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UKRAINIAN NATIONAL CLUSTER OF RAIL EDUCATION AND RESEARCH

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Abstract: *The paper describes the characteristics of an education cluster and emphasizes the strong relation that must exist between the cluster and the business environment around it. This paper proves that the educational clusters can be formed around different industries, such as rail industry. The rail industry is facing unprecedented levels of potential growth over the next five to ten years and it is becoming more globally oriented. With growing demands, it will be a challenge to find new rail professionals for the industry's workforce. SE "Ukrzaliznytsia" (Ukrainian railways) is the world's 6th largest rail passenger transporter and the 7th largest freight transporter, as well the main employer in Ukraine. Rail education/research is a base for sustainable development of Ukrainian and world rail industry. Author analyzed Ukrainian market of rail education and research and concluded that it could be characterize as an national education cluster. Key actors of this market as a cluster core were identified. It was proposed an mechanism for increasing the efficiency of the cluster's activity and getting a positive synergistic effect.*

Key words: *rail education, rail science, national cluster, Ukrainian railways, system of rail education.*

1 INTRODUCTION

Education is one of the fundamental components that generate solutions to economy problems. Well educated and skilled people are the key elements for creating, sharing, disseminating and using knowledge effectively. A good economy requires a smart education system which is flexible and promotes creative, critical thinking, innovation.

The educational clusters are based on the same basic principles of economic and industrial cluster (the cluster concept was outlined in the 90's and a first synthesis done in 1990 by Porter). There are entities represented by educational institutions that collaborate, compete and manage an educational process. All these entities that form the cluster conduct processes that share knowledge and knowhow, teach. The competition between them is defined on the desire to be recognised as a leading educational organization and on the need for better candidates and more funding [1].

2 GLOBAL PRACTICE IN FORMATION EDUCATION CLUSTERS

At European level, strong education clusters are developed around prestigious universities. Because education clusters generate qualified human resources, it contributes to

the creation or it supports other economic clusters. Silicon Fen, in the UK, is one of the strongest R&D oriented cluster. It has developed around the Cambridge University. In this case, the cluster concentration around a generator of qualified human resources and the financial support from the industry that invests in innovation has enabled the development of a University-Industry relation which brings significant benefits to both parties.

The clusters economic model and in particular the education cluster is based on knowledge. The economic process end product of the education cluster is the professional competence, a set of knowledge acquired by a person who uses them to take part in other economic processes. The input in this economic process is represented by people who accumulate knowledge, skills going through the education system. These people are then absorbed by businesses that will use their experience to produce goods or other knowledge

The education cluster has strong connections with the surrounding economic which can be defined by different industrial clusters. Three of the most successful education clusters, around Stanford, MIT and Harvard and Cambridge have strong connections with well known IT and technology clusters. Analysis of these technology clusters have emphasize that their continuous development has been greatly influenced by the proximity to the university centres [2].

Based on Markusen cluster topologies [3], an education cluster is like a hub-and-spoke industrial cluster in which important universities and research institutions are surrounded by small private academies that fill the gap for short term and niche specializations. Because, educational institutions must adapt to local needs, social behaviour, culture you can't have a satellite organization. A state-anchored education cluster my exists in regions where the government policy is to allow and support only public educational systems but even in these situations universities have some form of autonomy regarding their internal management.

3 UKRAINIAN CLUSTER OF RAIL EDUCATION AND RESEARCH

The Ukrainian Railways or SE "Ukrzaliznytsia" (Укрзалізниця) is a public company managed by State Administration of Railroad Transportation in Ukraine, which controls vast majority of the rail transportation in the country. The railway network has a total length of over 23,000 km tracks that makes it the 14th largest in the world. It is also the world's 6th largest rail passenger transporter and the 7th largest freight transporter [4]. The total number of employees working on Ukrzaliznytsia is approximately 385 thousand as of 2013, that makes it one of the main employers in Ukraine [5].

Sector of training highly qualified personnel for the Ukrainian railways and conducting rail research is a base for sustainable development of the whole rail industry. Ukrainian railway system of education and science has a typical cluster structure (A cluster is a geographically proximate group of interconnected companies and associated institutions in a particular field, linked by commonalities and complementarities. The geographic scope of a cluster can range from a single city or state to a country or even a network of neighboring countries [6]).

The Soviet empire created an rail educational system, which included 2 institutes of Railway Engineers in Kharkov and Dnepropetrovsk and nearly two dozen Vocational colleges for training high-qualified specialists for the Ukrainian railways. At the same time, the main difference between the cluster of rail education and research of Soviet era is that there got synergetic effect from the cluster activity. In the absence of open competition and government support had been achieved the highest level of cooperation between rail industry and rail educational/research system. After the collapse of the USSR, the system retained its a structure, but the synergy effect of the Ukrainian national cluster of education and research

and rail industry isn't observed. As a result, Ukrainian rail industry now faces difficulties, including those related to human resources and innovation.

In such circumstances, a research associated with the development of a mechanism to increasing the efficiency of the cluster and formation synergy effect from cluster activities is relevant.

3.1 RAIL EDUCATION

The Law on Higher Education (2002) establishes the three-level structure of higher education: incomplete, basic, and complete educational levels with corresponding educational-proficiency levels of Junior Specialist, Bachelor, Specialist and Master. The education lasts for 4-5 years. Higher education qualifications combine both academic and professional qualifications. This is a very important feature of Ukrainian higher education inherited from its Soviet past. The State Diploma serves as both an educational certificate and a professional licence.

Currently for intellectual and professional rearmament of SE "Ukrzaliznytsia" in Ukraine functions the system of vocational and higher rail education, which includes 25 colleges (schools), 2 University and 1 Academy (Fig. 1). Moreover, the organizing structure of SE "Ukrzaliznytsia" includes the technical schools and road centers for the increasing to qualifications, preparation and refresher courses of the personnel. At technical schools the specialists get a narrow-profile profession (electrical supply, rolling stock maintenance, bookkeeping etc.). On the basis of technical schools preparation and upgrading of the personnel is held, namely: engine drivers, conductors, cashiers, station monitors etc. In order to employ at the SE "Ukrzaliznytsia" and its subdivisions the profile rail education is necessary. For example, the European railway industry is educating the personnel mainly in-house.

The main suppliers of human resources for railways still are centers of higher rail education in Kharkov and Dnepropetrovsk.

The main problem of Ukrainian rail education system is a competences gap. The competence level of the graduates of universities usually does not correspond to the industry requirement for certain specializations because in the process of university education the student's competence level is formed at the excess of theoretical knowledge and lack of practice. The universities base their educational programs on what they **can** teach the student, not what they **should** teach. As a result, Ukrainian rail universities prepare specialists, who were not quite ready for the demands of modern production. The universities won't meet their main objective of educating and preparing students for the job market. The main reason is not the harmonized university educational programs (rail education) with the current industry demands.

Innovative development of the railway industry requires for reforming the whole system of preparing the railway transport experts. Given the development of globalization processes in the world economy the demand in the specialists having universal knowledge and skills in railway transportations growths annually. For this reason the principles of rail education guided by the railway industry are in the process of transformation.

In general, new demands are not leaving out demands for existing competencies – but they add on to the existing training needs.

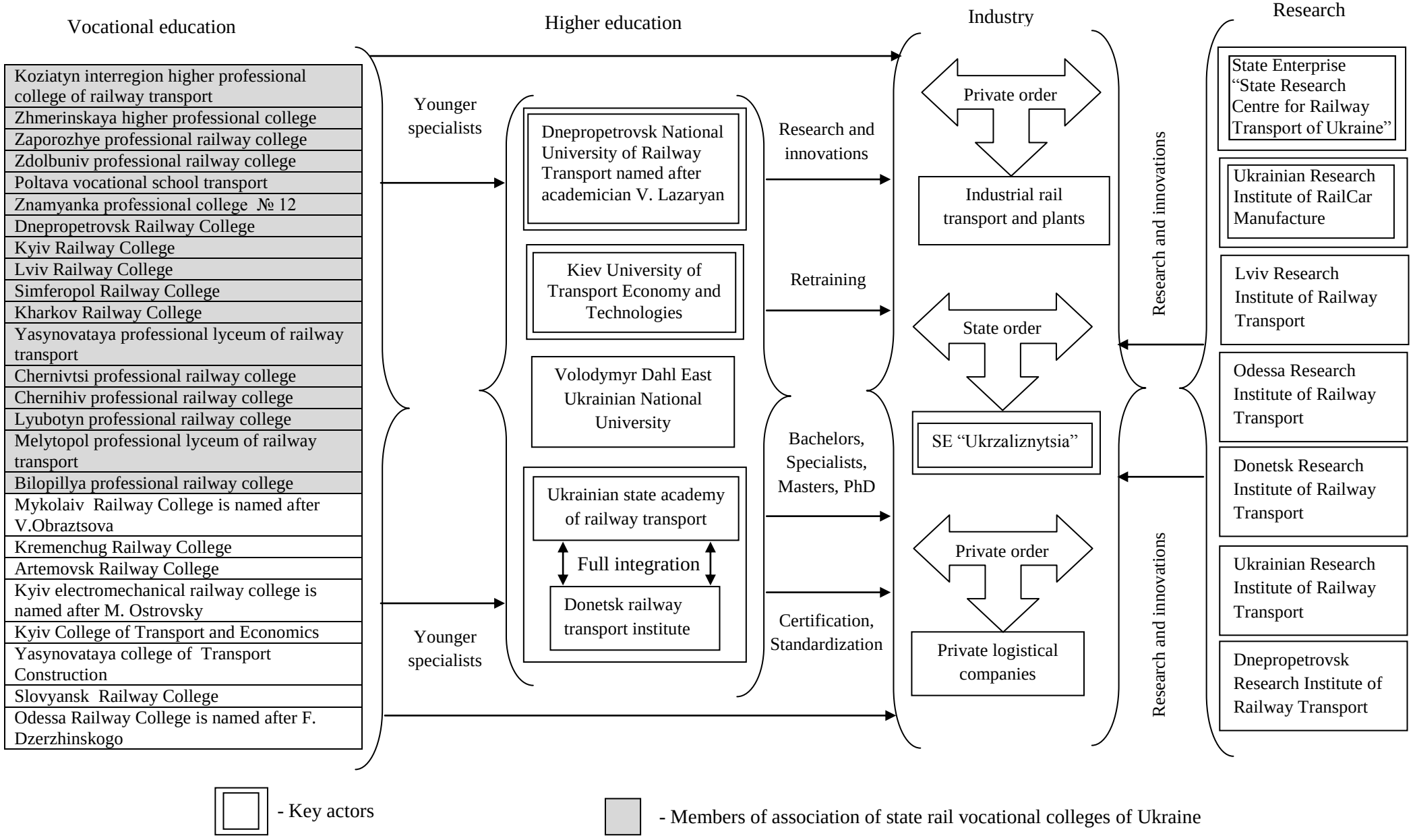

Fig.1. *The structure of Ukrainian national cluster on rail education and research*

Rail labor market of Ukraine is very dynamic. Every year rail SE "Ukrzaliznytsia" hires about 20 000 employees (2-2,5 thousands graduates from universities) [7]. This proves the rail industry leadership.

A number of students enrolled in full-time and part-time education in Ukrainian rail universities and technical universities (with rail program) is shown on Fig. 2**.**

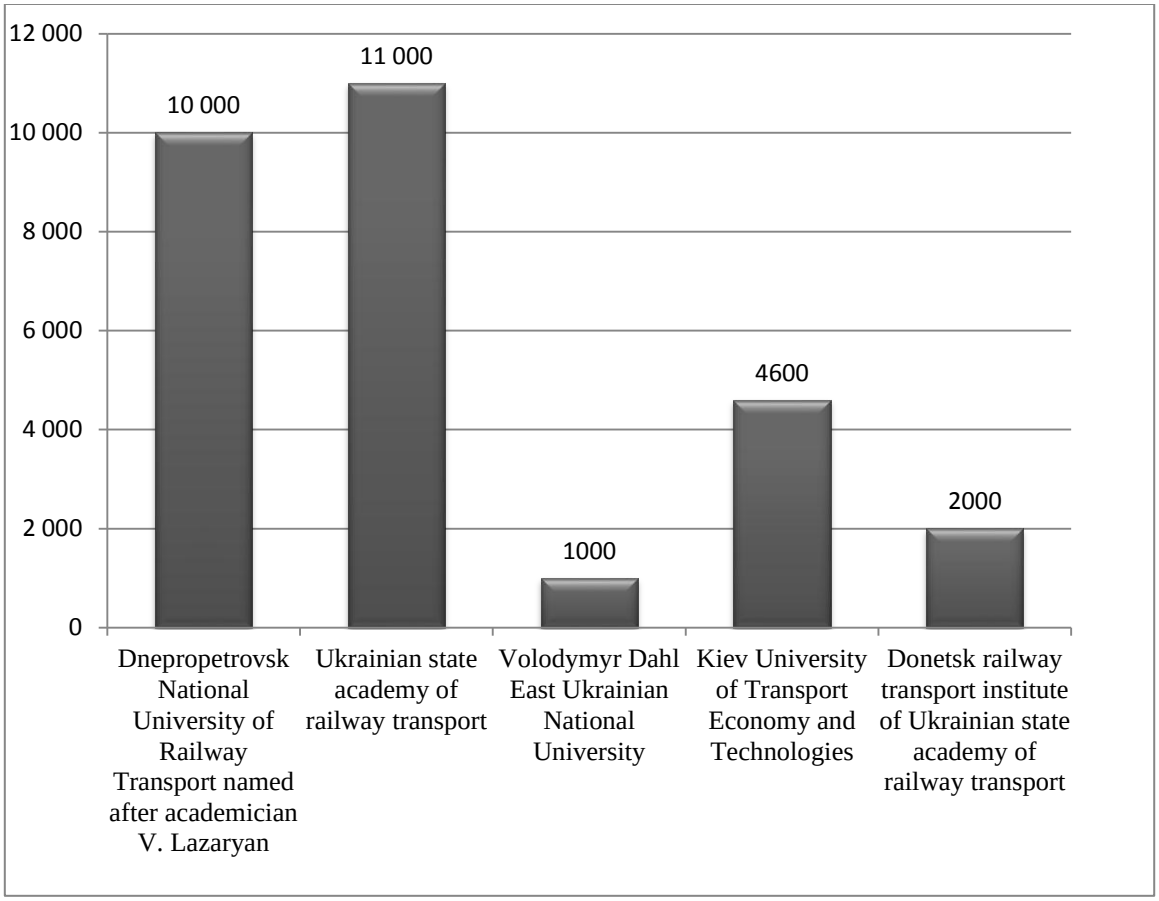

Fig.2. *The approximate number of student in Ukrainian higher educational institution of railway transport on 2013, per. [8-11]*

According to the Fig. 2 the total number of students enrolled in Ukrainian State Academy of Railway Transport is approximately 14,000 people. (together with the Donetsk Railway Transport Institute, because the institute is fully integrated into the Academy structure. Institute plays a significant role in the Eastern Ukraine and for 10 years had been a legal entity, in consequence of which authors consider it as a separate organization). However, a key role in the cluster plays Dnepropetrovsk National University of Railway transport, which proves the ranking of universities published by the Ministry of Education and Science of Ukraine in 2013 (Tabl. 1). Universities have been evaluated on the following criteria: "international activity", "quality of contingent of students", "quality of scientific and educational potential, "quality of research activities", "material and technical resources". The rank shows the level of competitiveness of Ukrainian transport universities.

Tab.1. *Ranking of Ukrainian universities of technology, building and transport*

Rank	Name of organization
1	National Aerospace University
2	**Dnepropetrovsk National University of Railway Transport is named after V. Lazaryan (DNURT)**
3	Odessa State Academy of Technical Regulation and Quality
4	Odessa State Environmental University
5	Ukrainian Academy of Printing
6	Kherson State Maritime Academy
7	Kharkov National Automobile and Highway University
8	Odessa National Maritime Academy
9	Odessa State Academy of Civil Engineering and Architecture
10	Kyiv National University of Technologies and Design
	….
19	**Ukrainian State Academy of Railway Transport (USART)**
	…
21	Kiev University of Transport Economy and Technologies (KUTET)

Training of rail specialists is conducting on various economic and technical fields (Tabl. 2). The main programs are Organization of transportation and transport management, Railway constructions and tracks, Locomotives, Automation and telemechanics, Management and Accounting and auditing.

Tab.2. *Main programs of education in Ukrainian rail educational institutions*

Domain	**Courses**	**Institution**				
		DNURT	USART	DRTI	KUTET	VDEUNU
Management and economics	Accounting and auditing	●	●	●	●	
	Management	●	●	●	●	
	Management of foreign economic activity		●			
	Economics		●	●	●	
	Finance	●	●		●	
	Marketing		●			
	Organization of transportation and transport management	●	●	●	●	●
Infrastructure	Bridges and Tunnels	●				
	Railway constructions and tracks	●	●	●	●	
	Water supply and waste water	●				
	Industrial and Civil Construction	●	●			
Electronics and telecommunications	Electronics and Telecommunications	●				
	Telecommunication systems and networks		●			
	Electromechanics	●			●	
IT	Information Systems		●			
	Computing and Software	●				
	Security of Information and Communication Systems	●				
	Computer systems and networks	●				
Rolling stocks	Transport, transport equipment and technology	●				
	Wagons		●			
	Locomotives	●	●	●	●	●
	Electrical transport and underground		●		●	
Automation and tele-mechanics	Automation and telemechanics	●	●	●	●	

3.2 RAIL RESEARCH

Rail research are conducted on the basis of universities and industrial research centers.

The main customers are the National Corporation “Ukrzaliznytsia”, enterprises with rail departments and industrial railway transport (e.g.: Kryukov Wagon Building Plant, Lugansk Wagon Building Plant, “Interpipe Steel”, PJSC “ArcelorMittal Kryvyi Rih”, PJSC “Alchevsk Iron & Steel Works” “Donetsksteel Group”, Alchevsk Iron and Steel Works, etc.

The leading Ukrainian centers of rail research are:

- Dnepropetrovsk National University of Railway Transport is named after V. Lazaryan;
- Ukrainian State Academy of Railway Transport;
- State Enterprise "State Research Centre for Railway Transport of Ukraine" (SRCRTU).

In order to evaluate the scientific potential of leading Ukrainian centers of rail research authors built the matrix of research fields based on the data collection forms completed during NEAR2 project financed by European Commission [12] (Tabl. 3). The matrix shows the key competences and potential for rail research in Ukraine. The matrix shows that main research field are rolling stock, infrastructure and signaling and safety and security.

The development of Ukrainian economics is based on growth in production and processing of raw materials. This leads to the need to revise the existing material and technical base, information systems and technological processes of work of the structural units of industrial and mainline railway transport.

Scientific developments for the rail industry of Ukraine have the stand-alone nature:

- structural units of Ukrainian railways engaged in the improvement of material and technical base and information systems individually;
- research outputs for rail industry are using very rarely in CIS countries;
- research organizations and universities are involved in cooperation with industry very rarely;
- it isn’t provided a collaboration with enterprise, which use the services of railway transport;
- funding research practically isn’t provided.

For effective using the rail scientific and production potentials it's necessary to use clustering method organizations and businesses in Europe and Asia.

Tab.3. *Matrix of research fields of activity of key rail research institutions in Ukraine.*

Pole	Field of activity	DNURT	USART	SRCRTU
Strategy and Economics	Rail regulations and policy issues; new investment models		●	●
	Main drivers of costs and demand for the rail system	●	●	●
	Creation of the strategic programs of development of railway systems			●
	Analysis and simulation using efficiency of rail systems considering trends in demand changing for rail transport		●	●
	Direction of the restructuring and reform of the railway		●	●
	Evaluation of the economic viability and investment in innovative projects in rail transport		●	●
	Determination of the transportation cost of cargo and passengers and pricing for rail transport		●	●
Rolling stock	Bogies and wheel sets	●	●	●
	Power systems	●	●	●
	Supply and energy efficiency	●	●	●
	Freight wagons and passenger cars	●	●	●
	Motive power	●		●
	Systems of automatic traction drive		●	●
	Loading, unloading and storage technologies		●	●
Product Qualification Methods	Rail legislation and legal aspects		●	●
	Assessment methods	●		●
	Test procedures and facilities	●		●
	Standardisation	●		●
	Test procedures	●		●
Safety and Security	Electrical safety in railway transport		●	
	Safety/ security management	●	●	●
	Active and passive safety	●	●	●
	Multi-modal risk analysis/ measures	●	●	
	Terrorism	●		
Operation and Systems Performance	Interoperability	●	●	
	Functional analysis	●	●	
	Operations – planning and managing	●	●	
	Capacity management and optimisation = system performance	●	●	
	Designing system architecture		●	
	Intelligent Control Systems		●	
	Intelligent Control Systems		●	
Infrastructure and Signalling	Track including subgrade and rail	●	●	
	“Switches, crossings”	●	●	
	Level crossings	●	●	
	Wheel/ rail interface	●		
	Signalling and control systems	●	●	
	Line-side equipment	●	●	
	Systems of wired and wireless communication technology		●	
Environment and Energy Efficiency	EMC	●	●	
	Energy consumption	●		
	Energy supply systems	●		
	Environment protection	●		
Human Factors	Human-machine-interface and human-computer-interaction		●	
	Functional division between the person and the machine/computer and automation		●	
	Human factor in the management of technical systems		●	
Intelligent Mobility	Forecast and strategy development of transport systems		●	
	Formation of railways tariff policy		●	
	The processing system of international wagon traffic		●	

4 CONCLUSIONS

It can be concluded that rail education/research is a base for sustainable development of the whole rail industry. Ukrainian market of rail education and research is organized as a national educational/research cluster. The educational clusters are based on the same basic principles of economic and industrial cluster. A key problem is the lack of cluster synergies from its activities. This may be due to the fact that the Ukrainian cluster is informal (isn't the declared cluster structure) and it's appropriate to formalize this cluster by forming an associations of Ukrainian rail educational institutions and research organizations.

In spite of good rail educational potential, the graduates of Ukrainian rail educational institutions were not quite ready for the demands of modern production. A competence gap between what is demanded by industry and what universities can offer is visible. The universities won't meet their main objective of educating and preparing students for the job market. Analysis of the global practice of training engineers shows that the engineering education focused primarily on the needs of the market (except of basic research). So, the main goal for Ukrainian rail educational institutions is a revision of educational programs in accordance with international standards.

The research institutions should think about development of cooperation between them. Coordination of research activities is very important for reaching synergy effect.

Further work should focus on finding an effective cooperation mechanism to reach a synergy effect and create a roadmap for the cluster activity.

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