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Rail vehicle and rail track monitoring system – a key part in transport sustainable development

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Abstract

Many definitions of "sustainable development" can be found in the literature. As some sources say the most frequently quoted definition is given in the Brundtland Report. It defines s*ustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs."* Sustainable devel*opment understood in that sense contains two key concepts: the concept of needs and the idea of limitations*. The first one is truly important*,* h*owever the second one* seems to be more relevant here. The need to ensure the safety of today and the future generations is one of the needs to be assured in the framework of sustainable development. Giving the fact that the assurance may be achievable with the imposed restrictions – for example the impact on the environment – the issues related to transport arise in mind as some of rather "obvious" suggestions. Realisation of the need to ensure the safety concerns of the integrated transport system as such, but the need realisation should be related primarily to infrastructure and means of transport. Mode of transport which seems to be the least harm to the natural environment is railroad transport. Therefore the example of this type of execution which is *Rail Vehicle's and Rail Track Monitoring System* is considered in the paper. It will be the main subject matter of the paper.

Key-words: monitoring system, transport sustainable development, railway vehicle, railway track.
JEL: L62, L91, L92

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Introduction

Despite the fact that The Report of the Brundtland Commission, commonly called Brundtland Report, "Our Common Future" was published quite a long time ago, the main aspects of its might be assumed as still obligatory. It was in 1987 when United Nations World Commission on Environment and Development (WCED) found multilateral approach and interdependence of nations as main targets in the search for a sustainable development path. Naturally, the definition of sustainable development was also given. The Brundtland Report defines sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs (World Commission on Environment and Development 1987)." One of its aims, to "re-examine the critical issues of environment and development and to formulate innovative, concrete, and realistic action proposals to deal with them (World Commission on Environment and Development 1987)," perfectly suits to the subject matter of the paper. Therefore the issue of transport in this aspect is briefly considered in the paper.

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Transport, without any doubts, impacts globally on aspects related to sustainable development. This is typically the conventional way of reasoning while sustainability development is discussed. Zuidgeest et al. (2000: 1-10), give the following examples of these impacts:

- "exhaust emissions from petrol and diesel engines (primary pollutants as carbon monoxide, nitrogen oxides, sulphur oxides, hydrocarbons and particulate matter), but also secondary pollutants due to chemical reaction of primary pollutants,
- noise which mainly results from the growth of motorization which can influence mood and reduces the performance of the cardiovascular system, as well as affects intellectual and mechanical tasks […],
- congestion, from which major cities throughout the world are suffering,
- the large area of land for the construction of roads, railways, airports and ports, as well as the land-use of developments which are derived from these constructions,
- traffic safety, with a majority of pedestrians, cyclists and motor cyclists as victims."

People make decisions about how to use the Earth's resources every day. They must take into account not only how much of these resources they are using, what processes they used to get these resources, and who has an access to these resources. Using eco-friendly transport, people would contribute to save resources for future generation and for the good of the planet's future. As Kanagawa (2011: 410) claims, "since railroads emit less carbon dioxide, which is one of the causal agents of global warming, than cars, it attracts attention as a countermeasure against global warming.". This kind of eco-friendly transport without any doubts is railroad transport, nowadays the most ecological one. According to Krohn et. al. (2014: 9), in 2005 CO_2 emissions in EU-27, considering it by sector and transport mode, in case of railway transport was 20 million tonnes which accounts for just 1.6% of total transport emissions, while it transports 6% of all passengers and 10.3% of all freight (Krohn et al. 2014: 7). Although this is a well-known fact, it is not often considered by people. First of all, it must be safe. In order to avoid railroad accidents or even there must be provided systems that, as a result of *e.g.* structural health monitoring, could inform the relevant authorities about potential faults.

In 2008 thanks to the financial support by the Polish Ministry of Science and Higher Education and Operational Programme Innovative Economy, the project *Monitoring of Technical State of Construction and Evaluation of its Lifespan – MONIT* started. The strategic objective of the *MONIT* Project was to raise the level and quality of life of Polish inhabitants by encouraging competition and innovation in a knowledge-based economy (which is obviously also a part of sustainable development problem). Achieving the strategic objective, according to authors of the Project's idea, must be "possible by carrying out the research tasks and through the development of innovative global technology solutions within the methods of construction state monitoring and of warning of possible emergency situations in objects where low risk level is required as well as through transfer of the achieved research results to various industries."[21]

The Project was carried out by the consortium that comprised four research teams based in Warsaw, Cracow and Gdańsk. The teams are as it follows: Warsaw University of Technology (four faculties: Faculty of Transport that was the leadership and headquarter, Faculty of Automotive and Construction Machinery Engineering, Faculty of Civil Engineering, Faculty of Mechatronics), AGH University of Science and Technology, Institute of Fundamental Technological Research and Szewalski Institute of Fluid – Flow Machinery (two previously mentioned institutes are part of Polish Academy of Sciences). As mentioned above, these institutions joined together as a consortium, where the role of coordinator has been granted to the Warsaw University of Technology – Faculty of Transport. Each of the realizing teams has a vast wealth of experience in carrying out actions related to the project as well as in realizing projects co-financed by the European Union funds.

Following systems of monitoring of the state of infrastructure and of technical means using

[21] Objectives of the Monitoring of Technical State of Construction and Evaluation of its Lifespan – MONIT Project can be found on: http://www.monit.pw.edu.pl/index.php/eng

this infrastructure are developed as the result of the project "SHM systems in the Monitoring of Technical State of Construction and Evaluation of its Lifespan – MONIT Project" (http://www.monit.pw.edu.pl/index.php/eng/SHM-Systems):

1. Monitoring system of the state of rail vehicle - railway track elements (the system's aim is to monitor condition of rail vehicle and railway track),
2. Dispersed monitoring system of large-size construction (the system's aim is to monitor large-size and span constructions),
3. Monitoring system of buildings and engineering constructions of bridges and roads (the system's aim is to monitor technical condition of objects within road and bridge infrastructure; the monitoring includes short, large-surface and tall, diverse-shaped buildings, built in existing urban developments),
4. Monitoring and measurement system using incoherent optical methods (the system's aim is to monitor and to measure relocations, deformations and strains of selected classes of building objects, as well as of devices and their parts and materials with the use of relatively big measuring area and big range of measuring sensitivity),
5. Monitoring and measurement system using selected coherent optical methods (the application of this system is similar to the application of the incoherent system but for objects/measuring areas of smaller scale but of much higher measuring sensibility),
6. Monitoring system of the state of engineering constructions based on video measurements (the system elaboration will enable non-contact measurements of constructions' geometry, especially observation of changes in constructions' distortion during exploitation),
7. Monitoring system of construction with the use of vibro–thermography (the system elaboration will enable continuous and periodical monitoring constructions' condition based on vibro–thermographic measurements),of
8. Monitoring system of construction, with the use of modal filter (the system will serve as software system compatible with any measurement set),
9. Monitoring system of diagnosing of wind power plants' rotor based on an active method of condition diagnosing through provoking high frequency vibration effect,
10. Monitoring system for construction with the use of impedance measurement (the system will be used to evaluate construction joints as well as cracking of critical elements),
11. Dynamic Railway Scale (DKW; the system will enable weight and speed measurements for railway vehicles at full speed),
12. Dynamic Road Scale (DWD, the system will enable axle load and speed measurements for road vehicles at full speed),
13. TRANS – MONIT (the system will enable monitoring of technical condition of road and rail truss steel bridges),
14. ELGRID system (the system will enable monitoring of cracking development in concrete structural elements),
15. Damage identification system based on piezoelectric transducers (the system aim is to monitor technical condition and damages of air construction elements and devices, renewable power engineering devices *e.g.* rotor blades, building constructions *e.g.* halls, bridges, road transport means, constructions based on composite structures, *etc.*,
16. Risk identification system based on signal measurements from FBG sensors transmitted through optical fibre (the application of this system is similar to the application of the system based on piezoelectric transducers).

As the reader can see the multiplicity of solution is high. Nevertheless it is not possible to describe all solution in the paper (even related only to the transport problems), there only one system is described. It is the first of mentioned above, the monitoring system of the state of rail vehicle - railway track elements: *Rail Vehicle's and Rail Track Monitoring System*.

As it was mentioned before, railway transport to be chosen by people for public transportation either for freight transport, first of all it must be safe. Therefore elements of railway vehicle and track should be observed. It would be the best to observe them in the same time. Why? As Chudzikiewicz and Melnik state, "detection of suspension components damages are among the most complex processes of diagnosing the technical condition of rolling stock. In terms of active safety, maintaining suspension in correct condition is very important issue. The condition of suspension elements (springs and dampers) determines vehicle dynamic behaviour and affects directly derailment safety. A significant difficulty in monitoring system development is the lack of an effective method of distinguishing nominal and faulty suspension conditions. In considered mechanical system rail vehicle-track substantial source of vehicle vibrations are geometrical irregularities of the track. Vehicle dynamic responses are thus dependent on irregularities amplitude, its wavelength and vehicle speed. The exact parameters of track irregularities - excitation are generally unknown. In some cases misleading situations may occur - the level of excitation is significant and this is interpreted as faulty operation. This fact, to an utmost degree, makes it difficult to develop a method which is insensitive to track irregularities (Chudzikiewicz, Melnik 2014: 149)." Therefore, the simplest answer for the "why?" question is: because both items (railway vehicle and track) of these considerations have mutual influence each other.

Research Methodology

The problem of diagnosing the technical condition of rail vehicles and track using *on-line* mode (in real time) is a complex research task. The railway vehicle – railway track set is a compound mechanical system of a non-linear structure enriched by variable exploitation conditions (Knothe, Kisilowski 1991; Knothe, Bohm 1999: 283-325). The vehicle's structure itself seen as a mechanical system is characterized by a considerable number of resilient and damping elements put together in various configurations, forming primary and secondary suspension. Moreover, there exists a strong coupling between the vehicle and the track in the wheel and rail contact area (Chudzikiewicz 1995: 7-19).

The rail vehicle is a system consisting of a large number of resilient and damping elements. In case of monitoring the steel spring suspension, it would be an easy solution to assemble strain gauge sensors on each of the springs. However, it would not be acceptable for economic reasons. Moreover, passenger wagons and modern electronic multiple units are often equipped with pneumatic springs of secondary suspension. In such cases, strain gauge sensors would not be applicable. Apart from resilient elements, in the vehicle's suspension also the vibration dampers are subject to wear out and damage. Their condition cannot be directly examined without removing them from the vehicle. The only method of examination would be to deduce from indirect measurements obtained by way of analysing the vibration signals registered in selected places of the railway vehicle. Despite the described difficulties, it is possible to encounter research in the literature, which try to deal with this problem (Mei, Ding 2008: 277-287; Li et al. 2007: 43-55; Hayashi et al. 2008: 88-99) by using methods elaborated for other mechanical systems. Nevertheless, these solutions have never been implemented in the exploitation conditions. Therefore, the methodology of the *Rail Vehicle's and Rail Track Monitoring System* development had to be integrated into several realisation tasks including the exploitation conditions.

First of all, the basis formulation of main research method was prepared. Development of the theoretical basis for methods monitoring of the vehicle and track was done. The UIC 518 (UIC 518 Ed. 4 2009) leaflet defines the parameters, which are taken into account in the process of granting the certification of approval for rail vehicles with bogies. It was important reference while main research method formulating. The algorithm idea adopted for the evaluation of the primary and secondary suspension condition was based then on the measurement of the vibrations' accelerations on the bogie's frame and on the vehicle's body.

The idea of the monitoring system was modelled and subjected to test with use of a mathematical model for the railway vehicle – railway track system. The mathematical model of this system may be visualized in the form of:

$$M\ddot{q} + C\dot{q} + Kq = p(t, q, \dot{q})$$
$$p(t, q, \dot{q}) = f(t) + h(q, \dot{q}) \qquad (1)$$

where:

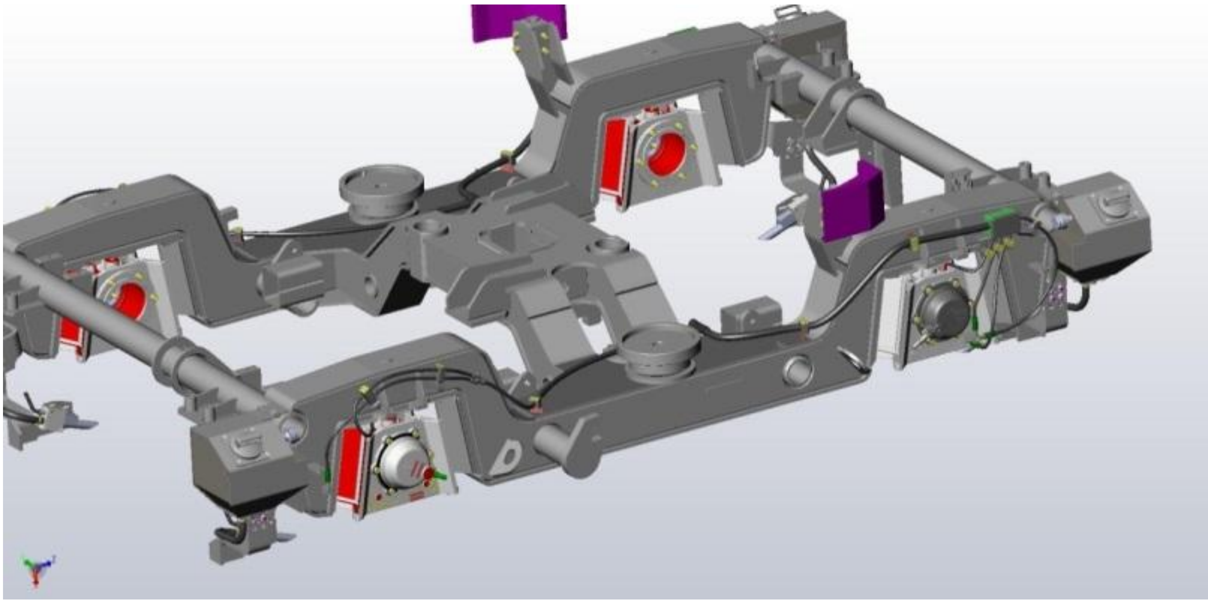
M, C, *K* – matrices of inertia, damping-gyroscope matrix, and flexibility matrix,
q – vector of generalized coordinates,
p – vector of forces,
f(t) – vector of exciting forces,
$h(q, \dot{q})$ – contact forces.

And after that, as the second main task, simulation study of the effectiveness of the formulated method was realised. The research tool was simulation study of passenger wagon. That wagon was modelled by the use of VI-Rail software package. Simulations were made in turnout zone and on a straight track for various velocity of railway vehicle and various track maintenance condition.

The next tasks considered formulation of the requirements for the vehicle and track monitoring system at selected points of a vehicle. As measures of the accelerations' signal statistical parameters of the recorded signals were assumed, such as: root mean square value (RMS), maximum value (zero-peak), kurtosis and interquartile range.

After previous task realisation the theoretical part of the system was ready to be implemented as the prototype of its and then to test the prototype – firstly in laboratory conditions and secondly on a real object, in exploitation conditions on the testing track in Żmigród. At least the system was installed on a passenger electric multiple unit ED74. Demonstration of the sensors' location used in the system's prototype on one of the bogies is given in Fig. 1.

Figure 1. Traction bogie – visualization of the sensors location



Source: authors' own elaboration.

The *Rail Vehicle's and Rail Track Monitoring System*

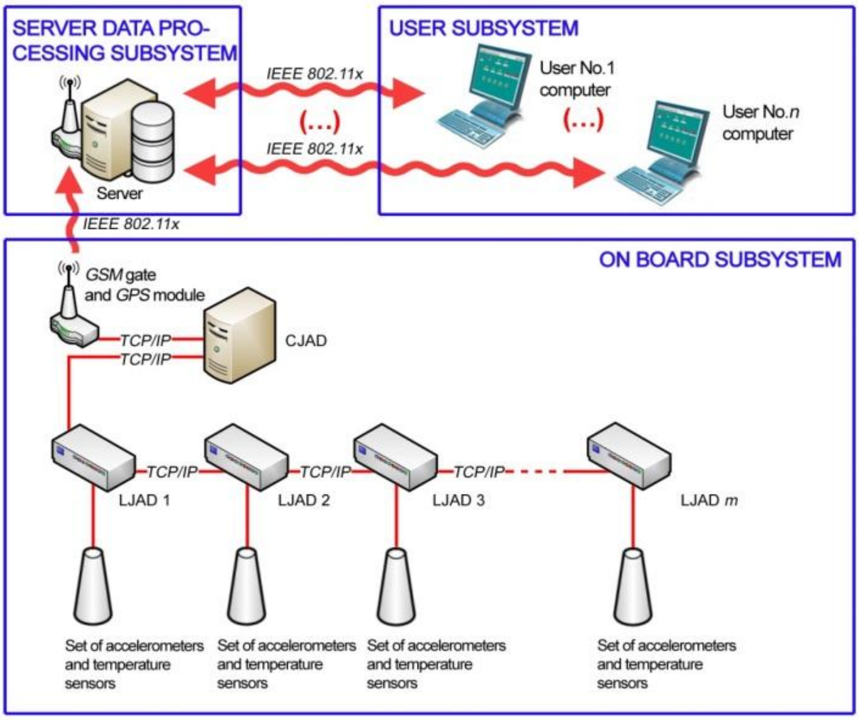
Before the Project started some research on the monitoring system of the condition of rail vehicle - railway track elements, evidently related to the Project, were done. These works can be treated and considered as independent and, without any doubt, can be constituted as fundamental for the work carried out directly in the project. These are, among many others, some research on railway vehicle (Bogacz et al. 2006; Chodzikiewicz et al. 1999: 107-117; Chodzikiewicz et al. 2000: 1-6) and railway track (Chodzikiewicz et al. 2000; Chodzikiewicz et al. 2000; Bogacz et al. 2009).

The *Rail Vehicle's and Rail Track Monitoring System* is characterized by versatility and modular architecture. Its aim is qualitative assessment of the primary and secondary suspension, axle bearing temperature measurement and evaluation of track quality. However, the *Rail Vehicle's and Rail Track Monitoring System* was described from different points of view in many papers (Chudzikiewicz et al. 2009: 123-130; Chudzikiewicz, Sowiński 2011: 1103-1110; Chudzikiewicz 2012; Chudzikiewicz, Kostrzewski 2013: 10-17; Chudzikiewicz, Sowiński 2010: 1-4; Melnik, Kostrzewski 2012: 281-288; Melnik, Chudzikiewicz 2013: 99-106; Melnik, Sowiński 2013: 3-8; Bogacz et al. 2009a: 117-122; Bogacz et al 2009: 549-565; Bogacz et al. 2011: 11-23; Bogacz 2012: 19-33), it is worth to mention some information here.

The system, as it can be seen in Fig. 2, is decomposed into *subsystems and* consists of three of them. These are:

- On-board Subsystem,
- Server Data Processing Subsystem,
- User Subsystem.

Figure 2. Scheme of the *Rail Vehicle's and Rail Track Monitoring System*



Source: Chudzikiewicz, Kostrzewski 2013: 11.

The *Server Data Processing Subsystem* means server where data measured on different railway vehicles are collected and subjected under re-sampling and statistical processing before being submitted to *User Subsystem(s).* User Subsystem mainly consists of data viewer (*see Fig. 3*) dedicated to user.

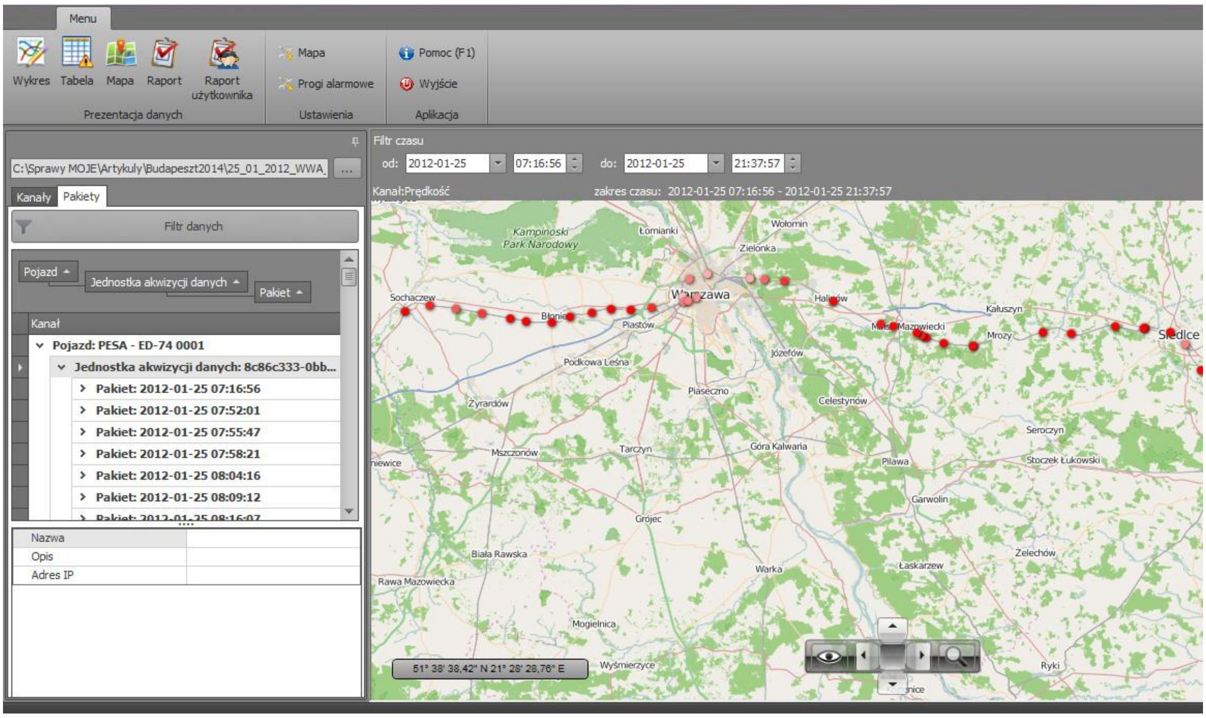
While two last subsystems do not need further explanation, the first one does.

The *On-board Subsystem* contains:

- central data acquisition unit (*CJAD*),
- communication unit (*GPS* module),
- local data acquisition units (*LJAD*),
- accelerometers,
- temperature sensors.

The functional scheme of the system structure is given in Fig. 2. Signals of acceleration and temperature measurements are transmitted from the sensors (accelerometers and temperature sensors) by wire connection to a *LJAD*. A *LJAD* are mounted on a railway vehicle in quantity equal to number of bogies in a rail vehicle. Then all signals are transmitted from a *LJAD* to a *CJAD* (again *via* wire connection), where data (signals) are subjected to preliminary analysis. Subsequently, the signals from a *CJAD*, in accordance of a *Global System for Mobile Communications* (*GSM*) gate and a *Global Positioning System* (*GPS*) module, and are sent wirelessly (the *IEEE 802.11x* given in Fig. 2 is a local wireless and is a network standard capable of providing data rates of 1 and 2 Mbps) to a system server (*Server Data Processing Subsystem*), where they are analysed and collected.

Figure 3. Data viewer of the *Rail Vehicle's and Rail Track Monitoring System*



As the results of preliminary analyses and then after subjecting of data under re-sampling and statistical processing, the appropriate diagnostic indicators – characterizing the condition of vehicle and track – are calculated. These diagnostic indicators are parameters such as: signal energy, interquartile range (*IQR*), amplitude (zero-peak), peak-peak (based on the research by, e.g., Andrzej Chudzikiewicz and Bogdan Sowiński (2011), Melnik and Kostrzewski (2012) and Melnik and Sowiński (2012)) and at last but not the least track quality indicator (based on the research by, e.g., Bogacz et al. (2009a: 117-122); Bogacz et al. (2009: 549-565); Bogacz et al. (2011) and Bogacz et al. (2012)).

After calculating diagnostic indicators values, qualitative information about condition of vehicle and track are generated. In the mind of the system creators, this information is sent to the relevant railway departments supervising the technical, operational condition and movement of vehicles and authorities responsible for technical and operational track condition. The location of the vehicle is described by geographical coordinates and is shown on the electronic map of Poland (as it can be seen on *Fig. 3*). Therefore, information about vehicles and condition of track is uniquely to be identified with the place in the area the country (*see Fig. 6*). Based on this information, it is possible to make decisions about necessary repairs, renovations or replacement of rail vehicle or track or even remodelling the existing railway network (or its part) in extreme situations. That occurs to be especially important when it is said about rational and sustainable development in transport area.

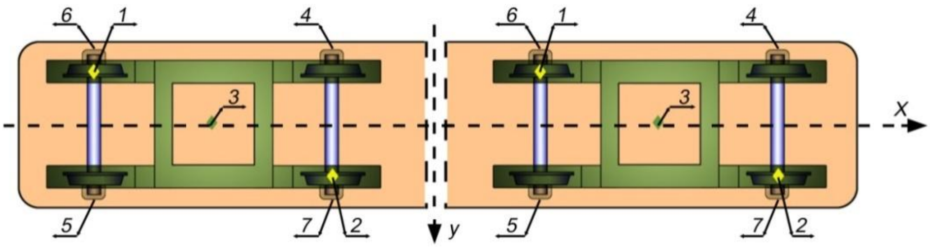
In the *On-board Subsystem*, acceleration signals are recorded by piezoelectric accelerometers and temperature high is recorded by temperature sensors. "The piezoelectric accelerometers used in the monitoring system sensitivity is ~ 100 mV/g, the range of measured signal ~ ± 100 g and the frequency range of measured signal is up to ~ 5000 Hz. And in case of temperature sensors, the temperature range operating is - 55 – + 100 C (Chudzikiewicz et al. 2012: 271-280)."

In general, the number of sensors and their placement can be configured in any way. However, for diagnostic purposes and the approval testing, it must comply with the requirements of Polish norm: PN EN 14363: 2007. During simulation part in research on the *Rail Vehicle's and Rail Track Monitoring System*, the following sections of a railway vehicle were taken into consideration in case of acceleration and temperature sensors position to be installed:

- wheelset bearing (axle boxes – accelerators and temperature sensors),
- bogie frame, over the wheel (accelerators),
- vehicle body, over the centre of the bogie frame (accelerators).

To be specific, the proposed localization of chosen measurement points can be seen in Fig. 4.

Figure 4. Localization of chosen measurement points – scheme of railway vehicle top view



Source: Melnik, Kostrzewski 2012: 282.

In general, it can be said that the *Rail Vehicle's and Rail Track Monitoring System* is suitable to detect faults in primary[22] and secondary suspension[23] (some of the most important railway vehicles elements while railway transport safety is considered), alike to detect some problems related to track, its quality, irregularities *etc.* For the primary suspension condition assessment, acceleration signals recorded on a bogie frame are used (*Fig. 4 – marked as 1 and 2*). Sensors mounted on a body, above bogie centre (*Fig. 4 – marked as 3*) are used in order to monitor secondary suspension condition. As far as the track condition is concerned, acceleration signals are registered by accelerometers located on wheelset bearings (*Fig. 4 – marked as 4-5 on one side of construction and as 6-7 on other side of construction*). And the temperature of axles bearing is considered on signals recorded by temperature places located on wheelset bearings (the same as in case of the

track condition consideration, the sensor are marked as 4-5 on one side of construction and as 6-7 on other side of construction, *see: Fig. 4*).

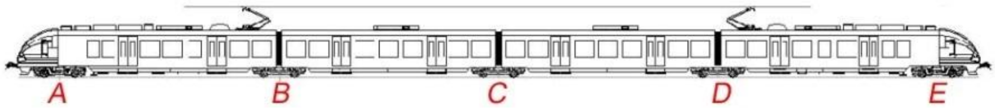
In this project the real condition reference is the prototype of the *Rail Vehicle's and Rail Track Monitoring System*. The prototype of mentioned system was installed on electric multiple unit (*EMU*) *ED74* produced by *PESA Bydgoszcz SA.* and lent for prototype installation by *PKP Intercity SA.*

ED74 EMU is four electric traction unit which car bodies are based on five intermediate bogies (*see Fig. 5*): two utmost located bogies are motor bogies (*marked as A and E in Fig. 5*) and three are Jacobs bogies (bogies connecting the four trailing segments; *marked as B-D in Fig. 5*).[24] This implementation should be treated as test implementation. Motor bogie E has a different configuration of sensors from other bogies.

[22] Primary suspension are elements that connect wheelsets to a bogie's frames.
[23] Secondary suspension are elements that connect bogies to a vehicle's body.

[24] Jacobs bogies idea can be find *e.g.* in the document: http://www.cabbagepatchrailway.co.uk/mls/g3/bogies.pdf (accessed on-line: March 15th, 2014).

Figure 5. ED74 train sketch



Source: PESA Bydgoszcz S.A.

Chosen basic technical parameters of *ED74 EMU* are as follows (PESA Bydgoszcz S.A.). Its mass is 158.9 t, length: 80.33 m, width: 2.87 m, height: 4.36 m, wheel diameter: 840 mm, supply voltage: 3 kV DC, the number and engine power: 4 x 500 kW, continuous power: 2000 kW, acceleration boot: 1 m/s², design speed: 160 km/h.

The system prototype installed on the *ED74 EMU* contains:

- central data acquisition unit (*CJAD*) which is computer MOXA V2406-XPE, with 2 GB of RAM and a 16GB CF card,
- Sierra Wireless AirLink GX400 router with *GPS* module,
- 5 local data acquisition units (*LJAD*),
- 50 VIS-311A accelerometers,
- 20 Pt100 temperature sensors,
- system server with operator's station.

The *Rail Vehicle's and Rail Track Monitoring System* as one of Key Part in Transport Sustainable Development

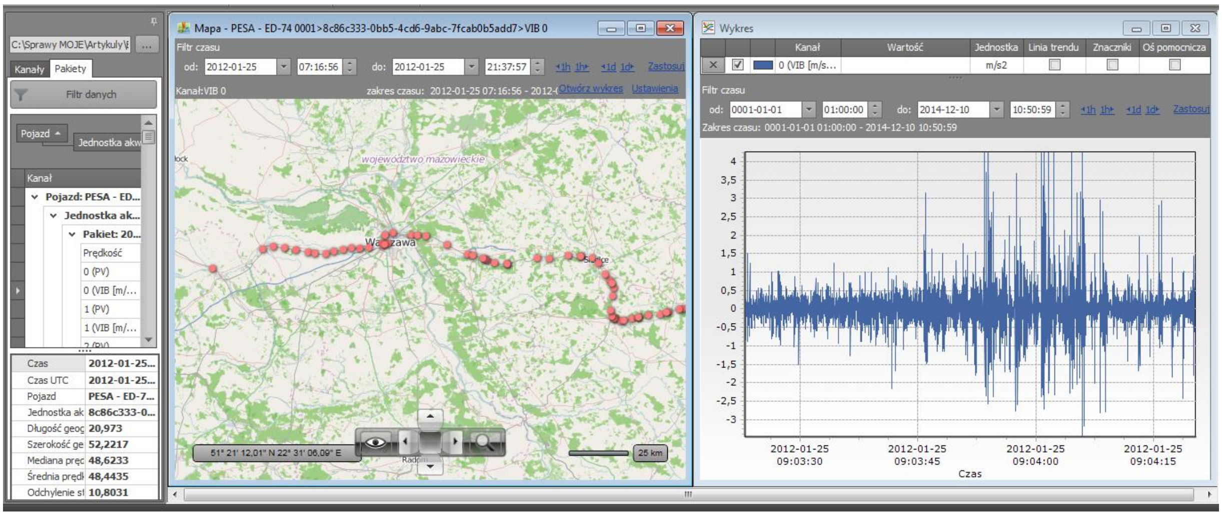
In the introduction chapter, one of the definition of sustainable development was given. The *Rail Vehicle's and Rail Track Monitoring System* is considered here, in the paper, as one of key part in transport sustainable development. Then what does the sustainable transport mean?

Black defines it as "transport that meets the current transport and mobility needs without compromising the ability of future generations to meet these needs (Black 1996: 151; Black 2010: 3)." The definition is given in appropriate explanation in chapter 1 of the book "Sustainable Transportation Problems and Solutions" of the same author (Black 2010: 3).

Lee Schipper says that "sustainable transport is transportation where the beneficiaries pay their full social costs, including those that would be paid by future generations (Schipper 1996)." He generally attributes non-sustainability to the negative externalities generated by transport.

According to Centre for Sustainable Transportation (1998) the sustainable transport system is the system that that: "1. allows the basic needs of individuals and societies to be met safely and in a manner consistent with human and ecosystem health, with equity within and between generations; 2. is affordable, operates efficiently, offers choice of transport mode, and supports a vibrant economy; 3. limits emissions and waste within the planet's ability to absorb them, minimizes consumption of non-renewable resources, reuses and recycles its components, and minimizes the use of land and production of noise (Transportation Planning and Sustainability 2014)."

Figure 6. Printscreen of the *User Subsystem* software in the *Rail Vehicle's and Rail Track Monitoring System*



More recently, Transport Canada (2003) has identified a framework that addresses the social, economic and environmental elements of a sustainable transport system. They seek "the highest practical standards of safety and security economic efficiency, and respect for the environment so that transport's impact on the environment and health of Canadians [it can be change for any nation or all the nations in the world – included by M.K.] is acceptable to current and future generations (Transportation Research Board 2004: 36)."

Other kind of consequences (financial, social, etc.) for current and future generation, all concern safety features. Referring to railroad transport as truly important part of transport sustainability development, "the development of measurement techniques and the tendency to increase the operating speed of rail transport, while raising the level of safety, is the reason for the development of vehicle monitoring systems. Currently used monitoring methods of the rail vehicles represent monitoring systems directly related to the control of the vehicle, such as power supply, power train, braking system. Application of monitoring systems allows to increase safety through early detection of malfunctions in selected vehicle systems, and prediction of the future state. This allows to perform early repairs and to reduce costs in case of unexpected failures. It can be added that the use of monitoring has also economic significance (*Melnik, Chudzikiewicz 2013:* 99)."

In case of high-speed rail vehicles, it is extremely important to monitor axle bearing temperature and acceleration signals in any moment while railway vehicle passing through the track. Railway vehicle suspension determines significantly riding dynamics, safety and comfort. The suspension condition should be checked regularly, and even monitored continuously. Therefore it is expected that in the near future the requirements for the rail vehicle monitoring systems will increase according to Chudzikiewicz (2002). This is also affected by the specificity of the rail transport. The engine-driver operating *EMU* or other kind of train (consisting of many wagons) may not perceive abnormal behaviour of the distant wagons. Therefore, due to safety of passengers, freight and team of the railway unit, the driver and special staff should be informed on technical condition of this unit.

Why is the *Rail Vehicle's and Rail Track Monitoring System* believed to be the part of sustainable transport development? It should be mentioned that the answer would be social and economic aims of whole *MONIT* Project's realization. They are as it follows:

- increasing safety of users of engineering objects and vehicle and devices equipped with the monitoring systems (railway vehicles and railway track in case of the *Rail Vehicle's and Rail Track Monitoring System*),
- prolonging the lifespan of the monitored objects and devices as well as decreasing their failure frequency (it is evidently in

case of the *Rail Vehicle's and Rail Track Monitoring System*),
- reducing the social costs related to disasters (that means railways disasters briefly mentioned in first part the paper), failures or periodical closure of objects (condition both of vehicles and track should be high quality and the *Rail Vehicle's and Rail Track Monitoring System* can provide unwavering action through early warning of problems that could potentially arise),
- rationalizing the costs of maintenance and repairs of objects and devices (the same matter as in case of the previous parenthesis),
- increasing the innovativeness of Polish companies using the new technological solutions and also their competitiveness on the international market (talks about the *Rail Vehicle's and Rail Track Monitoring System* together with proper entrepreneurs get underway),
- increasing the share of the innovative products of Polish economy in the international market and improving the role of the Polish science in the economic development and what is hand-in-hand with that improving the human potential of research and development institutions through engaging into conducted research tasks experienced research staff, postgraduates, students and through creating new job posts essential to the project's realization.[25]

It has to be underlined that thank to realisation of the goals mentioned above, conducting the *Monitoring Of Technical State of Construction and Evaluation of its Lifespan – MONIT* Project will contribute to the increase in high-tech technologies in the Polish economy, to the improvement of competitiveness of Polish science and its involvement in the economic development.

Conclusion

"The fact is that, almost two centuries after the first train ran, the railways are still a means of transport with major potential, and it is renewal of the railways which is the key to achieving modal rebalance. This will require ambitious measures which do not depend on European regulations alone but must be driven by the stakeholders in the sector (WHITE PAPER 2001: 26)." Therefore, next to creating a single European railway system by 2020, what is master problem about railway transport in UE nowadays, using railway should be safe and especially reliable. And then it would be highly possible that people and entrepreneurs choose this kind of transport mode as the major one. What is needed then, a veritable cultural revolution to make rail transport competitive enough to remain one of the leading option in the transport system not only in UE but also in the world.
The technological progress and fast industrial development to make rail transport competitive lead to the need of quality control, both during the production and usage stages. In order to detect defects fast and to minimize the transport devices' failure frequency, various tests of materials are carried out. The preferred methods are the non-destructive tests of finished products, mainly in places where peoples' safety is involved (parts of machines, welded joints, casts, thickness measurements, defects

[25] However it is not related to the subject matter of the paper, the realization of the other actions and strategic objective should be mentioned. It is based on realization of the following partial goals: (1) equipping the research units of the research institutions involved in the project through purchases of professional research equipment, (2) strengthening co-operation between the R+D sphere and the economy through engaging into co-operation within the realization of the research tasks, enterprises from various sectors of industry and also companies interested in the project's results, (3) development of innovative global technology solutions within the methods and systems of construction state monitoring and of evaluating its failure frequency warning of possible emergency situations, (4) creating new research posts and job posts resulting from the enterprise's realization, (5) increasing the number of legally protected technological solutions made in Poland through submitting patent applications on innovative solutions developed within the project's realization, (6) increasing the young scientists' professional qualifications through enlarging the number of scientific degrees obtained directly as a result of the project's realization.

occurring in the usage stage, structural alterations and corrosion loss). The conducted analysis and research aim at preventing human losses, material damage and ecological disasters. The described system is one of these which can prevent of them all. Research tasks were planned to develop innovative global technological solutions for non-destructive methods of monitoring of the state of construction. The system needs more test and data gained so far need to be analysed. This has some limitation due of quantity of gained data and by the fact that the prototype is not researched more (it had to be uninstalled due to company reasons). Authors and the rest of research team hope that finance would be given for future research.

A good point to conclude is to repeat after Robert Joumard and Jean-Pierre Nicolas that "any project to improve accessibility should not be reduced to the «transport» alternatives only (Joumard, Nicolas 2010: 136-142)." The surrounding is extremely important. It is hard to consider the system at micro scale, especially that sustainable development is multidimensional issue. Therefore it should be opted to the installation the systems on all railway vehicles all along the country.

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System monitorowania układu pojazd szynowy-tor jako kluczowy element zrównoważonego rozwoju transportu

Abstrakt
W literaturze przedmiotu znaleźć można wiele definicji zrównoważonego rozwoju, niemniej jednak najczęściej cytowaną definicją wydaje się być ta pochodząca z Raportu Brundtlanda. Według niej zrównoważony rozwój to taki w którym potrzeby obecnego pokolenia mogą być zaspokojone bez umniejszania szans przyszłych pokoleń na ich zaspokojenie. W tym kontekście zrównoważony rozwój zawiera dwa kluczowe pojęcia: koncepcje podstawowych potrzeb oraz idee ograniczonych możliwości. Mimo, że oba pojęcia mają nader istotne znaczenie, to jednak w kontekście niniejszego artykułu idea ograniczonych możliwości odgrywa ważną rolę. To właśnie konieczność zapewnienia bezpieczeństwa obecnym, ale również przyszłym pokoleniem ma niebagatelne znaczenie w kontekście zrównoważonego rozwoju. Zważywszy na fakt, że wspomniane bezpieczeństwo może być wypracowane poprzez nałożenie restrykcji m.in. dotyczących oddziaływania na środowisko, kwestie związane z transportem narastają do rangi oczywistych sugestii. Bez wątpienia zapewnienie bezpieczeństwa związane jest z wdrożeniem systemu zintegrowanego transportu, tym niemniej zagwarantowanie bezpieczeństwa powinno być związane przede wszystkim infrastrukturą oraz środkami transportu. W tym kontekście środkiem transportu, który wydaje się być najmniej szkodliwy dla środowiska naturalnego jest transport kolejowy, dlatego przykładem zapewnienia zasady bezpieczeństwa jest wprowadzenie Systemu monitorowania układu pojazd szynowy-tor. System ten będzie głównym przedmiotem zainteresowania niniejszego opracowania.

Słowa kluczowe : system monitorujący, zrównoważony rozwój transport, transport kolejowy