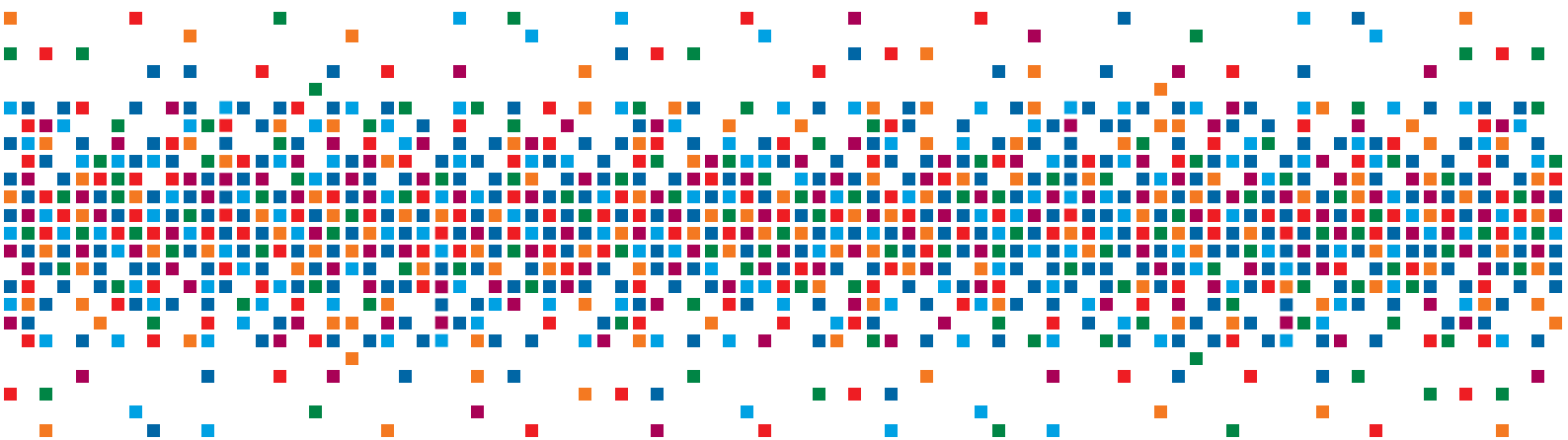


Annual Report
2022

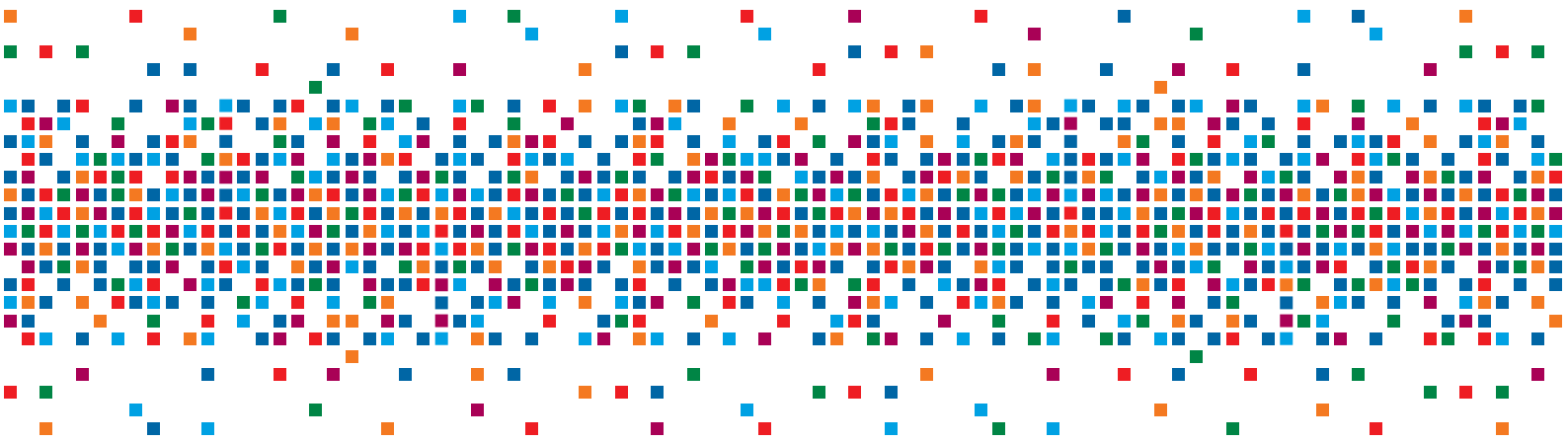
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Contents



CESNET Association	5
CESNET e-infrastructure	11
Association's Research Activities	26
Public Relations	35
Financial Performance	38

A word from the director



In 2022 we commemorated the 30th anniversary of the connection of the former Czechoslovakia to the Internet. At a conference organised to mark the occasion, we looked back at the past, evaluated the present of this phenomenon and presented the challenges that lie ahead.

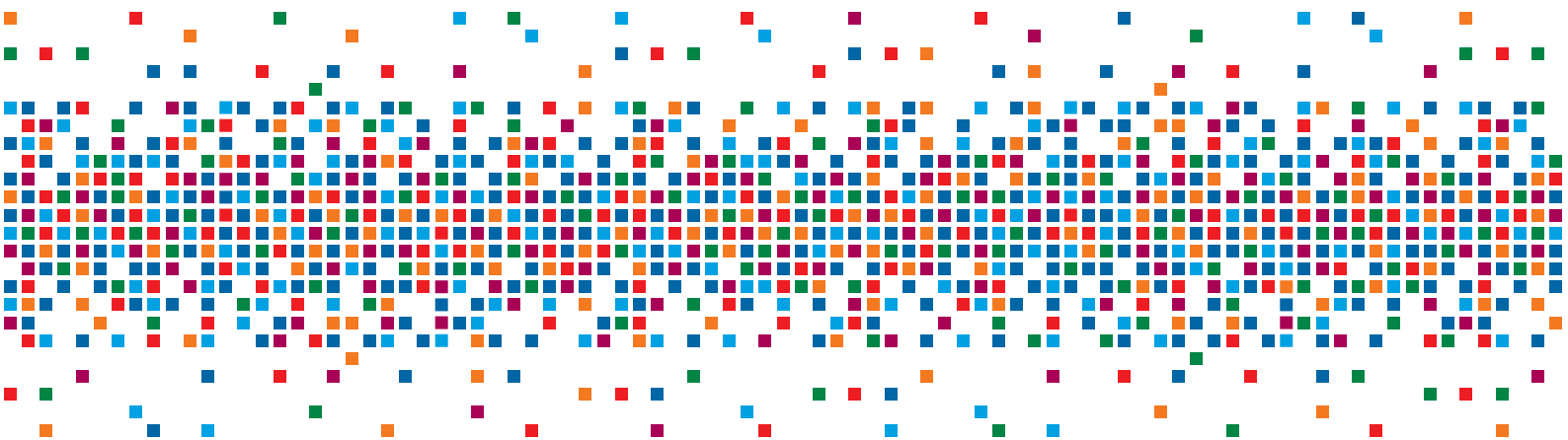
Last year the implementation of the **backbone communication network modernisation** project called CESNET3 was in full swing. In practice this is a radical upgrade of the data network operated on approximately 2,250 kilometres of optical routes. This large-scale project, when completed in 2023, will bring the potential for higher data volumes and better availability of other services to users.

In the area of providing distributed computing infrastructure services in accordance with the modernisation schedule, we have expanded the computing capacity of the cloud part of MetaCentre by acquiring two nodes equipped with technologies to support the solution of tasks using artificial intelligence methods. The data storage infrastructure will be functionally complemented by a new object storage facility in Ostrava from 2022. In addition, its capacity is directly connected to the systems of the IT4Innovations supercomputing centre, which brings interesting possibilities for many tasks.

In 2022 CESNET changed its headquarters for the first time in its history. We moved from the historic building of the former CTU Rector's Office to modern premises in the Teletype building. The move became a necessity because the existing premises no longer suited capacity needs, so we made use of the situation and built a new modern facility, which also raises the level of work culture for colleagues and associates from among our members. Our new space also



includes multiple meeting rooms for community collaboration in general. The second half of the year in the life of the Czech Republic was significantly influenced by the ongoing presidency of the Council of the European Union. This also affected some of the activities of our Association. We participated in the preparation of major pan-European meetings on e-infrastructures, such as the e-IRG Workshop, the EGI 2022 Conference and the EOSC Symposium, and on the occasion of the start of the presidency itself we




organised a special concert, where musicians from the Academy of Performing Arts in Prague and the Luca School of Arts in Belgium connected to our unique technology with very little delay. Incidentally, in autumn 2022, the CESNET Association received the very prestigious Czech Head scientific award in the Industry category for the development of this technology.

Another important factor influencing the activities of the Association in the past year was the entry into force of a general legislative measure in January 2022 that made CESNET a critical infrastructure entity under Section 2 of the Crisis Act and administrator of the critical information infrastructure communication system under Section 3 of the Cybersecurity Act (CSA). As of the effective date of this measure, CESNET began to face deadlines to comply with the requirements of the CSA and to meet the related obligations in the areas of cybersecurity, authentication, authorisation, access control and monitoring among many others. For many of our colleagues the implementation of these organisational and procedural changes has meant a significant amount of work above and beyond their normal activities, and I thank them for that.

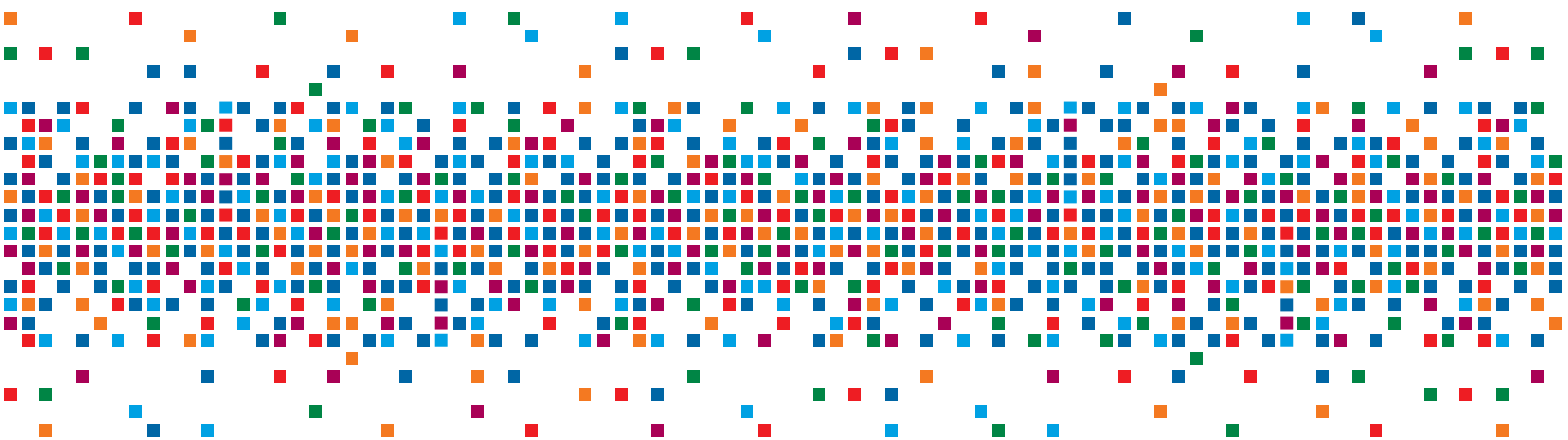
Finally, I would like to thank all CESNET employees for their commitment to the Association during the successful past year... A year of great change. However, thanks also go to our members and partners for their support and cooperation. At the same time I believe that we will be similarly successful in 2023.

Ing. Jakub Papírník
Director of CESNET



 **30**
In 2022 we commemorated the 30th anniversary of the connection of the former Czechoslovakia to the Internet.

The CESNET Association



Association's history and current tasks

CESNET was founded by public universities and colleges and the Czech Academy of Sciences (CAS) in 1996.

CESNET's mission is to

- provide the scientific, research and education community with unique and comprehensive e-infrastructure services with a quality comparable to the world's best and support the Open Science concept;
- offer stable services with high added value covering the widest possible spectrum of needs of our users;
- contribute its in-house research activities towards the development of information and communications technology and put their results into practice.

When it was founded the Association also operated as a commercial internet service provider in order to earn additional money from these activities for its principal activity. It discontinued that activity in 2000, chiefly for economic and legislative reasons. Since then it has worked exclusively with the **development and operation of science, research and education e-infrastructure** and related activities.

Another milestone in the Association's history came in 2010, when the CESNET e-infrastructure became part of the **Czech Republic Roadmap for Large Research, Experimental Development and Innovation Infrastructures**¹. In 2014 the CESNET e-infrastructure received the highest research infrastructure rating possible and was included in the updated Czech Republic Roadmap for Large Infrastructures.

Based on further assessment of large research infrastructures in 2017, the CESNET e-infrastructure was included in the top category of research infrastructures with excellent quality com-

parable to that of similar infrastructures worldwide, highly relevant to the future development of the Czech Republic's research and innovation environment and necessary for the enhancement of the Czech Republic's competitiveness. Furthermore, the international assessment board recommended the **CESNET, CERIT-SC and IT4Innovations** e-infrastructures to establish closer cooperation in terms of capacity building and the provision of services to users. The operators of those infrastructures (CESNET, Masaryk University and VŠB – Technical University of Ostrava) formed a consortium in 2019 and have provided services under a unified brand, **e-INFRA CZ**, since 2020.

Since 2020 e-INFRA CZ has been the sole national e-infrastructure included in the Czech Republic Roadmap for Large Research, Infrastructures for 2016 to 2022.

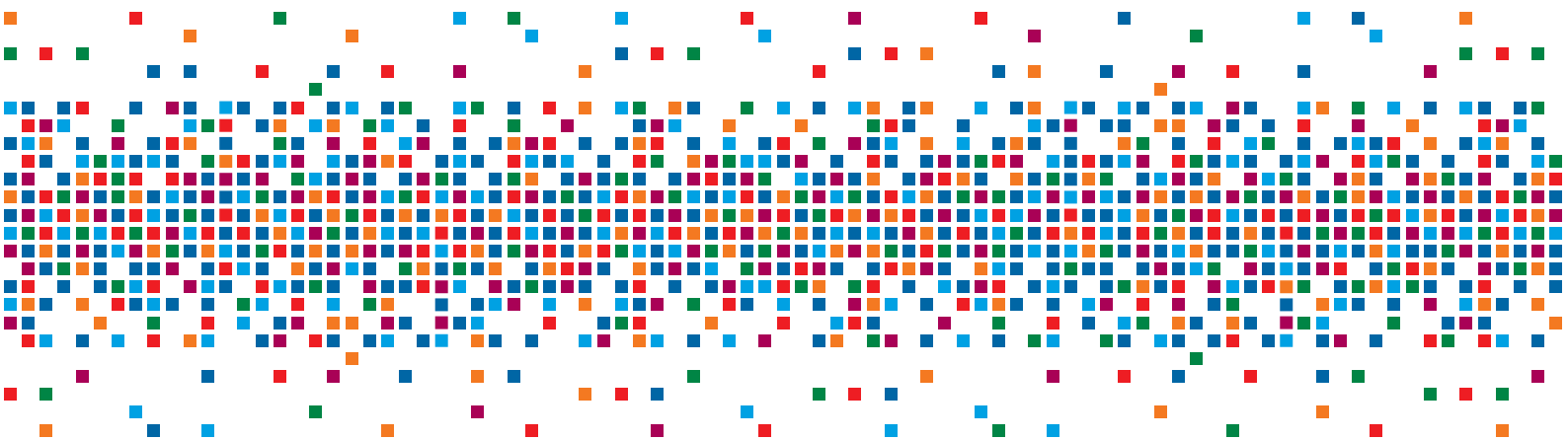
CESNET accepted its first two **associate members, the National Museum and the Moravian Gallery in Brno**, in 2020.

CESNET, Masaryk University and VŠB – Technical University of Ostrava are now **members of the EOSC (European Open Science Cloud) association**.

In 2022 the **modernisation of the backbone communication network** built on 2,240 kilometres of fibre optic routes began. This upgrade will bring faster speeds and better service availability for users. The backbone network will then be called CESNET 3.

On 27 January 2022 a general legislative measure came into force, under which the CESNET Association became a **critical infrastructure entity** pursuant to Section 2(k) of the

The CESNET Association



Crisis Act and, at the same time, administrator of the critical information infrastructure communication system pursuant to Section 3(d) of the Cybersecurity Act (CIA).

In the second half of 2022 CESNET moved to new offices in the Telehouse building.

In December 2022, CESNET received the highest domestic scientific award, **the Czech Head Award in the Industry category**, for low latency transmissions for distance collaboration.

Scope of Activities

The scope of the Association's main activities is:

1. conducting independent research and development activities in information and communications technologies and providing research services in this field;
2. supporting education in information and communications technologies;
3. putting the results of in-house research and development into practice through technology transfers of an internal nature;
4. undertaking the following activities for the benefit of its members, their subsidiary organisations and other entities:
 - developing and operating the national communications and information infrastructure to enable the interconnection of their infrastructures, provide access to the CESNET infrastructure and connect to similar third-party infrastructures (including internet access),
 - building shared hardware, communications and software and information services,
 - verifying new applications, collaboration and complementarity of member activities at a level comparable to that of leading academic and research infrastructures abroad.

¹ "A large infrastructure for research, development and innovation means a unique research facility, including its acquisition, associated investments and operational arrangements, which is necessary for comprehensive research and development activities with high financial and technological demands and is approved by the government and established by a research organisation to also be used by other research organisations (large infrastructures)."

Infrastructure definitions Ministry of Education, Youth and Sports [online]. [quote 2020-04-24]. Available from: <http://www.msmt.cz/vyzkum-a-vyvoj/definice-infrastruktury>

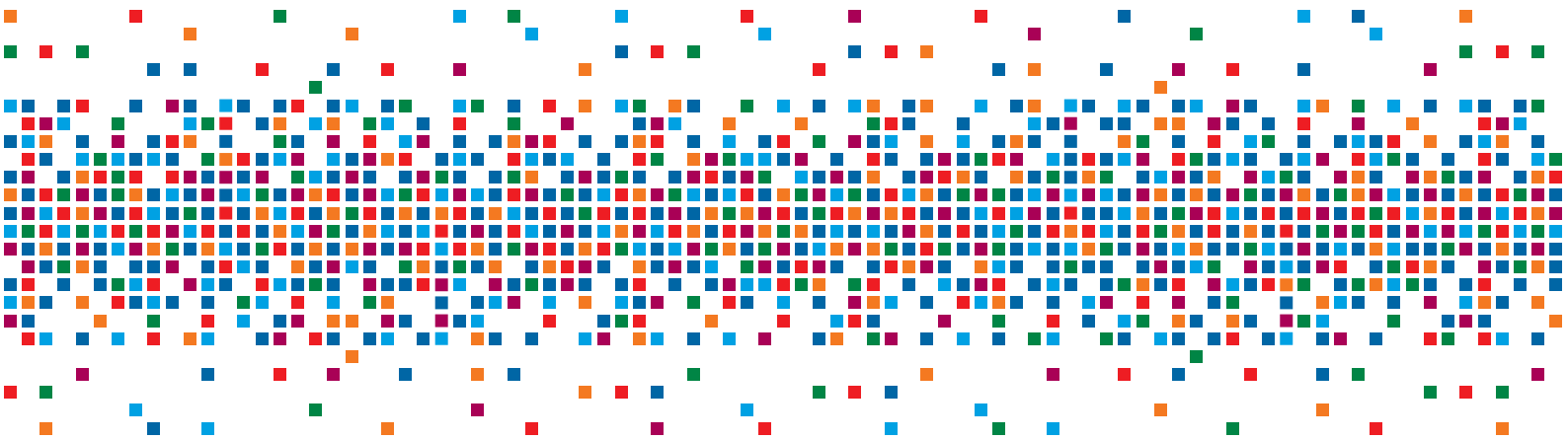
The Association performs and provides its activities within the scope of received subsidies and partial compensation for expenses associated with these activities. It is not the Association's objective to generate any profit from these activities.

The Association pursues supplementary activities in addition to its main activities, but solely for the purpose of making more efficient use of its property and without any negative impact on research activities. The services are not provided on a publicly available basis.

Any loss incurred in connection with the Association's supplementary activities will always be settled by the end of the relevant fiscal period or the supplementary activity in question will be discontinued before the beginning of the following fiscal period.

The Association uses all of its profits to promote research and development.

The CESNET Association



Membership of international and national organisations

International organisations

- **EOSC AISBL** - international association of institutions involved in the building of the European open science cloud concept (www.eosc.eu).



- **GÉANT Association** - association of European national research networks that works in the operation and advancement of the GÉANT European communications infrastructure and coordination of related activities (www.geant.org).



- **EGI.eu** - organisation focusing on coordinating European computing grids used for scientific computations and supporting their sustainable development (www.egi.eu).



- **Shibboleth** - international consortium for coordinating the development of a service providing a single sign-on solution, meaning that a user can use multiple secured network resources using a single login. Shibboleth is the foundation for academic identity federations (www.shibboleth.net).



- **QUAPITAL** - Central European partnership for secure communication with security at the quantum level and quantum internet (www.quapital.eu).



National organisations

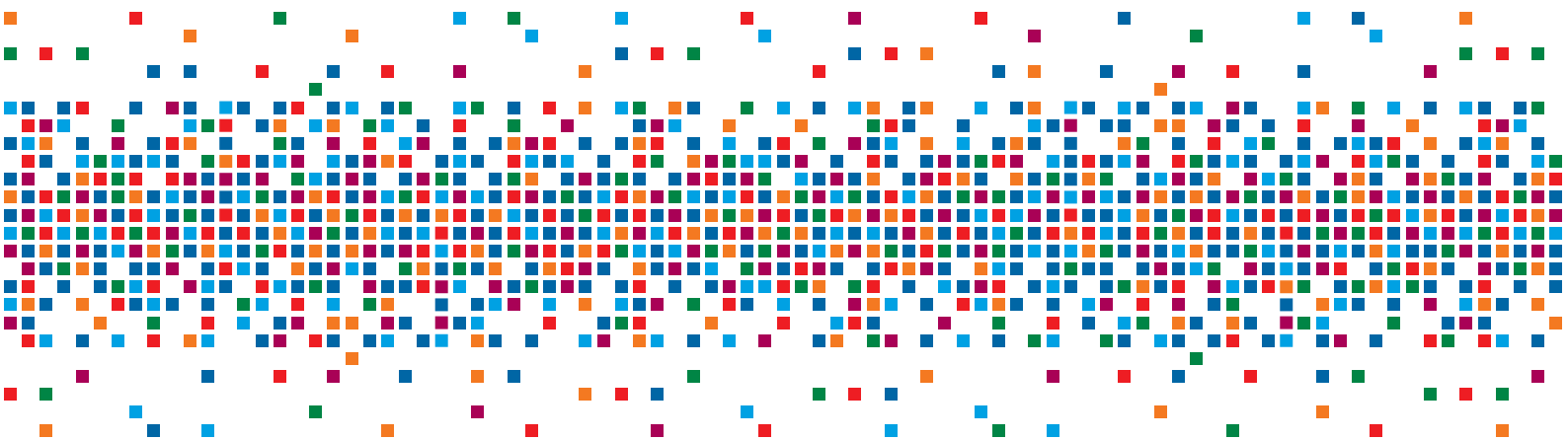
- **NIX.CZ** - CESNET is one of the founders of NIX.CZ, z.s.p.o. (Neutral Internet Exchange), an association of internet service providers in the Czech Republic that provides interconnectivity for its members' networks (www.nix.cz).



- **CZ.NIC** - association and one of the founding members of CZ.NIC, z.s.p.o., which administers the .cz internet domain and supports publicly beneficial projects and activities relating to the internet (www.nic.cz).



The CESNET Association



Association members

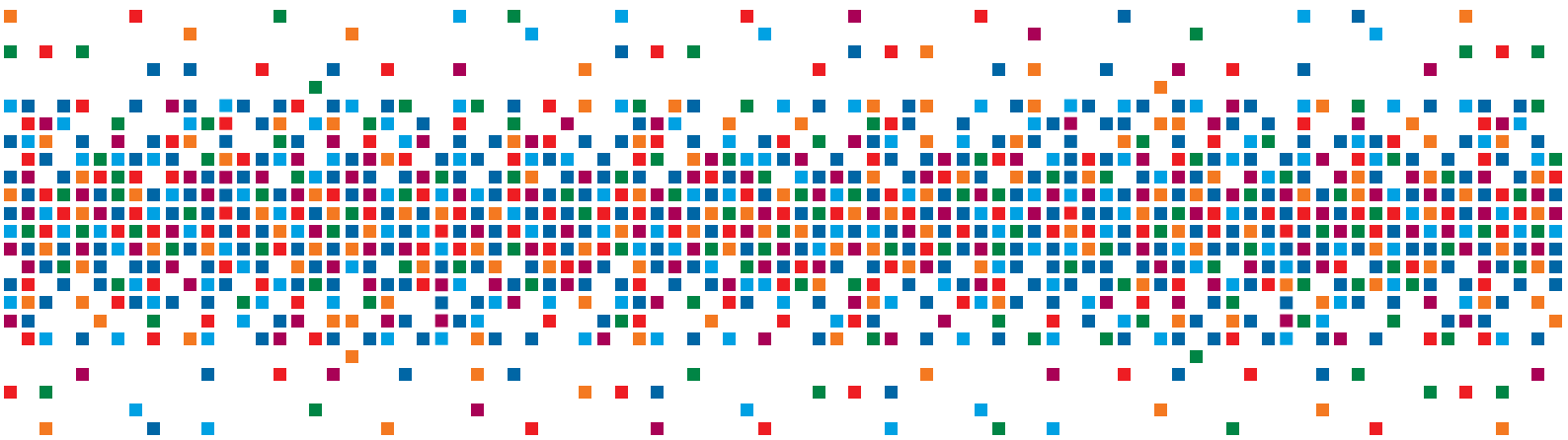
The following institutions were regular members of the Association in 2022:

- Academy of Performing Arts, Prague
- Czech Academy of Sciences
- Academy of Fine Arts, Prague
- Czech University of Life Sciences, Prague
- Czech Technical University, Prague
- Janáček Academy of Musical and Dramatic Arts
- University of South Bohemia, České Budějovice
- Masaryk University
- Mendel University, Brno
- University of Ostrava
- Police Academy of the Czech Republic, Prague
- Silesian University, Opava
- Technical University of Liberec
- University of Hradec Králové
- Jan Evangelista Purkyně University, Ústí nad Labem
- Charles University
- University of Defence
- Palacký University, Olomouc
- University of Pardubice
- Tomáš Baťa University, Zlín
- University of Veterinary Sciences, Brno
- VŠB – Technical University of Ostrava
- University of Economics, Prague
- University of Chemistry and Technology, Prague
- Academy of Arts, Architecture and Design, Prague
- Brno University of Technology
- University of West Bohemia, Plzeň

The following institutions were associate members in 2022:

- Moravian Gallery in Brno
- National Museum

The CESNET Association



Internal organisational structure

CESNET has the following bodies:

- General Assembly
- Board of Directors
- Supervisory Board
- Director of the Association

The **Supervisory Board** comprised the following members until June 2022:

- Mgr. Michal Bulant, Ph.D.
- RNDr. Igor Čermák, CSc.
- RNDr. Alexander Černý
- Ing. Jan Gruntorád, CSc.
- Mgr. František Potužník
- Doc. RNDr. Pavel Satrapa, Ph.D.
- prof. Ing. Miroslav Tůma, CSc.

The **Supervisory Board** comprised the following members from June 2022 onwards:

- Mgr. Michal Bulant, Ph.D.
- RNDr. Alexander Černý
- Ing. Jan Gruntorád, CSc.
- Ing. Radek Holý, Ph.D.
- Mgr. František Potužník
- Doc. RNDr. Pavel Satrapa, Ph.D.
- prof. Ing. Miroslav Tůma, CSc.

In 2022 the office of **chairman** was held by prof. Ing. Miroslav Tůma, CSc.

The offices of **vice-chairmen** were held until June 2022 by RNDr. Igor Čermák, CSc., and Mgr. František Potužník, and from June 2022 onwards Ing. Radek Holý, Ph.D. and Mgr. František Potužník.

The **Supervisory Board** comprised the following members in 2022:

- Ing. Radek Holý, Ph.D. (until June 2022)
- Mgr. Martin Maňásek
- Ing. Jaromír Marušinec, Ph.D., MBA
- prof. JUDr. Radim Polčák, Ph.D. (co-opted in September 2022)
- RNDr. David Skoupil
- Ing. Michal Sláma.

In 2022 the **chairman** of the Supervisory Board was Ing. Michal Sláma.

In 2022 the office of **director** of the Association was held by Ing. Jakub Papírník

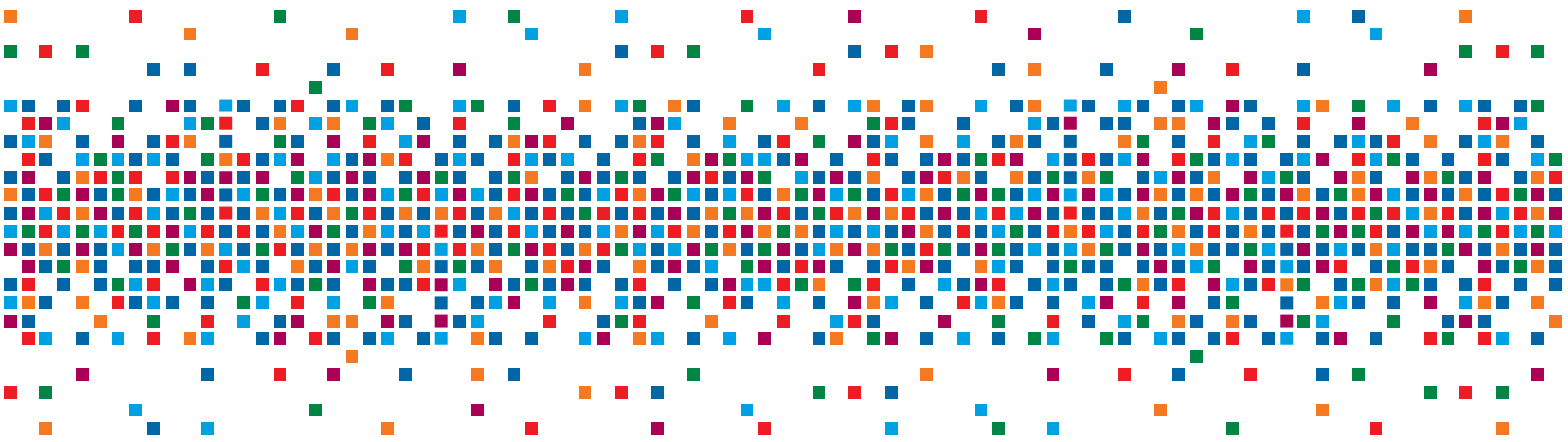
Development Fund Board

The **Development Fund Board** comprised these members in 2022:

- Doc. RNDr. Eva Hladká, Ph.D.
- Ing. Jaromír Holec
- Mgr. Monika Hrabáková
- Ing. Olga Klápšťová
- Doc. RNDr. Antonín Kučera, Csc.
- Ing. Tomáš Podermarski
- prof. Ing. Zbyněk Škvor, CSc.

The office of the **chairwoman** of the Development Fund Board was held in 2022 by Ing. Olga Klápšťová.

The CESNET Association

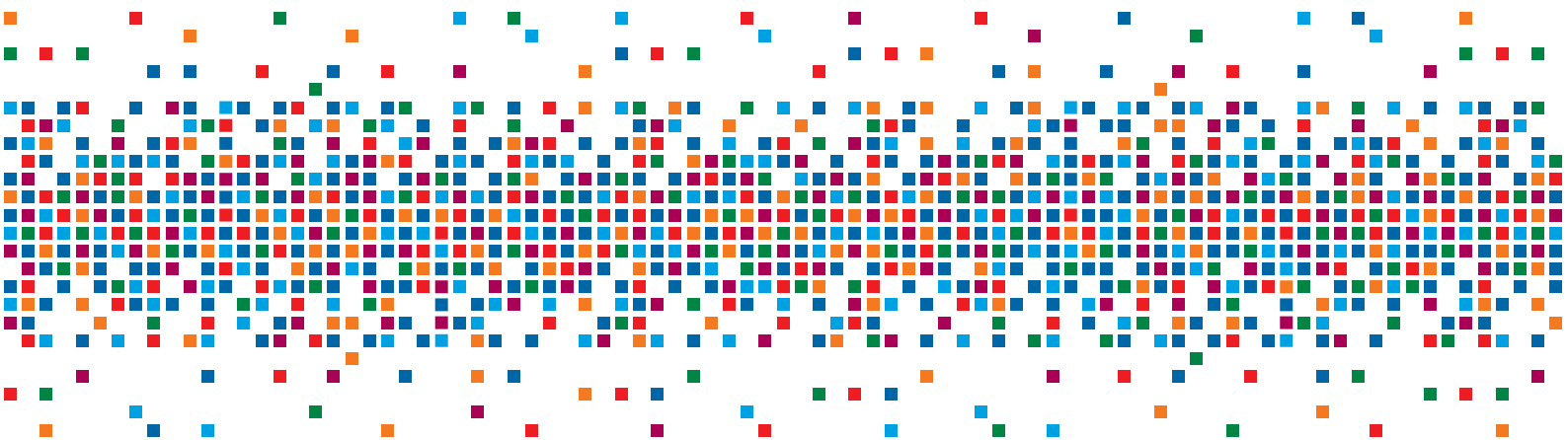


Organisational chart

The Association’s basic organisational structure comprises departments that are grouped into sections. Management within this structure is performed by line managers. The Association had a total of 203.5 recalculated full-time jobs in 2022.



e-Infrastructure e-INFRA CZ



CESNET is the host organisation of the large research infrastructure e-Infrastruktura CZ (acronym e-INFRA CZ), which is an important element of the Roadmap of Large Research Infrastructures of the Czech Republic for the years 2016 to 2022. It provides a universal environment for the transfer, processing, sharing and storage of scientific data and user collaboration that is independent of any specific field of research and indispensable today for contemporary research, development and innovation in any field.

e-INFRA CZ is the result of collaboration of three e-infrastructures:

- **CESNET e-infrastructure** operated by CESNET,
- **CERIT Scientific Cloud** operated by Masaryk University,
- **IT4Innovations national supercomputing centre** operated by VŠB – Technical University of Ostrava.

CESNET is also the coordinator of two complementary projects for the development and operation of e-INFRA CZ:

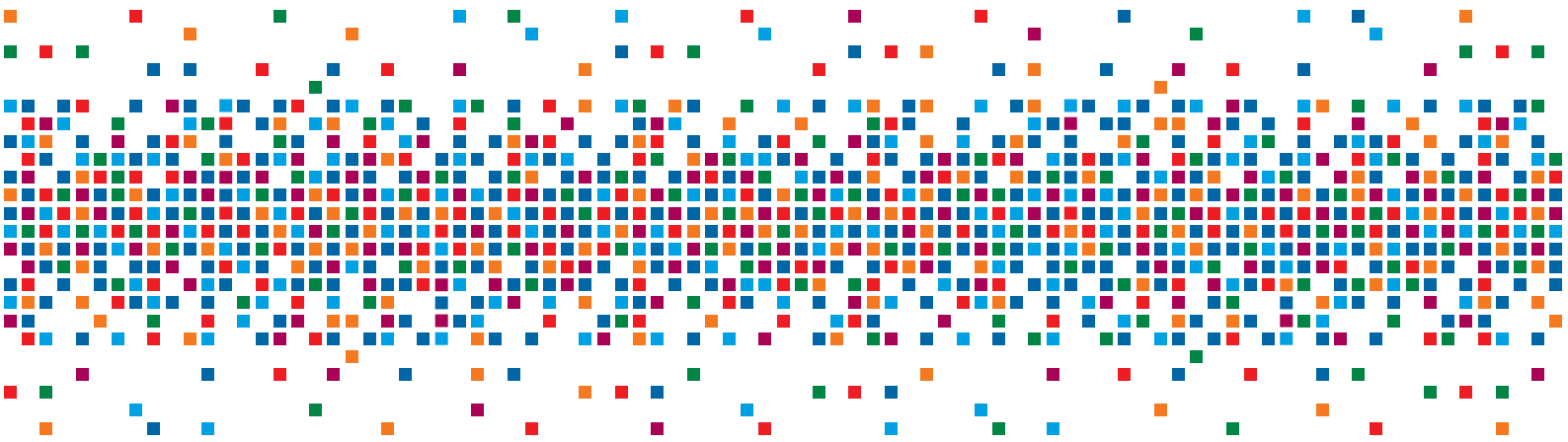
- **e-Infrastruktura CZ** (LM 2019140, 2020-2022) funded under the Large R&D&I Infrastructure Projects programme (2010-2022). Special-purpose aid in the subsidy form is earmarked for covering a portion of operating costs associated with e-infrastructure operation.
- **e-INFRA CZ: Modernisation** (EF18_072/0015659, 2020-2022) funded from the Research, Development and Education operational programme, which is the main source of investment funds for a major e-infrastructure upgrade.



The objective is to modernise and ensure the operation of individual e-INFRA CZ components. The members of the consortium therefore build on the previous operation of their e-infrastructures while striving to **align their approach to users** so that they can see the e-INFRA CZ e-infrastructure as a coherent whole.

The CESNET e-infrastructure is used to **provide services for Czech science, research, development and education**. The following chapters describe the development of this e-infrastructure, its portfolio of services and the associated research activities. The Association not only provides these services to its members, but also to other entities that comply with the CESNET e-Infrastructure Access Policy.

CESNET e-infrastructure development



In 2022, in addition to ensuring the routine operation of the CESNET e-infrastructure, we focused on modernising the e-INFRA CZ components for which CESNET is responsible:

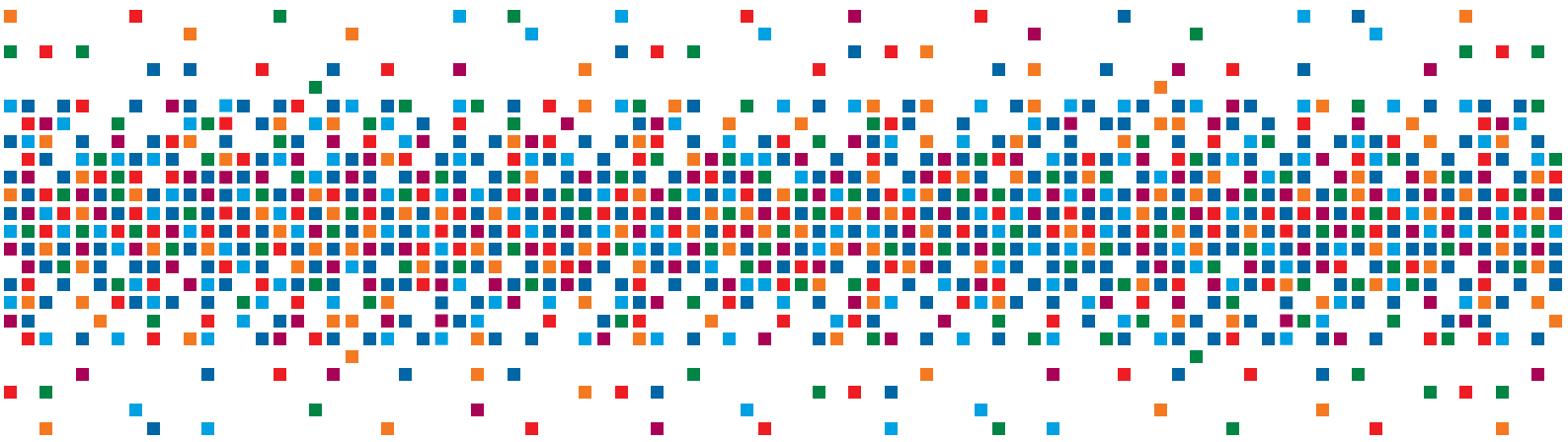
- the IP/MPLS layer of the CESNET network was upgraded,
- a selection procedure for the modernisation of the peripheral circuits of the DWDM network (backup and access circuits) was held,
- we expanded the capacity of the compute cloud with two nodes with a total of 8 NVIDIA A40 GPU cards,
- the disk capacity for operational data storage was expanded by 1,750 TB,
- a tender procedure was prepared for the procurement of new computing capacities, specifically high-capacity CPU nodes planned for location in Prague,
- further steps were taken to unify AAI under e-INFRA CZ,
- a tender procedure for another object system, which will be located in the premises of the ELI Beamlines centre in Dolní Břežany, was announced and evaluated.

CESNET as a critical information infrastructure

On 27 January 2022 a general legislative measure entered into force, under which the CESNET Association became a critical infrastructure entity pursuant to Section 2(k) of the Crisis Act and, at the same time, administrator of the critical information infrastructure communication system pursuant to Section 3(d) of the Cybersecurity Act (CSA). As of the effective date of the measure, the time limits for CESNET to comply with the requirements of the CSA and to fulfil the related obligations began to run.

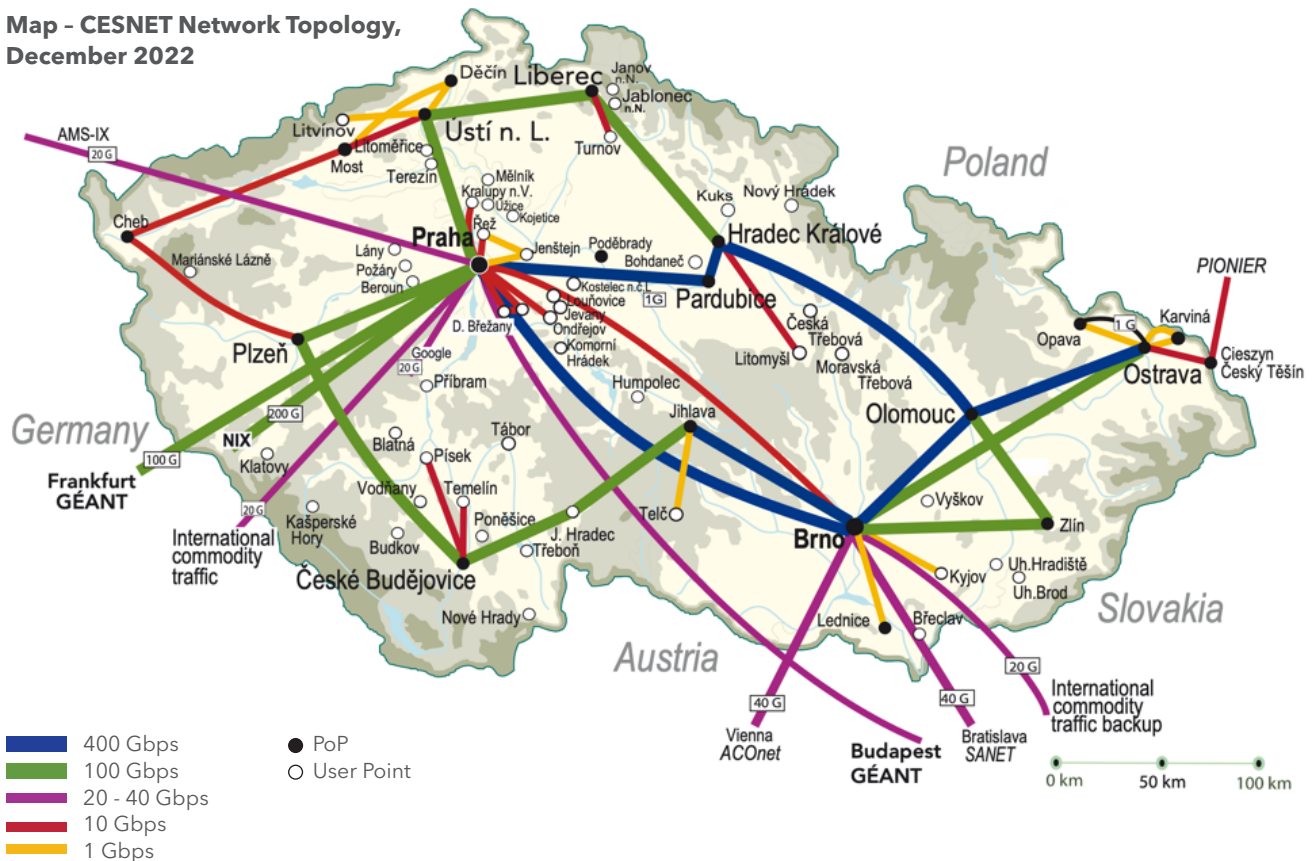
CESNET has to achieve compliance with the requirements of the CSA and the Cybersecurity Decree on Security Measures (CDSM) within one year of the entry into force of the general legislative measure. The relevant work started immediately and it is expected that the requirements of the CDSM will be met in due course.

Communications infrastructure

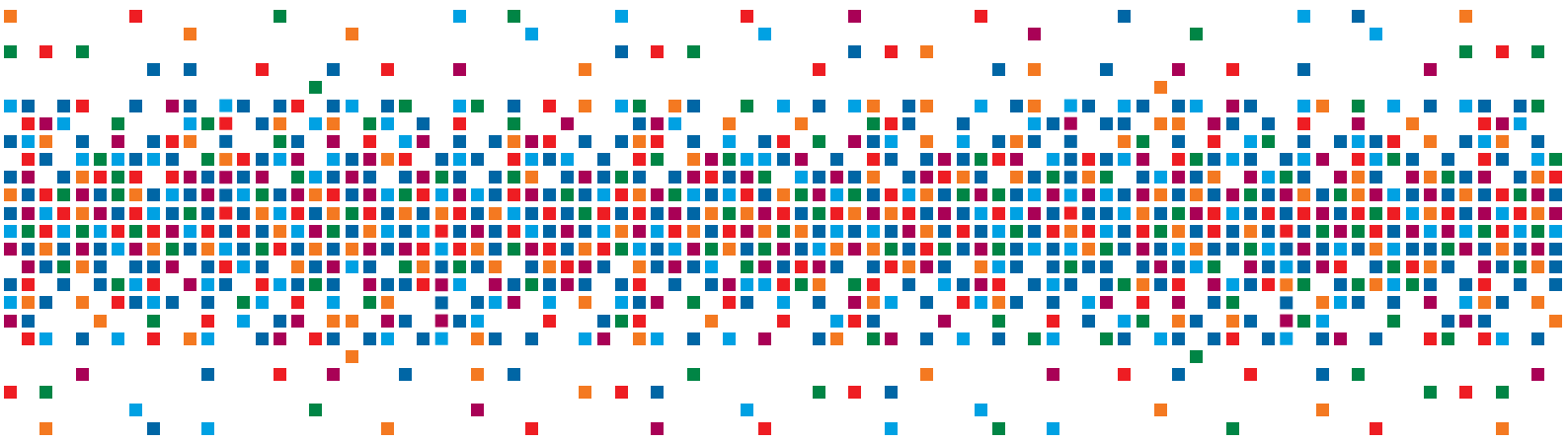


The foundation of the e-infrastructure is a high quality, high speed and low latency backbone communication network with wide international connectivity. It offers many advanced functions and features, including dedicated transmission channels and non-IP services (precise time and stable frequency transmission or quantum key distribution).

Map - CESNET Network Topology, December 2022



Communications infrastructure



CESNET develops and operates a state-of-the-art communication infrastructure to connect resources, services and users of the e-infrastructure, as well as other large research infrastructures, with each other and with their international partners.


The foundation is a backbone infrastructure, which is designed to provide sufficient capacity for data transmissions and to be as resilient to link and technology outages as possible. The infrastructure is connected in a variety of ways with a capacity of over 400 Gbps. This involves global connectivity (Tier 2 operator and interconnection nodes) and links to research networks (GÉANT and several cross-border fibres) that not only provide users with connectivity having sufficient capacity and redundancy but also with specialised links for specific applications.

The offered network access services include:

- a redundant, high-capacity connection to the backbone,
- dedicated circuits and networks,
- lambda services with physically reserved capacity and a fixed delay,
- photonic services for the most demanding applications with an all-optical pathway between points,
- internet identifier administration (CESNET NIC), including a LIR sponsoring service,
- authoritative and secondary DNS services,
- Stratum 1 primary time servers with an internal time source,
- infrastructure monitoring and tracking at several levels,
- services of the internationally accredited CSIRT security team, CESNET-CERTS,
- permanent network operability monitoring (NOC),
- a 24/7/365 service desk - support contact point (monitoring centre and help desk).

An integral part of this is high-quality protection of the infrastructure against security incidents. **Semi-automatic protection against DDoS** attacks is deployed in the network at several levels to achieve scalable and targeted protection. Detection and reduction of unwanted traffic is based on the deep knowledge of our expert team using detailed infrastructure monitoring based on our own tools (FTAS, G3, ExaFS).

The ExaFS monitoring and service is also available to administrators of connected institutions. Through rules in a user-friendly environment, administrators of connected organisations can already influence the traffic that belongs to the institution on the backbone network routers. For example, it may be discarded or redirected for further analysis to the DDoS Protector (a result of CESNET's own research activities), which filters out unwanted traffic. Another level of protection that can be applied before traffic enters the backbone network perimeter is provided by global protection against volumetric attacks in the form of a global scrubbing centre.

**400**
The infrastructure is connected in a variety of ways with a capacity of over 400 Gbps.

Communications infrastructure

A major upgrade of the entire backbone network is currently under way and will be completed in 2023. After the successful upgrade of the main DWDM optical transmission system to FlexGrid technology (with support for optical transmission channels with capacities of 100 Gbps to 1 Tbps), the next phase comprising the **IP/MPLS layer upgrade** was launched. Two of the four phases of IP/MPLS network layer upgrades took place in 2022. The backbone links have a unit capacity of 400 and 100 Gbps with the possibility of creating multiple channels. The capacity for subscriber connections scaled up to 100 Gbps is also being increased with the possibility of further growth in the future. In cooperation with the technology supplier, migration scenarios and procedures were prepared in individual nodes. The launch of the gradual migration of subscribers (including migration of their services) in each node started in mid-2022 and is progressing successfully. Along with the upgrade of network hardware, the development and deployment of means for automating the configuration of active network elements and network services and their connection to modernised internal information systems continued.

In the upgraded part of the network, **Segment Routing IPv6 (SRv6) technology was deployed**, replacing MPLS. The migration of the entire CESNET3 network and its services to SRv6 is planned once the upgrade is complete. The main benefit of the new technology is better programmability of packet traversal through the network to allow controlled use of different path parameters in the network or to apply more complex functions for demanding applications.

Effective deployment of network protection measures is also possible for entire communities of users, provided that they share similar policies and operate similar systems. CESNET

participates in the hSOC (Hospital SOC) initiative, which aims to provide connected hospitals with better protection against cyber threats and attacks. It is a dedicated network within the CESNET e-infrastructure, isolated from standard traffic, with specific policies and rules, complemented by a number of security tools for monitoring and managing communication with involved entities. The isolation allows for more comprehensive and more detailed protection of hospitals.

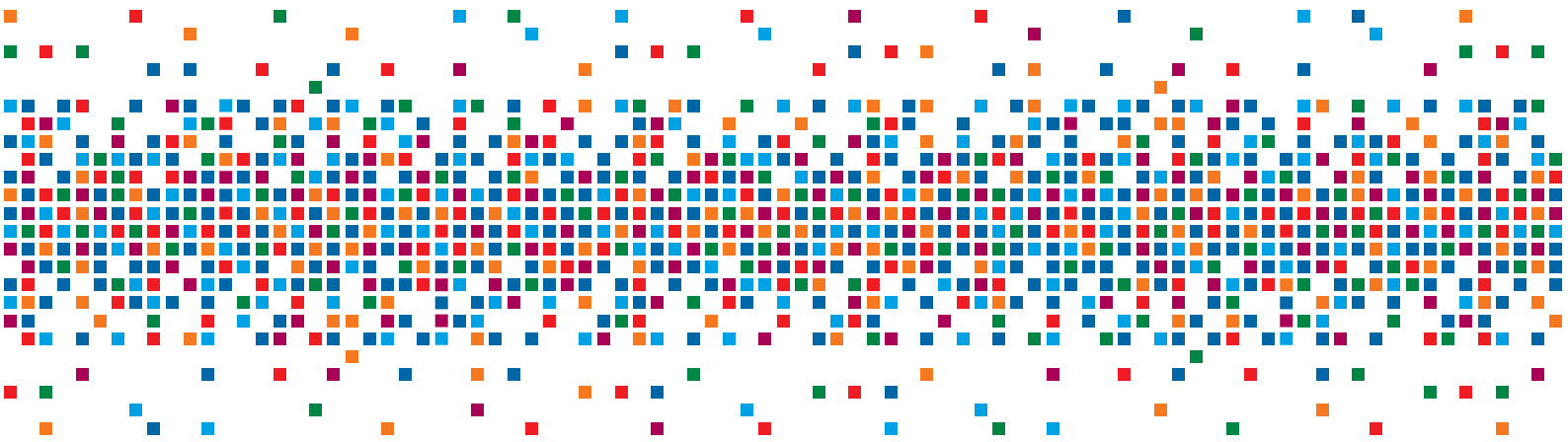
Participants in the hSOC initiative comprise 56 healthcare organisations, 8 hospital authorities and 8 other entities (such as the National Cyber and Information Security Agency [NÚKIB], the National Agency for Communication and Information Technologies [NAKIT] and the Czech Ministry of the Interior). The separate network (hSOC-VRF) connects 12 hospitals (Bulovka University Hospital, Olomouc University Hospital, St. Anne's University Hospital in Brno, Liberec Regional Hospital, Ústí nad Labem Regional Hospital, Jihlava Hospital, Na Homolce Hospital, Tomáš Baťa Hospital in Zlín, Mladá Boleslav Regional Hospital, Central Military Hospital in Prague, Olomouc Military Hospital and General University Hospital in Prague).



56

 Participants in the hSOC initiative comprise 56 healthcare organisations, 8 hospital authorities and 8 other entities

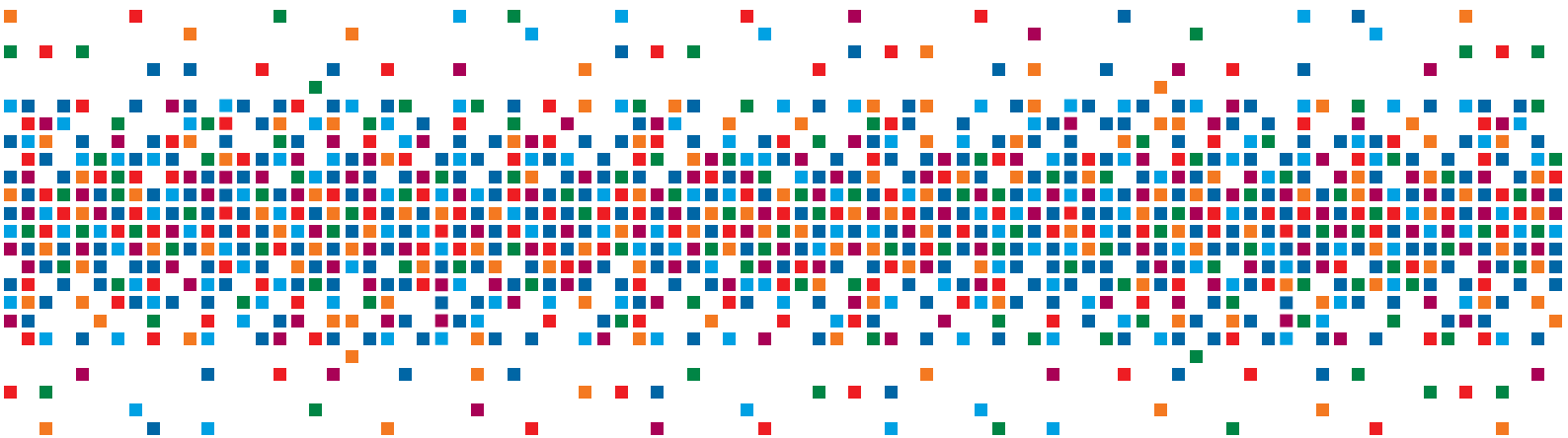
Demanding computations



Metacentre Map - 2022



Demanding computations



The expansion and upgrade of MetaCentre computing capacities ran on schedule and in accordance with users' needs:

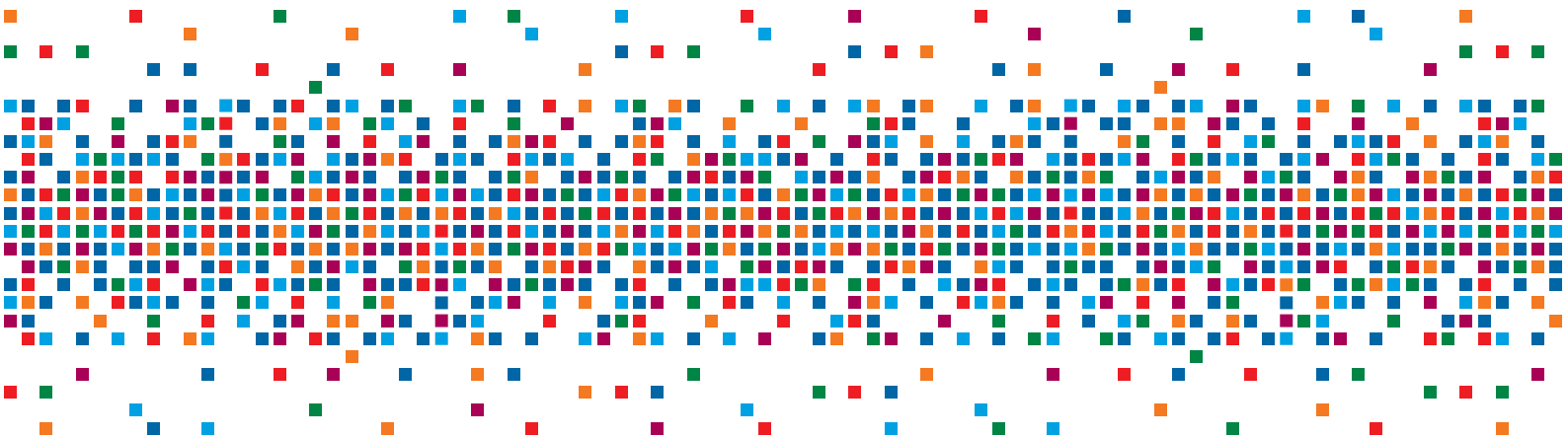
- The computing capacity has been expanded with the addition of the galdor GPU cluster with 20 nodes and a total of 80 A40 GPU cards and the halmir compute cluster with 30 nodes and a total of 3,000 CPU cores, and the cloud computing capacity has been expanded by two nodes with a total of 8 NVIDIA A40 GPU cards.
- The capacity for operational data storage has been expanded, specifically by: 1 PB in Brno, 500 TB in the adan cluster at BIOCEV and 250 TB as a capacity renewal for ELIXIR CZ services at IOCB.
- Based on an evaluation of resource requirements, a procurement procedure has been prepared for the acquisition of new computing capacity, specifically high-capacity CPU nodes planned for location in Prague at UMG and in Brno, with a total capacity of 5,000 CPU cores.
- In connection with the upgrade of the CESNET backbone network, a new concept of connecting MetaCentre nodes to the CESNET3 network has been prepared. Its implementation included a shift of the basic capacities of the interconnection network so that the connection of the computing node was at least 10 Gbps and the connection of the cluster 100 Gbps. In a new concept inspired by the principles of Science DMZ network architecture, computing clusters, storage systems and important scientific data sources are connected directly to the aggregation layer of the corresponding CESNET presence node (PoP). In 2022 the first phase of installation took place, and in 2023 the clusters will be connected at 100 Gbps.



Development in MetaCentre went in the following direction:

- Intense attention was paid to **the development of services provided in the form of SaaS** (software as a service), specifically: an environment for running applications (Matlab, Ansys, etc.), support for Jupyter laptops (also run for EGI) in cooperation with the CERIT-SC Kubernetes environment, support for the use of ready-made and portable environments (containers) and the Singularity tool, which allows for the use of images prepared by NVIDIA for the NVIDIA GPU Cloud.
- **AlphaFold calculations**, which are currently in high demand by users, were intensively supported, and workflow and automation support (NextFlow, Snake-Make, KubeFlow, Terraform) was improved.
- We have demonstrated **MetaCentre's readiness for use of public cloud (Azure) resources**, including procedures for efficient use of very expensive resources tailored to user needs (in connection with the availability of OCRE framework contracts from GÉANT).

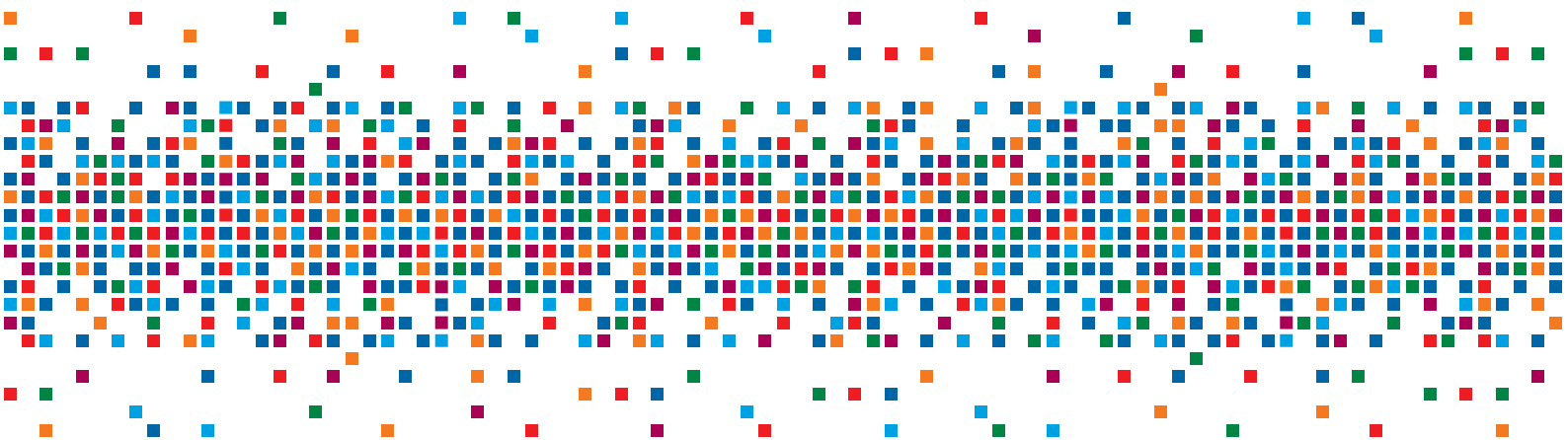
Demanding computations



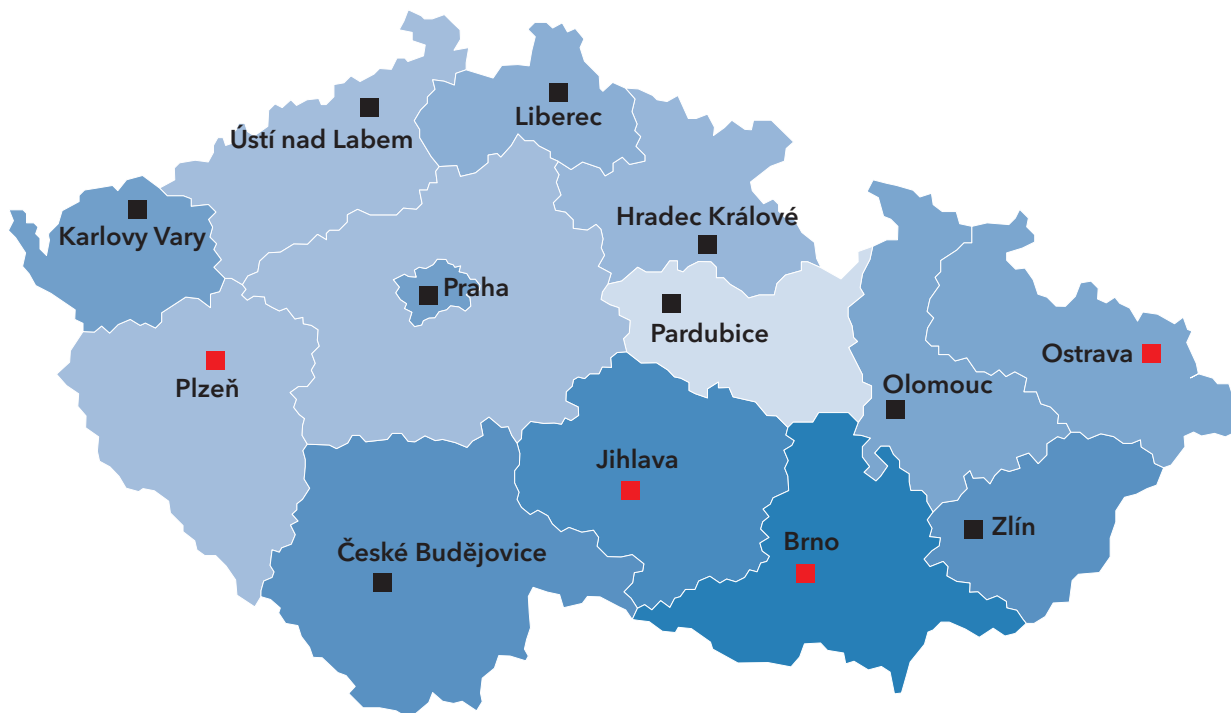
- We continued to **upgrade the virtualisation platform** and to support the strategic relocation from the CESNET Association premises to the DC tower site, and the Advanced Network Protection System for Operational Services (IDS/IPS) was put into operation.
- In the area of planning the focus was on **automated improvement of estimated job runtime and consideration of a cluster performance according to the SPEC benchmark**.
- The **security of MetaCentre** has been continuously **strengthened**, particularly by developing cooperation in the area of security monitoring of the MetaCentre network **through FTAS technologies** (detection of compromised virtual machines and their abuse for cryptocurrency mining and detection of anomalies in network traffic in general), **by linking MetaCentre with the Warden reputation database** (source of data on IP addresses involved in attacks) and by improving the quality of authentication (detection of weak passwords and multi-factor authentication), while an analysis of the strength of MetaCentre user passwords was also conducted.
- Significant efforts have been invested in the **integration of services and joint support of user needs within e-NFRA CZ**, in 2022 especially in the area of common documentation for computing services.

We comprehensively presented Metacentre services at the **e-INFRA CZ conference** (on 10 May 2022). A whole afternoon session was devoted to the computing and storage part of the infrastructure, and at the end of the conference there was not only a **practical part** dedicated to demonstrations of specific procedures, but also to collecting feedback from current and potential users. **EGI activities resulted in the EGI 2022 conference, organised in Prague.**

Data repositories



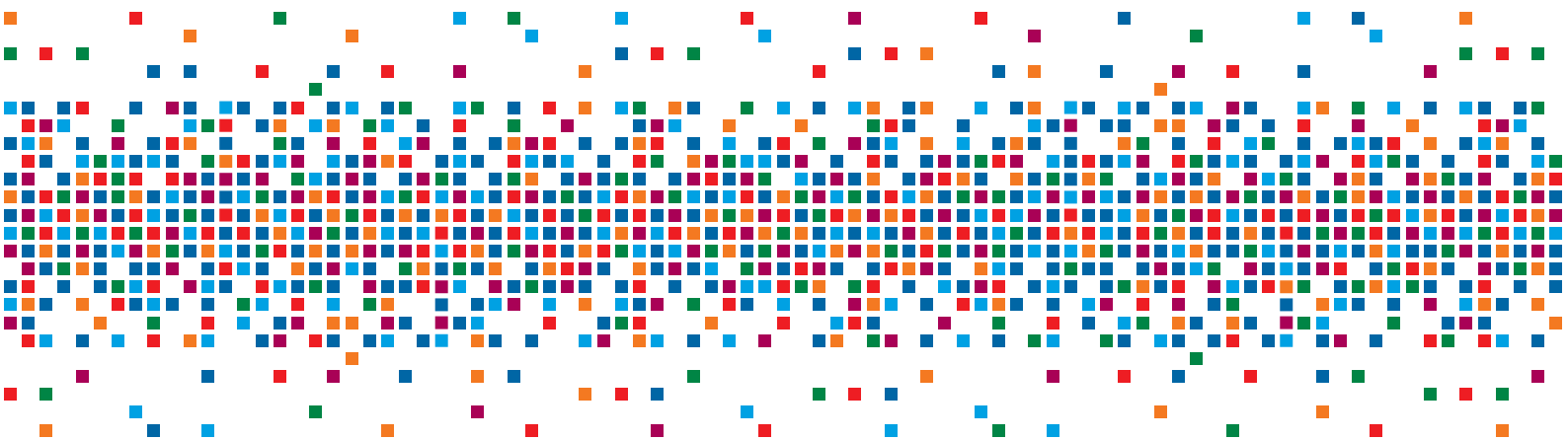
Map of data repositories



In 2022 the data storage infrastructure was operated by the following systems:

- hierarchical data warehouse repository in Ostrava,
- standard disk array in Jihlava,
- object repositories in Plzeň, Jihlava and Ostrava.

Data repositories



Since the hierarchical repository in Ostrava is practically full and is also nearing the end of its lifetime, the most active users have to the greatest extent possible been moved to other systems and the migration of all remaining users has been prepared. A new object repository was put into operation in Ostrava at the beginning of the year. Bids were also evaluated in a tender procedure for an object repository to be located at Mendel University in Brno, and a tender procedure for another object repository to be located in the ELI Beamlines centre in Dolní Břežany was conducted. Contracts have been signed for both supplies.

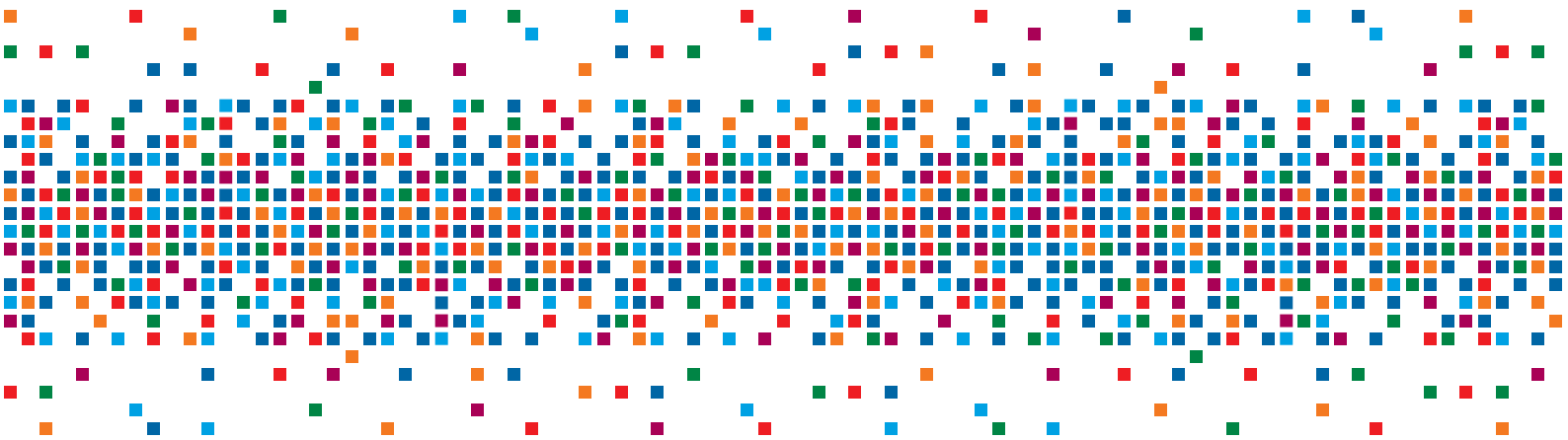
In addition to equipment purchases, attention was turned to continuity of operations, development of services and international cooperation, and support of application communities. A long-term archive service with a high guarantee of binary data preservation was put into operation. An open data repository with metadata support was in pilot operation for selected user groups. Other development activities included the preparation of auxiliary mechanisms for object storage, which will enable delegation of the management of provided spaces, efficient administration of users and credentials and easy configurability of data sharing. This also involved changes in the operational metrics collection system and modifications to the accounting system. By joining the international CS3MESH4EOSC project, the Association participated in the development of sync'n'share systems for easy management of data access, applications and other resources. Object repository capacity was provided through Virtual Access under the international DICE project.



Data repositories administered an object system for the cloud computing platform (MetaCentre/CERIT-SC) and provided data space for the virtualisation platform. The cloud platform in particular represented a community-based approach to the development of an infrastructure in which resources provided by Masaryk University were directly deployed. Several external user groups participated in its pilot operation.

The data repositories were also intensively involved in the preparation of **the implementation of EOSC in the Czech Republic**, where key components include a **multi-tenant repository platform as part of the national data infrastructure**, as well as a **national metadata directory for aggregation and searching in metadata**. This activity has materialised in the form of the upcoming IPs EOSC CZ project, within the framework of which a **national metadata directory** will be built and operated. A consortium of institutions is also being formed to participate in **building a national repository platform**.

CESNET e-Infrastructure security



Since 2018 CESNET has held internationally recognised certification for its information security management system (ISMS) in accordance with the standard ČSN EN ISO/IEC 27001:2014, which specifies requirements for an information security management system within an organisation's activities and provided services with the aim of eliminating the risks of loss of data availability, confidentiality and integrity. A surveillance audit was successfully completed in June 2022.

In the field of security incident prevention and facilities for efficient handling of identified security incidents, an important component is technology complexes for **backbone network monitoring, security event and incident detection, and sharing such information through the FTAS, G3, Warden and Mentat services**. All of those systems were under continuous development, which reflected requirements made by both the Association as the operator of the e-infrastructure and users (members and subscribers). All systems are still proving to be stable and useful projects that have potential to serve, among other things, as means for fulfilling requirements imposed by the Cyber Security Act (CSA) on either CESNET or connected institutions that are subject to the CSA.

In 2022 work began on strengthening and developing additional security services (**the SOC, Security Operations Centre project**). The first phase involved the specifications of the SOC BASIC service in the CESNET service portfolio and the creation of a portal for structured communication (<https://soc.cesnet.cz>). Furthermore, the practice of CESNET CSIRT working groups on important topics in the field of operations and security has been renewed. **Three working groups were assembled for the following topics:**

- Security event processing
- Secure network design
- Network monitoring using FTAS

The security services portfolio has grown to include **Phishingator**, a service that allows users to test, practice and improve their

cesnet cesnet-certs

ability to detect phishing attacks. Furthermore, a service from the vulnerability assessment (and situational awareness) family has started to emerge, where CESNET-CERTS security team analysts monitor sources providing information about newly identified vulnerabilities or problems and create alerts for the community of administrators and security specialists, along with guidance on how to deal with the situation.

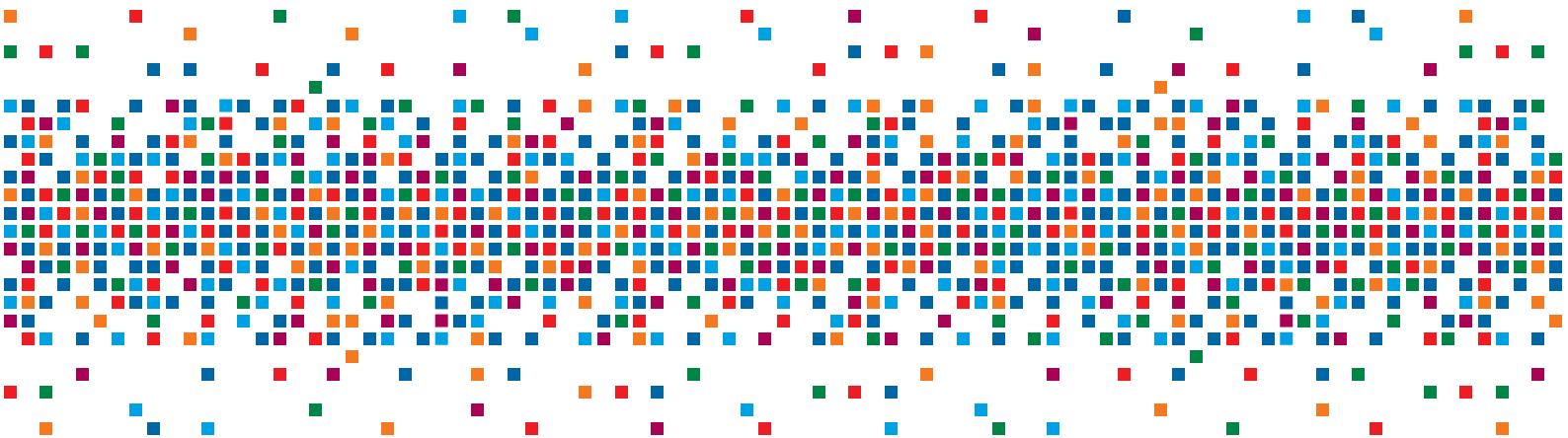
The needs of connected subscribers in the area of security services were also surveyed (among other things through the CRP project led by Masaryk University, of which CESNET is a partner). A group of new services will be defined to help connected organisations ensure security in their home networks as a result.

The CESNET Forensic Laboratory (FLAB) processed **seven penetration test orders** in 2022.

The online **Network and Services Security Workshop**, focusing on the operation and security of networks, services and internet applications, was once again held in 2022.

For the occasion of Cybersecurity Month (October), FLAB prepared, as it does every year, **The Catch**, an educational competition with the title "Catch the Packet", an event in which over 474 contestants took part.

Network identity



Identity federation

The purpose of authentication infrastructure services is to provide a trusted electronic identity and easy access to e-infrastructure services.

The infrastructure is based on **eduid.cz, the Czech academic identity federation** whose members use shared information about the identity of their users to facilitate their access to various network services. Every full member of the federation can have either or both of the following roles:

- An **identity provider** (IdP), who administers user names, passwords and other user data and makes selected information available to service providers.
- A **service provider** (SP), who runs a web application or network service and uses information about users' identity and other properties, if applicable, to control access to it.

There are currently 250 identity providers in the eduid.cz federation - 37 belong to universities, 48 to institutes of the Czech Academy of Sciences, 14 to hospitals, 98 to libraries and 31 to other institutions such as international research groups, museums, archives and regional authorities.

Within the eduid.cz federation, the **MetaMan application** was launched in production mode in 2022, not only serving for managing metadata of the eduid.cz federation, but also for managing internal federations of individual members who have long been interested in this service. We currently



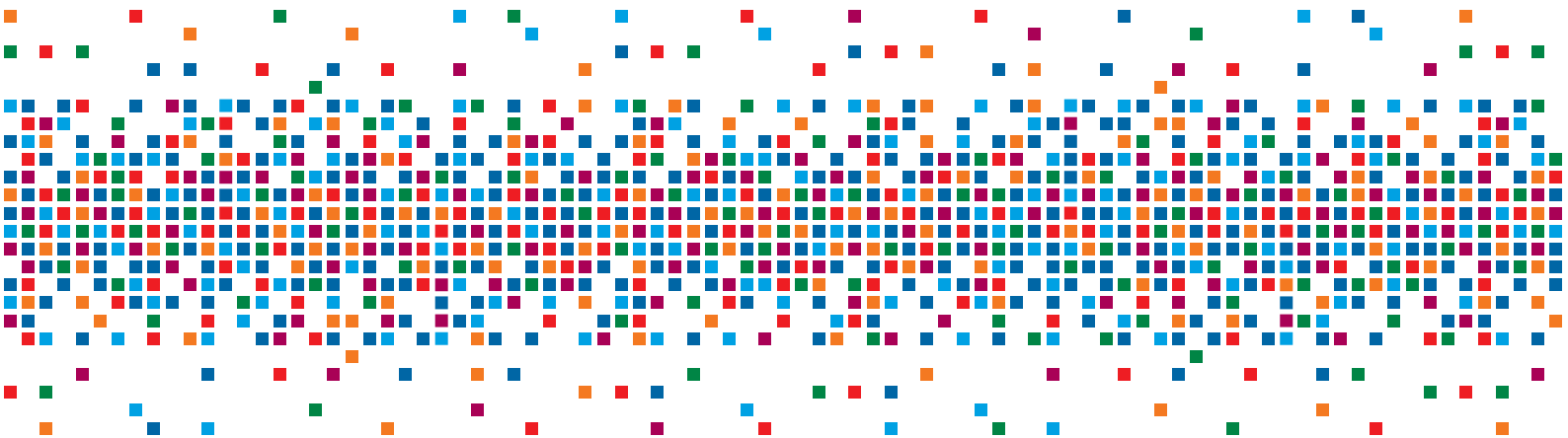
run 5 internal federations for our members, and are also gradually converting entity managers to the use of MetaMan.

The **resources** PressReader, Society for Industrial and Applied Mathematics, American Physical Society, MIT Press, Public and Proceedings of the National Academy of Sciences (PNAS) have been newly made available to members of the eduid.cz federation.

Members of eduid.cz had the opportunity to **use standardised federated authentication using Seamless Access** at AIP Publishing - Scitation, American Chemical Society, Cambridge University Press Core, De Gruyter, Elsevier ScienceDirect, Emerald Publishing, IEEE, IOP Publishing, Mark Allen Group, Nature, REFEDS Metadata Explorer Tool, Sage Publishing, Taylor&Francis, Wiley Online Library and Wolters Kluwer - Ovid.

For eduid.cz members, options were described for using anonymous or personalised access according to institutional policies to protect personal data and personal preferences during federated authentication via eduGAIN for EBS-COhost, Elsevier Science Direct and Wiley Online Library.

Network identity



In the new version of the **Central Library Portal (CPK) on the Knihovny.cz website**, logging in has been significantly easier since March 2022 thanks to the deployment of **WAYF/DS eduID.cz** instead of the local WAYF/DS. In the CPK users were then able to link identities from libraries and identities from myID, Google, LinkedIn and Facebook via federated eduID.cz authentication. Facebook account logins for the GAIN service in the CPK were discontinued at the end of October 2022. In addition to logging in with accounts from CPK participating libraries, it was possible to log in with myID, Google and LinkedIn accounts. **Thanks to login via eduID.cz, it was possible to work with valid registrations in several libraries in CPK with a single login to a favourite account.**

The field of public key cryptography has also undergone significant changes. **A new solution providing high availability of the service has been deployed for the servers providing CESNET CA certificate revocation lists.** The issue of CESNET CA 4 certificates using federated login for server certificates is under preparation. As part of the "CA Disaster Recovery" exercise, the composition of the CESNET Root CA key was verified in case of a hardware failure and the need for recovery. Cooperation and sharing of data about issued certificates also took place with the CESNET security department and an application is being prepared to allow administrators to check certificates stored in Certificate Transparency logs. An analysis has been performed to link TCS and RemSig so that RemSig systems can request a user's personal TCS certificate on the user's behalf, thereby pooling the user's certificates in one place in a virtual token accessible on the user's workstation. Through the RemSig API it will then be possible to offer the user operations with both PostSignum and TCS certificates.

The **eduroam project is preparing the renewal of the national infrastructure**, which will take place during 2023. In addition to replacing servers a technological update is planned to increase availability. The rewriting of the existing support applications is also gradually being worked on.

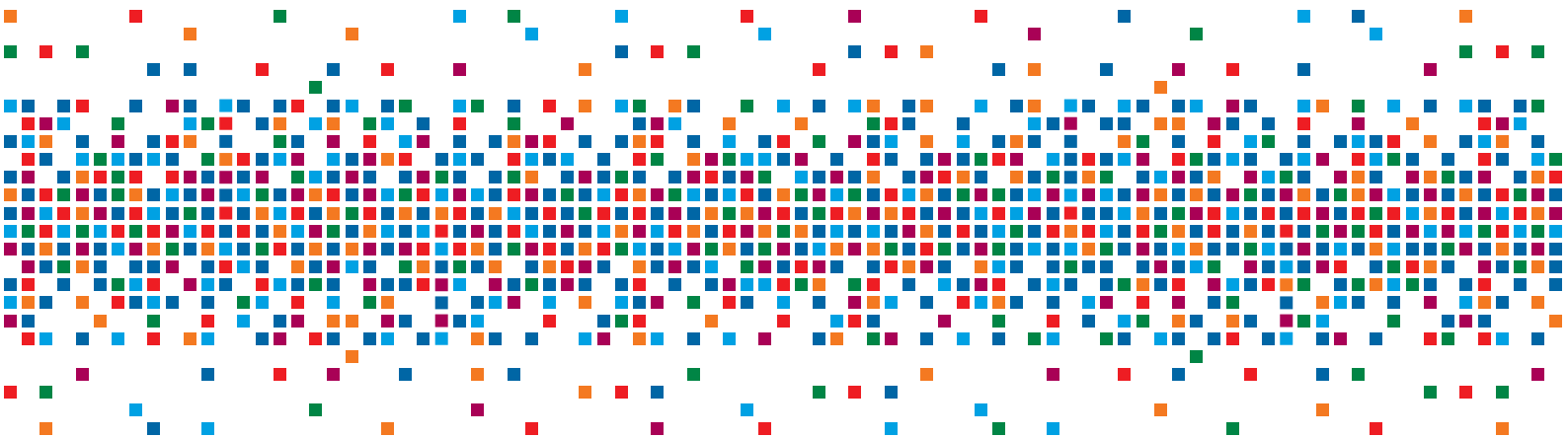
In connection with the move of CESNET to new premises, the servers providing cryptographic services have been moved to a new server room. Furthermore, several portals for issuing different types of certificates have been consolidated into one portal. The issue of CESNET CA 4 server certificates using federated login is in preparation. The **development of the CT Log service** has continued with the Security Department to allow administrators to review certificates stored in Certificate Transparency records.

The **eIDAS** service has continued in production mode and other information systems (20 in total) from 13 connected organisations were gradually connected to it. In addition to virtual tokens for Windows and Linux, macOS has also been added and tested by selected customers. In 2022 over 70,000 documents were signed or sealed and 32,000 time stamps were issued. We also managed 515 valid qualified certificates.

250

There are currently 250 identity providers in the eduID.cz federation – 37 belong to universities, 48 to institutes of the Czech Academy of Sciences, 14 to hospitals, 98 to libraries and 31 to other institutions

Network identity



Authentication and Authorisation Infrastructures (AAIs)

In January 2022 the AAI for **e-INFRA CZ** was unified so that the user perceives e-INFRA CZ as a unified environment regardless of whether they access CESNET, CERIT-SC or IT4Innovations services. The purpose of this unification was to ensure uniform access of users to the services of all three operators of e-INFRA CZ and to ensure common user care and user support (i.e. the creation of centralised user support for all services).

In July 2022 an extension of the AAI for e-INFRA CZ was put into live operation with the support of **MFA (Multi-Factor Authentication)**, i.e., the possibility of confirming a login with a second independent verification of the user's identity. Due to the large variety of user devices, the implementation of MFA in the AAI for e-INFRA CZ supports two standardised mechanisms: TOTP (Time-Based One Time Passwords, RFC 6238) and WebAuthN (Web Authentication). Users can identify themselves using a fingerprint reader, camera facial recognition, a gesture to unlock a touchscreen, a PIN, a hardware token connected via a USB or contactlessly via NFC, or a one-time code that changes every minute. When logging in on a PC not equipped with suitable interfaces, the second factor can also be used on a nearby mobile phone (within Bluetooth range). As a backup option in case of a personal electronics failure, you can have a paper list of one-time passwords.

The introduction of MFA has enabled work to begin on related **Step-Up Authentication** - the ability to escalate login

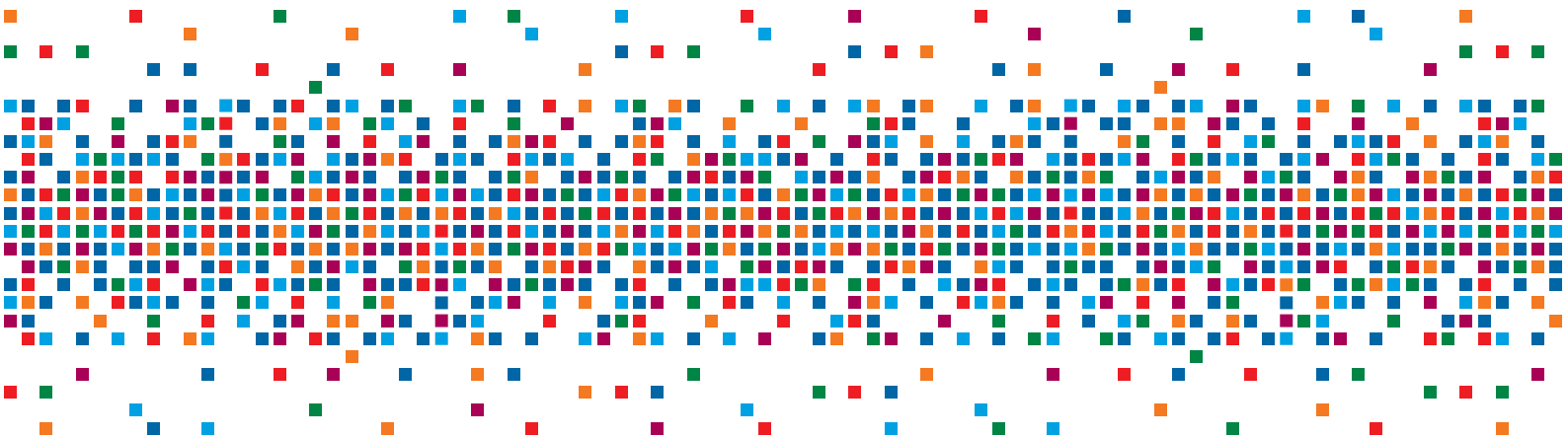
security gradually, where users identify themselves for normal operations using only one authentication method, but for sensitive operations they must confirm their login using a second method. The ability to step-up authentication is important for access control when processing sensitive data, for example, in the SensitiveCloud computing and storage environment for sensitive data in CERIT-SC.

A new **separate instance of the Perun identity management system** was created for the EGI infrastructure.

The Perun system was systematically developed further, which is not only an essential part of the AAI e-INFRA CZ but also other international infrastructures. The same technology was therefore operated within the GÉANT eduTEAMS service (eduteams.org) for:

- SURF, Dutch national education and research network (surf.nl),
- UmbrellaID, a digital identity for photon and neutron users (umbrellaid.org)
- FENIX Research Infrastructure, an association of supercomputing centres (fenix-ri.eu)
- MyAccessID, an association of supercomputing centres
- MyAcademicID, a project for student mobility (myacademic-id.eu)
- European Life Science Research Infrastructures (lifescience-ri.eu)
- European Consortium for the Development of Fusion Energy (euro-fusion.org)
- eduTEAMS service (eduteams.org)
- GEANT (geant.org)

Cooperation with large research infrastructures



The CESNET e-infrastructure is part of relevant European e-infrastructures, forming a communications and information environment for national large infrastructures in other scientific fields and facilitating their cooperation with their foreign partners:



GÉANT - the European backbone communications infrastructure ensures inter-connection of European national research and education networks and connection

to similar infrastructures on other continents. Funding for this infrastructure and related activities at a European level was provided until the end of 2022 with the support of the GN4-3 project (856726; H2020 programme), which aimed to increase the quality of European research, to support its scientific excellence, to provide access to research data and to enable its re-use. The successor project GN5-1 will be launched in January 2023. As in the ending project, we will once again be involved, especially in project activities relating to the building of specialised network environments (for example, for transfers of precise time and stable frequency or QKD), network security or AAI matters.



EGI.eu - the European infrastructure for distributed computing coordinates national activities for the implementation of grid technologies at European level. Cooperation

takes place within the intentions of the EOSC-Future project and EGI-ACE programme H2020. CESNET's collaboration involves participating in all primary operational activities, ensuring the operation of the national EGI grid node and providing computing resources comprising both its own computing capacities and those of the Institute of Physics of the Czech Academy of Sciences. The capacities involved are also part of MetaCentre and use its virtualised infrastructure. We continue to support the virtual ELIXIR (bioinforma-

tics), Auger (cosmic rays), Belle (particle physics) and CTA (gama astronomy) organisations, and directly support user groups from the Czech Republic interested in the use of the Pan European grid. It is a priority to focus on specific needs of these groups and their international projects.



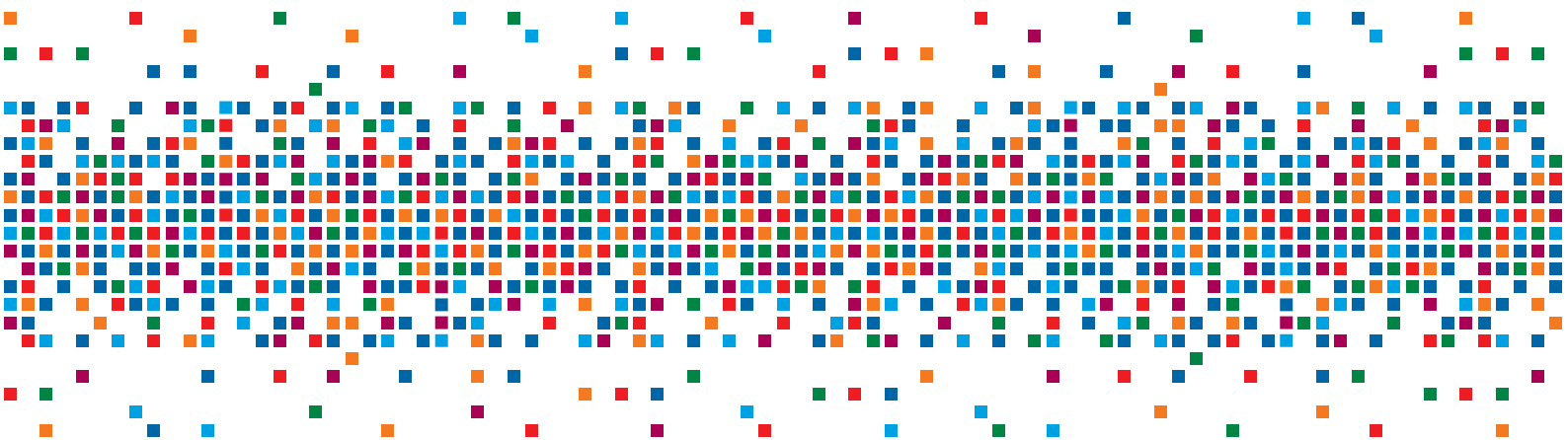
ELIXIR is a European bioinformatics infrastructure that combines advanced computing environments, data resources and unique tools for the purposes of bioinformatics research

across Europe. CESNET contributes to the development of the European infrastructure under the Technical Services activity of the ELIXIR Compute Platform, focusing on the establishment of a common framework for the provision of computing services and services related to data storage and to the building of the Life Science AAI. CESNET is also directly involved in national activities in this field - it is one of the founding members of the ELIXIR CZ infrastructure, which provides an advanced computing environment, data resources and unique tools to the bioinformatics science community in the Czech Republic and in Europe. CESNET is a direct participant in the Czech National Infrastructure for Biological Data (LM2018131) project from the Large R&D Infrastructure Projects programme, which ensures the operation of this infrastructure.



QUAPITAL is a Central European partnership for secure communications with quantum-level security and a QUAPITAL quantum internet. The initiative's goal is to build a quantum-compatible infrastructure interconnecting quantum experiments between various research facilities throughout Central Europe.

Cooperation with large research infrastructures



National large research and development infrastructures

In addition to the above-mentioned close collaboration with national e-infrastructures and participation in the ELIXIR CZ large infrastructure, CESNET also holds continuous negotiations with representatives of other large infrastructures which are listed in the Roadmap of Large Research Infrastructures of the Czech Republic for the years 2016 to 2022, provides for their information and communications technology needs and offers collaboration in addressing them. Examples include:

- cooperation between the Institute of Molecular Genetics of the Czech Academy of Sciences and CESNET on the operation of the European Chemical Biology Database (ECBD),
- collaboration between e-INFRA CZ, ELIXIR CZ and EATRIS on procuring high-performance computer technology for the Institute of Molecular and Translational Medicine of the Faculty of Medicine and Dentistry of Palacký University in Olomouc.



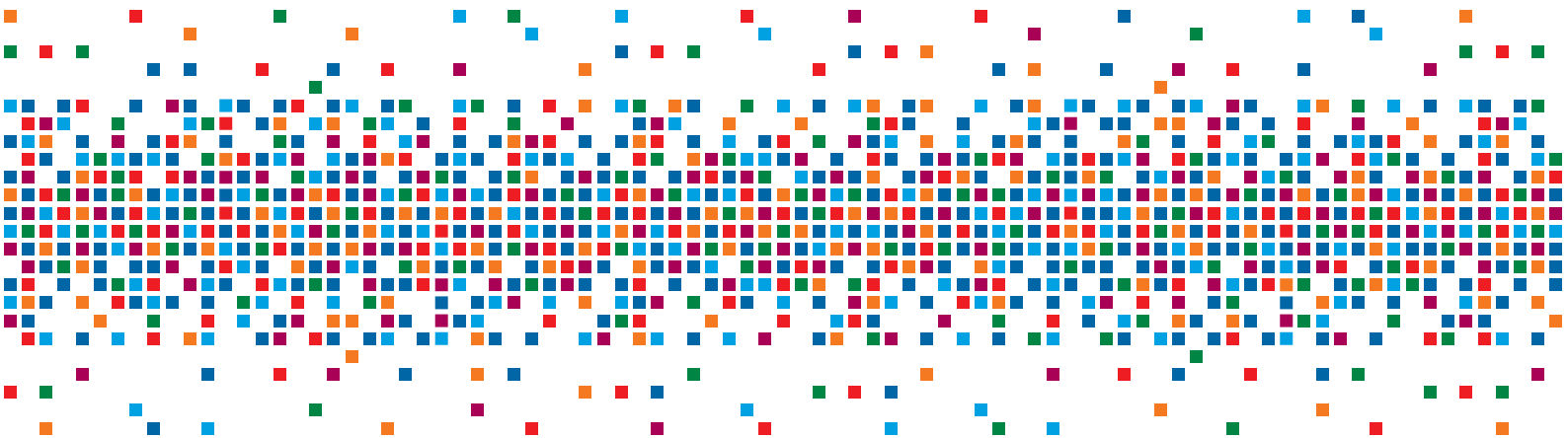
EOSC

CESNET, as part of e-INFRA CZ, is involved in the **implementation of the Open Science concept in the Czech Republic**, the aim of which is to create a national data infrastructure as an environment for storage, accessibility and further work with FAIR (Findable, Accessible, Interoperable, Reusable) data in the Czech Republic.

The **national data infrastructure** includes a national repository platform, a metadata repository, disciplinary repositories and a national EOSC secretariat. In this concept CESNET and e-INFRA CZ are expected to participate in the creation of the national repository platform and support for the national EOSC secretariat. The construction of the national data infrastructure is planned from the funds of the Operational Programme Johannes Amos Comenius and, together with Masaryk University and VŠB – Technical University in Ostrava, the first of the projects that will lead to the construction of the infrastructure is being prepared.

In 2022 the **EOSC Roadshow** took place in Prague, Brno and Ostrava. The aim was to **introduce EOSC and FAIR data** principles and to inform about the status of the preparation of their implementation in the Czech Republic, as well as the whole area of active involvement in the current and especially subsequent steps of EOSC implementation and the broad introduction of FAIR data principles in the Czech Republic.

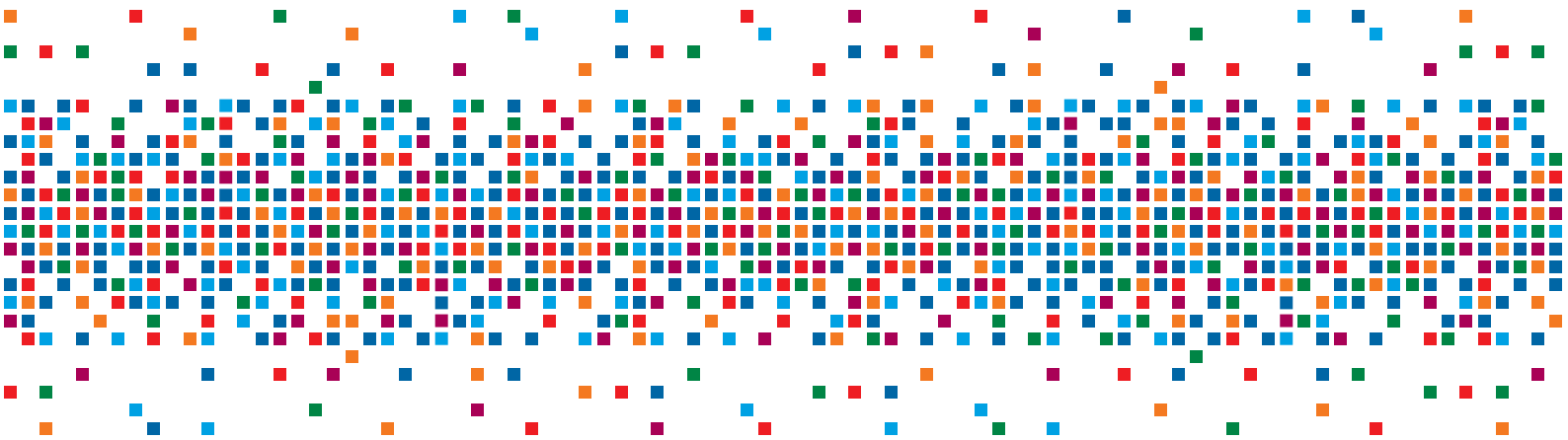
Cooperation with large research infrastructures



At an international level CESNET is a member and official representative of the Czech Republic in the EOSC aisbl association and is involved in a number of projects:

<p>PaNOSC Photon and Neutron Open Science Cloud</p>	<p>The project aims to create federated services for easy data accessibility, interoperability and reusability (FAIR) over existing metadata catalogues and data archives. It also deals with scientific data analysis with the aim of offering services that will help users work with primary data.</p>
<p>EOSC-synergy European Open Science Cloud - Expanding Capacities by Building Capabilities</p>	<p>The project aims to coordinate the establishment of a European open environment for scientific data and their processing, which should promote mutual collaboration between infrastructures at national and European level.</p>
<p>CS3MESH4EOS Interactive and agile/responsive sharing mesh of storage, data and applications for EOSC</p>	<p>The aim of the project is to develop a platform for easy and user-friendly data sharing and transfers between sync'n'share systems. Another project focus is controlled access to applications integrated into sync'n'share systems. CESNET's participation in the project concerns, most significantly, the development and implementation of a federated authentication and authorisation infrastructure.</p>
<p>EGI-ACE EGI Advanced Computing for EOSC</p>	<p>The project aims to develop services operated by the EGI infrastructure as part of EOSC activities. This concerns both fundamental services for the EOSC (AAI, accounting, monitoring) and computing services used by scientific groups. CESNET is involved in the fields of AAI (integrating the Perun system with EGO Check-In), operational security and use of EGI FedCloud cloud services; moreover, it assumes responsibility for the operation of the Jupyter Notebook EGI service.</p>
<p>DICE Data resources and Interoperable services for EOSC</p>	<p>The DICE project is part of the development of a European data storage and management infrastructure and provides user groups with fundamental data resources. CESNET offers the archiving capacity of its object storage under the project in the form of Virtual Access and uses the project for fundamental integration with EUDAT services.</p>
<p>C-SCALE Copernicus - eoSC AnaLytics Engine</p>	<p>The C-SCALE project aims to develop a platform for the analysis of Earth observation data provided by the Copernicus project within the European Open Science Cloud (EOSC) environment. CESNET is primarily involved in the establishment of a federation of partners operating extensive archives of remote sensing products. To a lesser extent CESNET works on building an expert community and providing access to computing resources in the EOSC environment under the C-SCALE project.</p>
<p>EOSC FUTURE</p>	<p>The project aims to operate and develop services for the EOSC; CESNET is involved as a third-party under EGI.eu in the fields of operational security (CSIRT, training, monitoring) and AAI (Identity Management).</p>

Research, development and innova-



The development of CESNET e-infrastructure requires an innovative approach. That is why the Association, in addition to building and operating its e-infrastructure, is also engaged in research and development in the field of information and communications technology, most importantly in the areas mentioned below.

Optical transport systems

CESNET has long looked into the software management of optical networks, transfer of precise time and stable frequency, quantum transfer of cryptographic keys and use of optical networks as physical quantity sensors.

CESNET e-Infrastructure security

CESNET has long been committed to e-infrastructure security. In addition to developing tools for ensuring user privacy and security of their data or tools for sharing information on security incidents, we have also been intensively developing tools for network monitoring and detection of operating anomalies as potential sources of attack. The Association continues to develop its own **DDoS protector**.

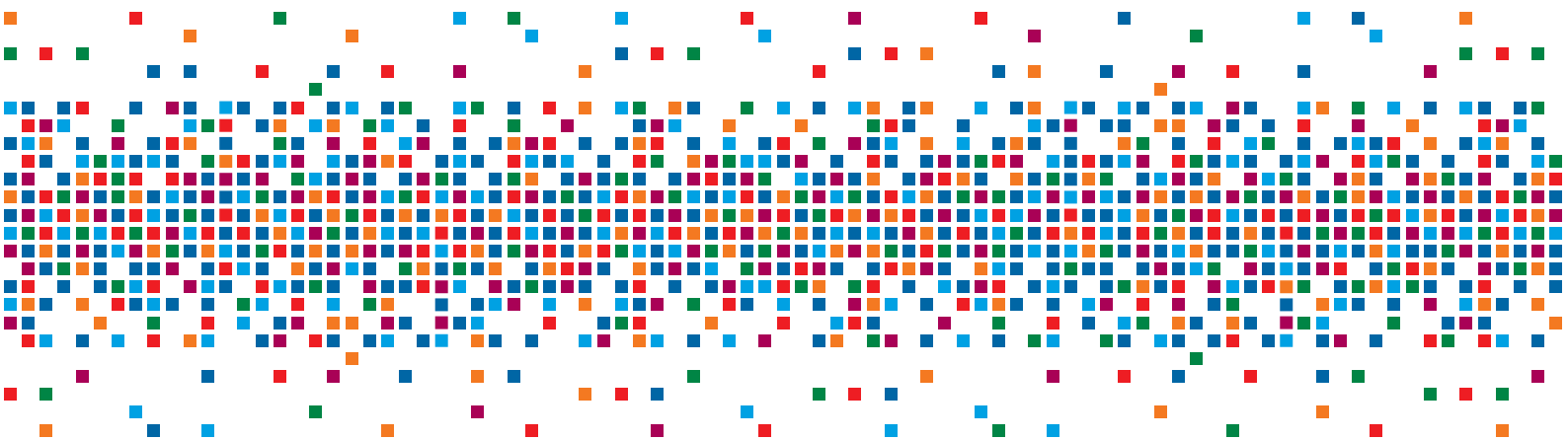
Network identity

In the field of identity management and access control, CESNET and Masaryk University jointly develop **Perun**, a system that allows for organising users into virtual organisations and groups, allocating resources and controlling access to them.

New applications

CESNET constantly looks at possible applications of its e-infrastructure in new fields such as medicine, culture or architecture. Research in the area includes the development of two platforms, a hardware platform named **MVTP** and a software platform named **UltraGrid** (in collaboration with Masaryk University), for working with high-definition video (up to 8K) while maintaining low latency. Furthermore, the Association is also heavily involved in the digitisation and presentation of cultural heritage objects and the internet of things.

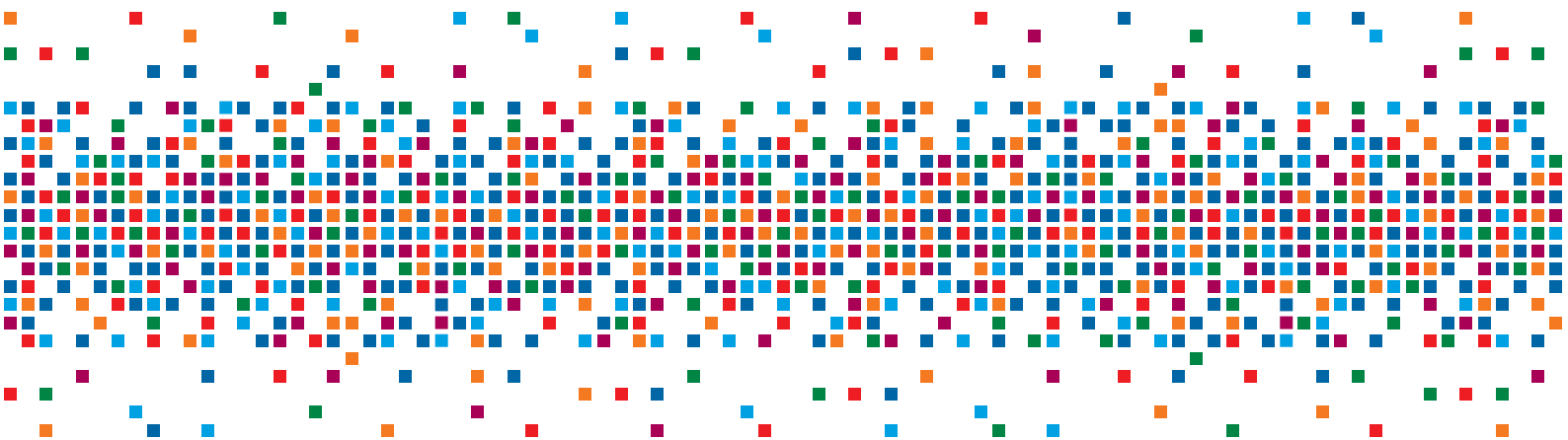
Projects undertaken in 2022



International projects

Area	Project title	Subsidy provider	Programme
Large infrastructures	GN4-3	GN4-3 Research and Education Networking - GÉANT	EU
EOSC	CS3MESH4EOSC	Interactive and agile/responsive sharing mesh of storage, data and applications for EOSC	EU
	C-SCALE	Copernicus - eoSC Analytics Engine	EU
	DICE	Data Infrastructure Capacity for EOSC	EU
	EGI-ACE	EGI Advanced Computing for EOSC	EU
	EOSC - SYNERGY	European Open Science Cloud - SYmbiosis for New and Established Research Groups Yield	EU
	EOSC-FUTURE	EOSC-FUTURE	EU
	EuroScienceGateway	leveraging the European compute infrastructures for data-intensive research guided by FAIR principles	EU
	PaNOSC	Photon and Neutron Open Science Cloud	EU- EGI.EU
Cybersecurity	PRIVILEGE	PRIVacy and homomorphIc encryption for artificial intelliGence	European Defence Agency
	SAPPAN	Sharing and Automation for Privacy Preserving Attack Neutralization	EU
	SPARTA	Special projects for advanced research and technology in Europe	EU
Advanced network technologies and applications	CLONETS-DS	Clock Network Services - Design Study	EU
	GREAT	The Green Deal Data Space Foundation and its Community of Practice	EU
	HPLT	High Performance Language Technologies	EU
	interTwin	An interdisciplinary Digital Twin Engine for science	EU
	TiFOON	Advanced time/frequency comparison and dissemination through optical telecommunication networks	EURAMET

Projects undertaken in 2022

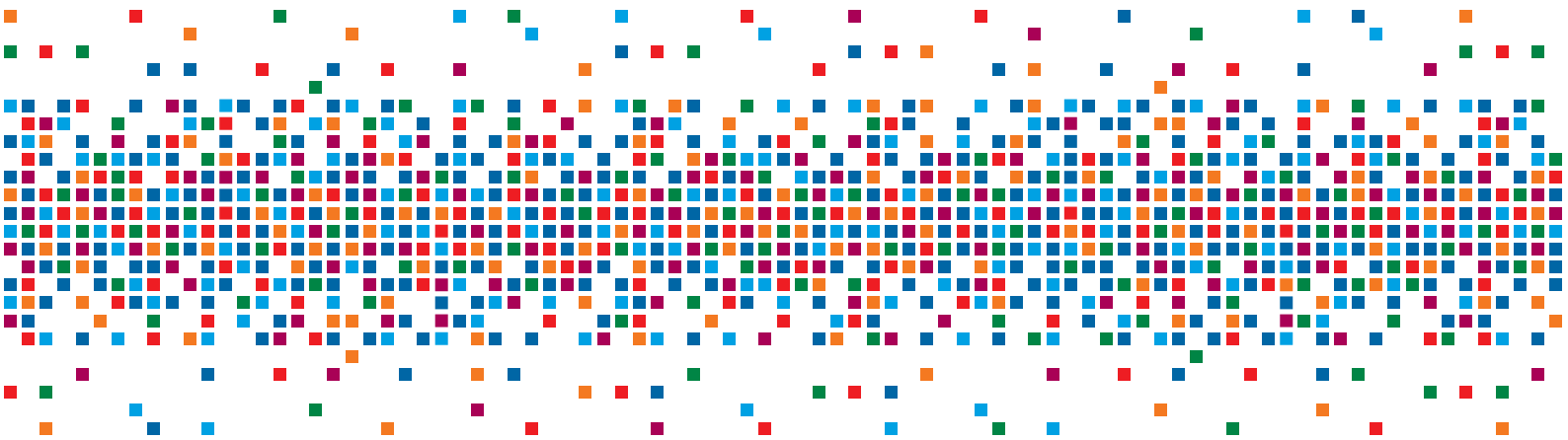


National Projects

Area	Project title	Subsidy provider	Programme
Large infrastructures	e-INFRA CZ	e-Infrastructure CZ	MŠMT
	e-INFRAMod	e-INFRA CZ: Modernisation	MŠMT
	ELIXIR-EXCELERATE (2020-2022)	Czech National Infrastructure for Biological Data	MŠMT
Cybersecurity	AdaptDDoS	Adaptive Protection against DDoS Attacks	MV ČR
	CYBERTHREATS	CYBERTHREATS - Using artificial intelligence to defend against cyber attacks	MO
	DoSIX	Distributed DDoS Mitigation in a Critical Infrastructure Environment	MV ČR
	FETA	Encrypted Traffic Analysis Using Network Flows	MV ČR
	FlowTest	FlowTest: Testing Network Monitoring Devices	MV ČR
	HFT	Acceleration platform for low-latency exchange trading	TA ČR
	NCK	National Cybersecurity Competence Centres	TA ČR
	NeSPoQ	Network Cybersecurity in the Post-Quantum Era	MV ČR
Advanced network technologies and applications	JPEGXS	Equipment for Low-latency Transmissions of JPEG XS Video	TA ČR
	NAKI3D	Presentation and Protection of 3D Digital Objects in Museum Collections	MK ČR
	VR wardrobe	Virtual digital wardrobe	TA ČR

We would like to thank all subsidy providers for providing the funds for undertaking the projects.

Research and development outcomes



Research and development outcomes

32 articles

Research activities in 2022 resulted in 12 papers in peer-reviewed scientific journals, 20 papers in collections, 5 functional specimens, 6 pieces of software and 1 pilot test.

Significant achievements

Czech Head award for a solution for video and audio transmission via a computer network across large distances with exceptionally low time latency.

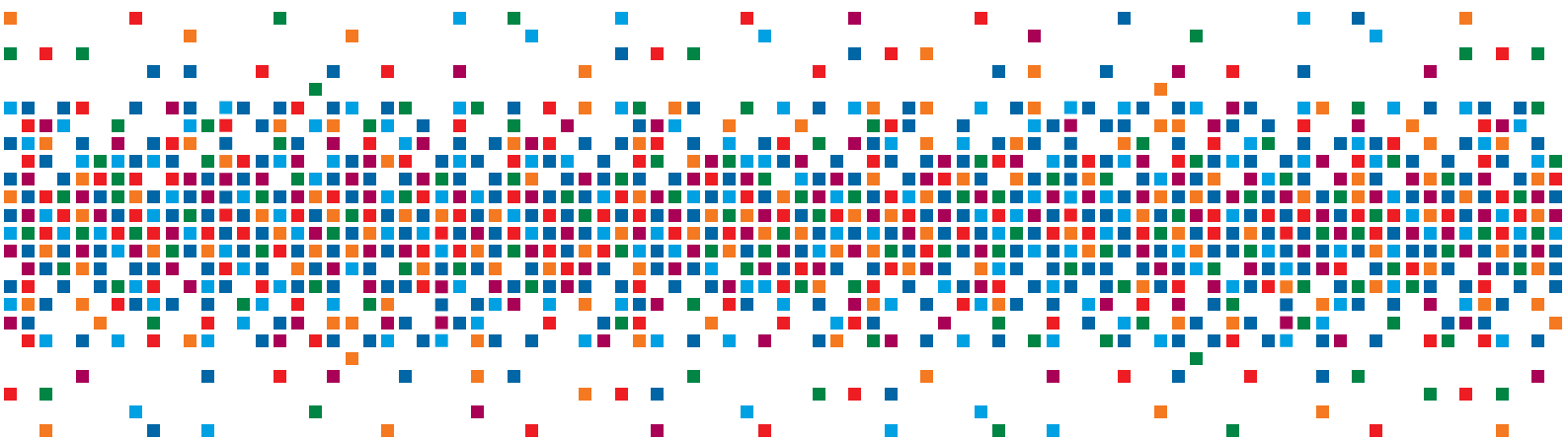
Creation of an interactive digital model of jewellery from the 5th century in the T.G.M. Museum in Rakovník.

Preparation of the **interactive Robot for Children application** in the Karel Čapek Memorial in Stará Huť near Dobříš.

In collaboration with French company Reflex CES **development one of the first 400Gb FPGA accelerator cards**. The new card is primarily designed for precision network monitoring and network infrastructure security applications.

Development of a sensor system to detect possible damage to the fibre infrastructure and experimental verification on a real route in cooperation with ČD - Telematics.

CESNET Development Fund



In late 2021 the Development Fund Board prepared and launched the first round of a selection procedure for projects for 2022. On the basis of the revised Development Fund documents, associate members were also able to participate in this selection procedure. One associate member, the National Museum, took advantage of this opportunity and submitted a project to the selection procedure.

The following topics were chosen in cooperation with the Association:

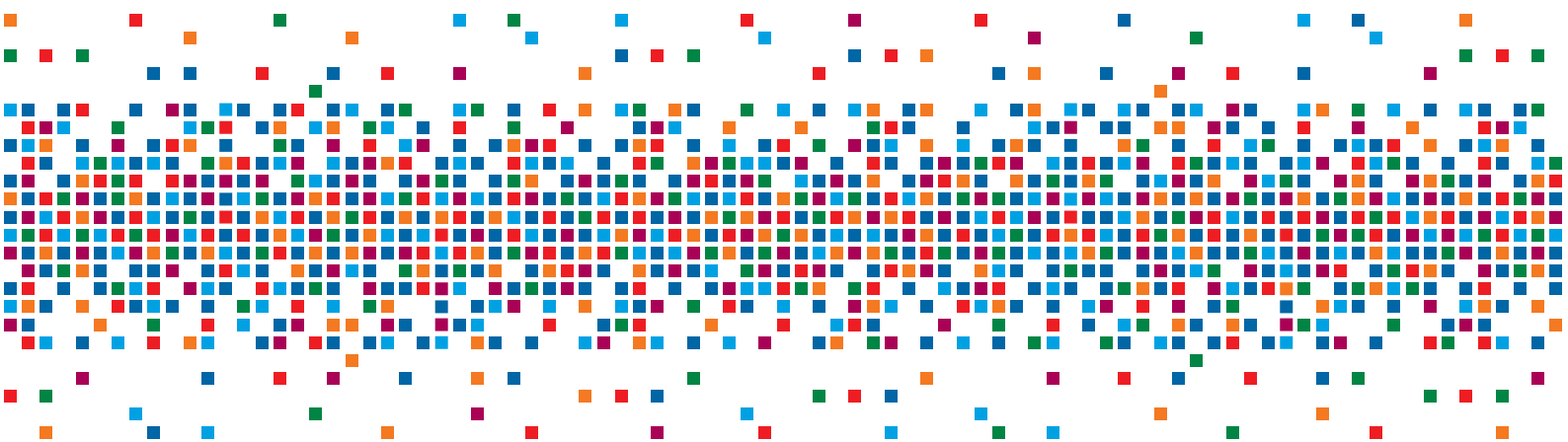
- Use and advancement of CESNET e-infrastructure services and modern information and communications technologies in teaching and learning processes, creative and scientific research work and management of public universities and the Czech Academy of Sciences
- Advanced applications utilising the CESNET e-infrastructure

A more detailed specification of the objectives and focus was given in the text of the announcement.

The tendering process resulted in the submission of 30 projects. **Twenty-one of those projects were accepted for co-funding**, including one project admitted after revision. An overview of accepted projects is shown in the table below.

Project number	Project holder	Project title
687/2022	UTB	Development of a tool for monitoring the availability of federated services and implementation of tools for automated release of minimised attribute sets.
688/2022	Masaryk University	Mapping and analysis of user requirements for services provided through the Security Dashboard platform
690/2022	Masaryk University	Creation of a data lake for the needs of storing operational data of Masaryk University
691/2022	Masaryk University	Comprehensive Access Control System for Public Universities
692/2022	Technical University of Liberec	Data Driven Research @CXI TUL
693/2022	Czech Technical University	Pilot implementation of a QKD scheme based on entangled photons in a wireless optical link
694/2022	Masaryk University	Asset Management-Online records and complete asset management of the university's IT infrastructure
695/2022	VŠB - Technical University of Ostrava	Options for integrating your own infrastructure with public clouds
696/2022	Masaryk University	Archiving and sharing scientific data in Onedata
698/2022	Masaryk University	Analysis and improvement of the PERUN graphical interface user-friendliness

CESNET Development Fund



Project number	Project holder	Project title
700/2022	Masaryk University	Usability of Self-Sovereign Identities in Academic Settings
703/2022	Masaryk University	Documentation of federated services integration
705/2022	Masaryk University	Implementing multi-factor authentication in an academic environment
706/2022	University of West Bohemia	Development of a system for practical user training in the field of social engineering
707/2022	Academy of Performing Arts	Supplementing the PAVE perceptual testing web application with a graphical interface for defining test screens
708/2022	NM	Solution of the long-term data archiving process in the National Museum
709/2022	University of Hradec Králové	Connecting to a central service point
710/2022	Czech Academy of Sciences	Phase coherent transmission of optical frequencies over fibre optic and cable-free optical paths
711R1/2022	VŠB- Technical University of Ostrava	Coordinated cybersecurity in CESNET2
712/2022	Czech Academy of Sciences	Geographically distributed data storage
716/2022	University of Economics Prague	Connection of the University of Economics Prague to the WARDEN, NERD and MENTAT CESNET system

Two rounds of expert review procedures on completed projects took place in the course of 2022. In total, **eight projects were successfully completed**. For one project the Development Fund Board recommended that the findings

and conclusions of the project be presented at an appropriate conference so that they could be used by other members of the Association. Final reports for projects carried out under the CESNET Development Fund are available on the Association's website at fondrozvoje.cesnet.cz.

Public relations

This year we have also organised a number of seminars, conferences, workshops and working group meetings, and participated in other events aiming to educate the professional public and to inform them about the services we offer.

The beginning of 2022 was still affected by the COVID-19 pandemic. That is why the traditional **Seminar on Network and Service Security** was again held in an online environment.

On 10 February we organised a conference to celebrate the **30th anniversary of the internet** in the Czech Republic. In a number of discussion panels we looked back at the past, assessed the current direction, the challenges of internet governance and finally opened the topic of the digital future. The participants were first greeted remotely by one of the creators of the network, Vint Cerf, who is known as a "father of the internet". Prominent experts, including contemporary witnesses, took the floor thereafter.

The **e-INFRA CZ Conference** was held in May, where the e-INFRA CZ infrastructure, its services, international projects and research activities were presented.

In early June we gathered for the **IPv6: Ten Years On seminar**, which focused on the features and deployment of the new version of the internet protocol. We also launched the **EOSC Roadshow** in Prague, Brno and Ostrava and introduced the concept of open science in the Czech Republic. We also participated in the traditional CSNOG community meeting.

After the holidays, we co-hosted EGI (European Grid Infrastructure) 2022, a major international conference focusing on innovations in scientific computing and on services and solutions for building a research ecosystem.

Another annual run of the competition The Catch, this time with the title "Catch the Packet", was held as part of Cybersecurity Month. More than 474 contestants tried to solve difficult problems, with 23 of them successfully completing all of the problems. On the topic of internet safety we organised a conference on Digital Literacy and Safety in the Online Environment with our partners.

The popular **Forensic Training** was also held twice this year.

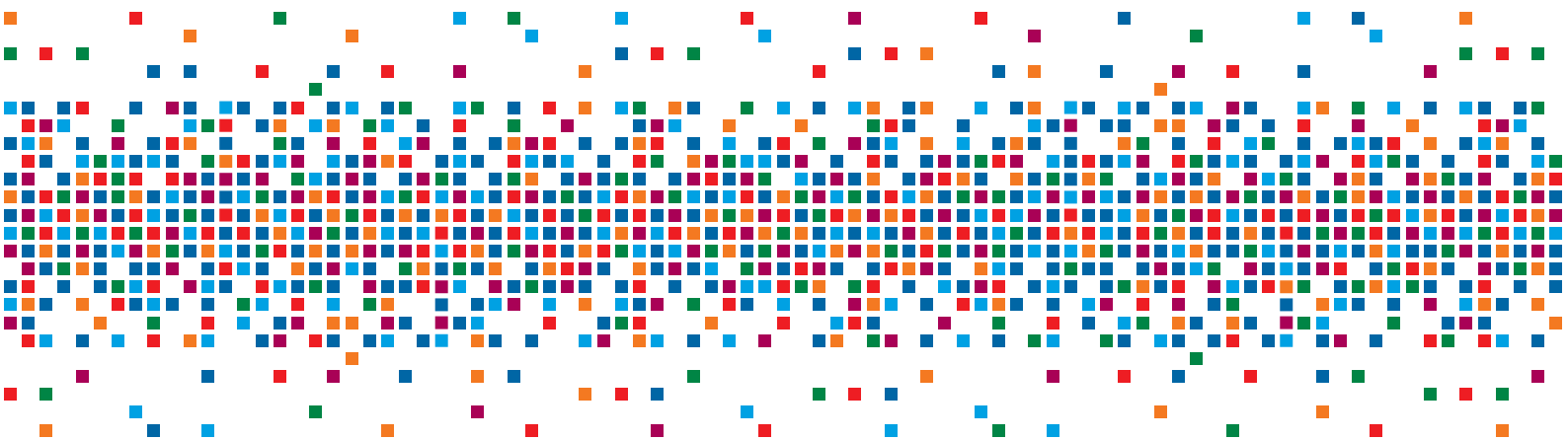
We presented the e-INFRA CZ consortium through a virtual stand at the International Conference on Research Infrastructures, ICRI 2022.

At the end of the year, and at the same time at the end of the Czech Presidency of the Council of the EU, we organised a e-IRG Workshop focusing on large research infrastructures.

30

On 10 February we organised a conference to celebrate the 30th anniversary of the internet in the Czech Republic.

Public relations



We were a technology partner of the Cybersecurity Hall of Fame 2022 and supported the FameLab competition looking for talent among young scientists in the field of science popularisation.

For the occasion of the Czech presidency of the Council of the EU, we organised a concert that connected the Czech Republic with Belgium through unique low-latency MVTP technology, for which we won the Czech Head award at the end of the year. We also demonstrated this technology for long-distance collaboration at the international Network Performing Arts Production Workshop in Estonia, connecting musicians between Tallinn and Prague for a joint performance.

We connected musicians in Prague and Košice in the "Playing for Ukraine" teleconcert. For the first time in our history we connected two choirs from different cities, Prague and Plzeň, at a benefit concert for the SMArt Gospel project, which supports children with spinal muscular atrophy.

We also participated in live broadcasts, for example, the Benefit Concert from the Church of St. Simon and Jude in Prague, and the transmission of the 25th Ústí nad Labem Symposium "Endo Live 10".

At the Karel Čapek Memorial we put Čapek's robot into motion in 3D using an interactive application. For The Mystery of the Golden Jewellery exhibition at Rakovník Museum, we created a digital model of a 5th-century golden treasure.

This year we also went to unusual places where our services are provided, such as 130 metres underground in the Josef mine adit in the Příbram region and at the northernmost Czech research site in Spitsbergen.

We regularly prepare the latest news, present employee activities and achievements, and publish information on upcoming activities and other events on our website, our social media accounts and in our newsletter.

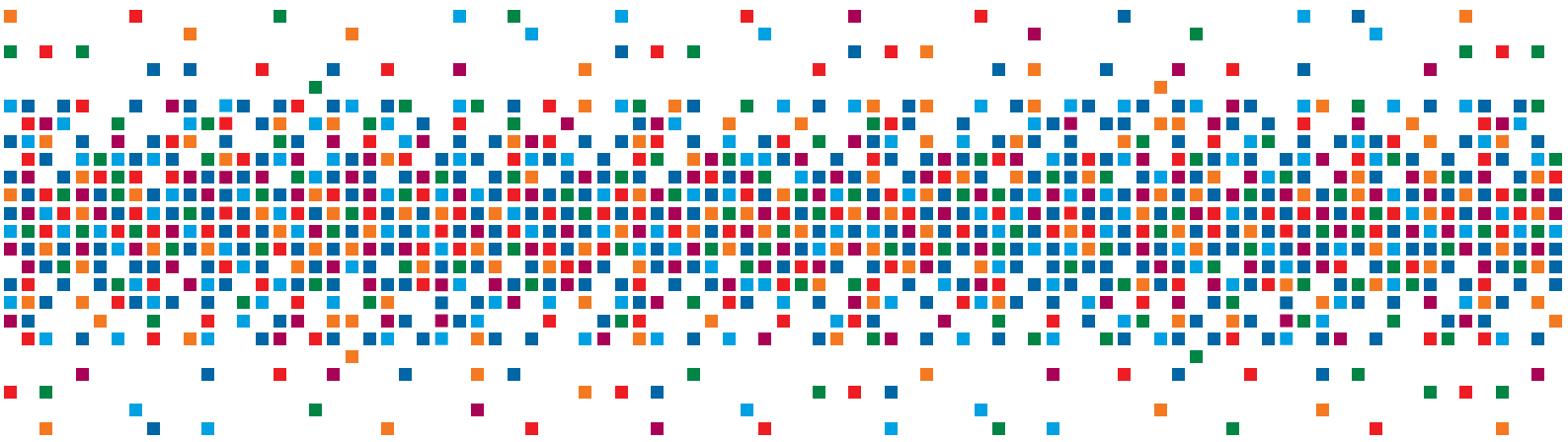
We administer the websites of Large Research Infrastructures of the Czech Republic and the e-INFRA CZ consortium.

In 2022 we published **21 press releases** and made **327 media appearances**.

130

This year we also went to unusual places where our services are provided, such as 130 metres underground in the Josef mine adit in the Příbram region and at the northernmost Czech research site in Spitsbergen.

Public relations



30 years of the internet
- an interview
with the director
of the Association
for Czech
Television



30 years of the internet - opening of the conference

The Department of Technologies for Network Applications received the Czech Head award



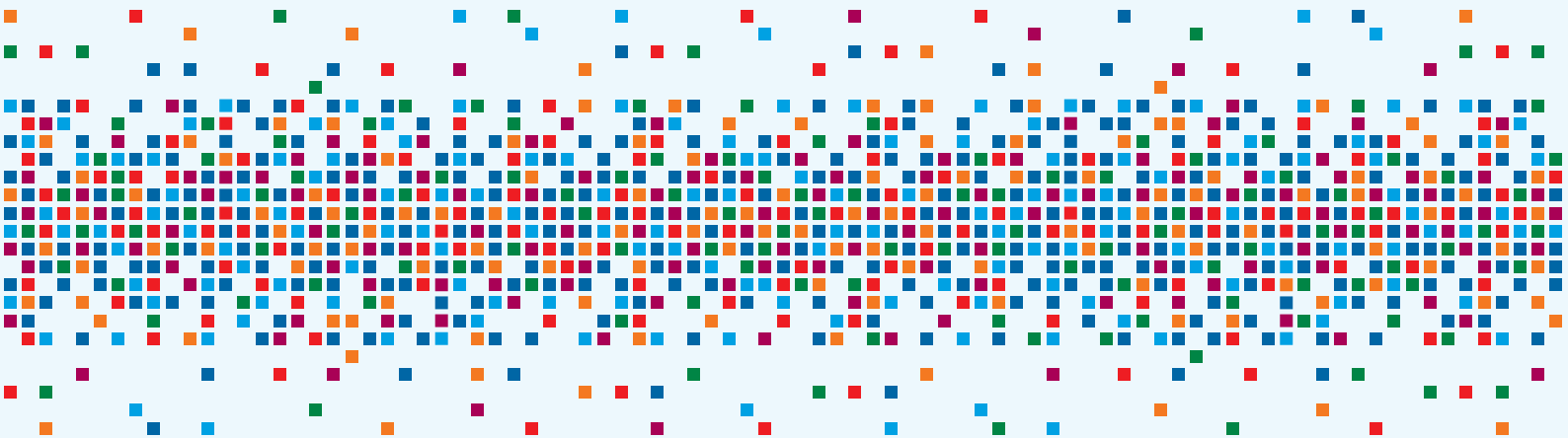
CESNET day at the Academy of Sciences

EGI International Conference



Winners of the competition 'The Catch 2022'

Economic results



Economic results in 2022

CESNET's activities are divided into two categories in accordance with its statutes: Principal activities and Supplementary (Economic) activities.

Principal activities

As part of its principal activities, the Association continued to build the qualitatively new CESNET e-infrastructure to provide a comprehensive set of services to Association members and other entities eligible for connection to the CESNET network.

The Association also participated in international research projects under the Horizon 2020 programme, national projects supported by the Ministry of Education, Youth and Sports, the Technology Agency of the Czech Republic, the Ministry of the Interior and the Ministry of Culture, and projects supported by the CESNET Development Fund Board, as already mentioned in the previous section of this Annual Report.

The Association's principal activities in 2022 generated an accounting profit of CZK 13,511,000 before tax. The revenue of the Association's principal activities amounted to CZK 693,926,000, and costs reached CZK 680,415,000.

The income tax base for principal activities in 2022 was positive, amounting to approximately CZK 24,233,000.

Economic activities

The Association's economic activities in 2022 consisted primarily in holding a prevalently bond-based portfolio of the Development Fund Board, comprising financial resources obtained by selling the commercial part of the CESNET network in 2000, and in managing financial resources in other funds.

The non-economic activities in 2022 generated an accounting profit of CZK 1,925,000 before tax. The revenue of the Association's economic activities in 2022 amounted to CZK 36,516,000, and the costs of the economic activities amounted to CZK 34,591,000.

The income tax base of the Association's economic activities in 2022 was positive, amounting to CZK 1,955,000.

Total accounting and taxable profit

The total book economic result of the CESNET Association before tax reported in 2022 was profit amounting to CZK 15,436,000.

The Association's total income tax base was CZK 26,188,000. The Association's total legal entity income tax for year 2022 amounted to CZK 4,985,000, giving a profit after tax of CZK 10,451,000.

Conclusion

In the past year CESNET managed the entrusted funds responsibly and properly, meeting all of its obligations resulting from legislation, decisions of the Ministry of Education, Youth and Sports of the Czech Republic and concluded contracts.

BDO Audit s. r. o., an auditing company with its registered office at the address V Parku 2316/12, Prague 4, Chodov, Chamber of Auditors authorisation No. 018, audited our financial statement. Its report, together with the financial statement, is part of this Annual Report.



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Independent Auditor's Report

To the members of the CESNET Association, an interest association of legal entities

Auditor's Statement

We have conducted an audit of the attached Financial Statement of the CESNET Association, an association of legal entities, with its registered office at the address Generála Píky 430/26, Dejvice, 160 00 Prague 6, Company Identification Number 638 39 172 (hereinafter referred to as the "Association"), drawn up on the basis of the Czech accounting regulations, consisting of a balance sheet as of 31 December 2022, a profit and loss statement for the period from 1 January to 31 December 2022, and annexes containing a description of the basic accounting methods used and other explanatory information.

In our opinion, the Financial Statement presents a true and honest picture of the Association's assets and liabilities as of 31 December 2022 and its revenue, expenses and profit or loss from the period between 1 January 2022 and 31 December 2022 in compliance with Czech accounting regulations.

Basis for the Statement

We conducted the audit in compliance with the Act on Auditors and Standards of the Chamber of Auditors of the Czech Republic, which are international standards for audit (ISA), where appropriate supplemented and modified by related application clauses. Our responsibilities established by these regulations is described in more detail in the Responsibilities of the Auditor for Auditing the Financial Statement section. In compliance with the Act on Auditors and the Code of Ethics adopted by the Chamber of Auditors of the Czech Republic, we are independent of the Association and we have also fulfilled other ethical obligations ensuing from the specified regulations. We believe that the evidence that we have collected provides a sufficient and suitable basis for our statement.

Other Information Presented in the Annual Report

According to Section 2(b) of the Act on Auditors, other information means information that is presented in the Annual Report but not in the Financial Statement or our Auditor's Report. The Association's Board of Directors is responsible for this information.

Our statement on the Financial Statement does not regard other information. However, it is part of the duty relating to the Financial Statement audit to familiarise ourselves with other information and judge whether this other information is not in significant conflict with the Financial Statement or our knowledge of the accounting unit that we gained while conducting the audit, or whether this information appears to be significantly incorrect in any other way. We also assess whether this other information has been prepared in all significant regards in compliance with applicable legislation. By this assessment we mean whether the other information meets legal requirements for formal matters and methods of preparing other information in the context of significance, i.e., whether potential failure to comply with the specified requirements could possibly influence a judgment made on the basis of the other information.



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Based on the methods used, to the extent that can be judged, we state that:

- other information describing facts that are also subject to representation in the Financial Statement complies in all significant respects with the Financial Statement, and

- other information has been prepared in compliance with legislation.

We are also obliged to state, based on our findings and knowledge of the Association that we acquire while conducting the audit, whether the other information contains any significant factual inaccuracies. Within the scope of the specified procedures, we did not find any significant factual inaccuracies in the other information received.

Responsibilities of the Board of Directors and Supervisory Board of the Association for the Financial Statement

The Board of Directors of the Association is responsible for compiling a Financial Statement that presents a true and honest picture in compliance with Czech accounting regulations, and for such an internal control system that it considers essential for compiling the Financial Statement so that it does not contain significant factual inaccuracies caused by fraud or error.

When compiling the Financial Statement, the Board of Directors of the Association is obliged to judge whether the Association is capable of remaining in continuous existence and, if relevant, to attach an annex to the Financial Statement describing matters regarding its continuous existence and projections for its continuous existence in the future used while compiling the Financial Statement, except in the case that the Board of Directors plans to or has no other real choice than to liquidate the Association or to terminate activities.

Supervision of the financial reporting process is the responsibility of the Supervisory Board.

Responsibilities of the Auditor for Auditing the Financial Statement

Our aim is to obtain reasonable assurance that the Financial Statement as a whole is does not contain any significant factual inaccuracies caused by fraud or error, and to submit an auditor's report expressing our opinion. A reasonable level of assurance is a high level of assurance, but is not a guarantee that the audit conducted in compliance with the regulations specified above will uncover the potential existence of significant inaccuracies in the Financial Statement in all cases. Significant inaccuracies can result from fraud or error, and are considered significant if we can realistically suppose that they could individually or collectively influence a financial decision that a user of the Financial Statement adopts on its basis.

When conducting the audit in compliance with the regulations specified above, it is our duty to use our professional judgement throughout and to maintain professional scepticism. It is also our duty:

- to identify and evaluate risks of significant inaccuracies in the Financial Statement caused by fraud or error, to propose and conduct auditing procedures that respond to such risks and to obtain sufficient and suitable evidence on the basis of which we can express our opinion. The risk of not uncovering a significant inaccuracy caused by fraud is higher than

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the risk of not uncovering a significant inaccuracy caused by error as fraud can make use of collusions, falsification, deliberate omissions, untruthful declarations or circumvention of internal controls.

- to familiarise ourselves the Association's internal control system relevant to the audit to such an extent that we can propose auditing procedures that are suitable with regard to the specific circumstances, but not so that we can express an opinion on the efficiency of the internal control system.

- to assess the suitability of the accounting rules used and the adequacy of the accounting estimates made and the information that the Board of Directors presents in an annex to the Financial Statement in this regard.

- to assess the suitability of the projections used by the Board of Directors for continuous future existence when compiling the Financial Statement and whether, with regard to the evidence gathered, there is a significant uncertainty ensuing from events or conditions that could significantly cast doubt on the Association's ability to continue to exist. If we reach the conclusion that such a significant uncertainty exists, it is our duty to point out in our report the information presented in this regard in the annex to the Financial Statement and, if this information is not sufficient, to express an altered opinion. Our conclusions regarding the capability of the Association to continue to exist are based on evidence that we gathered up to the date of our report. However, future events or conditions could cause the Association to cease to exist.

- to assess the overall presentation, structure and content of the Financial Statement, including annexes, and whether the Financial Statement depicts underlying transactions and events in a manner that results in a true representation.

It is our duty to inform the Board of Directors, among other things, of the planned scope and timing of the audit and of significant findings that we make in the course of the audit, including discovered significant inadequacies in the internal control system.

BDO Audit s. r. o.

Prague, 26 May 2023

Auditing company:

BDO Audit s. r. o.
Registration number 018

Statutory auditor:

[illegible signature]
Ing. Ondřej Šnejdar
Registration number 1987

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