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Causal Loop-based Modeling on System Dynamics for Risk Communication

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1. Introduction

It is true that a national policy should be based on public confidence, analyzing their recognition and attitude on life safety, since they have very special risk perception characteristics. For achieving effective public consensus regarding a national policy such as nuclear power, we have to utilize a risk communication (hereafter, calls RiCom) process. However, domestic research models on RiCom process do not provide a practical guideline, because most of them are still superficial and stick on an administrative aspect. Also, most of current models have no experience in terms of verification and validation for effective applications to diverse stakeholders.

This study focuses on public's dynamic mechanism through the modeling on system dynamics, basically utilizing casual loop diagram (CLD) and stock flow diagram (SFD), which regards as a critical technique for decision making in many industrial RiCom models.

2. Overview of Modeling

2.1. Simulation for System Dynamics

There are 3 objectives for the simulation, i.e. demonstration, education and training, and solving problem. In terms of modeling process, we want to focus on the third objective. Actually, in order to solve a dynamic problem, we can choose a trial-and-error as a simulation technique for any scenarios. In terms of an academic subject, the name of "system dynamics" is used for simulation technique. The "system" means a set of given problems and related variables, not a physical system. Also, the "dynamics" means that a system change in some time interval is considered.

2.2. Overview of Causal Loop Diagram (CLD)

As a qualitative system dynamics model, CLD shows simple relationship between factors, therefore, has a big advantage in terms of easy understanding, even though we are not an expert. We can divide system dynamic characteristics into external factors and internal factors.

Let's take an example, the market model. In the model, external factors such as economic growth rate, a price index, etc. have dynamic characteristics by themselves, sub-factors relating with the factors also have similar characteristics. On the other hand, a system can have dynamic characteristics due to some internal factors such as a total stock. That is why we need a model of system dynamics.

In the modeling process of system dynamics, it is also important to define "customer." Relating with a customer, political variables and objective variables are selectively provided. "A political variable" can be managed by a customer. "An objective variable" is a variable concerned by a customer. It is essential to reflect the effectiveness of political variables into objective variables. "System boundary" is the other important element in the system dynamics. By accurately defining the system boundary, we can easily define above variables.

3. Development Process of CLD Model

3.1. Basic CLD model

In this study, diverse variables and related specific factors affecting the delay and/or troubles of RiCom are considered in the reference for specifying S-M-C-R-E models [1]. Those variables and factors will support to make comprehensive and strategic approach for overcoming failures in terms of RiCom process. Many sub-CLDs are used for identifying the structure and causal relationship of delaying variables, which utilizes analytical tool such as VENSIM software.

It is noted that RiCom processes were diversely performed in terms of the scope, characteristics, and participation types due to the inter-relationship between stakeholders. Because of these features of RiCom process, the types of failure and delay were also diverse. In this study, special characteristics for creating residents' opposition are identified, considering circumstances of publicity and internal planning problems, except budget.

3.2. Detailed CLD model

3.2.1. Internal circumstances

The steps of risk communication consist of closed loop – from participation demand & negotiation, through convergence of public opinion and planning adjustment, up to implementation and accumulation of outcomes of negotiation, and feedback.

Affecting factors of participation demand & negotiation are level of cooperation, demand by residents, conflict level of residents, incentive level, and so on. Affecting factors of convergence of public opinion and planning adjustment are public attitude on government policy, public risk perception, and so on. Also, affecting factors of active participation by

residents are sharing information, and public confidence especially in case of occurrence of incidents.

3.2.2. External circumstances

In general, succeeding factors of negotiation for resolving conflict are an incentive criteria by government, existence of conference system, and on-going connectedness, etc. It is noted that the residents are willing to establish the basis for reflex of opinion, for example, by deriving active participation from diverse public interest groups.

3.3. Development of Stock Flow Diagram (SFD)

SFD is a special CLD in quantitative form. Therefore, most of the feedback occurred in CLD must be reflected in SFD. Fig. 1 shows a SFD developed in this study for providing a relationship between factors and variables affecting participation demand & negotiation.

In defining variables' value, we used NUMBER technique. The NUMBER stands for normalized unit modeling by elementary relationship. It usually used for transferring CLD to the model of system dynamics, establishing fundamental relationship between level variables and varying variables.

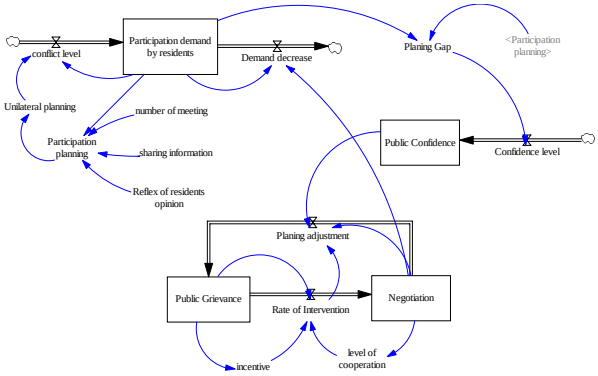

Fig.1. SFD for RiCom Simulation

4. Simulation Results

After simulating RiCom process for expecting participation demand & negotiation, from adopting models of corresponding CLD and SFD, it is noted that (1) negotiation can easily change the level of residents' participation, (2) ultimately, it causes great difference on outcomes of planning. Also, participation demand & negotiation can be changed by the level of conflict and planning adjustment rate.

Fig. 2 shows daily changes of conflict level and planning adjustment in terms of progression of negotiation. As expected, the planning is much adjusted at initial stage, so the level of conflict is reduced, following negotiation progression. The figure also depicts that there is a top point in terms of maximum effectiveness of negotiation, and at that time, the level of conflict is highly minimized. Therefore, most of residents' conflict may depend on the incentive based on negotiation, and other planning adjustment.

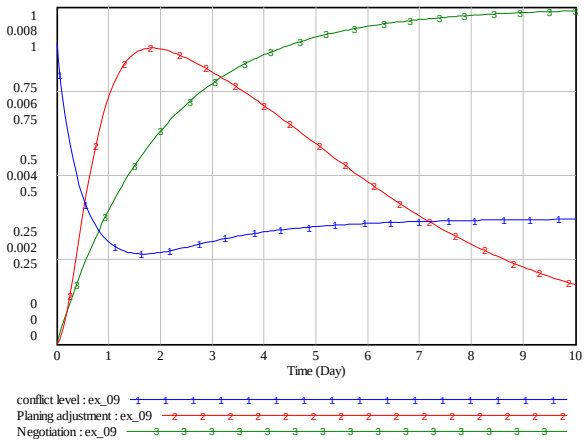

Fig.2. Changes of residents' conflict level, planning adjustment, and negotiation in the simulation

5. Conclusions

This paper has a major objective for identifying causes and structure in delaying risk communication using a tool of system dynamics (so, CLD and SFD).

The results of simulation of system dynamics model show that there is a little effectiveness of planning in the initial stage of negotiation process; however, there is a relatively-great effectiveness of planning after the ending stage of negotiation. It is also noted that the factor on sharing information is most important for their effectiveness.

The modeling used in this study can be easily adopted in actual cases for enhancing risk communication reflecting negotiation and public confidence, in terms of successfulness of policy planning.

REFERENCES

[1] W. J. Kim, et al., *A Study of Casual Loop Diagram Modeling of the Nuclear Policy Communication,* KINS/HR-920, U-Plus/KINS (2009).