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A MODEL OF TRANSDISCIPLINARY PRODUCT DEVELOPMENT IN AUTOMOTIVE INDUSTRY

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1. Introduction

The aim of the article is to present a concept or model of an effective product development in the automotive industry based on the transdisciplinary approach. In product development, companies generally use the approach of concurrent engineering which is mainly focused on engineering process only. The classical interdisciplinary approach to work under which experts from different research disciplines aim at a common project goal, has also become insufficient. As a matter of fact, it occurs too often that experiences, intuition and external stakeholders are neglected. The transdisciplinary approach is, however, a combination of (inter)disciplinary and undisciplinary approaches and based on the principle of concurrence allows a significantly better interaction between science, development entities and technologists on one hand, and other environment on the other hand.
Furthermore, our intention is to identify possible correlation between level of emotional intelligence and intuitive decision-making among top and middle-level managers in automotive industry, and to present the use of business intelligence at the management of the company in automotive industry. An important co-creative part of the model of transdisciplinary product development in the automotive industry consists of a modern information environment which is consistent with the company's strategic goals.

2. Transdisciplinarity

Interdisciplinarity is a type of collaboration in which specialists drawn from different research disciplines work together in pursuit of common goals. This type of collaboration boasts numerous benefits, however there are some restrictions. The key restriction is that the team members usually follow the project goal while they fail to deal with how this goal or the result affects other stakeholders in the process or the wider society. We are aware of cases of excellent development groups who nevertheless have difficulties acquiring financial resources, communicating, managing or marketing their development outcome. In our company, we try to avoid these difficulties as much as possible; therefore we are searching for new approaches conveying most effectively the development solutions to users or customers.
Unlike the interdisciplinarity, the transdisciplinarity is a less recognized category involving progress of concepts which cannot be comprehended in terms of any individual discipline and needs a simultaneous combination of knowledge related to several disciplines. Transdisciplinary approach is a combination of (inter)disciplinary and (un)disciplinary sphere allowing interaction between science or researchers and wider society. In addition to »hard« disciplinary knowledge, the approach also involves the so-called »soft« knowledge, information and know-how existing in a company [Nicolescu

2008]. Figure 1 symbolically shows disciplinarity, multidsciplinarity, interdisciplinarity and trans-disciplinarity.

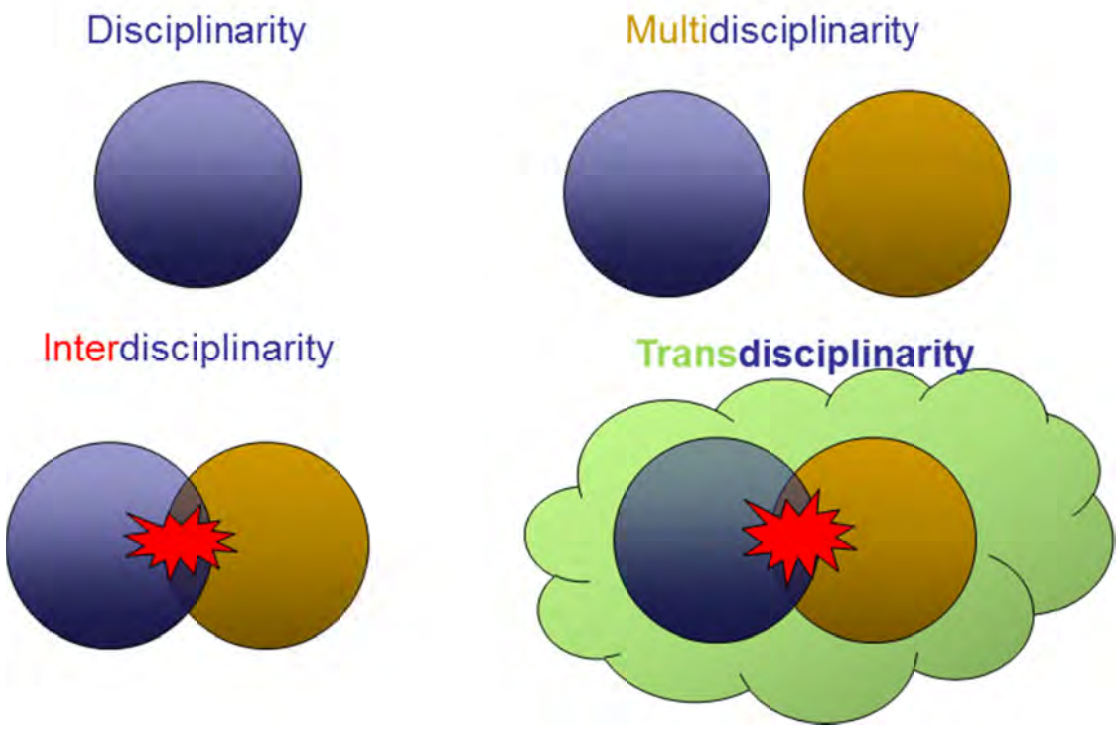

Figure 1. Disciplinarity, multidisciplinarity, interdisciplinarity and transdisciplinarity

3. Concurrent Engineering

Concurrent Engineering (CE) is a systematic approach to integrated product development that emphasizes the response to customer expectations. It embodies team values of co-operation, trust and sharing in such a manner that decision making is by consensus, involving all perspectives in parallel, from the beginning of the product life cycle [Ashley 1995].

Concurrent Engineering is a systematic approach to the integrated, concurrent design of products and their related processes, including, manufacturing and support. This approach is intended to cause the developers from the very outset to consider all elements of the product life cycle, from conception to disposal, including cost, schedule, quality and user requirements [Pennell and Winner 1989].

In order to define development activities within the industry, we can summarize that concurrent engineering is a simultaneous performance of sequential development task. Concurrent engineering is a philosophy, a concept, a way of thinking, a way of organizing work whose basic characteristics are as follows [Mihelič 2012]:

- concurrent/parallel performance of activities,
- multidisciplinary team approach, common goal of all participants,
- project organisation and
- early sharing of information.

Concurrent engineering is a thorough, comprehensive and sustainable approach to product development taking into consideration the lifetime use of product already at the stage of its design. It is directed to the user; it reduces time to market and is based on application of advanced development methods and a strong joint information and communication platform.

Figure 2 symbolically shows the concept of concurrent engineering while Figure 3 shows key stages in product development according to the system of concurrent engineering.

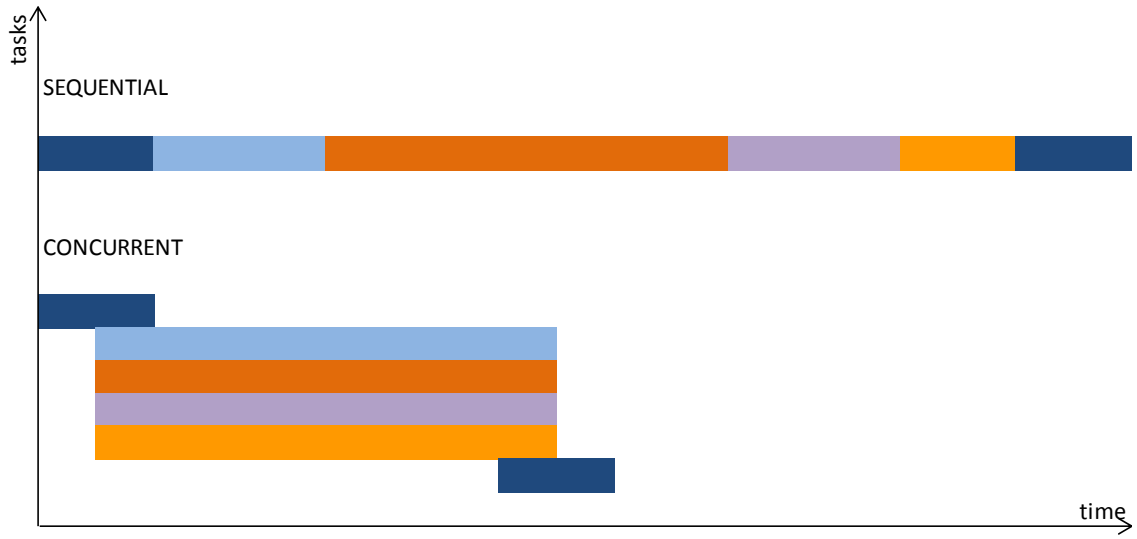

Figure 2. Concept of concurrent engineering

4. Intuitive decision-making

A high level of dynamics in automotive industry requires a high level of skills from its managers to deal with the surprising and unexpected new challenges. According to the testimony of scientific evidence through the use of intuition and in time limited resources, decision-making can improve the time needed to solve them, as well as improve the quality of decisions. The main purpose of the study was to identify possible correlation between level of emotional intelligence and intuitive decision-making among top and middle-level managers in automotive industry.

Intuition is a process of thinking. The input to this process is mostly provided by knowledge stored in long-term memory that has been primarily acquired via associative learning. The input is processed automatically and without conscious awareness. The output of the process is a feeling that can serve as a basis for judgments and decisions. People are often able of direct understanding of truth-the essence of which in times can be quite not obvious or hidden, and may even be contrary to common sense. Occasionally, we are able to withdraw from their own frame of knowledge, facts, logical thinking, and existing thought patterns and solve the problem just like that, on the basis of something for which we know that we have and we do not know how and when we gain. In these cases, it is an area of intuitive thinking and decision-making. Intuition is known to a lot of people. Despite the fact that they rarely contemplate about it is nevertheless consciously or unconsciously often used. Gladwell argues that the ability to read fragments of data is not a special gift, which only a few have, but the main function of the human brain. Intuition is not used until we realize we need to quickly resolve a problem or find ourselves in unfamiliar circumstances [Betsch 2008]. He said that fragments of the data are used in intuition, because we have to and we also rely on them even though we focus on them only for a second or two. Intuition cannot be inferred by an algorithm by which we come to certain conclusions. Our starting point is the unconscious level, where information is not accessible to consciousness. Intuition is related to the human subconscious mental processes and includes all previous experience to support our findings. The most important role in the process of solving problems which managers face is both rationality and reasonableness-causality. Namely, solving problematic situations in this manner is polished, already used and can therefore be augmented, have its own facts, its limitations and its logical conclusions, which may, if necessary, be controlled. But rationality alone does not necessarily mean the best solution for many problems, especially not for complex-multi-faceted problems which do not completely clear the input data and the solutions require resources (for example, sufficient time). In this case, the manager meets a completely new situation which he has never experienced in his career. The situation can be compared to a computer, which is programmed to solve certain types of problems. But when a problem occurs, for which the program does not exist yet, the problem is at the moment for a specific computer unsolvable. In these situations, which are in

times of insecurity increasingly more visible, intuitive decision-making is increasingly gaining in importance.
The results of the study partly supported the hypothesis, which says that the statistically significant correlation between level of emotional intelligence and intuitive decision-making among top and middle-level managers in automotive industry exist [Erenda 2013].

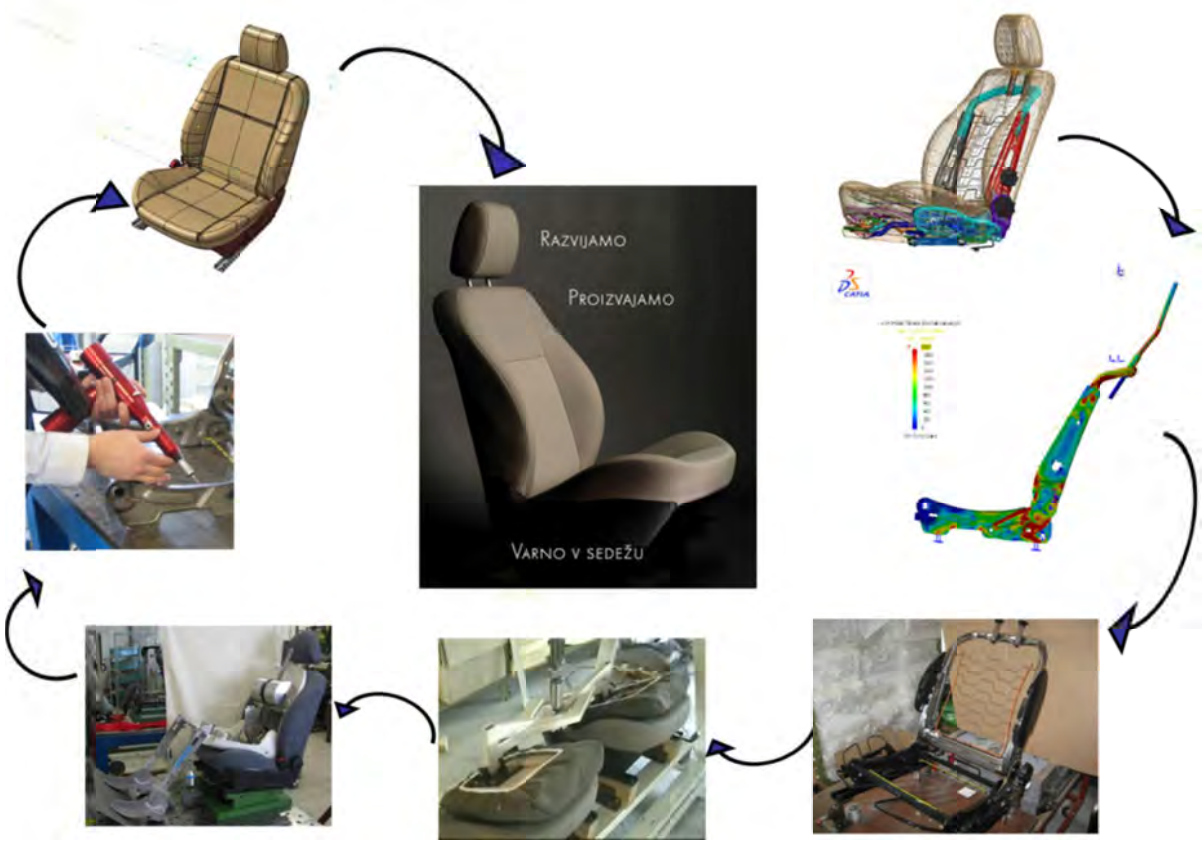

Figure 3. Design and development stages according to the system of concurrent engineering

5. Use of business intelligence in corporate management

In today's fast changing environment, corporations with higher awareness of their operations and environmental involvement are privileged. They gain competitive advantage after having used this awareness to make good decisions. Systems of business intelligence (BI) enable them to develop knowledge by means of data gathering and provide for the shortest time interval possible between the data and the information or in other words for an almost immediate response [Makovec 2013].
Decision-making process takes place continuously. Decisions are made about strategies, action plans, budget and corrective actions in case the factual situation for different reasons deviates from the desired results. Today, processes are complex and relying on intuition is no longer enough. We need information about process flow here and now. However, to get a perfect picture, information needs to be completed with information from the environment.
Since Henry Ford's famous statement in 1909 that customers could have any colour the Ford Model T as long as it was black, a lot has changed in the automotive industry. Today, almost every manufactured car is unique. Customers are offered various engine, exterior, interior and colour options. This diversity, however, is reflected in a demand for a quick response in the supply chain and a need for excellent planning. On the other hand, the price pressure requires lean operations and minimum stocks. In terms of information, all this implies a lot of data which need to be monitored and controlled. A well-known management principle says that what we are not able measure, cannot be managed. The same holds true saying that we are not able to manage what is not supervised. Some studies shows, that only about 20% of the collected data is used by about 20% of decision-makers.

Why so little?! The first reason is that data are difficult to access, and the second is that it takes too much time to create new extracts, reports and summaries for decision makers [Makovec 2013].

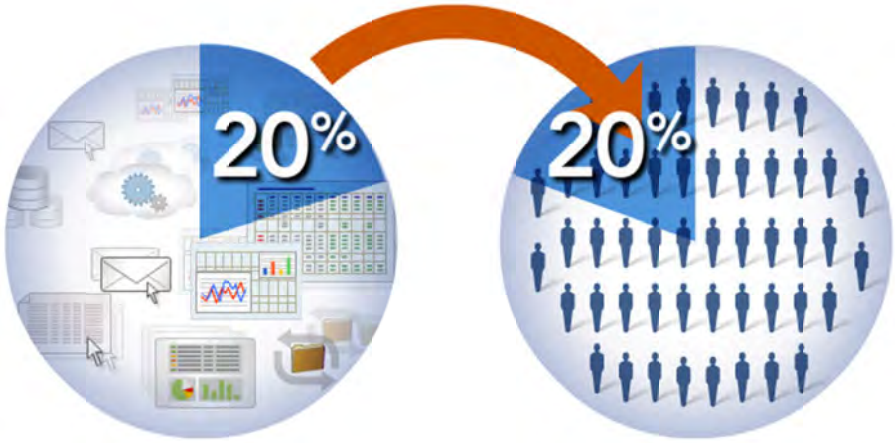

Figure 4. Proportion of data used as information

BI is defined as a capability to understand mutual relations in a way to be able to conduct activities towards attainment of objectives [Luhn 1958]. BI can also be seen as a concept and methods for improvement of corporate decision-making process by using a support system based on data [Power 2007]. Today, definitions of BI are currently being amended and modified in accordance with development of BI tools. One of the latest definitions [Jaklič 2013] says that BI is a corporation's ability to reason, plan, forecast, solve problems, think abstractly, comprehend, innovate and learn in a way to increase organisational knowledge, provide information for decision-making processes, enable effective and efficient activities and help determine and meet the business objectives.
BI can also be seen as a transfer of data into information and delivery of information to the right people at the right time. Nevertheless, we should consider BI is not a mere methodology but a set of processes, technologies and tools.
Reasons for application of BI in companies are varied:

- The information obtained contribute to better decision-making;
- The information is fast, therefore we can make decisions and implement actions on time;
- Data integration from different sources including data from transaction systems, different data bases, files of various formats and web data.

6. Business value of Information Technology in the environment of transdisciplinary product development

In a competitive corporate environment, effective corporate management comprehends their information environment as a strategic tool for creation of new business models and competitive advantages in the market. Company's business strategy is becoming increasingly connected with development strategy of the information environment and the latter mainly focuses on development of their strategic capacities to support the implementation of company's strategic objectives [Smith et al. 2007]. New business models [Kovačič and Bosilj-Vukšič 2005] intended to increase the added value determine the operations, relationships and progress of implementation of individual business actions. Moreover, they provide answers to key questions related to corporate sustainability and therefore determine the strategic reference lines, process model, and organization, structure of knowledge and conduct of business rules, roles and responsibilities and spatial dimensions of the company's operations.
Searching for levers enabling the information technology to impact directly or indirectly the growth and progress of the company is one of the current and first-rate joint missions of the business management and the IT manager. The future of the company and the business value of the IT depend to a large extent on efficiency of this strategic reflection and cooperation. Progress and deployment of

modern approaches and tools in the area of product development in automotive industry (ERP – Enterprise Resource Planning, PLM – Product Lifecycle Management, SCM – Supply Chain Management, CRM – Customer Relationship Management, ECM – Enterprise Content Management, BI – Business Intelligence, SOA – Service Oriented Architecture) enable the company (providing the IT development strategy is in compliance with the company strategy) to operate more effectively and more sustainably and to increase their competitiveness. Therefore, the real power and sustainability of the IT's business value lies mostly in [Cerovšek 2012]:

- moderate use of information technology (compliance of IT objectives with the company's objectives),
- business process management (extended view on renewal and informatization of operations),
- involvement and progress of informed and motivated employees.

In the process of transdiciplinary product development the information technology upgrades its technological value with business value which is becoming an essential element in orientation of its function. It provides [Groznik et al. 2005] measurable (tangible) and non-measurable (intangible) benefits for the company. The latter ones are getting more and more importance, yet they are often neglected (see Table 1).

Table 1. Measurable and non-measurable benefits for the company

MEASURABLE BENEFITS	NON-MEASURABLE BENEFITS
• Higher productivity. • Lower operating costs. • Change in personnel structure. • Higher added value. • Lower sales costs. • Lower administration costs. • Reduction in growth of expenses. • Lower costs of work equipment.	• Higher customer's satisfaction. • Increased flexibility of operations. • Better quality of information. • Improved control of sources. • Improved planning process. • More favourable consideration of employees. • Improved portfolio management. • Better corporate presentation of company.

Strategic management of information environment has through the management of process of product development an important impact on the company's effectiveness and efficiency. The word is about management of modern information technology according to the principles of business environment and on the correct understanding and application of approaches related to management of business processes.

7. Transdisciplinary model of product development

Proposed transdisciplinary model of product development in the industry is based on three main parts:

- Design and Development,
- Production, and
- Management.

Design and development of a new product is based on the principles of concurrent engineering. This process consists of two phases:

1. Phase of new product design, and
2. Phase of product development.

The phase of new product design is coordinated by key account managers from the commercial division. Activities are organised according to the team work, where experts from different areas are involved:

- Design of a product:
  - Definition of design, virtual analysis.
- Design of a production process:

    - Definition of technology.
- Logistics:
    - Draft planning of logistics in plant(s), logistics between plants, and transportation to the customers.
- Purchasing:
    - Draft planning of materials, of equipment, tools, machines, and buildings.
- Quality:
    - Failure Mode and Effects Analysis (FMEA).
- Economics:
    - Pricing.

In the phase of new product design team members contribute knowledge and expertise from different areas or disciplines, like: mechanical and electro engineering, materials, logistics quality management and economics. Besides knowledge from so-called "hard" sciences also knowledge from the "soft" disciplines is necessary, like communications skills, psychology and global understanding of the trends and market. The result of that part is an offer for the customer. There is an important milestone of the whole process, where a decision about the further development should be made. Decision making is a complex process, which is based on existing knowledge and relevant information. However, the decision making is very often supported by emotional intelligence and intuitive decision making.

The phase of product development is coordinated by project managers from the project office. Activities are organised according to the project work, where experts from different areas are involved:

- Development of a product:
    - Analysis, testing, prototyping, standardization.
- Development of a production process:
    - Design of machines and tools.
- Logistics:
    - Detailed planning of logistics in plant(s), between plants, transportation to the customers.
- Purchasing:
    - Detailed planning of materials, equipment, tools, machines, and buildings.
- Quality:
    - Detailed planning using methods like
        - FMEA,
        - Advanced product quality planning (APQP),
        - Sorting, Straightening or Setting in Order to Flow or Streamlining, Shining, Standardize, and Sustain (5S), and
        - Statistical Process Control (SPC).
    - Industrialization: constructions, installations, equipment.

In the phase of product development project members contribute knowledge and expertise from different disciplines. Project team must follow the project goals, so we can talk about the interdisciplinary approach. However, the project manager should be aware about the broader, strategic goals of the company, about the changes in the environment and be able to react to different risks. That is why we can also talk about the interdisciplinary approach. One of the most important pre-condition for the successful project is an appropriate level of communication in the project team, and communication of project manager with the top management and with other project managers in the company. Project manager as the representative of the middle-level management is very often confronted with the decision making. Sometimes he/she has enough information for relevant decision, but it happens very often that he/she must make a decision with insufficient information in a fuzzy environment. It that cases experienced project manager comprises emotional intelligence and intuitive decision-making

Decision making at the top-level as well as at the middle-level management is much more relevant and less frustrating, if these is available appropriate information technology and IT solutions (see also Figure 5).

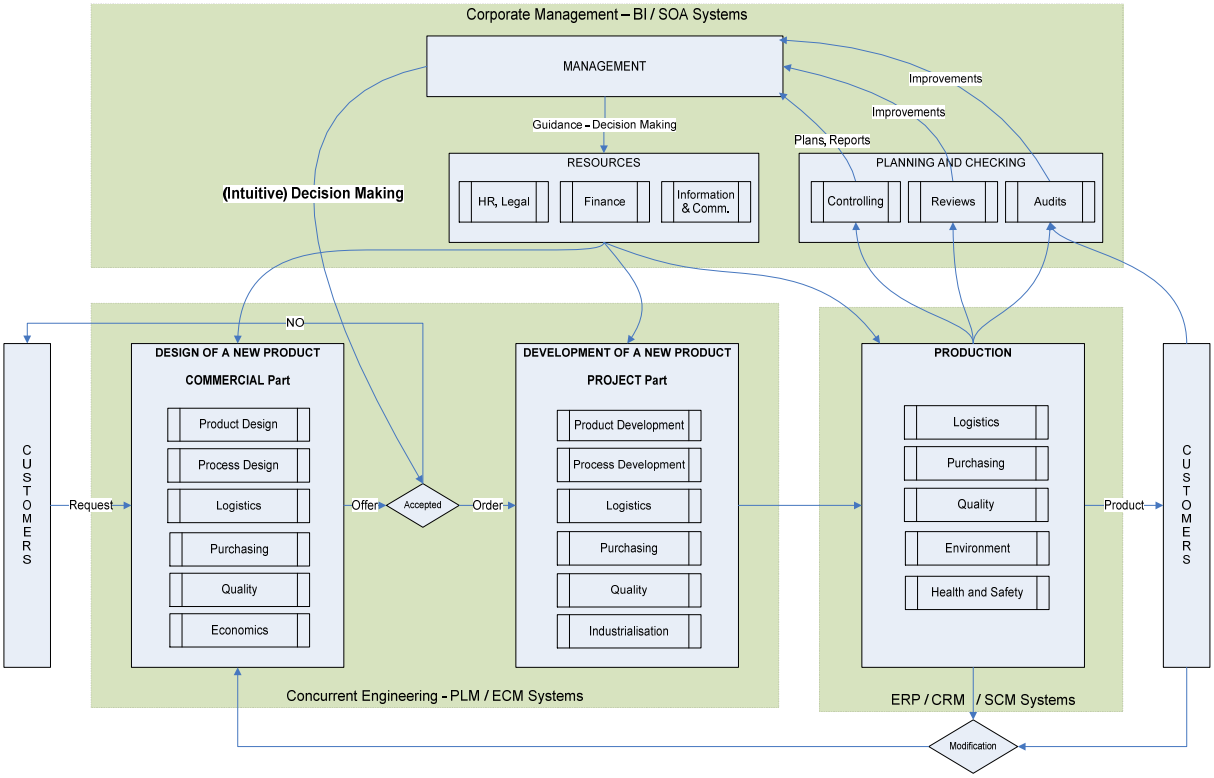

Figure 5. Schematic presentation of transdisciplinary model

8. Conclusion

Business environment surrounding the automotive industry is extremely dynamic. Many times, some unpredicted circumstances might occur and data might be incomplete or even false. In such critical situations, all available know-how and information need to be used in a very short time and people have to be able to communicate properly within the company, as well as with external stakeholders, e.g. customers, suppliers, partners and wider society. In such a situation, all disciplinary knowledge and set goals have to be overcome. In such a case we talk about a new, the so called transdisciplinary approach.

Transdisciplinary model represents a significant leap in thinking while developing products in automotive industry. The traditional engineering knowledge based on interdisciplinary concept is supplemented with new »soft« know-how allowing a faster penetration of technical solutions to the end customer. The new model of efficient development represents a basis not only for automotive but also for other industries with the purpose of implementing a new development concept in their processes customizing their infrastructure and organization. The use of transdisciplinary model in the product development will not only reach the limits but will also exceed them.

Product development in traditional production companies usually belongs to development departments which are due to their specificity often isolated from other processes in the company. In automotive industry, the product development usually starts with customer's demand to develop a certain car component. This demand involves geometric and functional requirements, estimated volumes and expected price. Time of offer preparation including all aspects of product and process development as well as overall costs is extremely short and there is usually no possibility to review. This is the reason why the product development cannot lie within exclusive competence of development departments and all stakeholders contributing to a successful realisation of the offer have to get involved in the early stage of development projects, i.e. commercial, product design and development, process design

and development, purchasing, production, logistics, information and communications technology, environmental section and last but not least human resources and finance. The process of product realisation gathers experts from different areas or professional disciplines sharing a common goal which is why we talk about interdisciplinary teams. Product development in automotive industry is performed on the basis of concurrent engineering determined as a simultaneous planning and deployment of all processes and information which are necessary for product manufacturing, its sales, distribution and after-sales.

The innovativeness of the presented model lies in the upgrading of the concurrent engineering with »soft« and non-disciplinary contents, such as intuitive decision making. The model could be easily upgraded to involve product optimisation in terms of its functionality, technological applicability and price adequacy, as well as business intelligence, enterprise contents management, and communication channels module.

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References

Ashley, S., "Cutting costs and time with DFMA, Mechanical Engineering", March 1995, 1995., pp. 74-77

Betsch, T., "The nature of intuition and its neglect in research on judgment and decision making", In H. Plessner, H., Betsch, C., Betsch, T. (Eds.), "Intuition in judgement and decision making." Mahwah, NJ: Lawrence Erlbaum Associates Inc., 2008., (pp. 3–22)

Cerovšek, M., "Vzvodi informatike za rast in razvoj organizacije" (IT levers for organization growth and development), Organizacija, 45(1), A27-A35, 2012.

Erenda, I., "Correlation between emotional intelligence and intuitive decision-making style among top and middle-level managers in Slovenian automotive industry", Journal of Business Economy, STED Conference, Banja Luka, September, 2013., pp. 48 – 54

Groznik, A., Štemberger, I. M., Kovačič, A., "Vloga menedžmenta pri zagotavljanju poslovne vrednosti informatike" (The role of management in achieving business value), Uporabna informatika, 13(4), 2005., pp. 213-222

Jaklič, J., Slides from the lectures "Business Intelligence Technology", Faculty of Economics Ljubljana University, Ljublana, 2009.

Kovačič, A., Bosilj-Vukšič, V., "Management poslovnih procesov: prenova in informatizacija poslovanja s praktičnimi primeri" (Business Process Management: modernization and computerization of operations with practical examples), Ljubljana: GV Založba, 2005.

Luhn, H. P., "A Business Intelligence System", IBM Journal of Research and Development, vol.2, no.4, 1958., pp. 314-319

Makovec, I., "Od podatkov do informacij v primeru proizvodnega podjetja avtomobilske industrije" (From the data to information in a manufacturing company in automotive industry), Industrijski forum IRT 2013, Portorož, 10.-12. June, 2013.

Mihelič, P., Slides from the lectures "Concurrent Engineering", Faculty for industrial engineering Novo mesto, Novo mesto, 2012.

Nicolescu B., "Transdisciplinarity – Theory and Practice (Ed.)", Hampton Press, Cresskill, NJ, USA, 2008.

Pennell, J. P., Winner, R. I., "Concurrent engineering: practices and prospects, Global Telecommunications Conference and Exhibition Communications Technology for the 1990s and Beyond (GLOBECOM)", 1989. IEEE, vol., no., vol.1, 27-30 Nov, 1989., pp. 647,655

Power, D. J., "A Brief History of Decision Support Systems", http://dssresources.com/history/dsshistory.html.

Smith, H. A., McKeen, J. D., Singh, S., "Developing InformationTechnology Strategy for Business Value", Journal of InformationTechnology Management, 18(1), 2007., pp. 51-60

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