

Research on Development Strategy of Space Security based on AHP-SWOT

Shuxing Feng ^a, Xiancheng Su ^b, Yongping Wang ^c

Space Security Study Centre Space Engineering University Beijing, China.

^a fengshuxing@sohu.com, ^b suxiancheng7896@163.com, ^c wangyongping@163.com

Abstract. It is becoming the high topic to keep space security in the world, and it is great useful for making decision and making a choice to analyze development strategy of space security based on SWOT, with analyzing the strength, the weakness, the opportunity the threat, with qualitative estimate and quantitative evaluation which depends on applying the matrix model about the influent factors and strategy measures. To some extent, it uses for reference to carry out development strategy.

Keywords: space security, development strategy, AHP, SWOT.

1. Introduction

Outer space is a new field of national security and a "high frontier". The effective development and utilization of outer space resources, better taking the initiative and advantages in the space field and safeguarding national security interests have increasingly become hotspots for space powers. Space security involves a wide range of fields and many influencing factors. It is not only a non-traditional security field, but also intertwined and interacts with the traditional security field, including both survival security and development security. It is particularly important to scientifically analyze the space security environment and formulate a reasonable development strategy as a basis for the unified planning and guidance of space security capacity building, technology development and resource development.

2. AHP-SWOT Method

The theory of SWOT originated from the 1960s, and was put forward by E. P. Learned, the management professor of Harvard University. It has been gradually popularized and widely used in making enterprise strategic plans, by systematically evaluating various factors of internal and external environment, so as to facilitate the selection of the best business development strategy [1]. As to the China's space security development strategy, we can obtain the four sets of strategy matrix including the external and internal factors of space security development as well as its own strengths and weaknesses. See Table 1.

Table 1. SWOT Composite Matrix

External conditions	Internal conditions	
	<i>Strengths (S)</i>	<i>weaknesses (W)</i>
<i>Opportunity (O)</i>	SO strategy (growth strategy) play to its own advantages and use external opportunities	WO strategy (reverse strategy) to take advantage of external opportunities and overcome its own disadvantages
<i>Threat (T)</i>	ST strategy (diversification strategy) utilizes its own advantages to avoid external threats	WT strategy (defensive strategy) overcomes its own disadvantages and avoids external threats

We need to construct the hierarchical structure model and use AHP to judge the relative importance of each factor at each level when establishing the SWOT analysis model of space security development strategy. Through professional questionnaires and interviews, we can get the judgment value of the importance of each factor at each level, and then form a judgment matrix, A, S, W, O, T, and then calculate the feature vector W corresponding to the maximum eigenvalue n . After normalization, the sorting weight of the factors at the same level for the relative importance of a factor at the previous level is obtained, which is the single hierarchical ordering. And then the consistency

test is conducted to determine whether to accept or not. After a consistency check, a four and a half d coordinate system is constituted with four variables as half shaft, advantage value S, disadvantage value W, opportunity value O and threat value T. According to the calculated values of variables, tracing and wiring on the corresponding half axis in the coordinate system, the strategic quadrilateral is obtained. At last, quadrant two Angle area is needed to be calculated to determine the strategic position, to put forward the strategic options.

3. Space Security Development Strategy Analysis based on AHP-SWOT

3.1 Establish the SWOT Analysis Model of Space Security Development Strategy

In view of the internal and external environment of space security development, we are focusing on the following aspects, the space security development situation, equipment development, organization structure, personnel, military-civil integration, legal system, etc., through interviews and surveys of experts in the space security field, combined with academic research, to list the SWOT analysis model of China's space security development strategy.

Table 2. Space Security Development Strategy Swot Matrix

	<i>Strengths (S)</i>	<i>Weaknesses (W)</i>
<i>Internal condition</i>	<p>S1. The space field is receiving more and more attention from the state and economic investment is growing.</p> <p>S2. The construction of equipment in the space field is constantly improving, and the infrastructure of aerospace equipment is being strengthened.</p> <p>S3. The technological level is constantly improving, providing strong technical support for space security and development.</p> <p>S4. Space talents have grown and provided intellectual support for space security.</p> <p>S5. The development of military-civilian integration strategy and innovation, the research results have been transformed smoothly.</p>	<p>W1. The innovation capability in space security needs to be strengthened, including technological innovation and management innovation.</p> <p>W2. There is a short board in the construction of the space power system, and the system development is still unbalanced.</p> <p>W3. The top-level design of space security still needs to be strengthened, and the overall construction of space agencies for military and civilian businesses needs to be completed.</p> <p>W4. The space law system is still not perfect, and the supporting regulations need to be strengthened.</p> <p>W5. The degree of military-civilian integration and international cooperation will be further deepened.</p>
	opportunity (O)	threat (T)
<i>External condition</i>	<p>O1. Peaceful use of space resources and peaceful development of space have become important consensus in the world.</p> <p>O2. The rapid development of science and technology provides a rich means of access to space, space utilization and space control.</p> <p>O3. The willingness of space cooperation among major western countries is obvious, and space cooperation is deepening.</p> <p>O4. The space powers do not want space security to deteriorate due to their own safety and development considerations, and they are willing to maintain space security.</p>	<p>T1. The outer space is in disorder, the environment such as space debris is deteriorating, and space security is threatened.</p> <p>T2. The competition in the "public domain" of outer space is increasing, and the hidden dangers of space militarization and space weaponization cannot be underestimated.</p> <p>T3. Space powers seek space hegemony and use space to intervene in other countries. Space peace faces serious challenges.</p> <p>T4. Space international regulations are not binding, and space competition is increasingly fierce, and space security cannot be guaranteed.</p> <p>T5. Technological development has made the threshold for entering space lower and lower, and the vulnerability of space systems and the uncertainty of space threats have made space security increasingly challenging.</p>

3.2 Quantitative Analysis of the Key Factors in SWOT Model

The relative importance of each factor was compared between any two by the decision makers participating in the evaluation, and the judgment matrix A was obtained by AHP method, as shown in table 3. The maximum Characteristic root value λ_{\max} of the judgment matrix A is calculated, and tested for consistency. Similarly, the relative importance of internal strengths S , weaknesses W , external opportunities O and threats T was compared between any two, and the judgment matrix S, W, O, T are obtained in turn.

Table 3. Judgment Matrix of Space Security Eevelopment Strategy

A	Strenghts S	Weaknesses W	Opportunities O	Threats T
Strenghts S	1	4	3	2
Weaknesses W	1/4	1	1/3	4
Opportunities O	3	3	1	3
Threats T	1/2	1/4	1/3	1

Table 4. Judgment Matrix S of Space Security Development Strategy

Strenghts S	S1	S2	S3	S4	S5
S1	1	5	1/3	6	7
S2	1/5	1	1/5	1/3	1/5
S3	3	5	1	1/3	5
S4	1/6	3	3	1	5
S5	1/7	5	1/5	1/5	1

Table 5. Judgment Matrix W of Space Security Development Strategy

Weakness w	w	w2	w3	w4	w5
w1	1	3	3	1/3	5
w2	1/3	1	1/3	1/5	7
w3	1/3	3	1	1/5	5
w4	3	5	5	1	5
w5	1/5	1/7	1/5	1/5	1

Table 6. Judgment Matrix O of Space Security Development Strategy

Opportunities O	O1	O2	O3	O4
O1	1	1/3	3	1/5
O2	3	1	5	1/3
O3	1/3	1/5	1	1/3
O4	5	3	3	1

Table 7. Judgment Matrix T of Space Security Development Strategy

Threats T	T1	T2	T3	T4	T5
T1	1	1/5	1/3	3	1/3
T2	5	1	3	7	3
T3	3	1/3	1	3	5
T4	1/3	1/7	1/3	1	3
T5	3	1/3	1/5	1/3	1

Passing the consistency test of CI, RI and CR indicators, the eigenvalues and eigenvectors of the judgment matrix mentioned above can be used as the basis for weight calculation.

Table 8. Total Hierarchical Order of Total Target by Internal and External Factors

	X1	X2	X3	X4	X5
S	0.1310	0.0148	0.1120	0.0946	0.0321
W	0.0373	0.0192	0.0239	0.0738	0.0071
O	0.0515	0.1013	0.0335	0.1910	
T	0.0075	0.0346	0.0189	0.0074	0.0085

Then, the intensity of the factors summarized above was graded. Referring to the relevant literature study, we divided the intensity into 10 levels, where the factor intensity strength (S) and opportunity (O) are expressed by positive values, taking 1~10. The factor intensity of weakness (W) and threat (T) are expressed in negative values, taking -10~-1. The bigger the absolute value, the bigger the factor intensity. 10 experts were asked to grade various factors, and the DeLphi method was applied [2]. After three rounds of collection of opinions and information feedback, the consistent results were obtained, as shown in table 9.

Table 9. Intensity Rating Scale of Internal and External Factors

S ₁	S ₂	S ₃	S ₄	S ₅
8	7	6	4	4
W ₁	W ₂	W ₃	W ₄	W ₅
-7	-5	-5	-8	-4
O ₁	O ₂	O ₃	O ₄	
7	6	6	5	
T ₁	T ₂	T ₃	T ₄	T ₅
-6	-7	-7	-5	-8

3.3 Construction of Strategic Quadrilateral

According to the calculation formula of total intensity, the total intensity of S, W, O, and T are calculated as follows:

$$\text{Total intensity of strength } FS = \sum_i^5 S_i \cdot X_i = 2.3306$$

$$\text{Total intensity of weakness } FW = \sum_j^5 W_j \cdot X_j = -1.0955$$

$$\text{Total intensity of opportunity } FO = \sum_k^4 O_k \cdot X_k = 2.1248$$

$$\text{Total intensity of threat } FT = \sum_h^5 T_h \cdot X_h = -0.5236$$

After determining the total order of each influencing factor of SWOT for strategic selection, the SWOT quadrilateral can be used for strategic selection. Use the four variables, S, W, O and T, as semi-axes to form a four-half-dimensional coordinate system.

Corresponding points S₁, W₁, O₁ and T₁ of FS, FW, FO, FT are found respectively in the four-half-dimensional coordinate system. The strategic quadrilateral can be obtained by connecting four points in sequence with line segments, as shown in figure 1.

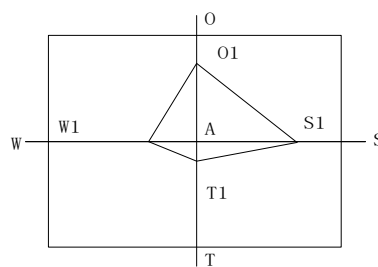


Figure 1. Strategic quadrilateral

Then the following calculation can be obtained:

$$S_{SAT} = \frac{1}{2} \overline{S_1A} \cdot \overline{T_1A} = \frac{1}{2} \times 2.3306 \times 0.5236 = 0.6101$$

$$S_{SAO} = \frac{1}{2} \overline{S_1A} \cdot \overline{O_1A} = \frac{1}{2} \times 2.3306 \times 2.1248 = 2.4760$$

$$S_{OAW} = \frac{1}{2} \overline{O_1A} \cdot \overline{W_1A} = \frac{1}{2} \times 2.1248 \times 1.0955 = 1.1639$$

$$S_{WAT} = \frac{1}{2} \overline{W_1A} \cdot \overline{T_1A} = \frac{1}{2} \times 1.0955 \times 0.5236 = 0.2868$$

Therefore, the order of strategic choices can be obtained as follows: SO > WO > ST > WT.

At the same time, the barycenter coordinate P (X, Y) of strategic quadrilateral was calculated:

$$P(X, Y) = \left(\frac{\sum x}{4}, \frac{\sum y}{4} \right) = (0.6175, -0.8006)$$

3.4 Determination of Specific Strategies

For the same type of strategy, we can either adopt a proactive attitude or a stable and conservative attitude. Therefore, for the same type of strategy, the strategic intensity should also be determined. The positive strategic intensity is defined as: $U = O_1 \cdot S_1$, that is, the positive strategic intensity is the result of the interaction of external opportunities and internal strengths. The negative strategic intensity is the result of the interaction of external threats and internal weaknesses. The formula is $V = T_1 \cdot W_1$.

What kind of intensity should be adopted should be considered comprehensively positive strategic intensity and negative strategic intensity. For that, we can judge by calculating the strategic intensity coefficient. The strategic intensity coefficient ρ is defined as $\rho = U/(U+V)$, and the magnitude of ρ reflects the implementation intensity of the strategic type, $\rho \in [0, 1]$. With the increase of U value, the strategic intensity coefficient increases, indicating that the strategic intensity increases. When V value increases, the strategic intensity coefficient decreases, indicating that the strategic intensity decreases. Generally, 0.5 is used as the critical point. The exploiting strategy is adopted when $\rho > 0.5$. When $\rho < 0.5$, the conservative strategy is adopted. When analyzing SWOT model, strategic type is identified by strategic azimuth θ , and strategic intensity is judged by strategic strength coefficient ρ . Then the schematic diagram of strategic type and strategic intensity is made (see figure 2).

According to the coordinates of the barycenter, calculate θ , U , V and ρ respectively. The results are as follows:

$$\theta = \arctan \left(\frac{Y}{X} \right) = 52.3559^\circ$$

$$U = O_1 \cdot S_1 = 4.9520$$

$$V = T_1 \cdot W_1 = 0.5736$$

$$\rho = \frac{U}{U + V} = 0.8962$$

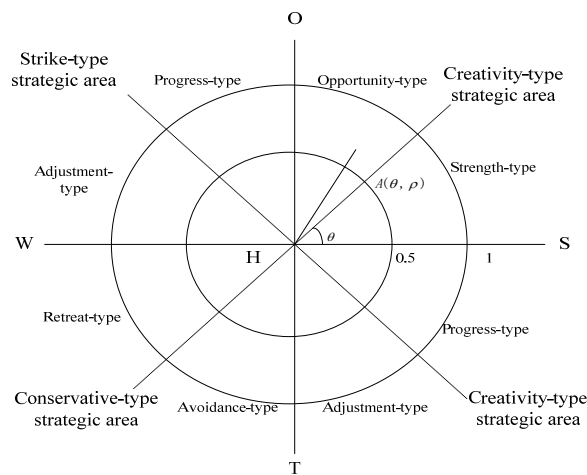


Figure 2. Schematic diagram of strategic type and strategic intensity

3.5 Conclusion

According to the calculation, the strategy should be selected, and it is an opportunistic strategy. The SWOT analysis matrix of space security development is shown in table 2. On the occasion, We should rely on the space power strategy, seize the opportunities of international space development, actively promote the national space development strategy, promote the in-depth development of national space policy, strengthen technical research, use a complete industrial system, promote the

development of the aerospace industry, and actively strengthen the development level of aerospace equipment. Carry out cooperation and exchanges, strengthen the training of aerospace talents, improve the overall ability and quality of space talents; promote the transformation of space research results, and the strategic development of military-civilian integration.

4. Summary

In this paper, AHP-SWOT method is used to analyze the space security development strategy, which is only one of many methods to study the development strategy. It is proved that AHP-SWOT analysis method can well combine qualitative analysis with quantitative analysis, it can help make relatively scientific, accurate and reliable development strategies. However, it must be pointed out that the correlation between various factors still needs to be further considered. And the space security development strategy is complex and systematic, which is limited by many realistic factors. Therefore, how to ensure the comprehensiveness of strategic analysis and the accuracy of calculation remains to be further studied.

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