

# Proposal of an Assurance Case Description Method Considering External Environment of Systems: Application to Operation of an Ice-Skating Rink

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— *Review of* —  
**Integrative  
Business &  
Economics**

— *Research* —

## ABSTRACT

This study aims to 1) propose an assurance case description method which allows considering simultaneously the inside of a system, and the assumed changes outside the system, and 2) evaluate whether the proposed method contributes to business improvement for the operation of a Japanese ice-skating rink run by a company. Japanese ice-skating rinks have a difficulty with year-round operation; only about 20% are open all year, during not only summer but winter. If they obtain assurance of profits as a commercial enterprise, year-round operation of ice-skating rinks will be feasible. The previous study refers to discussion using assurance cases for improving the feasibility of accomplishing management vision and management strategy. This study determines, through an interview to the ice-skating rink manager by using an assurance case, whether what are described in the assurance cases can be realized. As a result, this study visualizes what can and cannot be accomplished. Description of assumed changes in the external environment enables the user to recognize changes in the external environment. This study thereby evaluates through an interview whether the operation of the ice-skating rink can change. Finally, we conclude with future research topics.

Keywords: Assurance Case, Dependability-Case, Ice skating, Business improvement.

Received 13 July 2018 | Revised 21 October 2018 | Accepted 14 November 2018.

## 1. INTRODUCTION

Japanese ice skating rinks have a difficulty with year-round operation; only about 20% are open all year, not only during summer but winter. (JAPAN SKATING FEDERATION) If they obtain assurance of profits as a commercial enterprise, year-round operation of ice skating rinks will be feasible. Referring to glacier skiing, which is skiing on large glaciers regardless of season including summer, Yokoyama (2007) shows the advantage of running glacier skiing business throughout the year.

Ice skating rinks, however, cannot start all-year operation only with their internal changes. If so, many ice skating rinks would be operating throughout the year. This study thus assumes the necessity of assumed changes in the external environment so that ice skating rinks can start operating throughout the year. Recognizing the relationship between “assumed changes in the external environment” and “corporate sales”, however, is difficult. The reason is that what people think varies as to how changes in the external environment affect corporate sales.

Kobayashi et al. showed that using assurance cases (ISO 15026-2-2011 (2011)) improves the feasibility of accomplishing management vision and management strategy (Kobayashi et al. (2018a)). This study uses an assurance case to visualize the user’s understanding of changes in the external environment since assurance cases can show the relationship between changes in the external environment, and the influence to the company’s judgement. In other words, this study first proposes an assurance case description method, which allows considering simultaneously the inside of a system, and the assumed changes outside the system. Subsequently, we assess if the proposed assurance case description method addresses the problem.

This study thereby tries to evaluate whether the proposed description method using assurance cases contributes to business improvement of an ice skating rink’s operation throughout the year. Specifically, we cooperated with a Japanese ice skating rink run by a company, and conducted an interview using an assurance case to the rink manager.

Next, we will describe the novelty of this study. To describe the literature first, with regard to assurance case description methods, Kaneko (2014) demonstrated models relevant to assurance cases. Information security based on Common Criteria was described with the use of a Logical Model and a Concrete Model. Kobayashi et al. (2016) proposed a method of creating an assurance case for a business process by using a Logical Model and a Concrete Model. Kobayashi et al. (2017) proposed an assurance case description method connecting the management vision, management strategy and business process, while Kaneko (2014), and Kobayashi et al. (2016) focused on a specific layer of the hierarchical structure of an assurance case. Kobayashi et al. (2018b) proposed an assurance case description method to reduce misunderstanding caused by the differences of grasping the objects that are managed in various departments as a monolithic system or System of Systems (SoS). What differentiates this study is that we consider not only the internal of the managed subject but also the assumed changes outside the managed subject. Yokoyama (2007) showed the advantage of running glacier skiing business throughout the year, but did not discuss how to logically assure the operation of ice skating rinks throughout the year.

The novelty of this study is therefore two-fold. First, we propose a method which allows considering simultaneously the inside of a system, and the assumed changes outside the system. Second, the proposed method logically assures the operation of ice skating rinks throughout the year.







This study determines, through an interview to the rink manager, whether what are described in the assurance case can be realized. As a result, this study visualizes what can and cannot be accomplished. Description of assumed changes in the external environment enables the user to recognize changes in the external environment. This study thereby evaluates through an interview whether the operation of the ice skating rink can change. Furthermore, we show that the findings obtained from the results of

this study suggest that the results of Evidence nodes change in accordance with the results of Monitoring nodes. Finally, we conclude with future research topics.

## 2. PREVIOUS STUDIES

A safety case has been proposed by Kelly (1998) in 1998 as a means for performing clear, complete and reasonable discussion. Using the safety case helps the operation reach an acceptable level in terms of safety between stakeholders. An assurance case (Menon et al. (2009)) extends the discussion area to the whole quality of the discussed system including the “safety” proposed in the safety case. An assurance case is mainly an assurance method using six nodes, including Goal, Context, Strategy, Evidence, Monitoring and Undeveloped. (GSN Community. (2011)) (Matsuno et al. (2010)) These six nodes are shown in Table 1.

Table 1. Six nodes in assurance cases.

Node	Figure	Explanation
Goal		Goal describes what to assure, with a combination of a subject and predicate.
Strategy		Strategy describes how to break down the Goal into sub-goals leading to the lower layer.
Context		Context describes the state, or environment and conditions of the System, and shows ways to lead to the Goal and Strategy.
Evidence		Evidence eventually assures that we can reach the Goal, and shows ways to lead to the Goal.
Monitoring		Monitoring is intended to represent Evidence available at runtime, corresponding to the target values of in-operation ranges.
Undeveloped		Undeveloped shows the status that there is no Evidence or Monitoring, or discussion supporting the Goal.

## 3. PROPOSED DESCRIPTION METHOD

First, we describe the concept of the proposed description method.

Step 1: Define the goal that the system should achieve.

Step 2: Separate the inside of the system and the outside of the system, by using the Strategy node. For the inside of the system, the user can describe it using the existing method. For the outside of the system, we use the Monitoring node for the Goal node since the outside of the system indicates assumptions, and we cannot use the Evidence node for the Goal node. Subjects that affect the goal to be achieved should be monitored. In this case, it is the number of new customers on a monthly basis in Figure 1.

We confirm that linking the Monitoring node outside the system to the Evidence node inside the system (shown with a dotted arrow in Figure 1) leads to an excess of a certain figure. The reason is that when the monitoring results exceed the certain figure based on the monitoring results, achievement to the top goal can be agreeable.

This description method is however limited in that:

- Assumptions are not always correct.
- Monitored subjects are not always correct.
- Monitoring results do not necessarily become the evidence that affects the inside of the system.

Existing assurance case description methods also involve these limitations, and assure the agreement among participants. Thus, this study uses the same way.

Next, we will describe the procedure to apply our proposed method to an ice skating rink. The Japanese ice skating rinks need to attract more customers in order to make profits throughout the year. If they take measures to address the reasons they currently fail in attracting the customers, the number of customers would increase. They can then expect an increased profit.

The proposed description method is an assurance case description method that makes it possible to show “the measures” and “the expected profit from the increased number of customers who are attracted by the measures.” Using the proposed method, we monitored the impact of the company’s strategies and others, and visualized how it affected the company’s business management. In other words, using the assurance cases assures the business by showing in Evidence node the increased profit that is expected due to the increased number of customers, as well as grasping in Monitoring node the increased number of new customers on a monthly basis. The description results of the proposed method are shown in Figure 1.

In the rest of this chapter, we will show the steps of the proposed description method.

Step 1: Set the Goal node.

Step 2: For the Strategy node, divide the Goal into sub-goals (the business management, and the social contribution). The assumed change of the external environment in this case is regional revitalization. Regional revitalization (external environment) will increase the number of new customers on a monthly basis (internal environment).

Step 3: Set the sub-goals underneath the Strategy node. Assume Step 3 to be Step 1, and repeat this process until sub-goal nodes are completely decomposed.

Step 4: Set the Evidence nodes or the Monitoring nodes for the Goal nodes.

Step 5: Check the relationship between the Monitoring nodes and the Evidence nodes.

Step 6: Draw a dotted arrow from the Monitoring node to the Evidence node for the result of Step 5.

As a result, we can show with the dotted arrow in Figure 1 the relationship between the prospected plan for the expected performance as described in the Evidence node, and the increased number of customers on a monthly basis as described in the Monitoring node.

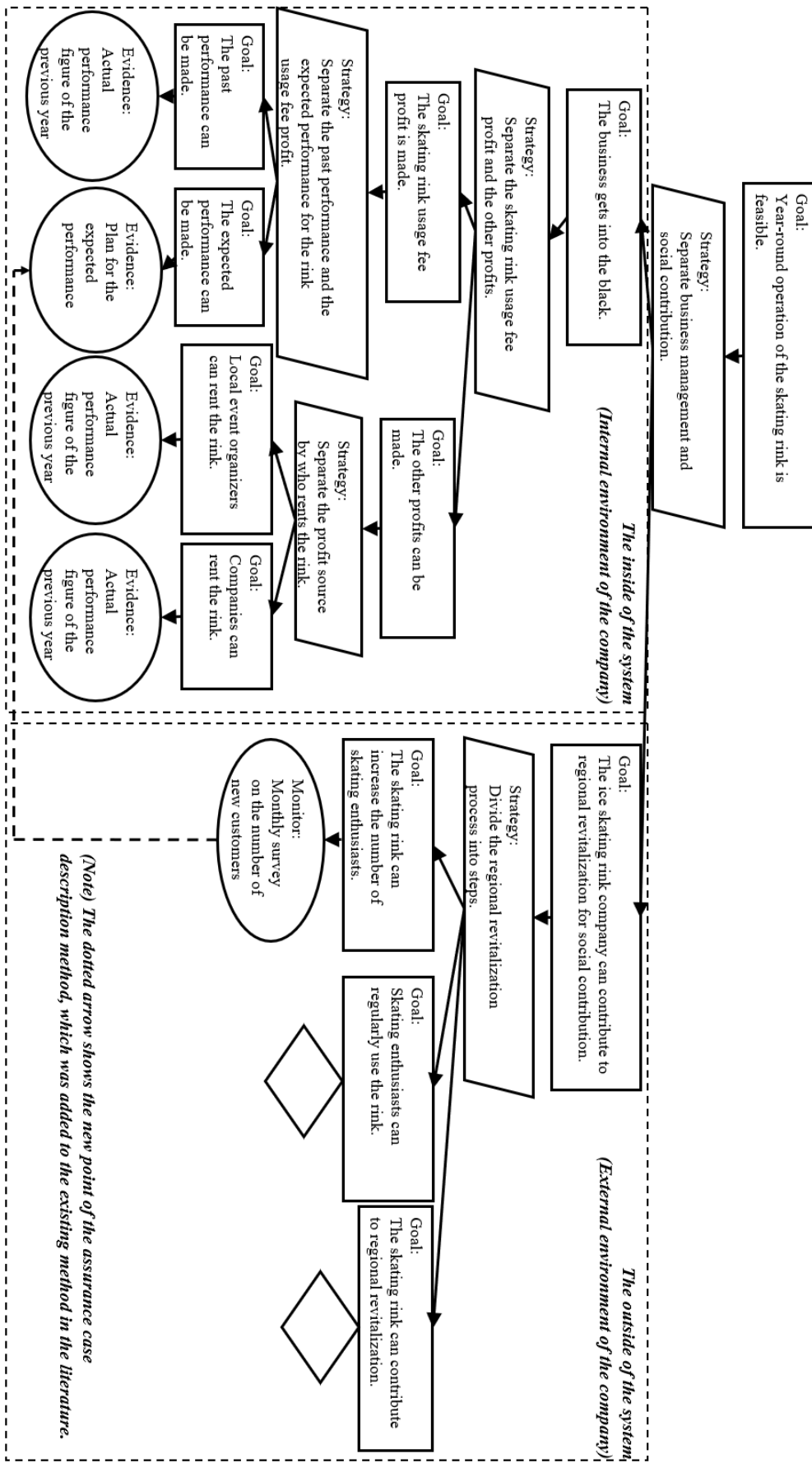


Figure 1. Results of using the proposed description method.

## 4. EVALUATION AND DISCUSSION

### 4.1. Evaluation Methods

Figure 2 shows the relationship among evaluation methods and evaluation points.

First, this study evaluates whether the user can create an assurance case.

Second, this study determines, through an interview to the rink manager, whether what are described in the assurance case can be realized. This study thereby visualizes what can and cannot be accomplished.

Third, this study evaluates through an interview whether the operation of the ice skating rink can change.

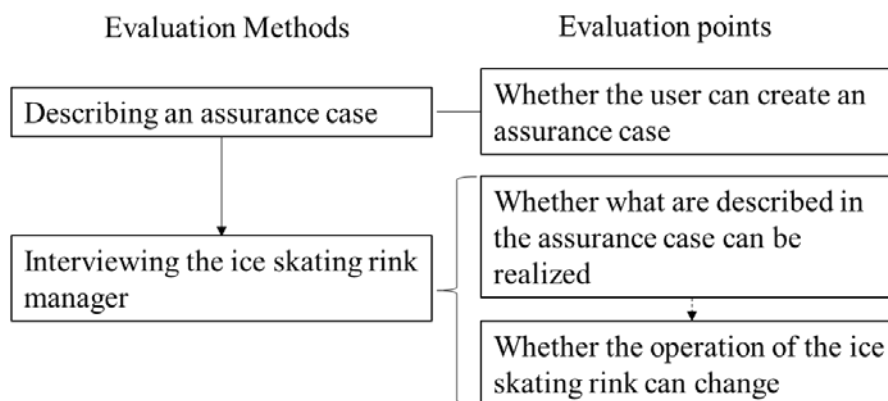


Figure 2. A relationship among evaluation methods and evaluation points.

### 4.2. Evaluation Results

The assurance case description results are shown in Figure 1. The user of the assurance case was the rink manager, an employee of the ice skating rink with the working experience over 20 years.

The user gave comments as shown in Table 2 as to whether what are described in the assurance case can be realized, and whether the operation of the ice skating rink can change.

Table 2. Comments on whether what are described in the assurance case can be realized, and whether the operation of the ice skating rink can change.

Comments
The assurance case shows ways to realize year-round operation, but there still remain many issues that are not described in the assurance case.
The reason ice skating rinks cannot operate throughout the year is that the business is not profitable enough.
Realization of the year-round operation depends on which the management policy will focus on, regional revitalization or business.
When the focus of the management policy changes between regional revitalization and business as time goes by, employees' views on business operation also change.

We need to consider the expected increase in the number of new customers on a monthly basis as well as the expected growth in performance.
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Given many ways for regional revitalization, we need to consider all of them.
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### 4.3. Discussion

First, this study evaluated, by using the results shown in Figure 1, whether the user can describe the assurance case, in other words, the effectiveness of the proposed method. If the user cannot create the assurance case, Figure 1 does not show the assurance case created. Second, this study evaluated, through an interview to the rink manager, whether what are described in the assurance case can be realized, and evaluated through an interview whether the operation of the ice skating rink can change.

Now we will discuss the interview comments.

“The assurance case shows ways to realize year-round operation, but there still remain many issues that are not described in the assurance case.”: This comment shows that creating an assurance case leads to addressing other issues since the users consider what are not described in the assurance case as well.

“The reason ice skating rinks cannot operate throughout the year is that the business is not profitable enough.”: This comment shows that year-round operation is not profitable. Profitability needs to be indicated in the assurance case.

“Realization of the year-round operation depends on which the management policy will focus on, regional revitalization or business.”: This comment shows that the user recognized the issues to consider for realizing year-round operation. In other words, description of assumed changes in the external environment enables the users to recognize changes in the external environment.

“When the focus of the management policy changes between regional revitalization and business as time goes by, employees’ views on business operation also change.”: This comment shows that the evaluation points for realizing year-round operation can change. The user discussed as such, using an assurance case. In other words, description of assumed changes in the external environment enables the users to recognize changes in the external environment.

“We need to consider the expected increase in the number of new customers on a monthly basis as well as the expected growth in performance.”: This comment shows that the items indicated by the dotted arrow in Figure 1 are necessary. The comment shows that the items connected with the dotted arrow in Figure 1 are necessary. The user, using assurance cases, discussed the way to realize year-round operation as he pointed his fingers at nodes.

“Given many ways for regional revitalization, we need to consider all of them.”: This comment shows that considering and describing further layers are necessary. In other words, discussion on the way to realize year-round operation was enhanced.

This study therefore indicated that what are described in the assurance case can be realized if the profitability is ensured; the assumed changes in the external environment, namely regional revitalization for social contribution in this case, are judged to be effective; and the steps set for regional revitalization process are taken. This study also indicated that description of assumed changes in the external environment enables the users to recognize changes in the external environment. This study thereby suggested the operation of the ice skating rink can change.

## 5. CONCLUSIONS

This study aimed to evaluate whether the proposed description method using an assurance case contributes to business improvement of a Japanese ice skating rink, which intends to start year-round operation. Specifically, we cooperated with an ice skating rink in Japan, and conducted an interview to the rink manager by using an assurance case.

As a result, this study indicated that what are described in the assurance case can be realized if the profitability is ensured; the assumed changes in the external environment, namely regional revitalization for social contribution in this case, are judged to be effective; and the steps set for regional revitalization process are taken. This study also indicated that description of assumed changes in the external environment enables the users to recognize changes in the external environment. This study thereby suggested the operation of the ice skating rink can change.

Future research topics include:

- Visualize items to be emphasized for the management policy
- Increase application cases of the proposed assurance case description method
- Apply the proposed method to other fields related to year-round operation

## ACKNOWLEDGEMENTS

The authors thank Sara Ito, who belongs to the doctoral course of Graduate School of System Design and Management, Keio University, for her cooperation.

Nobuyuki Kobayashi, the first author of this research, is supported by Andgate Inc. (<https://www.andgate.co.jp/>).

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