

Progress Report on the Implementation of the Large Research, Experimental Development and Innovation Infrastructure (LI) CzechGeo/EPOS in 2015

Full name of the LI: CzechGeo/EPOS – Distributed System of Permanent Observatory Measurements and Temporary Monitoring of Geophysical Fields in the Czech Republic – Development and Operation of the National Node of the Pan-European EPOS Project

LI's code: LM2010008

Recipient: Institute of Geophysics of the AS CR, v.v.i., Boční II./1401, 141 31 Praha 4, Id. No. 67985530 (IG ASCR)

Another participant/s of the LI:

Institute of Rock Structure and Mechanics of the ASCR, v.v.i., Praha (IRSM ASCR)

Institute of Geonics of the ASCR, v.v.i., Ostrava (IGN ASCR)

Institute of Physics of the Earth, Faculty of Sciences, Masaryk University in Brno (IPE MU)

Department of Geophysics, Faculty of the Mathematics and Physics, Charles University in Prague (FMP CU)

Institute of Hydrogeology, Engineering Geology and Applied Geophysics, Faculty of Science, Charles University in Prague (FS CU)

Research Institute of Geodesy, Topography and Cartography, v.v.i., Zdíby (RIGTC)

Principal investigator of the LI: RNDr. Pavel Hejda, CSc.

Resolution of the Government of the day, number: 15 March 2010, number 207

Start of the LI's financing: 7 October 2010

The main mission of the LI (max. 500 characters):

Permanent observatories and temporary monitoring networks of geophysical fields in the Czech Republic are carried out by several universities and public research institutes. Integration of these infrastructures on the national level and in the frame of the ESFRI Roadmap European Plate Observing System (EPOS) project is aimed at conceptual development, stable operation and improved data services for user community.

A. Scientific and Technological Excellence

1. Research Team

List the members of research team (all persons that are paid via personnel costs), append brief job descriptions and classifications including their full-time equivalent (lowest, highest and average) and overall budget; distinguish as well between permanent and temporary staff.

The project money does not cover personal costs of all persons engaged in the development

and operation of observatory infrastructures. The budget had to be completed by institutional money. Forty-one persons (17,3 FTE) are paid via project personnel costs. The average load is 0,42 FTE. Short term labour contracts are mostly made with local people who help with operation of observatories. The complete list is in Appendix 3.

2. Scientific results

I. Indicate the main scientific results achieved on the basis of the infrastructure's use during last period of time. Present single results according to valid methodology of CRDI (Council for Research, Development and Innovation), if possible J type results supplement with impact factor according to WoK or Scopus. Among these results specify 10 most important ones.

II. Indicate the main scientific results (not more than 10) achieved on the basis of the LI's use (its Czech branch in case of distributed research infrastructure) by its users, if possible to attest. Present single results according to valid methodology of CRDI (Council for Research, Development and Innovation), if possible J type results supplement with impact factor according to WoK or Scopus.

Ad I. Main scientific results achieved by internal workers

Papers in journals with IF

1. Bachura, M. - Fischer, Tomáš (2015). Coda attenuation analysis in the West Bohemia/Vogtland earthquake swarm area. Pure and Applied Geophysics, 172, DOI: 10.1007/s00024-015-1137-3, **IF =1.618**
2. Briestenský M., Rowberry M. D., Stemberk J., Stefanov P., Vozár J., Šebela S., Petro L., Bella P., Gaal L., Ormukov Ch. (2015): Evidence of a plate-wide tectonic pressure pulse provided by extensometric monitoring in the Balkan Mountains (Bulgaria). Geologica Carpathica, 66, 5, 427-438. doi: 10.1515/geoca-2015-0035 **IF = 0.761**
3. Brokesova J., Malek J. (2015): Six-degree-of-freedom near-source seismic motions II: Examples of real seismogram analysis and S-wave velocity retrieval. Journal of Seismology, 19, 2, 511-539, DOI: 10.1007/s10950-015-9480-5. **IF = 1.386**
4. Čermák V., Bodri L., Krešl M., Dědeček P. and Šafanda J. (2015): Eleven years of ground-air temperature tracking over different land cover materials, International Journal of Climatology. (submitted in 2015, in review). **IF=3.157**
5. Čermáková, H., Horálek, J. (2015). The 2011 West Bohemia (Central Europe) earthquake swarm compared with the previous swarms of 2000 and 2008. *J. Seismol.*, **19/4**, 899-913, doi: 10.1007/s10950-015-9502-3. DOI: 10.1007/s10950-015-9502-3, **IF=1.388**
6. Flechsig, Ch., Heinicke, J., Mrlina, J., Kämpf, H., Nickschick, T., Schmidt, A., Bayer, T., Günther, T., Rücker, C., Seidel, E. and Seidl, M. (2015): Integrated geophysical and geological methods to investigate the inner and outer structures of the Quaternary Mýtina maar (W-Bohemia, Czech Republic). – *Int J Earth Sci (Geol Rundsch)*, 2087-2105, DOI 10.1007/s00531-014-1136-0. **IF = 2.093**
7. Kalenda P, Wandrol I., Holub K., Rušajová J. (2015). The Possible Explanation for Secondary Microseisms Seasonal and Annual Variations. *Terr. Atmos. Ocean. Sci.*, 26, 103–109. **IF = 0.703**
8. Kalenda, P., Wandrol, I., Holub, K. and Rušajová, J., 2015. The Possible Explanation for

- Secondary Microseisms Seasonal and Annual Variations. *Terrestrial Atmospheric and Oceanic Sciences*, 26, 2, 103-109. ISSN 1017-0839. **IF=0.703**
9. Kämpf, H., Németh, K., Puziewicz, J., Mrlina, J. and Geissler, W.H. (2015): From mantle roots to surface eruptions: Cenozoic and Mesozoic continental basaltic magmatism. – *Int J Earth Sci (Geol Rundsch)*, 1909-1912, DOI 10.1007/s00531-015-1252-5. **IF = 2.093**
 10. Lednická, M. and Kaláb, Z. (2016). Vibration effect of near earthquakes at different depths in shallow medieval mine. *Acta Geophysica*, (in print)
 11. Klimes, L. & Bulant, P. (2016). Prevailing-frequency approximation of the coupling ray theory for S waves. *Stud. geophys. geod.*, 60, in press. **IF=0.806**
 12. Kostecký Jan, Douša, J., Kostecký Jakub, Václavovic P.: Analysis of Time Series of Station Coordinates – a Comparison of the Network and PPP Approach. *Acta geodynamica and geomaterialia*, vol. 12, No. 2(178), 2015. pp 127-133 DOI: 10.13168-AGG.2015.0019. **IF=0.389**
 13. Majorowicz J., Osadetz K. and Šfanda J. (2015): Models of Talik, Permafrost and Gas Hydrate Histories—Beaufort Mackenzie Basin, Canada. *Energies* 8(7), 6738-6764. DOI:10.3390/en8076738. **IF=2.072**
 14. Majorowicz J., Šafanda, J. (2015): Effect of postglacial warming seen in high precision temperature log deep into the granites in NE Alberta. *Int J Earth Sci (Geol Rundsch)*, 104, 1563–1571. DOI 10.1007/s00531-014-1075-9. **IF=2.093**
 15. Mullick, N. - Buske, S. - Hrubcová, Pavla - Růžek, Bohuslav - Shapiro, S. - Wigger, P. - Fischer, T. (2015). Seismic imaging of the geodynamic activity at the western Eger rift in central Europe. *Tectonophysics*, 647-648, 105-111., DOI: 10.1016/j.tecto.2015.02.010, **IF = 2.866**
 16. Nickschick, T., Kämpf, H., Flechsig, C., Mrlina, J. and Heinicke, J. (2015): CO₂ degassing in the Hartoušov mofette area, western Eger Rift, imaged by CO₂ mapping and geoelectrical and gravity surveys. – *Int J Earth Sci (Geol Rundsch)*, 2107-2129, DOI 10.1007/s00531-014-1140-4. **IF = 2.093**
 17. Novotný O., Málek J., Boušková A.: Wadati method as a simple tool to study seismically active fault zones: a case study from the West-Bohemia/Vogtland region. *Studia Geophysica et Geodaetica*, in print. **IF = 0.806**
 18. Novotný, O., J. Vackář, and E. Sokos (2015). Dispersion of Love waves from the 2010 Efpalio earthquake in the Corinth Gulf region, Greece. *J. of Seismology*, 19, 801–806. **IF=1.386**
 19. Novotný, O., Málek, J. & Boušková, A. (2016): Wadati method as a simple tool to study seismically active fault zones: a case study from the West-Bohemia/Vogtland region, central Europe. *Stud. Geophys. Geod.*, (in press), **IF = 0.806**
 20. Růžek, B., Valentová, L., Gallovič, F. (2016). Significance of geological units of the Bohemian Massif, Czech Republic, as seen by ambient noise interferometry, *Pure Appl. Geophys.*, in press. **IF=1.618**
 21. Sokos, E., Kiratzi, A., Gallovič, F., Zahradník, J., Serpetsidaki, A., Plicka, V., Janský, J., Kostecký, J., Tselentis, G-A. (2015). Rupture process of the 2014 Cephalonia, Greece, earthquake doublet (Mw6) as inferred from regional and local seismic data, *Tectonophysics*, 656, 131-141. Electronic supplement. **IF=2.872**
 22. Stemberk J., Briestenský M., Cacon S. (2015): The recognition of transient compressional fault slow-slip along the northern shore of Hornsund Fjord, SW Spitsbergen, Svalbard.

Polish Polar Research, 36, 2, 109-123. doi: 10.1515/popore-2015-0007 **IF = 1.275**

23. Zahradník, J., J. Janský, V. Plicka (2015). Analysis of the source scanning algorithm with a new P-wave picker. *J Seismol* 19, 423–441. **IF=1.386**

Papers in other journals

24. Bulant, P. & Klimes, L. (2015): Nonlinear hypocentre determination. *Seismic Waves in Complex 3-D Structures*, 25, 17-36.
25. Bucha, V. & Klimes, L. (2015): Nonlinear hypocentre determination in the 3-D Western Bohemia a priori velocity model. *Seismic Waves in Complex 3-D Structures*, 25, 37-50.
26. Bucha, V. (2015): Kirchhoff prestack depth migration in a homogeneous triclinic velocity model for P, S and converted waves. *Seismic Waves in Complex 3-D Structures*, 25, 89-102.
27. Hoppe A., Košťák B., Kuhn G., Lehné R., Simons U., Stemberk J. (2015): Rezente Bewegungen an den Haupttrandverwerfungen im Nördlichen Oberrheingraben. – *Jber. Mitt. oberrhein. geol. Ver., N.F. 97*, 321-332, Stuttgart. doi: 10.1127/jmogv/97/0014
28. Kalenda, P., Neumann, L., Kvetko, J., Nazarevych, A., Boborykina, O. (2015): Detekce napěťových vln ve střední Evropě. Nové poznatky a měření v seizmologii, inženýrské geofyzice a geotechnice - OVA'15. Ostrava 7.4.2015. *EGRSE Journal*, 2015/1, 10-17. ISSN 1803-1447.
29. Kaláb, Z., Lednická, M., Kaláb, T., Knejzlík, J., 2015. Evaluation of vibration effect in shallow mine caused by natural and technical seismicity. 15th International Multidisciplinary Scientific Geoconference SGEM 2015, Albena, Bulgaria, Conference proceedings, Science and Technologies in Geology, Exploration and Mining, Vol. III, 855 – 862. ISBN 978-619-7105-33-9, ISSN 1314-2704, DOI: 10.5593/sgem2015B13
30. Klimes, L. (2015): Determination of the reference symmetry axis of a generally anisotropic medium which is approximately transversely isotropic. *Seismic Waves in Complex 3-D Structures*, 25, 177-185.
31. Klimes, L. & Bulant, P. (2015): Ray tracing and geodesic deviation of the SH and SV reference rays in a heterogeneous generally anisotropic medium which is approximately transversely isotropic. *Seismic Waves in Complex 3-D Structures*, 25, 187-208.
32. Pazdírková J., Zedník J., Prachař I., Krumlová H., Zacherle P. 2015 Zeměřesení v Hostěradicích v červnu 2014. *Geol. výzk. Mor. Slez.*, 22, 1-2, 61-64.
33. Špaček, P., Ambrož, V., Tábořík, P., Štěpančíková, P. (2015): Digging for records of slow fault slip in the region with strong Pleistocene periglacial mass wasting: experience from the Bohemian Massif (Alpine-Carpathian foreland). In: Blumetti A.M. et al. (eds.): 6th International INQUA Meeting on Paleoseismology, Active Tectonics and Archaeoseismology, 19-24 April 2015, Pescina, Fucino Basin, Italy *Miscellanea INGV* 27, 471-474.

II. Scientific results achieved on the basis of the infrastructure's use by external workers

Papers in journals with IF

34. Kolář, Petr, Růžek, Bohuslav (2015). Estimation of finite seismic source parameters for selected events of the West Bohemia year 2008 seismic swarm. *Journal of Seismology*. 19, 403-421. DOI: 10.1007/s10950-014-9474-8, **IF = 1.388**
35. Kolář, Petr (2015). Estimation of parameters of finite seismic source model for selected event of West Bohemia year 2008 seismic swarm-methodology improvement and data extension. *Journal of Seismology*, 19, 935-947, DOI: 10.1007/s10950-015-9504-1, **IF = 1.388**

36. Růžek, Bohuslav, Valentová, L., Gallovič, F. (2015). Significance of geological units of the Bohemian Massif, Czech Republic, as seen by ambient noise interferometry. *Pure and Applied Geophysics*, 172, DOI: 10.1007/s00024-015-1191-x, **IF = 1.618**
37. Valentová, L. - Gallovič, F. - Růžek, Bohuslav - de la Puente, J. - Moczo, P (2015). Choice of regularization in adjoint tomography based on two-dimensional synthetic tests. *Geophysical Journal International*. 202, 787-799. DOI: 10.1093/gji/ggv183, **IF = 2.560**
38. Vavryčuk V., Kim So Gu, 2014. Nonisotropic radiation of the 2013 North Korean nuclear explosion. *Geophysical Research Letters* 41, 20, 7048-7056. Doi: 10.1002/2014GL061265 IF=4.196
39. Vavryčuk, Václav (2015). Determination of parameters of viscoelastic anisotropy from ray velocity and ray attenuation: Theory and numerical modeling. *Geophysics*. Roč. 80, č. 3 (2015), C59-C71. DOI: 10.1190/GEO2014-0355.1, **IF = 1.662**

Papers in other journals

40. Růžička V. (2015): Statistické zhodnocení seismické aktivity zóny Mur-Mürz-Leitha. - *Gelogické výzkumy na Moravě a ve Slezsku*, 22, 1-2, 65-68

3. Utilisation of the LI

Describe utilisation of the LI's capacity (according to the type and scientific field of the LI describe the percentage utilisation, eventually number of accesses, volume of produced, stored or provided data, distribution of users by their affiliation – universities, public research institutions, industry). In case of construction of the LI describe the current status or data from performed tests or limited service providing, etc.

The backbone of the infrastructure consists of permanent observatories that work in non-stop regime. The use of infrastructure is thus 100 per cent. Data are on-line sent to data centres and are free available for non-commercial use. We suppose that the general distribution of users is Universities 40%, Research Institutes 50%, Industry and public authorities 10%. In addition, most observatory data are displayed on the web of the project and on the web of host institutions

Czech Regional Seismic Network consists of 19 permanent broadband observatories operated by the institutions involved in the Consortium. Digital records of the stations are transferred in real time to data centers at IG-ASCR Prague and IPE Brno.ÚFZ. Data are automatically processed, archived and exchanged with international and national data centers. In case of strong regional or global earthquakes, automatic alert messages are sent to international data centers, Integrated rescue system and to other interested subjects. Monthly bulletins of station readings, and regional catalogues of earthquakes as well as digital data are available through the seismic portal of the CzechGeo project.

Almost all the WEBNET data which have been recorded since the deployment of the network in 1992 have been utilised in the domestic as well as European geoscience institutes, mostly in Germany. Data from the WEBNET network served as a resource for more than 10 doctoral and master theses here and in Germany. At present the data are used by 4 PhD students in Czech Republic (2 PhD student of the Faculty of Mathematics and Physics and 2 of the Faculty of Science, Charles University), and 4 PhD students in Germany (Potsdam University, Leipzig University and Freiberg University).

The group investigating the geodynamics of earthquake swarm areas deals prevalingly with monitoring of the active zone of West Bohemia, a part of the MOBNET pool supports the WEBNET stations on the long-term basis. In 2013, the project REYKJANET was initiated, consisting of 15 stations from the MOBNET pool which monitors the active zone Reykjanes in South Iceland, with the observation period estimated to 3 years. At present the data are used by 2 PhD students in Czech Republic (2 PhD student of the Faculty of Mathematics and Physics, Charles University) and 1 PhD students in Germany (Potsdam University University).

Infrastructure devices of PSLNET (8 broad-band seismographs and 10 accelerographs) work in a continual mode and deliver the data to the data centre of the Patras University, from where the data are further distributed to partner organizations, especially to universities, research institutions and international data centres. Infrastructure in 2015 was confronted with the technical problems more than in other years (two seismographs in repair, power break, due to the fallen tree on the line), so the infrastructure provided less data than the previous years (148 GB). Most of the data are used by the research community. The representation of the universities and research institutions is roughly equal.

According to the monitoring, the Seismological software centre provided 119591 files with total extent of 82 GB of data in year 2015.

Institute of the Physics of the Earth operates 4 broadband stations and local seismic network MONET consisting of 6 short-period stations. In the region covered by MONET network approx. 170 natural local microearthquakes with $M < 2.3$ were registered. In the records of broadband stations more than 13000 seismic event (mostly from central Europe) were identified and processed.

With regard to a few medium intensity local earthquakes in 2014 near Nový Kostel we carried out another campaign of precise levelling with the aim to evaluate surface vertical movements related to the post-seismic period

CO₂ flow data from the CarbonNet network were subject to enhanced interest of German colleagues due to possible anomalies related to the occurrence of several stronger earthquakes at spring/summer 2014.

Our industrial partner in the coal mining company Severočeská energetická, a.s., Most, continues to require a document on our monitoring of unstable slopes of the Krušné hory Mts. In the surroundings of the historici Castle Jezeří located just above the Mine ČSA. They include it into their report for the Mining Bureau. We consider this fact as a confirmation of the importance of our observatory data.

We re-observed both networks of GREVOLCAN in volcanic islands of Nisyros and Thira in Greece necessary for the startup of work on a complex publication focused at the dynamics of volcanoes in cooperation with colleagues at the Kapodistrian University of Athens.

The GNSS network VESOG consists of 8 stations now. The stations work in permanent regime and the data are distributed to International GNSS service's data centre (IGS - 3 stations), to EUREF Permanent Network (EPN – 3 stations) and to Network of permanent GNSS stations of Czech Republic – CZEPOS (3 stations). The data are also available after request (for example from Faculty of Electrical Engineering of Czech Technical University in Prague) and the data are

also used in processing and further analysis in the Research Institute of Geodesy, Topography and Cartography.

In the cooperation of the Department of geophysics of Faculty of Mathematics and Physics of Charles University, the Research Institute of Geodesy, Topography and Cartography and the Seismological Laboratory of University of Patras (Greece) the PPGNet – network of GNSS stations in Greece – was build. The network consists of 6 stations. Beside the VALY station at middle-west part of Pelopones peninsula other stations are located at the north from Patras Gulf on the west of Greece. The data are – beside of using for monitoring of geodynamic movements related with earthquake – transferred to National Observatory of Athens and they are available for use in the Corinth Rift Laboratory. Newly, the data from 3 stations are distributed to the METRICA S.A. company and the data from nearest stations are received reciprocally.

The gravimetric laboratory at the Geodetic Observatory Pecny performs daily campaign with absolute gravimeter FG5 No. 215 on month basis and continuous observations with superconducting gravimeter OSG-050. The second absolute gravimeter FG5X No. 251 was put on operation but it was send for warranty repair to producer in second part of year. The data are distributed to the International Gravity and Earth Tides Service and they also processed at the Research Institute of Geodesy, Topography and Cartography.

The network TECNET operates recently 167 stations monitoring fault active displacement. The frequency of recording in Automated stations is between 10 minutes and 1 hour (EU: CZ: Bedřichov Gallery, Šeptouchov Cave, Na Pomezí Cave, 13C Cave; Travná Gallery, Zbrašov Aragonite Caves, Koněprusy Caves, Strašín Cave Germany: tunnel Wattkopf; tunnel Loretto; Swiss: Deep underground rock laboratory Grimsel; Slovenia: cave Postojna; Austria: cave Eisenstein Hohle, cave Emmeberg Hohle, cave Obir Hohle, cave Pottstein Hohle, cave Zede Hohle; Italy: underground space Norcia, Mattinata; Canary Islands: gallery Tijirote on El Hierru; Slovakia: Čachtická cave; Svalbard: Hornsund 2; Belgium: Rochefort Cave; out of EU: USA: Imler, Anza (CA); Peru: gallery Nana by Lima). Other stations (EU: CZ, Poland, Germany, Slovenia, Italy, Bulgaria, Slovakia, Greece, Canary Islands, Svalbard; out of EU: Peru, Kyrgyzstan, Ethiopia) are operated with a manual reading with frequency 14 to 30 days. The data are centrally processed and archived in the IRSM.

GNSS measurements on GEONAS network are carried out on 19 stations in continuous mode (30 s). The data transfer to IRSM is also continuous. The data are there archived and further processed.

The network of tiltmeters TILTNET consists of 14 vertical static pendulums in 11 localities, mostly in the underground (Praha, Příbram, Ida Gallery, cave No. 13C in Moravian Karst, Karlovy Vary, Lubeník (Slovakia), Beregovo (Ukraine), Sevastopol (Russia), Magdalena jama (Slovenia), Trebiciano abyss (Italy), Garni (Armenia)). The newest stations Garni (Armenia) and Karlovy Vary were put into the operation at the end of 2014. All of data are transmitted on-line to the server in Prague. The data are pre-processed and transmitted to internet for next public use.

4. Cooperation

I. Indicate newly established or running cooperation within the Czech Republic and abroad with research institutions, industry and other entities using results of the LI.

II. Indicate newly established or running cooperation with other research infrastructures in the field, both Czech and foreign ones.

Only newly established cooperation is described in this section. The list of all cooperation is in Appendix 4. There are 6 home research institutions and universities, 13 private companies and institutions of public administration, 111 foreign partners and 23 cooperating infrastructures.

Ad I.

The Seismological software centre established cooperation with University of Bergen, Norway. The aim is to cooperate during development and application of seismological software.

Memorandum on cooperation in the underground laboratory in Garni and data exchange was signed between IRSM and Survey for Seismic Protection" Agency (MES of Republic of Armenia).

Memorandum on cooperation and data exchange in the field of geodynamic processes, active tectonics and monitoring of seismicity and fault slips was signed between IRSM and The University of Arba Minch in the frame of TecNet in 2015.

Memorandum of Understanding was signed between METRICA S.A. company, The Research Institute of Geodesy, Topography and Cartography, Geodetic Observatory Pecny (RIGTC) and The Charles University in Prague, Faculty of Mathematics and Physics, Department of Geophysics (FMP CU). Main topic is exchange of data between stations of PPGNet network and nearest stations of METRICA network in Greece.

U.S. Naval Observatory, USA – development of a unique database system (GOP-TropDB) for intra-/inter-space-geodesy-technique comparisons of tropospheric and meteorological parameters in support of research and applications in space geodesy, meteorology and climatology.

Ad II.

Institute of the Physics of the Earth joined the Central and Eastern European Earthquake Research Network (CE3RN) for cooperation in the field of seismological data acquisition, exchange and use for seismological and earthquake engineering and civil protection purposes.

5. Service to Science Community

Indicate the number of users (eventually number of accesses) of the LI from the Czech Republic and abroad. Indicate the number of conferences and seminars organized by the LI, including the number of participants from the Czech Republic and abroad. Indicate the number of meetings with users and the feedback results thus obtained. Indicate the number of agreements with other institutions (e.g. contracts, memoranda).

The basic service for research community consists in continuous observations of geophysical fields and publication of data via international networks. The number of users cannot be

plausibly estimated. For example, number of accesses of portal www.tecnet.cz was 32 685 (40% of new visitors) users data of Geomagnetic Observatory Budkov have been download from www.intermagnet.org server by about 80 unique users per year. However, most data portals do not have such statistics. Twenty-one new users of Seismologic software centre were registered, including twenty users of program ISOLA.

Users of the infrastructure are, of course, all cooperating institutions. Stays of foreign workers on observatories are quite exceptional, sometimes for comparison measurements or training.

Selected users from commerce or public administration:

- Broadband seismic station VRAC is a part of international monitoring system CTBTO - Comprehensive Nuclear-Test-Ban Treaty Organization
- SÚRAO (agency managing repositories of nuclear waste) subscribes to reports on the seismicity of Czech Republic and Central Europe quarterly.
- RWE (gas distribution company) subscribes to annual reports on the seismicity on the territory of Czech Republic, and to alerts of increased earthquake activity.
- ČEZ (power plant operator) is provided by regular reports on seismicity in the region of the two Czech nuclear power plants.
- The company VODNÍ DÍLA-TBD subscribes to the WEBNET data monitoring the West Bohemia earthquake swarms. We deliver annual reports on seismic activity and alerts in case of increased activity resulting in earthquakes above magnitude 3, the alerts contain data on the ground displacement and ground acceleration amplitude. In 2015, the data from an intense earthquake activity in May 2014 were used for an updated assessment of the earthquake hazard related to the water storage Horka, which is situated just in the epicentre area Nový Kostel.
- Communal offices within the districts Cheb and Sokolov subscribe to the alerts of increased earthquake activity.
- New users of GNSS data are Institute of Atmospheric Physics of the ASCR and U.S. a Naval Observatory, USA (USA-CR bilateral project)
- GNSS stations of PPGNet network are used by Greece company METRICA based on the "Memorandum of Understanding" concluded in 2015.
- Severočeská energetická, a.s., Most – monitoring of unstable slopes of the Krušné hory Mts. In the vicinity of the Castle Jezeří just over the mine ČSA. Also the Reserach Institute of Brown Coal in Most is interested in our data – we start data exchange in 2016.

Conferences, Workshops

- 16th Czech-Polish Workshop „On recent geodynamics of the Sudeten and the adjacent areas“, Srebrna Góra, 5.-7.11.2015 organized by IRSM, many contributions used data from GEONAS and TecNet, about 100 participants from Czech Republic, Slovakia and Poland.
- IRSM and IGN organised in Ostrava on July 3, 2015 workshop „Precursors of the seismicity on the global scale“.
- At the General Assembly of IUGG Prague Istanbul, Turkey, the session Seismological Observation and Interpretation: Seismic Swarms and Tectonic Tremors was convened by T. Fischer a T. Yamashita, H. Horálek and Dahm. Contributions based on the WEBNET data formed significant part of the session. About 80 persons participated in the event .
- In the frame of conference OVA'15 New knowledge and measurements in seismology, engineering geology and geotechnics (7.-9.4.2015) a session devoted to CzechGeo/EPOS

was organized (about 60 participants from CZ, SK a PL)

- Workshop "Active and passive seismics in laterally inhomogeneous media", June 8-12, 2015, Loucen Castle, Czech Republic (32 participants).
- In the frame of international workshop Best Practices in Physics-based Fault Rupture Models for Seismic Hazard Assessment of Nuclear Installations (Vienna, 18. - 20. November 2015), excursion to NPP Dukovany was co-organised and talk on monitoring of seismicity for Czech NPPs was given. (ca 30 participants)
- Joint meeting of Seismological services (Austria, Czech Rep., Slovakia, Hungary) (Vienna 20. - 21. 10. 2015) (24 participants)

6. Internationalisation

Indicate the number of international research grants gained by research team, their names, a brief description and financial volume.

H2020-INFRADEV-1-2015-1, EPOS-IP (Grant agreement No. 676564) – implementation phase of European observatory infrastructure EPOS, 1.10-2015 – 30.9.2019, 18,37 mil EUR, IG ASCR 132 500 EUR, RIGTK 125 000 EUR.

Evaluation of tectonic movements along the faults, project LH12078 (Kontakt II)- 2012-2015, spolupráce s University of San Diego, CA, 3 mil. CZK

Scientific Co-operation Agreement GZ 4150/15-23a/92, partner: Central Institute for Meteorology and Geodynamics, Department of Geophysics, Hohe Warte 38, A-1190 Vienna, Austria, 1,2 mil CZK yearly.

Active tectonics and recent dynamics of micro-displacements along major fault systems of the Eastern Alps registered in caves (SPELEOTECT) – 2013-2016. Principal investigator Naturhistorische Museum Wien, 5.000 EUR in 2015.

ESA project ITT AO/2-1610/14/NL/CVG DARTMA – Development and Assessment of Regional Tropospheric Model for Augmented GNSS Position and Navigation, 2014-2015 – improvement of GNSS localisation based on augmentation info from surface stations with introduction of tropospheric effects from regional model - about 2 mil. CZK.

LASMO (Large Scale Monitoring Project) 2014 – 2018 – monitoring fault active displacement in underground laboratory Grimsel (Switzerland) – cca 0,5 mil. CZK yearly (2,8 mil. CZK altogether)

GACR project El Hierro megalandslide dynamics analysed using "big data" to predict the future behaviour of megalandslides on other volcanic island – 2016 – 2018 – about 3.4 mil CZK

COST Action ES1206 „Advanced Global Navigation Satellite Systems tropospheric products for monitoring severe weather events and climate – „GNSS4SWEC“ (Dr. Michal Kačmárik, Dr. Jonathan Jones)

„Norwegian Funds“ - project NF-CZ08-OV-1-006-2015 Preparation of a Research Pilot Project on CO2 Geological Storage in the Czech Republic (REPP-CO2). Cooperation with International Research Institute of Stavanger (in 2015 ca 1 mil CZK).

7. Multidisciplinarity

Indicate the number and titles of scientific disciplines that use the LI's services. Append particular results.

12 scientific disciplines. Numbers in brackets refers to results in the part A.1.

geodesy [11], geodynamics [14], geology [6], geomagnetism and geoelectricity [16], geomorfology [6], geotechnics[27], geothermics [4], gravimetry [16], meteorology and climatology [13], seismology [5], tectonics [2], volcanology [8].

8. Strategic Management of the Scientific Development of the Infrastructure

Indicate the main features of the scientific strategy of the LI, including plan for update of the technology used and plan of possible decommissioning.

The project is aimed at long-term stability in order to get time series as long as possible. Priorities are: continuous upgrade of observatory systems aimed at data quality enhancement, integration of data and continuous maintenance in order to ensure high reliability and 100% time coverage. On-line connecting of stations wherever technically possible and financially bearable belongs to permanent tasks. Cooperation with the infrastructure CESNET is developing successfully.

Upgrade will concentrate on improvement of reliability of measuring equipment, enhancement of their resolution and on improvement of data connection.

Managerial staff is in close contacts with the scientific community in corresponding branches and can thus guarantee that observatories and mobile systems will be on sufficiently high level that is necessary for achievement of scientific goals.

We have submitted proposal to the new call related to the upgrade of the Czech roadmap of large research infrastructures for the period 2016-2022. The consortium was completed by the Czech Geological Survey, because geological and geophysical data in databases managed by CGS are inevitable for complex interpretations. According to the resolution of the government, the LI will be supported by non-investment in the period 2016-19. The investments could be asked in the frame of Structural funds.

Strategic management of CzechGeo was coordinated with the EPOS PP, which the CzechGeo project team took active part in. EPOS PP was crowned by the preparation of preparatory documents for establishment of European legal body EPOS ERIC. Following-up project EPOS implementation phase was approved in April 2015. IG ASCR and RIGTC participate in this project. Pavel Hejda is coordinator of WP 13 Magnetic observations, Jan Douša coordinates task GNSS Data Dissemination in WP10 GNSS Data and Products and Jan Šílený is a leader of IG team in WP14 Anthropogenic Hazard. The project was started on 1 October 2016.

B. Stable and Efficient Management

1. The Efficiency of the Use of Funds

Describe and document by table the use of the provided grant for past period; primarily describe the personnel costs (e.g. number of jobs), overheads and investments. Describe the mechanism of calculation of overhead costs approved by the host institution. Indicate how the allocated funds are used in the context of the overall budget of the LI. Indicate the percentage of the budget of the LI that has been obtained from external international grants, in collaboration with industry or other entities using the LI's services.

The operation and maintenance of observatories and mobile systems is carried out by 41 (mostly graduated) technicians (17,22 FTE) financed by CzechGeo budget and 38 employees (20,5 FTE) paid by institutional or project money of corresponding institute or faculty. Separate components are managed by research workers. They should guarantee that the infrastructure will be developed in accordance with the needs of scientific community and other users. Their personnel costs are not paid from CzechGeo grant.

Labour capacities according to institutions (list of participating institutes and their acronyms is in Appendix 3.

	paid by CzechGeo		paid from other sources	
	employees	FTE	employees	FTE
IG ASCR	6	6,0	10	8,0
IRSM ASCR	16	5,8	10	7,0
IGN ASCR	4	0,9	2	0,3
IPE MU	4	1,5	6	3,0
FMP CU	2	1,75	1	0,1
FS CU	2	0,65	1	0,1
RIGTC	5	1,3	7	1,5
Total	41	17,3	37	17

Beneficiaries do not have an analytical accounting system to fully identify their indirect costs. The overheads of projects are transferred to a common account that is used for covering costs of energy, maintenance, cleaning, cost of administrative staff, etc. The overhead costs are less than 7% of the project budget and do not cover indirect costs related to the project.

The investments were concentrated on improving the quality of instrumental basis, strengthening of computing capacity for storage, processing and accessing data and on high quality internet access for observatories. Investments are listed in the Financial sheets and justified in part B.3.

Large items in the running costs are electrical energy (power supply of instruments and heating of observatory huts), telecommunications (data transfer from many remote localities), repairs and maintenance of instruments. Travel costs were mostly spent on trips to observatories and stations or for field survey.

The project money was entirely used in benefit of the observatory infrastructure and in accordance with the project targets. The funding had to be completed by additional, mostly institutional sources. These costs are estimated in the bellow table/

Financing of the observatory infrastructure. Funding by CzechGeo and other public sources

(institutional money, grants) in thousands of CZK.

	IG ASCR	IRSM ASCR	IGN ASCR	IPE MU	FMP CU	FS CU	RIGTC	Total
CzechGeo	7 061	7 101	504	1 575	1 175	458	1 575	19 989
other	4 800	5 500	35	2 800	20	100	1 400	14 655

2. Stable Management

Describe your plan for human resources development. Describe your strategy for allocation of the LI's capacity. Provide an organizational chart of the LI, changes in staffing of the LI. Indicate the composition and any changes in the external advisory bodies (scientific and management focus). Describe new ways in addressing the challenges that have been implemented in the area of LI's management in the period.

Geophysical observation systems are often unique apparatuses that cannot be simply maintained and repaired by commercial companies doing service of common electronic or laboratory devices. Purpose-trained experienced technicians are crucial for the system run. In the frame of CzechGeo/EPOS we therefore aim at long-term stabilization of these working posts. The number of students of master and PhD level, who are working with observatory data, give a good prospects for the future. The workers responsible for infrastructure must continuously follow new trends in measuring data acquisition and processing techniques. Long-term participation in the project plays a key role. Possibility of a broader international cooperation in the frame of EPOS project can be beneficial.

Personal changes: IPE: Ing. RNDr. Pavel Zacherle has been replaced by Ing. Lukáš Klozar as a station operator since Feb 2015. Mgr. Jaroslav Štrunc discontinued his activity in IRSM team and was replaced by Lukáš Čermák.

Regarding the transparent allocation of the infrastructure capacity it must be noted that the observatory infrastructure is not designed for visiting researchers. The broader science community uses the data by means of data centres or directly by data providers.

CzechGeo/EPOS integrates observations and mobile systems of seven geoscience institutions. The coordination is directed by the Agreement on collaboration by the performance of the project of large research infrastructure. The agreement is every year amended in order to reflect necessary changes. The Project is coordinated by the Council consisting of representatives of the parties as well as of the Czech representative in the EPOS project. The Council is chaired by the Principal Investigator.

The Council had two meetings in 2015. The annually meeting was held on 21 January 2015, jointly with the meeting of the National EPOS group. All collaborators responsible for components of the infrastructure were invited. The meeting on 18 November 2015 was devoted to the upgrade of the proposal for the next period. The infrastructure was split into five sections and leading institutions of the sections were appointed:

1. Section of Seismology (IG ASCR)
2. Section of GNSS and Gravimetry (RIGTK)
3. Section of Geodynamics (IRSM ASCR)
4. Section of Geomagnetism (IG ASCR)
5. Section of geological and geophysical databases (CGS).

In the frame of preparation for the next financial period the International Scientific Board was established. Its members are Prof. Carla Braitenberg (University of Trieste), Dr. Carine Bruyninx (Royal Observatory of Belgium), Dr. John Clinton (ETH Zürich), RNDr. Jaroslava Plomerová, DrSc. (GFÚ AV ČR), Dr. Alan Thomson (British Geological Survey Edinburgh), Dr. Jørgen Tulstrup (Geological Survey of Denmark).

3. Progress towards Objectives and Compliance with the Timetable of the Realization of the LI

Indicate the comparison with the original plan of the realization of the LI stated in the LI's proposal approved by the Government; describe the progress in meeting LI's objectives and the compliance with the timetable of the realization of the LI. Indicate all changes (financial, personnel, etc.) in the realization of the LI and their explanation.

The performance of the project is in agreement with the purpose declared in the application (securing long-term stable operation with emphasis on the high quality of data; on-going modernization of existing facilities with the aim of sustaining high technical standards of facilities; development of methods of processing and distributing data; support of joining significant international structures – at present particularly the project ESFRI/EPOS). Following actions were carried out in 2015:

- A fundamental upgrade of 13 seismic WEBNET stations was performed. The obsolete short-period seismometers SM-3 (from the turn of the years of 70's and 80's) were replaced by up-to-date broadband seismic sensors Guralp CMG-3ESPC. Besides, the obsolete data-acquisition units of four various types and operation age were replaced by new Centaur – Nanometrics ones. A new instrumentation, the price of which was beyond the capability of CzechGeo, was bought from the financial support of the Academy of Sciences in 2014.
- Optical gyrocompass purchased from the project investment funds served in 2015 to check and correct orientations of sensors of seismic stations in the Reykjanet local network in Iceland, permanent stations of the Slovak National Seismic Network and temporary stations of the international AlpArray project which were deployed on the territory of the Czech Republic.
- Obsolete, 15 years old digitizer at the station Sergoula, was replaced by a new DM24S3EAMU of Guralp production. Satellite data transmission at the station Pylos has been replaced by cheaper GPRS telemetry. Accelerograph at the station Paravola (PVO) was moved from the extremely wet vault to the small house of the telecommunications company, 5 meters away from origin place.
- Automation of data acquisition from 3-D dilatometers TM71 of TecNet has been in progress, selected sites have been instrumented for additional monitoring of Rn, CO₂, EM emission.
- In the MONET seismological network the Skalka and Luká stations were modernised completely. Both stations were equipped with a new steel shaft and power supply from the internal budget of IPE. Following station instrumentation was purchased largely from LI budget - Quanterra 330S seismic data acquisition system (Kinematics Inc., USA) and the three-component passive L4C-3D seismometer (Sercel, USA). Purchase of these instruments was partly funded from other sources to cover increased cost due to higher

exchange rate. To supply on-line data transfer to data centre at IPE Brno GSM routers WR44-EDGE were installed at both stations (purchased from LI budget in 2014). Both upgraded stations were included in the international register with the codes SUPC and LUKC and data were made accessible to other users.

- The CO₂ monitoring CarbonNet was expanded by one station Bublák and station Hartoušov has been reconstructed; novel methods of CO₂ flux monitoring are being tested.
- The geomagnetic observatory Budkov was equipped with a Potassium magnetometer for better control of absolute value of the geomagnetic field.

C. Socio-economic Impacts of the Infrastructure

1. Impact on the Economy

I. Indicate the number of jobs in the LI (researchers/research staff/other).

II. Indicate the number and volume of contracts with industry concluded in the framework of public procurement to maintenance and renewal of the LI.

Ad I.

The support by MEYS was used for salaries of 17,3 FTE: researchers 3,35, research staff 8,22, other 5,73. For details see Appendix 3.

Ad II.

Investment costs were used for the purchase of specialized instruments of domestic or foreign provenience (c.f. the Table of Real; Financial Costs). Other running costs – material, small equipment, services, travel costs – are carried out by companies acting on the Czech territory.

2. Impact on the Society

I. Indicate the number of master and doctorate students using the LI.

II. Indicate the number of new textbooks, lecture notes and other practical outputs carried out in connection with the LI's operation, number and names of curricula whose students are using the LI.

PhD students (16):

IG: H. Čermáková, H. Munzarová, J. Doubravová, K. Freyerová, B. Pechačová,

IRSM: J. Balek, J. Holešovský, Jakub Stemberk, F. Staněk

FMP CU: M. Halló, D. Křížová, J. Vackář, L. Valentová, F. Kostka

FS CU: J. Vlček, M. Bachura,

Master students (7):

IG: J. Podolník

FMP CU: J. Anderle, M. Dostálík,

FS CU: J. Vlček, M. Bachura

IPE MU: V. Ambrož, M. Urban

Bachelor students (7):

IG: J. Chyba, K. Pantůčková, R. Klanica, M. Labuta

FS CU: J. Pokorný

IPE MU: L. Potůček, V. Růžička

The infrastructure is presented to students of secondary schools and to general public during every-year Days of open doors, One day with physics, the Day of the Earth (IG ASCR 520 participants, IRSM ASCR 50, IGN ASCR 60, FMP CU 150) and to the participants of the University of the Third Age.

On the occasion of the 30th anniversary of strong seismic swarms in West Bohemia Outreach workshop in Skalná was organized combined with the visit of Observatory (60 participants). Moreover, a seismic exposition in Skalná was open on 19 December 2015 by Mayor of the town and Director of the IG (about 250 participants). The exposition was installed by the Institute of Geophysics and the running costs will be shared between the Institute and Town Skalná.

Seismic station Kašperské Hory was visited on the occasion of workshop of the association "Čechy nad zlato".

Study programs:

physics/geophysics – FMP CU

geology – FS CU, IPE MU

physical geodesy and geophysics – Technical University Ostrava

3. Impact on Innovation

I. Indicate the number of spin - off companies established on the basis of LI's operation.

II. Indicate the number of pilot plants, utility models, demonstrators made in connection with the operation of the LI, number of patents (including their names) recognized in connection with the operation of the LI.

Spin-offs are not supposed in this infrastructure

D. Appendices

1. Required:

- 1) *Table of the real financial costs of the LI in 2015*
- 2) *Table of monitoring indicators of the LI's implementation*

2. Optional:

- 3) *CzechGeo Research team*
- 4) *Cooperation with research institutions, industry and other entities using results of the infrastructure*

In Prague

Date: 28 January 2016

Signature of investigator: