The role of the key educational paths for ESA new member states as a risk reduction index for the newcomers.

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Abstract

The new ESA member states are an important factor in the development of European sustainability and independence in space. Cooperation between European countries in the field of space, gives a strong conviction that we operate without borders in space. It is therefore necessary to create not so much international links, but rather supranational ones. This also applies to space education. One of the primary missions of ESA is to create a community of highly specialized engineers, managers, as well as scientists who will focus on developing the space economy and allowing societies to understand our role and interactions with space.

Based on the experience gained in the period after Poland's accession to ESA, the authors would like to emphasize the role of key educational pathways that can guide ESA officers in new member countries and in any country that has already entered ESA structures or plans to enter in the near future. The authors would like to emphasize that there are several ways to share and improve knowledge and would like to present the main insights of the study conducted in this respect.

Drawing on the Polish space industry and using it as a reference basis, but also applying some observations from the Czech Republic and now Latvia, the authors identified the following main learning paths:

- The activity of students within student associations, who implement space projects through dedicated programs;
- The role of YGTs who, after a period of training at ESA, return with a set of knowledge to their countries;
- The importance of the know-how of the international space market, in particular global companies setting up subsidiaries in new ESA member countries and bringing their experience and knowledge there;
- Dedicated educational programs for people who do not have a formal space education (engineering) but want to develop in various areas of the space industry;

The sequence of the presented educational pathways is not accidental. The authors want to present the role of each pathway and show how it can be applied in practice. The authors recognize some deficiencies in the presented pathways, as well as note a trend towards strengthening interest in dedicated educational programs at the undergraduate and postgraduate levels. Based on their own educational experience and taking into account the status quo of space education (at least) in central Europe, the authors would like to present ideas for structuring professional education in the space industry, taking into account its recent changes, where the demanding factor of business competition should be added to the technological factor. So, where an interdisciplinary approach should be adopted. Each educational pathway has been analysed from the point of view of risks and opportunities. This analysis can be applied by new participants in the commercial space market (understood as new companies or scientific groups), but also by new ESA member states at the institutional level.

Keywords

space education, space economy, risk management

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1. Introduction

The authors' aim is to examine the main educational pathways that can be crucial for risk mitigation in the development of the space market in the country and beneficial for the European space community. The paper presents the state of the space market in Poland before joining the ESA structure. The authors then present a research methodology leading to the identification of the educational pathways of a few groups of skills in space sector. Each of these educational pathways is analysed. The authors focus not only on engineering education, but also on management education. Based on the identification and analysis carried out, an investigation of the shortcomings is carried out, which is discussed and concluded.

The authors are aware that the investigation carried out can help new member states or emerging countries to focus on areas where they are not yet present, but which can have a great impact on the development of this part of the industry in the country. The approach leads directly to risk mitigation, but more importantly, it leads to the identification of risks that can be managed in a further step.

2. Research methodology

The research methodology applied in this paper based on review of:
(1) Literature, publications,
(2) Documents published by: Administration, Business and Professional associations,
(3) Analysis of Space studies programmes
(4) Analysis of postgraduate studies available on the market,
(5) Trainee programmes organized by Industrial Development Agency
(6) Others: Foreign companies offices in the Country; structure of the polish entities, which takes parts the ESA market.
(7) Organization maturity level, measured by at least possessed certified quality management system.

The investigation shall answer the main questions:

- The basic education paths are enough to provide technical specialist in the market?
- Do the engineers have the wide possibility work in space companies?
- Does the market see the need for managerial / economical / law competencies?
- Are there possibilities to increase the increase the “soft” skills?
- Are there dedicated programmes to provide condense knowledge for administration or “new comers”?

The analysis included in the paper concern the space sector understood as "all entities involved in the systematic application of engineering and scientific disciplines to the exploration and use of space" [10]. Non-coincidental and multiple involvement is important. Several criteria for belonging to the space sector are proposed in this regard, including: documented participation in the European supply chain, developing R&D competencies, conducting implementation or industrial work related to space technologies and satellite techniques. The concept of the space sector is not the same as that of the space economy, which generally encompasses the activities of entities involved in the development, provision and use of products and services related to space activities [11]. The analysis included in the paper concerns solely the space sector.

3. The educational paths before joining ESA

The history of formal cooperation between ESA and Poland started in 1992. That time Poland had cooperation agreement with ESA. 10 years later, in 2002, there was signed prolongation agreement. In 2001 ESA defined dedication program called “Plan for European Cooperating States” PECS. Poland joined this program in 2007. The biggest advantage was possibility to participate in ESA programmes.

That long period from establishing ESA and Poland accession to its structures, does not mean that Poland was not active in space activities, but that, due to political reasons, focused on cooperation with Soviet Union. In in the 70s of last century, Institute of Aviation (ILOT) was developing a metrology rockets with the attitude of near 100km. In 1977 there was established the Space Research Centre of Polish Academy of Sciences (CBK). From that time, many instruments were designed, developed and launched by CBK [1].

The carrier development paths form 1977 till 90s last century, was focused on scientific or engineering development paths. The education path followed the clear scientific path. Engineering activities in institutes were leading with respect to getting the scientific title, which assured the employment. From 2007 the possibility of entering the space sector started to increase. Still the major role was being played

by the Scientific Institutes, however on universities, which were closely collaborating with scientific Institutes as ILOT or CBK, students associations were starting to be set.

The background of engineering knowledge was available mainly in scientific institutes, which was due to a limited number of faculties related to space sector. This knowledge was well established as a lot of instruments were design and developed. Participating students started to gain more and more technical knowledge. New projects started to be run in students associations with, not well known at that time, knowledge about ESA standards.

4. Educational paths in the course of 10 years in ESA.

4.1. Technical development

4.1.1. Technical development needs

The needs of education and technical development seem to be a fundamental issue in the space sector. These needs developed in Poland in the last decade, initially much faster than educational opportunities, due to the rigid general rules of conducting and creating new fields of study. Thus, technical education was generally possible at only a few universities in the fields of aviation, aerospace and astronomy. This changed in 2011, when Polish higher education institutions (academic departments) were allowed to autonomously create and define new fields of study, both in terms of educational results and curriculum. Units with the right to habilitation received the possibility of creating new majors independently. Thanks to this amendment, it was possible to set up new faculties of studies in Poland strictly oriented to the issues of space engineering, starting from 2014.[7]

After 10 years, can these needs be considered satisfied? The answer to this question is facilitated by a sectoral survey conducted by the Polish Space Agency [6] on the assessment of knowledge and skills (including technical skills) of graduates of technical faculties, taking up a job in the space sector. And so, according to the survey, most employers indicated mediocre technical preparation. This seems to result not from a low level of studies programme, but rather is attributed to the lack of practice of people admitted to internships and work, as well as lack of information on what tools are used in the enterprises. Respondents answering a question about the specific technical knowledge needed to work in the sector indicated deficiencies in general knowledge of on-orbit operations, methods for analyzing the impact of the environment space environment, and ECSS.

In order to construct advice for students and to learn about the so-called "recipe for success," respondents were asked what factors they consider most important in preparing for a job in the space sector. In their answers, they indicated participation in internships and apprenticeships, workshops, and platforms that foster knowledge exchange.

4.1.2. Technical development possibilities

At the moment (though the data are subject to continuous fluctuation), the possibilities of technical development are guaranteed as first and second degrees of studies in the field of astronomy and aerospace engineering or space engineering. Basic educational pathways refer to the bachelor's or master's degree programmes offered in the country. According to ESPI [2], there are between 20 and 40 degree programmes in Poland that deal with space education.

First and second degree studies in astronomy in Poland have an established high position in the system of Polish higher education. As regarding engineering education, according to the data gathered by POLSA [7] most Polish universities conducting aerospace studies do not have in their educational content subjects directly related to space engineering. The only exception is Warsaw University of Technology, which at second degree studies conducts classes in aerospace specialization, where the educational content to a large extent includes the subject of space engineering. In addition, 2 universities independently and 3 universities of Pomerania jointly lead programs which directly includes the topics of space engineering.

A third Degree Studies should also be mentioned. Two Polish Institutes of the Polish Academy of Sciences provide education at the 3rd degree level. Space Research Center of PAN is the only Polish institution conducting 3rd level studies in the area related to space engineering. They are addressed to expert level - preparing specialists for technical industry. In addition, the M. Kopernik Astronomical Center of the Polish Academy of Sciences conducts third-degree studies in the area of astronomy with elements of astrophysics.

Even taking into account the rather large potential of regular technical education in space techniques and technologies at the

disposal of individual Polish (technical) universities, they are not able to build the comprehensive competencies required to operate in the space sector. To this end, the initiative 'Network of Space Universities' in Poland was established. As it was stated in the manifesto of its establishment: 'As individual universities we have a lot of potential to offer, such as unique faculties, modern equipped laboratories or joint research with other universities. However, only as a Network of Space Universities we have a chance to appear in the awareness of world leaders'. Space Universities Network aims primarily at developing Polish science in the area of space research, education in the field of space engineering, realization of joint research and its commercialization [13].

In addition, there are various internships for recent undergraduate and postgraduate students in Polish space companies (for example, organized by Industrial Development Agency). These possibilities form a Polish Space Fellowship Program which is an extended formula of the first internship program: "Development of Human Resources for Space Sector". The aim of the program is to educate and develop young personnel in the space sector and to support knowledge transfer between universities and companies of the space sector.[8]

Thus, answering the first question, from the Polish point of view, the technical background provided by the educational institutions at the current level of development of the Polish industry is sufficient.

4.2. Non-technical development

4.2.1. Need for non- technical skills in space sector

Looking at the structure of space companies based on [4], 78% are small and medium-sized enterprises. The other 14% are large companies, 8% are R&D institutions. The large companies are mainly national companies or subsidiaries of foreign companies. The SMEs are spin-off companies from universities or scientific institutions. Looking at the structure of SMEs, 48% are micro-enterprises, 39% small and 13% medium-sized.

Businesses that develop skills begin to grow. As the number of employees increases, so do the demands on management. Considering that the owners and managers in the companies are engineers with limited management background, this issue becomes more and more important. It must also be taken into account that the space sector needs elevated management skills. The structure of ESA programmes, financial rounds, ministerial meetings, delegate structure and programmatic requirements need to be known and understood not only by engineers but also by management. From this perspective, a new area of management specialization is being sought in the market.

Identification of non-technical skills in the Polish space sector, among young staff was made based on research conducted by the Polish Space Agency [6]. Numerous skill deficiencies of Polish graduates were indicated there, and consisted mainly in lack of project management skills, sense of being a part of the project, teamwork and independent work, lack of communication skills and preparation of technical documentation. From the other side, among students and young graduates interested in the career path in the space sector, there is little interest in fields such as administration, accounting, finance, space law, HR, or media communications and standardization management. Respondents most often cite competency gaps in areas such as expertise and practice. This pattern of responses may suggest the need to look into the content of education at universities in the topics of interest to us.[6]

4.2.2. Need for non- technical skills in space sector

In the European market, there are only few opportunities to develop managerial skills for the space market. The best known is the International Space University. Of course, there are also specialized management courses, but the space industry is not the first choice of graduates. The natural way to develop management personnel is to progress within the company from engineer to project manager and then to middle or high management level.

Subsidiaries of foreign companies play a special role that is not always visible. These large companies entering the market of a new Member State have well-defined corporate structures, management processes and knowledge of business development. Employees have the unique opportunity to acquire this knowledge and know-how as part of their normal work. This gives them the opportunity to acquire practical skills in a relatively short time to become an expert in the growing market. After 10 years of Polish

presence in ESA, there is a visible trend of migration of such specialists from large companies to the SME sector. From the subsidiaries' point of view, this is not a desirable phenomenon, but from the national market's point of view, SMEs gain the knowledge, when a person decides to change employing enterprise.

The need for general space market, space project management and space law knowledge has been identified and space studies have been defined at the business universities, the example of which may be Kozminski University. From 2020, there is a special programme for entrepreneurs, engineers and start-ups. From this point on, the interest in a special educational programme is increasing. The last two editions were in Polish, i.e. aimed at the national market, but the great interest comes from the new member states, which gives confidence that the next editions will be international and in English.

5. Identified deficiencies

From one side, lots of universities offer technological education at a good level, from the other side, the space employers observe lack of basics needed for the work in the space sector. It is probably due to the fact that the education at this stage consists rather of knowledge and not skills transfer and even in that context is transferred without a context, that could be practical for the future work. Such a context is missing especially with respect to the current situation and structure of the Polish space sector and its tight links with ESA projects. The reason for this may be seen also in lack of practical knowledge among the Professors themselves and thus focusing on theoretical knowledge.

As results from the analysis, both based on the study made by POLSA and the content of the curricula of technical studies (of I, II and even III degrees), no space-related skills, or knowledge is taken into account. What is more, the students and post-graduates even don't show the interest in deepening their skills in finance, administration, project management specific to space sector, etc. claiming that they use the standard tools, learning them in practice. Same time, the space employers note the lack of such skills and knowledge as a serious gap in qualifications needed in the work for space sector.

6. Discussion of findings

Though it is proclaimed that in the Polish space sector, universities are one of the strong determinants of the sector's development [9] as they are a source of qualified staff and graduates, and basic knowledge and technologies used by space sector enterprises, and they make available specialized knowledge and infrastructure (laboratories, equipment, studios) to space sector enterprises – some doubts must be raised in this respect.

The deficiencies identified in the analysis lead to the conclusion that the graduates of the I and II degrees of the studies are mainly engineers theoretically prepared for entering the space sector. Though, the theoretical knowledge is often without a context which makes them during the first period unsuitable for the work on space projects.

This, then, leads to the conclusion that while universities have an important role in preparing for the space sector, their role is overestimated as the sole source for acquiring knowledge and skills for that purpose, or they should not be limited to transferring knowledge, but through scientific activity they should shape entrepreneurial attitudes [9]. In cooperation with the space enterprises, sharing the results of research conducted by the university and participation in the creation of new entities should foster the transfer not only of knowledge but also of skills. Also companies can implement joint projects with universities, resulting in improved curricula adequate to market needs, knowledge transfer and development of entrepreneurship.

Another issue worth discussing is how to combine the acquisition of knowledge with the acquisition of skills needed specifically for the space sector. Even just focusing on technical knowledge, it is important to consider whether apprenticeships during studies or, as in the case of the Young Graduate Training at ESA, the acquisition of practical skills only after the completion of the second stage of studies, are an effective way to train personnel for the sector. No doubt YGT forms a great opportunity to gain extensive experience that could open doors to a long-term career within Europe's space sector and is visible as such in Poland[12]

No doubt, that promotion of participation in such ESA education projects would allow increase the participation of Polish teams in the projects [6]. The effect of this would be an increase in the skills and experience of Polish

students and young professionals. Alternatively, due to limited capacity of schemes led by ESA in that respect, there should be considered additional /alternative schemes developed both nationally and in the CEE region. The success of the ARP Academy, Kozminski University program on “Entrepreneurship in Space Sector’ and similar initiatives shows the right direction in that field.

An issue that has received increased attention is the lack of non-technological skills as well as the lack of interest in them among students and graduates. This attitude, as already mentioned, is due to the lack of building entrepreneurial attitudes by universities. It is a source of quite a serious risk for the development of the space sector in such countries as Poland or other CEE countries.

7. Conclusions

Having in mind the above analysis the authors identified the main recommended learning paths for the purposes of developing work force suitable for space sector. The sequence of the educational pathways should be as follows and consist of:

- Formal education (technical or other)
- The activity of students within student associations, who implement space projects through dedicated programs
- The role of YGTs who, after a period of training at ESA, return with a set of knowledge to their countries [12]
- The importance of the know-how of the international space market, in particular global companies setting up subsidiaries in new ESA member countries and bringing their experience and knowledge there;
- Dedicated educational programs for people who do not have a formal space education (engineering) but want to develop in various areas of the space industry;

It is highly desirable to create a pan-European space carrier development paths. This need is clearly visible in the new Member States, where the ESA market is not always well understood. This misunderstanding or lack of understanding that ESA is a kind of commercial market where high technical but also management, project management, legal and quality competences are equally important. The authors believe that the ESA can take the leading role in cooperation with national agencies, universities or entrepreneurs. There may already be a solution, such as the ESA Lab, but the scope of activities could be broadened.

8. References

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