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A STUDENTS' PROJECT - DESIGNING OF A LUGGAGE SPACE FOR ESTATE CAR USING A MAP OF ENGINEERING DESIGN SCIENCE KNOWLEDGE

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Keywords: Design Engineering, Engineering Design Process, Methodology, Design Science

Abstract

The paper will introduce a team students' project carried out for and evaluated by an industrial partner. The team consisting of the four students - engineering designers from the Department of Machine Design, and of the one student - industrial designer from the Institute of Art and Design at the University of West Bohemia in Pilsen, Czech Republic performed the project using an enhanced theory and methodology developed on the basis of a "map" of Engineering Design Science knowledge, which seems to be very promising for achieving efficient and effective cooperation even for interdisciplinary teams.

1. Introduction

The purpose of this paper is to provide you through the project which was worked out by engineering and industrial designers within product development and their different perspectives on the technical product that is to be developed. The following sections try to introduce a possible way of developing efficient and effective cooperation between these two professions depicted on example of this project.

This approach has been developed for and during the education design projects which took place at the Department of Machine Design, UWB, Pilsen, where the students were working in multiple teams consisting of both engineering and industrial designers.

This approach has been also validated during education design projects carried out for and evaluated by industrial partners. This projects have been carried out at the Department of Machine Design, University of West Bohemia in Pilsen over the last few years. Students were working in several multiple "competing" teams consisting of both engineering and industrial design students.

2. Procedure

The methodology that we present that is used in this project stems from the engineering design methodology of [Hubka&Eder 1996] based on the theories of technical systems and design processes. This fact makes this methodology different from other methodologies in the sense that it can be used as a "map" of knowledge and not only as "rigid procedural commands" as are often used.

2.1 Clarifying and Elaborating the Assigned Task – Integrated engineering and industrial Product Design Specification

As usual this introductory phase [Hubka&Eder 1996] of the project started with a critical recognition of the assigned problem. Search for State of the Art is mostly focused on collecting information both about the company's existing product and about competitive products (Figure 1), however corresponding standards, patents, etc. are also investigated.

Figure 1. Company's own existing product and competitive products

A rough examination of the possibilities of realization (feasibility study) is then performed. The resulting stated, generally implied and/or obligatory requirements [CSN EN ISO 9000] of the designed product are completed, classified and quantified in the following step. These should optimally be expressed in the form of the requested and/or maybe not requested values and/or limit values (expressed numerically and/or textually) of property characteristics and/or behavioural characteristics. The "EDS knowledge map" enables a systematic and transparent arrangement of all requirements in relationship to the processes and operators of the life cycle phases of a technical product/system ($TS_{(s)}$) in the form of a series of Transformation Systems (TrfS)

The resulting product design specification document is called the List of Requirements. This document generally consists of written formulations of the requirements of the designed product including the textual requirements of its visual appearance (Figure 2 left). In the integrated concept presented here the industrial design students are asked to visualize/predict their correspondingly clearer image of the product's industrial design (appearance). These first industrial design studies (aesthetic, ergonomic and so forth) (Figure 2 right) became graphic enclosures/extensions of the textual part of the List of Requirements. This helped both engineering and industrial design students to better develop a mutual communication platform and to hold a common course in the subsequent design phases.

Using the Integrated List of Requirements our team evaluated corresponding (values of characteristics of) properties and behaviours of the "Existing Company Product" and evaluated its current (engineering & industrial) design competitiveness by comparing it with three "competitive product" (using the weighted point method). Based on these evaluations a simplified SWOT analysis was performed, and decisions about strategic (engineering & industrial design) priorities and possible risks for the design project are specified.

A SW programme in MS Excel we used to support these specifications and evaluations (Figure 3 - Part 1) including on-line graphs for simplification of the mentioned decisions (Figure 3 - Part 2).

Based on these analyses and the recommended standard/outlined procedural path in the "EDS knowledge map" [Eder&Hosnedl 2007] then we established a rough schedule for their integrated engineering & industrial design work for the project as a whole.

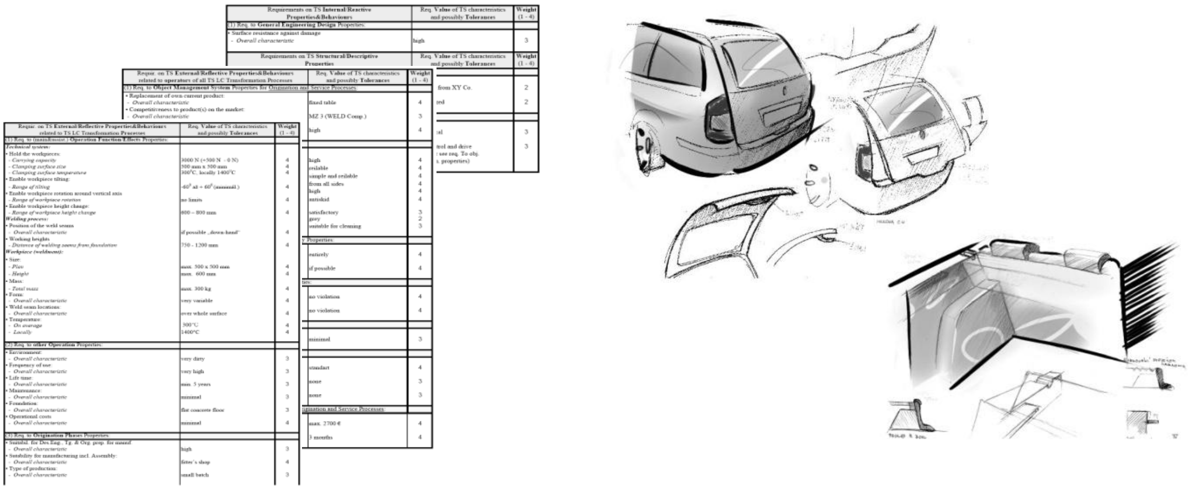


Figure 2. Integrated List of Requirements with textual and graphical parts

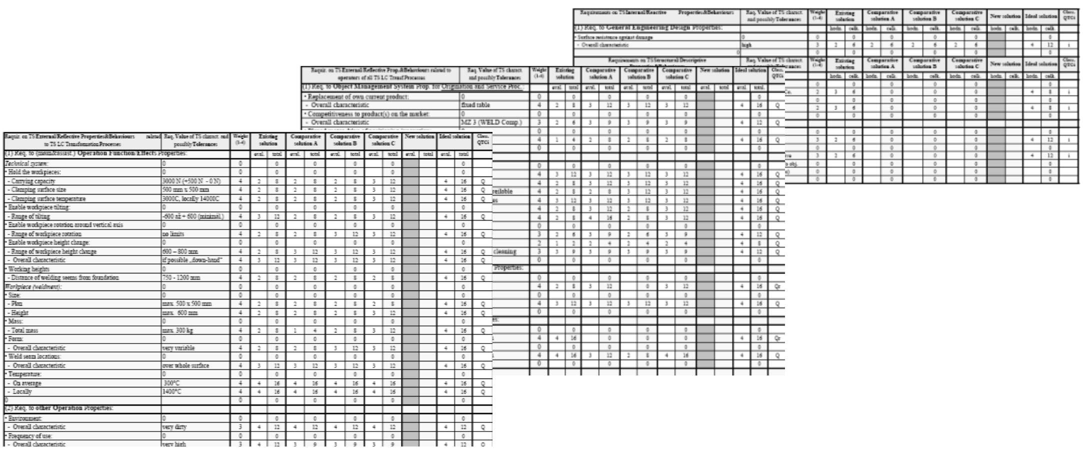


Figure 3 – Part 1. MS Excel SW support of the Product Design Specification and corresponding evaluation of the Existing Company Product, and its Competitive Product(s)

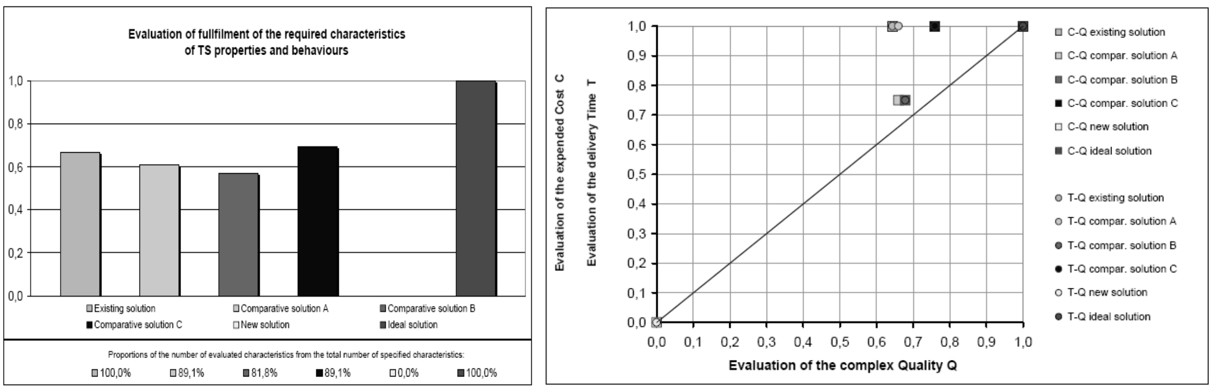


Figure 3 – Part 2. MS Excel SW representation of evaluation of the Existing Company Product for the established Product Design Specification (left), and its (engineering&industrial) design competitiveness with the competitive product(s) (right)

2.2 Establishment of the Function Structure and corresponding Industrial Design

Design and analyses of the Operation Process of a designed product helped us to establish the optimal transformation functions needed to perform the designed operations transforming the operand from its input state to the required output state according to the established technology. The optimal Function Structure of the designed technical product, which provides the Operation Process with the established transformation effects (achieved from the established active and/or reactive M, E and I inputs to the operator - technical product) for the main and assisting inputs to the transformation process, is then designed (Figure 4).

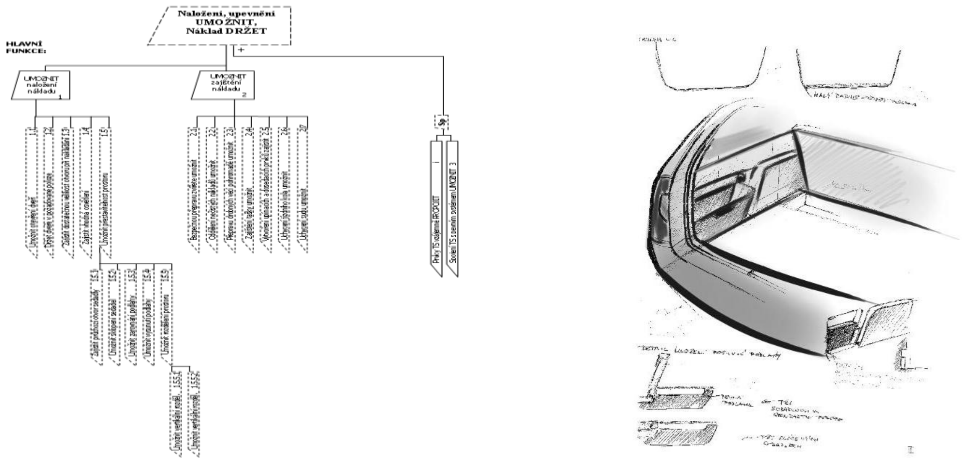


Figure 4. Function Structure with its derived/predicted appearance

2.3 Establishment of the Organ Structure and corresponding Industrial Design

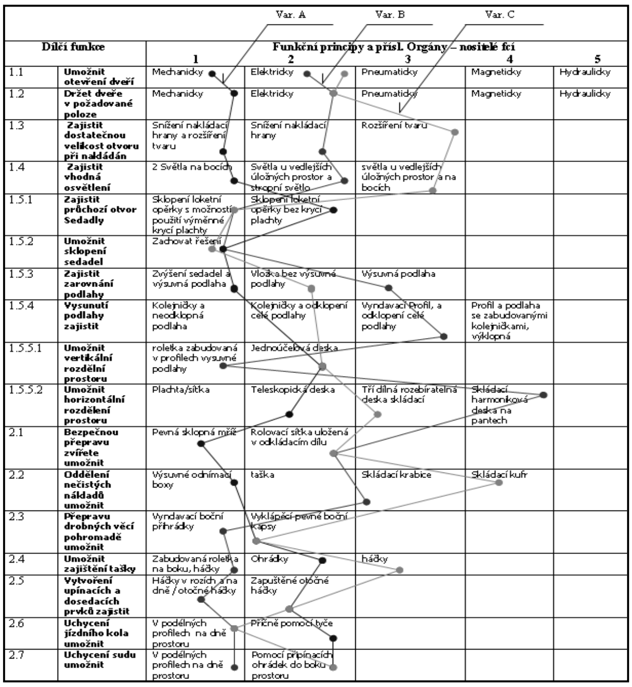
The Organ Structure as a concretization of the Function Structure of a product, but it is still an abstract model of the designed technical product. It consists of organs (the carriers of functions) that realize certain modes of action (as the aim), and the relationships between those means [Hubka&Eder 1988].

A technical equivalent of the example above is shown in Figure 5. Organ structures of the designed product are mostly designed in several alternatives and their variants using the morphological matrix. It enables simple combinations of different organs which were established for fulfilling the respective functions from the established Function Structure. An optimal alternative/variant is then usually selected based on the weighted point evaluation according to the criteria selected from the Product Design Specification. Now, the predicted industrial design of the respective alternatives/variants can be used as one of the evaluation criteria for choosing the optimal variant. Until now this has not been possible in this phase when using only a usual concept without integrating industrial designers.

2.4 Establishment of the Component Structure - Engineering and Industrial Design

In the final two design phases the engineering and industrial design of the rough component structure (preliminary layout) and final component structure (dimensional layout) of the designed product (Figure 7) for the selected optimal variant of the organ structure are established.

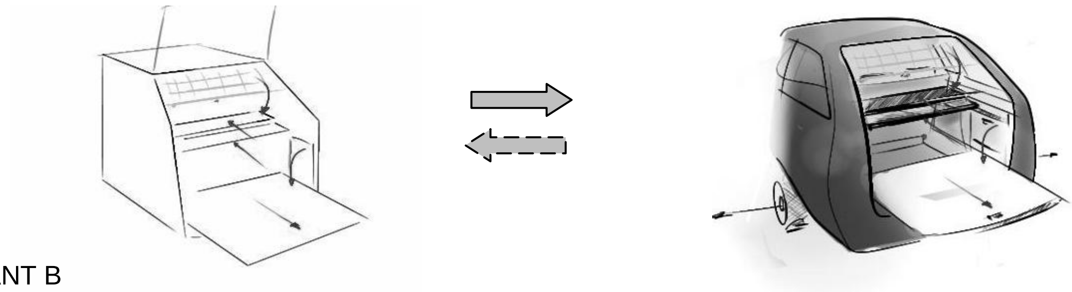
Now using the Integrated List of Requirements evaluated the achieved/predicted (values of characteristics of) properties and behaviours of the “Newly Designed Company Product”, and evaluated its current (engineering & industrial) design competitiveness by comparing it to three ”competitive product” (using the weighted point method). The SW programme in MS Excel mentioned above also supported these evaluations (Figure 8 - Part 1) including on-line graphs for visualisation of the comparisons (Figure 8 - Part 2).



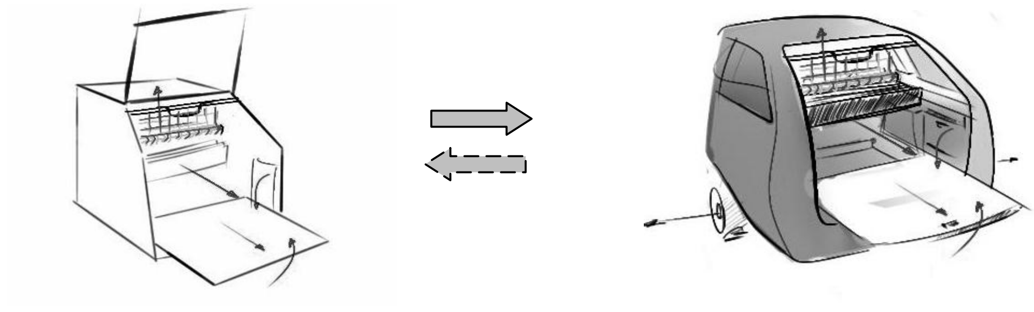
		Var. A	Var. B	Var. C	
Dílčí funkce		Funkční principy a přísl. Orgány – nositelé fci			
		1	2	3	4	5
1.1	**Umožnit otevření dveří**	Mechanicky	Elektricky	Pneumaticky	Magneticky	Hydraulicky
1.2	**Držet dveře v požadované poloze**	Mechanicky	Elektricky	Pneumaticky	Magneticky	Hydraulicky
1.3	**Zajistit dostatečnou velikost otvoru při nakládán**	Snížení nakládací hrany a rozšíření tvaru	Snížení nakládací hrany	Rozšíření tvaru		
1.4	**Zajistit vhodná osvětlení**	2 Světla na bocích	Světla u vedlejších úložných prostor a stropní světlo	světla u vedlejších úložných prostor a na bocích		
1.5.1	**Zajistit průchozí otvor Sedadly**	Sklopení loketní opěrky s možností použití výměnné krycí plachty	Sklopení loketní opěrky bez krycí plachty			
1.5.2	**Umožnit sklopení sedadel**	Zachovat řešení				
1.5.3	**Zajistit zarovnání podlahy**	Zvýšení sedadel a výsuvná podlaha	Vložka bez výsuvné podlahy	Výsuvná podlaha		
1.5.4	**Vysunutí podlahy zajistit**	Kolejničky a neodklopná podlaha	Kolejničky a odklopení celé podlahy	Vyndavací Profil, a odklopení celé podlahy	Profil a podlaha se zabudovanými kolejničkami, výklopná	
1.5.5.1	**Umožnit vertikální rozdělní prostoru**	roletka zabudovaná v profilech vysuvné podlahy	Jednoúčelová deska			
1.5.5.2	**Umožnit horizontální rozdělení prostoru**	Plachta/sítka	Teleskopická deska	Tří dílná rozebíratelná deska skládací	Skládací harmoniková deska na pantech	
2.1	**Bezpečnou přepravu zvířete umožnit**	Pevná sklopná mříž	Rolovací sítka uložená v odkládacím dílu			
2.2	**Oddělení nečistých nákladů umožnit**	Výsuvné odnímací boxy	taška	Skládací krabice	Skládací kufr	
2.3	**Přepravu drobných věcí pohromadě umožnit**	Vyndavací boční přihrádky	Vyklápěcí pevné boční kapsy			
2.4	**Umožnit zajištění tašky**	Zabudovaná roletka na boku, háčky	Ohrádky	háčky		
2.5	**Vytvoření upínacích a dosedacích prvků zajistit**	Háčky v rozích a na dně / otočné háčky	Zapuštěné otočné háčky			
2.6	**Uchycení jízdního kola umožnit**	V podélných profilech na dně prostoru	Příčně pomocí tyče			
2.7	**Uchycení sudu umožnit**	V podélných profilech na dně prostoru	Pomocí připínacích ohrádek do boku prostoru			

Figure 5. Establishing variants of Organ Structure concept using morphologic matrix

VARIANT A



VARIANT B



VARIANT C

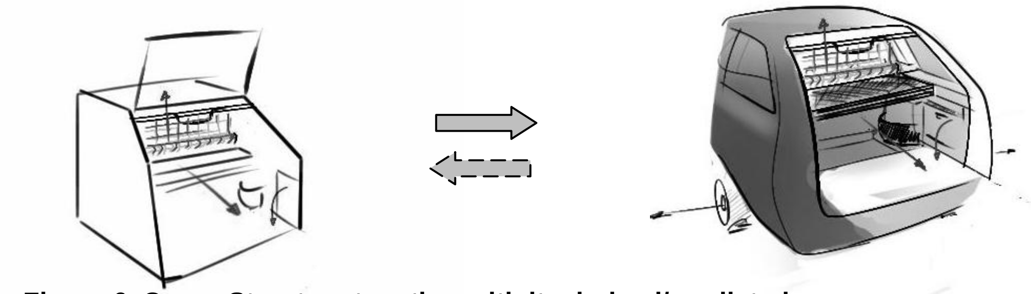


Figure 6. Organ Structure together with its derived/predicted appearance

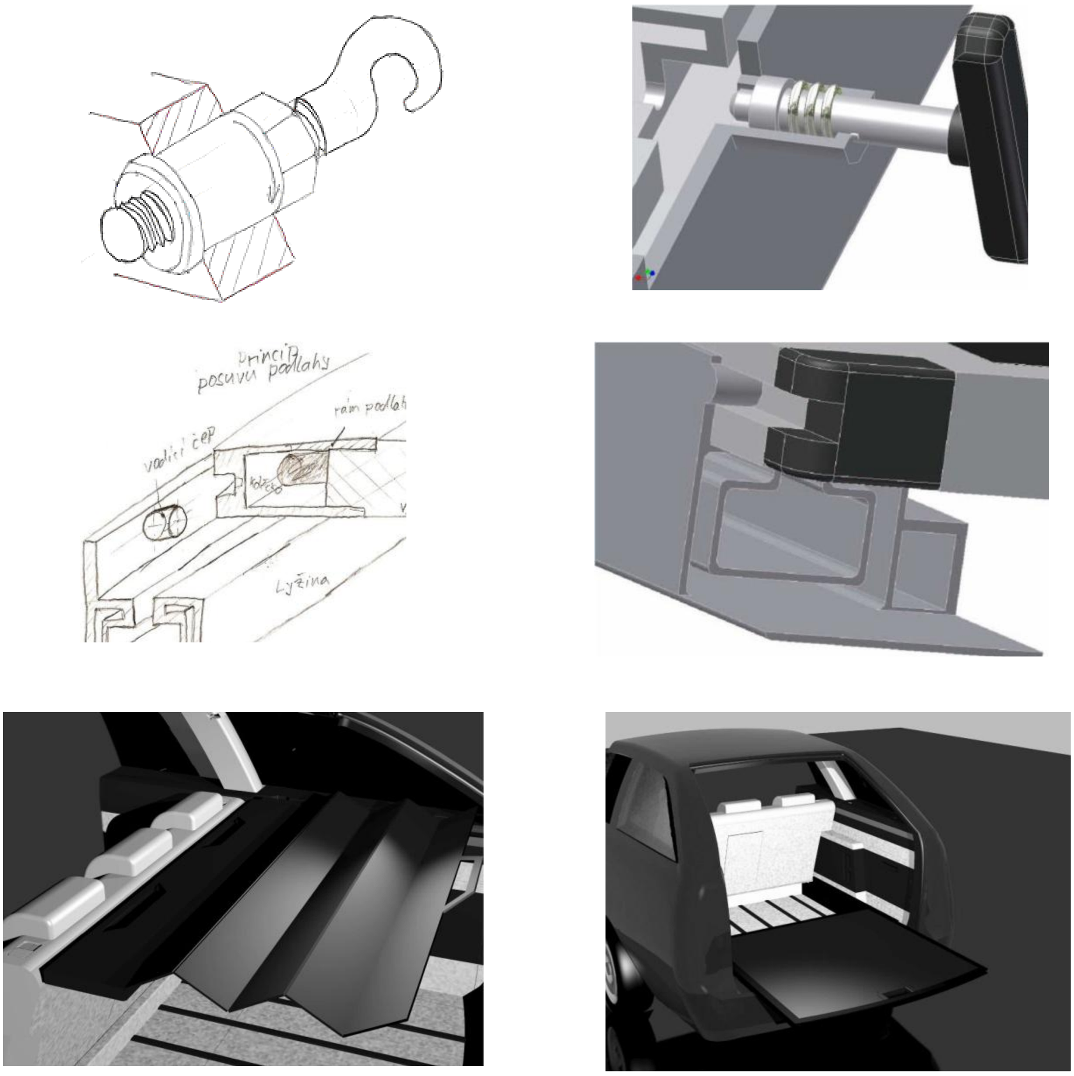


Figure 7. Integrated Engineering and Industrial Design of the Constructional Structure

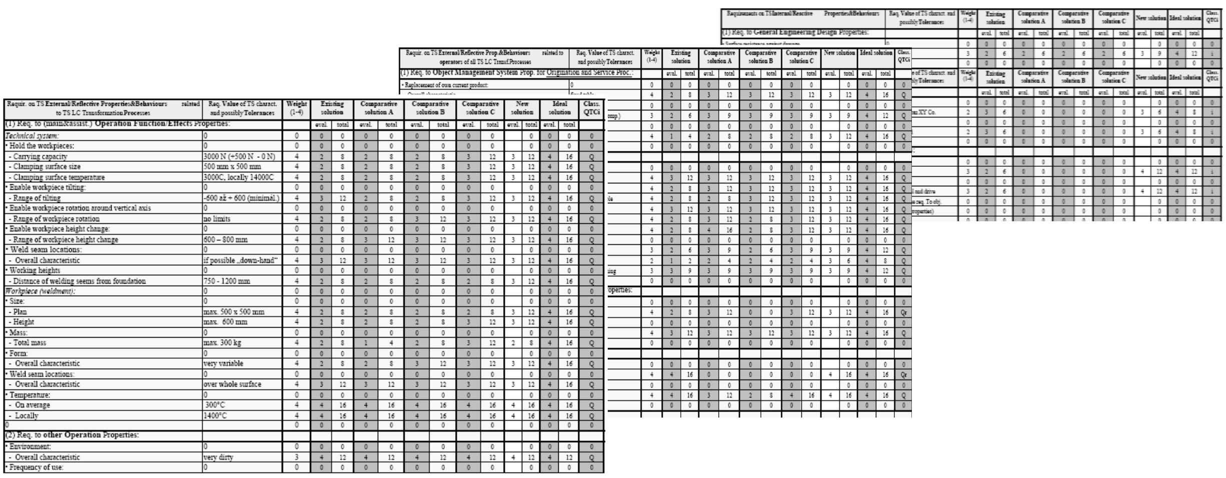


Figure 8 – Part 1. MS Excel SW support for evaluation of existing and newly designed company products, and their (engineering&industrial) design competitiveness compared to competitive products

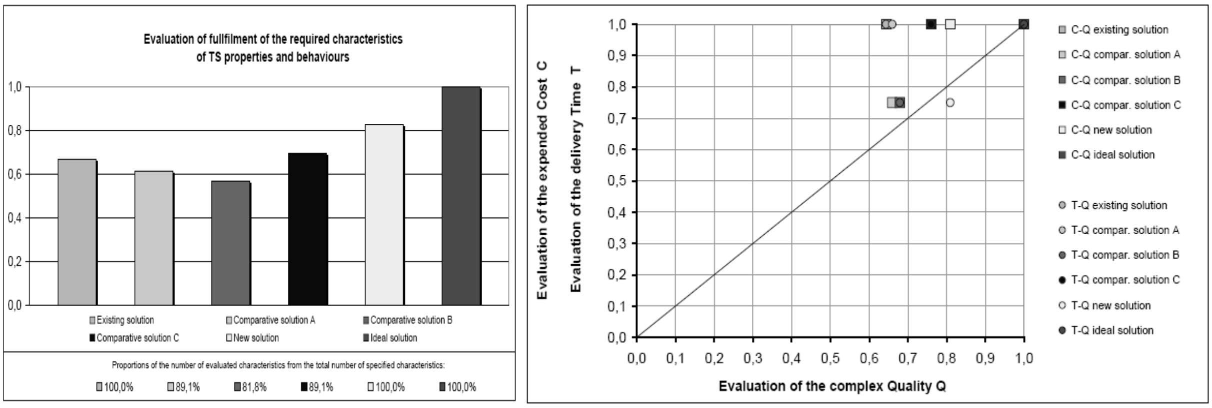


Figure 8 – Part 2. MS Excel SW representation of the evaluation of existing and newly designed company products for the established product design specification (left), and their (engineering&industrial) design competitiveness compared to competitive products (right)

3. Conclusions

The strategy presented in this paper helped us, engineering & industrial designers, to consolidate our cooperation. This increased the design competitiveness of the product and improves its chances of succeeding in the market place we think.

This experience also helped us to recognize our roles and responsibilities within a design process. Furthermore, it enabled us to gain their own experience in cooperation and communication with different professions, which encouraged our discussions and provided us with feedback of how we are able to assert their own ideas in a design team and how we are able to accept the thoughts and ideas of each team members.

The results of the project were presented in a university exhibition called Design^2 held in the “Over the Stairs” gallery on the university’s Bory campus. These projects were greatly appreciated not only by the teachers and students involved but also by the participating industrial and research partners.

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References

[Eder&Hosnedl 2008] Eder, W. E., Hosnedl, S.: Design Engineering, A Manual for Enhanced Creativity. CRC Press, Taylor & Francis Group, Boca Raton, Florida USA, 2008, 588 p.,ISBN 978-1-4200-4765-3

[Hosnedl&Vanek 2001] Hosnedl, S., Vaněk, V.: Design Science for Engineering Design Practice. In: Proceedings of International Conference on Engineering Design – ICED 01. Glasgow, UK: IMechE, London, 19.-25.8.2001. Vol 3, s. 363-370. ISBN 1 86058 1.

[Hubka&Eder 1988] Hubka,V., Eder, W.E.: Theory of Technical Systems. Berlin Heidelberg: Springer - Verlag, 1988, (2nd ed. in German. 1984) ISBN 3-540-17451-6

[Hubka&Eder 1996] Hubka,V., Eder, W.E.: Design Science. London, Springer,1996, ISBN 3-540-19997-7

[CSN EN ISO 9000] ČSN EN ISO 9000 (ed. 2, 01 0300, idt ISO 9000:2000) Quality mangement systems – Fundamentals and vocabulary. Prague: Czech Institute for Standardisation, 2002

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