A Development of Group Decision Support System for Strategic Item Classification using Analytic Hierarchy Process

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1. Introduction

Korea has carried out export controls on nuclear items that reflect the Nuclear Suppliers Group (NSG) guidelines [1] (Notice on Trade of Strategic Item [2] of Foreign Trade Act) since joining the NSG in 1995.

Nuclear export control starts with classifications that determine whether export items are relevant to nuclear proliferation or not according to NSG guidelines. However, due to qualitative characteristics of nuclear item definition in the guidelines, classification spends a lot of time and effort to make a consensus.

The aim of this study is to provide an analysis of an experts' group decision support system (GDSS) based on an analytic hierarchy process (AHP) for the classification of strategic items.

2. Strategic Item Classification

In the Notice on Trade of Strategic Item, 51 major nuclear items are defined, with the exception of uranium concentration and reprocessing equipment. Uranium cannot be produced in Korea according to the ROK-U.S. civil nuclear cooperation agreement. However, application for classification11 items in Table I and their related software and technology have been made.

In case of goods, distinguishing whether it is strategic item related parts or not is difficult. There is no specific criteria used to define nuclear item related technology. Therefore, group discussions regarding the classification of strategic items have been discussed by the export control division of KINAC. Nevertheless, due to subjective opinions about the criteria of classification, it is not easy to reach consensus. To solve this problem, a GDSS based on an AHP has been proposed and analyzed for group decision-making of classifying items.

Table I: NSG Part I items related to nuclear reactor

Control No.	Name	Description
0A001.a	Complete nuclear reactors	Nuclear reactors capable of operation so as to maintain a controlled self-sustaining fission chain reaction
0A001.b	Nuclear reactor vessels	Metal vessels, or major shop-fabricated parts especially designed or prepared to contain the core of a nuclear reactor
0A001.c	Refueling machine	Manipulative equipment especially designed or prepared for inserting or removing fuel in a nuclear reactor
0A001.d	Nuclear reactor control rods and equipment	Especially designed or prepared rods, support or suspension structures to control the fission process in a reactor
0A001.e	Nuclear reactor pressure tubes	Tubes especially designed or prepared to contain both fuel elements and primary coolant in a reactor
0A001.f	Nuclear fuel cladding	Zirconium metal tubes or zirconium alloy tubes especially designed or prepared for use as fuel cladding in a reactor
0A001.g	Primary coolant pumps or circulators	Pumps or circulators especially designed or prepared for circulating the primary coolant for nuclear reactor
0A001.h	Nuclear reactor internals	Especially designed or prepared for use in a nuclear reactor. Ex) support columns for the core, fuel channels, diffuser plates
0A001.i	Heat exchangers	(a) Steam generators especially designed or prepared for the primary, or intermediate, coolant circuit (b) Other heat exchangers especially designed or prepared for use in the primary coolant circuit
0A001.j	Neutron detectors	Especially designed or prepared neutron detectors for determining neutron flux levels within the core or a reactor
0A001.k	External thermal shields	Especially designed or prepared for use in a nuclear reactor for reduction of heat loss and containment vessel protection

3. GDSS based on AHP

The AHP is a multi-criteria decision model based on mathematics and psychology. It helps decision makers find the best alternatives by providing a comprehensive and rational framework for structuring a decision and for representing and quantifying its elements. It has advantages of measuring consistency, hunting down outliers, and offering anonymity, etc. [3], [4]

3.1 Structuring the decision hierarchy

In order to apply AHP to the GDSS for classification, a problem is divided into a hierarchy of more easily comprehended sub-problems, each of which can be analyzed independently. In Fig. 1, shows a hierarchy of group of decision-making for classification.

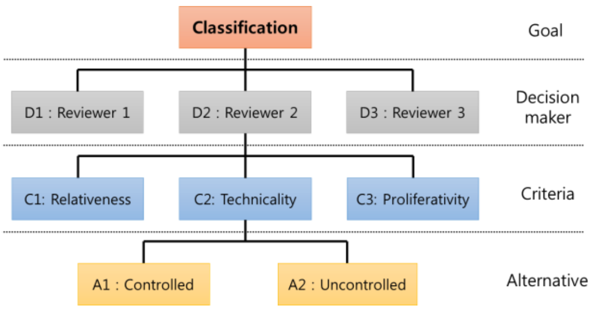

Fig. 1. AHP hierarchy for classification

3.2 Constructing comparison matrices

To make comparisons, a scale of numbers that indicates how many times one particular element is more important than another, with respect to how they are compared, is needed. The scale is represented from 1 to 9 in Fig. 2. [5]

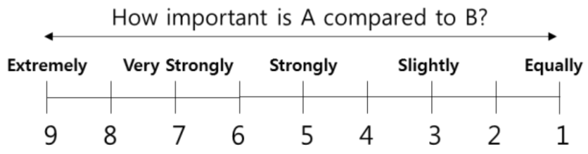

Fig. 2. Scale of measurement for AHP

In this study, we have selected relativeness, technicality, proliferativity as the criteria to quantify attributes of the problem, and to reflect each reviewer's opinion objectively. The alternative should be either "controlled" or "uncontrolled".

In decision-making process, it is possible to include decision error by psychological variation. Therefore, an error model, which is represented as geometric mean, is applied to synthesize a reviewer's characteristic value in a pairwise comparison matrix.

Since the actual classification data is confidential, a dummy value is used only to analyze the GDSS characteristics. Pairwise comparison matrixes for each criteria are shown in Table II, III.

Table II: Pairwise comparison matrix for the subcriteria

C1: Relativeness

	A1: Controlled	A2: Uncontrolled
A1: Controlled	1	7
A2: Uncontrolled	1/7	1

C2: Technicality

	A1: Controlled	A2: Uncontrolled
A1: Controlled	1	5
A2: Uncontrolled	1/5	1

C3: Proliferativity

	A1: Controlled	A2: Uncontrolled
A1: Controlled	1	3
A2: Uncontrolled	1/3	1

Table III: Pairwise comparison matrix of the main criteria

	Relativeness	Technicality	Proliferativity
Relativeness	1	5	7
Technicality	1/5	1	3
Proliferativity	1/7	1/3	1

3.3 Priority calculation

From pairwise comparison matrixes, eigenvectors will be derived as outlined below. The consistency index (CI) represent the consistency of response, which is calculated as $\mathrm{C.I.} = (\lambda_{max} - n)/(n-1)$. Normally, C.I. under 0.1 means that the response has consistency.

$$W_{C1}^{T} = (0.875, 0.125), \mathrm{C.I.} = 0$$
$$W_{C2}^{T} = (0.833, 0.166), \mathrm{C.I.} = 0$$
$$W_{C3}^{T} = (0.750, 0.250), \mathrm{C.I.} = 0$$
$$W_{C} = (0.731, 0.188, 0.081), \mathrm{C.I.} = 0.01$$

Using eigenvectors, the priority of alternatives can be calculated. From the results below we can decide if an item should be controlled.

A1. Priority of controlled

$$0.731 \times 0.875 + 0.188 \times 0.833 + 0.081 \times 0.750 = \mathbf{0.857}$$

A2. Priority of uncontrolled

$$0.731 \times 0.125 + 0.188 \times 0.166 + 0.081 \times 0.250 = \mathbf{0.143}$$

3. Conclusions

In this study, we have applied an analytic hierarchy process method to a group decision support system for strategic item classification in order to identify the feasibility of this method.

The results of this study clearly demonstrated that a GDSS based on an AHP proved positive, systematically providing relative weight among the planning variables and objectives. By using an AHP we can quantify the subjective judgements of reviewers. An order of priority is derived from a numerical value. The verbal and fuzzy measurement of an AHP enables us reach a consensus among reviewers in a GDSS. An AHP sets common weight factors which are a priority of each attribute that represent the views of an entire group. It makes a consistency in decision-making that is important for classification.

It remains to be seen how specifying criteria to represent qualitative evaluation can adequately reflect the experience and knowledge of each reviewer. In order to also supplement a GDSS, a subsidiary decision-making method (cognitive mapping, Dialectical approach, Brainstorming, Devil's advocate, Nominal group technique) can be applied.

REFERENCES

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