EGI-InSPIRE

EGI-InSPIRE PAPER

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Abstract

This white paper from the EGI-InSPIRE project gives overview information about the European Grid Infrastructure, outlining the human, technical and infrastructure services that have been established and supported across Europe through the project. It provides a condensed overview of the activity supported by EGI-InSPIRE that can be found in the Description of Work, but in a form that can be more easily referenced. Many of the topics briefly addressed in this paper are expanded on in other work within the project and these are referenced where appropriate. The detailed plans relating to longer-term issues and future challenges for the infrastructure in the areas of sustainability, virtualisation and expanding the user community are reviewed.

Therefore, this paper provides a reference for individuals writing their own paper on EGI-InSPIRE and provides material that can be used within the project and by its collaborators in other publications.

New users of the infrastructure should consult http://www.egi.eu to find information on how to get started in EGI.

I. COPYRIGHT NOTICE

II. DELIVERY SLIP

	Name	Partner/Activity	Date
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III. DOCUMENT LOG

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IV. APPLICATION AREA

This document is a formal deliverable for the European Commission, applicable to all members of the EGI-InSPIRE project, beneficiaries and Joint Research Unit members, as well as its collaborating projects.

V. DOCUMENT AMENDMENT PROCEDURE

Amendments, comments and suggestions should be sent to the authors. The procedures documented in the EGI-InSPIRE "Document Management Procedure" will be followed:
https://wiki.egi.eu/wiki/Procedures

VI. TERMINOLOGY

A complete project glossary is provided at the following page: http://www.egi.eu/about/glossary/.

VII. PROJECT SUMMARY

To support science and innovation, a lasting operational model for e-Science is needed − both for coordinating the infrastructure and for delivering integrated services that cross national borders.

The EGI-InSPIRE project will support the transition from a project-based system to a sustainable pan-European e-Infrastructure, by supporting 'grids' of high-performance computing (HPC) and high-throughput computing (HTC) resources. EGI-InSPIRE will also be ideally placed to integrate new Distributed Computing Infrastructures (DCIs) such as clouds, supercomputing networks and desktop grids, to benefit user communities within the European Research Area.

EGI-InSPIRE will collect user requirements and provide support for the current and potential new user communities, for example within the ESFRI projects. Additional support will also be given to the current heavy users of the infrastructure, such as high energy physics, computational chemistry and life sciences, as they move their critical services and tools from a centralised support model to one driven by their own individual communities.

The objectives of the project are:

1. The continued operation and expansion of today's production infrastructure by transitioning to a governance model and operational infrastructure that can be increasingly sustained outside of specific project funding.
2. The continued support of researchers within Europe and their international collaborators that are using the current production infrastructure.
3. The support for current heavy users of the infrastructure in earth science, astronomy and astrophysics, fusion, computational chemistry and materials science technology, life sciences and high energy physics as they move to sustainable support models for their own communities.
4. Interfaces that expand access to new user communities including new potential heavy users of the infrastructure from the ESFRI projects.
5. Mechanisms to integrate existing infrastructure providers in Europe and around the world into the production infrastructure, so as to provide transparent access to all authorised users.
6. Establish processes and procedures to allow the integration of new DCI technologies (e.g. clouds, volunteer desktop grids) and heterogeneous resources (e.g. HTC and HPC) into a seamless production infrastructure as they mature and demonstrate value to the EGI community.

The EGI community is a federation of independent national and community resource providers, whose resources support specific research communities and international collaborators both within Europe and worldwide. EGI.eu, coordinator of EGI-InSPIRE, brings together partner institutions established within the community to provide a set of essential human and technical services that enable secure integrated access to distributed resources on behalf of the community.

The production infrastructure supports Virtual Research Communities (VRCs) − structured international user communities − that are grouped into specific research domains. VRCs are formally represented within EGI at both a technical and strategic level.

VIII. EXECUTIVE SUMMARY

This paper provides an overview of the EGI-InSPIRE project, a 4 year €72M project with a €25M contribution from the European Commission, set up to support the development of a sustainable e-Infrastructure for research in Europe. This document updates the state-of-the-art described in the previous EGI-InSPIRE paper (D2.3, [R1]).

The European Grid Infrastructure (EGI) is an e-Infrastructure for multi-disciplinary e-Science, supporting more than 21,000 researchers across dozens of fields of research through a wide range of technical and infrastructure services. EGI's services are provided by more than 350 resource centres, supporting in excess of 1.4 computing million jobs per day, as well as data storage, transfer and open access.

EGI leads the development of e-Infrastructures for science building on a vision to support the digital European Research Area through a pan-European research infrastructure, based on an open federation of reliable services. These services provide uniform access to national computing, storage and data resources. EGI's mission is to connect researchers from all disciplines with the reliable and innovative ICT services they need to undertake collaborative world-class and world-inclusive research. EGI's work is developed around four key values: Leadership, Openness, Reliability and Innovation.

The EGI ecosystem is a thriving community of independent technology providers, platform integrators and operators, resource infrastructure providers and research communities, as well as national (NGIs) and European (EGI.eu) coordination bodies. The community works together to provide researchers with the computing resources they need for their research work.

EGI.eu is a not-for-profit foundation established in the Netherlands to nurture this environment and develop it into a sustainable ecosystem, able to maintain a consistent and reliable level of ICT services for European researchers. To ensure this, the different components of the ecosystem need to be developed and supported individually, with effective processes, supported by governance structures and partnerships that enable them to scale as required.

EGI.eu offers a global set of services that complement and add value to the activities developed by NGIs and EIROs in the areas of: governance; strategy & policy development; communications, events & outreach; operations management; technology provision; cooperation and community-building, some of which are provided through the virtual team framework.

EGI is built around a set of Infrastructure Platforms that provide the computing services researchers need for their work. The Core Infrastructure Platform offers services contributed by members of the EGI federation: Operations Portal, Monitoring Portal, Accounting Portal, Helpdesk, Configurations Database, Metrics Portal. Together, these services allow researchers to access an integrated and seamless computing e-infrastructure spanning more than 30 countries.

Deployed in parallel with the core infrastructure services, EGI users can also benefit from the Collaborative Infrastructure Platform – a set of services that allow knowledge transfer within the community helping to maximise productivity and efficiency, namely: the Training Marketplace, the Applications Database, the Requirements Tracker, Science Gateways, Workflows & Workflow systems.

The Cloud Infrastructure Platform is the answer to the interest expressed by several research communities in on demand flexibility provided by virtualisation within EGI. Work on the federated cloud model started at the EGI User Virtualisation Workshop and has progressed well over the past few months. The Federated Clouds Task Force has defined a total of eight capabilities required of a future EGI Federated Cloud. These are: Virtual Machine Management, Storage/Data management, Information Discovery, Accounting, Monitoring, Notification, Federated Authentication & Authorization Infrastructure and Virtual Machine Image sharing.

EGI is not a static resource. The EGI Strategic Plan – Seeking New Horizons: EGI's Role in 2020 [R2] – which has been endorsed by the EGI Council, describes how EGI will evolve into a universal federated platform for supporting compute and data intensive research and education communities. EGI will develop into a framework capable of hosting a range of high-throughput computing solutions, including both grid and cloud approaches.

In practice, this means developing EGI's strengths in three key strategic investment areas: Community and Coordination, Operations Infrastructure and Virtual Research Environments.

EGI's future strategy aims to provide an alignment of the funding it receives to the different types of activities it supports, reflecting the priorities of the funding source. For example, there is a distinction between the routine operation of the ecosystem (which should become supported solely by national infrastructure or community funds), and changes to the operation or technology of the ecosystem (funded from national research councils or the European Commission).

EGI has identified three potential funding sources: community funding; Horizon 2020 and/or National Innovation Funding; Horizon 2020 Support Funding.

The next generation of European research innovation will increasingly rely on collaboration across multiple disciplines and across national and international borders. Recognising this trend and opportunity, the European Commission has unveiled Europe 2020 – a strategy to develop a smart, sustainable and inclusive economy based on innovation and knowledge transfer. In practice, EGI's contribution to the Europe 2020 strategy will focus on the Digital Agenda for Europe (DAE) and Innovation Union (IU) flagship initiatives, as well as providing an underlying added value that will bring cross-cutting benefits to European research and society as a whole.

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1 INTRODUCTION

E-Infrastructures are geographically distributed computing resources and data storage facilities, linked by high-performance networks. They allow scientists to share information securely, analyse data efficiently and collaborate with colleagues worldwide. They are an essential part of modern scientific research and a driver for the discoveries that can solve challenge problems. By 2020, e-Infrastructures need to be deployable on demand to provide a foundation for the digital European Research Area (ERA).

The European Grid Infrastructure (EGI) is a prime example of a mature pan-European e-Infrastructure. EGI is the result of pioneering work that has, through the federation of national resource providers over the last decade, built a collaborative production infrastructure based on uniform and accessible services aimed at researchers across Europe and around the world.

Today EGI is an e-Infrastructure for multi-disciplinary e-Science, supporting more than 21,000 researchers across dozens of fields of research through a wide range of technical and infrastructure services. The provision of EGI's services is distributed across Europe and beyond, including more than 350 resource centres, supporting in excess of 1.4 computing million jobs per day, as well as data storage, transfer and open access.

Looking towards 2020, EGI will continue to lead the development of e-Infrastructures for science building on:

A **vision** to support the digital European Research Area through a pan-European research infrastructure, based on an open federation of reliable services, which provide uniform access to national computing, storage and data resources.

A **mission** to connect researchers from all disciplines with the reliable and innovative ICT services they need to undertake their collaborative world-class and world-inclusive research.

Both vision and mission will be developed around the core values of:

- **Leadership**: EGI is a leading pan-European infrastructure, integrating worldwide computing, storage and data resources to support an ecosystem built on innovation and knowledge transfer.
- **Openness**: EGI operates collaboratively with a transparent governance structure that integrates the views and the requirements of all stakeholders, from research communities to resource providers.
- **Reliability**: EGI provides a reliable infrastructure that research communities can depend on in order to collaborate with their peers and deliver innovation.
- **Innovation**: EGI will continue to meet the needs of research communities operating at unparalleled geographic and technical scale by partnering to bring new technologies into production.

EGI is coordinated by EGI.eu, a not-for-profit foundation set up in the Netherlands to manage the infrastructure on behalf of its stakeholders: National Grid Initiatives (NGIs) and European International Research Organisations (EIROs).

The first four years of EGI activity are supported by the project EGI-InSPIRE (Integrated Sustainable Pan-European Infrastructure for Researchers in Europe), coordinated by EGI.eu. Starting in May 2010, the project is co-funded by the European Commission (contract number: RI-261323), as a collaborative effort involving more than 50 institutions in over 40 countries. By the time EGI-InSPIRE concludes in 2014, EGI will have transitioned towards providing sustainable and dependable computing resources for European scientists and researchers for the decades to come.

Table 1 – EGI in numbers (as of May 2012, end of Project Year 2) [R3]

Operations Centres	36
Resource Centres	352 (in 56 countries and CERN)
CPU cores available	270,800
Disk and tape capacity	139 and 134 Petabytes
Number of users	20,883 researchers in 226 topical Virtual Organisations
Computing resources used	10.5 billion CPU hours (measured in HEP-SPEC06)
Successful submitted jobs	1.35 million jobs/day (average)
Availability & Reliability	94.5% & 95.4%

2 SUPPORTING THE EGI ECOSYSTEM

The EGI ecosystem is now becoming a thriving community of independent technology providers, platform integrators and operators, resource infrastructure providers and research communities, as well as national (NGIs) and European (EGI.eu) coordination bodies. The community works together to provide researchers with the computing resources they need for their research work.

EGI.eu's mission is to nurture this environment and develop it into a sustainable ecosystem, able to maintain a consistent and reliable level of ICT services for European researchers and their colleagues. To ensure this, the different components of the ecosystem need to be developed and supported individually, with effective processes, supported by governance structures and partnerships that enable them to scale as required.

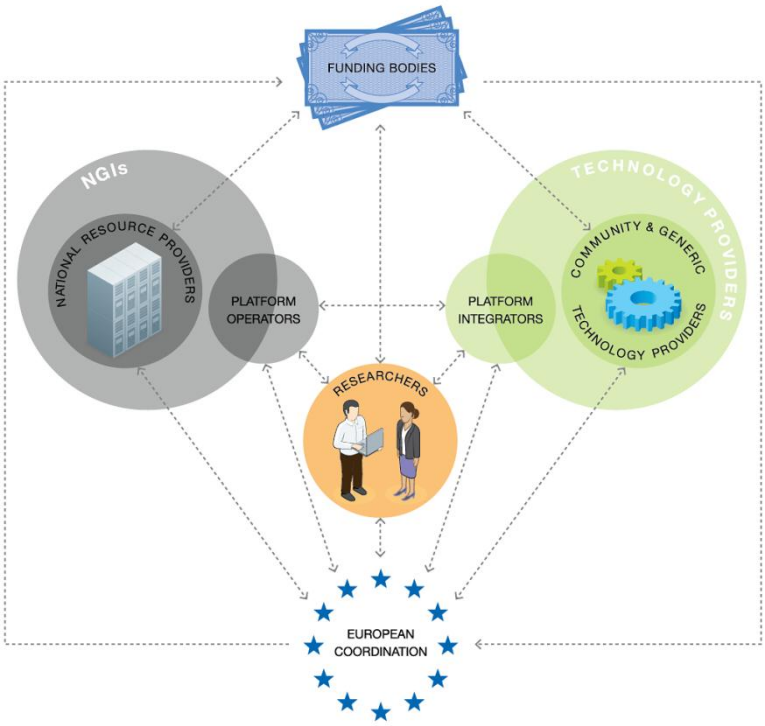

Fig. 1. The elements of the EGI ecosystem.

2.1 The EGI ecosystem

2.1.1 Researchers

The researchers who use grid computing for their work are at the heart of the EGI ecosystem. They are grouped into Virtual Organisations (VOs) – associations of researchers with similar scientific interests and computing requirements, who are able to work collaboratively with other members and/or share resources (e.g. data, software, expertise, CPU, storage space), regardless of geographical location.

Currently there are more than 220 VOs for communities with interests as diverse as Earth Sciences, Computer Sciences and Mathematics, Fusion, Life Sciences and High-Energy Physics. EGI supports

the VOs by providing the services and tools they require to make the most of the available computing resources.

At a higher level, the Virtual Research Communities (VRCs) are groups of like-minded individuals organised by discipline or computational model. VRCs typically have an established presence in their field (for example an European Strategy Forum on Research Infrastructures (ESFRI) project, EIROFORUM laboratory or national research structure) and represent a well-defined structured scientific or research community. VRCs are self-organised and give individuals within their community a clear mandate to represent the interests of their research field within the EGI ecosystem. They can include one or more virtual organisations and act as the main communication channel between the researchers they represent and EGI.

EGI establishes partnerships with individual VRCs through a Memorandum of Understanding (MoU). Following the accreditation process and final agreement, VRCs can access the computing resources and data storage provided by the EGI community through open source software solutions. International scientific communities can draw many benefits from a strong partnership with EGI. EGI offers an open process that involves the community in improving its user oriented services (e.g. a register of grid-ready applications and training resources), as well as workshops and forums that collect and refine community input, help and support in resolving specific technical issues, and involvement in the evolution of EGI's production infrastructure.

In turn, VRCs provide EGI with their technical and service requirements, which are then fed into the overall development of the infrastructure as a consumer-driven resource. VRC representatives sit on the User Community Board and advise EGI on its planning and operational priorities, based on requirements collected from its members.

2.1.2 NGIs & NILs

The National Grid Initiatives (NGIs) are the key stakeholders of EGI, together with CERN and EMBL, and the main resource infrastructure providers. NGIs are organisations set up by individual countries to manage the computing resources they contribute to the pan-European e-Infrastructure, and represent the country in the international e-Science community.

Typically, NGIs interact with each other and EGI.eu, as their coordinating body, through three main points of contact:

- The support teams allow new and current researchers to make the most of the infrastructure and enable researchers to organise themselves into sustainable virtual research communities.
- The operations teams are responsible for supporting their Resource Centres, monitoring their performance, collecting requirements and representing them in EGI's Operations Management Board and its associated groups.
- The NGI International Liaisons (NILs) work together with teams in EGI.eu and link the strategic non-operational activities taking place in their own NGIs (e.g. outreach, marketing, communication, training, new community engagement) with the rest of the community.

The NILs are especially important to the cohesion of EGI as an integrated pan-European community, acting as a spearhead and channelling their country's skills from a local to an international level, thereby demonstrating the added value of each NGI.

2.1.3 Technology Providers

EGI does not develop the software deployed in the grid infrastructure – all upgrades and new components are produced in partnership with independent technology providers.

Technology providers are organisations or projects collaborating with EGI to develop or deliver software for use within the production infrastructure or its user community. Typically, a technology provider commits to provide software to implement one or more user requirements described on the EGI technical roadmap [R4].

2.1.4 Collaborations overview

One of the main goals of EGI.eu is to bring European distributed computing initiatives into an integrated e-Infrastructure that is able to seamlessly peer with equivalent e-Infrastructures around the world. To nurture such collaborations, EGI needs to establish and formalise agreements with relevant partners on a European and global level, namely with Resource Infrastructure Providers, Technology Providers, Virtual Research Communities, projects and organisations. Each external collaboration is formalised via a Memorandum of Understanding (MoU), which is a signed document defining a collaboration framework between EGI.eu or EGI-InSPIRE and the collaborating organisations or activities.

The following list provides an overview of the MoUs that have been signed since the setup of EGI.eu in 2010. More information is available in the Memorandum of Understanding Annual Report [R5].

Technology Providers

- European Middleware Initiative (EMI)
- Initiative for Globus in Europe (IGE)
- The SAGA project (Simple API for Grid Applications)
- StratusLab
- University of Virginia Alliance for Computational Science and Engineering (UVACSE)

Resource Infrastructure Providers

- Basic Coordination Centre (BCC) – Ukraine National Grid (UNG) / Ukraine
- CSIR Meraka Institute – South African National Grid (SAGrid) / South Africa
- Universidade Federal do Rio de Janeiro (UFRJ) / Latin America

Virtual Research Communities

- Hydro-Meteorology Research Community (HMRC)
- The Life-Science Grid Community (LSGC)
- A worldwide e-Infrastructure for NMR and structural biology (WeNMR)
- Worldwide LHC Computing Grid (WLCG)

Other Projects

- Co-ordination & Harmonisation of Advanced e-Infrastructures (CHAIN)
- Diagnostic Enhancement of Confidence by an International Distributed Environment (DECIDE)
- European Desktop Grid Initiative (EDGI)
- The European e-Infrastructures Observatory (e.nventory)
- E-ScienceTalk
- Grid Initiatives for e-Science virtual communities in Europe and Latin America (GISELA)
- Grid Service Level Management (gSLM)
- Multiscale Applications on European e-Infrastructures (MAPPER)

- Scalable Software Services for Life Science (ScalaLife)
- Scientific Gateway Based User Support (SCI-BUS)
- Sharing Interoperable Workflows for large-scale scientific simulations on Available DCIs (SHIWA)
- Standards and Interoperability for e-Infrastructure Implementation Initiative (SIENA)

2.2 EGI.eu services

The role of EGI.eu is to coordinate and manage EGI on behalf of its participants. As such, EGI.eu offers a global set of services that complement and add value to the activities developed by NGIs and EIROs. These services focus on the following areas:

2.2.1 Governance

EGI is a federation of nationally and domain specific resource providers coordinated by a dedicated organisation based in Amsterdam – EGI.eu.

The governance of EGI.eu, a Dutch Foundation (or Stichting) is entrusted to the EGI Council which draws its membership from appointed representatives of the national or domain specific organisational resource providers that are participants in the foundation. Participation in the foundation is open to new members, subject to the approval of the Council, to those organisations willing to agree to its statutes and pay the fees agreed by the EGI Council. It is the EGI Council that decides the policies of the organisation, and therefore the community it represents, through a voting scheme that is currently weighted by the financial contribution each participant makes to the organisation, which is derived from the country's Gross Domestic Product (GDP)

Day-to-day, the activity of the EGI.eu organisation is managed by the Director who is advised by an Executive Board with six members and a chair elected from the EGI Council. Technical activity across EGI's three main areas – Operations, User Community and Technology – is managed through groups containing representatives from the relevant communities.

The EGI-InSPIRE project brings together many of the participants in EGI.eu and provides financial support to the development of EGI during the first four years of its existence, as it transitions towards sustainability. The programme of work within EGI-InSPIRE helps to establish EGI, by committing the partners within the project to also work together within EGI.eu, and by supporting the persistent structures within EGI that will remain after the project is complete.

Within this framework, individual countries retain management of the day-to-day and strategic planning of their own national infrastructures, while EGI.eu handles the universal needs and works to find the common ground required to integrate the resources which are geographically distributed across Europe and the world. This model of governance reduces fragmentation and enhances cohesion, trust and interoperability within EGI.

2.2.2 Strategy and policy

This activity is supported by the EGI.eu Strategy and Policy Team (SPT) and encompasses strategic planning and support for executing strategy, policy development and liaison with external partners.

From a strategy point of view, EGI.eu's work focuses on developing an integrated model for governance, standardisation and integration with other infrastructures; analysis of and alignment to EU strategy (e.g. EU2020 strategy); preparation of briefing papers and reports to support decisions by the EGI management bodies and to inform the EGI community about strategic-level developments. The

Strategy and Policy Team also organises meetings and workshops on strategic themes key to EGI and nurtures and develops collaborations within and outside the EGI ecosystem. One activity started in 2012, which will produce rich results in future years, is the establishment of an EGI Compendium which will track the evolution of the NGIs that comprise the EGI Community on an annual basis.

In the area of policy development, the established process rests on three fundamental principles: openness, transparency and consensus. Policies can be developed internally by policy groups or in collaboration with external partners. The internal policy groups are governed by Terms of Reference (ToR), i.e. documents describing their responsibilities, composition and operational procedures. The following list contains the policy groups active within the EGI community:

- Technology Coordination Board (TCB)
- Operational Tools Advisory Group (OTAG)
- Operations Management Board (OMB)
- Operations Automation Team (OAT)
- User Community Board (UCB)
- Security Policy Group (SPG)
- Software Vulnerability Group (SVG)
- Security Coordination Group (SCG)
- Computer Security Incident Response Team (CSIRT)

With a common strategic and policy background championed by EGI.eu, the members of the EGI federation can stand together as a united player in the wider Distributed Computing Infrastructures (DCI) community, with a stronger ability to defend the interests of the federation at a European Union level.

2.2.3 Communications, events and outreach

The partners in the EGI federation recognise the importance of communicating their achievements to a wider audience and the technical and integrative added value of a strong community spirit. EGI.eu coordinates the achievement of this common goal through the work of its communications and technical outreach teams.

The focus of the communications team is to publicise the achievements of the EGI federation and its research communities to its target audiences: new and existing user communities, journalists, the general public, grid research and standards communities, resource providers, collaborating projects, decision makers and governmental representatives. Means for dissemination include the project website, wiki site, materials and publications, media and public relations, social media channels and participation in events in order to market EGI to new users, including driving the outreach for EGI's two large annual community events.

Events are one of the key services provided by EGI.eu. Bringing together partners in the EGI ecosystem regularly is vital to enable collaborations within the community and provides an opportunity to showcase EGI's achievements internally and to new user communities. EGI.eu organises two community-wide meetings per year:

- The Community Forum in Spring, driven by contributions from the community
- The Technical Forum in Autumn, focusing on a more structure-driven technical agenda

EGI works in collaboration with other European e-Infrastructure providers and their user communities to make these meetings as infrastructure and research discipline neutral as possible, to promote harmonisation, integration and interoperability. In addition to the flagship events, smaller targeted events and workshops are organised to address specific technical issues relevant to new and existing user communities.

Recognising the particular importance of new communities to the ecosystem, EGI.eu provides dedicated technical outreach to new communities. Converting a potential new user community into an active user community requires technical effort and planning to accommodate their individual needs, since each new group is different in its nature and requirements. This means that for each new community it is important to identify which resources they need, to consider the integration of new resources into EGI, to port applications to an EGI platform, to deploy services to meet new requirements, advise on training and so on.

Another positive outcome of this service is that it ensures that new users make the most of the expertise and the tools accumulated and developed by EGI and its predecessors. By providing technical outreach to new communities, EGI.eu also promotes knowledge transfer from (and within) the early-adopter heavy user communities and a suite of collaborative infrastructure platforms (including, for example, the training marketplace and the applications database). Details are provided in section 3.2

2.2.4 Operations management and technology provision

The EGI.eu distributed Operations Team coordinates and performs the activities required to deliver services at an agreed service level to the consumers of those services. Operations is also responsible for the ongoing management of technology deployment and technical support services. This includes the security monitoring, and incident response team, monitoring of the NGI service availability, staged rollout of both major and minor software updates, the integration of ARC, GLOBUS, UNICORE and Desktop Grids, and investigating interoperation with HPC resources from PRACE.

The role of Operations in EGI is to coordinate and perform the activities required to deliver services at the agreed service level to the targeted consumers. Operations teams are also responsible for the ongoing management of the technology that is used to deliver and support these services.

EGI.eu has an Operations team that coordinates the work of (about) 32 distributed Operations Centres. Of these, 22 Operations Centres are managed at a national level, one is coordinated by a European Intergovernmental Research Organisation (CERN) and four are responsible for non-European operations: Asia Pacific, Canada, IGALC, and Latin America.

All software deployed on EGI is produced through independent platform integrators and technology providers. EGI.eu helps to manage the outsourcing of technology developments through the Technology Coordination Board (TCB), according to the requirements gathered from the User Community Board (UCB), the Operations Management Board (OMB), VOs and potential user communities. EGI.eu negotiates with potential technology providers and assesses the quality of the new software.

EGI.eu also coordinates the process that identifies and integrates new technologies into the infrastructure, keeping it up to date with the latest technical developments. An example of this remit to pioneer new technologies is the work conducted by the Federated Cloud Task Force. (See also in Section 3.3)

2.2.5 The Virtual Team framework

After a decade of development, the European grid infrastructure has reached production quality, with high levels of service availability and reliability. The next challenge is to make the most of this achievement by putting in place an equally effective collaboration infrastructure. This is achieved through the establishment of a Virtual Team model.

EGI.eu operates the Virtual Team (VT) framework, to pool the distributed competences within the EGI federation and develop EGI-wide activities to engage with research communities and NGIs. The

VT framework is a mechanism to allow interaction, knowledge transfer and cooperation within the community on non-operational activities, focusing on areas such as outreach to new user communities, communications, policy and strategy, user support and tailored events.

The NGI International Liaisons (NILs) are key to the success of the virtual teams. They are responsible for the delivery and interaction of non-operational tasks within the NGIs and liaise on these aspects with their peers in the EGI federation and the EGI.eu staff. This is achieved through participation in the virtual teams. Their involvement can be proactive (e.g. a NIL identifies an issue of importance to his/her NGI and proposes/leads a VT to address the matter), or responsive (e.g. a NIL learns about a new VT, decides that this is of interest to his/her NGI and contributes to the VT work, benefitting from the pool of experience).

The ultimate goal of the VT model is to achieve human integration, in parallel with the resource centre integration in EGI – this is the most effective way to make the most of the distributed experience and competences that have evolved over the years within each country.

More information on the Virtual Team framework can be found on D2.14 Annual Report on EGI and its External Relations Activity [R6].

3 INFRASTRUCTURE PLATFORMS

3.1 Core Infrastructure Platform

The main purpose of EGI is to allow scientists and researchers access to an integrated and seamless computing e-infrastructure spanning more than 30 countries. To fulfil its commitment to its user communities, EGI relies on a series of services contributed by members of the EGI federation summarised in Table 2. Together, these services make up the core infrastructure platform.

More information on the core infrastructure platform, its services and state-of-the-art is available on:

- The D7.2 Annual Report on Operational Tool Maintenance and Development Activity [R7]
- The D2.3 EGI-InSPIRE Paper [R1]

Table 2 – Summary of the core infrastructure services

Name	Description	Links & references
Operations Portal	The Operations Portal provides status information to operations centres, VO managers and other interested parties, as well as related services such as the VO registration tool and user statistics, the broadcast and downtime notification tool and the regional dashboard. *Developed by the CC-IN2P3, part of the French NGI.*	http://operations-portal.egi.eu/
Monitoring Portal	The Service Availability Monitoring is the backbone of the monitoring infrastructure and tests the performance of grid services continuously. The monthly availability and reliability figures are calculated from the test results, accessible from this portal. *Developed by CERN.*	https://grid-monitoring.egi.eu/myegi (certification required)
Accounting Portal	The EGI central Accounting Portal presents a homogeneous, user-friendly view of the usage data and provides a good understanding of resource usage. Local operations are responsible for the validation of the gathered data and supervise the publication process. Usage information is persistently stored in central repositories. *Developed by CESGA, part of the Spanish NGI.*	http://accounting.egi.eu/
Helpdesk	EGI provides support to users and operations staff through the EGI Helpdesk– a distributed helpdesk with central coordination. The EGI Helpdesk is a central tool, fully interfaced with several local helpdesks. *Developed by KIT, part of the German NGI.*	http://helpdesk.egi.eu/
Configuration Database - GOCDB	The Grid Configuration Database – GOCDB – contains general information about the resource centres that make up the grid infrastructure. GOCDB is accessed by end-users, managers, support teams and VO managers, as well as by other tools and third-party middleware with an interest in grid topology. *Developed by STFC, part of the UK NGI.*	https://goc.egi.eu/ (certification required)

Metrics Portal	Collects a set of metrics from different resources to help measure project performance and keep track of the project evolution by displaying historical values of the metrics in a single place. *Developed by CESGA, part of the Spanish NGI.*	http://metrics.egi.eu/

3.2 Collaborative Infrastructure Platform

Deployed in parallel with the core infrastructure services, EGI users can also benefit from the Collaborative Infrastructure Platform – a set of services that allow knowledge transfer within the community helping to maximise productivity and efficiency, summarised in Table 3.

Table 3 – Summary of the collaborative tools

Name	Description	Links & references
Training marketplace	The EGI Training Marketplace is a service to coordinate training across communities, projects and national teams. The Training Marketplace enables trainers to advertise events, materials and resources, and researchers using EGI to locate, access and comment on training material, events and resources that meet their needs. *Developed by STFC, part of the UK NGI.*	http://go.egi.eu/training More information: [R6]
Applications database	The EGI Applications Database (AppDB) stores information about grid-based computing tools for scientists and grid/cloud application developers to use. The scope of the database embraces all scientific fields, from resources to simulate exotic excitation modes in physics, to applications for complex protein sequences analysis. *Developed by GRNET, part of the Greek NGI.*	http://appdb.egi.eu/ More information: [R6]
Requirements tracker (RT)	RT is a highly customisable ticketing system with a web portal that the EGI community uses to keep track of emerging needs and requirements of the user and operational communities, and to match these with offerings from existing and new technology providers and software developers. The RT system – based on widely popular open source software – available through portal, web gadget and dashboard interfaces, provides a customisable solution for EGI members, for ticket managers and the general public to keep track of individual and community requirements. *Hosted by CESNET, part of the Czech NGI.*	https://rt.egi.eu
Science gateways	An EGI science gateway is a community-specific set of tools, applications, and data collections that are integrated together via a web portal or a	http://go.egi.eu/sciencegateways

	desktop application, providing access to resources and services from the European Grid Infrastructure. These gateways can support a variety of capabilities including workflows, virtualisation software and hardware, visualization as well as resource discovery, job execution services, access to data collections, applications, and tools for data analysis. A science gateway enables community members to define and perform custom research scenarios or other types of use cases. *Hosted by individual communities.*	
Workflows and workflow systems	Workflows allow the reuse of software, applications and simulations. They are a powerful mechanism to develop, execute and share scientific calculations. Workflows allow researchers to improve the repeatability of scientific calculations and to become more efficient. Workflow systems are graphical or text environments that can be used to design workflows. *Hosted and run by individual communities and researchers.*	http://go.egi.eu/workflows

3.3 Cloud Infrastructure Platform

With the emergence of cloud computing as a distributed computing infrastructure, several research communities have expressed an interest in adopting the on-demand flexibility provided by virtualisation within EGI. EGI is not a homogenous e-Infrastructure providing static computing resources to researchers. A number of resource centres integrated in EGI have already been experimenting with the deployment of virtualised management environments, to make the local delivery of services more akin to on-demand virtual resources, and to expose some of this capability to their local user communities.

EGI's roots lie over a decade ago in the effort to federate the batch computing clusters that were being established at resource centres to meet the needs of their local user communities. As local cloud computing resources start to emerge through the adoption of virtualisation, the next step is to explore how the virtualised resources deployed by individual resource centres can also be federated to create an EGI Cloud Infrastructure. Providing a solution to this specific and widespread user requirement is now a priority for EGI's resource providers and its partner technology providers. This is the primary goal of EGI's Federated Cloud Task Force.

Work on the federated cloud model started at the EGI User Virtualisation Workshop[1]. The discussion focused on understanding whether and how EGI should move towards providing an Infrastructure as a Service (IaaS) model to support data intensive science and whether this service should be provided by federations of resource providers from the research community. The consensus emerging from the workshop was to introduce virtualised resources alongside the current grid services to increase the flexibility of infrastructure while retaining the current federated model used within EGI. This approach should not be a 'big bang' migration, but rather a gradual change transparent to the end-user.

[1] Amsterdam, 12-13 May 2011: http://go.egi.eu/uvw1

Following the workshop, the EGI-InSPIRE PMB endorsed the establishment of a Federated Clouds Task Force[2], starting in September 2011, which in the Summer 2012 evolved into a new task within the EGI-InSPIRE project that will run until the project completes in 2014. The work of the taskforce, continued now as a dedicated project activity, is to work with the community to develop a 'blueprint' containing technical guidelines for EGI resource centres who wish to federate and share their local virtualised environments externally with collaborators as part of the production infrastructure. The goals of this work include:

- Define and prototype solutions for monitoring, accounting and advertising through the information services virtualised resources
- Investigate and analyse requirements from early adopting research communities
- Provide feedback to relevant technology providers (both within and external to the TCB)
- Identify issues which need to be addressed by other areas of EGI (e.g. policy, operations, support and communications)

The group has defined a total of eight capabilities required of a future EGI Federated Cloud. These are: Virtual Machine Management, Storage/Data management, Information Discovery, Accounting, Monitoring, Notification, Federated Authentication & Authorization Infrastructure and Virtual Machine Image sharing.

Phase 1 ran from September 2011 to March 2012 and concentrated in the scenarios summarised on Table 4.

Table 4

Scenario	**Workbench**	**Capability**
Scenario 1	Running a pre-defined VM Image	VM Management
Scenario 2	Managing users' data and VMs	Data management
Scenario 3	Integrating information from multiple resource providers	Information discovery
Scenario 4	Accounting across Resource Providers	Accounting
Scenario 5	Reliability/Availability of Resource Providers	Monitoring

[2] Federated Clouds Taskforce wikipage: https://wiki.egi.eu/wiki/Fedcloud-tf:FederatedCloudsTaskForce

4 STRATEGY FOR THE FUTURE

EGI today is the result of pioneering work that has, over the last decade, built a pan-European production infrastructure through the federation of national resource providers, to support multi-disciplinary science across Europe and around the world. With thousands of users across many fields of science, EGI is already making a positive impact on European research and innovation.

But EGI is not a static resource. The EGI Strategic Plan – Seeking New Horizons: EGI's Role in 2020 [R2] – which has been endorsed by the EGI Council, describes how EGI will evolve into a universal federated platform for supporting compute and data intensive research and education communities. EGI will develop into a framework capable of hosting a range of high-throughput computing solutions, including both grid and cloud approaches.

The goal is to deploy higher-level software solutions (the virtual research environments) independently from the operational infrastructure, depending on the needs of each user community. The underlying infrastructure platform will be a managed environment able to support services for a wide variety of software stacks. With these services, EGI will become a universal e-Infrastructure, capable of hosting the complete range of distributed computing approaches required by the European Research Area.

In practice, this means developing EGI's strengths in three key strategic investment areas: Community and Coordination, Operations Infrastructure and Virtual Research Environments.

4.1 Community & Coordination

EGI has developed from a domain-specific activity focused on a handful of resource centres to a multi-disciplinary infrastructure with usage across many different disciplines. Individual researchers can expect uniform access to reliable services anywhere within EGI's federated network of national resource providers, regardless of location. The value of such widespread integration has been amply demonstrated (e.g. during the data collection runs of the Large Hadron Collider in 2010-12, when scientists analysed data using EGI services, leading to the identification of a Higg's-like particle in July 2012).

EGI is a truly pan-European infrastructure. This means that EGI federates resources from dozens of European countries, each with their own strengths, structures, priorities and procedures. The uniform functionality and quality of service offered to scientists today across these distributed and independent resources is the result of a decade of cooperation and consensus-building around many non-technical issues, including privacy, governance and strategy.

Therefore, EGI's main governing body – the EGI Council – is ideally placed to build on these achievements and lead the network of NGIs and EIROs to the next level needed to support the digital European Research Area as envisaged within the European Commission's Innovation Union flagship initiative. With the coordination provided by EGI.eu, EGI will continue to develop as an infrastructure and, just as importantly, as a community through communication, marketing, outreach, support and public events.

Strengths	> Community-building and coordination experience help to guarantee integration and deliver uniform and open access to computing resources.
Opportunities	> Developing the technical expertise within the newer and smaller NGIs to support a borderless ERA > Building and promoting an open EGI ecosystem > Supporting the governance and coordinated planning

	> Building a grass-roots infrastructure for technical dissemination and support
Short-term activities	> Develop the Virtual Team model and establish a proactive and engaged NIL network > Develop the Campus Champions model > Demonstrate the scientific impact of EGI resources
Long-term goals	> Support the governance functions through planning and policy development > Support community-building and collaboration through workshops and forums > Produce communication materials about EGI for a wide variety of audiences > Outreach to research communities new to EGI > Provide technical support to research communities new to EGI > Support integrated European e-Infrastructures

4.2 Operational Infrastructure

EGI's success in providing reliable services to research communities depends on a sophisticated, infrastructure-wide network of services. These operational services allow for the monitoring of individual resource centres, the collection of accounting records nationally and across the whole infrastructure, the resolution of technical issues across different organisational structures, and the compilation of availability and reliability statistics.

EGI's mature monitoring, accounting and service offer was not born in a day – it is the fruit of the knowledge and expertise built up and shared by individual resource centres within their NGIs and brought together within the community. EGI's decade-long experience in managing a federated infrastructure is a key asset and a service that can be offered to any research community seeking to build a European-wide operational infrastructure.

This experience will now be used to support services being run in other data centres, for other research communities, and to create a federated cloud infrastructure that will complement the EGI service offering with virtualised resources.

Virtualisation technologies are already being adopted by many resource centres through private clouds (accessible only to internal users) that improve management and give greater flexibility to local users. Up to now, no clear model has emerged on how to maximise private cloud infrastructures through federation and integration so as to benefit non-local users. EGI provides a perfect environment to tackle this problem by developing a federated cloud infrastructure built around open standards.

Strengths	> A wide portfolio of tools and services required to support and manage a pan-European, integrated e-Infrastructure. > Experience in integrating distributed computing resource centres into one seamless e-Infrastructure
Opportunities	> Apply the operational experience to deploy new technologies in the EGI federation (e.g. virtualised resources) > Apply the operational experience to help new research communities integrate their services into the core infrastructure platform > The fast deployment of an integrated EGI federated cloud that builds upon the

	core infrastructure platform
Short-term activities	> Operate a European wide infrastructure > Offer its use to other research infrastructures (proof-of-concept integration with EBI and the ELIXIR project is being explored) > Build a federated cloud environment
Long-term goals	> Foster innovation in operational tools > Allow customisation of community-facing operational tools > Maintain a sustained infrastructure operation > Encourage capacity building in small and emerging NGIs > Provide computing and storage resources to European Research Communities > Invest in open-source core infrastructure platform > Invest in open-source technologies for cloud provisioning > Support the platform integrators

4.3 Virtual Research Environments

Virtual Research Environments (VRE) are applications, services and tools deployed as an interface between the researcher and the e-infrastructure.

Initially, VREs were developed as command-line interfaces, simple to use with the right training. Over the years, the EGI community of users expanded to include researchers with more diverse backgrounds and interests, not always technically-oriented. The diversification of EGI led to the development of higher-level generic tools and domain-specific VREs to simplify the data analysis process. As the democratisation of the infrastructure continues, research communities using EGI in the future will have divergent needs and a requirement to deploy the VRE that they need, where they need it. The only scalable solution is to allow customisation.

Science gateways are VREs designed to reduce the technical barriers to accessing remote computing resources. This is an area ripe for innovation opportunities and already supported by EC and national investment initiatives, alongside an active open-source community and standards activity around generic portal frameworks.

EGI will coordinate VRE development, collecting requirements and organising domain-specific workshops and sessions at the Technical and Community Forums. The use of the web as a route to accessing the e-Infrastructure (ranging from desktops, to tablet applications or mobile phone browsers) provides an unprecedented opportunity to meet and anticipate the demand coming from young researchers to access e-Infrastructures with the tools available to them during their daily activities.

Strengths	> VREs are a powerful tool to reduce the technical barriers preventing new research communities to make the most of remote computing resources.
Opportunities	> Provide a source of maintained customisable portlets to access EGI services > Develop the use of mobile devices to access EGI services > Provide centrally-managed EGI services > Train software developers > Nurture an open software development ecosystem

Short-term activities	> Develop synergies and cooperation within the EGI community
Long-term goals	> Develop web-based frameworks to access EGI services > Engage the long-tail of researchers in the ERA > Invest in domain specific open-source technology providers

4.4 Funding strategy

Funding drives the evolution of the e-Infrastructure towards the priorities of the funding source. EGI's future strategy aims to provide an alignment of the funding it receives to the different types of activities it supports. For example, there is a distinction between the routine operation of the ecosystem (which should become supported solely by national infrastructure or community funds), and changes to the operation or technology in the ecosystem (funded from national research councils or the European Commission).

The future activities identified above are grouped under the most appropriate funding sources. An analysis of how these funding sources could be exploited by the different components of the EGI Ecosystem is available in the report 'Evolving the EGI Business Model' [R8].

EGI has identified three potential funding sources: community, Horizon 2020 and/or National Innovation funding and Horizon2020 support funding.

4.4.1 Community Funding

Community-based funding models, either through membership fees or direct service charges, must focus on covering the costs of coordinating the e-Infrastructure at a European level so as to ensure that its sustainability is in the hands of those that benefit from it. This approach also acts as a mechanism to drive consolidation and efficiency in the routine baseline operations of the infrastructure. Community funding can therefore assure the continued operation of the core infrastructure to meet the needs of the research communities which directly benefit from it. The majority of the infrastructure's operating costs (e.g. hardware, staff, support, buildings, electricity) that are located within the NGIs are already funded directly from national funding sources. Moving the long-term steady-state infrastructure support completely to national funding schemes would send a strong message on its continued sustainability to the research communities who depend on it.

EGI.eu is currently supported by a community-based funding model, through the participation fees set by the EGI Council and levied annually. Recently, the EC has adopted a new legal instrument to facilitate the establishment of pan-European organisations dedicated to supporting research communities – the European Research Infrastructure Consortium (ERIC). The ERIC is a legal instrument that requires government endorsement and is primarily designed to support the long-term community driven collaborations needed to build collaborative world leading research infrastructures. The ERIC is being explored by EGI, in collaboration with its participants to establish its benefits, for example in increasing access to national funding opportunities.

Direct funding and/or support from the research communities for the resources they rely on might be achieved through a range of models. Individual researchers and those in small research collaborations who use e-Infrastructures directly are likely to be a limited and small source of funds in the short-term. Researchers are not accustomed to a 'pay for use' model for the research services they consume, nor are they set up to procure and pay for these services from an institutional or funding grant perspective. Virtual research communities however are able to join EGI.eu as an associated partner through the legal entities that represent their needs and hence directly influence the governance of EGI as a paying

participant in the EGI Council. Alternatively, a research community can agree to collaborate with EGI in a way that does not provide direct funding, with an associated restriction in influence compared to fee paying participants. These partnerships established at a European level can also translate into partnerships at a national level, for example through the joint development and integration of software to build community platforms, operation of community specific platforms on national resources, and this could allow local funds to be leveraged to support national deployment costs.

The introduction of technological innovation into the infrastructure with its associated technology stabilisation and operational integration costs would need to be supported exclusively by short-term focused projects funded from other sources, as described below.

4.4.2 Horizon 2020 or National Innovation Funding

Further technological innovation is needed within the operational infrastructure and crucially in the mechanisms that are available for individual researchers to easily access the infrastructure. Short-term projects can be used to develop, integrate and deploy new capabilities into the operational infrastructure, innovations which are then ultimately maintained and operated through community-based funding models once they have matured. Potential areas needing such innovation funding include:

- Improved web based tools for individual researchers and research collaborations to easily access services tuned to their needs through virtual research environments.
- The supported development of centrally managed services using the Software as a Service model to eliminate the need for individuals to distribute, install, operate and maintain software services.
- Development of easily reusable open source technologies which provide common functionality that can be reused by platform integrators to serve the needs of multiple communities.
- Consolidating the roles of the platform integrator (who works closely with a research community to assemble the software environment needed for their research activities) and the platform operator (who operates the established software environment across distributed resources for the research community) to provide technical outreach to researchers new to EGI by facilitating interactions between these groups.
- Enhancement of the operational tools to meet the technical challenges of operating a larger and more diverse infrastructure for a greater number of research communities.

4.4.3 Horizon 2020 Support Funding

While the EGI community has been in existence in various forms for over a decade it continues to evolve. The pioneering experimentation phase undertaken between resource providers and a few early adopting research communities is now complete, with the establishment of the production infrastructure. The challenge for the next decade is to scale out the delivery of services to meet the needs of the whole of the digital ERA. This will require future investment at a European level to build further cooperation and coordination in areas such as:

- Development of policies and processes to scale an ecosystem designed for a few large research communities to one that can manage many large communities, small communities and even support countless individual researchers.
- Continuing to build the international ecosystem and the community within it through regular Forums that promote collaboration and the exchange of best practices between NGIs; by raising awareness of the different activities taking place within the ecosystem, and topical workshops to help develop a community-wide approach in specific areas.

- Communications within EGI's own technical community (resource providers, technology providers, platform integrators and platform operators), and communications within the research communities which use e-Infrastructures (including publications such as International Science Grid This Week) and marketing to research communities not already using e-Infrastructures.
- Training and education of the technology providers and operations staff to promote community-wide best practice and ensure that the smaller NGIs and communities new to EGI have the skills required for using and operating EGI's services securely and effectively.

5 EUROPEAN IMPACT OF EGI

The next generation of European research innovation will increasingly rely on both geographical and intellectual collaboration across multiple disciplines and across national and international borders. Recognising this trend and opportunity, the European Commission has unveiled Europe 2020 – a strategy to develop a smart, sustainable and inclusive economy based on innovation and knowledge transfer.

The driving force behind this vision is the digital European Research Area (ERA) – a transnational effort combining research centres with ongoing programmes and projects aimed at building multidisciplinary collaborations and enabling rapid knowledge transfer across borders.

The full implementation of the digital ERA depends heavily on the development of e-Infrastructures that will enable the accomplishment of the 'fifth freedom' - free circulation of researchers, knowledge and technology across Europe.

Together with other pan-European e-infrastructures such as GÉANT (for networking) and PRACE (for supercomputing), EGI will be a key enabler of this vision by linking thousands of researchers across Europe to the resources they need.

In practice, EGI's contribution to the Europe 2020 strategy will focus on the Digital Agenda for Europe (DAE) and Innovation Union (IU) flagship initiatives, as well as providing an underlying added value that will bring cross-cutting benefits to European research and society as a whole.

5.1 EGI & the Innovation Union

In the context of the Innovation Union, EGI can:

- Position itself as a key enabler of the digital ERA that will allow for the free circulation of researchers, knowledge and technology.
- Promote excellence in education and skills development by simplifying multi-disciplinary cooperation.
- Bridge geographical boundaries beyond Europe thanks to the many collaborations and integration with worldwide e-infrastructures.

5.2 EGI & the Digital Agenda for Europe

In support of the Digital Agenda for Europe, EGI will:

- Provide a single uniform market for accessing distributed computing resources and connected data in Europe through EGI's federation of national resource providers.
- Promote competitiveness and interoperability for e-Infrastructures through open standards.
- Reduce inefficient research spending and stimulate innovation across Europe by maximising the use of national resources and knowledge within a common federated infrastructure and community.
- Offer large scale ICT facilities that enable the exploration of new computing and data processing models that address scientific grand challenges facing society.

5.3 Added value for Europe

In the wider context of Europe 2020 and funded in future through the Horizon 2020 programme, EGI offers a range of added value for Europe:

- EGI ensures that researchers have access to uniform and reliable computing resources, enabling faster scientific results and avenues of multi-disciplinary research otherwise not possible.
- EGI allows researchers to focus on their research rather than managing their e-Infrastructures needs.
- EGI's monitoring and operational services guarantee an integrated, reliable and uniform service provided across organisational and national boundaries.
- EGI's transnational integration provides effective use of resources and ensures the most effective return on Europe's e-infrastructure investments.
- EGI enables knowledge transfer and sharing of solutions through community events, an application database and a training marketplace.
- EGI promotes open science through the availability, accessibility and reuse of scientific data and results, the provision of web-based tools that facilitate scientific collaboration and by ensuring public access to research.

6 CONCLUSIONS

EGI provides human, technical and infrastructure services through the federation of national and domain specific resource providers to researchers in Europe and their international collaborators. EGI is managed by EGI.eu, a not-for-profit foundation set up to nurture a collaborative innovation ecosystem of researchers, developers and coordinating bodies. Together, the EGI community provides the services required to maintain a world-class e-infrastructure for European researchers.

EGI's strategy for a sustainable future will focus on developing the ecosystem's strengths in three key strategic investment areas: Community and Coordination, Operations Infrastructure and Virtual Research Environments. As part of this vision, EGI has established a Federated Clouds Taskforce to oversee the integration of virtualised resources in the e-infrastructure.

EGI is committed to the European Commission's strategy to develop a smart, sustainable and inclusive economy based on innovation and knowledge transfer (Europe 2020) and will contribute to the Digital Agenda for Europe (DAE) and Innovation Union (IU) flagship initiatives.

7 REFERENCES

R1	D2.3 EGI-InSPIRE Paper (http://go.egi.eu/ 201)
R2	D2.30 EGI Strategic Plan: Seeking New Horizons - EGI's Role in 2020 (http://go.egi.eu/EGI2020)
R3	D4.5 Annual Report on the EGI Production Infrastructure (http://go.egi.eu/1059)
R4	D5.4 Unified Middleware Distribution Roadmap (http://go.egi.eu/612)
R5	EGI.eu and EGI-InSPIRE Memorandum of Understanding Annual Report 2011-2012 (http://go.egi.eu/MoU-2011-2012)
R6	D2.14 Annual Report on EGI and its External Relations Activity (http://go.egi.eu/ 1069)
R7	D7.2 Annual Report on Operational Tool Maintenance and Development Activity (http://go.egi.eu/1063)
R8	D2.18 Evolving the EGI Business Model (http://go.egi.eu/1040)