Project co-financed by the European Regional Development Fund of the European Union.

BUSINESS ANALYSIS OF THE FACULTY OF SCIENCE, UNIVERSITY OF ZAGREB, WITH RECOMMENDATIONS

Zagreb, 10 August 2020

Project *CeNIKS – Centre for advanced research of complex systems* is co-financed under the Operational Programme Competitiveness and Cohesion of the European Regional Development Fund.

Project:	**CeNIKS – CENTRE FOR ADVANCED RESEARCH OF COMPLEX SYSTEMS** KK.01.1.1.01.0013 **BUSINESS ANALYSIS OF THE FACULTY OF SCIENCE, UNIVERSITY OF ZAGREB, WITH RECOMMENDATIONS**
Document status:	Final version
Analysis commissioned by:	**FACULTY OF SCIENCE, UNIVERSITY OF ZAGREB** Horvatovac 102a, 10000 Zagreb
Contracting authority represented by:	**Prof Aleksandra Čižmešija, PhD** Faculty Dean
Analysis authored by:	**VITAR U KRMU, obrt za stručne, znanstvene i tehničke djelatnosti, vl. Mojca Soža** Vukovac 5, 22202 Primošten
Responsible person:	**Mojca Soža, MSc, BEcon** Sole trader
Project manager:	**Mojca Soža, MSc, BEcon**
Date of document:	**10 August 2020**

CONTENTS

INTRODUCTION

The Business Analysis of the Faculty of Science, University of Zagreb, with Recommendations is an integral part of the project CeNIKS – Centre for Advanced Research of Complex Systems funded under the Operational Programme Competitiveness and Cohesion of the European Structural and Investment Funds (KK.01.1.1.02.0013). The total value of the project is HRK 57,806,124.58, out of which HRK 49,135,205.89 from the EU source. The project is implemented by the Faculty of Science's (hereinafter: PMF) Department of Physics and it includes the acquisition of modern research equipment and an organisational reform with the aim of ensuring that PMF has the necessary capacities to conduct high-quality research and deliver on the general goal of the project: developing the PMF's Department of Physics into a regional centre of excellence within the national and European Research Area. Once the project is completed, PMF will have put in place the conditions necessary to conduct activities as will create new scientific, social and economic values, especially in the priority areas of the Smart Specialisation Strategy.

This document, the Business Analysis of the Faculty of Science, University of Zagreb, with Recommendations (hereinafter: Business Analysis), will help define the guidelines for future business operations and activities of this institution, including research development guidelines, and thus contribute to the sustainability of organisational reform and the conditions conducive to the development of PMF into a regional centre of excellence.

PMF's problems are linked to an inadequate development of research potential and the organisational impediments hampering research activity. This Business Analysis defines the guidelines for the development of PMF. By integrating organisational reform and infrastructural investment, conditions will be put in place for excellence in research and transfer of knowledge and skills, and consequently, for PMF delivering on its general goal - the development of the PMF's Department of Physics into a regional centre of excellence within the national and European Research Area.

After a brief review of the last Report of the Expert Panel on the Re-accreditation of the Faculty of Science, University of Zagreb (July 2015), this Business Analysis consists of the following chapters:

1) Analysis of internal infrastructural and human support capacities of PMF in delivering its core activities;
2) Analysis of collaboration with Croatian and international research institutions;
3) Analysis of cooperation with the business sector;
4) SWOT analysis;
5) PEST analysis;
6) Defining recommendations for strategic goals, priorities and actions for PMF's future development;
7) Strengthening PMF's capacity for writing grant proposals for EU funds as well as possible funding by industry sources;
8) Range of activities for positioning within the European and global research area; and
9) PMF visibility analysis.

The above listed chapters as proposed by the project terms of reference, are preceded by Chapter 0 - Review of Expert Panel conclusions in 2015 PMF Re-accreditation Report, where we wanted to show the current state of affairs in the three areas singled out by the Expert Panel in the PMF re-accreditation report as the main future challenges for PMF. This previous analysis is very important if we are to understand both the main issues PMF encounters and the progress made

in these areas in recent years. Additionally, the above analysis is very important in terms of proposing future activities and actions.

METHODOLOGY AND DATA SOURCES

The Business Analysis of the Faculty of Science, University of Zagreb, is based on the following relevant documents:

- Statutes of the Faculty of Science, University of Zagreb (consolidated text) of 4 October 2019;
- Internal Job Structure of the Faculty of Science, University of Zagreb (consolidated text) of 2 January 2019;
- 2015-2020 Development Strategy of the Faculty of Science, University of Zagreb;
- Faculty of Science - Strategic Research Programme 2018 -2023;
- Quality Policy at the Faculty of Science, University of Zagreb of 7 May 2019;
- Annual Reports on the teaching, research, and expert work and other activities at the Faculty of Science in academic years 2015/2016, 2016/2017, 2017/2018, 2018/2019;
- Annual Reports on the teaching and research work at the Faculty of Science in academic years 2012/2013, 2013/2014, 2014/2015;
- 2015 Self-evaluation document;
- Report of the Expert Panel on the Re-accreditation of Faculty of Science, University of Zagreb from July 2015;
- Response to the Report of the Expert Panel on the Re-accreditation of the Faculty of Science, University of Zagreb, from November 2015;
- Accreditation recommendations of the Agency for Science and Higher Education in the procedure of re-accreditation of the Faculty of Science, University of Zagreb, from November 2015, February 2016 and February 2019;
- Reports of the Expert Panel on the Re-accreditation of individual postgraduate university study programmes: Geology, Oceanology, Biology, Mathematics and Chemistry, all from August 2018; and Physics from January 2020;
- Decision on the method of monitoring, generating and spending of own resources and receipts of 3 January 2015;
- International Mobility Policy of 11 April 2017.

The financial analysis is based on the following documents:

- Annual Financial Statements for years 2014, 2015, 2016, 2017, 2018 and 2019;
- Additional data provided by the PMF accounting service.

Other data provided (upon request) and processed as part of the analysis:

- The number of published research papers and related citations in the period 2015-2020 (from the Web of Science Core Collection data base);
- PMF employees and their posts and positions as at 17 February 2020;
- PMF non-budgetary income in 2015, 2016, 2017, 2018 and 2019;
- Active research and professional projects;
- List of partner organisations.

For the input on students, teaching staff, researchers etc., we have extracted data from the Self-evaluation document (2015) and the Annual Reports (2012/2013 – 2018/2019), considering that a detailed statistical analysis of that segment is not the primary objective of this Business Analysis.

In the first phase of the analysis, we developed a questionnaire in order to collect data concerning the international cooperation of PMF departments with other scientific research institutions, their

cooperation with the economic sector and their inclusion in the EU-funded projects. In January 2020, all PMF departments received the questionnaire, which covered the reference period from the beginning of 2019 until the date of the survey, and they all completed and returned it by the designated date. Their responses informed the relevant parts of this Analysis.

In the SWOT and PEST analyses, we used theory models to define their respective content and methodologies.

During the drafting stage, regular meetings were held with a broad circle of PMF representatives. Namely, the Department of Physics as the lead coordinator of this project chose to include the PMF management and departmental management in the development of this document, to make sure that the final document is as relevant and useful as possible for PMF as a whole.

The study is based on the project terms of reference, which make an integral part of the Public Procurement Contract concerning the elaboration of the Business Analysis of the Faculty of Science, University of Zagreb, with Recommendations, and a Work Plan, which was developed after the conclusion of the Contract.

0 REVIEW OF EXPERT PANEL CONCLUSIONS IN 2015 PMF RE-ACCREDITATION REPORT

In 2015, the Faculty of Science, University of Zagreb, was subject to a re-accreditation procedure. The Report of the Expert Panel on the Re-accreditation of PMF highlights the following major future challenges for PMF:

1. Financial constraints;
2. Limited internationalisation; and
3. Geographical dispersal of Biology and geo-sciences.

Below is a brief comment on each of the highlighted areas.

0.1 Financial constraints

The Expert Panel concluded that it was necessary to be more pro-active in exploring possibilities and accessing funds from non-traditional sources of support. The recommendation was that a separate task force should work on an innovative and ambitious strategy to develop a broad range of non-traditional sources of finance, such as alumni, industry, sponsorships, donations, private sector and foreign private foundations. The Panel also pointed to a wealth of opportunities within EU funding schemes that should be tapped more effectively. The Expert Panel expressed their concern with respect to the future budgetary situation of PMF unless it succeeded in expanding its other income streams, in addition to the state budget funding. The conclusions of the Expert Panel were based on the financial data from 2012 and 2013.

Based on the analysis of the PMF's ability to tap other sources of financing apart from direct budgetary allocations as shown in more detail below, we can conclude that the current state of PMF income structure differs significantly from the one in 2012 or 2013. We can also conclude that there is still a considerable potential for further improvement of the funding situation.

In 2012, the total PMF income was HRK 164,060,376; state budget allocations (direct income) accounted for 88.5% of the total income. The total PMF income in 2019 exceeded the total income in 2012 by 22.9%; budgetary allocations (direct income) in 2019 accounted for 66.8% of the total income.

Table 1: Income of the Faculty of Science, University of Zagreb, 2012-2019

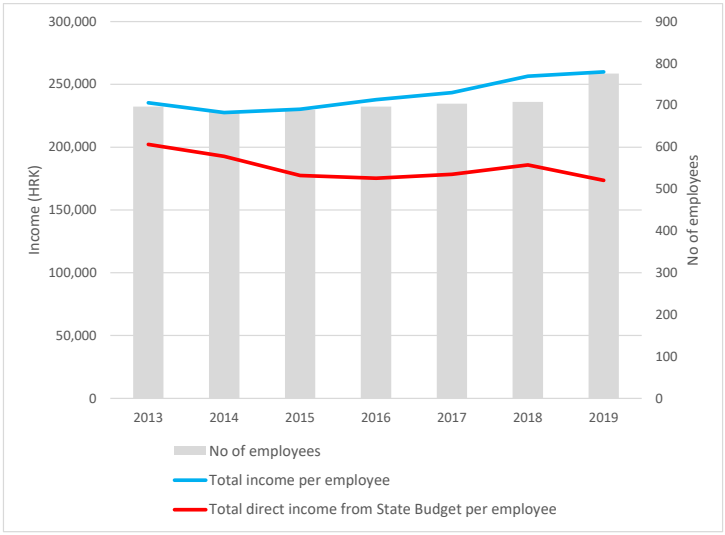
	2012	2013	2014	2015	2016	2017	2018	2019
Direct income from state budget	145,213,629	140,924,004	131,777,461	122,219,561	122,125,976	125,520,719	131,599,903	134,639,543
Income from other sources	18,846,747	23,083,837	23,834,732	36,428,612	43,668,983	45,873,087	49,996,725	67,012,943
Total income	**164,060,376**	**164,007,841**	**155,612,193**	**158,648,173**	**165,794,959**	**171,393,806**	**181,596,628**	**201,652,486**

Source of data: PMF Annual Financial Statements

In 2019, direct income from the state budget declined by 7.3% in comparison with 2012, while income from other sources rose by 255%.

If we look at the income per employee, it has been steadily rising, while direct income from the state budget has been shrinking.

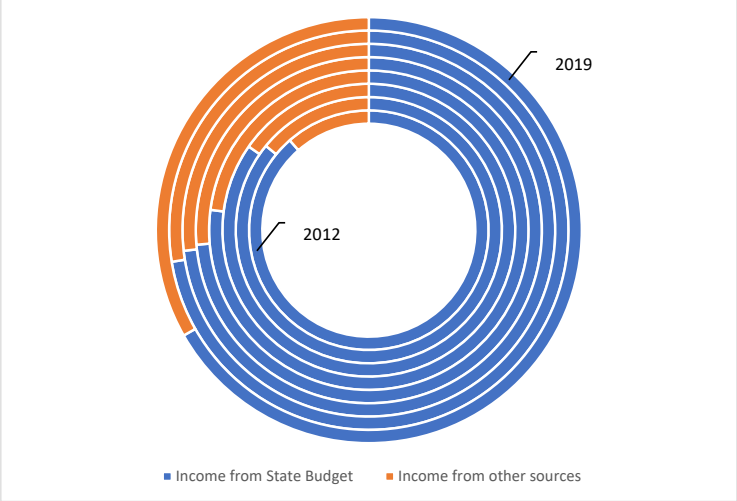
Chart 1: Total income per employee and direct income from State Budget per employee, 2013-2019



Data source: PMF Annual Financial Statements

The ratio of direct income from the State Budget to income from other sources has considerably changed and in 2019, income from other sources (other than the State Budget) accounted for as much as one third of all income. In 2012, the share was considerably lower (11.5%).

Chart 2: Ratio of direct income from State Budget to income from other sources, 2012-2019

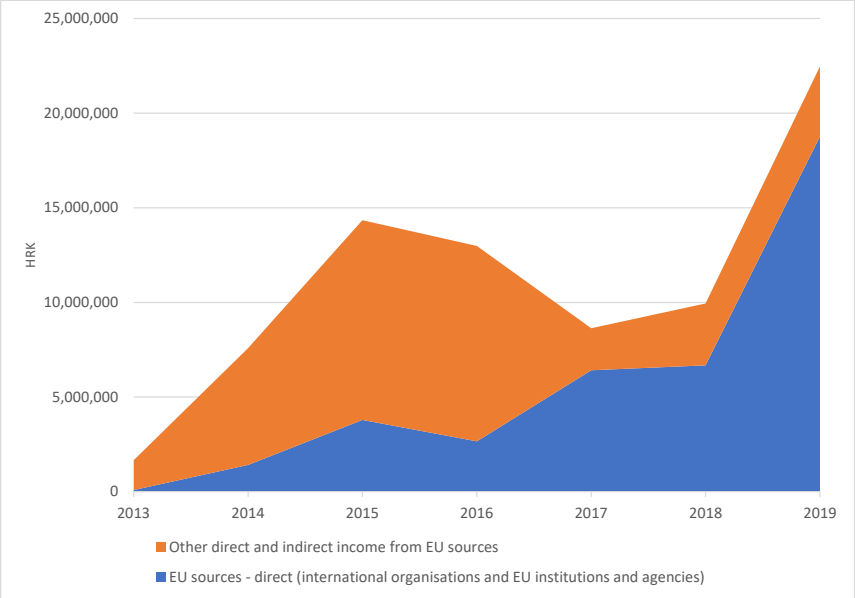


Data source: PMF Annual Financial Statements

PMF has demonstrated a strong ability to generate income from other sources (i.e. sources other than the State Budget). A great progress has been made in a short period of time, particularly if we consider that no significant structural (organisational) changes have been introduced that would have a direct bearing on such an outcome. In light of the foregoing, we suggest there is still a considerable untapped potential that can be developed once the structural changes are implemented.

In the context of other sources, i.e. income other than direct budgetary allocations, we would like to emphasise two important issues. The first concerns income from international organisations and EU institutions and agencies, which has grown at a significant rate over the past years. It should be a self-set goal for PMF to stabilise this source of income at a constant targeted share of the total income. This can be achieved only through a larger project portfolio, which will ensure a stable cash flow. All projects are different; some of them possibly take a few months, others can last for a year, two years or more. With an increasing number of projects, PMF will have created a portfolio, which will considerably increase its income continuity.

Chart 3: Level and structure of project-based income stream funded by EU or other funds and international organisations and income from the General Budget beneficiaries (indirect income from EU and other funds), 2013-2019



Data source: PMF Annual Financial Statements

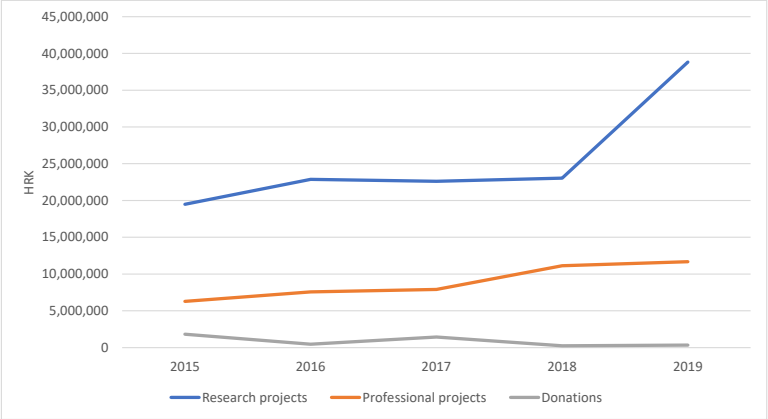
These two groups of income together accounted for 1.01% of the total PMF income in 2013. In 2019, those two income groups accounted for 11.14% of the total PMF income.

The above chart shows a significant change in the structure of the income received either directly or indirectly (through Croatian institutions – ministries, agencies, and so on) from the EU and other international funding schemes. In the early years, the prevalent share of this income came from within Croatia, but it was sourced internationally. Although the projects were submitted to national calls managed by Croatian institutions (ministries, agencies), the source of funding was a European funding scheme. As it gained experience and expertise, PMF became capable of writing successful project proposals for direct funding schemes (e.g. Horizon2020), resulting in a considerable growth of that income stream. Again it has to be emphasised that no structures exist either at the PMF level or at departmental level that would support all these processes; on the contrary, any success achieved is for the most part the result of personal enthusiasm and additional commitment of a few individuals who had recognised an opportunity for PMF and for personal growth, and started producing exceptionally successful project applications. Namely, the average success rate of project applications for directly managed EU funding schemes is less than 10%, meaning there really is room only for the best projects.

The second matter that we wanted to highlight here is income from research and professional projects. We included income from donations in this Analysis to better highlight its practically negligible level. It currently accounts for only 0.17% of the total income, and thus represents a huge potential that has to be developed.

Income from research projects has grown steadily, and so has income from professional projects, as evident from the annual increase in the number of those projects. The growth of income from research projects is closely linked to income from EU and other international funds, as many of them are co-financed from those sources.

Chart 4: Movement of income from research projects, income from professional projects, and income from donations, 2015-2019



Data source: PMF Annual Financial Statements

The fact is that PMF still operates under financial constraints. It is also a fact that raising enough money to finance big infrastructural investment is by far more challenging than raising enough to fund a research project or a study. The financial data from the past five or six years indicate that PMF has made a significant progress in generating income from external sources (i.e. sources other than direct budgetary allocations), but they also show there is a huge, but untapped potential in light of the fact that the current progress has been achieved largely without any significant structural change. Nevertheless, PMF has acquired important experience and knowledge that has to be expanded in the future by establishing support structure which will streamline, manage, monitor and support this segment of PMF's operations.

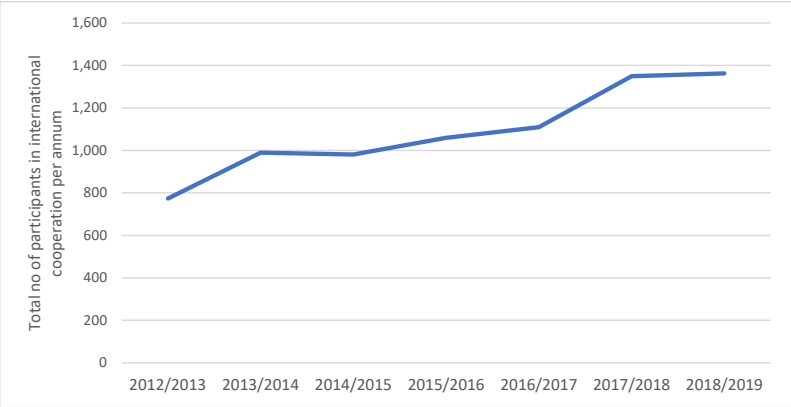
0.2 Limited internationalisation

According to the conclusions of the Expert Panel on the Re-accreditation of PMF, mobility is not sufficiently developed, there are major obstacles to faculty exchange with institutes and the majority of the research and teaching faculty have had nationally focused careers. The Expert Panel recommended radical changes in the culture and method of work, to make the most of the opportunity for internationalisation. Two significant obstacles to international exchange were mentioned: one is the excessive teaching load of the teaching staff, and the other is the language barrier, which is an unsurmountable obstacle for recruitment of international teachers (prior knowledge of Croatian is required), researchers and international students (absence of courses taught in English).

The opinion of the Expert Panel on the Re-accreditation of PMF was formed based on the data for the academic year 2013/2014. Since then, international collaboration has been on the rise, but there is still a lot of room for improvement, especially in terms of the number of courses taught in English. Additionally, in the survey conducted in the departments in preparation of this Analysis, several respondents still emphasised the excessive workload of the teaching staff and the resulting obstacles to their long-term absence in the context of international exchange.

Although the intensity of internationalisation can be measured through different indicators, the simplest one and yet still quite reliable is the total number of participants (students, PMF staff) involved in at least one form of international cooperation (international exchange, joint research, participation at conferences, study tours etc.). Before we proceed to a more detailed analysis, let us look at this indicator over the years.

Chart 5: PMF intensity of internationalisation in academic years 2012/2013 through 2018/2019 (annual aggregate data)

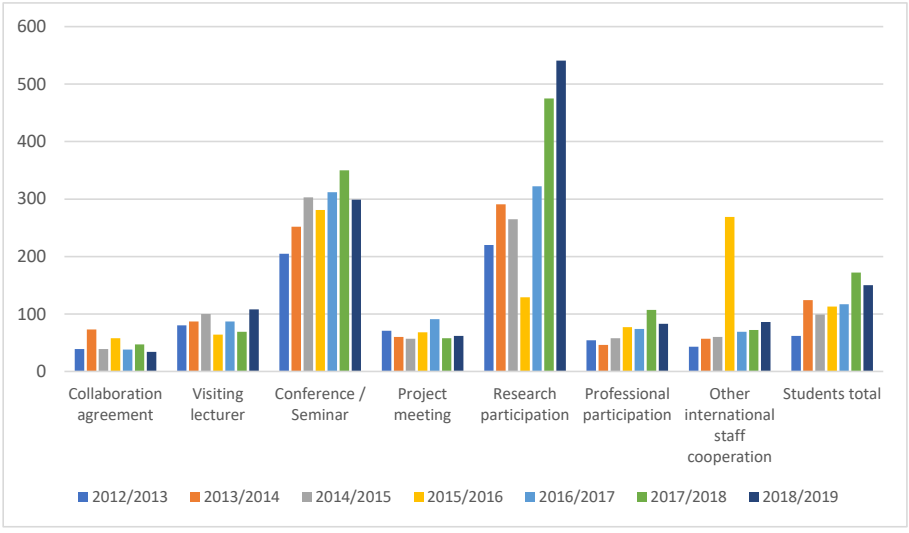


Data source: Annual Reports on the teaching, research and expert work, and other activities at PMF in academic years 2012/2013, 2013/2014, 2014/2015, 2015/2016, 2016/2017, 2017/2018, 2018/2019

The chart above shows that in the past six years only, the intensity of internationalisation (based on the indicator of the total number of participants in international collaboration and mobility) has increased by 76%, partly due to the recruitment of several teachers during the same period. In the academic year 2012/2013, a total of 774 staff and students have been involved in international cooperation and exchange, out of which 92% were staff participating in international cooperation and exchange, and 8% were students participating in international student exchange programmes. In the academic year 2018/2019, a total number of 1,363 persons were involved in international cooperation and exchange, out of which 89% were staff participating in international cooperation and mobility, while 11% were students involved in international exchange programmes.

Depending on the type, international cooperation and mobility have recorded different growth rates. Research participations had the highest rate of growth (mostly short-term), followed by participations at conferences and seminars, as well as student exchange programmes, all recording a steady rate of growth.

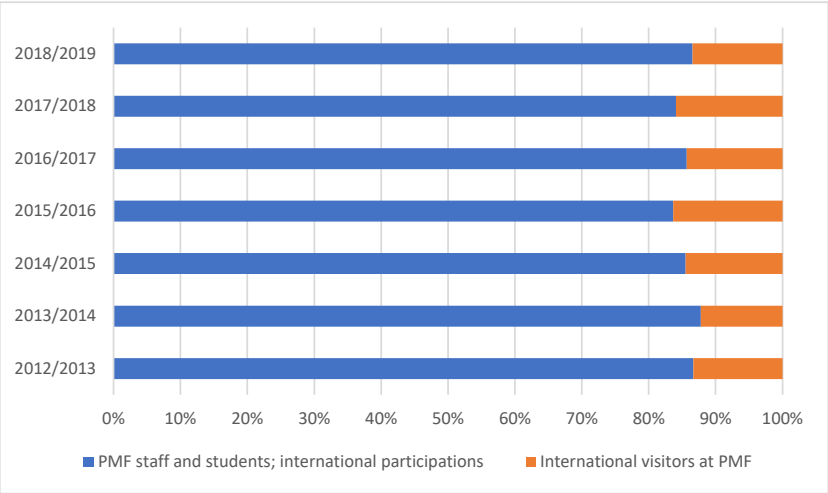
Chart 6: Intensity of international cooperation and staff and student mobility at the Faculty of Science, University of Zagreb, in academic years 2012/2013 through 2018/2019 by type of international cooperation



Data source: Annual Reports on the teaching, research and expert work, and other activities at PMF in academic years 2012/2013, 2013/2014, 2014/2015, 2015/2016, 2016/2017, 2017/2018, 2018/2019

Throughout this period, the intensity of international cooperation and mobility has been considerably higher with the outbound PMF staff and students than with the inbound international teachers and students; the ratio is about 85% to 15% throughout the entire period observed.

Chart 7: Ratio of international cooperation and mobility at the Faculty of Science, University of Zagreb, academic years 2012/2013 through 2018/2019, outbound vs inbound



Data source: Annual Reports on the teaching, research and expert work, and other activities at PMF in academic years 2012/2013, 2013/2014, 2014/2015, 2015/2016, 2016/2017, 2017/2018, 2018/2019

Further improvement is necessary in the area of internationalisation. The Analysis shows that progress has been made; it could be a good trigger for future actions proposed later in the document.

0.3 Dispersal of and poor work conditions in Departments of Biology, Geology and Geography

Dispersal of the departments of biology and geo-sciences, as well as a generally unsatisfactory state of their current premises and facilities are arguably the greatest challenges that PMF will have to face in the coming period. The buildings and equipment were additionally damaged in the earthquake that struck Zagreb on 22 March 2020.

The proposed new Biology, Geology and Geography building in the Northern Campus is absolutely essential for the future operation of PMF. Raising funds for its construction will be a huge challenge. However, the opinion of the Expert Panel for the Re-accreditation is that this challenge also offers an opportunity for PMF to enhance its engagement with the alumni, policy-makers, media and industrial and institutional partners. In addition, the Expert Panel conveys the sense of urgency, and suggests public and private partnership model as one of the financing options.

The above problem is multi-faceted; many of the PMF's problems stem precisely from the dispersal and mutual separation of the departments. This affects the entire operation and organization of PMF. The major reason as to why PMF does not capitalise sufficiently on the interdisciplinary potential it possesses is the dispersal of the departments. Several departments largely function as completed entities and have excellent research results and achievements. However, their cooperation is not satisfactory, causing an opportunity loss for the whole of PMF.

Furthermore, mostly due to geographical dislocation, every department has formed its own administration; more elaborate in some departments, less so in others. Some departments even

have their own accounting service, as well as one department-level human resource office, which is neither rational, cost- and time-effective, nor transparent. Another important consequence of the fragmentation of premises is the understaffing of the libraries in practically all the departments. The total number of library staff across all departments is currently 11; according to the plan, i.e. the projected number of staff under the Internal Job Structure in all departments and the Dean's Office of the Faculty of Science, University of Zagreb, there should be 21. The 11 librarians currently employed would represent a strong capacity if they all worked in a single central library; as it is, with 11 employees split across 7 libraries, the result is 7 exceptionally understaffed libraries.

As for research work, it seems that dislocation of the departments is one of the most important reasons for a situation where certain departments practically do not cooperate with each other. And yet, interdisciplinarity is what gives PMF a great advantage. Specifically, having examined similar institutions in the neighbourhood, we did not identify any similar examples. In most cases, study programmes are split across several faculties, which makes their cooperation more challenging than it should be the case with a single institution that brings together so many different branches.

There is no simple and quick solution. The construction of a new building is a long-lasting process, where all stages take their time: from planning, permits, designs, fund raising and budgeting, to construction itself which, all things considered, would appear to be the easiest part and which cannot begin before everything else is put in place and arranged. In the meantime, there are several opportunities for change in the existing circumstances, as described in detail below.

1 ANALYSIS OF INTERNAL INFRASTRUCTURAL AND HUMAN SUPPORT CAPACITIES OF PMF IN DELIVERING ITS CORE ACTIVITIES

The aim of this chapter is to analyse the sufficiency and relevance of the infrastructural and human support capacities of PMF in delivering its core activities. The analysis includes a review of the following capacities:

- Infrastructural capacities (buildings, laboratory equipment and libraries),
- Human capacities – teaching staff (teaching, research, professional work, other activities delivered by teaching staff),
- Human support capacities – non-teaching staff.

The financial resources of PMF were analysed in the previous chapter.

1.1 Infrastructural capacities

The PMF resources were listed meticulously in the 2015 Self-evaluation document, and the Report of the Expert Panel on the Re-accreditation of PMF assessed them as adequate or satisfactory despite significant differences between the departments. The most urgent problem for PMF are the existing buildings and facilities for biology and geo-sciences, which were assessed as entirely inadequate by the Expert Panel, emphasising that the completion of the proposed new Biology, Geology and Geography building was essential and of the highest priority. All the buildings used by PMF, and particularly the buildings at 6 Rooseveltov trg and 19

Marulićev trg, where the PMF's Departments of Biology and Geography are based, were damaged in the earthquake that struck Zagreb and the surrounding area on 22 March 2020. As the buildings in all mentioned locations housed sophisticated research equipment, the damage is considerable, to both the buildings and the equipment.

The majority of difficulties and restraints that PMF faces stem from the dispersal of the departments and the inadequate state of the buildings and facilities of the Departments of Biology, Geology and Geography. This was analysed within our introductory chapter, where we gave a brief review of the conclusions of the Expert Panel in 2015. The problems arising from this fact are multi-faceted and, as there are no short-term and quick fixes, PMF will have to adapt and optimise within the current limitations. Already a poor state of the buildings was additionally aggravated in the Zagreb earthquake of 22 March 2020. Here are only a few of the main problems (consequences) resulting from PMF's spatial constraints:

- constraints in the operation of PMF;
- the departments have grown to be autonomous, and there is considerable closure of the departments within themselves, with a tendency to evolve into entities of their own;
- the departments do not communicate and collaborate with each other, leaving an otherwise huge interdisciplinary potential untapped;
- multiple duplication of administrative jobs, where each department has its own administration service which, if assessed individually at the departmental level, or at the central level, displays certain deficiencies, despite having a sufficient overall number of administrative staff (looking at PMF as a whole);
- the organisation of professional and administration services is not optimal and there is a lot of room for enhancement of efficiency and improvement of accessibility for users;
- low effectiveness and accessibility of libraries (inadequate number of staff per library, limited opening hours, problems with access to literature, operational costs of libraries, additional library services).

The 2015 Report of the Expert Panel on the Re-Accreditation of PMF states that there are excellent equipment and resources at PMF, particularly in the new premises of the Departments of Mathematics and Physics in the Northern Campus.

As to the equipment excellence, there are two comprehensive EU-funded projects that both include, among other, the acquisition of modern equipment which should lead to the establishment of two centres of excellence, in chemistry and in physics. These projects are CIuK – Centre of Excellence in Chemistry, coordinated by the Department of Chemistry, CeNIKS – Centre for Advanced Research of Complex Systems, coordinated by the Department of Physics. Once CIuK is completed, the Department of Chemistry will have state-of-the-art research equipment. The project will establish fourteen new research labs and the computer centre for the Department of Chemistry. Under the CeNIKS project, the Department of Physics will receive new equipment for seven existing labs, as well as set up two entirely new labs. Both projects will considerably improve the existing state of equipment in the departments by adding excellent research equipment, which will help strengthen the ties with the economic sector and other research institutions. The new equipment will also improve the quality and expand the scope of potential research for PMF staff and students, thus enhancing the departments' appeal to international students, researchers and teachers.

A catalogue of research equipment and computer programmes, both in Croatian and in English, was compiled, giving PMF departments an opportunity to present all their available research equipment. The Catalogue is very detailed, with each item presented visually and factually, including: name, type of equipment, location, accessibility, technical features, the year of production, price, services, working hours and the name of a contact person with contact details.

The Catalogue is a valuable document, even more so since it is available in English, as well as in Croatian. The date of publication of the Catalogue on the PMF website is 1 February 2018. The Catalogue should be kept up-to-date.

1.2 Human capacities – teaching staff

According to the data from the Annual Report on the teaching, research and professional work and other activities at PMF in academic year 2018/2019, PMF has 792 employees, out of which 512 are teaching staff and 280 are non-teaching staff. The employee structure by departments and in the Dean's Office is as follows:

Table 2: PMF employee structure by department and in Dean's Office

	Non-teaching staff	Teaching staff	Total no of employees
Dept. of Biology	83	141	224
Dept. of Physics	35	98	133
Dept. of Geophysics	17	21	38
Dept. of Geography	13	32	45
Dept. of Geology	14	28	42
Dept. of Chemistry	47	78	125
Dept. of Mathematics	29	114	143
Dean's Office	42	0	42
PMF total	280	512	792

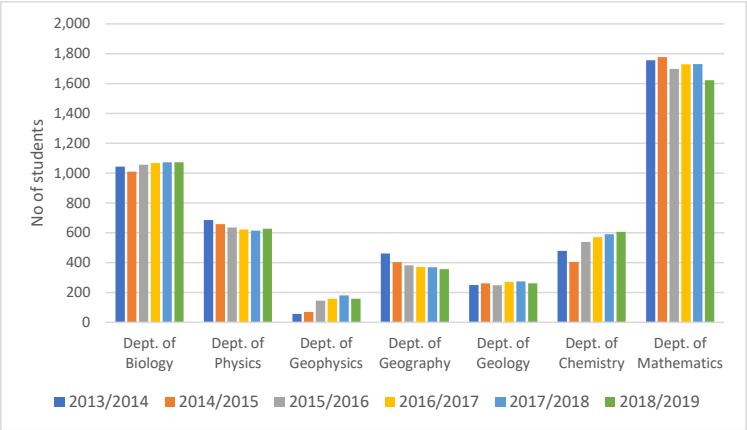
Data source: Annual Reports on the teaching, research and expert work, and other activities at PMF in academic year 2018/2019.

The total ratio of teaching to non-teaching staff has been assessed as adequate and consistent with the specific features that arise from the dispersal of departments and the methods and contents of activities delivered by PMF, which requires a comparatively large number of non-teaching staff. In this Analysis, we have not addressed the structure of PMF in terms of numbers of teaching and non-teaching staff, as it was assessed as mostly adequate.

In the academic year 2018/2019, the total number of students enrolled in the study programmes at PMF was 4,706, out of which 1,873 in undergraduate, 764 in integrated undergraduate and graduate, 1,384 in graduate, 661 in postgraduate university doctoral, and 24 in postgraduate specialist study programmes.

Table 3 and Chart 8: Total number of students by department, 2013/2014 through 2018/2019

	2012/2013	2014/2015	2015/2016	2016/2017	2017/2018	2018/2019
Dept. of Biology	1043	1009	1056	1067	1073	1072
Dept. of Physics	686	659	635	622	615	628
Dept. of Geology	57	70	145	159	181	159
Dept. of Geography	461	404	382	372	370	357
Dept. of Geology	251	262	249	272	274	262
Dept. of Chemistry	480	405	539	571	591	606
Dept. of Mathematics	1756	1777	1698	1729	1730	1622
PMF Total	4734	4586	4704	4792	4834	4706

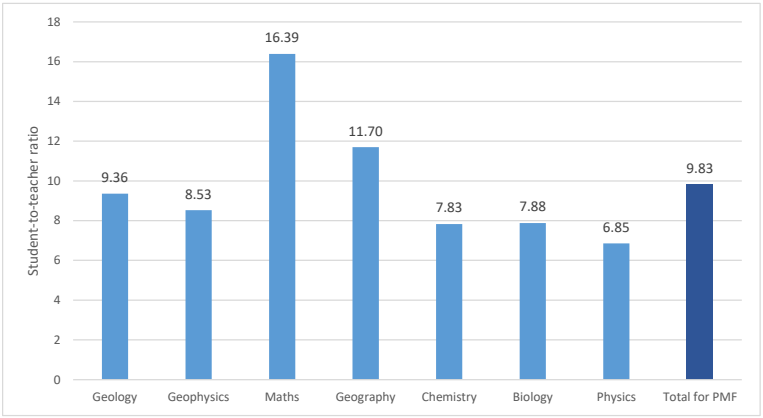


Data source: Self-evaluation document (2015), Annual Reports on the teaching, scientific and professional work, and other activities at PMF in academic years 2015/2016, 2016/2017, 2017/2018, 2018/2019

The total number of students is stable, going up over the past several years with only a slight drop again in the last observed academic year, i.e. 2018/2019.

The 2015 Report of the Expert Panel on the Re-accreditation of PMF stresses that the teacher workload at the Departments of Geophysics, Geography, Geology and Chemistry is above the average, with an unacceptably high number of teaching hours per person per year. The teacher workload is partly evident from a high (above average) student-to-teacher ratio. The ratio is highest at the Departments of Mathematics and Geography.

Chart 9: Student-to-teacher ratio by department and the average for PMF, academic year 2018/2019



Data source: Annual Reports on the teaching, research and expert work, and other activities at PMF in academic year 2018/2019

The excessive workload of the teaching staff with teaching responsibilities may affect their research work and interest or more generally speaking their chance to participate in international teacher exchange considering the need for longer absences. The Expert Panel on the Re-accreditation of PMF also warned of the problem of excessive workload of the teaching staff and the necessity of reducing their burden based on a prior rationalisation of the curriculum. As for the research work, the workload could be reduced by providing project support; below we propose a whole set of actions to that purpose.

At this point, we would also like to address the scientific productivity of individual departments. There are considerable differences in scientific productivity among the departments. We have made an analysis based on the data on the number of research papers and related citations in the period between 1 January 2015 and 20 January 2020. Since the analysed period is rather long, our reference number of teaching staff is the number of teaching staff as at the date that is

approximately in the middle of the analysed period, according to the available data. The data that we used were extracted from the Annual Report on the teaching, research and professional work, and other activities at PMF in academic year 2017/2018, including the data on the number of teaching staff by departments as at 9 April 2018.

Table 4: Number of PMF research papers and related citations in the period 01.01.2015-20.01.2020

Department	No of papers*	No of citations	Teaching staff**	No of papers per teacher	No of citations per paper
Geology	83	319	31	2.68	3.84
Geophysics	104	558	18	5.78	5.37
Mathematics	392	886	101	3.88	2.26
Geography	59	286	31	1.9	4.85
Chemistry	315	1682	76	4.14	5.34
Biology	532	3532	136	3.91	6.64
Physics	788	9266	90	8.76	11.76
PMF Total	2273	16529	483	4.71	7.27

*Papers include the following types of documents: article, review, letter, note
**Number of teaching staff as at 19 April 2018.

Data source: PMF teacher scientific productivity data according to the Business Analysis of 20 January 2020 and the Annual Report on the teaching, research and professional work, and other activities at PMF in academic year 2017/2018

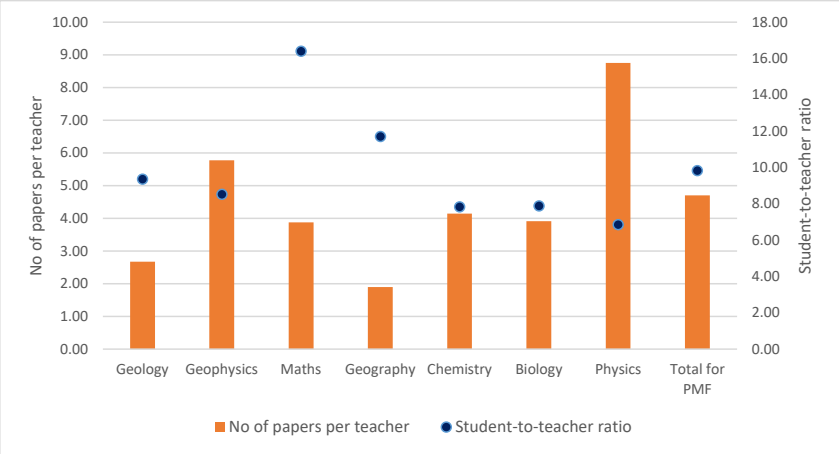
According to the data, the average number of papers per teacher, if PMF is taken as a whole, over the observed period is 4.71 research papers. The average number of citations per paper is 7.27.

As for the number of papers per teacher, it varies significantly from department to department. The highest number of papers per teacher in the observed period was registered at the Department of Physics (8.76) and the lowest at the Department of Geography (1.90). The departments differ from each other by method of work and research results so certain differences in the average scientific productivity are to be expected, consistent with natural differences among the departments. Regardless, in the departments with a lower output of research papers, there should be a more detailed analysis of the main reasons for the lower scientific productivity. Once the effects of the departments' specific features are excluded, the results should serve as a basis for the solutions that could help the departments converge towards the average values.

As already mentioned, one of the possible reasons for the lower scientific productivity of teachers in certain departments could be linked to their excessive workload. The 2015 Report of the Expert Panel on the Re-accreditation of PMF emphasises that the teaching staff of the Departments of Geophysics, Geography, Geology and Chemistry have an above-the-average workload with an unacceptably high number of teaching hours per person per annum. Teachers' excessive workload can be partly viewed through the prism of the student-to-teacher ratio, which for the academic year 2018/2019 was the highest in the Departments of Mathematics and Geography, and the lowest in the Department of Physics, which also registers the highest number of papers per teacher.

The chart below presents the comparative indicators, i.e. the number of papers per teacher and the student-to-teacher ratio. The reference period for the number of papers per teacher is 01.01.2015-20.01.2020, and for the student-to-teacher ratio (average) academic years 2016/2017 through 2018/2019.

Chart 10: Comparison of indicators – number of papers per teacher and student-to-teacher ratio



Data source: PMF teacher scientific productivity data according to the Business Analysis of 20 January 2020 and the Annual Reports on the teaching, research and professional work, and other activities at PMF in academic years 2016/2017, 2017/2018, and 2018/2019.

Decreasing the teaching staff's workload has to be one of the main future goals, as emphasised by the Expert Panel in the context of the 2015 re-accreditation exercise. The implementation of this measure, along with the setting up of a research support structure (another emphasis by the Expert Panel during the 2015 re-accreditation exercise), will significantly improve the situation of the teaching staff and thus help them increase their capacity to participate in research and competitive international projects.

1.3 Human support capacities – non-teaching staff

In relation to the issue of PMF support capacity, we wanted to receive answers to the following questions:

- Are there sufficient support structures offering high quality and sufficient support for the research and professional activities, and for preparation and implementation of EU projects and project work in general?
- If not, are the support structures one of the reasons for insufficient utilisation of capacities in EU projects, and for inadequate development of research potential?
- Are there organisational obstacles hampering research activities and stronger external links of PMF with other national and international research institutions and the economic sector?
- Could the improvement of support capacities help PMF win more grants from various national and international sources and have a long-term stabilising effect by keeping the income stream from grants at a targeted level in terms of its share in the total income of PMF?

It is a fact that the methods of work are changing with the project-based work becoming more prevalent, and although it is not a novelty for researchers, EU-funded projects require somewhat different type of project work. The changes do not affect the research itself as much as the project management and project administration. Furthermore, it takes a great effort to write a successful project application facing a competition of other high-quality project applications. Therefore, structural changes are necessary both at the PMF level and at the level of departments, to allow the researchers to focus on their research work. Well-trained support structures will relieve them of the administrative burden and other similar tasks that nevertheless have to be done competently and professionally. It is not optimal to burden the teaching staff (researchers)

with those tasks. As they do not have specialist training for such tasks, when they have to perform them, they experience insecurity and unnecessary stress, exposing themselves to a considerable risk of failure and generally an extra load in addition to their primary responsibilities.

With the help of the questionnaire, we have gathered information from the departments about the problems they encounter in the application for, and implementation and management of EU-funded projects. The responses of individual departments are presented in the table below.

Table 5: Overview of main problems linked to EU-funded project application, implementation and management

	In your experience, what are the major problems linked to successful application for EU-project funding?	**Have you encountered any problems in your search for an adequate partner for EU projects?**
Department of Mathematics	Researchers' motivation to participate, as the project finance structure does not take into consideration specific features of mathematics as a profession and as a research discipline.	No
Department of Geophysics	In the initial phase, administrative requirements act as a discouragement for those who want to apply. It is also a problem to find qualified young people willing to accept short-term (fixed term) project-based work. Calls whose rules include ranking of applications by order of submission rather than their quality.	(not mentioned)
Department of Chemistry	Writing project proposals	Yes - project administration (related to the information on business sector partners)
Department of Biology	Department does not have sufficient infrastructure, it is working out of 5 different locations. Slow administration related to contracting, financing and implementation of EU projects.	No
Department of Physics	Heavy administrative burden related to project monitoring and periodical reporting, constant uncertainty regarding potentially ineligible costs, insufficient institutional administrative support, difficulties in the implementation of public procurement (all of the above refers mostly to the EU-funded projects managed through RoC. The second problem is the PMF management structure; project managers, unless they themselves are part of the management structure, are not given an opportunity to manage PMF resources in an optimal manner (e.g. space, administrative staff) with the aim of maximising the results. The situation has improved, but the actual state of affairs is far from optimal. The third problem is inadequate evaluation of successfully implemented projects in career advancement context. The situation has improved in that respect as well in the past few years, but the actual situation is still not optimal. Another important problem is inadequate incentive system for project managers through salary increase; it is made difficult by regulations, as well as by the fact that many projects have very limited or no eligible indirect costs, which then have to be paid from PMF budget. Since EU-funded project calls are extremely competitive, with a success rate of less than 10% of the total number of applications, the applicants from PMF are at a considerably more disadvantaged position than the applicants from those EU countries where science is a priority and a basis for innovation and development in terms of legislation, financing, availability of consulting services, and support in development and submission of project applications. At PMF, project applicants are mostly enthusiasts who are self-taught and self-trained in skills necessary to apply successfully for projects. There is no institutional support for development of project applications, as it is customary in respectable international universities. Low salaries in the public sector are demotivating for good consultants and project administration managers who should be handling project application and monitoring issues at PMF.	No
Department of Geography	Lack of spatial and administrative capacities. Lack of administrative staff to handle high administration demands at the department level.	No
Department of Geology	Lack of infrastructure as well as administrative support during project preparation, application and management.	No

The answers above confirm that the absence of (administrative) project support is one of the major difficulties encountered by practically all the departments regarding EU-funded project application and implementation. Another big problem is the absence of systematic development of human resources in this area, inadequate rewarding of success and active engagement in EU-funded projects.

A review of the job structure at the level of individual PMF departments and Dean's Office has lead us to conclusion that the support structures that would assist in project-based work, efforts to win EU- and other international grants, as well as the management and administration of those projects, are practically non-existent. There are some differences between the departments, but it is a fact that there is evidence of new developments as something to build upon in the future.

Having reviewed the Statutes of the Faculty of Science, University of Zagreb (of 4 October 2019), Internal Job Structure of the Faculty of Science, University of Zagreb (of 1 January 2019) and an updated list of all jobs at PMF (as at 17 February 2020), we have established the following:

1) In the Dean's Office, there are currently 42 employees. The latest amendments to internal organisation introduced under the ordinance Internal Job Structure at PMF (consolidated text) of 2 January 2019, proposed significant reinforcement of the Sub-department in the (central) service for projects and international cooperation, which represents an important step in the formation of the structures and prerequisites that are necessary for the future development of project work and boosting income streams from project work and international project collaborations. The ordinance in this aspect proposes the following organisational structure and jobs:

	Proposed no of jobs	Number of staffed jobs
7. Sub-department in the (central) service for projects and international collaboration		
7.1 I grade position – head of sub-department	1	
7.2 II grade post – senior clerk	1	
7.3 Other organisational unit for international cooperation and projects		
7.3.1 I grade position – head of organisational unit	1	1
7.3.2 I grade post – expert assistant (for international cooperation and public procurement)	2	1
7.3.3 Sub-department for international cooperation, projects and procurement		
7.3.3.1 II grade position – head of sub-department	1	1
7.3.3.2 II grade post – senior clerk	2	
7.4. Other organisational unit for projects and project procurement		
7.4.1 I grade position – head of organisational unit	1	
7.4.2 I grade post – expert assistant (for projects and procurement)	2	1
7.4.3 II grade post – senior clerk	2	
TOTAL	**13**	**4**

Out of the 13 posts according to the plan, 4 are currently staffed. Once all vacancies are filled, the basic structure will be in place and this will significantly improve the PMF capacity for project-based work, subject to an important condition, i.e. that all the staff should have skills needed for the proposed posts, that they should be willing to regularly attend training, and that the PMF management should also be willing to invest in them and their continuous empowerment and competence enhancement. Furthermore, by creating a good and pleasant work environment, PMF should reduce staff turnover in these posts and positions as much as possible. This will be discussed in further detail in Chapter 7. Strengthening PMF capacity for writing grant proposals for EU funds as well as possible funding by industry sources, including proposals of activities for changes.

2) At department level, the structure and capacities that are necessary as support for the project work and EU projects are practically non-existent. The Departments of Physics and Chemistry have laid the groundwork, and so has the Department of Biology to an extent; the remaining departments are still missing such structures. In those departments, the following posts offering a level of support to project activities have been organised (and staffed):
    - Department of Biology: „project management administrator" (1 person)
    - Department of Chemistry: „chief project administrator" (1 person)
    - Department of Physics: the following units were formed:
        - Other organisational unit for monitoring of research projects and material costs – Projects Office, and the project support staff are employed in the following posts:
            - Chief project administrator (1 person);
            - Expert assistant (1 person); and
            - Head of organisational unit (1 person),
        - Other organisational unit for procurement and economic and financial operations, with 1 employee:
            - Head of organisational unit (1 person),

      I.e. a total of 4 employees. In addition, the Department of Physics has split the Other organisational units for administrative affairs into a research administration unit, a general administration unit and a teaching administration unit, which seems to be an efficient division of the administrative unit's capacity into the three basic areas of activity.

At this point, it has to be said that project development, governance and management cannot be reduced to just project administration, as it is often misconstrued and misinterpreted. Project administration is only a part (though very important) of the entire process of successful project application development and implementation; other basic elements include writing project applications (which again comprises all the elements, from administrative to technical development and elaboration of the project concept and, finally, of the entire project proposal), and project management, reporting, monitoring of project costs, finances and materials, implementation of public procurement procedures, implementation of project visibility activities and finally (technical) implementation of the project itself.

All the departments are included in EU projects, and in light of the proposed high-level allocation for research grant programmes in the Multiannual Financial Framework 2021-2027, there will be many more such projects in the future, if the departments get an adequate and properly structured support. It is very important that all the departments have acquired certain experience by now; this will serve as a basis for the future development of organisation of work and the administrative support from the central PMF level. By now, everyone is more aware of how the work has to be organised, which resources are needed, what knowledge every department has or does not have and needs to pursue. The management of PMF now also has a clearer view of the kind of support that should be organised at the central level, and what should remain at departmental level. All this experience of the past seven years is very important, something that PMF simply had to go through in order to be better prepared for the next Multiannual Financial Framework. Considering the absence of project support, PMF has achieved considerable success with EU projects, as evident from a large number of projects involving all the departments. As part of this Analysis, we have sent a questionnaire to each department, asking them to list the EU projects they were involved in in 2019, or those in which they are currently involved (information gathering exercise was launched in January 2020). The table below shows the list of projects based on the responses received.

Table 6: Overview of involvement in EU-funded projects by department (currently active projects (January 2020) and projects in 2019)

	Name of project	PMF's project status (Project coordinator / Partner)
Department of Mathematics	Development of efficient methodology for finite element method based structural analysis of marine structures – Remake	Partner
	Teachers' Inquiry in Mathematics Education (TIME)	Project coordinator
Department of Geophysics	KLIMA_4HR	Project coordinator
	Severe Weather over the Alpine-Adriatic region in a hanging Climate (SWALDRIC)	Partner
Department of Chemistry	Centre of Excellence in Chemistry	Project coordinator
Department of Biology*	BIOengineered grafts for Cartilage Healing in Patients (BIO-CHIP)	Partner
	Marine Ecosystem Restoration in Changing European Seas – MERCES	Partner
	Systems medicine approach to chronic inflammatory disease (SYSCID)	Partner
	Innovative training in methods for future data (IMforFuture)	Partner
	New generation of high-speed glycoservices	Project coordinator
	Personalized Medicine Inquiry-Based Learning	Partner
	Competence centre in molecular diagnostics	Partner
Department of Physics	Constraining Stellar Mass and Supermassive Black Hole Growth through Cosmic Times. Paving the way for the next generation sky surveys; ERC Starting grant	Project coordinator
	Implementation of top-tier research within the scientific excellence centre for quantum and complex systems and representations of Lie algebras; EU Structural and Investment Funds	Project coordinator (Departments of Physics and Mathematics)
	CeNIKS - Centre for advanced research of complex systems; EU Structural and Investment Funds	Project coordinator
	Development of the study programme of physics with application of Croatian Qualifications Framework – FizKO; EU Structural and Investment Funds	Partner
	The Janus-face of the localized carrier in cuprates: Generating the pseudogap and high temperature superconductivity – TheONE; ERC Consolidator grant	Partner
	STRONG-2020; EU program Horizon 2020	Partner
Department of Geography	Standards for Teachers, Educators and Mentors' Competence standards	Partner
	The future of Europe's Shrinking Rural Regions: Trends, Perspectives and New Agendas for Territorial Governance	Partner
Department of Geology	REEBAUX – Prospects of REE recovery from bauxite and bauxite residue in the ESEE region	Project coordinator
	Computer model of flow, flooding and spread of pollution in rivers and coastal sea areas	Partner

EU and other international funds offer great research and infrastructure funding opportunities, and PMF needs to make the necessary adaptations, to position itself favourably and secure better opportunities in the Multi-annual Financial Framework 2021-2027. In order to bring it to fruition, it has to undertake organisational and structural changes, expanding the existing body of knowledge and experience.

As we analyse the support capacities, we should also mention that the posts and positions in the support structures have to be staffed adequately and rationally. In Chapter 7, we have elaborated a proposal as to how the support capacities should be organised. Indeed, there is the issue of availability of quality recruits, another issue we address in Chapter 7. The first step should not be recruitment, but re-assignment and strengthening of own (existing) capacities. The existing administration services at the departmental level could represent a significant capacity.

The existing general PMF administration appears to be large, non-transparent and inefficient. In view of the geographical dispersal of some departments, department-level administrations have developed in addition to the central administration. The total number of administrative posts is therefore high, and yet the administrative support is still insufficient. In addition, departments have to handle burdensome project administration, which often makes active participation in EU and other international projects impossible. General administration is mostly neither specialised nor competent for project administration, in addition to being burdened with the general administrative duties, while researchers are preoccupied with teaching, research, professional and other tasks. Based on the questionnaire, the majority of departments saw the excessive administrative burden as one of the main obstacles to stronger external relations and stronger activity in EU projects. As we described in detail in Chapter 7, we propose as a solution the restructuring of the general administration and setting up of projects offices.

Having reviewed the posts in each department, it is clear that the departments have opted for different organisation of their administrative and professional services. In terms of improving the effectiveness of these services and their accessibility to users, it is necessary to determine which aspects of administration can be handled centrally, regardless of the fact that the departments operate from various locations, and which segments cannot be handled centrally, precisely because of the geographical dispersal. In this determination, it is important to take into account the existence of modern technologies, as they have considerably improved remote communication, enabled digitalisation at all levels, improved document editing and storage etc. As we have partly linked the formation of the projects offices to the general PMF administration, it would appear that these two support pillars should be considered together. On the one hand, PMF needs an effective general administration, which also has to become more efficient than is presently the case, if possible, and on the other hand, potential scenarios for the setting up of the essential projects offices, i.e. of strong central and department-level projects offices, have to be also considered.

The centralised (general) administration has certain advantages, but so does decentralised administration, and they both have certain weaknesses. Below are the most important ones:

	ADVANTAGES	DISADVANTAGES
CENTRALISED general administration	- greater transparency; - greater cost and general effectiveness; - easier to train administration specialists; - total capacity needed is lower; - PMF has a sufficient total number of administrative staff; - good accessibility to end users; - part of the existing administrative resources could be re-assigned to projects offices;	- organisational changes are necessary; (most people generally do not like and often resist change); - spatial constraints in the central location; - good IT support is needed, especially in light of fragmented department premises; - communication made difficult due to geographical dispersal of premises;
DECENTRALISED general administration	- "business-as-usual" scenario; - ease and simplicity of communication; - often greater speed of communication; - no need for organisational changes in administration;	- greater overall capacity is needed; - multiple duplication of the same business processes; - lower cost effectiveness; - less transparent; - not streamlined; - more complicated organisation of projects offices with existing constraints (infrastructure, human resources).

The optimum scenario is probably somewhere in the middle, between the one and the other, although there is enough room for different variations. The proposal concerning the setting up of projects offices is elaborated in detail in Chapter 7.

2 ANALYSIS OF COLLABORATION WITH CROATIAN AND INTERNATIONAL RESEARCH INSTITUTIONS

PMF collaborates with numerous Croatian and international research institutions, with varying degree of intensity depending on the department involved. A great majority of collaborations with research institutions takes place at the international level, although PMF is very active locally.

Below is the list of PMF's Croatian research partner institutions (as of January 2020):

Table 7: List of PMF's Croatian research partner institutions (as of January 2020)

No	Name of institution	Department
1	Faculty of Electrical Engineering and Computing, University of Zagreb	Department of Physics
2	Institute of Oceanography and Fisheries	Department of Geology
3	Croatian Geological Survey	Department of Geology
4	Faculty of Mining, Geology and Petroleum Engineering University of Zagreb	Department of Geology
5	University of Pula	Department of Geology
6	University of Split, Faculty of Science	Department of Geology
7	University of Split, Faculty of Civil Engineering, Architecture and Geodesy	Department of Geology
8	Institute of Oceanography and Fisheries, Split	Department of Geology
9	Institute for Marine and Coastal Research, Dubrovnik	Department of Geology
10	Ruđer Bošković Institute, Center for Marine Research, Rovinj	Department of Geology
11	University of Rijeka, Faculty of Civil Engineering	Department of Geology
12	Academy of Fine Arts, Zagreb	Department of Biology
13	Faculty of Pharmacy and Biochemistry, University of Zagreb	Department of Biology
14	School of Medicine, University of Zagreb	Department of Biology
15	Srebrnjak Children's Hospital	Department of Biology
16	St. Catherine Specialty Hospital	Department of Biology
17	Faculty of Medicine, University of Osijek	Department of Biology
18	Department of Chemistry, University of Osijek	Department of Biology
19	Fidelta d.o.o. za istraživanje i razvoj	Department of Chemistry
20	Pliva Hrvatska d.o.o	Department of Chemistry
21	Genos d.o.o.	Department of Chemistry
22	Faculty of Agriculture University of Zagreb	Department of Chemistry
23	Croatian Meteorological and Hydrological Service	Department of Geophysics
24	Hydrographic Institute Croatia	Department of Geophysics
25	The Ruđer Bošković Institute	Department of Geophysics
26	University of Rijeka, Centre for High Throughput Technologies	Department of Geophysics
27	Faculty of Forestry, University of Zagreb	Department of Geophysics
28	Institute of Agriculture and Tourism Poreč	Department of Geophysics
29	Agricultural Institute Osijek	Department of Geophysics
30	Faculty of Agrobiotechnical Sciences, University of Osijek	Department of Geophysics
31	Podravka d.d.	Department of Mathematics
32	Croatian Institute for Public Health	Department of Mathematics
33	Faculty of Organization and Informatics, Varaždin	Department of Mathematics

Data source: PMF

As the next step in our analysis, with the help of the questionnaire, we collected from all the departments information concerning their collaborations with international research institutions (as of January 2020).

The table below shows how the respondents replied to the following questions: "Is your department currently involved in any international collaboration projects? Was it involved in any in 2019? Please supply the following information about all the international collaborations taking place now or in 2019".

Table 8: Overview of international research collaborations, currently and in 2019

	Name of institution you collaborate(d) with	Is collaboration institutionalised based on a contract, agreement or another document?	Did/Will the collaboration result in any publication, conference presentation or other?	Number of PMF staff taking part in collaboration
Department of Mathematics	(Total: 6 institutions) 1) Universität Wien; 2) Universität Bern; 3) University of Copenhagen; 4) Utrecht University; 5) University of Ljubljana; 6) University of Berkeley.	"Unknown" in each case	YES – in all listed collaborations	Total of 12 staff involved in collaborations with 6 institutions (6x 2)
Department of Geophysics	(Total: 4 institutions) 1) The Abdus Salam International Centre for Theoretical Physics (ICTP), Trieste, Italy; 2) Univerzitet u Beogradu, Beograd, Srbija; 3) ETH Zurich; 4) Eötvös Loránd Tudományegyetem: Budapest, HU;	2x NO 1x YES – contract 1x YES – bilateral agreement	YES – in all listed collaborations	Total of 12 staff involved in collaborations with 4 institutions (1x 6, 1x 4, 2x 1)
Department of Chemistry	1) (Total: 22 institutions) 2) LCC- IUT Toulouse III; 3) University of Padua; 4) McGill University; 5) University of Birmingham; 6) University of Jyväskylä; 7) Kansas State University; 8) University of Pretoria; 9) Austrian Institute of Technology; 10) Institut für Nukleare Entsorgung (INE), Karlsruher Institut für Technologie (KIT)/Karlsruhe/Germany; 11) Lawrence Berkeley National Laboratory, U.S. Department of Energy (DOE), Berkeley, USA; 12) Institute of Physical Chemistry/Warsaw/Poland; 13) Dipartimento di Chimica, Università degli Studi di Milano, Milan , Italy; 14) Faculty of Health Sciences, University of Ljubljana; 15) Institut für Chemie, Karl-Franzens-Universität Graz, Austria; 16) Department of Chemistry „Ugo Schiff", University of Florence, Italy; 17) Faculty of Physics, Babeş-Bolyai University, Cluj-Napoca, Romania; 18) CEITEC (Central European Institute of Technology, Brno, Czech Republic); 19) Proteome Center Tuebingen, University of Tübingen, Germany; 20) Department of Chemistry, – Biomedicinska Centrum (BMC), Uppsala University, Uppsala, Sweden; 21) ETH Zuerich, Switzerland;	15x NO 7x YES	YES - in all listed collaborations	Total of 61 staff involved in collaborations with 22 institutions (1-7 per collaboration)

	22) Weizmann Institute of Science, Israel; 23) Freie Universität Berlin.			
Department of Biology	(Total: 6 institutions)	YES – in all listed collaborations	All projects are still under way and they all foresee some type of dissemination of results.	Total of 12 staff involved in collaborations with 6 institutions (1-3 per collaboration)
Department of Physics	(Total: 103 institutions) 1) Cavendish Laboratory, Quantum Matter, University of Cambridge, Cambridge, United Kingdom; 2) Department of Physics, University of Toronto, Ontario Canada; 3) High field magnet laboratory, Nijmegen, Netherlands; 4) National High Magnetic Field Laboratory, Los Alamos, USA; 5) Department of Physics, Faculty of Arts and Science, Yildiz, University, Istanbul, Turkey; 6) Universita degli studi di Milano, Italy; 7) Institut de Physique Nucleaire, Universite Paris Sud, Orsay, France; 8) School of Nuclear Science and Technology, Lanzhou University, Lanzhou, China; 9) Institute of Biomedical Engeneering and Informatics,TU Ilmenau, Ilmenau, Germany; 10) IFW Dresden, Germany; 11) Nuklearni institut Vinča, Beograd, Serbia; 12) University of Minnesota, USA; 13) SISSA, Trieste; 14) HIT, Holon; 15) Linkoping University, Sweden; 16) Columbia University, NY, USA; 17) Karolinska Institute, Sweden; 18) PHENIX Collaboration, Brookhaven National Laboratory, USA; 19) The University of Sydney; 20) Thomas Jefferson National Accelerator Facility, Jlab HallA PREXCREX 21) Collaboration, USA; 22) Thomas Jefferson National Accelerator Facility, Jlab HallC A1nd2n collaboration , USA; 23) ETH-Zurich; 24) Department of Chemistry, Faculty of Natural Sciences and Mathematics, Ss Cyril and Methodius University of Skopje, Republic of North Macedonia; 25) Materials Science, Institute for multidisciplinary research, Belgrade, Republic of Serbia; 26) Jožef Štefan Institute, Ljubljana, Republic of Slovenia; 27) Institute of mathematics, physics and mechanics, Ljubljana, Republic of Slovenia; 28) Faculty of Civil and Geodetic Engineering, University of Ljubljana, Republic of Slovenia; 29) Institute for Materials Research-UNAM, Ciudad Universitaria Coyoacan, Mexico;	86x NO 17x YES	YES – in all listed collaborations but one	Total of 224 staff involved in collaborations with 103 institutions (1-6 per collaboration)

	30) Tehnološki fakultet, Univerzitet u Novom Sadu, Republika Srbija; 31) École polytechnique fédérale de Lausanne, Švicarska; 32) Politecnico Milano, Italia; 33) Bergische Universität Wuppertal – Fakultät für Mathematik und Naturwissenschaften, Wuppertal, Njemačka; 34) Hiroshima Synchrotron Radiation Center, Hiroshima University; i Institute of Solid State Physics, Vienna University of Technology; 35) Department of Physics, Faculty of Science, Mahidol University; 36) University of Vienna, Austria; 37) International Union of Crystallography, University of Pavia, Italy; 38) University of Pavia, Italy; 39) Justus Liebig Universitat, Giessen, Germany; 40) Southern University of Science and Technology, Shenzhen, China; 41) Hong Kong University, Hong Kong; 42) New York University Abu Dhabi, EAU; 43) Adam Mickiewiz University of Poznan, Poland; 44) University of Vienna, Austria; 45) International Union of Crystallography, University of Pavia, Italy; 46) University of Pavia, Italy; 47) GANIL, France; 48) University of Cologne, Germany; 49) Peking University, China; 50) Liaoning Normal University, China; 51) Autonomous University of Madrid, Spain; 52) Kuwait University, Kuwait; 53) INAF - Osservatorio di Astrofisica e Scienza dello Spazio, Bologna, Italy; 54) Max-Planck-Institut für Radioastronomie, Bonn, Germany; 55) CEA, IRFU, DAp, AIM, Universite Paris-Saclay, Universite Paris Diderot, Sorbonne Paris Cite, CNRS, F-91191 Gif-sur-Yvette, France; 56) Max-Planck-Institut für Astronomie, Königstuhl 17, D-69117 Heidelberg, Germany; 57) International Centre for Radio Astronomy Research (ICRAR), University of Western Australia, 35 Stirling Hwy, Crawley WA 6009, Australia; 58) Department of Astronomy, University of Cape Town, Private Bag X3, Rondebosch 7701, South Africa; 59) INAF - Osservatorio di Astrofisica e Scienza dello Spazio - Bologna, Via Piero Gobetti 93/3, I-40129 Bologna, Italy.; 60) Chalmers University of Technology, Dept. of Space, Earth and Environment, Onsala Space Observatory, SE-439 92 Onsala, Sweden; 61) Department of Physics and Astronomy, Clemson University, Clemson, SC 29634, USA; 62) Centre for Space Research, North-West University, Potchefstroom 2520, South Africa; 63) Max-Planck-Institut für Radioastronomie, Auf dem Hügel 69, 53121 Bonn,			

	Germany; 64) School of Physics and Astronomy, Rochester Institute of Technology, Rochester, NY 14623, USA; 65) Max-Planck-Institut für Astronomie, Königstuhl 17, 69117, Heidelberg, Germany; 66) National Observatory of Athens, Lofos Nymfon, Thession, Athens 11810, Greece; 67) ICMPE, Universite Paris-Est, 94320 Thiais, France; 68) Inst. for Materials Research, UNAM, CP04510, Mexico D.F., Mexico; 69) Diamond Light Source Ltd.„ Didcot, Oxfordshire OX11 ODE, U.K.; 70) Institute of Physics, Faculty of Science, P.J. Šafarik University, 04154 Košice, Slovak Republik; 71) Institute for Particle and Nuclear Physics, Wigner Research Centre for Physics, Department of Theory; 72) KFKI Campus, MTA Wigner Fizikai Kutatóközpont, 1121 Budapest, Konkoly-Thege Miklós út 29-33, Hungary; 73) Department of Chemistry, University of Helsinki, P.O. Box 55 (A. I. Virtasen aukio 1), FI-00014 University of Helsinki, Finland; 74) NASA Goddard Space Flight Center, Greenbelt, MD 20771, USA; 75) The Johns Hopkins University, Department of Physics and Astronomy, 366 Bloomberg Center, 3400 N. Charles St., Baltimore, MD 21218, USA; 76) Institute for Basic Science, Daejeon, R. Korea; 77) CERN, Switzerland; 78) Laboratori Nazionali di Frascati; 79) Institut fuer Kernphysik, Universitaet Johannes Gutenberg, Mainz, Germany; 80) Stefan Meyer Institut, Bec, Austria; 81) RIKEN, Wako, Japan; 82) Laboratori Nazionali del Sud, Istituto Nazionale di Fisica Nucleare, Catania, Italy; 83) University of Vienna, Faculty of Physics (Fakultaet fuer Physik), Austria; 84) University of Vienna, Austrian Educational Competence Centre Physics, Austria; 85) Goucher College, Baltimore, USA; 86) Ruhr Universität Bochum, Bochum, Germany; 87) University of Gothenburg, Göteborg, Sweden; 88) Chalmers University of Technology, Göteborg, Sweden; 89) B. Verkin Institute for Low Temperature Physics and Engineering of the National Academy of Sciences of Ukraine, Kharkov, Ukraine; 90) V.N. Karazin Kharkiv National University, Kharkov, Ukraine; 91) Raymond and Beverly Sackler School of Physics and Astronomy, Tel Aviv University, Tel Aviv, Israel; 92) Ben Gurion University, Beer Sheva, Israel; 93) Department of Astronomy, University of Geneva, ch. d'Ecogia 16, 1290 Versoix, Switzerland; 94) INAF - Osservatorio Astronomico di Bologna, P. Gobetti 93/3, 40129 Bologna, Italy; 95) ASTRON, the Netherlands Institute for Radio Astronomy, Postbus 2,7990 AA, Dwingeloo, The Netherlands;			

	96) H.H. Wills Physics Laboratory, University of Bristol, Tyndall Avenue, Bristol BS8 1TL, U.K.; 97) INAF, IASF Milano, via Corti 12, 20133 Milan, Italy; 98) Chalmers University of Technology, Department of Space, Earth and Environment, Onsala Space Observatory, 439 92 Onsala, Sweden; 99) CSIRO Astronomy and Space Science, PO Box 1130, Bentley WA 6102, Australia; 100) Leiden Observatory, Leiden University, Niels Bohrweg 2, 2333 CA, Leiden, The Netherlands; 101) Centre for Space Research, North-West University, Potchefstroom 2520, South Africa; 102) AIM, CEA, CNRS, Universite Paris-Saclay, Universite Paris Diderot, Sorbonne Paris Cite, F-91191 Gif-sur-Yvette,France; 103) Inter-University Centre for Astronomy and Astrophysics Ganeshkhind, Post Bag 4, Puné 411 007, INDIA; 104) School of Physical Sciences, University of Tasmania, Private Bag 37, Hobart, Tasmania 7001 Australia;			
Department of Geography	(Total: 10 institutions) 1) University of Ljubljana, Faculty of Arts, Department of Geography; 2) Lomonosov Moscow State University, Faculty of Geography; 3) Daugavpils University, Faculty of Natural Sciences and Mathematics, Department of Chemistry and Geography; 4) University of Belgrade, Faculty of Geography; 5) University of Bucharest, Faculty of Geography, Department of Meteorology and Hydrology; 6) University of Prishtina, Department of Geography; 7) University of Novi Sad, Faculty of Sciences; 8) Jagiellonian University, Institute of Geography and Spatial Management; 9) University of Primorska; 10) Institute of Speleology, Cluj-Napoca;	2x NO 8x YES	2x NO (more precisely, no answer given) 8x YES	Total of 24 staff involved in collaborations with 10 institutions (1-5 max. per collaboration)
Department of Geology	(Total: 6 institutions) 1) COST Action; 2) University of Pécs; 3) University of Tromsù - The Arctic University of Norway; 4) Universität Stuttgart, Institut für Mineralogie und Kristallchemie; 5) Universität Wien, Department für Lithosphärenforschung; 6) Univerity of Vienna, Faculty of Earth Sciences, Geography and Astronomy - Department of Paleontology; 7) Štátnygeologickýústav Dionýza Štúra, Oddeleniešpeciálnychlaboratórii, Bratislava; 8) Slovenskejakadémievied, Geologickýústav, Bratislava; 9) Comenius University, Department of Mineralogy and Petrology, Faculty of Natural Sciences, Bratislava. 10) Ivan Rakovec Institute of Palaeontology, Research Centre of the Slovenian Academy of Sciences and Arts 11) Slovaki Academy of Science;	9x NO 21xYES	YES – in all the listed collaborations	Total of 30 staff involved in collaborations with 30 institutions (1-4 max per collaboration)

	12) University La Sapienza; 13) University of Genova; 14) University of Ferrara; 15) Slovenian Academy of Science; 16) University of Modena; 17) University of Trieste; 18) University of Pisa; 19) University of Siena; 20) University of Ljubljana; 21) Naturalis Biodiversity Center (Leiden); 22) Mining and Geological Survey of Hungary (Palaeomagnetic Laboratory); 23) Geologische Bundesanstalt für Österreich; 24) University Federico II (Naples); 25) University of Barcelona; 26) University of Lausanne; 27) University of Bergen; 28) Geologische Bundesanstalt Vienna; 29) Lancaster University - Lancaster Environment Centre; 30) Smith College, Northampton, MA, SAD			

Based on the table above, we can conclude the following:

- All the departments are involved in collaborations with international research institutions;
- There are great differences among the departments in terms of intensity of international cooperation;
- The departments have a varying degree of institutionalisation of their international research collaborations. Nevertheless, those with a higher overall number of collaborations tend to have fewer contract-based collaborations, and in several cases collaboration takes place without any formal framework, often with already familiar partners (institutions) with whom PMF cooperates frequently or even continuously;
- In most cases, the collaboration results in publications, conference presentations or other forms of dissemination of findings;
- In most cases, the number of PMF staff involved in any given international collaboration is small (1-4), the average being 2.35 PMF staff per above listed collaboration.

The answers also clearly show that the Department of Physics, for instance, which among all the departments has by far the highest number of international collaborations, in most cases does not conclude any formal contracts with its partner institutions. The leadership of the department argue that they have not observed any need to sign formal contracts, especially when the institutions involved are those they cooperate with regularly or continuously. International collaboration is formalised and contracts are signed whenever they have bilateral cooperation projects or other types of projects that require contract-based work.

In the context of international cooperation, we asked the departments to answer the following question: „What are the main problems linked to the negotiation and implementation of international collaborations in your department?“ We received the following answers:

Table 9: Overview of main problems linked to negotiation and implementation of international collaborations by department

	In your experience, what are the main problems linked to negotiation and implementation of international collaborations in your department?
Department of Mathematics	A complicated and rigid project implementation monitoring system and issues linked to completion of public procurement procedures within project due dates
Department of Geophysics	Projects without the advance payment option, where the cost eligibility burden is transferred to the implementing institutions. If any costs are ineligible, they must be borne by the project coordinator. Currency conversion. Insufficient logistics and administrative support (insufficient number of staff responsible for those functions relative to the number of potential projects and their needs) of the parent institution.
Department of Chemistry	(no answer)
Department of Biology	Lack of infrastructure (operating from five different locations) Complicated project administration
Department of Physics	No major problems.
Department of Geography	High teaching load of the staff and the resulting limited mobility UniZG-imposed constraints during contract negotiations
Department of Geology	Teaching load that limits mobility and insufficient administrative support.

Based on the answers provided, we can conclude that the main problems linked to the negotiation and implementation of international collaborations lie primarily in the implementation phase (insufficient administrative support, implementation of public procurement, missing infrastructure and, of course, teaching load of the staff), rather than finding adequate partners or negotiating a collaboration agreement.

3 ANALYSIS OF COOPERATION WITH THE BUSINESS SECTOR

The current 2015-2020 Development Strategy of the Faculty of Science, University of Zagreb does not elaborate in detail the cooperation with the business sector. It is addressed in the section focused on the PMF's mission and vision, and in the section on strategic goals, but without details.

- Part of the MISSION statement that addresses the cooperation with the business sector:

A contribution to the development of the economy and society as a whole through applied and developmental scientific research within the national knowledge triangle realised through the cooperation with the business sector, especially with the industry and the financial institutions.

- Part of the VISION statement addressing the cooperation with the business sector:

The university study programmes of PMF within the University of Zagreb are based on science, innovativeness and acquired new knowledge, and they contribute to the social and economic development of the Republic of Croatia.

- The STRATEGIC GOALS referring to cooperation with the business sector:

Strategic Goal 3: Improving the quality of academic work, transfer of knowledge and technology.
Strategic Goal 5: Increasing the influence on the development of society as a whole and accepting social responsibility.

The Development Strategy does not reveal what type and method of cooperation with the business sector are of strategic importance for PMF. In addition, the Strategy does not elaborate the position in relation to potential cooperation with the business sector in international projects, or to industry-funded research or equipment investment.

With the help of the questionnaire prepared for this Analysis, we have asked the departments to supply information on their cooperation with the business sector. The questionnaire refers to 2019 and the beginning of 2020 (as at January 2020). All the departments have completed the questionnaire. The first conclusion is that there are significant difference among the departments in terms of the intensity of their cooperation with the business sector. However, those differences can be partly explained by specific features of each department.

When asked: "Is your department currently cooperating with an economic operator? Did you cooperate with the business sector in 2019? Please supply the following information for collaborations taking place now or in 2019", this is how each department replied:

Table 10: List of collaborations with economic operators, currently or in 2019, by department

	Name of economic operator and the subject-matter of collaboration	Is collaboration institutionalised based on a contract, agreement or another document?	Financial outcome of collaboration (income)	Is collaboration long-term (permanent) or one-off?
Department of Mathematics	(Total: 0)	/	/	/
Department of Geophysics	(Total: 10) HEP d.d.: Monitoring seismic activity in 2019, 2020 and 2021; MORH: Seismological monitoring at E. Kvaternik military training area; Hrvatske vode: 2019 Instrumental seismic observation at the Ričica dam site; Dubrovnik-Neretva County: Measuring the impact of seismic activity on the buildings of strategic interest – READINESS project; Dubrovnik-Neretva County: Assessment of earthquake resistance of the General Hospital Dubrovnik, Building D; Split – Dalmatia County: Procurement of services of instrumental and seismological research of strategic public buildings in the Split-Dalmatia County - project READINESS; Split – Dalmatia County: Assessment of earthquake resistance of the strategically important public building in the region of Split-Dalmatia County – Pučišća Elementary School - project READINESS; Krško Nuclear Power Plant Decommissioning Fund: Seismic hazard assessment at Čerkezovac location; Ivana gas field seismicity – study revision; Study of Turbulence – SESAR 2020: Study of Correlations between measured turbulence parameters and output fields of numerical weather prediction models;	YES – based on a contract for all 10 collaborations	Total: HRK 2,215,076 + VAT	3x long-term, multiple collaborations; 7x one-off collaborations
Department of Chemistry	(Total: 11) Jadran - Galenski laboratorij d.d.: Crystallization and structural analysis; Pliva Hrvatska d.o.o.: crystal form screening of active ingredients; Xellia d.o.o.: Crystalline forms of active ingredients; Xellia d.o.o.: Physicochemical properties of drugs in solution; Pliva Hrvatska d.o.o..: Suspension stability; PP Medvednica: Chemical analysis of environmental samples; Faculty of Civil Engineering UNI ZG.: Chemical analysis of cement and construction materials; CSS d.o.o..: Aggregate analysis; Geoexpert d.o.o..: Aggregate analysis; Safety Institute: Electrolyte analysis; Fidelta: Compound purity analysis;	YES – bids, contracts	Total: HRK 473,000	5x long-term collaborations, 6x one-off collaborations
Department of Biology	(Total: 7) Hrvatske vode HEP – proizvodnja d.o.o. NP Krka (National Park)	YES – based on contracts	All collaborations have a financial impact, values are not disclosed	All collaborations are one-off

	The town of Šibenik Istarski vodovod NP Kornati (National Park) NP Sjeverni Velebit (National Park)			
Department of Physics	(Total: 1) Picologic j.d.o.o.: It is a Department of Physics research spin-off. The co-founder is a professor at PMF Department of Physics. Multichannel picoammeters are produced, for measuring low currents at high voltage. Picoammeters are calibrated and produced in the Department of Physics lab and workshop.	NO	In the first year of collaboration, economic operator invested HRK 30,000 in workshop equipment	Collaboration has lasted for 4 years
Department of Geography	(Total: 7) Hrvatske vode: Project – Systematic monitoring and assessment of hydro morphological quality elements in rivers in the year 2018; JU Park prirode Velebit: Project – Geomorphological and geoecological study of the Zrmanja river; JU Park prirode Velebit: Project – Supervision services within the project of Cerovačke špilje Excellence Centre; JU Park prirode Biokovo: Project – Geomorphological and microclimate research/monitoring of Crna ledenica cave; Hrvatske vode: Development of methodology for hydromorphological assessment of stagnant waters and implementation of hydromorphological monitoring; JU NP Plitvička jezera: Project – Hydro morphological study of the Plitvice flows; JU Zeleni prosten: Project – Together for the Sava river;	YES – based on contracts	All collaborations have a financial impact, values are not disclosed	Only one-off collaborations
Department of Geology	(Total: 12) Croatian Conservation Institute (Zagreb): Archaeological sample analysis; International Centre for Underwater Archaeology (Zadar): Rock sample analysis; ANT – Laboratory for Analytics and Toxicology Ltd.: Solid sample analysis; Vet-Point (Zagreb): Solid sample analysis; Town of Čazma: Geological and petrological study; Institute of Archaeology (Zagreb): Rock sample analysis ; DvokutEcro (Zagreb): Granulometric and mineral analysis of marine sediment sample from the island of Maun; Public Institution for Management of Protected Natural Areas of the Dubrovnik-Neretva County: Elaboration of study – report on the flow and quality of sediment and water in the area of the Neretva Delta ecological network; Urbanistički Institut Hrvatske d.o.o.: Sample analysis – sampling of sediment nuclei by diving at 5 locations, granulometric and mineral analysis of sediment in the area of Funtana bay; METRIS - Center for Materials Research of the County of Istria; Plitvice Lakes National Park Public Institution – project „Sedimentology, stratigraphy and structural-geological features of Plitvice Lakes“; Učka Nature Park Public Institution – micropaleontological analyses	YES – based on contracts	All collaborations have a financial impact – values are not disclosed	3x long-term collaborations, 9x one-off collaborations

Based on the table above, we can conclude the following:

- All the departments, except for the Department of Mathematics, were engaged in some kind of cooperation with the business sector in 2019;
- The cooperation with the business sector is mostly regulated by contracts, except for one of the Department of Physics' collaborations, where the business partners is a Department of Physics research spin-off;
- All collaborations generate income for PMF;
- The cooperation with the business sector is usually in the form of one-off, professional, project-based collaboration, and rarely a long-term, strategic type of cooperation, which would imply long-term partnership and joint research.

PMF has no strategy of cooperation with the business sector, nor has it established the support mechanisms of knowledge transfer in cooperation with the business sector, which is also an observation made by the Expert Panel during the 2015 PMF re-accreditation exercise. PMF's cooperation with the business sector is very important, however, it should be framed into certain strategic guidelines. As this is one of the most important issues and tasks for PMF in the coming period, in this Analysis we identify it as one of the future strategic goals of PMF, including a prior adoption of a strategy.

In order for the proposed actions to boost PMF's cooperation with the business sector to be as specific as possible, we sent several additional questions to the departments as part of this Analysis. The questions concern their cooperation with business, and the replies received are displayed in the table below:

Table 11: PMF Departments' views on opportunities and difficulties linked to cooperation with business sector

	In your experience, how informed is business sector about possible cooperation with your department and potential benefits?	**Is there equipment (laboratories) in your department that could be offered to the business sector under commercial terms (to use independently or alongside your experts)? What obstacles do you see to such a scenario?**
Department of Mathematics	Insufficiently	Yes, there is (computing equipment on our high-performance computers (HPC) and scientific computing). The main challenge is lack of awareness in the business sector.
Department of Geophysics	Between insufficient and satisfying	Yes, there is. The main challenge is additional administrative and bureaucratic burden.
Department of Chemistry	Information about the expertise that our laboratories cannot be found in the media used by various manufacturing industries, agriculture and biomedicine. Advertising via PMF website is sufficient only to inform a narrow circle of professions that rely on research. There is a great need for expertise in manufacturing and industry, but it is usually satisfied by international commercial laboratories, which have a different approach to advertising.	The existing equipment has already been used for long time to provide expert services to various economic operators. Our ability to expand the scope of services that we can deliver to business with our equipment depends mostly on the quantity and availability of our experts who currently have an excessive workload. For instance, our expert assistants, who are expected to focus on supporting and capitalising on the effects of the sophisticated research equipment, spend most of their time teaching or doing administrative tasks. The business sector, unlike the research sector, usually seeks quick fixes to its problems, rather than participation in joint activities using research equipment. That is why we should increase the number of our experts as one of the possible solutions if we want to bolster our cooperation with the business sector.
Department of Biology	Not well enough.	No. Lack of time and space.
Department of Physics	The business sector is only partially aware of the possibilities for cooperation. Information exchange takes place during organised events at the Department of Physics or at PMF, in the framework of events such as the PMF Career Day, PMF Open Days or Physics Today. Interested business organisation have their own exhibition stands during such events and sponsor certain activities of the Department. The presentation of the CeNIKS attracted a lot of interest among economic operators. In addition, as we were presenting the project on several TV programmes, we stressed the possibility to access and use our research equipment. In ZICER – Zagreb Innovation Centre, the first workshop was held in order to introduce the CeNIKS capacities to the business sector. On several occasions, we reached out to the business sector but they rarely showed any interest in cooperation. Even when they were	Yes, at the Department of Physics, there are laboratories and equipment that may be offered to the economic sector under commercial terms, depending on the interest of both parties. - There is an ongoing cooperation with a company called Picologic j.d.o.o.; they use the lab on the 3rd floor of the Department of Physics for the production of multichannel picoammeters. So far, the company has invested around HRK 30,000 in the equipment for the Department of Physics, and we believe that this type of cooperation is the best as both the company and the Department benefit from it. The rental rates for the use of lab is possibly the only obstacle in this model. - The Solid State Nuclear Magnetic Resonance (NMR) Laboratory at the Department of Physics is another lab that could offered its services commercially. The main problem is that our business sector has no idea what kind of measurements performed by our science equipment could be of use to them (i.e. their technological level is such that they do not understand what measurements (and expertise) can be provided by the Solid State Nuclear Magnetic Resonance Lab. Another problem is that economic operators are unaware that such services can be funded by the EU sources so they would not have to pay for them. - Furthermore, the Nuclear Physics Lab could also offer its services commercially. The lab has a PALS set up (Positron annihilation lifetime spectroscopy). It is a method used to test the quality and the properties of porous and poriferous materials (zeolites, plastic foils, membranes etc.). The said method could be offered commercially, and we tried to do that as part of a project, however, there is a general problem of the lack of industry in Croatia and a lack of information about the availability and benefits of such methods. - The business sector could also have use of our X-ray diffractometer for different measurements. For many years, we have cooperated with the Croatian Agency for Medicinal Products and Medical Devices

	told that we would write the project and give them as partners access to the funding. We suppose the response was poor because they expect us to impose certain rules on them, which they are not familiar with, or they are not sure if it can be done legally, or they expect to have to deliver many documents, which is something they did not have to do in the past.	(HALMED), in the area, among other, of sample detection and analysis, while our cooperation with the company Beton Lučko is just beginning. X-ray diffractometer, which is available to the business sector, is extremely sophisticated and a unique piece of equipment, not only in Croatia but in this part of Europe, so that measurements can be conducted only by our lab staff. In order to deliver services to the business sector, we need a quicker and more flexible assistance and support of the projects office with the administrative aspect of our collaborative projects with the business sector. A detailed description and tariff of services offered should be approved at the PMF level and published on the website (CeNIKS, PMF, Department of Physics, laboratory, ...) or in one of the equipment catalogues (Šestar, …). Obstacles: Business operators rarely recognise what they can achieve with the equipment available at the Department of Physics. To illustrate this, the Ministry of Science and Education announced in May 2018 that SMEs would have an option to use vouchers and benefit for free from the research at any research institution in Croatia. The total value of the fund was HRK 50 million, and by the end of January 2020, only HRK 2.8 million was spent, on 37 applications. It happened several times that we would construct our own equipment from scratch, using raw materials, only for Croatian companies to argue they did not exist anywhere in the world; then we would have to buy them abroad – the lack of technical knowledge on the part of the business sector is evident. In large companies that have experts (for example, Končar), our activities are not of a sufficient volume, i.e. the value of the Ministry's vouchers is too small to tempt those companies or to make it profitable for them to get involved. The equipment at the Department of Physics is too complex and too sophisticated for external operators to use it on their own, as it requires long training and constant supervision. The Department of Physics, on the other hand, lacks human resources who could spare enough time for such tasks, in addition to their research and teaching responsibilities, under their current employment contract and the limitations concerning the share of work hours that has to be split between research and teaching duties according to the Collective Agreement for Science and Higher Education (KUZVO) currently in force. In case an economic operator is interested in measurement services by our staff, again it takes a lot of time, and is practically very hard to do because our researchers and teachers are over-burdened, particularly with the existing constraints in place. So, in both cases there is the problem of not enough trained staff and too few staff members who could possibly perform those tasks. There is not enough support for the Department staff who would venture to spend part of their work hours on these activities. Whenever economic operators want to use our equipment, they are looking for the person who would solve it for them. However, the problem is they need it right away, and do not see it is a complex matter, that it takes time to learn, start, measure, analyse, comprehend... It cannot be done if the order is for a quick delivery; it takes much more than the economic operator expects. Such activities are actually mini-projects for the Department staff, and the business sector does not have enough time, nor can they put in enough effort. Economic operators can be rigid, set in their own routine processes (manufacturing, design, etc.) and is not ready to make adjustments. On the other hand, they expect the Department staff to make adjustments, and to make them in the shortest time possible. In the opinion of the Department staff, economic operators usually require ready-made solutions, and will not take a risk with a longer research, as they are not ready to accept the possibility that the desired result might never be achieved. In addition, economic operators do not follow scientific developments sufficiently in order to be able to take advantage of all the potential at the Department of Physics. It is not enough for the Department of Physics to promote, popularise and reach out to the business sector; the other side has to show more interest too. A generally poor response of business organisations is evident even at workshops, conferences or similar events.

Department of Geography	Although both the PMF and the Department put in a lot of effort, we believe that businesses are still not sufficiently informed.	Yes, there are, but cannot be used independently by third parties. The greatest obstacles are a lack of staff and space.
Department of Geology	Not good enough	Yes, mostly there is. Lack of time due to teaching and administration workload.

Based on these answers, we can conclude that all the departments face quite a few obstacles in their efforts to cooperate with the business sector. The majority are linked to a lack of understanding and knowledge about the needs of the business sector on one hand, and on the other, about the services that PMF can offer to the business sector. In addition, another problem is insufficient technical and administrative support to the PMF departments. As a rule, economic operators seek quick solutions in the stage where the problem has already escalated. In order for the solution to be solid and adequate, a process is needed, as well as time and resources, which is often unacceptable to the economic operator. The business sector most commonly searches for a ready-made solution, rather than cooperation in terms of joint research and long-term partnership. Furthermore, the business sector is not sufficiently informed about the possibilities to forge ties and conduct joint research with PMF within EU projects, where they will have to cover only a fraction of the costs, while the rest will be financed from the EU source. The visibility of capacities, work and accomplishments of PMF is a significant problem; business organisations tend to reach out to commercial laboratories, which communicate more forcefully and aggressively even if they are not better or more successful. The PMF staff are overburdened, the premises limited and also overburdened and, on top of everything else, the project and administrative support is unsatisfactory.

As part of the questionnaire, the departments also expressed their views related to the possibility giving the business sector access to certain pieces of PMF equipment. The positions and opinions are different, depending on the specific nature of each department or laboratory, but they all believe that the business sector should not be able to use the equipment on their own. For the most part, the equipment is sophisticated, and only trained experts can operate it; economic operators tend not to have such experts. We can conclude that this information, among other, dictates that the cooperation of PMF and the business sector should be in the form of joint research, rather than commercialisation of the laboratories and equipment.

The process of further approaching and opening towards the business sector will certainly be a long and complex one, starting from the adoption of a clear PMF strategy and better awareness of each other. On the one hand, PMF or any of its departments has to continuously gather information about the needs of the business sector, and on the other, PMF should get closer to the business sector by raising its visibility and by getting better at presenting what PMF has to offer.

In the next section of this document, we propose actions, including how to reach out to and enhance the cooperation with the business sector.

4. SWOT ANALYSIS

Every entity (organisation, institution, enterprise), including PMF, operates in a business environment or surroundings, which consists of many different forces that affect each other, as well as potentially all of the entity's functional areas. The knowledge of the environment in which an entity operates is a great advantage; it is important that the entity should be able to respond as readily as possible in those areas where it has influence (internal environment), and turn the external environment factors it has practically no influence over to its own advantage, or otherwise adapt to them as much as possible.

The SWOT and PEST analyses are the two most commonly used methods enabling identification of factors from both the internal environment and the external environment in which every business organisation operates. Before we proceed with our analyses, let us briefly clarify the concepts of internal and external business environment.

According to the Robert Duncan's definition (Duncan, 1972), a business environment is the totality of material and social factors that have to be taken directly into account in decision-making processes in an enterprise. Such an interpretation means there are also factors within the boundaries of the enterprise, which have to be considered as the environment. In view of the location of the factors, we differentiate between internal and external business environments. The internal environment comprises the relevant material and social factors within the boundaries of an enterprise, which individuals in the enterprise directly take into consideration in the decision-making process within the system. The external environment consists of those relevant material and social factors that lie outside the boundaries of the enterprise but have to be taken directly into consideration. Everything that is outside of the enterprise towards which attention is consciously directed in a decision-making process, is the business environment of an enterprise.

The above definition, which refers to enterprises, can be applied directly and without any changes to other institutions, including PMF. An internal environment comprises the PMF management system, staff, teaching and research activities, students' work, relations among the staff's and among the students', relations between staff and students, administrative systems, etc. PMF can strongly affect the listed factors and thus adapt itself to the external factors, which also keep changing.

It depends on the ability of PMF (and every other company or institution) to operate flexibly to what extent they it will be able to adapt to the present and future forces of the external environment, by maintaining its power and vitality to confront the unfavourable changes. Regardless of the fact that PMF and other similar institutions are less flexible, due to their structure, method and purpose, it is extremely important to know the external environment, the opportunities it presents, as well as the threats it poses. The knowledge of all the above enables fast and efficient adaptation and activity in an environment it can influence, i.e. in the internal environment.

In order to make it possible, PMF has to be aware of all the important factors, external as well as internal. There are several methods for their analysis, among which SWOT and PEST are the most commonly used. We have analysed the PMF environment by using precisely these two methods.

The analyses and the descriptions of the methods used are presented in this (SWOT analysis) and the next chapter (PEST analysis).

SWOT analysis provides a relatively simple approach to the exploration of the environment or surroundings, including all of the important features of both the internal and external

environment, with the aim of identifying the strategic factors that will determine the future of an organisation – an enterprise, an institution (PMF, in our case). The analysis of the environment and the identification of strategic factors may be regarded as a support to decision-making in the process of strategy formulation. The key element in the formulation of a strategic option is the harmonisation of organizational strengths and weaknesses with the opportunities and threats that exist in the external environment. SWOT analysis should identify the opportunities that cannot be seized momentarily due to a lack of necessary resources and the unique competences that the organisation possesses and the manner in which it uses them.

In the internal environment, we identify **S**trengths and **W**eaknesses, while the external environment consists of **O**pportunities and **T**hreats. The external environment factors are beyond the short-term control of the management, providing a context within which the organisation operates. The ultimate goal of the SWOT analysis is to discern what is crucial for the organisation at the time of the analysis, so that the key strategic factors of the environment of this particular organisation could be identified.

In a SWOT analysis, it is important to register not only the quantifiable factors, but also those that are not quantifiable and can be mentioned only as a qualified statement or opinion.

The SWOT analysis has a temporal dimension; it is useful to compare and monitor the SWOT analyses made for an organisation at different points in time, and observe the changes in the state and movement.

The basic SWOT scheme is as follows:

	POSITIVE	NEGATIVE
INTERNAL ENVIRONMENT	**STRENGTHS**	**WEAKNESSES**
EXTERNAL ENVIRONMENT	**OPPORTUNITIES**	**THREATS**

The internal strengths and weaknesses largely differ from one organisation to the next, falling into the following categories:

- management and organization;
- operations;
- finances; and
- other factors.

The PMF's strong points will be defined as its strengths, and its weak points, both from the point of view of PMF as well as from the point of view of users and other external stakeholders, will be defined as weaknesses.

As we analyse the external environment, we take into account the factors that can be either threats or opportunities; those can be grouped into the following categories:

- economic factors;
- social factors;
- political and legal factors;
- technological factors;
- environmental factors; and
- other factors.

In terms of identifying opportunities, an important goal is to determine how PMF can keep raising its brand awareness and continuing the future development of the teaching and research

activity by taking advantage and drawing benefit of external opportunities. On the other hand, based on a timely identification of threats, PMF should be ready to face them, to adjust to them and act in such a way so as to make sure they have the least possible impact on PMF even during tumultuous times.

Below is the SWOT analysis of PMF. We took for our basic template the SWOT analysis that is part of the document „Faculty of Science – Strategic Programme of Scientific Research 2018-2023" The SWOT analysis below is complemented and completed so that in each part the listed factors are divided into the following categories:

- management and visibility;
- environment, infrastructure and equipment;
- study programmes;
- human resources;
- research activities and projects; and
- international cooperation and cooperation with the business sector.

STRENGTHS

MANAGEMENT AND VISIBILITY

1. Long-standing tradition and reputation of PMF in university education, research and expert work in the area of natural science and mathematics.
2. Research excellence and international brand awareness of individual researchers, competitive research groups and results of their research.
3. PMF has the status of the national and regional centre of research and teaching and has been one of the leading scientific institutions in Croatia ever since its inception.
4. The unique interdisciplinary dimension of PMF at the national and international level.
5. PMF demonstrates a high ability to generate income from sources other than the direct income from the State Budget, making great progress in recent years.

ENVIRONMENT, INFRASTRUCTURE AND EQUIPMENT

6. The proximity of other University of Zagreb constituents and public scholar institutes provides a stimulating environment for research and teaching and professional work.
7. Strong local and regional ties with public institutions in the areas of sustainable development and computerisation.
8. Active involvement in the everyday life of the citizens of Zagreb and the Republic of Croatia (Seismological Service, Botanical Gardens, etc.).
9. A dialogue with and acceptance of the needs of certain regions in the Republic of Croatia (Osijek, Split, Dubrovnik, etc.) towards expansion of natural science, primarily their development in research areas and teaching activities.
10. Carrying out research in the attractive and marketable STEM area.
11. Popularising science.
12. Availability of excellent equipment and resources, especially in the new premises of the Department of Mathematics, the Department of Physics (particularly once project EU CeNIKS is completed) and the Department of Chemistry (particularly once project EU CluK is completed).

STUDY PROGRAMMES

13. Wide choice of study programmes.
14. Highly motivated, hard-working and responsible students at all programme levels.
15. High number of excellent students interested and highly motivated to continue their education towards doctoral level degrees.
16. Ability to deliver online remote courses, with possible improvements.

HUMAN RESOURCES

17. Intellectual potential of a large number of highly competitive and motivated staff in research and teaching and associate grades and a favourable teacher to student ratio.
18. Favourable PMF ratio of teaching to non-teaching staff.
19. Very motivated individuals who are proactive in generating income streams, representing an excellent potential for transfer of knowledge, experience and motivation to a broader circle of scientists in all of PMF.

RESEARCH ACTIVITIES AND PROJECTS

20. Networking at the national and international level with a significant number of national and international research projects and accompanying research infrastructure, libraries and periodicals.
21. Research projects in different fields of science.
22. High scientific productivity of most staff and regular publishing in the leading international academic high-impact journals.
23. Significant enhancement of the quality and scope of possible research for PMF staff and students, as well as stronger pull factor of the Departments of Physics and Chemistry for international students, researchers and teachers after the CluK and CeNIKS EU projects are completed. Motivating for all other departments.

INTERNATIONAL COOPERATION AND COOPERATION WITH THE BUSINESS SECTOR

24. Numerous research groups in all the departments have ties to the leading international groups and institutions in research and technology development.

25. Past experiences of cooperation with business are a good basis for an integral strategy of cooperation with the business sector and long-term strengthening of cooperation in accordance with the adopted strategy.

WEAKNESSES

MANAGEMENT AND VISIBILITY

1. Insufficient reliance on international sources of financing, i.e. on international projects.
2. Complex organisation causes multiplication of procedures.
3. Organisation of administration services is ineffective cost- and time wise, wasteful and non-transparent (partially because of dislocation).
4. Quality of project administration is not at an adequate level.
5. Existing organisational structure is not conducive to good project management or monitoring of project and research activity.
6. Inadequate engagement in the promotion of PMF in public, from websites to the presentation of PMF researchers' findings in the Croatian media.
7. Insufficient international brand awareness of PMF and consequently an untapped potential for international collaboration.
8. Fragmentation of resources reduces the connections between professions and scientific fields, hampering the introduction of common standards and criteria, has a negative impact on the (quality) indicator effects, promotion of interdisciplinarity and establishment of joint research in natural science.
9. Insufficient (practically negligible) income from donations.
10. Sub-optimal organisation of libraries (largely a consequence of dispersal of premises).

ENVIRONMENT, INFRASTRUCTURE AND EQUIPMENT

11. Physical separation and inadequate premises of segments of natural science have a strong negative impact on research and teaching activity and administrative operations, leading to loss of resource and time effectiveness.
12. Entirely inadequate state of the buildings and resources of biology and geoscience departments (parts of buildings are ill fitted for work, cramped and physically separated). Additionally, the premises were hit by an earthquake in March 2020.
13. Absence of an efficient and updated information (IT) system for monitoring research activity and project work.

STUDY PROGRAMMES

14. Insufficient interest of applicants for teachers' study programmes.
15. Mismatch between the departments when it comes to study programmes, resulting in illogical organisation of instruction.
16. Poor ties and insufficient cooperation among the departments in delivery of the study programmes.
17. Lack of transparency and an uneven student (and thereby teacher) workload in certain programmes, in terms of exams as well as courses and other obligations. Streamlining and more transparency are needed.

HUMAN RESOURCES

18. Insufficient number of research and teaching and assistant jobs as well as postdoctoral researchers, resulting in the excessive workload of the staff with teaching and administrative duties.
19. Inadequate evaluation of internationally visible groups of researchers with big project funding sources, especially from EU.
20. International and national projects, in all stages from successful application to implementation and reporting, do not have the necessary human resource (project) support, neither at the PMF- nor at the department level.
21. Understaffed libraries in all departments.
22. Understaffed administrative services, regardless of a high total number of administration staff (decentralisation of administration).

RESEARCH ACTIVITIES AND PROJECTS

23. Insufficient number of good international postdoctoral researchers (partly due to the fact that the salaries of postdoctoral researchers from domestic sources are subject to national standard), and of doctoral students and project managers/researchers.
24. Lack of collaboration among the departments weakens their ability to launch interdisciplinary and multidisciplinary research.
25. Insufficient motivation and focus of scientists on EU-funded and other internationally funded project proposals.
26. Absence of institutional support for writing international project proposals.
27. Incompleteness of the strategy related to professional projects and market-oriented projects; different attitudes among the departments relating to the implementation of such projects.
28. PMF's untapped interdisciplinary potential. The departments act as individual entities, with very little interaction except in rare cases.

INTERNATIONAL COOPERATION AND COOPERATION WITH THE BUSINESS SECTOR

29. Insufficient involvement in international projects/big differences among the departments. The untapped potential is huge.
30. Underdeveloped portfolio of international projects dos not ensure a stable and constant cash flow from EU and other international souces.
31. Absence of strategy for cooperation with the business sector.
32. Underdeveloped ties with the business sector because of insufficient knowledge of the needs of the business sector on the part of PMF, and insufficient knowledge of the possible ways cooperation with PMF can be useful and beneficial to the business sector.
33. No transfer of knowledge and experience acquired in the implementation of international projects among the departments.
34. International mobility (long-term stays) of staff and students is not satisfactory.
35. Too few courses taught in English and insufficient interest on the part of Croatian students for courses in English.
36. No alumni club, hence severance of ties with former successful PMF students.

OPPORTUNITIES

MANAGEMENT AND VISIBILITY

1. Positive evaluation of PMF's re-accreditation (in 2015) and its doctoral programmes in certain departments of PMF (in 2018).
2. Priorities of the new Multiannual Financial Framework (2021-2027) and the objectives of the Cohesion Policy 2021-2027.
3. Harmonization with the European higher education systems, internationalisation, and enhancement of international competitiveness of educational programmes.
4. Research projects and doctoral students funded by the Croatian Science Foundation.
5. EU-funded research projects and joint project applications with other Croatian or international institutions.
6. Support to STEM area by the Ministry of Science, Education and Sport helps decrease the students' participation in the programme costs.
7. Participation in the drafting and monitoring of new bills related to higher education and research.

ENVIRONMENT, INFRASTRUCTURE AND EQUIPMENT

8. Appeal of PMF's geographic location to international students and researchers.
9. Improvement of research infrastructure by writing successful grant proposals for EU funding schemes and by doing joint project application with industry.
10. Establishing functional relations with other stakeholders in the education, business and media sectors
11. Integration of research capacities in natural science, mathematics and biomedicine at the University of Zagreb Northern Campus site.
12. Integration of departmental libraries into a central PMF library at the Northern Campus site

STUDY PROGRAMMES

13. Modernization of the teaching and research programmes and a better balance between the existing enrolment capacities in accordance with the modern achievements and social needs.
14. Launching new study programmes/reshaping the existing ones in accordance with the needs of the business sector.

HUMAN RESOURCES

15. Maximum possible reduction of administrative and teaching workload for the most productive researchers at PMF, in accordance with the regulations and legislation in force.
16. Introduction of higher standards and better reward system for teachers and research productivity, and introduction of high-quality career advancement policies in research and teaching grades.
17. Inclusion of teaching staff into the project evaluation processes under the EU funding schemes.

RESEARCH ACTIVITIES AND PROJECTS

18. Active involvement in international projects.
19. Stronger research ties with other national and international research and academic institutions.
20. Establishing ties with successful scientists – former PMF students within the PMF alumni's club.
21. Establishing excellence centres.

INTERNATIONAL COOPERATION AND COOPERATION WITH THE BUSINESS SECTOR

22. Increasing ingoing and outgoing student and teacher mobility at the university, national and international level.
23. Stronger partnership with economic operators in the development of their innovations.
24. Stronger partnership with economic operators in joint EU-funded project
    research.
25. Stronger relations with international research institutions and participation in international research projects.
26. Greater availability of international scholarships.

THREATS

MANAGEMENT AND VISIBILITY

1. Constant decrease of State Budget allocations and insufficient funding from non-budgetary sources;
2. Insufficient absorption of research funding from EU sources may lead to a poorer positioning of PMF compared to research organizations in the region;
3. Underdeveloped legal framework for research development.
4. Considerable further cuts to the budgets of Croatian universities', especially in the research-related segment, because of the financial crisis that Croatia is facing.

ENVIRONMENT, INFRASTRUCTURE AND EQUIPMENT

5. The Departments of Biology, Geology and Geography operating from different premises at the Horvatovac location.
6. Inadequate State Budget allocations for the maintenance of the existing infrastructure.
7. Postponement of the construction of the University of Zagreb Northern Campus.
8. Insufficient spending on science of the public and private funds and foundations.

STUDY PROGRAMMES

9. Loss of interest in natural science studies and a lack of appeal and poor social status of teaching professions.
10. Depopulation – falling number of students.
11. Discrepancy between certain study programmes and the needs of the development of the knowledge-based society.

HUMAN RESOURCES

12. Failure to retain high-quality human resources in Croatia.
13. Failure to approve new developmental jobs by the Ministry of Science and Education.
14. Absence of an incentive system for the best international call applicants.
15. Limited career advancement opportunities in research and teaching jobs have a demotivating effect.
16. Uncompetitive employment conditions for researchers at PMF when compared to jobs in other sectors. The same is true of other jobs (project office, procurement), which proportionally to the increase in internatonal project activities, require an increasing number of competent staff.
17. Greater appeal of research work abroad.

RESEARCH ACTIVITIES AND PROJECTS

18. Insufficient number of new research and teaching or teaching assistant jobs, as well as postdoctoral researchers.
19. Rigid labour legislation and financial constraints significantly hamper recruitment of international researchers.
20. Underdeveloped legal framework for research development

INTERNATIONAL COOPERATION AND COOPERATION WITH THE BUSINESS SECTOR

21. Unfavourable structure of the business sector – insufficient promotion of the knowledge-based business sector;
22. Poor interest of the business sector in research projects.
23. Economic crisis, which would decrease research activities of the business sector.

5 PEST ANALYSIS

We used PEST analysis to scrutinise the external factors in the remote business environment affecting PMF's operation, which are outside of the PMF's operational perimeter. The remote business environment consists of an almost unlimited number of factors, and as such for PMF it is a source of possibilities, risks and constraints. PMF, on the other hand, very rarely finds itself in a situation where it can exert any significant influence over the factors that are part of the remote business environment. In other words, the remote business environment strongly affects PMF, whereas the PMF's influence over the remote business environment is generally low.

The most commonly used tool for analysis of the various elements of the remote business environment is PEST analysis, comprising the analysis of the following factors (sectors): political and legal (**P**), economic (**E**), sociocultural, environmental and media (**S**), and technology and science (**T**). It is important to understand that a remote business environment is a system of interconnected sectors, where each is connected to the other, and each affects the other.

The PEST analysis of PMF consisted of the following four steps:

1) Defining the material factors that affect the PMF's business operation and its environment and grouping those factors into the four main fields of the PEST table.
2) Evaluating the strength of impact of the previously identified factors in the categories of PEST analysis. In order to assess the impact strength of the analysed factors, a rating scale from 1 to 5, with 1 signifying the lowest impact of a factor, and 5 signifying the highest possible impact, was used. Additionally, if a factor also presents a threat (hindering the PMF's objectives and business operation), a minus (-) was added to the rating; if the factor also presents an opportunity (improving the chances of PMF's objectives being achieved and its business operation), the rating was added a plus (+).
3) Evaluating the significance of individual factors' effect in different categories of the PEST analysis. In order to assess the significance of the analysed factors' effect, a rating scale from 0 to 10, with 0 signifying that a factor has no significant effect, and 10 signifying that the effect is exceptionally significant, was used.
4) Evaluating the product of the impact strength multiplied by the significance of effect, of each individual factor, to calculate the overall rating of each individual dimension (the sum of the products of multiplication of all factors' ratings in individual sectors), and the overall rating for all four sectors i.e. for the remote business environment of PMF as a whole (the sum of the sums of ratings of individual sectors). In this context, plus and minus signs imply a stimulating or unstimulating impact of the environment, respectively, while higher results imply higher favourability or unfavourability.

Below is the PEST analysis of PMF.

FACTORS	IMPACT ON PMF BUSINESS OPERATION AND ACTIONS	IMPACT STRENGHT	SIGNIFICANCE OF EFFECT	OVERALL RATING
POLITICAL AND LEGAL FACTORS				
Positive re-accreditation decision for PMF (2015) and individual doctoral study programmes (2018) (confirmations were issued on compliance with the requirements for performing the activities)	Recognition of the past performance; Compliance with requirements for future operation; Improvement recommendations received;	+5	10	50
Issuance of a letter of expectation with the deadline for resolving deficiencies of up to three years for Geology and Chemistry doctoral programmes (2018)	Negative perception by the research community in the relevant fields, possibly even wider; Opportunity for future improvements;	-3	8	-24
Accession of the Republic of Croatia to the European Union	Positive impact on international collaborations; Access to European Union funding; Possibility of influencing EU policies;	+5	10	50
Access to EU funds	Possibility of accessing funds to finance development of research and teaching infrastructure and research activity; Joint action by similar institutions and pooling of research capacities;	+5	8	40
Priorities of the new (2021 -2027) Multiannual Financial Framework and the objectives of Cohesion Policy 2021-2027	Depending on the priorities of the new Multiannual Financial Framework and Cohesion Policy objectives, the total allocation for research funding will be set, and this will then impact funding programmes and grants available for activities within PMF operation; New opportunities to win grants;	+5	8	40
National Development Strategy 2030 (in preparation)	Indicator of direction of Croatia's future development; The basis for development of sectoral strategies;	+2	3	6
Government science and research funding policies	Sketchy policies or policies that fail to support research work sufficiently (funding wise), negatively impact research activity.	-4	8	-32
Higher education reform process at the European level (Bologna process)	Improving and bringing together higher education at the European level; Improved conditions for international student exchange; Croatia, PMF included, have far more student outbound traffic (positive), than inbound international students (negative);	+3	9	27
Teaching and research productivity reward systems, and policy of appointment and progression to research & teaching grades	Negative impact of the current restrictive policy of progression in research & teaching grades implemented by the Ministry of Science, Education and Sports.	-5	8	-40

Government employment policy	Restrictive employment policy negatively affects PMF's ability to improve its financial sustainability by winning more international research grants, which are also the prerequisite for attracting and retaining excellent research & teaching staff.	-5	8	-40
SUBTOTAL:				**77**
ECONOMIC FACTORS				
Government budget allocations for research and development	Negative impact of insufficient R&D budget expenditure as a share of the GDP (RoC is below 1% of GDP, while EU average is above 2% of GDP);	-5	8	-40
Availability of grants in EU research programmes	EU programmes strongly promote research activity; In recent years, PMF demonstrating the ability to win EU grants, but there is still a huge potential for improvement:	+5	4	20
General state of the economy in the country and wider (GDP trends)	Impact on businesses and thereby on their research activities; Impact on Croatia's financial capacity to increase government-funded research allocations;	-2	5	-10
Availability of capital in the economy	Impact on the promotion and hindrance of new entrepreneurial activities, which then affects their research and innovation operations.	+2	7	14
SUBTOTAL:				**-16**
SOCIOCULTURAL, ECONOMIC AND MEDIA FACTORS				
General awareness of society concerning the importance of lifelong education	General interest in higher education services;	+4	3	12
Role of community in research projects	I.e. to what extent PMF as the promotor of research projects consults and seeks the support of the community that might be affected by the project; Positive impact of the science promotion activities;	+3	5	15
Demographics of the Republic of Croatia	Deteriorating demographics in Croatia means smaller pool of prospective students;	-2	5	-10
Quality of students enrolled	According to PMF data, the quality of students enrolled is high; Impact on the programme completion rates, and the motivation for studies and research;	+4	8	32
Interest in natural science study programmes	Natural science is less attractive; More natural science promotion and introduction is needed, and it has to start already at primary school level; As an upside, natural science studies are chosen by those with genuine interest (no *en masse* enrolment of students due	+2	5	10

	(only) to popularity of any given programme);			
Rise in labour market competition and internationalisation, outflow of quality human resources from Croatia and availability of required (necessary) human resources	Rise in labour market competition is welcome because it generally leads to higher quality of staff; Internationalisation of the labour market makes it easier to attract talent, but also for the existing or prospective PMF staff to leave for other institutions in the EU and further afield; The creation of the open European labour market unfortunately turned Croatia into a country recording a negative total balance of outbound and inbound traffic of quality staff (other countries are more attractive than Croatia); The same trends are evident in international student exchange (PMF included), which often leads to final departure from Croatia after completion of studies;	-5	10	-50
Attractiveness and social status of teaching grades	Negative social status and general perception of teaching grades in society; Negative impact on students' interest in teacher education study programmes;	-3	6	-18
General (international) brand recognition of PMF, visual identity, visibility of PMF in international research sector	For participation in international projects, the brand recognition of institutions, researchers and their results is very important; PMF is an internationally recognisable institution, whose international activity increases year on year; however, there is room for improvement; There is a great potential for increasing the visibility in the international setting and for international participation at all levels of PMF operation;	+3	9	27
Media bias and impartial coverage	Media and impartial (and increasingly frequent) coverage may have a significant impact on the visual identity of the institution.	+3	3	9
SUBTOTAL:				**27**

TECHNOLOGICAL AND SCIENTIFIC FACTORS				
Society's research needs that can be met by PMF	Contribution to society's needs; Fulfilling the main purpose of existence;	+4	9	36
Level of government budget spending on the maintenance of the existing and development of the essential new infrastructure (Northern Campus)	Creating conditions for collaboration with research institutions in the proximity; Availability of modern resources for research & teaching work; Mutual benefits from collaboration of individual departments and research institutes located therein;	-5	10	-50
Economic growth rate and business innovation capacity	Intensity of the economy's demand for research services; Economy's readiness to innovate; Capacity of business organisations to develop their own research; Economy's ability to apply and incorporate research results in their own processes; Mutual cooperation of PMF and business sector;	-3	8	-24
Business investment in research and development	General state of the economy and the stage of its development determine research and development investment levels, which is unsatisfactory in Croatia;	-3	6	-18
Quality of research institutions in the proximity	High quality of research institutions in the proximity is conducive to high quality and excellent results of mutual cooperation;	+4	9	36
e-Education, the ability and preparedness for remote teaching and research	Capacity for e-operation increases the opportunities for distance collaboration, and thereby its volume;	+3	9	27
Level of equipment, organisation and funding of PMF libraries (PMF libraries in comparison with the libraries of comparable institutions in the proximity)	Availability of libraries, good selection and availability of important collections, contribute to the quality and volume of research, as well as the quality of the studies; Decentralisation and dispersion of individual libraries decrease their availability, increase financial difficulties and impact negatively on the availability of qualified staff;	-2	10	-20
Labour market needs	High employability of PMF students; PMF's ability to recognise labour market needs and incorporate them in the design of their study programmes; Collaboration with the business sector has to intensify in order to have the best possible and most up-to-date information on the real labour market needs.	+4	8	32
SUBTOTAL:				**19**
TOTAL:				**107**

PEST analysis identified the key external factors and their respective impact. The total score clearly shows that external factors are favourable for the future development of PMF. In our analysis, we tried to cover as many relevant factors as possible, i.e. those that directly or indirectly have a very significant impact on the PMF's operation.

Looking at each of the four areas of analysis, we can conclude the following:

- Political and legal factors are mainly positive because of the funding and research opportunities available to PMF due to the access to EU funds. On the other hand, the political and legal factors at the national level are extremely negative. Notwithstanding the fact that these factors are external and that PMF can exert very little influence over them, it is safe to state that PMF can still turn the positive, EU-related factors, to its very great advantage. Similarly, PMF can influence even the negative factors at the RoC level by taking active role in the drafting of new legislation and development programmes in the field of higher education and research.
- Economic indicators are consistent with the biggest difficulties that PMF has faced i.e. insufficient government research funding and, in the total score, they account for the negative external impact on the PMF business operation and activities. Nevertheless, even in this area of analysis, there are positive factors that mitigate the negative impact of the funding constraints. The global economic crisis and the lack of innovation readiness in the economy over a longer term would add to the negative impact on the PMF's business operation and activities by this set of external factors.
- Sociocultural, environmental and media factors contribute to the total score with a positive impact on the PMF's business operation and activities.
- The technology and science segment of the PMF's environment has a positive impact on its activities, although they are unfortunately strongly and adversely affected by inadequate levels of government investment in research infrastructure. The factors that PMF can influence to some degree (despite those factors being external factors) are positive and they need to be developed further.

6 DEFINING RECOMMENDATIONS FOR STRATEGIC GOALS, PRIORITIES AND ACTIONS FOR PMF'S FUTURE DEVELOPMENT

The Development Strategy of the Faculty of Science, University of Zagreb, for 2015-2020 defines the following strategic goals:

1) Improving the quality of teaching, and promoting the importance of educational process;
2) Improving the quality of scientific research;
3) Improving the quality of academic work, the knowledge and technology transfer;
4) Improving infrastructure, organisation and management, as well as self-control system; and
5) Increasing the influence on the development of society as a whole and acceptance of social responsibility.

The current strategic goals are still valid, covering all of PMF's core areas of activity, and therefore should not materially change in the future. In the next development strategy, the strategic goals should be adapted to take into account the need for stronger international activity of PMF and the opportunities arising from expanded international collaborations. Similarly, a stand-alone strategic goal should be established for PMF's improved collaboration with the economic sector. The current Strategic Goal 3 should be incorporated partially into Strategic Goal 5.

When drafting strategic documents, it is generally recommended that no more than five strategic goals should be adopted and that, once adopted, the strategic goals should not be changed too often, unless, of course, there are compelling reasons to do so.

Taking into account the present and future challenges that PMF will face in the coming years, that it has faced already, and the fact that the current solutions to some of those challenges are not optimal, a few priorities, and in particular the measures (actions), would have to be modified and added.

The recommended measures (actions) below comprise a large number of actions, which, although undoubtedly relevant, will not be all incorporated into the new strategy. A development strategy is a strategic document which, in order to be implementable, has to include actions adopted by consensus of all stakeholders (organisational units of PMF) who will be responsible for the future implementation of the strategy. There must be a vision, a will and a desire to implement the strategy and take ownership of the goals s that have been set.

Recommendations for strategic goals for the next PMF development strategy period include as follows:

Strategic Goal 1: Improving the quality of teaching, strengthening the internationalisation of teaching and promoting the importance of educational process

Strategic Goal 2: Improving the quality of research and strengthening the internationalisation of PMF research activity

Strategic Goal 3: Enhancing research collaboration with the industry and improving knowledge and technology transfer

Strategic Goal 4: Improving PMF infrastructure, organisation and management, building human resources and improving self-control system

Strategic Goal 5: Bolstering the influence of PMF on the development of society as a whole, improving the promotion of social responsibility and improving visibility and international brand awareness

Each proposed strategic goal is further developed into several priorities (special objectives) and the priorities into measures (actions), as shown below.

Strategic Goal 1 **Improving the quality of teaching, strengthening the internationalisation of teaching and promoting the importance of educational process**	
Priorities: Priority 1.1 Harmonising the existing and developing new study programmes Priority 1.2 Improving the teaching quality assurance system Priority 1.3 Improving interdepartmental cooperation in delivery of study programmes Priority 1.4 Establishing a sustainable lifelong learning system Priority 1.5 Enhancing international student and faculty mobility (both inbound and outbound)	
Priority 1.1 Harmonising the existing and developing new study programmes	Actions: A/1.1.1 Align, adapt and integrate general student conditions, requirements and obligations at the institutional level and in parallel align and integrate the faculty workload (based on a prior detailed analysis of the current state) A/1.1.2 Rationalise study programmes and workloads A/1.1.3 Improve the existing study programmes, by tapping into primarily ESF grants – OP Efficient Human Resources, and other available funding sources A/1.1.4 Continuously identify the needs of the economy and tailor the curricula or develop new study programmes accordingly, as necessary A/1.1.5 Develop occupational standards / qualifications standards
Priority 1.2 Improving the teaching quality assurance system	Actions: A/1.2.1 Track student performance during and after the studies A/1.2.2 Track alumni employment rate A/1.2.3 Continuously survey and analyse in detail student experience at all levels (course, department, university) and prepare and implement actions to adopt useful suggestions with the aim of improving the quality of teaching A/1.2.4 Improve the student objection tracking and evaluation system and promptly resolve all objections, in particular those related to the unsatisfactory quality of teaching A/1.2.5 Carry out continuous (annual) faculty self-assessment and monitor the progress achieved A/1.2.6 Carry out continuous (at least biennial) self-analysis of PMF as a whole A/1.2.7 Take active role in external evaluations and implement proposed improvements A/1.2.8 Draft and roll-out a teaching skills development plan for the faculty A/1.2.9 Promote and identify teacher excellence
Priority 1.3 Improving interdepartmental cooperation in delivery of study programmes	Actions: A/1.3.1 Improve interdepartmental communication A/1.3.2 Carry out a detailed review of all study programmes and identify potential common ground that could, based on mutual participation, increase the value (quality) of the study programmes by complementing and upgrading them A/1.3.3 Improve the planning and implementation of joint activities A/1.3.4 Ensure mutual sharing of experience regarding the use of various modern teaching methods
Priority 1.4 Establishing a sustainable lifelong learning system	Actions: A/1.4.1 Organise topical workshops, courses and e-courses for the wider community (smart specialisation) A/1.4.2 Continue the implementation of the existing and design new science promotion activities

	A/1.4.3 Organise a summer school for the interested gifted high school students who have just completed grade 3 A/1.4.4 Enhance the activities of the Centre for advancement of education in the fields of natural sciences, mathematics and physics – PRIMATEH. A/1.4.5 Promote, identify and reward teacher engagement in development of education materials for primary and secondary school students and raise the visibility of such activities A/1.4.6 Promote and reward the scientific and professional support given to popular science magazines for primary and secondary school students and raise the visibility of such activities
Priority 1.5 Enhancing international student and faculty mobility (both inbound and outbound)	Actions: A/1.5.1 Improve information access for foreign students through direct promotions at targeted foreign universities and other targeted research institutions A/1.5.2 Increase the number of courses delivered in English and develop and deliver study programmes fully delivered in English A/1.5.3 Encourage domestic students to take courses in English by informing them better about the advantages A/1.5.4 Enable students to learn occupational/professional English A/1.5.5 Improve information access for domestic students by expanding the activities of the Office for International Relations and organise meetings with the returning international exchange students A/1.5.6 Organise mentoring schemes for visiting international exchange students at PMF (using internal calls to select the PMF students interested in the mentoring of the visiting students) A/1.5.7 Decrease the teacher workload based on the prior analysis of potential programme rationalisation in order to create the preconditions for mitigation of their longer-term absence in the context of international exchange A/1.5.8 Encourage the faculty to take part in international exchange and improve the access to information A/1.5.9 Mitigate long-term teacher absence by improving e-education A/1.5.10 Expand continuously the circle of prospective partner institutions for future international faculty exchange and improve the access to information for the targeted exchange partner institutions

Strategic Goal 2 **Improving the quality of research and strengthening the internationalisation of PMF research activity**	
Priorities: Priority 2.1 Promoting and recognising excellence in research Priority 2.2 Improving the systemic support (administrative, project and IT) for research project application and implementation Priority 2.3 Increasing the number of EU-funded and other internationally funded projects Priority 2.4 Strengthening multidisciplinary interdepartmental collaboration in research Priority 2.5 Strengthening cooperation with internationally recognised national and international research institutions and proactively creating intradisciplinary, interdisciplinary and multidisciplinary groups Priority 2.6 Improving PMF's doctoral study programmes	
Priority 2.1 Promoting and recognising excellence in research	Actions: A/2.1.1 Promote excellence in research by publishing papers in the top high impact factor magazines A/2.1.2 Promote excellence in research by successfully applying for competitive research projects A/2.1.3 Track and reward special research achievements by the PMF research & teaching staff A/2.1.4 Track and reward special research achievements by doctoral students A/2.1.5 Develop criteria for identifying specially gifted students and get them involved in additional research activities and research projects
Priority 2.2 Improving the systemic support (administrative, project and IT) for research project application and implementation	Actions: A/2.2.1 Reorganise PMF by strengthening the (PMF) central projects office, setting up separate projects offices for departments (departmental projects offices) and set up an office for public procurement in EU projects A/2.2.2 Improve knowledge dissemination concerning project preparation and management at PMF, establishing functional links and internal growth A/2.2.3 Reinforce human resources in the following areas of knowledge: administrative project management, EU project governance and management, writing project applications (writing project proposals), public procurement in EU-funded projects A/2.2.4 Introduce the appropriate project management models (proposal: common EU PM² methodology which can be adapted i.e. simplified depending on the level of difficulty presented by individual projects) and build human resources capacity for their use A/2.2.5 Develop and introduce IT support for project management and build human resources capacity for its use A/2.2.6 Use projects to recruit human resources and fund their salaries
Priority 2.3 Increasing the number of EU-funded and other internationally funded projects	Actions: A/2.3.1 Continuously monitor EU priorities and programmes, and public call publication plans; monitor public call announcements A/2.3.2 Develop and continuously update a data base of projects to be funded by EU and other available international funders A/2.3.3 Set objectives and draft framework plans for applying to the public calls already available or announced (annual objectives and plans) A/2.3.4 Develop and notify a high volume of projects, applying for as wide a spectrum of different tenders as possible A/2.3.5 Improve interdepartmental transfer of knowledge, experience and information A/2.3.6 Offer attractive working conditions and promote them (opportunity to work on big projects, to collaborate with excellent scientists, international work environment, good administrative support etc.), as well as design an appropriate system of rewards A/2.3.7 Maintain contact with internationally recognised research institutions as potential project partners (i.e. in PMF projects or in the projects of PMF's partner institutions)
Priority 2.4	Actions:

Strengthening multidisciplinary interdepartmental collaboration in research	A/2.4.1 Form an interdisciplinary group with representation from all departments A/2.4.2 Analyse common interests and needs, as well as opportunities for joint research; develop plans of potential areas of cooperation A/2.4.3 Submit joint applications to public calls for research project funding whenever possible A/2.4.4 Share the experience, knowledge, success and difficulties related to project acquisition and management, maintain regular communication A/2.4.5 Set up PMF centres according to the field of cooperation
Priority 2.5 Strengthening collaboration with internationally recognised national and international research institutions and proactively creating intradisciplinary, interdisciplinary and multidisciplinary groups	Actions: A/2.5.1 Develop and continuously update a list of institutions PMF has collaborated with, at departmental level A/2.5.2 Designate a responsible person for every research institution PMF has collaborated with and maintain contact through the designated person; monitor research activities carried out by those institutions and link up with them where necessary / opportune from either side A/2.5.3 Promote proactive formation of internationally recognisable groups of researchers by setting up an appropriate reward model (setting up a reward model based on the previously determined main motivators) A/2.5.4 Organise science days with partnering research institutions (once a year)
Priority 2.6 Improving PMF's doctoral study programmes	Actions: A/2.6.1 Analyse in detail all the Reports of the Expert Panel on re-accreditation of postgraduate doctoral study programmes at PMF and develop an improvement plan as recommended by the Expert Panel; implement activities and monitor their implementation A/2.6.2 Have doctoral students evaluate doctoral study programmes (annually) and continuously develop and implement improvement actions A/2.6.3 Ensure self-assessment of doctoral study programmes by their coordinators (annually) and continuously prepare and implement improvement actions A/2.6.4 Continuously prepare the activities aiming to improve the existing doctoral study programmes and prepare new ones, in accordance with the market needs (including possibly even consortium study programmes for specific closed groups from certain branches of industry) A/2.6.5 Promote co-degree programmes and joint doctoral programmes with other national and international higher education institutions A/2.6.6 Promote the mobility of doctoral students and doctoral study programme teachers, and attract international teachers and scientists A/2.6.7 Promote doctoral degrees in cooperation with the economic and public sectors

Strategic Goal 3 **Enhancing research collaboration with the industry and improving knowledge and technology transfer**	
Priorities: Priority 3.1 Increasing visibility in the economic sector Priority 3.2 Improving research links with and promoting research activity in the economic sector Priority 3.3 Improving the knowledge and technology transfer to the economy, in accordance with its needs Priority 3.4 Creating long-term connections with business	
Priority 3.1 Increasing visibility in the economic sector	Actions: A/3.1.1 Organise Doors Open days for business (at least once a year), including a presentation of the available science equipment and bilateral meetings to identify common interests and a presentation of successful application of PMF's research results by business A/3.1.2 Monitor closely and participate in professional conferences with the aim of identifying business trends and needs A/3.1.3 Continuously promote achievements in the media, business and professional magazines, professional conferences
Priority 3.2 Improving research links with and promoting research activity in the economic sector	Actions: A/3.2.1 Develop and implement a strategy for forging links with the business sector (define the types of relationships with the economic sector that would be of strategic importance to PMF) A/3.2.2 Provide administrative and PR support at the institution-wide level to enable continuous successful and effective communication with the economic sector A/3.2.3 Monitor tenders for co-funding of research activities in the economic sector and seek opportunities (interests, needs) for joint research / PMF-lead research – promoting research activity in the economic sector A/3.2.4 Maintain regular contact with all the businesses that PMF has a good cooperation record with A/3.2.5 Get businesses involved in PMF's own research as partners in EU-funded and other internationally funded projects A/3.2.6 Provide scientific expertise to the business sector in the areas where there are no other adequate providers A/3.2.7 Set up consortium postgraduate study programmes for closed groups in certain industries (i.e. where the curriculum is adapted to the needs of the closed group, a consortium agreement is signed between a business organisation sending the student to the study programme (and paying for it), the student and PMF
Priority 3.3 Improving the knowledge and technology transfer to the economy, in accordance with its needs	Actions: A/3.3.1 Monitor business trends and needs and adapt PMF's own research to the actual needs of the business sector A/3.3.2 Engage proactively to ensure long-term collaborations with R&D-oriented companies that have a great demand for research without having adequate equipment and knowledge A/3.3.3 Create new patents, promote the protection of intellectual property rights, copyrights and similar rights A/3.3.4 Take part in formation of spin-off businesses A/3.3.5 Keep contact with former doctoral students working in the business sector through the PMF Alumni Club (access information on business needs and at the same time support business in their research work)
Priority 3.4 Creating long-term connections with business	Actions: A/3.4.1 Start a PMF Alumni Club and maintain regular activity at the institution-wide and departmental levels A/3.4.2 Set up a career centre A/3.4.3 Invite business sector representatives to deliver motivational lectures (presenting how research and knowledge are transferred into business practice) A/3.4.4 Engage in long-term joint research cooperation (long-term research partnerships)

Strategic Goal 4 **Improving PMF infrastructure, organisation and management, building human resources and improving self-control system**	
Priorities: Priority 4.1 Building new physical infrastructure at the Northern Campus location Priority 4.2 Improving and upgrading the science, teaching and IT infrastructure Priority 4.3 Optimising PMF organisation and management and improving self-control system Priority 4.4 Reinforced industry funding of infrastructural projects Priority 4.5 Building human resources	
Priority 4.1 Building new physical infrastructure at the Northern Campus location	Actions: A/4.1.1 Plan and develop project study documentation and technical designs, and resolve property title issues to expedite the roll-out of the infrastructure development project at the Northern Campus location A/4.1.2 Plan the construction of the central PMF library at the Norther Campus location A/4.1.3 Set up the central PMF library as a knowledge centre for the wider community (local, regional, national and international) A/4.1.4 Raise funds: track opportunities for winning grants through EU-funded infrastructural projects, launch donation initiatives, keep regular contact with Zagreb University and the line ministry
Priority 4.2 Improving and modernising scientific, teaching and IT infrastructure	Actions: A/4.2.1 Draft procurement plans for science labs equipment and update them regularly A/4.2.2 Improve the certification and accreditation of laboratories A/4.2.3 Monitor tenders and develop projects to enable the procurement of new, advanced science equipment. Apply for as many different available tenders as possible with different projects A/4.2.4 Be active in engaging with the business sector and seeking opportunities and interests for joint investment in research equipment A/4.2.5 Analyse the state of affairs and deficiencies and continue the use of e-learning/e-instruction and introduce advanced technologies into the instruction process at PMF A/4.2.6 Ensure continuous teacher training and empowerment in modern teaching technologies A/4.2.7 Increase the inventory of textbooks, scientific and professional literature A/4.2.8 Computerise the project management process A/4.2.9 Provide user training and apply select IT solutions in practice
Priority 4.3 Optimising PMF organisation and governance and improving PMF self-control system	Actions: A/4.3.1 Start the standardisation and digitalisation of business processes A/4.3.2 Roll out specialisation of administrative services and functional coordination of the administration at the institution-wide level A/4.3.3 Restructure support services with the aim of their streamlining, and making them more transparent, effective, and accessible to the users A/4.3.4 Integrate the departments' planning, objectives and strategies at the level of the institution A/4.3.5 Analyse the current control systems, update internal rules and implement improvement actions
Priority 4.4 Reinforced financing of infrastructural projects from business sources	Actions: A/4.4.1 Build, continuously adapt and expand a database of projects that could be funded through business investment A/4.4.2 Set up a donation fund, define its purpose and goals, and use PR activities to promote it A/4.4.3 Manage the fund transparently and inform the public about the projects benefitting from the fund

	A/4.4.4 Start a PMF Alumni Club and continuously design activities to establish and maintain contact with the business sector and forge long-term partnerships A/4.4.5 Design PR activities to present successful knowledge transfers to the business sector and intensify efforts to present the benefits to be gained by the business sector through enhanced research activity A/4.4.6 Enter into an arrangement with businesses that are prepared to fund the procurement of certain equipment regarding the use of such equipment
Priority 4.5 Building human resources	Actions: A/4.5.1 Critically examine skills deficiencies among the staff, analyse the needs and draft a (annual) training plan A/4.5.2 Ensure knowledge and skills transfer among the staff A/4.5.3 Monitor and use all available options for free-of-charge education and training of staff A/4.5.4 Use tailored internal trainings (in-house training) A/4.5.5 Organise day-long workshops (at least once a year) for heads of departments and heads of individual Projects Offices delivered by external experts for EU projects A/4.5.6 Design projects and applying for open tenders of the European Social Fund – OP Efficient Human Resources

Strategic Goal 5 **Bolstering the influence of PMF on the development of society as a whole, improving the promotion of social responsibility and improving visibility and international brand awareness**	
Priorities: Priority 5.1 Continuous planning and implementation of science promotion activities Priority 5.2 Building a strong visual identity, improving self-promotion and increasing international brand awareness Priority 5.3 Continuous participation in professional projects and expertise of strategic importance for the development of society Priority 5.4 Improved cooperation with decision makers in pre-tertiary education	
Priority 5.1 Continuous planning and implementation of science promotion activities	Actions: A/5.1.1 Continue the current activities and design and organise new activities aimed at science promotion within the wider community A/5.1.2 Improve the public communication both quality- and quantity-wise A/5.1.3 Organise a summer school for gifted high school students (after they complete the third grade) A/5.1.4 Take part in popular science events organised by others A/5.1.5 Give support to professional organisations, associations and popular science magazines
Priority 5.2 Building a strong visual identity, improving self-promotion and increasing international brand awareness	Actions: A/5.2.1 Develop an annual and tri-annual action plan to raise visibility and promote PMF, plan the necessary financial and human resources for implementation of these plans A/5.2.2 Regularly project cost plan for visibility and promotion actions at the level of maximum eligible costs, and plan activities that highly impact the promotion A/5.2.3 Promote systematically work (research and teaching) and achievements A/5.2.4 Reconstruct and upgrade the website and actively use all modern communication channels A/5.2.5 Ensure that the departments have the central PR service's professional support so that they can adequately present themselves to the public A/5.2.6 Ensure the participation of competent staff at all public speaking engagements A/5.2.7 Raise the international brand awareness through enhanced collaboration with internationally recognised research institutions A/5.2.8 Regularly take part in professional conferences of good international repute
Priority 5.3 Continuous participation in professional projects and expertise of strategic importance for the development of society	Actions: A/5.3.1 Set priorities in terms of participation in professional projects as those professional projects that bring higher societal benefits, whose results will bring benefits to the wider community or society as a whole, and which have been initiated by the public sector A/5.3.2 Regularly accept invitations to participate in professional projects described in the previous indent A/5.3.3 Offer professional expertise in those areas where PMF is the only competent provider of such expertise, which brings benefits to society and is in the interest of the wider community
Priority 5.4 Improved cooperation with decision makers in pre-tertiary education	Actions: A/5.4.1 Encourage mutual communication with decision-makers in pre-tertiary education A/5.4.2 Strengthen professional and research collaboration with stakeholders in pre-tertiary education and draft proposals for improvement of teacher training and competences at the pre-tertiary level

7 STRENGTHENING PMF CAPACITY FOR WRITING GRANT PROPOSALS FOR EU FUNDS AS WELL AS POSSIBILE FUNDING BY INDUSTRY SOURCES

In this chapter, we shall further develop two important potential sources of funding for PMF projects, which could also represent two important opportunities for developing research activity and knowledge transfer to the real sector, helping PMF's future growth and development in all aspects. The chapter is divided accordingly into two parts:

- Strengthening the PMF capacity for writing grant proposals for EU funds; and
- Improving access to funding from industry sources.

7.1 Strengthening the PMF capacity for writing grant proposals for EU funds

The analysis of the current state of affairs pointed to a notable improvement in the writing of project proposals, and successful submission of applications for various calls, both national and EU or other international calls, which tend to be even more competitive.

Research and innovation have been one of the fundamental priority areas in all the previous Multiannual Financial Frameworks of the EU. Investment in research and innovation is an investment into Europe's future. The European Union's support for research and innovation adds value by encouraging cooperation among research teams across countries and disciplines, which is a key prerequisite for great discoveries. The EU multiannual framework programs for research and innovation provide the support aimed at:

- Reinforcing EU's position in science;
- Promoting industrial innovation, including investment into key technologies, better access to capital and support for small enterprises;
- Addressing societal challenges such as climate change, sustainable transport and renewable energy sources;
- Producing sustainable products with actual commercial potential based on technological discoveries, by building partnerships with the industry and government stakeholders;
- Strengthening international cooperation in research and innovation.

According to the most recent information, in the following 2021-2027 Multiannual Financial Framework, a similar level of funding is expected to be available for research and innovation projects as has been the case with the current Multiannual Financial Framework expiring at the end of this year. The European Commission proposed a significantly higher budget for 2021-2027; however, the proposal was reduced to the level roughly consistent with the 2014-2020 Multiannual Financial Framework. The proposal harmonised at the level of the European Council has still to be approved by the European Parliament and the EP has already rejected the Council's proposal and asked for further alignment so more changes can be expected. Regardless of these considerations, a considerable budget will be available again for investment in science and PMF can thus expect to have numerous new opportunities to fund one of its core activities.

It is important to emphasise here that, in addition to research and innovation, there are many other segments where PMF could competitively apply for EU grants, such as human resource development and digitalisation, as well as infrastructural investments under the Cohesion and Values heading which, at around 35% of the total allocation, represents the biggest EU budget heading.

In recent years, PMF has made an enormous progress in successfully applying for EU- and other internationally funded grants. However, for the most part, this result can be credited to individual enthusiasts who more or less used their own initiative to start writing project proposals, won a

few grants and successfully managed or now manage their projects in the same vein. Bearing in mind that such a big progress was made without any major structural change, our estimate is that the untapped potential is huge. Therefore, it is an ideal moment to draft an action plan for building PMF capacity for writing project proposals for EU funding, as well for running and managing projects so as to make the most out of the EU Multiannual Financial Framework 2021-2027.

Below we present detailed and as practical as possible descriptions of proposed actions to build PMF' capacity and thus increase its chances of winning grants, successfully implementing projects and managing them in an organised and consistent manner.

The key capacity building actions for PMF to be better able to attract EU funding can be grouped into three action segments:

1. Set up a strong central (institution-wide level) projects office, as well as individual department level projects offices, reinforcing the support for public procurement in EU projects;
2. Provide IT support for the project work and mutual communication, gradually digitalising the project preparation and management processes;
3. Building human resources in terms of knowledge and skills needed for EU projects; and
4. Providing a motivating work environment and working conditions.

Below is a detailed breakdown of actions.

1. 1 Set up a strong central (institution-wide level) projects office, as well as individual department level projects offices, reinforcing the support for public procurement in EU projects	
Problem	The call announcements and publications monitoring, submission of applications and EU project governance and management, are not organised systematically. The capacities of the existing PMF projects office and the departmental projects offices (most departments have yet to set them up) are not sufficient and therefore the tracking of EU projects, project applications and their management, are primarily the result of elevated efforts by motivated individuals, with a practically negligible support of the system. The existing arrangements and capacities do not ensure continuous, professional, dedicated and systematic handling of EU-funded projects. Excessive faculty teaching and research workload is another problem, while good preparation of (EU-funded) projects and their successful implementation present a set of complex tasks, requiring a large number of work hours in order to guarantee success. Furthermore, project implementation implies demanding and voluminous project administration, which is not structurally organised, occasionally putting the research and teaching staff into a situation where they have to deal with administrative issues, rather than to be dealt by specialised project administration specialists.
Purpose	Setting up support infrastructure, systematic support that is missing from the current arrangements. Enabling researchers to focus on the technical preparation of the project proposal and their research work, providing them with a strong and systematic support in all other aspects of EU-funded projects, and thus relieving them of the administrative burden linked to project preparation and management. Tapping into the existing pool of knowledge and experience; reinforcing the existing channels of cooperation, restructuring general administration in order to make it more effective, and systematically streamlining a portion of the current administrative capacities to project administration. Getting a detailed and accurate overview of the existing capacities and, based on a previously adopted plan, building the existing capacities with new resources (partly, if

	possible, by permanent employment, and the rest by project-based employment and use of external consultancy services).
Actions	An adequate structure should be set up, i.e. the following basic organisational structures: - a central project administration support service and a central unit for EU projects: the (PMF) Central Projects Office; - professional project support: departmental projects offices; - public procurement support: Public Procurement Unit for EU projects or specialised public procurement units to deal with procurement in EU projects. The main tasks of the (PMF) Central Projects Office: - Monitoring call announcements and publications; - Communicating call information to departmental projects offices; - Drafting project applications for calls on behalf of PMF as a whole (e.g. for the calls under the European Social Fund - OP Efficient Human Resources), or launching an initiative to set up a group representing all projects offices or wider (e.g. for more complex infrastructural calls); - Taking part in the implementation of public procurement in the projects as described in the previous indent; designing project terms of reference, procurement items lists; taking part in the examination and assessment of bids received; - Providing administrative support to departmental projects offices in terms of the necessary application documents, certificates, etc.; - Making the last completeness check of the project application (whether all of the required certificates, attachments etc. have been enclosed); - If necessary, assisting the departments in the search for eligible project partners; and - Organising joint training workshops for all projects offices. The main tasks of the departmental projects offices: - Developing the technical content of projects according to the respective department's field of expertise; - Preparing (writing) the technical content of project applications, with the administrative support of the Central Projects Office which handles the administrative part of project applications; - Project governance and management with the administrative support of the Central Projects Office; - Taking part in the implementation of public procurement; designing terms of reference, procurement items lists, taking part in examination and evaluation of bids received; - Continually seeking opportunities for multidisciplinary participation of the departments in individual project proposals; - Promoting interdepartmental cooperation and exchange of information, knowledge and experience through simple workshops (proposal: each departmental projects office should organise one workshop per annum, with attendance by all other departments). The Public Procurement Office for EU projects can be structured as an independent unit (in addition to the existing public procurement unit) or it can be organised to have a portion of the capacity specialise for EU projects, but working within the integrated public procurement office. Public procurement should remain centrally organised, and individual departments should get involved, as necessary, in individual procurement procedures for equipment, works and services for their respective department. In view of the limitations affecting the employment opportunities and availability of good public procurement specialists, the specialisation of a portion of the public procurement capacity for EU projects will likely be a more realistic approach, because it requires a

	smaller number of public procurement specialists for EU-funded projects. The problem is compounded by the difficulties linked to the retention of such specialists in the long-run and therefore, the approach based on dedicating part of the public procurement capacity (at least one person, and preferably two or more) carries a lower risk for PMF. The public procurement in EU projects requires a lot of specific knowledge, keeping abreast of the practice of the State Commission for Supervision of Public Procurement Procedures (hereinafter: DKOM) and continuous training, and yet, it is still subject to the same Public Procurement Act just like any other public procurement. Therefore, the proposal is for the public procurement to be organised so that a portion of capacity (at least one or preferably two or more persons) are dedicated to the task, supported by the general public procurement team and provided with continuous training on the public procurement in EU-funded projects. A large enough capacity has to be ensured in terms of a number of staff assigned to project administrator, governance and management jobs, and the jobs related to public procurement in EU-funded projects. The projects offices can be staffed partly by reorganisation and reassignment of the existing staff and restructuring of administrative services, provided additional training is provided and improved circulation of knowledge and experience within PMF is ensured. The EU project governance and management, and public procurement in EU-funded projects, require special skills as described in detail under key capacity building action no. 3 (Building human resources in terms of knowledge and skills needed for EU projects). Staff shortages can be resolved by project-based hiring, partly by regular employment (in accordance with the possibilities for new employment), and partly by using external EU project consultants. In order to ensure better working conditions for researches (focus on research work) and good project preparation and management, the project administration, governance and management tasks have to be consistently separated from the research work within the same project, with mutual participation as necessary.

2. 2 Provide IT support for the project work and mutual communication, gradually digitalising the project preparation and management processes	
Problem	Insufficient IT support preventing sufficiently fast and simple communication and transparent mutual document sharing within a team or among several teams in the context of project work (drafting project applications, project implementation, project administration). Insufficient digitalisation, which can slow down and hinder work on EU projects. Ahead of us is an uncertain period of time, where all those who had introduced at least some digitalisation measures will be at an advantage, whereas those who had not already feel the adverse consequences of failing to adapt their work and business operation. Project governance and management is a complex process, however, digitalised procedures can greatly simplify, expedite and facilitate the future work regardless of the social distancing measures, which, it would appear, we will be subject to for a foreseeable time. Over the past several months, since the start of the Covid-19 crisis, it has become obvious that there is still a lot of room for improvement and progress by PMF in this area; therefore, as the IT support for project activities is being developed and rolled out, this process should run in parallel with digitalisation.
Purpose	To improve, simplify, enable faster, more efficient and more transparent communication and facilitate joint project work among within individual teams or across several teams. The achievement of this goal will ensure better quality of project applications and improvement of communication during project implementation.

	By digitalising all the project preparation, governance and management procedures, where possible, thus contributing significantly to an unhindered implementation of projects even with the social distancing measures in place or while working in the office. PMF also faces infrastructure issues, i.e. a shortage of workspace, and enhanced digitalisation and improved IT support would contribute to the resolution of this problem too, by dispersing certain segments of the projects offices' work.
Actions	Key tools needed for project activities should resolve the following basic needs of the joint project activities: - Simple, transparent and safe document sharing (shared document storage in a single location, defining document access and editing rights); - Team conversations; - Creating, accessing and editing activities in joint collaboration tools. When developing adequate IT solutions, in addition to PMF's IT specialists, the end users should also get involved (i.e. the representatives of all the departments that are actively involved in the project preparation and implementation, and representatives of the (PMF) Central Projects Office), as they are best informed about the issues and needs and therefore need to be involved from the beginning. Drafting an upgrade plan for the existing IT solutions after a detailed review of the existing IT support and for the tools used by the users in the context of the mutual project cooperation after analysing user needs. The implementation of activities can combine simple software solutions and more complicated hardware-software solutions as necessary. After an adequate IT support is in place, the end users have to be proactively trained so that they can apply those solutions in practice. A continuous technical support has to be made available. The IT support for projects has to be designed in the spirit of enhanced digitalisation of all processes or at least those processes where digitalisation is possible. According to the European Commission's proposal, the European Recovery Plan should have a budget (at the EU level) of EUR 750 billion in total, and the common denominator for all investments will be an obligation to invest in a green, digital and resilient Europe. A large portion of the available funding will be dedicated to the digitalisation of society and the economy, considering that digitalisation (together with the "green") is regarded as one of the most important objectives in the next Multiannual Financial Framework.

3. 3 Building human resources in terms of knowledge and skills needed for EU projects	
Problem	The preparation, administration, governance and management of EU projects is a set of complex tasks requiring a lot of knowledge and skills, as well as experience. The research segment itself of the EU-funded projects is not in doubt as PMF has excellent researchers with excellent results. However, project preparation and management should be in the hands of persons who are trained for such tasks. The individuals involved in EU projects have knowledge and experience in project preparation and management; some of that experience is positive, some of it is negative. However, there is no sufficient circulation of experience and knowledge within PMF. In addition, the acquired experience and knowledge are most often the result of exceptional individual engagement and enthusiasm, and only rarely of the systematic knowledge about how to prepare, run or manage EU projects. EU-funded projects are most often handled by persons who are not specialists, which causes additional stress and insecurity linked to project preparation, application and implementation, greater time

	investment, fewer applications than are objectively possible, missed opportunities, as well as lower success rate of project applications. The faculty's excessive workload combined with a lack of knowledge on details needed in preparation and management of EU projects presents a big hurdle in building PMF capacity for successful preparation and implementation of EU projects.
Purpose	Staff reinforcements and specialisation in the following areas of work: EU project administration, governance and management, writing project applications, public procurement in EU-funded projects. To separate the work linked to the technical preparation, administration and management of projects, from the research work. To improve the approach to the preparation and implementation of EU projects, and relieve researchers from project administration and management tasks, enabling them to focus on the research work (the substance of the project). To improve the quality of project preparation and implementation, and increase the number of EU-funded projects.
Actions	The proposal is to staff the projects offices so that from the very beginning each office has a person familiar with PMF's EU projects in order to be able to initiate internal knowledge transfer right away. In view of the fact that PMF currently does not have a high number of individuals who are proficient in project preparation, governance and management, and that the capacity for knowledge transfer to others is thus limited, this situation can be used in order to launch project-based employment (often an eligible cost) for the project governance and management functions, with active participation of PMF's own resources (active learning). Education institutions offering training in project preparation, governance and management often have a database of best attendees, i.e. attendees whom they can recommend and who are interested in being hired for such project work. Additionally, PMF can seek to recruit staff who already have experience. Project preparation can also be contracted out to external consultants (project preparation is often an eligible cost as well) which, if accompanied by proactive own learning, can also be used as one of the methods of training PMF's own human capacities. The use of external consultants in any case has to be in the function of PMF's own staff learning, and not only as a substitute for their work. In any case, PMF should set as its goal building of its own capacities and autonomy in project preparation, however, in the medium term, external capacities can be used to provide own human resources with learning opportunities. Namely, PMF's projects are specific, requiring expertise from each individual, which external consultants will often not be able to offer. Therefore, the key is to enable accelerated learning of project preparation and management techniques, including even learning by trial and error method, so as to be able to make an effective mix of research excellence and good project preparation and management. External partners i.e. project partner/partners can be used by PMF to strengthen own capacities. Project partners are designated already during the drafting of a project proposal, so that knowledge and experience sharing can start already in this stage (for instance, through joint consultations on how to prepare a certain segment of the project application). The contracting authority i.e. the lead partner in the project generally handles project governance and management (during its implementation). If PMF is the lead partner, it can consult its project partners concerning certain ambiguous situations. If PMF were the project partner, it would be advisable to monitor how the lead partner governs the project and to run systematically the PMF's own segment of the project. When it comes to acquiring experience, it would be advisable to take active part in the projects, regardless of the size of PMF's contribution.

A decision has to be made concerning the choice of the project management methodology. The proposal is to use PM² methodology whose main advantage is the fact that it is a common EU methodology, agreed upon across the entire EU, and used as the uniform methodology for management of all EU-funded projects. It has an additional advantage of being a methodology (rather than a standard) which makes it user friendlier, more practical, and easier to implement in the day-in day-out project work. The PM² methodology can be relatively easily adapted to project complexities (i.e. simplified in less complex projects, and applied more comprehensively when projects are more complex).

The staff appointed to the positions linked to the preparation and management of EU projects need structured training in the following fields:

- General project management (project management according to the chosen project management method) – „project manager";
- Writing project applications – a specialist for proposal writing and implementation of EU-funded projects;
- Project administration – project administrator;
- Project governance and management – a specialist for preparation and implementation of EU-funded projects;
- Public procurement in EU projects – a certified public procurement specialist for EU projects.

In view of its size, PMF can have external trainers delivering fully customised training on EU projects according to the current needs (in-house training).
We also propose organising full day workshops, at least once a year, for the projects office staff and heads of departments, or other representatives of the departments involved in the implementation of EU projects. The workshops can be organised together with external specialists for EU funding programmes. The workshop participants will thus be able to learn about new developments and annual project procurement plans. Each workshop should focus on a single prominent topic in the area of EU project preparation, governance and management, and the choice of the topic will always depend on the needs. In addition, a number of those workshops can be organised in smaller groups with external specialists as moderators and PMF staff taking an active part and focusing on the joint analysis of problems and review of specific scenarios. The workshop participants will receive the necessary information, new knowledge and a fresh boost of motivation at their workplace.

PMF already has a pool of knowledge; it is important to identify all the expertise accumulated thus far and enable and encourage knowledge transfer within PMF, constantly adding to it. The market offers specialised trainings in the relevant areas so what is required is drafting a training plan and then implementing it. We also recommend for those who have been or could be in the future in any way involved in preparation and implementation of EU projects, to keep expanding their knowledge through free of charge workshops/seminars/webinars, which are ever more frequently on offer.

The importance of a well-executed public procurement in EU projects is often forgotten. As a rule, mistakes in public procurement are costly and it is surely more cost-effective to invest in knowledge and continuous training of public procurement specialists than having to pay for expensive financial corrections that may easily occur. Financial corrections can range from 5% to 100% of the grant award (e.g. conflict of interest, fraud, failure to publish calls or tenders, grouping identical or similar procurement items, mismatch of deadlines, ineligible costs being paid or reimbursed…).

Internal dissemination of knowledge and experience concerning EU projects can be ensured by:

- Promoting continuous mutual communication and cooperation;

	- Organising regular weekly working meetings within the departments and regular monthly meetings of all the departments and the (PMF) Central Projects Office, or more often if necessary; - Alternating project leaders in individual projects within a department and appointing the following team functions for each project: project leader, project coordinator, project administrator; - Identifying which projects will be subject to interdisciplinary monitoring and then putting in place such continuous interdisciplinary monitoring with the aim of sharing experience (positive and negative) and boosting the motivation to launch similar projects in other departments, sharing information on the application of project results after its closing, examining ways in which project results or certain research methods can be applied or integrated into the teaching content and the business sector; - Holding final project presentation at the PMF level (presenting not only the project as such and its results, but also of the entire experience, issues, challenges, problem-solving methods, communication methods, new knowledge, overall impressions; - Creating a common (and accessible online to all) database of useful contacts; - Creating a common (and accessible online to all) database of useful information and documents; - Encouraging all the staff involved in EU projects to share information that might be useful.

4 Providing a motivating work environment and conditions	
Problem	As the financial reward that PMF can pay to those employees who have been successful in the preparation and implementation of EU projects is capped, it faces difficulties in attracting competent and successful individuals from the private sector and in retaining the existing human resources once they reach a certain level of knowledge and experience (eventually, the private sector becomes more attractive as it can offer higher financial rewards). Another issue concerns motivation of the faculty, who have a huge capacity for development of EU projects. However, because of their generally excessive workload and inadequate reward system for special achievements, they often lack motivation to undertake additional work on EU projects, which often requires many hours of additional work and personal engagement. The majority of EU projects are quite demanding, requiring high-level engagement and dedication to the project. Demanding and burdensome administration, which is, unfortunately, an integral element of those projects, very often has a dissuasive effect on those thinking of launching a project. It is a problem caused by external factors, but it can be resolved largely by adopting a systemic approach – first, by accepting the fact, then by studying the actual situation in detail, and finally by adapting and overcoming it.
Purpose	Putting in place good conditions and a positive work environment Attracting and retaining specialists for EU projects Organising work on EU projects so as to make project preparation, governance and management as one area of speciality, thus releasing the teaching & research staff from the administrative burden and enabling them to focus on their professional work. Successfully promoting work on PMF's EU projects, emphasising opportunities for personal growth and development.
Actions	By setting up and adequately staffing projects offices, conditions will be met to organise the project work so as to take the project administration load off of the research & teaching staff, allowing those functions to specialise. Thus, everyone will have better working conditions, bearing in mind that researchers will be able to concentrate on the

	research content of the projects and other project activities, whereas the preparatory, administrative and management work will be dealt with by specialists. Creating good working conditions could be even more important than financial reward itself, which is particularly significant for PMF whose financial incentive options are limited. In view of the fact that EU funding specialists are in high demand, it is practically impossible to compete for talent against the private sector using financial incentives. However, organised and attractive working conditions such as opportunities to work on large projects, collaboration with excellent scientists, international work environment, ready administrative support, personal income security, acceptable workload etc., can be decisive in attracting and retaining talent. Notwithstanding the above, the recommendation is to design a sustainable and motivating reward system, in accordance with the means available, which will be sustainable over a longer period. It is also important to make a prior analysis and determine what motivates people. A survey will point to differences and a wide spectrum of potential motivating rewards – for some it will be financial incentive (only), for others public recognition; possibility of attending a conference or additional training; chances to publicly present a project; or to manage some future, particularly valuable project; additional funding approved for procurement of laboratory equipment or teaching tools, et. For yet another group, it could be additional free days approved after the close of the project or other benefits. What type of incentive appears to be the most motivating is a question that can be easily resolved by surveying the staff and developing a reward system based on the results. A stimulating work environment for some may include the ability to work from home with only occasional physical presence at PMF. Taking into account the shortage of workspace at PMF, this option should be further explored; for PMF, it could resolve the issues linked to the lack of available workspace, whereas for others, it could be a huge advantage that other employers might not be able to offer. Therefore, creating a stimulating work environment again refers back to the importance of digitalisation and e-work in general. Writing project proposals, preparation of project applications, project administration, project governance and management – at least 80% of this work can be done in remote mode or other type of e-form. The ongoing Covid-19 crisis has brought this issue to the fore, and made it even more important.

Expected results:

- specialisation of the project preparation, administration, governance and management work, as well as separation of such work from the research work, simultaneously relieving the research & teaching staff from the project administration duties;
- a higher number of project applications;
- better quality of project applications;
- better success rate of project applications;
- a higher number of successfully implemented projects;
- easier, more competent, higher quality and more transparent project administration, governance and management;
- fewer financial corrections in the projects;
- growth and development of PMF in all its areas of work and activity; and
- an improved ability to attract and retain talent for EU project preparation and management work.

7.2 Improving access to funding from industry sources

One of the proposed strategic goals is strengthening cooperation with the business sector (Strategic Goal 3: Enhancing research collaboration with the industry and improving knowledge and technology transfer. In this context, there is a number of proposed actions, some of which relate to improving the access to funding from industry sources. In order to realise this objective, it is first necessary to meet the following prerequisites:

- become visible to the business sector;
- open up to the business sector for potential research cooperation;
- make long-term partnerships with the business sector.

The fact is there are great unknowns on both sides: the business sector is not sufficiently informed about the potential for collaboration with PMF, nor is it informed about the potential contribution of such collaboration to their business operations and future development; on the other hand, PMF is not sufficiently informed about the needs of the business sector, nor is it informed about the forms of collaboration that would be interesting to the economy. That is why in the first stage of approximation with the business sector, the most important thing is undoubtedly to get to know each other well. Implementation of the proposed actions should, in this context, result in clear identification of possibilities and opportunities for mutual collaboration with a number of business organisations. The actions are partly aimed rather broadly in order to create as large a pool of potential collaborations as possible, and partly rather narrowly, so that both sides can identify where exactly is the common ground and how to best develop activities that would be mutually beneficial.

First, PMF will have to set out a clear strategy: what type of collaboration with the business sector is of strategic importance for PMF, and will therefore be promoted, and what other types of collaboration with business can take place to some extent, without being strategically important. One of the important goals of the PMF's mission has to be application of research results in the economic sector, to benefit society as a whole. What is needed is a closer cooperation with the economic sector, in order to be able to identify the existing and future needs and developmental trends of the economy, and to adapt PMF's own research (and teaching) accordingly. Namely, the economic sector will be the one to put research outcomes into practice and therefore has to be involved in research. Thus, the strategic collaboration with the economy may include any type of cooperation that would eventually yield a positive contribution to the society (through new or improved goods and services produced by the economy using new technologies). The greater and more important the future benefit to society, the greater the strategic role of the cooperation that will lead to such benefit.

The main premises of the PMF's cooperation with business should be the following: a joint approach to research, development of new technology and/or new applications of the existing solutions that will now be materially improved owing to the additional scientific research. This type of research makes an exceptionally big contribution to the development of the economy and society in general, and is thus aligned with the basic goals of the PMF' mission. Joint research necessarily demands long-term partnerships with economic operators, developed based on mutual trust. The final result of such research cannot be foreseen, nor can the final end-date of research be set in advance, which makes this trusting partnering relationship all the more important. The leading research partner in such projects is PMF, however, the research has to be interactive and involve both partners on a continuing basis. The economic operator will be actively involved in the research, and often seek itself the access to certain research equipment and active participation with PMF's researchers. The partnering relationship with the business sector can potentially create interest among companies to finance the purchase of equipment,

laboratory fittings and furniture etc. Namely, these are companies that are always in some stage of research, always looking to develop new solutions, but lacking in own resources (human, technological) in order to carry out such research themselves. They have ideas, a vision, objectives, investment potential, they are exceptionally well informed about the available solutions; they monitor the development of the competition, as well as the development of market needs. However, in order to bring it all together, they need excellent researchers (which they do not have) and the equipment which will enable them to conduct all the necessary research (which they also do not have, and even if they did, they could not put it to good use, or at least not fully, because they do not have researchers). This is the profile of a business organisation that PMF should partner with in terms of collaboration with the economy, and the only way for PMF to become aware of such businesses and their needs is by becoming itself more visible to the business sector.

Apart from the long-term partnership with the business sector, there are several other types of potentially strategic collaboration:

- Participation in the EU-funded research projects of the business sector, the final goal of which is to commercialise the research outcome. PMF can act as a partner in the project, but the business sector must be first aware that such a partner is potentially available. Therefore: tracking public calls and tenders for the business sector, getting itself listed in the database of partners (if not done already) and using PR activities and established partnerships, to forge new high-quality partnering relationships.
- Collaboration with the business sector in projects/activities where PMF is the only party capable of offering (high-level) execution of a project/action.

On the other hand, the business sector is often looking for quick, instant solutions, which are of enormous importance to the operator at a given moment. For the most part, it would be difficult to call such projects strategic from the PMF's point of view. The so-called instant solutions cannot result in a long-term partnership as the business organisation is looking for a quick fix of a problem that has already escalated. All new research requires investment of time and resources, and in such a scenario it would be pointless i.e. not acceptable. PMF would waste time, capacities and resources in such projects, while the societal impact of such projects would be largely negligible.

PMF also has to make a decision concerning its participation in expert projects, which appears to be more acceptable in the public sector as such projects imply social responsibility and a general contribution to society. PMF should not be competing in the market; the aim has to be to be implementing such activities as the market is not capable of providing (due to the lack of knowledge, equipment, data…). If expert projects fit that criterion, they should remain one of the PMF's strategic orientations, regardless of apparently small contribution to PMF's own research work. In all other segments, PMF should to the greatest extent possible focus on those projects that require significant research work and make a great contribution to the economy and society.

The aforementioned guidelines can be used for positioning in relation to the business sector and considering what segments of the economy should be examined and promoted for potential collaboration purposes.

Opening up to the business sector, active cooperation and contribution to society: these are all prerequisites in order for PMF to be able to access industry funding sources. **There are two basic types of funding from business sources:**

- Targeted financing of particular equipment for which an economic operator estimates or believes its use will directly benefit him;

- General financing in the form of donation for equipment or other infrastructure for which an economic operator believes that it will contribute to the general economic and social development.

Targeted financing of particular equipment by the business sector is primarily associated with a long-term cooperation with a specific business organisation, which evolves through various phases before the business organisation can invest: building trust, building long-term relations, getting to know each other well and understanding (and accepting) business and research processes, and it often grows out of smaller collaborations in the past. Mutual trust and understanding are essential for an economic operator to invest. All such investment generally implies mutual obligations; for PMF, they are most likely to take the form of carrying out the greed research, involving the economic operator's human resources, if it has its own researchers, into research work – giving access to the equipment for their own research etc. In this case, the economic operator will not seek to contribute to society, but rather to his own business operation (which will eventually result in a significant contribution to society).

Joint research between PMF and business organisations based on long-term partnership is for PMF, in our view, a collaboration with the economic sector of strategic importance, and as such described above in detail.

For this category of companies, the important thing is to maintain a regular dialogue, both in the periods of active collaboration and in the periods where such active cooperation is absent. PMF can designate a liaison person at the department level for every business partner of this kind; this will ensure accountability in communication with the business partner, and the representatives of the business partner will know at all times whom to speak to. Besides, there are other ways to maintain contact with this category of companies:

- Inviting companies to hold presentations organised by PMF, where people from the business sector can present successful cases of research result transfer into business practice;
- Getting involved in the work of the PMF's Career Centre; and
- Taking part in, and considering different presentations and joint activities through the alumni club meetings.

General financing in the form of donations for equipment or other infrastructure is the second approach that PMF could use in order to (co)finance some of its future investments. Fundraising through donation initiatives is a well-known practice in Europe, and even better known in the rest of the world, so it is realistically possible, bearing in mind the PMF's mission & vision, research activity and achievements, to expect a successful development of this type of fundraising at PMF. The one particular prerequisite that is very important in this context is visibility, promotion and positioning, as we explain in more detail in the last chapter.

Donations from business to science and research can be directly linked to the principles of Corporate Social Responsibility (CSR) adopted by an ever-increasing number of businesses all over the world, Croatia included. The Corporate Social Responsibility is the manner in which organisations manage their business processes in order to make a positive impact on the society, i.e. taking responsibility for the organisation's impact on the society and the environment. A positive and proactive action of the business sector, going beyond and above what is mandated by law in various business processes (e.g. production processes, environmental impact, employment policy, employee training, investment in the community etc.) has become an established practice in the developed world. Over time, it transpired that such practice yields multiple benefits for both the organisation and the society as a whole. Big corporations, in particular, and increasingly middle-sized and even small companies, plan in their annual budgets certain amounts to offset the damage caused to the society by their business operation (e.g. a

company with a strong negative impact on the environment will invest certain amounts annually, or invest into development of the economic activity it engages in or in other economic activities that, in its view, have a potential for development). Business organisations also invest in research from the point of view of their own positioning as socially responsible organisations.

Here we have to mention the corporate social responsibility awards, presented jointly once a year by the Croatian Business Council for Sustainable Development and the Croatian Chamber of Economy, in the categories of small, medium-sized and large public companies. The award is called CSR Index ("Indeks DOP-a"), and in the past four years, in the category of large companies, it was presented to the following companies: AD Plastik d.d. (2019), AD Plastik d.d. (2018), Vetropack Straža d.d. (2017) and Ericsson Nikola Tesla d.d. (2016); and in the category of medium-sized companies to: HiPP Croatia d.o.o. (2019), HiPP Croatia d.o.o. (2018), Končar – Institut za elektrotehniku d.d. (2017) and Vivera d.o.o. (2016).

The corporate social responsibility concept includes, among other, enhancement of the philanthropic principle in business, or in this context, corporate philanthropy. By adhering to its principles, business organisations can clearly demonstrate its values and convictions to their employees, partners, customer and the public. By supporting the society, either financially or in products or services, business organisations demonstrate they are responsive to the needs of the wider community. Donating, in the sense of corporate philanthropy, elicits pleasure in bringing about a positive social change or in supporting some social value. For companies, there are different ways to donate:

- responding to direct requests – giving donations, services or products, and handling them as they come in, choosing whom to accept or reject;
- designing and developing their own donation plans, based on public calls and pre-defined criteria;
- establishing a foundation whose employees manage the assets given to the foundation, where the company makes a strategic decision as to what kind of work its foundation will engage in, and then sets up a permanent structure to control its donations and have an actual impact on society;
- selecting organisations engaged in social issues or problems, whose values are aligned to the company values, and using a partnership agreement to fund or assist their operation.

One of the best known Croatian foundations to have sprung from the business sector is Adris Foundation – Adris grupa d.d., established in 2007 by Adris grupa d.d with a mission of promoting corporate social responsibility and contributing to the advancement of the Croatian society. The Foundation funds the programmes titled Knowledge and Discoveries; Creativity; Ecology; Heritage; and Goodness. From the PMF's point of view, Knowledge and Discoveries is an interesting programme that supports pupils and students, scientists and innovators, scientific and research projects. The programme funds the following:

- scholarships for gifted high schoolers and undergraduate and graduate students or students at integrated undergraduate and graduate study programmes, postgraduate specialist study programmes, and specialisations or postgraduate doctoral studies at universities in the Republic of Croatia and abroad;
- individual and joint projects that promote knowledge, scientific discovery, excellence and innovation in the Croatian society;
- scholarships for pupils, students, innovators and scientists at international universities and other institutions for education or training purposes;
- academic competitions and other science or expert activities of pupils and students;
- organising events that contribute to the development of science and discovery, and financing science magazines and professional journals;

- rewarding inventions and discoveries, special achievements by individuals and institutions; and
- procurement of science and technology equipment for schools, universities, and other education institutions.

In recent times, media have given a lot of coverage to, for instance, donations by INA d.d. to research activity, and other big Croatian companies such as T-HT, Podravka, Pliva and many others are often mentioned as major corporate donors.

There is a strong link between the PMF's vision as an institution promoting social responsibility and contributing to the society's development, and those of business organisations whose goal is socially responsible business operation; therefore, PMF should more decisively position itself in that direction.

Industry funding can be bolstered by setting up a donations fund, which can be promoted through targeted PR activities. The donations fund must have clear objectives and purpose, a good selection of projects to be supported through the fund, and meet all the high standards of transparent management and governance.

University faculties have different solutions to the organisational issues associated with the collaboration with the business sector. It is a fact that this segment of their external work is demanding and requires certain resources. At the same time, the result will largely reflect the quantity of the resources invested. Therefore, if the leadership decides to strongly steer the strategy of PMF's activity towards the collaboration with the business sector, it follows necessarily that it will have to invest into the development of a structure that will deal with such collaboration in an organised, structured way, i.e. a Business Cooperation Office, which will have adequate capacities to support all the necessary activities: promotion, positioning, organisation and planning of events, management of the donations fund, supporting the PMF researchers in collaboration with business organisations etc. The office can be either an extension to the Career Centre or a fully independent office. Realistically, the cooperation with the business sector should not be too broad or too comprehensive because it might jeopardize the PMF's mission. However, less activity probably means fewer corporate funding opportunities. Irrespectively of that, according to the dominant school of thought, PMF should designate the cooperation with the business sector, in the sense of joint research and possibly targeted funding, as presented above, as being of strategic interest, whereas the second part, i.e. the philanthropic donations, should be raised through enhanced PR activities.

8 RANGE OF ACTIVITIES FOR POSITIONING WITHIN THE EUROPEAN AND GLOBAL RESEARCH AREA

Under the Lisbon Agreement, the European Research Area (ERA) is a unified research area opened to the world based on the Internal Market. The European Research Area enables free movement of researchers, knowledge and technology. The main objectives of this initiative were as follows: make Europe more competitive, improve the coordination of research activities on the national and European level, develop human resources and strengthen the pull factor of the European research among the best researchers of the world. The EU research and innovation programme Horizon2020 is regarded as the most important instrument for the implementation of the European Research Area.

The potential for the positioning of PMF within the European and global research area largely hinges on its international brand awareness. Therefore, it is important first to respond to the question: which actions will enhance the PMF's international brand awareness? In response to this question, rather than looking exclusively at the research work, PMF should be viewed as a whole, starting from its international brand awareness in terms of student and teacher exchange. The actions intended to enhance international exchange were developed in the context of strategic goals, priorities and actions. The implementation of proposed activities should result in an increased level of interest among international students, a higher number of domestic students going to international universities and an enhanced exchange of the faculty staff both inbound and outbound. International student and teacher mobility can significantly contribute to the international brand awareness of a university faculty and thereby to its positioning in the international research area, by keeping tabs on the European (and world) trends, which can be done continuously precisely through the mobility programme. In addition, international exchange creates the prerequisites in order for the university faculty to be generally identifiable and a targeted institution among international researchers.

Raising the degree of integration of PMF into the European and global research area is mostly linked to the higher spend on research, innovation and development nationally; in view of the significant limitations when it comes to available funding from the national source, the key is to ensure more effective absorption of EU funds and other international funds. Namely, more available funding means more research, more comprehensive and higher quality research, more results achieved, as well as more collaborations with internationally recognised research institutions. EU projects can be an important driver of improved cooperation with internationally recognised scientific research organisations. If PMF is not listed in the partner database yet, we suggest it should get itself listed, thus making itself available for participation in the projects to all those searching for an appropriate partner. In the next Multiannual Financial Framework (2021-2027), funding will be available again for research projects through Horizon Europe programme (previously Horizon2020). The budget proposed by the European Commission for Horizon Europe was around EUR 94.4 billion, however, the European Council agreed only to a budget of EUR 75.9 billion, which now has to be confirmed by the European Parliament. The latter amount is comparable to the Horizon2020 budget and, notwithstanding the scaling back of the original proposal, represents a huge potential for research funding and innovation development, as well as an enormous potential for various international collaborations.

Under the proposed Strategic Goal 2: Improving the quality of research and strengthening the internationalisation of PMF research activity, one of the priorities is: "Strengthening collaboration with internationally recognised national and international research institutions and proactively creating intradisciplinary, interdisciplinary and multidisciplinary groups". In this context, we defined the following as key activities:

- Establishing and continuously updating a list of institutions PMF has cooperated with, at the departmental level;
- Designating a responsible person for every research institution that PMF has had good cooperation with and maintaining contact through the designated person, monitoring of research activities of those institutions and re-establishing connections when necessary / opportune from side or the other;
- Promoting proactive formation of internationally identifiable groups of researchers by setting up an appropriate reward model (setting up a reward model based on the results of a prior survey on the main motivators); and
- Organising science days with collaborating research institutions (annually).

In its research work, PMF collaborates with many internationally recognised research institutions; some of them are permanent partners, others are sought out for specific research, and others yet are those PMF collaborates with coincidentally, as a partner in the projects run by other institutions. It is recommended that PMF should establish, maintain and continuously update at the departmental level lists of institutions it has collaborated with, keeping records of contact persons, capacities and resources of those institutions. In order ensure that contact is maintained and the work of all those research institutions is being properly tracked, the recommendation is to designate a responsible person for each of them (similarly to the recommendation for business partners, except that the number of research institutions is likely to be significantly higher). Institutionalising all collaborations by concluding formal agreements/arrangements would contribute to the general orderliness and structure of those collaborations without, probably, leading to a rise in their number. Nevertheless, the recommendation is to enhance the institutionalisation of collaborations. The administration and management of this task can be handled by the departmental projects offices once they are established. In order to best present itself, each department can prepare information leaflets (in e-form) about its laboratories and human and other resources, at least in Croatian and English, and distribute them to the partnering institutions or those they wish to collaborate with in the future.

The goal of every collaboration should be the result achieved, such as:

- Preparation of a publication or publication of a paper;
- Presentation at a conference;
- Delivery of a concluding lecture;
- Participation in the research projects of the research institutions that had participated in PMF's research projects.

For the positioning in the research area, the traditional promotion through general PR activities is not as important as the results and the promotion thereof in the expert circles (publication of papers and articles, citations analysis, presentations at professional conferences etc.), mutual exchange in research projects, delivered lectures and other types of professional participation and the visibility of results.

Among possible actions, "Organising science days with partnering research institutions (annually)" was proposed. If the partnering organisations are interested, they could alternate each year as hosts of those science days. The action is envisaged as a scientific and expert event, science days, where partnering scientific research institutions can take part and exchange information on research methods and approaches, presenting research results, available equipment and laboratories, and exchanging other useful information. For the positioning in the international research area, regular contact with internationally recognised research institutions plays a big role, and this action can contribute to it. As the initiator of the idea, PMF could

become the strategic centre of development and networking, based on strategic partnerships with research and academic institutions in Croatia and abroad.

The success of the faculty's research work can be measured, among other, by the quantity and quality of published papers and participations in national and international research projects, and all of it affects the international brand awareness and positioning. Therefore, these actions should be systematically promoted and enhanced. In addition, PMF should permanently supportive of the ideas aimed at setting up and strengthening the scientific research centres, centres of excellence, competence centres, and knowledge and technology transfer centres. All this will contribute to the PMF's international profile and its positioning in the international research area.

Actions that are fully under the PMF leadership's control and do not depend on external factors, and which are capable of having a significant impact on the international awareness of the work and results of PMF's researchers and thereby on the PMF's positioning in the international research area, include the following:

- promoting publication of research papers in reputable international science journals which are indexed in the reputable databases, in particular in the high-impact journals;
- promoting better quality of published papers;
- encouraging the submission of project applications, particularly for the competitive schemes (such as Horizon2020, or Horizon Europe, in the next Multiannual Financial Framework) and providing institutional support for the application and execution of the project;
- promoting interinstitutional cooperation and increasing the visibility of research groups' work;
- promoting organisation of international science events, workshops and similar activities;
- encouraging patent registration and providing funding for the registration process;
- systematically improving the research infrastructure and raising the quality of resource management;
- improving the access to the world science databases;
- reinforcing the research potential (financial and human); and
- continuous investment into researchers' training.

In addition to the high-profile of the results of research activity, PMF can promote and position itself in the research area also through excellence of equipment and resources, particularly in the new premises of the Department of Mathematics, Department of Physics (especially after the completion of the EU CeNIKS project) and the Department of Chemistry (especially after the completion of the EU CIuK project). CIuK and CeNIKS projects include the procurement of the most modern equipment, which will result in the establishment of two centres of excellence, in chemistry and in physics. After the completion of CIuK-a, PMF's Department of Chemistry will have state-of-the-art science and research equipment. As part of the project, fourteen new research labs will be set up, as well as the computer centre of the Department of Chemistry. Under the CeNIKS project, the Department of Physics will receive new equipment in the seven existing laboratories, and two brand new laboratories will be set up. The projects will significantly improve the current state of equipment in the departments, bringing in state-of-the-art equipment and allowing for stronger links with both the business sector and other research institutions. Furthermore, the new equipment will improve the quality and increase the volume of potential research for the staff and students of PMF, increasing the pull factor of these departments for international students, researchers and teachers. Unlike researchers' work and results, this element of brand awareness must receive stronger media coverage, or even be communicated directly to other research institutions.

PMF's great advantage is its interdisciplinary nature; however, this interdisciplinarity potential has not been sufficiently tapped. In the future, PMF could take a strong international position in interdisciplinary projects, the projects that require an interdisciplinary approach. Among the proposed actions, several very useful specific actions should improve the general cooperation among the departments, as well as the cooperation of those departments with other science and research institutions in individual projects.

PMF could add to its value and brand awareness by certifying the laboratories that so far have not obtained all the necessary certificates that would enable them to participate in certain international science and research activities.

The certification of PMF as a whole according to the ISO 9001:2015 standard would mean certifying business processes to a standard of great international repute. PMF is a complex system and certification would surely be a lengthy process, however, it would make a significant contribution to a positive image of PMF, and to the orderliness and optimisation of its business processes.

As part of a survey carried out in all of the departments of PMF within this project, when asked if the departments had had any issues in the past in their search for appropriate project partners, all the departments replied negatively, meaning that partner search was not a problem and that they were able to choose partners with whom to work, which reflects well on the quality of PMF. A strong and targeted promotion of the high-quality research environment, infrastructure, available equipment, excellent and recognised research groups, stimulating working and research conditions, possibility of working in a multidisciplinary and international environment, excellent results of its own researchers and a good reputation, have to produce results for PMF in terms of improved positioning in the international research area. All this together makes for a great motivational moment for the arrival of good international postdoctoral fellows, doctoral students, researchers, as well as for PMF being sought as a project partner by other research institutions.

9 PMF VISIBILITY ANALYSIS WITH RECOMMENDATIONS

Many actions recommended in this document have one thing in common and that is visibility. There are references to it in different segments and in different contexts, from the visibility of PMF as an institution to the visibility of researchers, their work and achievements, the visibility of individual projects, the visibility of international presence, the visibility of student programmes for national and international students etc. Visibility has long ago stopped being important only for the commercial sector, which has to somehow carve out a position for itself in a competitive market. From that point of view, PMF also operates in a highly competitive market – it runs against the competition in order to attract talented students, in terms of positioning itself in the research area, attracting high-quality postdoctoral fellows, researchers, reputable international teachers, project leaders etc. In short, visibility is not a mere formality that has to be satisfied in EU-funded projects, where "promotion and visibility" are a mandatory element; visibility is something that is very important and that, if applied correctly, can make PMF significantly more attractive in all aspects.

In different sections of this document, we emphasized that an improved visibility will improve the brand awareness of PMF, and thereby its attractiveness and positioning in the national, wider regional, European and world setting. PMF has a lot to show, but needs better presentation to highlight its achievements and resources.

A perusal of the main virtual channels of communication, PMF's website and the Facebook page, reveals the following:

- The PMF website offers a large quantity of information and documents, but the transparency of the website is very poor and it is difficult to navigate all the information on offer.
- The referrals to the webpages of different departments is a positive thing, however, those webpages are not mutually aligned, at least not visually, and they seem to vary a lot quality wise.
- It is only through further search that one can find the information about the major projects, such as CIuK and CeNIKS (bearing in mind that we are already aware of those projects).
- The website is up to date. The currency of departmental webpages is mainly fine at the level of the home page, with noticeable differences at the subpage level (some are up to date; the others are not, with variations among the departments).
- The website is maintained in Croatian language; there is a language menu offering the English version of the webpage; however, the English page is rather less comprehensive and does not offer the same quantity of information.
- During this analysis, i.e. over a period of over 6 months, multiple incidental visits to the website did not reveal any access issues; the website was always accessible and from that point of view, there were no problems.
- On the PMF's website, there is no link to its Facebook page. Similarly, the webpages of individual departments do not link up to their respective department's Facebook page.
- A search for the PMF's Facebook page by entering "PMF" into a search box takes us to a webpage displaying the PMF official logo; however, the webpage is not up to date and is probably some sort of a student page.
- If we enter "Prirodoslovno-matematički fakultet" (Faculty of Science) into the search box, it will take us to the official Facebook page of PMF, as pointed out in the paragraph describing the website. With a few more searches, it is possible to find the Facebook pages of the departments as well.
- The official Facebook page of PMF has 2,138 "likes" and 2,226 followers.

- Posting is relatively regular, but it could be more active (objective: a posting each day).
- In the current circumstances, it is commendable that the first post is the announcement of a donation drive "For our PMF", accompanied by a very relevant video clip.
- The posts on the Facebook page collect a relatively low number of "likes" (considering just the number of students and the faculty).
- There are not that many posts about achievements; the page focuses mainly on the information about the events.

PMF produces a very detailed annual report, the Annual Report on the Teaching, Research and other Expert Work and other Activities at the Faculty of Science, for each academic year. The annual report for the previous academic year was produced in April of the current academic year. The report gives a really detailed and comprehensive list of all annual activities and achievements. However, the visibility and readership levels of this report are questionable. The report is available from the Croatian language version of the PMF website. If not the entire report, however, at least the segment listing the activities would surely be of interest to the present or targeted future partners in the PMF-lead projects, particularly if the segment in question were also available in English and successfully promoted.

The PMF's promotional video is available on the PMF home page (video opens up in the PMF's official YouTube channel, which has a total of 51 subscribers). The visibility of the video on the website should be much better. The video itself is very interesting and the 10 minutes fly by very fast as all of the PMF's departments present themselves and the activities that students can get involved in during their studies. The promotional video currently has 12,087 views and definitely encourages prospective students to enrol. In terms of its duration, however, it is too long to be broadcast on TV so it would make sense to produce a shorter promotional video suitable for TV airing. The existence of the promotional video could be also promoted on the PMF's Facebook page. As of several days ago, the promotional video has also been available with English subtitles, but for the time being the posting of the English version of the video on YouTube has not been advertised on the webpage. The promotional video with English subtitles so far has seven views.

The PMF's YouTube channel also provides a promotional video for the "For our PMF" donation drive, and currently has 3,004 views.

There are a few more videos on YouTube about PMF (PMF' YouTube channel currently offers several very fine presentations titled "PMF Matematika – Što rade matematičari" (PMF Mathematics – What do the mathematicians do?) from 2017 with 2,818 views, "PMF Fizika – Nevjerojatan spoj" (PMF Physics – An Unbelievable Connection) from 2017 with 1,222 views, "PMF Biologija – Teorija evolucije" (PMF Biology – The Theory of Evolution) from 2017 with 1,601 views, as well as several other PMF-related videos on other channels). However, these videos are not linked to the official PMF YouTube channel so they can be reached only after several additional searches.

A promotional brochure about PMF is available on the PMF's home page. Just like the promotional video, the brochure is really interesting, offering a wealth of information to prospective students. The brochure, slightly different but also very appealing-looking, is available also in English. Moreover, it is by far better visible on the English language website, rather than Croatian. The Croatian website is loaded with information and links, with the effect that the links to brochures and the promotional video are simply lost or poorly visible.

The recommendation is to bolster strongly the promotion of PMF, its activities and achievements, and to materially improve the visibility. In the context of the proposed Strategic Goal 5, the Priority 5.2: "Building a strong visual identity, improving self-promotion and increasing international brand awareness" includes the following main actions:

- Developing an annual and a tri-annual plan of PMF visibility and promotion activities, planning the necessary financial and human resources for their implementation;
- Regular project cost planning for visibility and promotion activities at the level of maximum eligible costs and planning high impact promotion activities;
- Systematically promoting work (research and teaching) and achievements;
- Reconstructing and upgrading the website and proactively using all contemporary communication channels;
- Professional support by the central PR service to the departments in order for them to adequately present themselves to the public;
- Ensuring participation of competent staff at all public speaking engagements;
- Raising international brand awareness through enhanced participation in internationally recognised research institutions;
- Taking regular and active part in professional conferences of good international repute.

The recommendation is to contract out the development of the initial promotional strategy of PMF to one of the external professional promotion and communication agencies, with an active involvement of selected PMF representatives. Subsequent upgrades and changes in the promotion and communication strategy can be made internally.

PMF must significantly bolster its brand awareness, visibility and transparency of its work through a well-designed and clear communication strategy. It also needs to expand its communication channels and its online presence by using traditional and modern media, newspapers and TV, PMF's website, social networks, interactive portals, as well as other modern communications vehicles. The website, Facebook page, YouTube channel and other social platforms offering a myriad of options for free-of-charge promotion are perfect virtual space not only for the general provision of information, but also for promoting PMF's work and achievements.

As it is, the website is focused mainly on providing information to the current and prospective students, and to some extent the general public. On the other hand, the website does a poor job presenting the research work and the achievements of the PMF's research activity. The English language version of the website in particular has very little information on the research work. The recommendation is to carry out a general reconstruction of the website with a balanced presentation of all PMF's activities and much improved presentation of the EU-funded and other internationally funded projects. International PR activities also have to be significantly improved.

A mandatory element of every EU-funded project is "promotion and visibility", often with large sums recognised as eligible cost. The promotion and visibility activities should be planned at the maximum eligible level, and the preparation of the content can be contracted out to external experts (also an eligible cost), who will develop the concept and help implement the promotion of the project in the best possible way, based on the instructions given by the project team and the PMF's PR service. The promotion and visibility activities always have to be targeted, i.e. aimed at target groups, end users and to some extent to all other project stakeholders. A systematic promotion of a project can also serve to promote systematically PMF, its human capacities and infrastructure, which is very important for the relations with other research institutions and positioning in the research area.

It is also important to accept and continuously communicate the fact that every employee and every student is a promotor of PMF. Here we refer again to the example of the PMF's official Facebook page, where at the top of the page presently we find the promotional video for the "For our PMF" donation initiative, which has collected 126 "likes" and was shared 49 times. PMF has 792 employees and 4,706 students. The PMF's official Facebook page has 2,226 followers.

The recommendation is not only to pursue stronger media exposure, but also to significantly improve the tracking of media coverage. On the PMF's official Facebook page, we can find several referrals to media coverage. On the PMF's website, only the webpage of the Department of Biology has a segment called "Department in Media", but it is not up to date (it was last updated in 2016). The webpage of the Department of Physics also has a segment called "Video zapisi" (Videos) and it is not up to date.

As for the public exposure, in addition to the promotion of such exposure, better instructions (rules) should be given as to who the persons responsible for PR on behalf of PMF are. In addition to the Faculty leadership, it should also include the PMF's PR service and persons designated to this function by the departments. All those communicating with the public must be familiar with the communications strategy principles, adhering to the general guidelines in terms of professionalism and consistency. The PR service and its accessibility and responsiveness can be a major contributor to the quality of public exposure.

LIST OF TABLES

LIST OF CHARTS