Integrating and Strengthening the European Research Area

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1. Introduction

This is the second report concerning research in astronomy in the Central and East European (CEE) Countries of Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Serbia, Slovakia, Slovenia and Ukraine. Since research has been minimal in Albania, Bosnia and the Former Yugoslav Republic of Macedonia, they were excluded from this report. Slovenia did not respond to questionnaires sent and is also excluded. This report focuses on available and needed resources.

Many of these countries are not yet fully integrated into the future mainstream European astronomy as described in the ASTRONET Roadmap. The objective of ASTRONET WP3 is to analyse obstacles impeding full participation and propose appropriate action at the institutional and agency levels that could accelerate integration.

Methods and aims

In this report, we discuss supplemental resources required in each country to enable their astronomical communities to participate in major European projects. It is based partially on information collected in D3.1 *Report on the status and opportunities of the astronomical community in each country*. Other sources include ERAwatch pages, the Eurostat data, and direct questions to the funding agencies that fund research in astronomy. The report highlights general research funding systems and the countries' general level of funding of research, and external funding in astronomy. The working group consisting of ASTRONET partners and associates includes: Jean-Marie Hameury, Nikos Kylafis, Laurits Leedjärv, Birgitta Nordström, Míla Hůlová, Emma Olsson, Jan Palouš and Nedelia Popescu.

2. Governmental Expenditures on astronomical research

D3.1, *Report on the status and opportunities of the astronomical community in each country,* compares and investigates the size of the astronomical community in relation to the country's population. Obtaining information on how much exactly is spent on astronomical research has been difficult so some alternative measures have been explored. The first is using Eurostat data to ascertain the number of astronomers given in D3.1, and the gross annual average salary in each country. To include social and infrastructure costs, multiplying this by a factor of three provided reasonable estimates of spending in ground-based astronomy for France or Estonia, where we have independent information on their total expenditures. The result is presented in Table 1.

Table 1. Overview of population, number of astronomers, number of IAU members. The population and average salary data is taken from EUROSTAT data for the year 2011, number of astronomers from the country reports (D3.1)

Country	Population (millions)[1]	Number of astronomers[2]	Average annual salary[3] (EUR)	Annual Spending on astronomy (kEUR)
Bulgaria	7.3	101	4 668	1 414
Croatia	4.3	38	12 113[4]	1 381
Czech Republic	10.5	150	12 021	5 409
Estonia	1.3	40	10 368	1 244
Hungary	9.9	85	10 467	2 669
Latvia	2.0	50	8 923	1 338
Lithuania	3.0	40	7 425	891
Poland	38.5	340	9 702	9 896
Romania	20.1	115	6 146	2 120
Serbia	7.2	70		
Slovakia	5.4	63	11 224	2 121
Ukraine	45.4	320[5]		

Eurostat data for Ukraine were unavailable. Wikipedia[6] provides the following statistics: 3 951 kEUR, or 7 581 kEUR for the entire research staff (see footnote in numbers of astronomers in Ukraine). A similar estimate for Serbia is 1 213 kEUR.

[1]Data for 2012.
[2]For most countries, PhD students are included, but not technicians or astronomers without PhD.
[3] From Eurostat table on Wages and Labour costs, annual gross earnings in EUR, "Wages and labour costs" - Statistics explained (2013/12/6) <http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Wages_and_labour_costs#Source_data_for_tables_and_figures_.28MS_Excel.29>.
[4] Not available for the year 2010 and 2011.
[5] Ukraine has 614 astronomers but 320 with PhD or Dr Sc degrees.
[6] http://en.wikipedia.org/wiki/List_of_countries_in_Europe_by_monthly_average_wage.

As this contains many assumptions, another way of estimating the spending on astronomical research is used, by using EUROSTAT data on governmental spending on research and development (GOVERD), the number of R&D personnel in the governmental sector to calculate an average spending per R&D staff, which can be multiplied with the number of astronomers. For some countries this number is approximately the same, however they differ with a factor of two for Czech Republic, Poland and Romania, and for many other countries by 30%. This is due to involvement of these countries in ESA space experiments and other infrastructures like CERN, which is included into the GERD governmental sector spendings.

Table 2 Estimate of expenditures in astronomy and on research and development from governments

Country	**GERD govt. Sector MEUR**	**Total R&D personnel in Govt. sector**	**Number of Astronomers**	**Astronomers % of the total number of researchers in govt. sector**	**Estimate of expenditures in Astronomy MEUR**
Bulgaria	78,711	5 886	101	1,7	1,351
Croatia	92,105	2 901	38	1,3	1,206
Czech Republic	504,383	8 220	150	1,8	9,204
Estonia	31,097	733	40	5,5	1,697
Hungary	189,839	6 237	85	1,4	2,587
Latvia	32,847	915	50	5,5	1,795
Lithuania	55,346	1 732	40	2,3	1,278
Poland	979,421	16 098	340	2,1	20,686
Romania	267,643	6 117	115	1,9	5,031
Serbia	81,775	2 929	70	2,4	1,954
Slovakia	129,575	3 519	60	1,7	2,209

3. European infrastructures and organisations

3.1 ESO

As noted in D3.1, only one of these countries is currently a CEE member of ESO, namely, the Czech Republic. An estimate of costs involved for membership in ESO is based on the ESO model for calculating ESO costs. That in turn is based on a fraction of the country's GDP from the total GDP of all member states computed from the past three years. Included is the special contribution for accession the ESO, the remainder being the annual national contribution. The special contribution for the European Extremely Large Telescope is also provided, for new member states joining this project.

Table 3. Data for estimated costs of joining ESO. This table has been provided by Patrick Geeraert, ESO. His calculations were based on OECD data for NNI, ECB and national banks of Ukraine and Serbia for exchange rates.

NNI[7] data per country and calculated ESO contributions

	Weighted NNI average 2010-12 (billions of EUR) [8]	Calculated share 2014 (%)[9]	Calculated annual contribution 2014 (MEUR)[10]	E-ELT Special contribution (MEUR) [11]	Special contribution for accession 1 January 2015 (MEUR)[12]
ESO members					
Czech Republic	94,6	0,94	1,4		
OECD members					
Estonia	14,2	0,14	0,2	0,3	1,6
Hungary	59,8	0,58	0,9	1,1	6,6
Poland	306,7	2,95	4,6	5,9	34,0
Slovak Republic	53,5	0,51	0,8	1,0	5,9
Slovenia	23,9	0,23	0,4	0,5	2,7
Non OECD countries					
Bulgaria	30,8	0,30	0,5	0,6	3,4
Croatia	32,7	0,31	0,5	0,6	3,6
Latvia	17,7	0,17	0,3	0,3	2,0
Lithuania	26,8	0,26	0,4	0,5	3,0
Romania	111,4	1,07	1,7	2,1	12,4
Serbia	24,0	0,23	0,4	0,5	2,7
Ukraine	121,3	1,17	1,8	2,3	13,5

[7] NNI: Net National Income.

[8] NNI figures are estimated on NNI/GDP for countries where no OECD NNI data are available.

[9] Percentage share is based on 100% for the 15 ESO Member States in the EU.

[10] Including 2% E-ELT increase.

[11] Calculated share in E-ELT special contribution based on amount due 31.12.2014.

[12] Planned value of ESO net assets without non-current (long term) liabilities is basis for calculation of accession fees.

3.2 ESA

Three countries are members of ESA[13]: the Czech Republic, Poland and Romania. Three other countries have signed the PECS agreement: Estonia, Hungary and Slovenia, and three – Latvia, Lithuania and Slovakia – have individual agreements of cooperation.

3.3 Other European organisations in astronomy

Several European organisations provide access to research infrastructures. Some examples follow. For example, OPTICON deals with medium size optical/infrared telescopes. It has a transnational access programme allocating time on participating telescopes through a single international peer review. Radioastronomy has RADIONET of which Universitet Mikolaja Kopernika uToruniu in Poland is a member[14]. Another example is EVN, the European VLBI Network. Solar observations are available through the European Association for solar telescopes, EAST, of which the Czech Republic, Croatia, Hungary, Poland and Slovakia are members[15]. SOLARNET[16] is a consortium consisting of the Czech Republic, Croatia, Poland and Slovakia. Hungary and Ukraine are members of the International Virtual Observatory Alliance, IVOA.

4. Conclusions and recommendations

The needed resources can be divided into infrastructure building and maintenance, funding of the research, and publication of the results.

4.1 Local infrastructures

- In the survey, many countries indicated the main issue is access to up-to-date infrastructure. Many have their own telescopes which, while an asset, are also costly to maintain and upgrade. We recommend that each country make a careful analysis, considering the local astroclimate, considering observation with telescopes at other locations, or the costs of joining ESA and ESO compared with the cost of maintaining internationally competitive national facilities. Should a nation decide to join ESA and/or ESO rather than keep its national facility, it should ensure that its instrument development expertise remain in the country by contributing to instrument development on international projects. Countries with optical/IR telescopes with diameter 2 m or larger may consider joining OPTICON.
- Countries already members of ESA, sometimes for other reasons that astrophysics, should consider how to ensure that their membership in ESA will also benefit astrophysics. For example, in Romania, astrophysics might be advanced by being part of the upcoming GAIA mission.
- Countries with facilities in the radio astronomy domain, such as Ukraine, could consider joining the LOFAR consortium, which would promote its existing expertise. Involvement in SKA would also be a significant step for Ukraine.

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[13] According to ESA website: http://spaceinimages.esa.int/Images/2013/02/ESA_Member_States_and_Cooperating_States.

[14] According to http://www.radionet-eu.org/radionet-partners.

[15] See http://www.astro-east.org/index.php?id=217.

[16] According to http://www.solarnet-east.eu/consortium.

4.2 Access to international competitive facilities

To be internationally competitive and integrated into the main stream European astronomy it is important that the astronomers in each country have access to internationally competitive infrastructure. There are several ways to achieve this:

- Make funds available for buying telescope time and to travel there. A number of telescopes sell observing time.
- Make funds available to rent a telescope or buy a share of a telescope (an example of this is the Czech participation in the Danish telescope at La Silla, or the Polish participation in SALT).
- Make collaborative projects with telescope time granted.
- Participation in ESO and ESA.

International time is already available at some large facilities. But getting time is usually very competitive. However, obtaining observing time in international competition is healthy for the local astronomical community. Some initial measures to discuss necessary focus may be necessary to make projects competitive and provide courses on writing observing proposals in order to improve their success rate.

As pointed out in D3.1, increasing the involvement in European projects would be beneficial for all countries in this report. This report explores the cost of joining ESO compared to an estimate of the countries' expenditures in astronomy. Countries that have experience in instrument development may also gain by building on their expertise in this area as prime contractors or subcontractors of current and future European projects. On the way towards ESO a country should have a long-term vision what will be the benefits for astronomy and for ESO when a country joins. In the case of France or Czech Republic the yearly contribution to ESO is at the level of 15% of the astronomy spending, which is complementary to other current astronomy programs. Other countries are in different stages of negotiations with ESO: it mainly concerns Poland and Estonia. On the way towards ESO, the governments need to increase their spending on astronomy, since the proper use of this infrastructure is possible by a competitive astronomical community. This may lead not only to benefits for the astronomical research in the country, but it may have a positive impact on industry working with development of instrumentation.

In the meantime, joining the OPTICON collaboration could be interesting. A meeting between the relevant telescope directors and OPTICON management may be a way how to identify the relevant telescopes. The discussion should include 2.0 m telescope at NAO Rozen and similar telescopes, where the EU structural funds should be used.

For countries with small research communities it may be beneficial to buy observing time at relevant telescopes, rather than maintaining their own.

All countries under review will benefit from participation in large international projects that one can rely on the international expertise in instrument development, as well as data acquisition and scientific interpretation. This should also be of interest for more general research and development strategies in these countries, and it may in the long run positively influence the local industry. In many cases for these countries, a lack of funding seems to be the main issue.

4.3 Visibility of research results

In the study on publications made in D3.1 one could see that in some countries a sizable fraction of the publications were published in local journals, which have lower impact factor than international journals, such as for example the European journal *Astronomy & Astrophysics* (A&A). Therefore it is recommended that countries should consider whether joining A&A would be beneficial. Joining A&A will give authors the possibility to publish in a journal with better impact factor without page charges. There is a risk for those countries that have local journals that when libraries in many countries are cutting their spending on journals, the journals they will unsubscribe first will be the smaller journals, further lessening their impact. Costs for being a member of A&A are proportional to the GDP and consequently it varies every year. Taking the values for the year 2012 it goes from 510.- EUR for Estonia to 7 030.- EUR for Poland. We conclude that the country contributions are below the level of the costs of any local journal production, which lead us to strong recommendation that the non-member countries should join A&A.

A way to increase the international visibility and further the level of research and the exchange of research ideas is to increase the mobility of researchers. Young researchers should be encouraged to spend significant time abroad, and one should generally avoid continuing their professional career in the same group as where their PhD was performed. However, one has to make sure that an increased mobility does not lead to a “brain-drain”. Repatriation grants for young researchers could be considered to remedy this, together with an effort to recruit foreign researchers. Another way to encourage young scientists to return to their country, which also may help to attract foreign researchers when recruiting staff, is to ensure good access to relevant international research infrastructure.