ZARZĄDZANIE PUBLICZNE 2(26)/2014, s. 229–238
doi:10.4467/20843968ZP.14.019.2353
www.ejournals.eu/Zarzadzanie-Publiczne/

Anna Kononiuk
Bialystok University of Technology

ROADMAPPING AS A METHOD ENHANCING REGIONAL DEVELOPMENT

Abstract

The aim of the article is to present roadmapping as method enhancing regional development. The idea of the method manifests itself in integration of science and technology with business practice. In the article, there have been presented a short description of the method, the exemplary characteristics of the roadmapping process and its visualisation for the chosen priority technology groups defined for the Podlaskie region in the project entitled *NT FOR Podlaskie 2020. Regional strategy of nanotechnology development.* The project was granted financial support from the EU Operational Programme "Innovative Economy 2007–2013". An interesting element of the roadmapping process in the Polish foresight practice, presented in the article, is the application of the Watson's concept for the time zones visualisation to the graphical presentation of the method. The roadmapping methodology applied to the project has allowed to prepare seven roadmaps of the priority technologies that might contribute to creating a competitive advantage of the region. In the article, there have been used critical literature review, survey research, the method of logical analysis and construction and a case study.

Key words: roadmapping, regional development*, NT FOR Podlaskie 2020. Regional strategy of nanotechnology development*

Introduction

Technology roadmapping is a strategic decision process framework that supports innovation activities. The method has attracted the interest of an increasing number of academics and practitioners and has been applied in many different industrial sectors and organizations [Lee, Kim, Phaal, 2013, p. 286]. Its idea manifests itself in integration of science and technology with business practice as well as in the identification of chances in the scope of new technologies development [Daim, Oliver, 2008, p. 690]. According to Galvin, "a roadmap is an extended look at the future of a chosen field of inquiry composed of the collective knowledge and imagination of the brightest drivers of change in that field [Phaal, Farrukh, Probert, 2011, p. 7]. Although the method was elaborated more than twenty five years ago by Motorola in production planning, it is still very popular in the leading refereed journals of various aspects of management and has been used in

contexts such as: mining [Amadi-Echendu *et al*., 2011], open innovation environments [Caetano, Amaral, 2011], ICT industry [Chen, Wakeland, Yu, 2012], wind energy [Daim, Amer, Brenden, 2012], product-service integration [Geum *et al*., 2011], service sector [Martin, Daim, 2012]. It is also perceived as a systemic instrument for forward-looking policy-design [Ahlqvist, Valovirta, Loikkanen, 2012]. The method is still a subject to further enhancement and development in terms of using new concepts for improving its credibility [Lee, Kim, Phaal, 2012] or is jointly applied with different methods of strategic analysis such as scenarios [Saritas, Aylen, 2010]. As noted by Fiedeler *et al.* [2004, p. 20–30] roadmapping is an appropriate method for building strategic knowledge indispensable for assessing chances of nanotechnology development by policy makers, government and research institutions. The experience of the projects such as *Transforming our regional economy – action plan 2006 roadmaps, Asset mapping roadmap: a guide to assessing regional development resources*, shows that roadmapping may be successfully used in management of regional development which should be based on sound assessment of regional business potentials.

The focus of this article is on regional context for its application on the basis of the research project *NT FOR Podlaskie 2020. Regional strategy of nanotechnology development*.

Although the region in the European Union documents is not perceived *via* direct territorial-administrative relation [Klasik, Kuźnik, 2008, p. 85], for the purpose of this publication the region is defined as a territorial administration unit corresponding to the level below state one, possessing the local government.

In the article, there have been used critical literature review, survey research, the method of logical analysis and construction and a case study. The paper contributes to broadening understanding of technology roadmapping applied to regional context.

The paper is organized as follows. Section 2 presents the main assumptions of the project *NT FOR Podlaskie 2020. Regional strategy of nanotechnology development*. Section 3 is devoted to the presentation of the roadmapping activity backed up by a detailed case study. Finally, conclusions are presented in Summary, offering at the some core recommendations of using roadmapping in regional context.

The main assumptions of the project *NT FOR Podlaskie 2020. Regional strategy on nanotechnology development*

The application of technology roadmapping is presented in the context of the project entitled *Technological foresight NT FOR Podlaskie 2020. Regional strategy of nanotechnology development*. The reason for the selection of this project for the illustrative example of the method application in the regional context was that the author of the article coordinated the works of scenario analysis and technology roadmapping panel and therefore had and assess to the detailed data on

the method use in the project. The project was granted financial support from the EU Operational Programme "Innovative Economy 2007–2013" (Priority 1: "Research and development of modern technologies", Measure 1.1.: "Support for scientific research for establishment of a knowledge-based economy", Submeasure 1.1.1: "Research projects using the foresight method").

The project attempted to promote breakthrough technologies in a situation where the development of the traditional economic sectors no longer contributed to regional economic growth [Kononiuk *et al*., 2012, p. 1; Feasibility study, 2008, p. 6]. It is located in one of the least economically developed regions of Poland with a low level of economic welfare, little business competitiveness and a low intensity of innovation in technology and product development [Feasibility study, 2008, p. 5]. In the project's authors opinion the chances of the Podlaskie voivodship development are to be found in to fields of activities breaking hitherto prevailing approach to regional social-economic development policy: (i) the application of modern tools of future anticipation, (ii) the examination of breaking technologies which regional development may be based on [Feasibility study, 2008, p. 5–6]. One of the project's goals is putting forward roadmaps of breaking technologies development.

The methodology of the project comprises the following research methods and techniques [Nazarko, Kędzior, 2010, p. 8]: STEEPVL analysis, SWOT analysis, technology mapping, key technologies, the scenario method and roadmapping. The main research methods are supported by brainstorming, moderated discussion and bibliometrics. One of the projects results are seven priority technology groups for the Podlaskie region, namely [Nazarko *et al*., 2012, p. 3]:

- nanomaterials and nanosurfaces in medical equipment (T20);
- composite materials for dental fillings (T17);
- powder technologies in plastic, paint and varnish production (T31);
- surface nanotechnologies in biomedicine (T21);
- nanotechnology for cutting instruments and wood processing (T3);
- nanotechnology for specialised textiles (T24);
- nano-structuring of metals (T38).

The identification of priority technologies for Podlaskie region has been preceded by the following research tasks: (i) the elaboration of the 'preliminary technologies' catalogue, (ii) the elaboration of technology assessment criteria, (iii) the identification of key technologies, (iv) technologies prioritetisation [Kononiuk, Magruk, 2012, p. 5]. As a prioritetisation tool *Technology Readines Level* has been applied [Mankins, 1995].

In the next section the methodology of roadmapping for the identified priority nanotechnology in the project has been described.

Roadmapping methodology in the project *NT FOR Podlaskie 2020. Regional strategy on nanotechnology development*

The roadmapping literature suggests that the technology roadmaping process broadly consists of three different phases: preliminary activity, development of the technology roadmapping and follow-up activity [Lee, Phaal, Lee, 2013, p. 288]. Notable examples of research and practice relating to regional development include: *Transforming our regional economy – action plan 2006 roadmaps, Asset mapping roadmap: a guide to assessing regional development resources.* Polish literature on the subject provides only few examples of its application to regional foresight studies [Gudanowska, 2012, p. 28–31].

The methodology of roadmaping applied to the project *NT FOR Podlaskie 2020. Regional strategy on nanotechnology developmen*t comprised six research tasks [Nazarko *et al*., 2012, p. 23], namely:

1. The critical analysis of the Polish and foreign literature on the roadmapping method.
2. The identification of the best practices of roadmapping.
3. The preparation of questionnaires about the development of priority technologies in three time zones.
4. Filling up the questionnaires by the leading experts on priority technologies.
5. The elaboration of roadmapping results.
6. Linking roadmapping activities with scenario analysis.

The research process was supported by the research methods such as: the critical literature review, the method of analysis and logical construction, brainstorming and survey research. The selection of the research methods has been determined by the research scope. Nanotechnology roadmapping in the project was based on the Phaal *et al*. [2011, p. 3] concept indicating the necessity of roadmap layers identification, and Watson's concept on the graphical presentation of time zones in technology timeline.

The construction of the final roadmap of nanotechnology development was possible due to the succinct analysis of the questionnaires directed to the leading experts in priority technology on mapping and roadmapping activity. The questionnaires were sent to seven experts in December 2011. The author of this article was responsible for preparing a questionnaire on roadmapping activity.

Experts' task was the assessment in three time zones: 2012–2014, 2015–2017 and 2018–2020 four layers of the roadmap: namely (1) resources (subdivided into financial, human and tangibles), (2) R&D subdivided into (basic research, implementations and research directions), (3) the fields of potential applications, (4) the development of technology.

The graphical demonstrative layout of the roadmap was inspired by the trends&technology timeline shaping the future in the sixteen research field (society and culture, geopolitics, science and technology, economy, transport, tourism, media to name but a few) in five time zones.

The above presented trends' development has been described by Watson [2010] and is well documented in the book entitled *Future Files. A brief history of the next 50 years.* The shaping of megatrends and branching trends was the immediate inspiration for the time zones presentation in the project's roadmaps. Figure 1 shows the exemplary visualisation of roadmap of the composite materials for dentist fillings.

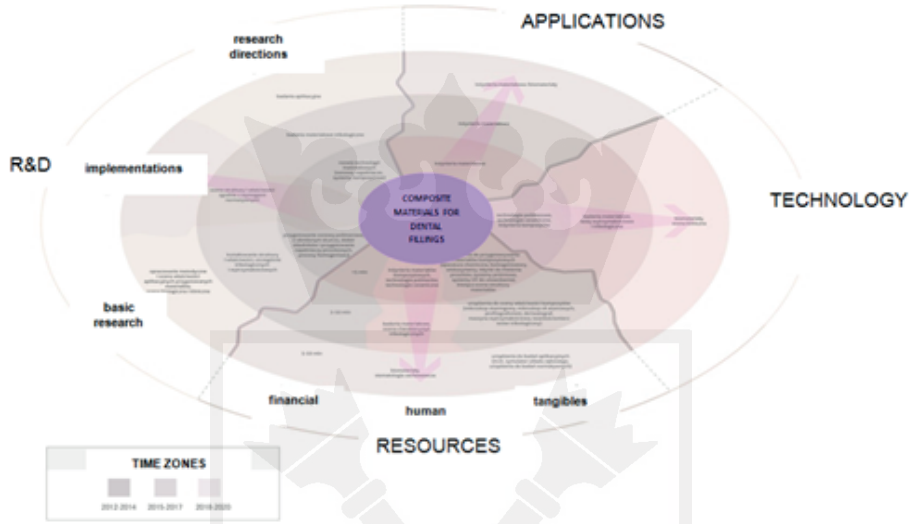

Figure 1. The roadmap of composite materials for dental fillings

Source: based on: J. Nazarko, A. Gudanawska, A. Kononiuk, E. Glińska, U. Glińska, I. Ejdys (2013), *Kierunki rozwoju nanotechnologii w województwie podlaski. Mapy. Marszruty. Trendy*, Oficyna Wydawnicza Politechniki Białostockiej, Białystok, s. 48.

On the basis of the questionnaire analysis filled by the leading expert, one may identify general directions of this nanotechnology in the scope of resources, R&D, technology development and fields of applications [Nazarko *et al.*, 2012, p. 44–45].

Required human qualifications for the development of composite materials for dental fillings in 2012–2014 perspective are composite materials engineering, polymer technology, ceramic technologies which will further evaluate from the skills in material research and tribological assessment in 2015–2017 perspective to the qualifications in biomaterials knowledge and preservative dentistry in 2018–2020 perspective.

Indispensable increase in expenditures in the first time zone is assessed as low, i.e. lower than 5 million zlotys, in the next two perspectives is estimated to be medium, i.e. amounting from 5 to 50 million zlotys.

Equipment required for laboratory developing composite materials in 2012––2014 time zone are devices for composite materials preparation, devices for the current assessment of materials' structure and nanostructure scanners. In 2015––2017 the equipment of laboratory should encompass devices for the assessment of composite properties. In 2018–2020 the laboratory equipment ought to include devices for applicatory research (dental system stimulator and devices for normative research to name but a few).

In 2012–2014 perspective, R&D in the scope of basic research indispensable for composite materials development will concentrate on the preparation of polymer warps with the lowered shrinkage, the selection and preparation of powder fillers and works on homogenization processes. In 2017–2018 perspective, the R&D will focus on the strength and tribological properties and structure shaping. In the next time zone, R&D will focus on the biological and clinical assessment of the prepared materials.

Implementation research will focus on the assessment of properties structure in accordance to normative requirements in 2015–2017 and *in vitro, in vivo* research in 2018–2020 perspective.

Key research directions and applications supporting the development of composite materials for dental fillings will focus on the development of material technologies (warps, fillers, composite systems) in 2012–2014 perspective, material and tribological research in 2015–2017 and applications in 2018–2020 perspective.

Indispensable components of composite materials for dental fillings are polymer technologies, ceramic technologies, composite engineering in 2012–2014, material research, strength and tribological tests in 2015–2017 and biomaterials and clinical assessment in 2018–2020.

The fields of possible composite materials applications are material engineering in three time zones, and in 2018-2020 perspective biomaterials additionally.

The leading project technology experts attempted to embed the priority nanotechnologies into four scenarios by assessing the chances of each technology's development in the context of a particular scenario [Kononiuk *et al*., 2012, p. 3; Nazarko *et al*., 2012, p. 66). The brief characteristics of scenarios is presented in the Table 1.

Table 1. Basic characteristics of the four scenarios of nanotechnology development in Podlaskie province

	Scenario profile	Scenario name
S_1	High R&D Effective regional collaboration of business, science and administration	NANO: New Dimension of Podlaskie
S_2	High R&D Ineffective regional collaboration of business, science and administration	NANO-scattered Podlaskie

	Scenario profile	Scenario name
S_3	Low R&D Ineffective regional collaboration of business, science and administration	NANO Indifference in Podlaskie
S_4	Low R&D Effective regional collaboration of business, science and administration	NANO-enthusiastic Podlaskie

Source: based on: A. Kononiuk (2012), *Metoda scenariuszowa w antycypowaniu przyszłości*, „Organizacja i Kierowanie", nr 2(151), s. 44.

The process of scenario building in the project was based on intuitive logic school of scenario construction. In the process, there were involved twelve experts deriving from the project team. The experts prepared four qualitatively different scenarios taking into account sixty five factors influencing nanotechnology development in the region. The factors were then ranked by importance and uncertainty. The results of such activity were further supported by structural analysis. Due to juxtaposition of the results of factors ranking and structural analysis, two driving forces of nanotechnologies in the region were identified which at the same time constituted two scenario axes. Scenario were constructed along these axes, one of which related to the level of R&D in the region and the other to the quality (effective versus ineffective) of collaboration among the actors from business, science and administration. The results of that exercise are presented in Figure 2.

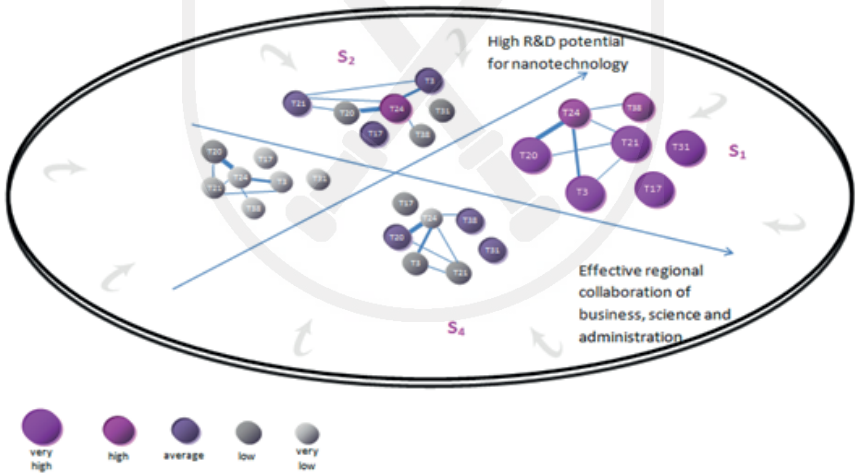

Figure 2. Experts' assessment of chances for priority technologies development in the context of different scenarios

Source: based on: J. Nazarko, A. Gudanawska, A. Kononiuk, E. Glińska, U. Glińska, I. Ejdys (2013), *Kierunki rozwoju nanotechnologii w województwie podlaskim. Mapy. Marszruty. Trendy*, Oficyna Wydawnicza Politechniki Białostockiej, Białystok, s. 61.; A. Kononiuk (2012), *Metoda scenariuszowa w antycypowaniu przyszłości*, „Organizacja i Kierowanie", nr 2(151), p. 4.

In the experts' opinions, five out of the seven technologies identified have very high chances of development under favourable conditions for R&D in nanotechnology and effective regional collaboration between business, science and administration, i.e. powder technologies in plastic, paint and varnish production (T31), composite materials for dental fillings (T17), surface nanotechnologies in biomedicine (T21), nanotechnology for cutting instruments and wood processing (T3), and nanomaterials and nanosurfaces in medical equipment (T20) [Kononiuk *et al.*, 2012, p. 3; Nazarko *et al.*, 2012, p. 66].

The roadmapping methodology in the project *NT FOR Podlaskie 2020. Regional strategy of nanotechnology development* has allowed to prepare seven roadmaps of the priority technologies that might contribute to creating a competitive advantage of the region. The main efforts in facing the challenges in the region should focus on building R&D potential for nanotechnology and establishing effective regional collaboration of business, science and administration.

Summary and recommendations

A critical analysis of publications on the roadmapping method has allowed for proposing a roadmaping methodology applied to regional context. The author of the article recommends the grounded in literature concept based on building multilayered time graphs for roadmapping activity which present the development of technology in the broad context taking into account issues such as resources (human, financial, tangibles), R&D (financial, human and tangibles), technology and applications. It also seems legitimate – depending on the research scope – to conduct expert consultation on individual roadmap layers and possible elements which are to be located on it. What is really important, in order to enhance effectiveness of communicating the roadmap content and incorporate multidimensionality of the environment, the roadmap should be prepared by interdisciplinary expert team (including key experts on a given technology, local business representatives and authorities) and be linked to regional strategic documents. It also seems legitimate to incorporate the scenario method in the process of roadmapping which guarantee encompassing many environmental factors into roadmapping activity. Hence the main difficulties in the method use are in the first place the selection and recruitment of the experts represented different theoretical and practical background, and secondly ensuring the compatibility of roadmaping normative aims with the goals of strategic documents in force. It is also pivotal that the layers of the roadmap correspond to the scope of roadmapping activity, therefore they may be treated flexibly within different projects.

The elaborated roadmaps in the project *NT FOR Podlaskie 2020. Regional strategy of nanotechnology development* are the part of regional nanotechnology strategy, which will set the direction for the introduction of nanotechnology into the economy of Podlaskie region. Roadmapping process in the project preceded the processes of formulating both strategic aims of nanotechnology implementation in the region as well as setting the directions of strategic intervention.

Although the subject of the article focuses on the foresight studies related only to presented case, the author believes that content of this article may be useful both for foresight practitioners and theoreticians, as well as decision-makers in the region.

References

Ahlqvist T., Valovirta V., Loikkanen T. (2012), *Innovation Policy Roadmapping as a Systemic Instrument for Forward-looking Policy Design*, "Science & Public Policy (SPP)", March, Vol. 39, Issue 2, p. 178–190.

Amadi-Echendu J., Lephauphau O., Maswanganyi M., Mkhize M. (2011), *Case Studies of Technology Roadmapping in Mining*, "Journal of Engineering and Technology Management", Vol. 28, Issue 1–2, March–June, p. 23–32.

Asset Mapping Roadmap: A Guide to Assessing Regional Development Resources (2007), Regional Innovation Initiative, Council on Competitiveness, Washington.

Caetano M., Amaral D.C. (2011), *Roadmapping for Technology Push and Partnership: A Contribution for Open Innovation Environments*, "Technovation", Vol. 31, Issue 7, July, p. 320–335.

Chan L., Daim T. (2012), *Exploring the Impact of Technology Foresight Studies on Innovation: Case of BRIC countries*, "Futures", Vol. 44, Issue 6, August, 2012, p. 618–630.

Chen H., Wakeland W., Yu J. (2012), *A Two-stage Technology Foresight Model with System Dynamics Simulation and Its Application in the Chinese ICT Industry*, "Technological Forecasting & Social Change", Vol. 79, Issue 7, September, p. 1254–1267.

Daim T.U., Amer M., Brenden R. (2012), *Technology Roadmapping for Wind Energy: Case of the Pacific Northwest*, "Journal of Cleaner Production", Vol. 20, Issue 1, January, p. 27–37.

Daim T.U., Oliver T. (2008), *Implementing Technology Roadmap Process in the Energy Services Sector: A Case Study of a Government Agency*, „Technological Forecasting & Social Change", No. 75, Issue 5, p. 687–720.

Feasibility study of *Technology Foresight „NT FOR Podlaskie 2020". Regional Strategy of Nanotechnology Developement* [Studium wykonalności projektu *Foresight technologiczny „NT FOR Podlaskie 2020". Regionalna strategia rozwoju nanotechnologii*] (2008), Białystok.

Fiedeler U., Fleischer T., Decker M. (2004), *Roadmapping as TA-tool: Pre-requisites and Potential Benefits for Assessing Nanotechnology*, EU-US Seminar *New Technology Foresight, Forecasting & Assessment Methods*, Seville, 13–14 May 2004, p. 20–30.

Geum Y., Lee S., Kang D., Park Y. (2011), *The Customisation Framework for Roadmapping Product-service Integration*, "Service Business", Vol. 5, Issue 3, September, p. 213–236.

Gudanowska A.E. (2012), *Roadmapping jako narzędzie wspomagające zarządzanie rozwojem regionu*, "Studia i Materiały. Miscellanea Oeconomicae", r. 16, nr 2, Wydział Zarządzania i Administracji Uniwersytetu Jana Kochanowskiego w Kielcach, Kielce.

Klasik A., Kuźnik F. (eds.) (2008), *Granice regionu funkcjonalnego nie są więc granicami administracyjnym*" [w:] *Priorytetowe technologie dla zrównoważonego rozwoju województwa śląskiego*, cz. 1: *Studia regionalne*, GIG, Katowice.

Kononiuk A. (2012), *Metoda scenariuszowa w antycypowaniu przyszłości*, „Organizacja i Kierowanie", nr 2(151), s. 33–48.

Kononiuk A., Magruk A. (2012), *Opracowanie rezultatów identyfikacji kluczowych czynników rozwoju nanotechnologii w województwie podlaskim*, materiały projektu NT FOR Podlaskie 2020. Regionalna strategia rozwoju nanotechnologii, Politechnika Białostocka, Białystok.

Kononiuk A., Nazarko L., Nazarko J., Ejdys J., Halicka K., Glinska U., Gudanowska A. (2012), *Nanotechnology for Podlaskie 2020*, EFP BRIEF, no. 235.

Lee J.H., Kim H., Phaal R. (2012), *An Analysis of Factors Improving Technology Roadmap Credibility: A Communications Theory Assessment of Roadmapping Processes*, "Technological Forecasting & Social Change", Vol. 79, Issue 2, February, p. 263–280.

Lee J.H., Phaal R., Lee S. (2013), *An Integrated Service-device-technology Roadmap for Smart City Development*, "Technological Forecasting & Social Change", Vol. 80, p. 286–306.

Mankins J.C. (1995), *Technology Readiness Levels*, A White Paper, Office of Space Access and Technology NASA.

Martin H., Daim T.U. (2012), *Technology Roadmap Development Process (TRDP) for the Service Sector: A Conceptual Framework*, "Technology in Society", Vol. 34, Issue 1, February, p. 94–105.

Nazarko J., Kędzior Z. (eds.) (2010), *Uwarunkowania rozwoju nanotechnologii w województwie podlaskim. Wyniki analiz STEEPVL i SWOT*, Oficyna Wydawnicza Politechniki Białostockiej, Białystok.

Nazarko J., Ejdys J., Kononiuk A., Gudanowska A. (2012), *Opracowanie marszrut (map) rozwoju nanotechnologii w woj. podlaskim*, materiały projektu „NT FOR Podlaskie 2020". Regionalna strategia rozwoju nanotechnologii, Politechnika Białostocka, Białystok.

Nazarko J., Gudanowska A., Kononiuk A., Glińska E., Glińska U., Ejdys J. (2013), *Kierunki rozwoju nanotechnologii w województwie podlaskim. Mapy. Marszruty. Trendy*, Oficyna Wydawnicza Politechniki Białostockiej, Białystok.

Phaal R., Farrukh C., Probert D. (2011), *Roadmapping for Strategy and Innovation. Aligning Technology and Markets in a Dynamic World*, Centre for Technology Management, Institute for Manufacturing, University of Cambridge, Cambridge.

Saritas O., Aylen J. (2010), *Using Scenarios for Roadmapping: The Case of Clean Production,* "Technological Forecasting and Social Change", Vol. 77 (7), p. 1061–1075.

Transforming our Regional Economy – Action Plan 2006 (2005), December, Cleveland State University, I-Open, The Cerulean Group, Ohio.

Watson R. (2010), *Future Files: A Brief History of the Next 50 Years*, Nicholas Brealey Publishing, reprint edition.

http://www.nowandnext.com/?action=misc&subaction=trend_maps (access: 12.06.2012).