor involvement of partners, loss of continuity if a contribution is lost for any reason.	Adopt a management plan feasible to the complexity of the enterprise
Failure in promoting the scientific and societal impacts of the EPOS RI	Failure to realise further scientific potential of products and services	Verify and strengthen communication and dissemination strategy and activities; guarantee the full exploitation of results

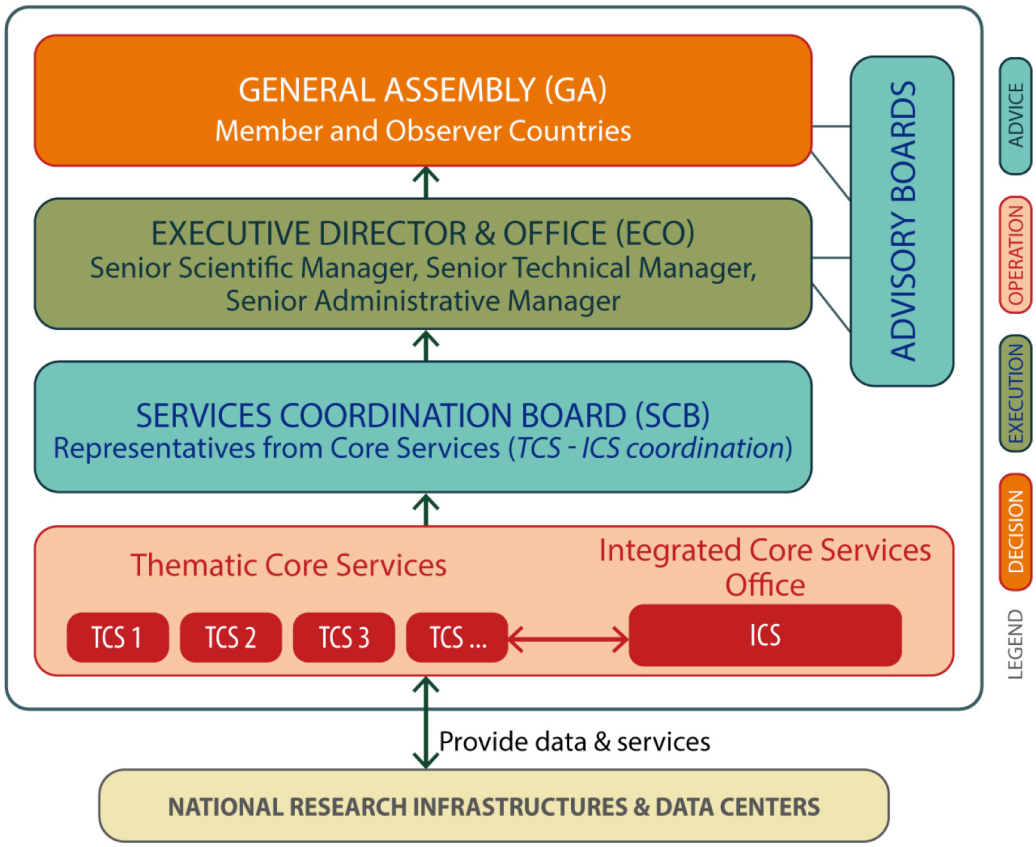
Table 3. EPOS PP data providers. The communities are listed referring to the corresponding EPOS PP WG. WG7 is omitted from this table, because specifically deals with e-science and IT integration.

Data/Products/Services Providers	Type of Data/Products/Services
Seismology (WG1)	seismic waveforms and metadata from permanent/temporary networks (including strong-motion data) and from ocean-bottom seismometers; derived parametric data (e.g. acceleration parameters for engineering) and metadata (Level 0, 1)
	seismological products: authoritative earthquake locations and magnitudes; bulletins; earthquake catalogues (including historical); moment-tensors; shaking and damage maps; seismic source models; site response data (Level 1, 2)
	earthquake hazard and risk data and products: tectonic fault maps and models; geotechnical, geological and site conditions inventory; tools for processing/analysing/interpreting building/infrastructure weakness; exposure and vulnerability data and models for building/infrastructure risk assessment; hazard maps; risk maps & scenarios (Level 2, 3)
	massive-data mining, data-intensive processing, visualization, processing (synthetic data from 3D Earth simulations)
Near Fault Observatories (WG5)	"standard" (seismic and geodetic) and "specific" (electro-magneto telluric, geochemical, geological, gravity, strain-tilt-meter and other multidisciplinary) near fault data and metadata, including borehole data (Level 0)
	Virtual Laboratory (online engagement and knowledge-sharing initiative) containing multidisciplinary products (Level 1, 2, 3) and services for describing the anatomy of active faults and the causative physical processes
GNSS Data & Products (WG4)	Global Navigation Satellite System (geodetic) observations (RINEX) and derived products (site coordinate time-series and velocities, strain rate maps) and metadata (Level 0, 1, 2)
	software tools facilitating the cross-disciplinary use of geodetic data and the interoperability with adjacent disciplines
Volcano Observations (WG2)	seismic, geodetic, geochemical (e.g. gas emission), volcanological (e.g. rock/ash), environmental (e.g. meteorological in co-located geochemical/geophysical stations) data and metadata (Level 0, 1)
	multidisciplinary volcanic and hazard products (e.g. geo-volcanological maps, chemical/physical data on rocks, ashes, and fluids, eruptive parameters, thermal characteristics of lavas, eruption rates, examples of hazard maps) (Level 2, 3)
	repository of open source software tools for modelling volcanic processes (e.g. magma intrusions, lava/pyroclastic flows movement)
	facilities of volcano observatories for (i) scientists; (ii) temporary deployments of mobile pool of multi-disciplinary instruments (ii) rock samples collections
Satellite Data (WG8)	SAR interferograms for tectonic, volcanic and resource extraction areas; satellite ground deformation maps (Level 1)
	value-added products/services from integrated satellite and in situ measurements and observations (Level 2, 3)
	on-line processing of satellite data for satellite ground deformation map generation; source mechanism retrieval of observed ground deformations; determination of surface three-dimensional displacements; source mechanisms of observed ground deformations
	Engagement of ESA and National Space Agencies to facilitate access to satellite Earth Observation data and services through shared observational strategies
Geomagnetic Observations (WG9)	magnetotelluric data; geomagnetic data from magnetic networks; airborne and shipborne magnetic surveys; auroral zone variometer networks (Level 0, 1)
	global and regional geomagnetic field and conductivity models (Level 2, 3)
	characterisation of geomagnetic activity and space weather conditions
	compilation of lithospheric conductivity models

Anthropogenic Hazards (WG10)	seismic, geological, technological data for anthropogenic hazards episodes and metadata (Level 1, 2)
	simulator for multi-hazard/multi-risk assessment in exploration/exploitation of geo-resources
	(i) AH users' designed problem tailored processing based on implemented specialized software library (ii) computationally demanding AH analysis; (iii) AH users' data handing and storage; (iv) visualisation of all types of AH data
Geological information and modeling (WG3)	geological multi-scale data (e.g. borehole data, sample and analysis data, geophysical data) (Level 1, 2)
	geological maps, subsurface (e.g. temperature, aquifers) and geo-hazard (e.g. landslides, surface faulting) data (Level 3)
	(i) borehole visualization, including visualization of logs, sampling/coring intervals, analyses; (ii) geological 3D-4D models, including structural geology models
Multi-scale laboratories (WG6)	volcanic ashes and rocks and magmas data; paleomagnetic data; experimental and analogue data (Level 0, 1) Properties data on rocks, ashes, magmas and fault rocks; paleomagnetic data; rock physics data and physical analogue modelling repositories (Level 0, 1, 2, 3) Benchmarking protocols and standard banks
	experimental and micro-analytical facilities (e.g. high temperature/high pressure, electron microscopy, micro-beam, analogue modelling, and paleomagnetic laboratories)

BOX 1

Sketch of the EPOS-ERIC Governance Model



The ERIC-mandated elements are central to the success of EPOS: a **General Assembly (GA)** of members will be the organization's governing body. The current Board of Governmental Representatives (**BGR**) will transform into the GA once the ERIC is operational in 2016. An Executive Director, supported by its Coordination Office (**ECO**), will be directly responsible to the GA for all aspects of the EPOS activities. A **Services Coordination Board (SCB)** representing all the TCS and the ICS will inform and advice the Executive Director in formulating and executing the EPOS Annual Work Programme. To foster coordination, the SCB of the EPOS-ERIC will be established in the EPOS IP project, initially as an internal technical coordination body with the intention to become the foreseen ERIC SCB. During the implementation phase the EPOS-ERIC legal entity will be composed of the *Executive and Coordination Office* (**ECO**), representing the ERIC legal seat that will be hosted in Rome (Italy), and by the *ICS central hub* (**ICS-C**) whose headquarter location will be decided in 2015. During this phase the TCS will be legally outside the ERIC, with the aim to integrate them when possible in the subsequent years.

BOX 2

EPOS Data policy and Access Rules document (principles and main issues)

EPOS aims to guarantee availability and access to DATA and facilities as well as to expedite the use, re-use and redistribution of DATA, including the intermixing with other datasets and services. Through its policy EPOS aims to promote: i) Innovation, to permit the coordinated application of scientific, social, and business knowledge to generate solutions to complex challenges; ii) Collaboration among diverse disciplines to foster greater productivity and creativity; iii) Efficiency by preventing duplication of effort and by enabling secondary analyses and enhancement of existing data; iv) Accountability by encouraging independent verification; v) Capacity Strengthening by facilitating the education of new researchers, and enabling broader access to data for secondary analysis and stimulation of bold and innovative ideas.

Because it is generally recognized that various scientific communities are at different stages of implementing data sharing and use different methods of data distribution, EPOS-ERIC will work closely with Suppliers and Users to ensure their diverse models and needs are accommodated. A culture of data openness and sharing within public research communities and within member countries and beyond will be encouraged to:

- disseminate data and knowledge through Open Access;
- provide a multidisciplinary data management plan to foster a community building for solid Earth Sciences through shared access policies and rules;
- make DATA and facilities available in a timely manner, without undue delay and preferably free of charge taking in due account the need to differentiate between access to DATA and access to facilities;
- use terms and definitions which are consistent with Article 2 of the Convention establishing the World Intellectual Property Organisation (WIPO) signed on 14 July 1967;
- create internal intellectual property rules between EPOS Partners which will be approved by the EPOS-ERIC General Assembly;
- comply with all relevant European and International legislation on data and IPR protection including the INSPIRE regulations;
- follow the OECD principles for research data from public funding;
- utilize a widely accepted community licensing schema, e.g. Creative Commons.

EPOS ERIC will encourage and promote "Open Access": making data available for unfettered use, re-use, and redistribution by anyone with no discrimination against fields of endeavour or against persons or groups. Open Access to data supports research, innovation and wider public use and, by enabling errors to be detected, leads to better exploitation of research results. Open Access, however, shall not always mean unlimited and/or free of charge access to data, and its implementation will support data protection rules as defined by the EU Data Protection Directive. The Environmental Information Directive gives examples where access can be restricted without violating Open Access principles. Reasonable restrictions still in line with Open Access may take the form of embargo periods for specific data sets or charging with justification and for marginal costs only.

Essential to the future success of EPOS-ERIC will be the relationship between EPOS-ERIC and Suppliers and Users. Wherever possible EPOS-ERIC will support the wishes and, inevitably, conditions placed by Suppliers on the way in which their DATA can be used. A fair proportion of the data and data products supplied to EPOS-ERIC may come with conditions and Users will have to accept those conditions in return for the right to use them.

EPOS-ERIC will set in place rules for access to DATA as well as to research facilities (e.g. laboratories).

In particular, within the EPOS Data Policy and Access Rules, "User", can be classified as follows:

- *Anonymous:* Access without any identification or accreditation limited to some TCS and/or to raw data.
- *Registered*: Identified access requiring prior registration, which may differ for specific EPOS services.
- *Authorized:* Identified access requiring specific permissions for particular DATA or EPOS services. Only a Registered User can become an Authorized User.

Notably, EPOS promotes that access to DATA and facilities shall as a rule require Registered Users.

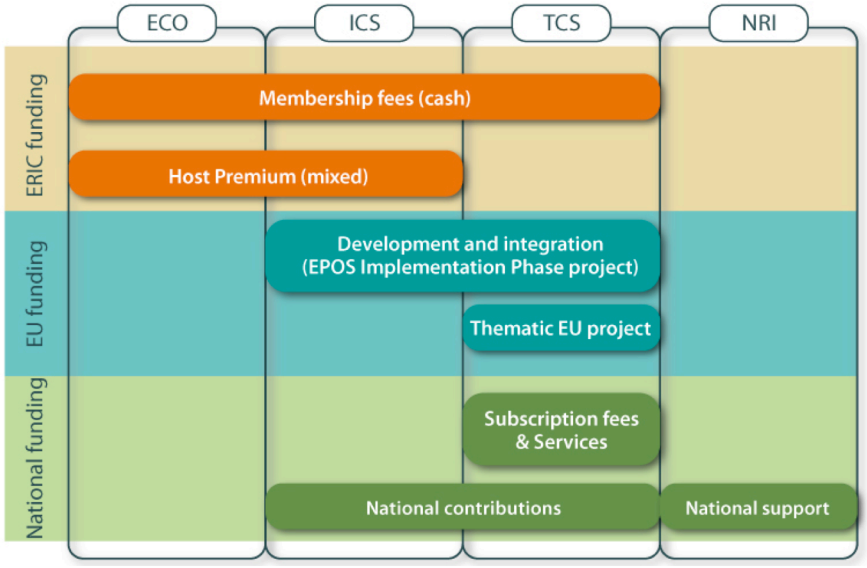
Within the EPOS Data Policy and Access Rules, forms of "Access to DATA", are classified as follows:

- *Open*: DATA freely available/accessible to any User either for download or for direct
- *Restricted*: DATA that are available under the conditions set out by the Suppliers.
- *Embargoed*: DATA that are available only after a specific time (embargo period) has passed since collection/generation. During the embargo period they will only be available to specific Authorized Users. Once the embargo period has expired, they may become either Open or Restricted.

In particular, Software disseminated via the EPOS Delivery Framework can be *Acquired* for use by EPOS or Users; *Contributed* by another RI and which may have restrictions on use; *Generated* within EPOS Core Services. EPOS-ERIC will provide software licences in each case appropriate to the type of use envisaged and to the type of access granted.

BOX 3

Sketch of the EPOS Funding Model foreseen for the EPOS Implementation Phase (2015-2019)



The figure shows the different funding sources (horizontal boxes) for each of the EPOS elements (vertical boxes).

The funding model was drafted to be:

- **inclusive**: to encourage the participation of new partners without damaging the existing ones
- **incentive**: to encourage the Members to support EPOS
- **fair**: to take into consideration the national situations (their necessities and possibilities)
- **adaptive**: to provide a framework which is a tool that can be re-balanced and adapted upon request to easily include new partners, new communities and therefore new services
- **simple**: to allow fast and easy use and comprehension for the EPOS staff, the regular Members, the observers and for all interest stakeholders.

The funding model relies on:

Membership Fees. Cash contribution from each Member of EPOS ERIC on an annual basis to:

- operate EPOS ERIC ECO (including the salary of EPOS ERIC Executive Director)
- operate the ICS (personnel costs as well as equipment, development and maintenance)
- provide funds for strategic activities to further implement TCS.

The IAPC recommended to further investigate a mixed model based on flat rate and GDP weighting. The definition of the level of flat rate and GDP still need to be assessed and discussed.

Host premium. It includes cash and in-kind contributions (*mixed)*. The country/ies hosting the ECO and the ICS-C (central hub) are free to cover part of the construction and maintenance costs on top of its normal annual Membership fee. No threshold was settled in the selection procedure for hosting the ECO. We foresee that no threshold will be settled in the procedure for hosting the ICS-C either.

In-kind contributions. (IKC) Other contributions (not cash) from EPOS ERIC Members. It is envisioned for EPOS Implementation Phase to limit the IKC to the development and maintenance of the distributed components of the ICS. As far as the IKC is concerned and in accordance with the ERIC regulation, "all items of revenues and expenditure of an ERIC shall be included as estimates to be drawn up for each financial year and shall be shown in the budget". Due to the non-profit nature of EPOS, cash and IKC can be uncoupled. The decisions on the definition of IKC need further discussions within the BGR. During its last meeting, the possibility of seconding personnel to the ERIC was discussed and deemed interesting by the delegates who expect EPOS to further work on the options.

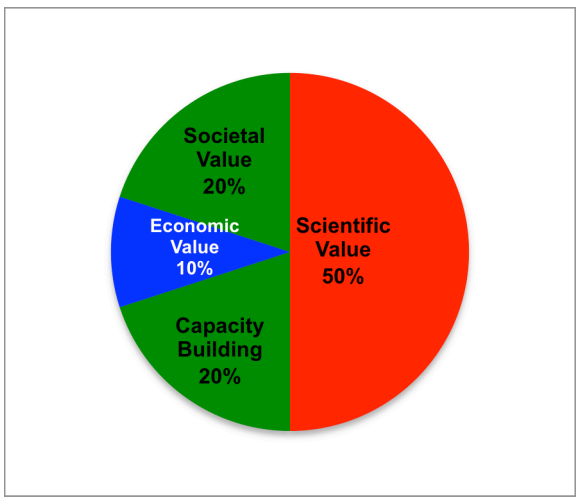
The funding sources for implementing TCS-ICS include the EPOS IP proposal, submitted on January 2015, and other thematic EC projects (I3, IT, ITN). National funds to maintain and operate NRIs are expected to be confirmed by Governments. Further national contributions to support TCS and ICS-d implementation are expected during the implementation phase.

BOX 4

SUMMARY of EPOS Socio-Economic Impact

	Scientific Value		Capacity Building		Economic Value		Societal Value	
	Importance	Impact	Importance	Impact	Importance	Impact	Importance	Impact
Overall EPOS	50%	high	20%	medium	10%	low	20%	medium
WG1: Seismology	50%	high	30%	high	5%	low	15%	medium
WG2: Volcanology	35%	high	20%	medium	10%	low	35%	high
WG9: Magnetic Observations	50%	high	10%	low	10%	low	30%	medium
WG10: Induced Seismology	40%	high	15%	medium	25%	high	20%	medium

Overall EPOS SEI Evaluation



BOX 5

SUMMARY of EPOS benefit to stakeholder groups

Benefit to All Stakeholders

- A single and authoritative point for data access, products, and services insuring key role of European research infrastructures
- Meet urgent needs to increase monitoring of and data distribution about natural and anthropogenic (such as induced seismicity) phenomena
- Identify strengths and weaknesses to optimize deployment of resources and effort

Benefit to Research Infrastructures

- Define common standards for RIs an an integrated services core
- Help in development, building, operation and maintenance of RIs through establishing best-practices and pooling expertise and resources
- Facilitate capacity building
- Provide Europe-wide visibility of national RIs

Benefit to Researchers

- Provide single-site access to all relevant data, products and services and foster the generation of new data products
- Ensure uniform quality of data, products and services on an open-community peer review basis
- Enable reproducibility of scientific results
- Enable cross-discipline collaboration
- Enable planning of new projects
- Serve as EU-level partner for international collaboration

Benefit to Industry

- Provide a comprehensive view of the state-of-the-art
- Respond, in a timely manner, to a wide range of industry requests for expertise
- Increase the accuracy and reliability of current industry processes and techniques
- Through collaboration, transfer knowledge, data and services to new technologies and to practice
- Facilitate innovation to enable sustainable exploitation of Earth's natural resources

Benefit to Funding Agencies

- More value for money through cross-EU collaboration, critical issue targeting, and synergistic resource sharing
- Single-point-of-partnership to provide efficient project preparation, review, funding distribution, and reporting mechanisms

Benefit to Society

- A single and authoritative point of contact for Earth science information from Europe
- Address major societal challenges of natural and anthropogenic hazards and risk mitigation
- Provide information relevant to management of natural resources in the Earth (geo-reources)
- Access to information and data products for Europe-wide emergencies for decision-making