

# Prioritizing Strategic Goals in Higher Education Organizations by Using a SWOT–PROMETHEE/GAIA–GDSS Model

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**Abstract** In this paper a hybrid model of SWOT–PROMETHEE/GAIA–GDSS is defined for the purpose of prioritizing strategic goals of the university and developed for the case of the Technical Faculty in Bor that belongs to the group of the Technology and Engineering Sciences faculties at the University of Belgrade, Serbia. Defined model is suitable for universities or autonomous faculties with diversified organizational structure, in which interests of individual departments are opposed, therefore there is a need for compromise in decision-making process while defining priorities of the strategic goals (SGs). SWOT factors, arising as a result of a survey based Brainstorming, are good foundation for further development of the model by assessing the opinions of the decision makers (DMs) through Group Decision Support System (GDSS), as a preparation for the PROMETHEE methodology which is used for prioritizing of the SGs. The Geometrical Analysis for Interactive Assistance (GAIA) plane is used to further analyze the alternative routes and to reach the group solution, which is consistent with managerial goals and objectives. The model is useful because it allows DMs a better understanding when defining a compromise in order to optimize the SGs, in the interest of growth and development of the University.

**Keywords** Strategy · SWOT · PROMETHEE/GAIA · GDSS · University

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## 1 Introduction

Higher education represents an investment in human resources and increases technical and managerial knowledge, skills and positive attitudes needed by organizations (Sharifi 2012). The development of society requires that the education systems are of high quality. Institutions of higher education have undergone numerous changes in the last decade, with the loss of financial support and under the conditions of rapid technological and demographic changes. It is obvious that universities play an important role in the world today, under the conditions of globalization and rapid technological changes that require new skills and training of people. The teacher–student relationship is changing, which requires organizational changes in the University and adaptation of the inputs and outputs to the changing environment (Akhavan 2005; Pavlović et al. 2014). Strategic planning of the development in higher education in modern conditions is becoming very important for the development of higher education institutions (Dyson 2004).

Various study programs (SPs) and departments exist at universities, which leads to expression of different, often conflicting interests, especially in the process of attracting new students, thus while determining the priorities of strategic goals of the University as a whole. Accordingly, the management of the University is faced with the problem of finding the compromise solutions (Dyson 2004; Sharifi 2012; Savić et al. 2014; Pavlović et al. 2014).

Technical Faculty in Bor (TFB), Serbia is existing since 1961 within the University of Belgrade (UB), which is, according to the Shanghai list of the best universities in the world, ranked among the top 400 for the last 3 years. University of Belgrade within has 31 faculties that are organized in 4 groups: social sciences and humanities, medical sciences, sciences and mathematics, and technology and engineering sciences). TFB is a member of the group of technology and engineering sciences, and today it has four study programs: Mining Engineering, Metallurgical Engineering, Chemical Engineering and Engineering Management, with a total number of about 1400 students at the bachelor (eight semesters), Master (two semesters) and doctoral studies (six semesters). High demands for the quality of teaching and scientific work, which are required by the UB (obliged by the position among the top 500 in the world), are accepted by TFB as well. In order to achieve increasing quality through continuous improvements in all aspects of work, in TFB there is a particular focus on the development of strategic planning for the utilization and allocation of available resources in order to achieve its mission (Li et al. 2002). The SWOT analysis (the acronym standing for Strengths, Weaknesses, Opportunities and Threats) is accordingly set in the context of the TFB strategic development process (Dyson 2004).

The process of strategic development consists of the harmonization of relations within the organization (relations between organization's strengths and weaknesses) as well as the harmonization of relations between organization and its environment (relations between opportunities and threats) (Kotler 1988). Moreover, Kangas et al. (2003) said that organization by identifying these four factors (strengths, weaknesses, opportunities and threats) can develop strategies based on their strengths, vanish their weaknesses, as well as it can gain maximum profit by using opportunities and neutralize threats. A organization achieves good performance with a proper interaction of

the internal part of the organization with the external environment, where the SWOT analysis is useful for defining additional criteria for the decision making process (Pana-[giotou 2003](#)).

The concept of strategic development of the University and the definition of SGs, based on the results of SWOT analysis, is limitedly presented in the literature ([Dyson 2004](#); [Sharifi 2012](#)). At the same time this concept is being developed in many areas, particularly with the utilization of hybrid models in which various techniques for decision making are being built upon the results of the SWOT analysis ([Kurttila et al. 2000](#); [Gorener 2012](#); [Tavana et al. 2013](#); [Marbini et al. 2013](#); [Bas 2013](#)). Other statistical and organizational models can also be used ([Chang and Piecece 2014](#); [Kalina 2014](#)). Furthermore, the organization tends to achieve all strategic goals during the realization of the strategic plan. However, accomplishing an organization's strategic goals at once is not usually possible. Since some difficulties are generally present, SWOT sub-factors and their analysis could be effectively used to identify these issues. Therefore, obtaining the priority list among SGs, based on their potential to be achieved, gives directions to managers on how they should react and create additional conditions in order to realize those strategic goals, for which organization currently has certain problems to achieve.

## 2 Literature Review

Generally, the SWOT analysis represents a list of conditions or results with a description of the current and future state of the organization and the environment. Estimates of this kind are subjective views of these areas. However, SWOT analysis is a convenient and promising way of conducting a situational assessment of the state of the organization and the environment ([Wickramasinghe and Takano 2009](#)). SWOT analysis is widely used in many fields ([Kurttila et al. 2000](#); [Arslan and Er 2008](#); [Sarter et al. 2010](#); [Gorener 2012](#); [Tavana et al. 2013](#); [Bas 2013](#)). Also, its application in the field of strategic development of the University is present in the academic literature ([Dyson 2004](#); [Sharifi 2012](#)).

Mathematical interpretation of the SWOT factors is recently gaining increasing importance ([Chang and Huang 2006](#)) which has largely expanded the application of this methodology. Due to the limitations of the application of the SWOT analysis, many authors have defined hybrid models which have provided new opportunities for the application of this descriptive methodology in defining the development strategy of the organization. For example, Kurttila with associates defined the hybrid model SWOT-AHP (Analytical Hierarchy Process) ([Kurttila et al. 2000](#)) which allows the definition of the global priorities on which the selection of appropriate strategies can be based. The introduction of fuzzy logic into the model SWOT-ANP (Analytical Network Process) creates opportunities to generate optimal strategy for the considered organization using appropriate software ([Sevкли et al. 2012](#)). Connection between Multiple Criteria Decision Support (MCDS) ([Hsu and Lin 2014](#)) and the SWOT analysis enables prioritization of SWOT factors in the decision-making process ([Kajanus et al. 2012](#)).

Decision makers in certain situations, depending on their positional power, influence the definition of the organization's development strategy in different ways. As a tool to assist the decision makers, Group Decision Support System (GDSS) was developed, which improves communication between decision makers (DMs), through a system of selection of strategic goals by combining the SWOT factors with the use of Preference Ranking Organization Method for Enrichment Evaluation (PROMETHEE) method in conjunction with the Geometrical Analysis for Interactive Assistance (GAIA) method to capture the DMs beliefs through a series of intuitive and analytical methods (Tavana et al. 2013).

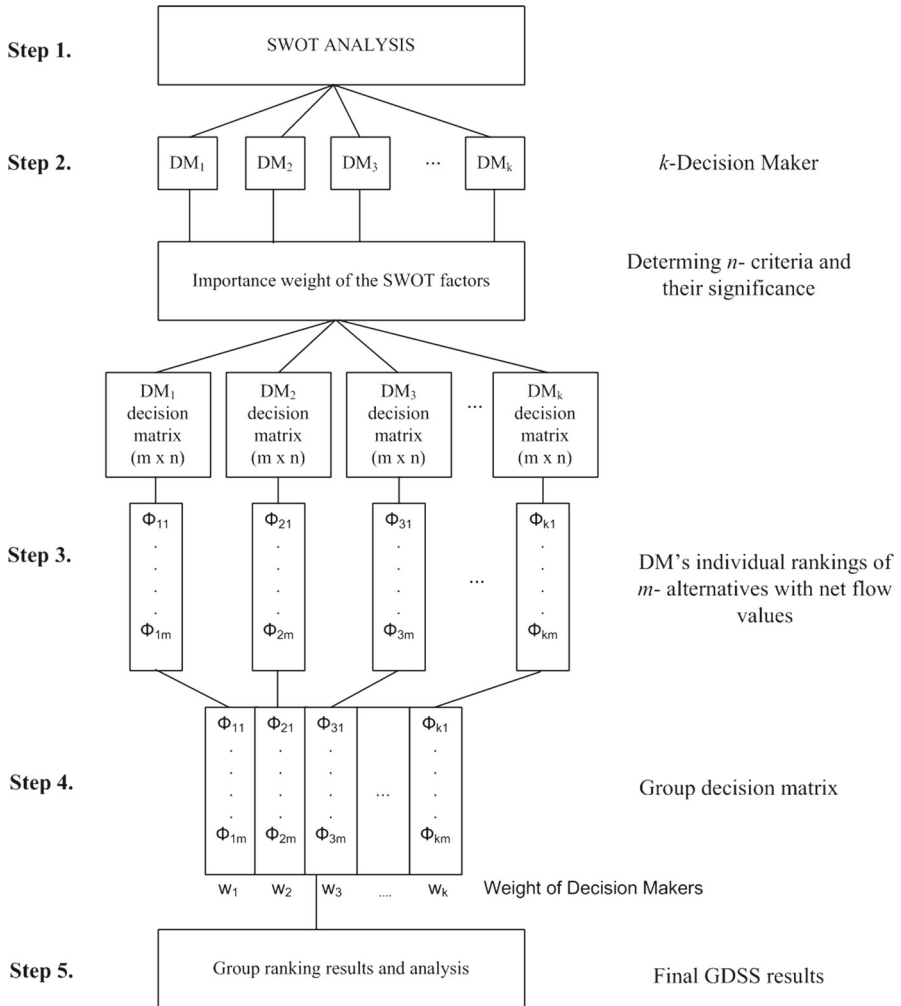
### 3 Methodology Framework

In this study a comprehensive hybrid multi-criteria decision analysis (MCDA) methodology is present for prioritization of the strategic goals according to the extracted SWOT factors and making optimal strategic decisions by the group decision makers—DMs (Tavana et al. 2013; Sheykhani et al. 2014). In this context, this paper aimed to investigate the application of hybrid SWOT–MCDS–GDSS model for analyzing the specific research topic, because the challenges regarding group decision making are very prevalent at universities due to the nature of their managerial structure. Therefore, a well-known group decision support method PROMETHEE GDSS (Preference Ranking Organization Method for Enrichment Evaluation- Group Decision Support System), was adopted in this research to reduce complexity, make relationships more tangible, and increase correctness and accuracy of obtained results by DMs (Goncalves and Belderrain 2012; Behzadian et al. 2013; Tavana et al. 2013; Montajabiha 2015).

The PROMETHEE GDSS approach was introduced in 1998 by authors Macharis, Brans and Mareschal, who proposed original three stages procedure for group decision support (Macharis et al. 1998). Behzadian et al. (2010) gave additional details about comprehensive literature review of the PROMETHEE–GDSS methodology and its applications. Later on, in 2015 Macharis et al published a state of the art survey of PROMETHEE GDSS application and gave recommendation for further developments of this methodology in the framework of SWOT analysis (Macharis et al. 2015). Furthermore, study (Macharis et al. 2015) showed that PROMETHEE–GDSS is increasingly used in a variety of domains such as environmental and natural resources management, logistics and transportation, energy planning, and so on. However, studies that applied the combined PROMETHEE–GDSS approach for analyzing decision making processes at educational institution are still insufficient in scientific literature (Montajabiha 2015). For that reason, the main contribution of this paper is to implement proposed hybrid SWOT–PROMETHEE–GDSS methodology in case of the strategic planning and development of higher education institution.

In this study proposed MCDA GDSS methodology is based on several steps presented in Fig. 1. The developed framework enables DMs to express their own individual preferences, and to integrate them further into the group decision.

*Step 1* The first phase includes a series of SWOT analysis rounds with the aim to extract relevant strengths, threats, opportunities and weakness.



**Fig. 1** Overview of proposed hybrid MCDA methodology Adopted from [Macharis et al. \(1998\)](#)

*Step 2* In this phase  $k$ -decision makers (DMs) are selected to assign weights to the each SWOT factor extracted in Step 1, which are defined as evaluation criteria  $C_j$  ( $j = 1 \dots n$ ) in this phase of the proposed methodology. To determine the importance weights, decision makers are using individual ratings between 0 and 1 for each factor (0-non important factor; 1- extreme important factor), with 0.1 increment. Subsequently, relatively unimportant factors (factors with overall importance less than 0.7) should be removed from further analysis.

*Step 3* Establishing individual DM matrix for evaluating the alternatives  $A_i$  ( $i = 1 \dots m$ ) in respect to defined criteria  $C_j$  ( $j = 1 \dots n$ ), which can be set by cardinal (quantitative) and ordinal (qualitative) data. Next, to rank alternatives from a group

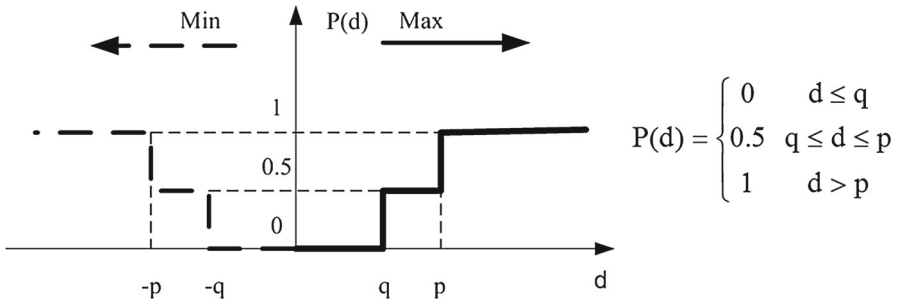


Fig. 2 Level preference function (type 4) used for individual ranking

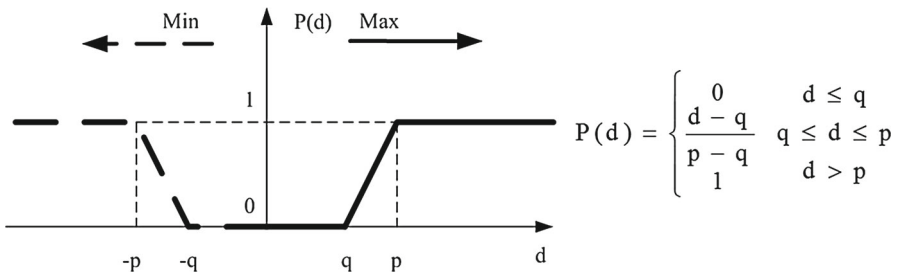


Fig. 3 Linear preference function (type 5) used for final group ranking

of DMs, the PROMETHEE GDSS methodology goes through the following sub-step procedure of classical PROMETHEE II complete ranking of alternatives:

*Step 3.1* Evaluate alternatives pairwise for each criterion and each DM, whereas the difference score or deviation between any two alternatives *a* and *b* for criterion *j* is given as (Brans and Vincke 1985):

$$d_j(a, b) = f_j(a) - f_j(b) \tag{1}$$

where  $f_j(\cdot)$  represents the evaluation value (i.e. scores) of each alternative, from set  $A_i$  ( $i = 1 \dots m$ ), for each criterion  $C_j$  ( $j = 1 \dots n$ ).

In order to take into account the scale of deviation for each criterion, the preference function  $P_j(a, b)$  should be given to each criterion *j* to express the degree of preference of any alternative *a* over alternative *b*. Brans et al. (1984) presented the choice of the six different shapes of the preference functions, with aim to help DMs with this issue. In this research, the type 4 Level preference function was adopted for the individual rankings (Fig. 2), with specified threshold values *p* and *q*, which express level of DMs preference and indifference, respectively.

Also, the type 5 Linear preference function (Fig. 3) was used in this research for group decision matrix and global rankings, where threshold values *p* and *q* were also determined.

The preference function value  $P_j(a, b)$  which is calculated for deviation  $d_j$  between two alternatives from set  $A_i$  ( $i = 1 \dots m$ ) defined for each criteria  $C_j$  ( $j = 1 \dots n$ ), can be expressed as:

$$P_j(a, b) = F_j[d_j(a, b)] \quad \text{where } P_j(a, b) \in [0, 1] \tag{2}$$

where  $F_j(\cdot)$  represents the type of preference function selected for each criteria  $C_j$ .

*Step 3.2* In this sub-step, calculation of an overall or global preference index  $\Pi(a, b)$ , that represents the intensity of preference of  $a$  over  $b$ , is done based on the expression:

$$\pi(a, b) = \sum_{j=1}^n w_j \cdot P_j(a, b); \left( \sum_{j=1}^n w_j = 1 \right) \tag{3}$$

*Step 3.3* Calculation of the outranking flows for each alternative  $a \in A_i$ :

- Positive preference flow (outranking) expresses how alternative  $a$  is outranking all the other  $m - 1$  alternatives  $x$  ( $x \in A_i$ ):

$$\Phi^+(a) = \frac{1}{m - 1} \sum_{x \in A} \pi(a, x) \tag{4}$$

- Negative preference flow (being outranked) expresses how alternative  $a$  is outranked by all other  $m - 1$  alternatives  $x$  ( $x \in A_i$ ):

$$\Phi^-(a) = \frac{1}{m - 1} \sum_{x \in A} \pi(x, a) \tag{5}$$

To calculate net-flow values, next formula was used to complete final individual rankings for each DM:

$$\Phi(a) = \Phi^+(a) - \Phi^-(a) \tag{6}$$

Accordingly, final individual rankings are obtained, where the better ranked alternatives are those with higher net-flow value.

*Step 4* Next, according to PROMETHEE GDSS procedure developed by [Macharis et al. \(1998\)](#) the net flow values of all the DMs ( $s = 1 \dots k$ ) are placed into the one global decision matrix, where DMs are introduced as criteria with proper influence weight for each of them.

*Step 5* Finally, the global evaluation and GAIA analysis are completed for group decision making and information about potential conflicts of interests between

k-DM’s decisions is presented. Sub-steps of the final group ranking procedure are further summarized as (Tavana et al. 2013):

*Step 5.1* Determining the preferences function value of alternative **a** over alternative **b** for each k DM:

$$P_s(a, b) = F_s[d_s(a, b)] \quad \text{where } s = 1 \dots k; P_s(a, b) \in [0, 1] \quad (7)$$

*Step 5.2* Calculate an aggregate preference index:

$$\pi_{gdss}(a, b) = \sum_{s=1}^k w_s \cdot P_s(a, b); \left( \sum_{s=1}^k w_s = 1 \right) \quad (8)$$

*Step 5.3* Complete global final rankings of PROMETHEE GDSS based on net - flow values  $\Phi_{gdss}(a)$  for the each alternative **a** from set  $A_i$  ( $i = 1 \dots m$ ):

$$\begin{aligned} \Phi_{gdss}(a) &= \Phi_{gdss}^+(a) - \Phi_{gdss}^-(a) = \frac{1}{m-1} \left[ \sum_{x \in A} \pi_{gdss}(a, x) - \sum_{x \in A} \pi_{gdss}(x, a) \right] \quad \text{or} \\ \Phi_{gdss}(a) &= \frac{1}{m-1} \sum_{x \in A} \left[ \sum_{s=1}^k w_s P_s(a, x) - \sum_{s=1}^k w_s P_s(x, a) \right] \quad (9) \end{aligned}$$

Furthermore, in order to obtain the complete overview of the conflicts between DM’s decisions for the individual as well as for the global ranking results, another advantage of PROMETHEE GDSS methodology–GAIA analysis was used in this study. In the GAIA plane, by using Principal Components Analysis (PCA) in matrix  $\Phi$  of all the unicriteria flows  $\Phi_j(a_i)$  (Brans and Mareschal 1994), the  $A_i$  ( $i = 1 \dots m$ ) alternatives and criteria  $C_j$  ( $j = 1 \dots n$ ) are projected in a plane defined by the two extracted factors (u and v) eigenvalues. However, according to the Macharis et al. (2015) when there is a problem with significant value of information that gets lost by projection in GAIA plane (Quality of GAIA plane projection  $\delta < 70\%$ ), the additional third extracted factor (w) eigenvalues can be used to obtain 3-dimensional GAIA analysis, which makes it possible to increase the quality of results interpretation by the quantity of information that is presented in such modified GAIA plane.

$$\Phi = \begin{bmatrix} \Phi_1(a_1) & \Phi_2(a_1) & \dots & \Phi_j(a_1) & \dots & \Phi_n(a_1) \\ \Phi_1(a_2) & \Phi_2(a_2) & \dots & \Phi_j(a_2) & \dots & \Phi_n(a_2) \\ \dots & \dots & \dots & \dots & \dots & \dots \\ \Phi_1(a_i) & \Phi_2(a_i) & \dots & \Phi_j(a_i) & \dots & \Phi_n(a_i) \\ \dots & \dots & \dots & \dots & \dots & \dots \\ \Phi_1(a_m) & \Phi_2(a_m) & \dots & \Phi_j(a_m) & \dots & \Phi_n(a_m) \end{bmatrix} \quad (10)$$



## 4 Case Study-Technical Faculty in Bor

The present organizational structure of the TFB defines the process of decision-making at the level of the Dean and Heads of the study programs (SPs). Under conditions of diversified SPs developed at TFB, conflicting interests exist between different SPs that require definition of certain optimum and compromise solutions in the process of constructing of the TFB development strategy. For these reasons, in order to define the development strategy of the faculty in the case of TFB within UB, SWOT-PROMETHEE/GAIA-GDSS methodology was chosen with four DMs: the heads of the four SPs at TFB, one of which is at the same time the Dean, second one is the Vice Dean, while third one is the President of the Faculty Council.

SWOT analysis of the TFB was done in 2012 for the purpose of national accreditation of the SPs and TFB. The process of SWOT analysis was carried out by survey brainstorming methodology, with the participation of all the teachers and assistants in TFB. SWOT analysis was carried out under the direction of the Commission for quality of TFB, in three rounds. Selection of the most influential parameters was performed on the basis of five-point Likert scale and by applying Pareto analysis with probability above 75% (Weiers 2011). Table 1 shows the results of SWOT analysis of TFB. In this way, 20 elements were identified as strengths, 14 elements as weakness, 10 elements as opportunities and 10 elements as threats.

The strategic goals-SGs of the Technical Faculty in Bor had been defined by faculty management after which they were verified by managing authorities of the faculty. Strategic goals were defined based on the mission and vision statements of the Technical faculty in Bor that were defined in the accreditation process in accordance with the legislative framework of the Republic of Serbia. Furthermore, following strategic goals have to accomplish vision of the Technical faculty in Bor during decennial strategic plan:

- SG<sub>1</sub> Developing competencies in graduate students in accordance with best practices in the world to ensure their effective and efficient integration into contemporary international scientific, economic and social trends.
- SG<sub>2</sub> Continuous improvement of scientific research and publication of the results in the world's leading journals listed in the SCI.
- SG<sub>3</sub> Cooperation with businesses and community organizations in the region in order to solve problems and encourage development.
- SG<sub>4</sub> Continuous improvement of the educational process in accordance with best practices in the world, in order to ensure horizontal and vertical mobility of students in the EU educational space.
- SG<sub>5</sub> Continuous training and development of employees.
- SG<sub>6</sub> Provision of all necessary resources required for the realization of the set objectives.

Due to the large diversification of the factors in all elements of SWOT analysis, another verification of these elements was carried out by the above defined four DMs, where DMs evaluated each factor according to the personal evaluation of its significance within the range [0, 1], with 0.1 increment. Next, the DMs eliminated several SWOT factors listed in Table 1 that they considered to be relatively unimportant for further

**Table 1** SWOT factors for TFB with the influence of above 75%

Strengths—(S)	Weaknesses—(W)
S <sub>1</sub> —Engaging in international networks	W <sub>1</sub> —A small number of leaders on TFB
S <sub>2</sub> —No tuitions for advanced students	W <sub>2</sub> —Inadequate informational system
S <sub>3</sub> —Membership in UB (top 400)	W <sub>3</sub> —Inadequate doctoral studies on mining department SP
S <sub>4</sub> —Very good quality of work of a part of teaching assistant staff	W <sub>4</sub> —Lack of students at some SPs
S <sub>5</sub> —Good reputation of some teachers	W <sub>5</sub> —Poor provision of additional revenues
S <sub>6</sub> —Good cooperation between professors and assistants	W <sub>6</sub> —Insufficient involvement of a significant number of employees in faculty activities
S <sub>7</sub> —Availability of scientific bases from around the world	W <sub>7</sub> —Irresponsible attitude of some employees towards work obligations
S <sub>8</sub> —Human and spatial resources are satisfactory	W <sub>8</sub> —The unwillingness of teaching personal to change
S <sub>9</sub> —Activities to improve teaching	W <sub>9</sub> —The decline of criteria for the student evaluation
S <sub>10</sub> —Organization of scientific conferences	W <sub>10</sub> —Stagnating wages due to the economic crisis
S <sub>11</sub> —Rejuvenated teaching staff	W <sub>11</sub> —Weakened links with industry and local government
S <sub>12</sub> —Half-century tradition of TFB	W <sub>12</sub> —Poor cooperation between SPs
S <sub>13</sub> —Favorable conditions for accommodation of students	W <sub>13</sub> —Obsolete equipment
S <sub>14</sub> —Positive communication with students	W <sub>14</sub> —Campus of TFB is insufficiently landscaped
S <sub>15</sub> —Affordable costs of studies for students	
S <sub>16</sub> —Participation in projects	
S <sub>17</sub> —Successful accreditation	
S <sub>18</sub> —A large number of verified mentors	
S <sub>19</sub> —Teachers publishing papers in journals from the SCI list	
S <sub>20</sub> —Journal JMM section B on JCR list	
Opportunities—(O)	Threats—(T)
O <sub>1</sub> —Mining and metallurgy are deficient occupations – opportunity for enrollment	T <sub>1</sub> —Degradation of scientific research system by the government
O <sub>2</sub> —The enthusiasm of some employees	T <sub>2</sub> —Demotivation of young people for acquiring knowledge
O <sub>3</sub> —International exchange of students	T <sub>3</sub> —Arrival of private colleges via illegal ways
O <sub>4</sub> —Lack of competitive universities in proximity of TFB	T <sub>4</sub> —Bad demographic situation at the market where TFB is present and currently operates
O <sub>5</sub> —Investing in IT equipment	T <sub>5</sub> —Poor educational system

**Table 1** continued

Opportunities—(O)	Threats—(T)
O <sub>6</sub> —Trans-border Cooperation on EU projects	T <sub>6</sub> —Poor economic conditions of the country
O <sub>7</sub> —Cooperation with public institutions in the city	T <sub>7</sub> —Significant privilege of the educational institution which are closer to state funds (located in Belgrade)
O <sub>8</sub> —Collaboration with industry and the alumni	T <sub>8</sub> —Weak economic development in Serbia
O <sub>9</sub> —Cooperation with foreign universities	T <sub>9</sub> —Insufficient state funding
O <sub>10</sub> —State authorities demand continuous quality improvement (national accreditation of higher education institutions at every 4 years)	T <sub>10</sub> —Reduction of the number of potential students in Serbia and in the wider surroundings (West Balkans countries)

analysis based on the 0.7 threshold value for overall weight scores (Tavana et al. 2013). The results of the evaluation of all SWOT analysis factors by DMs, with a overall weight score greater than 0.7 are shown in Table S1 (in the online supporting material). These results indicate that the DMs have different perceptions of the significance of the SWOT factors compared to other professors and associates of the TFB. Weaknesses are not recognized, as well as opportunities in the region, especially in the case of the DM<sub>4</sub>.

In the second round of evaluations, based on the previously reduced list of SWOT factors presented in Table S1 (in the online supporting material), the influence of each SWOT factor in realization of strategic goals of TFB was evaluated using a five-point Likert scale (1—very low influence, 2—low influence, 3—medium influence, 4—high influence, 5—very high influence). For the positive criteria (SWOT sub-factors: strengths and opportunities) in the proposed decision making model, higher mark defines higher positive influence of the sub-factors on the strategic goals. Opposite to that, for the negative criteria (SWOT sub-factors: weaknesses and threats) higher mark defines higher negative influence of these sub-factors on the strategic goals. The obtained results are shown in Table 2.

The obtained values, shown in Table 2, were used to develop GDSS model which is used to support PROMERTHEE/GAIA method, available in scientific practice for similar problems (Brans and Vincke 1985; Brans and Mareschal 1988; Tavana et al. 2013) and adapted for the purpose of this research. Extracted relevant SWOT factors were used as criteria, while the SGs were used as alternatives in the process of multi-criteria analysis (MCA) (Kheirkhah et al. 2014).

Relevant information including the average values, type of preference functions, threshold values q and p and weights are defined for each factor, with taking into account the characteristics of the strategic goals (alternatives). All factors for strengths and opportunities are maximized, while factors for weaknesses and threats are minimized. In this case, the preference function type with (q = 0.5) and (p = 1.5) was selected (Tavana et al. 2013).

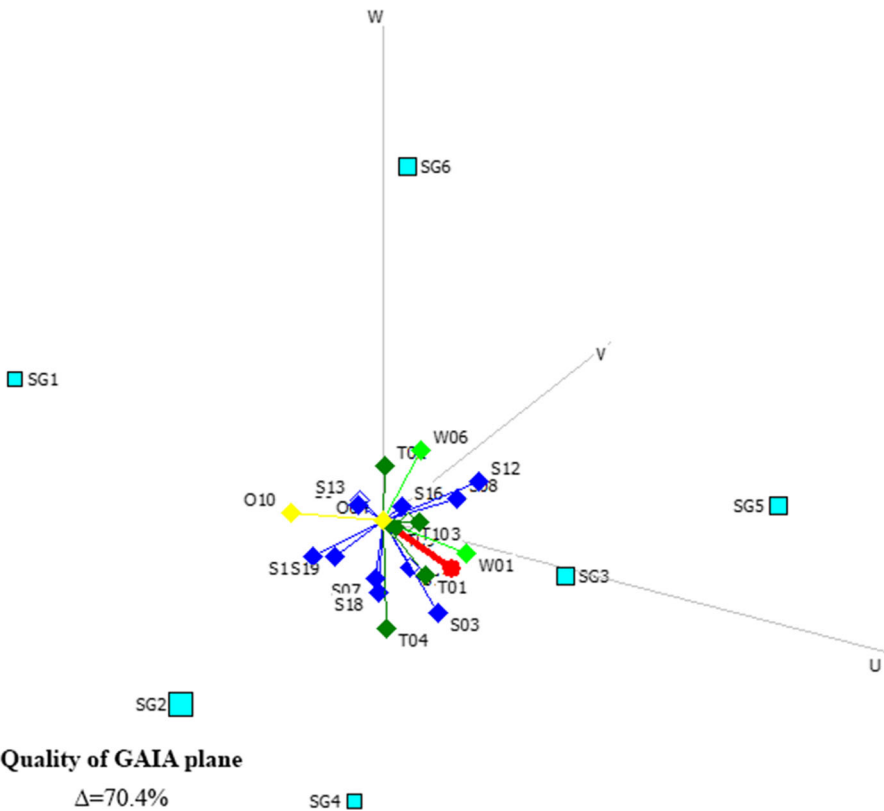
After the individual scores by DMs, a global analysis was performed using the PROMETTHEE–GDSS method. The results are presented in Table 3, which shows the

**Table 2** Results of evaluating the influence of the SWOT parameters on the realization of SGs, provided by DMs

SWOT factor	DM <sub>1</sub>						DM <sub>2</sub>						DM <sub>3</sub>						DM <sub>4</sub>						
	SG <sub>1</sub>	SG <sub>2</sub>	SG <sub>3</sub>	SG <sub>4</sub>	SG <sub>5</sub>	SG <sub>6</sub>	SG <sub>1</sub>	SG <sub>2</sub>	SG <sub>3</sub>	SG <sub>4</sub>	SG <sub>5</sub>	SG <sub>6</sub>	SG <sub>1</sub>	SG <sub>2</sub>	SG <sub>3</sub>	SG <sub>4</sub>	SG <sub>5</sub>	SG <sub>6</sub>	SG <sub>1</sub>	SG <sub>2</sub>	SG <sub>3</sub>	SG <sub>4</sub>	SG <sub>5</sub>	SG <sub>6</sub>	
S <sub>2</sub>	2	1	1	2	1	2	5	4	3	3	5	4	2	2	2	2	2	2	1	1	1	1	1	1	1
S <sub>3</sub>	1	3	4	4	3	2	5	5	5	5	5	4	4	4	2	4	4	4	4	5	3	3	2	3	
S <sub>7</sub>	4	5	5	4	4	3	4	4	3	5	5	5	5	5	3	5	4	3	5	5	5	5	5	5	
S <sub>8</sub>	1	2	3	3	3	4	4	4	3	4	3	5	4	4	3	4	3	3	4	4	4	4	4	4	
S <sub>12</sub>	2	1	4	3	4	4	5	5	4	5	4	4	4	4	3	4	3	3	4	4	4	4	4	4	
S <sub>13</sub>	3	1	3	3	1	3	5	5	2	3	3	5	2	2	2	2	2	3	3	3	3	3	3	5	
S <sub>15</sub>	3	4	1	4	2	3	5	4	3	4	3	5	2	2	2	2	2	3	3	3	3	3	3	5	
S <sub>16</sub>	4	3	4	4	4	4	5	4	5	3	3	5	4	5	3	4	4	3	4	5	5	5	5	5	
S <sub>17</sub>	3	4	4	5	4	4	4	4	3	5	4	5	4	4	3	4	4	3	5	5	4	5	5	5	
S <sub>18</sub>	4	4	4	5	4	3	4	4	3	4	4	5	5	5	3	5	4	4	5	5	5	5	5	5	
S <sub>19</sub>	5	5	4	5	4	4	4	5	4	4	4	5	5	5	3	5	4	4	5	5	5	5	5	5	
W <sub>1</sub>	5	4	4	3	1	4	5	5	4	3	4	4	5	4	5	4	4	4	5	3	4	3	3	3	
W <sub>6</sub>	3	3	4	5	1	3	4	4	3	5	4	4	4	5	4	3	3	4	1	1	2	1	1	2	
O <sub>4</sub>	1	1	1	1	1	1	5	4	3	4	4	3	2	2	2	2	2	2	4	1	1	1	1	1	
O <sub>10</sub>	5	4	3	4	2	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	5	5	
T <sub>1</sub>	4	5	4	3	3	5	3	4	5	2	4	3	4	5	3	3	4	4	4	5	4	5	5	4	
T <sub>2</sub>	5	3	3	5	5	2	3	5	4	4	5	4	4	3	2	4	3	3	5	5	5	5	5	5	
T <sub>3</sub>	4	1	2	2	2	1	3	4	4	3	4	3	2	1	2	3	2	3	5	4	4	3	4	4	
T <sub>4</sub>	4	1	2	2	3	4	3	4	3	3	3	3	2	1	3	2	2	3	5	1	1	5	1	3	
T <sub>9</sub>	4	4	3	5	4	5	4	4	4	3	5	4	5	4	3	4	4	5	5	3	5	5	5	5	
T <sub>10</sub>	4	1	3	4	2	3	5	4	3	2	3	4	2	2	2	2	2	3	5	1	1	5	1	1	

**Table 3** Ranking of the strategic goals by the four decision makers

Strategic goals	DM <sub>1</sub>		DM <sub>2</sub>		DM <sub>3</sub>		DM <sub>4</sub>	
	Net-flow	Rank	Net-flow	Rank	Net-flow	Rank	Net-flow	Rank
SG <sub>1</sub>	-0.2363	6	0.1571	1	0.0814	3	-0.0690	5
SG <sub>2</sub>	0.0409	3	-0.0467	4	0.1425	1	0.0729	2
SG <sub>3</sub>	0.0684	2	-0.2245	6	-0.1844	5	-0.0163	4
SG <sub>4</sub>	0.1135	1	0.1082	3	0.1353	2	-0.0922	6
SG <sub>5</sub>	0.0281	4	-0.1364	5	0.0132	4	0.0109	3
SG <sub>6</sub>	-0.0146	5	0.1424	2	-0.1880	6	0.0938	1



**Fig. 4** The GAIA plane analysis for DM<sub>1</sub>

net flows and rankings for each decision maker, indicating the diversity between DMs in the evaluation of SGs. The results indicate that the DMs have different opinions and attitudes in prioritizing the SGs (Tavana et al. 2013). Table 3 shows that DM<sub>1</sub> selected SG<sub>4</sub> with the highest priority, and SG<sub>1</sub> with lowest priority, while DM<sub>2</sub> regards SG<sub>1</sub> as top priority strategic goal. According to DM<sub>3</sub> the most important strategic goal is

**Table 4** Decision matrix of the global flows

	DM <sub>1</sub>	DM <sub>2</sub>	DM <sub>3</sub>	DM <sub>4</sub>
Weights	0.25	0.25	0.25	0.25
Max/min	Max	Max	Max	Max
Preference function	Linear	Linear	Linear	Linear
p	0.25	0.25	0.25	0.25
q	0.05	0.05	0.05	0.05
SG <sub>1</sub>	-0.24	0.16	0.08	-0.07
SG <sub>2</sub>	0.04	-0.05	0.14	0.07
SG <sub>3</sub>	0.07	-0.22	-0.18	-0.02
SG <sub>4</sub>	0.11	0.11	0.14	-0.09
SG <sub>5</sub>	0.03	-0.14	0.01	0.01
SG <sub>6</sub>	-0.01	0.14	-0.19	0.09

SG<sub>2</sub> and the least significant is SG<sub>6</sub>. While opposite, DM<sub>4</sub> had set SG<sub>6</sub> as the first priority.

On the basis of the results obtained with the PROMETHEE method, these elements are additionally presented in the GAIA plane (Brans and Mareschal 1994). Figure 4 depicts the factors presented in a 3-dimensional plane only for DM<sub>1</sub>. However, the results of GAIA planes for all four decision makers can be seen more clearly in Figure S1 (in online supporting materials), where total projected information for each DM (DM<sub>1</sub>–DM<sub>4</sub>) is preserved by 70.4, 80, 91.9 and 79.4%, respectively. Furthermore, all four values are above the threshold value of 70% suggested by Brans and Mareschal (Brans and Mareschal 2005).

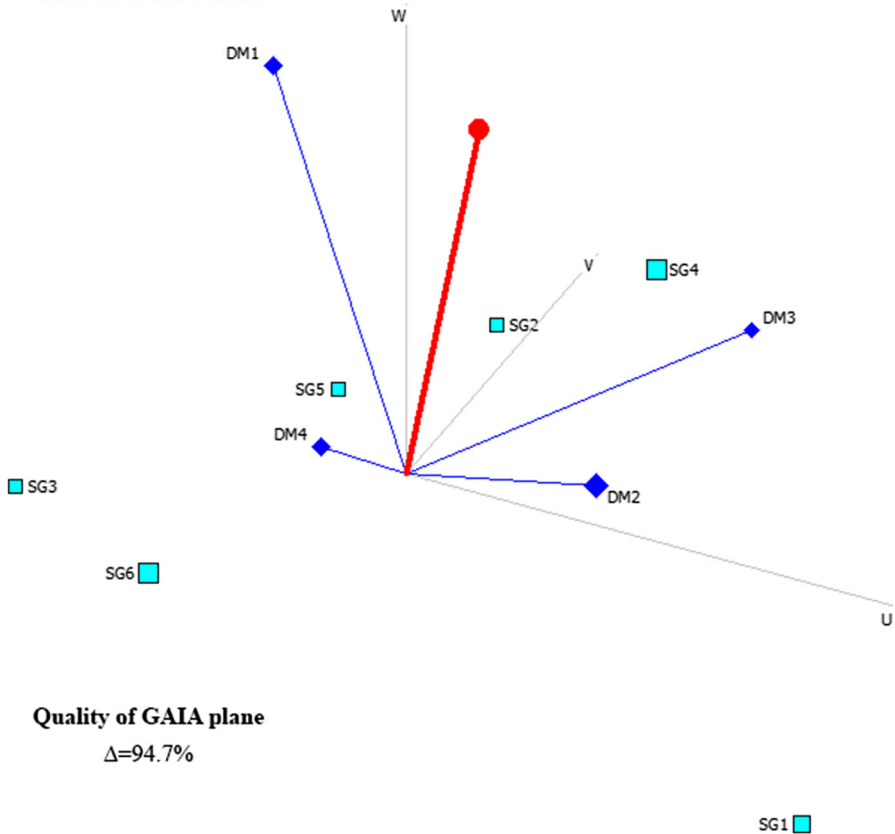
According to decision-maker DM<sub>1</sub> analysis of the 3-dimensional GAIA plane shows that the criteria have multiple heterogeneous factors such as T<sub>2</sub>, T<sub>3</sub>, and T<sub>10</sub>. According to decision stick for DM<sub>1</sub>, SG<sub>3</sub> is the best option. In order to accomplish this option, criteria which have a crucial role are W<sub>1</sub> and S<sub>3</sub>, followed by and T<sub>04</sub>. For DM<sub>1</sub>, according to the decision stick, SG<sub>1</sub> has the slightest importance. According to the DM<sub>2</sub> the best ranked options are SG<sub>1</sub> and SG<sub>6</sub> and criteria which have the greatest impact on these two options are S<sub>13</sub>, S<sub>15</sub>, S<sub>16</sub>, followed by S<sub>8</sub>. According to the decision stick, SG<sub>3</sub> has the slightest importance for DM<sub>2</sub>. For DM<sub>3</sub> the criteria which have the greatest importance for achieving SG<sub>1</sub> are: S<sub>3</sub>, S<sub>7</sub>, S<sub>17</sub>, S<sub>19</sub>, while criteria T<sub>3</sub> and T<sub>4</sub> are the most important for achieving SG<sub>2</sub>. According to the DM<sub>3</sub> other SGs are irrelevant. For DM<sub>4</sub> the best ranked option is SG<sub>6</sub> with the greatest impact of S<sub>15</sub> criteria. To accomplish SG<sub>3</sub>, SG<sub>5</sub>, SG<sub>2</sub> criteria which have the greatest impact are: T<sub>4</sub>, T<sub>9</sub> and T<sub>10</sub>. According to the decision stick, for DM<sub>4</sub>, SG<sub>1</sub> has the slightest importance.

In the GDSS, results of all DMs (DM<sub>1</sub>–DM<sub>4</sub>) are being summarized in a single list of options. All DMs in the model are considered as equally important, that is, their weight is 0.25. In case of this multicriteria model, participants in decision making—DMs represent the criteria, i.e. their individual rankings from the previous step with the net flows presented in Table 3. The resulting net flows in this step are presented in Table 4, while Table 5 shows the results of the group decision making in which SGs

**Table 5** Results of group decision making

Rank	Option	Phi	Phi+	Phi-
1	SG <sub>4</sub>	0.2454	0.3279	0.0825
2	SG <sub>2</sub>	0.1753	0.2804	0.1051
3	SG <sub>6</sub>	0.0471	0.2641	0.2170
4	SG <sub>1</sub>	-0.0639	0.2430	0.3069
5	SG <sub>5</sub>	-0.0661	0.1550	0.2210
6	SG <sub>3</sub>	-0.3378	0.0654	0.4032

**GLOBAL RANKINGS**



**Fig. 5** The GAIA plane of the global evaluation

were ranked four DMs (DM<sub>1</sub>–DM<sub>4</sub>) using GDSS method. Based on these results SG<sub>4</sub> has the best ranking, while the SG<sub>3</sub> is ranked as the worst.

Obtained results were again analyzed globally using 3-dimensional GAIA plane (Fig. 5). The diagram in Fig. 5 provides a visual aid for understanding the different perceptions among DMs as well as the performance of each strategic goal. DMs are presented as vectors, while SGs are presented as squares. The resulting high percentage

of 94.7 %, indicates that the information provided by the GAIA plane is very reliable. Direction of the decision stick is oriented towards  $SG_4$  which is the best ranked strategic goal, while the  $SG_3$ , which is in the opposite direction, represents the worst ranked strategic goal (Brans and Mareschal 1994; Tavana et al. 2013).

On the basis of the results shown in Fig. 5, according to the  $DM_2$  and  $DM_3$ , highest ranked strategic goal is  $SG_4$ . Also  $DM_2$  and  $DM_3$  are independent of  $DM_1$  and  $DM_4$  in terms of preferences, as represented by the direction of the orthogonal axes (Tavana et al. 2013). According to the decision stick, lowest ranked strategic goals are  $SG_3$  and  $SG_6$ . Accordingly, based on the SWOT factors and implemented GDSS methodology with  $DM_1$ – $DM_4$ , the most important strategic goal for TFB is  $SG_4$ . At the same time  $SG_4$  is the most important strategic goal for  $DM_2$  and  $DM_3$ ,  $SG_5$  for  $DM_1$  and for  $DM_4$  it is  $SG_6$ .

Based on the length of the vectors in the system (u, v, w) it can be concluded that SWOT analysis factors, which are obtained by collective brainstorming of the professors and assistants in TFB, are to the greatest extent supported and shared by:  $DM_3 \rightarrow DM_2 \rightarrow DM_1 \rightarrow DM_4$  (in descending order).

## 5 Conclusion

The position of the University as well as of independent faculties, in contemporary conditions of the changing environment, increasingly depends on their ability to adapt to the environment, together with the continuous improvement of teaching and research activities.

SWOT analysis with the use of survey based Brainstorming, combined with the participation of the entire teaching staff, represents an important foundation for defining the strategy of growth and development of the University. Bearing in mind the specifics of the organizational structure and the rules of functioning of the University, an important role for the implementation of the strategy, besides on the opinions of the DMs who are elected for a limited period of time, should be based on attitudes of all the employees who are de facto carriers of development and implementation of the adopted strategies and SGs.

The applied SWOT–PROMETHEE/GAIA–GDSS methodology provides an adequate assessment of the most important SGs as well as the possibility of their achievement. Visualization of the results of GDSS via PROMETHEE/GAIA methodology allows to highlights the conflict opinions, similarities and independences between DMs. Also, this model encourages communication between DMs and a review of individual attitudes of some DMs in relation to the SWOT determinants, which are derived from the collective attitude derived from the brainstorming of all the professors and assistants. The most important benefits for DMs which can be drawn from the defined model are a better understanding of the available options and optimizing the compromises in order to achieve better outcomes of their decisions in the interest of the growth and development of the University.

In the case of TFB, the ranked SGs, according to the vision of DMs who participated in GDSS, have the following significance in descending order:  $SG_4 > SG_2 > SG_6 > SG_1 > SG_5 > SG_3$ . According to decision stick,  $SG_4$  is the strategic goal



with the highest priority, based on the available SWOT determinants, i.e. continuous improvement of the educational process in accordance with the best practices in the world, to ensure horizontal and vertical mobility of students in the EU educational space. The smallest significance has SG<sub>3</sub>—cooperation with industry and community organizations.

Differences in attitudes of the DMs arise from their individual commitment to activities within the TFB and different personal goals. Since the positions on which DMs in TFB are elected to are with limited mandates, possible changes in the priorities of the SGs can be expected after the changes among DMs (election of new representatives in the future), as well as due to the changes in the environment (rapid economic growth and improvement of the living standard).

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