



# Main assumptions of the foresight of surface properties formation leading technologies of engineering materials and biomaterials

**A. Dobrzańska-Danikiewicz\***

Institute of Engineering Processes Automation and Integrated Manufacturing Systems, Silesian University of Technology, ul. Konarskiego 18a, 44-100 Gliwice, Poland

\* Corresponding author: E-mail address: anna.dobrzanska@polsl.pl

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## Manufacturing and processing

### ABSTRACT

**Purpose:** The purpose of this paper is presentation of the main assumptions of the foresight of surface properties formation leading technologies of engineering materials and biomaterials. That foresight called FORSURF is the new research project co-founded by European Regional Development Found. In that paper especially the following issues are considered: the project goals, socioeconomic environment, project methodology and expected final results.

**Design/methodology/approach:** The approach called foresight is the whole activity focused on choosing the best future vision and showing ways of that vision realisation using the right methods. FORSURF is one from the set of technology foresights. Technology foresight is the process concentrating scientists, engineers, industrialists, Government officials and others in order to identify areas of strategic research and the leading technologies, which in long term will contribute to the greatest economic and social benefits and sustain industrial competitiveness.

**Findings:** There are following expected final results of the considered project: information cards of identified leading technologies, scenarios of possible future events and a public debate on the foresight subject matter.

**Research limitations/implications:** The main research implication is identification of strategic research directions crucial in the next 20 years in the field of surface properties formation leading technologies of engineering materials and biomaterials.

**Practical implications:** The main practical implication is identification of priority innovative technologies in the next 20 years in the considered research scope.

**Originality/value:** That paper is the first publication concerning the new research project called FORSURF. Particularly, the main project assumptions are presented.

**Keywords:** Development in the field of materials; Manufacturing and mechanical engineering; Foresight; Surface engineering

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## 1. Introduction

Utility properties of many products and their elements depend on mechanical load moving possibilities of an used material through a whole active element section or material physicochemical properties. However, product utility properties arise also or mainly from surface structure and properties. That is why it is very important to ensure the most profitable properties combination of core and surface layer manufactured element [1,2]. It can be made by a right selection of material element and processes determining its structure and properties as well as right selection of surface layer kind and technology ensuring expected utility properties [3,4]. In that scope a level of the technological news implementation certainly in contemporary enterprises, especially small and medium ones (SME), is not satisfying. The considered problem does not concern only avant-garde technologies realised by top enterprises. First of all, there is an absolute need to increase an average level of technologies realisation by producers' statistic majority [5]. It is very important for quality and stability of product statistic majority on the market and it decides about domestic economy competitiveness. In the light of presented remarks the considered problem has great economic significance. Therefore, the project entitled "Foresight of surface properties formation leading technologies of engineering materials and biomaterials" co-founded by European Regional Development Found makes an effort to meet market needs. The achievement of project goals will facilitate development strategy formulation by many entities acting in more and more competitive and global economy.

## 2. Project goals

The project main goal is to identify priority innovative technologies and strategic research directions which development will be crucial during the next 20 years in the field of surface properties formation leading technologies of engineering materials and biomaterials. The project will be realised with the participation of high-class experts from Poland and foreign countries using the latest foresight methodology achievements. Work realised within the framework of foresight project concerns the following research scopes:

- laser technologies,
- PVD/CVD technologies,
- thermochemical technologies,
- other technologies,
- biomaterials,
- constructional materials,
- tool materials,
- functional materials.

Identification of priority innovative technologies concerning formation methods of surface structure and properties of engineering and biomedical materials will ensure an orientation of an increase in innovativeness of domestic enterprises and will cause balancing economic country development. Determination of strategic research directions in the field of the foresight subject matter will ensure the increase Polish academic research significance in economy. Moreover, it will increase the

competitiveness level of Polish technical researches in the European Union and in the world. Proinnovative orientation of domestic scientific researches and enterprises activity will contribute to broad the participation of innovative products in domestic economy. As a result it can be possible to create many new permanent workplaces connected with building of knowledge-based economy. The realised foresight will be a very important source of diagnose of key scientific, technological, economic and ecological problems. It will be a forecast and decision instrument used by Government officials managing Polish academic research, industrialists and public administrations institutions.

The achievement of project main goal is tantamount to the achievement of common goal. The project common goal is to increase Polish economy innovativeness and competitiveness by closer co-operation between economy and sphere of research and development (R&D). It is the most important to adjust a subject matter of research work to meet current and real production enterprises needs. Moreover, it is necessary to increase domestic enterprises involvement in proinnovative activity. It causes a high absorption level of innovations and financial resources allotted for proinnovative activity in economy.

The achievement of project main goal comes down to achieve the set of intermediate goals. The achievement of each intermediate goal is tantamount to the realisation of a specific task planned within the confines of the considered project. The finishing of each task causes a result being a milestone which moves significantly executors closer to finalise the whole planned works. The project intermediate goals with connected tasks and expected results called milestones coming closer to the realisation of tasks are presented in Table 1. The first project intermediate goal consists in the creation of project executors net as well as creation and initiation of the Internet platform. The Internet platform created within the framework of the project will enable the whole society, interested scientific entities and industrialists:

- to raise in any moment detailed information about project goals, assumptions and executors;
- to follow the current progress of project work;
- to formulate opinions about the project within the confines of social on-line consultations.

The Internet platform will enable to work in any time and any location. It concerns key experts and trade experts which will fill in on-line three iterations of questionnaires according to Delphi method rules as well as executors realising the project. That approach gives equal opportunity on the labour market, because together with teleworking it enables to appoint as a project team members people working at home, e.g.: mothers of babies and the disabled. The platform creators also can use that tool in order to collect fast and effectively information needed for preparation of database about experts. Moreover, the Internet platform will be designed for cyclic sending of electronic newsletters to experts and project participants [6]. The second project intermediate goal is to prepare a report determining current situation in the field of technology development and socioeconomic factors in the scope of the foresight subject matter. The consecutive project work is in accordance with the third intermediate goal. That work boils down to anticipate the preparation of database concerning the experts participating in the project. That should be preceded by following operations: a definition of expert selection criteria,

generating the Internet questionnaire of experts selection and also a final selection of leading, key and trade experts qualified for the participation in the project. The fourth project intermediate goal is the achievement of research results using Delphi method and a preparation of a report including results of three survey iterations. Parallel to basic researches using Delphi method other support researches of lower standing using other recommended foresight methods will run.

The fifth step of the project work concerns the creation of a neuronal network belonging to the set of artificial intelligence methods. The neuronal network will be used in order to determinate cross impacts between trends and events. Organisation of the International Conference is the sixth project intermediate goal. That Conference will be organised in order to

initiate open public debate and social consultations concerning the project realisation and results. Particularly, during the Conference the following activities will take place:

- presentation of research results achieved during the project realisation;
- recognising of opinions about research results formulated by Conference Participants from Poland and from foreign countries;
- propagation and popularisation of research results among Conference Participants representing groups of scientists, industrialists and officials from public administration;
- discussion results of on-line consultations realised using the Internet platform.

Table 1.  
Project tasks, intermediate goals and milestones

No	Project task	Intermediate goal	Milestone
1.	Project kick-off in true and virtual reality	The creation of project executors net as well as creation and initiation of the Internet platform	A detailed range of actions and the Internet platform
2.	Current situation analysis in the field of technology development and socioeconomic factors	Preparation of a report determining current situation in the field of technology development and socioeconomic factors in the scope of the foresight subject matter	Report <i>Current situation analysis</i>
3.	Experts selection	Preparation of database concerning the experts participating in the project	Database about the experts
4.	Research using a heuristic method. Delphi method	Achievement of research results using Delphi method and preparation of a report including results of three survey iterations	Report <i>Delphi method. Research results</i>
5.	Research using an artificial intelligence method. Neuronal networks	Creation of a neuronal network (one from artificial intelligence method) in order to determinate cross impacts between trends and events	The neuronal network
6.	Initiation and animation of open public debate and social consultations	Organisation of the International Conference in order to initiate open public debate and social consultations concerning project realisation and results	The International Conference
7.	Determination of leading technologies and strategic research directions in the scope of the foresight subject matter	Creation of database with information cards for industrialists and three scenarios of possible future events: optimistic, neutral and pessimistic.	Technology information cards Optimistic, neutral and pessimistic future events scenarios
8.	Management, administrative and financial services, flexible adjusting activities to meet environmental conditions as well as effective promotion	Competent project management, project flexibility enabling to adjust carried out activities to meet fast changing environmental conditions and effective project promotion, such as: conferences, workshops and seminars	High quality foresight realised on time with balanced budget

The seventh project step boils down to create database with technology information cards for industrialists and formulation of possible future events scenarios in three versions: optimistic, neutral and pessimistic ones.

The project dominant goal is connected with the realisation of the eighth task carried out during all project time. That task includes: competent project management, project flexibility enable to adjust carried out activities to meet fast changing environmental conditions and effective project promotion, such as: conferences, workshops and seminars. The effects of that activity should be high quality foresight realised on time with the balanced budget.

All presented project goals are compatible with the main goal of Innovative Economy Operational Programme (IE OP) 2007–2013. The main goal of IE OP is Polish economy development in the basis of innovative enterprises. The assumptions and goals of FORSURF project meet Priority Axis 1. Research and development of new technologies, Action 1.1. Scientific research supporting for building knowledge-based economy, Subaction 1.1.1. Research projects using foresight method. The project operations also meet the detailed goals of IE OP. Therefore, the project realisation directly and indirectly will contribute to:

- the increase of enterprise innovativeness;
- the increase of Polish academic research competitiveness and significance in economic development;
- the greater importance of innovative Polish products on international market;
- the create of many new permanent workplaces connected with building of knowledge-based economy and
- greater utilisation of information and communication technologies in Polish economy.

The project realisation will contribute to scientific research orientation at fields and disciplines which can have great influence on fast country economic development and building knowledge-based economy. Another effect of the project finalisation should be rational implementation of research results in industry. Moreover, it will create for the selected research fields and disciplines preferential conditions during the division of financial resources from a state budget.

### 3. Socioeconomic environment

The introduction level of technological news in the field of selection of material element and processes determining its structure and properties as well as selection of surface layer kind and technology ensuring expected utility properties currently is not satisfying. Especially, the level of the news introduction in small and medium enterprises (SME) in Silesia and also in all country is insufficient. Because of it, an absolute need for increase average level of technologies realisation by producers' statistic majority takes place. It is very important for quality and stability of products on the market and it decides about Polish economy competitiveness. Thus, presented issues have great economic significance.

The trade of surface properties formation of engineering materials and biomaterials is one from the most dynamic in all European countries [7]. It requires the continual introduction of technological news into industrial entities working in almost all divisions of industries, such as:

- automotive,
- machine-building and tools,
- mechatronical,
- metallurgical,
- electrical engineering,
- electronics,
- plastics,
- aircraft,
- medical equipment,
- sanitary equipment,
- jewellery,
- precision,
- building and others.



Fig. 1. Gliwice town compared to Silesian Province and its distance to capital cities of European countries

There is the headquarters of project executors in Gliwice situated in Silesian province at the technical university being the biggest one in Silesia and one from the biggest technical universities in Poland. The university entity responsible for the FORSURF project realisation is the Institute of Engineering Materials and Biomaterials belonging to Faculty of Mechanical Engineering of the Silesian University of Technology. The Institute of Engineering Materials and Biomaterials is the biggest in the country scientific-research entity specialised in the field of engineering materials and biomaterials. The Institute owns the large laboratory included several dozen of factual entities. That laboratory has high research potential and unique character both in the country and abroad. About investment attraction of Silesian Province decide the following factors [8]:

- geographical situation (Fig.1),

- large market for the goods,
- large base of raw materials,
- good infrastructure,
- high-skilled labour,
- specific work culture and discipline characterising Silesians,
- labour cheaper than in old Union countries,
- land fittings,
- international airport allocated in Katowice-Pyrzowice,
- broad-gauge railway line in Sławków,
- Katowice Special Economic Zone.

In Silesian Province 12,1 percent of research and development (R&D) domestic potential is allocated. It is second after Mazovia Province domestic research centre. There are 112 different R&D units at the Silesian Province area among other including entities of Polish Academy of Sciences and universities. Moreover, in the Province act near 200 business environment institutions, such as: local and regional development agencies, chambers of economy, trade, commerce and industry, guilds, enterprise support centres, consulting centres and economic information centres. Furthermore, one should point out the increasing numbers of industrial and technological parks as well as technology incubators. It is very important for quality and stability of product statistic majority on the market and it decides about domestic economy competitiveness [9,10].

Mentioning the Silesian Province advantages it should be distinctly emphasised that project results will concern all country. In heuristic researches will participate experts from different regions of Polish country as well as from abroad. It is necessary to pay attention to remove the traditional time and space barriers in FORSURF project. It appears from former creation and initiation of the Internet platform. That computational tool will enable work in any time and any location. It is facilitate experts from other domestic and foreign entities as well as for project team members working at home, e.g.: mothers of babies and the disabled.

## 4. Project methodology

All project work drawing to achieve the project main goal have been divided in eight tasks. Each project task consists in some more detailed subtasks. The project tasks are planned for the realisation during three years by the calendar. The project tasks layout is series-parallel and it has been marked on the Gantt chart in order to the issue visualisation. The end of each project task is tantamount to achieve the compatible project intermediate goal. Moreover, it leads to reach the result called the milestone causing that executors come close in a significant way to the project end. The realisation scheme of FORSURF project taking into consideration, as follows: source data, monitoring spheres, current state, used foresight methods and final results in Fig.2. is presented. It is planned of using the following data from original sources during the project realisation: Central Statistical Office (CSO), patent office, research and development (R&D) entities, Information Processing Centre (IPC), small and medium enterprises (SME). The original data will gather using survey questionnaires, call-interviews, visits and interviews in enterprises and institutions and expert opinions. The activity leaded within the framework of the project will concern to three spheres: R&D, economy and public administration. In the R&D sphere

development strategies, potential analysis, research achievements and education priorities are the most important. In the economy sphere especially innovativeness, production, employment, financial outlays and academic enterprise will consider. In the public administration sphere it is the most important to identify current key problems. Methodology and research tools which will be used in the project are typical for that kind of work. It is planned to utilise well-trying methods recommended as right and justifiable in foresight projects in *National Foresight Programme "Poland 2020"* and in the textbook *Technology Foresight* signed by United Nations Industrial Development Organization and Polish Agency for Enterprise Development. The exception is an innovative and experimental proposition concerning the appellation of one from artificial methods in the cross impacts analysis.

At the project beginning (e.g.: during current situation analysis) the set of specific methods of work, organisation and management, as follows: literature review, source data analysis, key technologies definition, environment scanning, technology mapping, beneficiaries mapping, trends extrapolation, SWOT (Strengths Weaknesses Opportunities Threats) analysis and PEST (Political Economic Social Technological) analysis will be applied.

The most important role between project methods plays Delphi method covering three survey iterations. The survey questionnaires will be filled-in by high-class experts from the country and from abroad. According to Delphi method assumptions consecutive surveys are constructed on the basis of the results of preceded surveys [11]. The detail level of consecutive surveys increases. During the researches the gradual transition from common level of issues included in a first survey iteration, by more detailed questions in second research step to whole process conclusion in third survey iteration takes place [12]. Parallel to basic researches using Delphi method other support researches of lower standing using the recommended methods, such as: expert panels, brainstorming, sketches, benchmarking, multi-criteria analysis, computational simulations and modelling, econometric analyses, statistical methods, e.g.: game theory will run.

The important place in planned researches scenario method using for creation of some alternative scenarios of possible future events takes also. The scenarios construction includes description of events appearing in the considered research field and showing of their logic and chronologic consequences [13]. Macroeconomic factors impacting on planned events development are taken into consideration. That impacting can be positive or negative, so it is connected with opportunities and threats coming from macro-environment [14]. Construction of three alternative versions of possible future events: optimistic, neutral and pessimistic is planned.

The executors during the project realisation also want to apply a modern approach and utilise one from the set of artificial intelligence methods in an inventive way. It is planned to use neuronal networks in order to improve the determination process of cross impacts between trends and events. The cross impact analysis shows relationships between analysed trends and events which can take place in a considered period [15]. That analysis takes into account probability of a given event appearing and an expected way, strength and time of interactions between considered trends and events. That approach is inventive and experimental, because it has never applied before in Poland during foresight projects realisation.

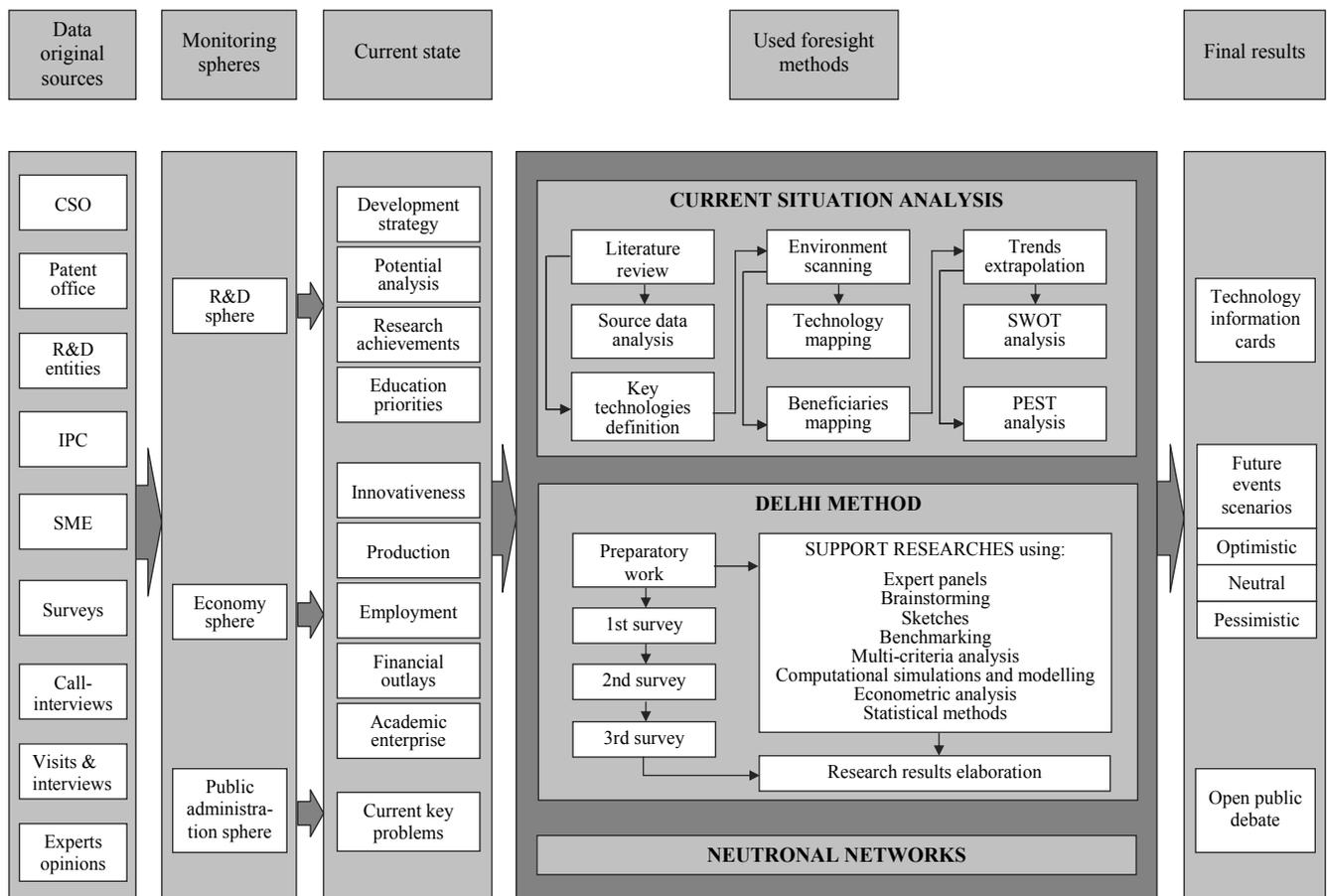


Fig. 2. The realisation scheme of FORSURF project

## 5. Expected final results

The project main goal realisation should lead to achieve the following final results:

- Technology information cards,
- Scenarios of possible future events,
- Open public debate on the foresight subject matter.

Project executors making an effort to meet industrialists' needs want to create the database with information cards for identified leading technologies. Each technology information card should include:

- main technology assumptions,
- information about entities which outworked and/or implemented the given technology,
- key publications on the given theme,
- possibilities of the given technology practical implementation.

The next expected final results of FORSURF project are three alternative scenarios of possible future events: optimistic, neutral and pessimistic ones. The outworked scenarios should concern events appearing in the considered research field and show their logic and chronologic consequences. According to scenario method assumptions macroenvironment impacting on future

events is taken into consideration. Different macroenvironmental factors can impact on future events positive or negative. External positive factors are called opportunities and it is necessary to know how to make the most of those opportunities. External negative factors are called threats and they should be fast identified and taken under control. Outworking of a few scenario versions of possible future events enables right control of the focusing process of research scopes development. Moreover, it helps with adjusting R&D entities and enterprises to fast changes of global environment requirements.

The expected results of FORSURF project finalisation is also open public debate on the foresight subject matter. Domestic and foreign representatives of science, economy, public administration and society are the main groups invited to join the debate. The social on-line consultations concerning the realised foresight results enable better process utilisation and determination of the scenario which the best meet social needs. The project social consultations should create among participants the feeling of involving and cooperation. That situation supports the maximal effectiveness and right decision making as well social acceptance for all activity connected with project goals realisation. Every opinions known during the social on-line consultations will be taken into consideration during project final conclusions formulation. Open public debate initiated and animated in groups

interested in a foresight subject matter should contribute to better cooperation between R&D and economy spheres and facilitate labour flow between them. The utility consequence of that is better competitiveness of Polish economy and science at the background of other European and world countries.

## 6. Conclusions

The trade of surface properties formation is one from the most dynamic economic sector in West Europe. That trade development in the east part of Europe is also forecast to increase. The realisation of FORSURF project concerning the technologies of surface structure and properties formation of products and their elements should contribute significantly to forecasted development. Within the framework of the project the best technological solutions taking into considerations the enterprises competitiveness increasing and improvement of product utility properties, stability and reliability will be founded. The expected practical project results are long-term ones. Identified and probably applied leading technologies and connected with them strategic research directions should be important minimum during the next ten or fifteen years. That is an average period of the amortisation of technological equipment in manufacturing sectors using those technologies. The group of small and medium enterprises plays an important role on the market of producers applying surface properties formation technologies. Generally, SMEs have not considerable financial outlays allotted for development. It forces necessity of their activity directions determination. That should increase the competitiveness level of Polish economy in European Union and in the world. The project results will create good conditions for making objective decisions concerning innovativeness development and researches financing. The additional effect will be knowledge propagation in scientific and industrial group of people interested in the foresight subject matter and activation of open public debate on the considered theme.

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**INNOVATIVE ECONOMY**  
NATIONAL COHESION STRATEGY

**EUROPEAN UNION**  
**EUROPEAN REGIONAL**  
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