Study on the Gap Measures between Recovery Time Objective and Current Recoverable Time in Business Continuity Management

Hitoshi Kawaguchi[1]

[1] Department of Social Engineering, Nagoya Institute of Technology

As a premise, an organization sets a Recovery Time Objective (RTO),[(1)] which is based on Maximum Tolerable Period of Disruption (MTPD)[(2)] and Current Recoverable Time (CRT), [(3)] as part of Business Continuity Management (BCM).[(4)] The author presents a selection model for a proposed solution to reduce the "Gap Time between RTO and CRT" (hereinafter referred to as Gap Time). The method used for Gap Time formalization is a 0-1 integer programming model. Because it comprises two models—"current recoverable time reduction maximization model (CRT model)" and "RTO achieved number maximizing model (RTO model)"—the author refers to it as the "Twin Model." These models sometimes have trade-off relationships.

Keywords: Business continuity management, Risk assessment, Business impact assessment, Recovery time objective, Maximum tolerable period of disruption

1. Background and Objectives

Generally, unexpected incidents interfere with an organization's overall performance, making its overall business continuation difficult in case of prolonged business recovery. Reducing the Gap Time between Recovery Time Objective (RTO) and its Current Recovery Time (CRT) is a major challenge of Business Continuity Management (BCM). When an organization experiences such an interruption, business continuation becomes difficult if there is no resilience allowing business restoral within its RTO. In this study, recognition of this Gap Time is performed in the Business Impact Analysis (BIA) [(5)] process. Gap Time reduction methods are developed in the Risk Assessment (RA) [(6)] process. Often, Gap Time reduction solutions cannot be created because of limited planning budgets. This study proposes a mathematical model to effectively create solutions for Gap Time reduction within a limited budget.

Section 4 (1) describes the concept which is the premise for the modeling. For example, RA is assumed to be performed by targeting the key business, after obtaining the results by BIA including the characterization of key business, critical elements/resources, and RTO.[1)2)]

Prior to this study, the author created a simple version of the CRT model. As part of that study, the author identified the following characteristics:

a) This simple CRT model simply selected solutions for reducing recovery time.
b) Some solutions selected by this simple CRT model may achieve RTO.
c) Other solutions may maximize the amount of shortening of the recovery time by sacrificing of RTO achievement.[3)]

On the basis of this simple version of the CRT model, the author created a simple version of the "RTO achieved number maximizing model" (RTO model). The author concluded that when the RTO is not achieved, despite maximization of CRT reduction, no solution could be selected.

From the BCM perspective, even though the solution cannot consistently achieve the RTO, optimally shortening the recovery time under existing conditions is critical toward business continuity. The logic behind this is that the possibility of RTO achievement increases by shortening the recovery time under existing conditions. In addition, when damage caused by an incident is minor, shortening the recovery time is effective for business continuity.

All organizations should always look to maximize the amount of recovery time shortening, and maximize the number of achieving their RTO. However, there is a trade-off between the two in some cases. It is logically impossible to simultaneously achieve both goals perfectly.[4)] Considering the BCM theory, however, both goals are important. In this situation, the priority is difficult to establish.

Therefore this study proposes a "Twin Model" that considers both models ("Current Recoverable Time reduction maximization model": CRT model and "RTO achieved number maximizing model": RTO model) as a single set. This "Twin Model" is intended to support management's judgment by providing multiple solutions to top management. Formulation of the selection method of the solution within budget is performed as a Knapsack problem by 0-1integer programming. The formal Twin Model has been used in experiments using hypothetical data. There is no special meaning to the solution obtained from hypothetical data; the solution should effectively achieve the purpose of the Twin Model as well as check the degree of specification realization. In addition, to test the trade-off between the two models, the author calculated the compromise solution using both model combinations.

2. Approach

As a measure to reduce Gap Time between RTO and CRT, this study develops a mathematical model to select the most effective solutions within a budget. This study is based on the following preceding studies.

a) The Time Gap grasping method between CRT and RTO referred to "Fig. 2: Decision Process Flow of RTO and its relevant matters" by Maruya.[6] In Fig. 2, understanding the gap between maximum tolerable period of disruption (MTPD) and CRT is required to set the RTO. In this study, reducing the Gap Time between CRT and RTO is considered as a problematic after setting RTO.
b) CRT is estimated using the pre-rate sheet method, which is a standard time setting method used in Kawashima [8] and Senjyu.[9]
c) Predicting the effectiveness of measures is based on methods such as that in Nishikawa et al.,[5] and it is therefore measured against them. The research in Nishikawa et al. employs a risk curve, which displays the size of the annual probability of exceedance and the length of the business suspension period. The score method introduced by Kon is an alternate method.[2]
d) The study is based on the "Development Process of Business Continuity Strategy" in the "Standard Text" of the Business Continuity Advancement Organization (BCAO).[7] This document addresses the BIA and RA processes. Moreover, it follows "RA conducted for key businesses selected by BIA," in Kobayashi-Watanabe [1] and Kon.[2]
e) When formulating based on the Knapsack problem to select optimal measures within the budget, the study follows the perception of the trade-off problem of Sato.[4]
f) The prioritization method for risk scenarios follows to the method of Ukagawa.[13]

This study builds on the preceding study results mentioned above; it has the following unique characteristics.

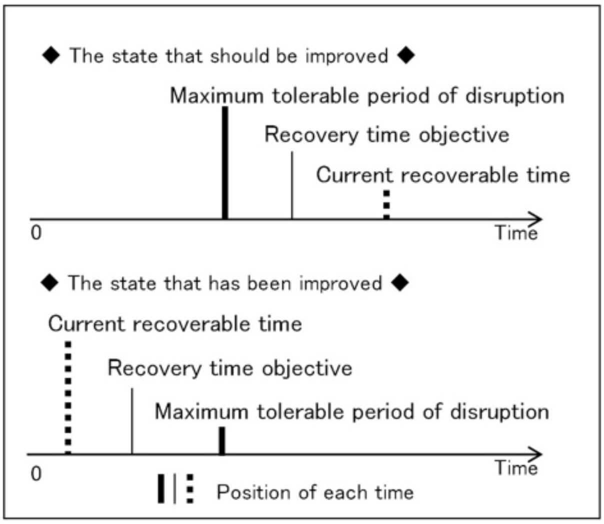
g) The author has applied to the estimation method of CRT the pre-rate sheet method—a "Setting method of work standard time" approach used on factory sites.
h) The 0-1 integer programming model for the Gap Time reduction in consideration of the trade-off problem is formulized as a Twin Model by the author.
i) This study implements a combined application of the RTO model and the CRT model as part of the numerical experiment.

3. Gap Time between RTO and CRT

(1) Recovery Time Objective (RTO)

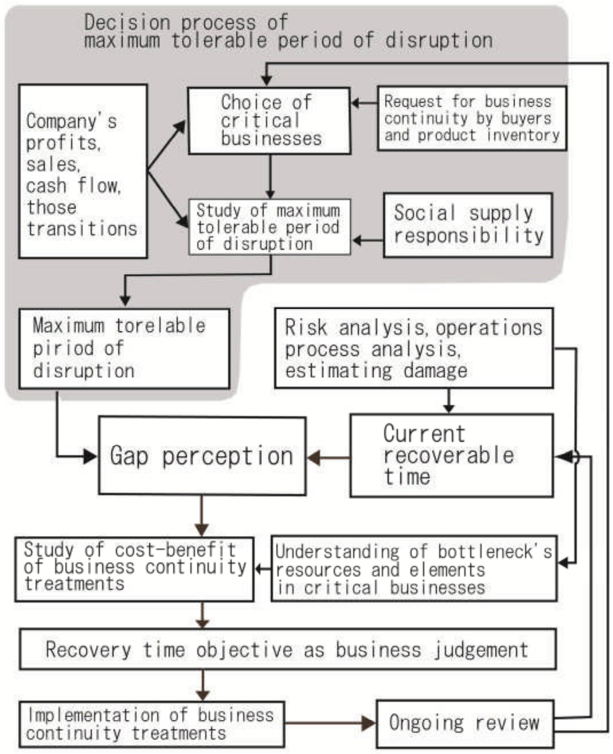
RTO (shown in Fig. 1) should be understood from three perspectives, the other two being MTPD and CRT. MTPD (shown in Fig. 2) is determined by an organization's financial ability, or by customer demand. MTPD represents the time limit of extended periods of business interruption making continuity in business operations difficult. RTO is a time objective for the recovery of resources and internal goals based on MTPD and CRT. CRT is the estimated time based on current recoverable ability (detailed in the next section).

Fig. 1 expresses typical situations before and after improvements in MTPD, RTO, and CRT. The upper part of Fig. 1 represents a state in which RTO and CRT should be less; however, the lower part represents the ideal state after the shortening of RTO and CRT. Although it would be ideal for the length of RTO to be shortened less than MTPD, and the length of CRT to be shortened less than RTO, realization of such an ideal state would incur some improvement costs to the organization.



† This figure is quoted from reference 10

Fig. 1 Concepts of Time



† This figure is quoted from reference 11 and translated into English.

Fig. 2 RTO Decision Process Flow

The RTO decision process is shown in Fig. 2. After measuring Gap Time between MTPD and CRT, the management sets the RTO. As shown in Fig. 2, measuring the Gap Time between MTPD and CRT is important before making the RTO decision. After which, measuring the Gap Time between RTO and CRT becomes important in achieving the RTO.

(2) Estimation Procedure of CRT and Improvable Recovery Time (IRT)

In case of an organization conducting recovery processes according to a recovery plan without any improvements, CRT is defined as the estimated time required to execute the recovery plan. The IRT is based upon the premise that the organization conducts improvement plans for shortening the Gap Time between RTO and CRT, and is defined as the estimated time required for the recovery plan after improvements. The estimate procedure applicable to both CRT and IRT is suggested below. The explanation presents and performs the CRT. CRT estimation applies the pre-rate sheet method— a standard time setting method.

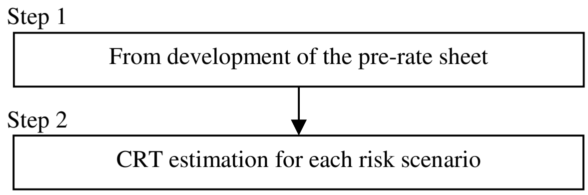
The pre-rate sheet method is a facile method, with low accuracy.[8)9)] However, the estimation of RTO does not have to be as accurate as the work standard time on factory sites. In addition, unpredictable external factors need to be considered; therefore, the author assumes the pre-rate sheet method as sufficient.

Table 1 depicts the function of the pre-rate sheet. This procedure can calculate the CRT for each recovery plan in each risk scenario.

a) By targeting only the component measures of the framework conducted by the organization, it indicates aspects such as the recovery time based on experience and so on.
b) By marking the component measures of the framework on the pre-rate sheet.
c) Summation while considering multiple parallel processes presents the estimation procedure for CRT.

Fig. 3 is the estimation procedure for CRT. The procedure consists of steps 1 and 2 in Fig. 3. In step 1, the organization must develop its own pre-rate sheet after referring to Table 1. In step 2, the organization fills the form by referring to past records. If the organization does not have the records, it may request business partners for the records.

As an operational example on how to estimate recovery process time, the procedure on how to estimate the recovery process time to construct a building's the reinforcement structure is described in Fig. 4. The database was created based on the construction company's experiences with recovering buildings damaged by the Great Hanshin Awaji Earthquake. On adding data on the seismic intensity of that area and the IS (Seismic Index of Structure) value of the indicated building in Fig. 5 and extending those two lines, the organization can estimate the damage caused to the building at the intersection point of the two lines. The organization can get the recovery process time from the database, using the estimated damage degree and specifications of the building as keywords for data retrieval. This allows the organization to record the time required to execute the structure reinforcement of building.



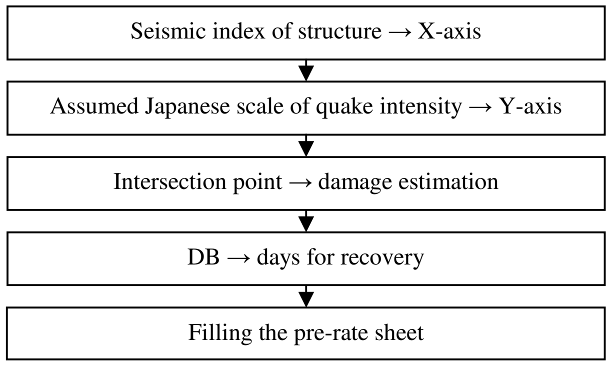
† This figure is quoted from reference 12.

Fig. 3 CRT Estimation Procedure

Table 1 Pre-rate Sheet Example

Work elements		Resources								
		Buildings			Annexed Structure			Productive Facilities		
		Construction of the structure reinforcement	Fixture repair		Power receiving equipment	Cooling system	Elevator	Repair	Purchase	
Wide area disaster	Confirmation of situation									
	Estimation									
	Settlement									
	Order									
	Purchasing									
	Personnel									
	Execution									
	Inspection									
	Maintenance									
	Payment									

† This figure is quoted from reference 10.



† The horizontal arrows indicate the direction from a cause to an effect.

Fig. 4 Pre-rate Sheet Entry Example

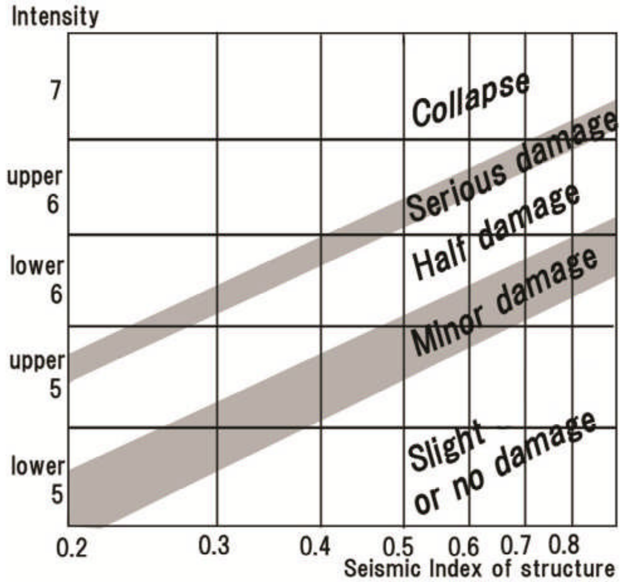
4. Modeling

(1) Twin Model Premises

As premises for modeling, attributes of the target organization and the method of executing BCM are assumed as follows.

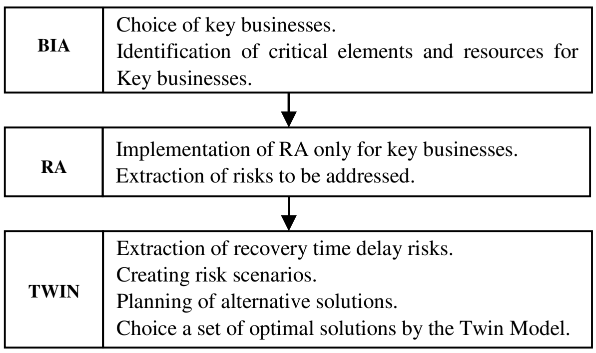
a) The target organizations are engaged in multiple businesses, and BIA is executed for these multiple businesses.
b) Selection of the key business is not necessarily singular. If there is more than one business, RTO is assumed to differ for each business.
c) CRT or IRT is separately integrated given each risk scenario. However, the integration is not as simple. CRT is integrated while considering the synchronization of measures of

individual solutions (component measures), which contain solutions to the risk scenario.



† This figure is quoted from reference 10. The above intensity represents Japanese scale of earthquake intensity.

Fig. 5 Estimating a Building's Damage



† Portions unrelated to the Twin Model are not explained in the description of the RA and BIA.

Fig. 6 Relationship among BIA, RA, and Twin Model

d) RA is initiated after obtaining BIA results, which enables the targeting of the key business and critical elements/resources. [1)2)]

e) RA assumes multiple hazards.[9)]

f) RA is calculated in terms of the risk values by a score method that evaluates the extent of damage that a resource may suffer from a hazard.[2)]

g) If the risk value exceeds the risk acceptance criteria, it is assumed to be a corresponding risk. In addition, if the risk value is less than the risk acceptance criteria, it is assumed to be an acceptable risk.

h) The Twin Model only targets risks that can result in a recovery time delay ("recovery time delay risk") among possible addressable risks. A risk scenario is created by the combination of the possible "recovery time delay risks" of concurrent occurrences. Other risks include reputation, brand, order decrease, cost increase, quality decline and so on.

i) In this study, risks are addressed not as individual measures, but as a set of component measures (solution) to component risks included in risk scenarios (constitution risk).

j) Since there is a limit to the number of feasible solutions within a budget, the solution determined as most effective at the present time is selected by the Twin Model on the basis of certain criteria.

k) The criteria to measure the effect of Gap Time of CRT and RTO are determined by using the amount of shortening of the recovery time and the number of achieving RTO.

l) Both are valid based on certain criteria and are difficult to prioritize. Therefore, the Twin Model presents multiple solutions to decision-makers (top managers).

The relationship between BIA, RA, and the Twin Model is shown in Fig. 6.

(2) Specifications of the Twin Model

The specifications of the Twin Model to reduce Gap Time between RTO and CRT are determined as follows.

a) To reduce Gap Time between RTO and CRT, the Twin Model creates two types of models. One maximizes the number of times RTO is achieved; the other maximizes the amount of shortening of the recovery time. cf. Formulae [1], [9]

b) The Twin Model uses the following information as input data: risk scenarios, solutions, solutions' cost, extent of shortening of CRT, RTO, CRT, budgets, and component measures. cf. Tables 3, 4

c) Total cost of solutions should not exceed the budget. cf. Formula [3]

d) The recovery priority is indicated in each risk scenario. cf. Formulae [1], [9]

e) The recovery priority value of each risk scenario is determined depending on the degree of relative priority by the management. cf. Table 3

f) Although each solution is unique, component measures are not necessarily unique. cf. Formula [3]

g) Duplicated implementation of the same component measures is not performed. cf. Formula [3]

h) The number of alternative solutions of each risk scenario is assumed to be n kind or less in each risk scenario.

i) An alternative solution to any risk scenario may be one kind or nothing. cf. Formula [2]

(3) Definition of Symbols

Table 2 lists the symbols used in the Twin Model. The Twin Model is explained in the following section, using those symbols.

(4) RTO Model

CRT can achieve RTO when it is reduced under RTO to a solution. Reducing CRT is an important BCM objective. This model chooses the optimal set of solutions to maximize the number of RTO achievements among multiple solutions able to reduce CRT within a given budget. This model comprises an objective function and seven constraint formulae.

a) Objective Function for Maximizing the Number of RTO Achievements

Z_{jk} of formula [1] is a binary constant indicating that the organization can achieve RTO. Z_{jk} is defined by formulae [6] and [7]. When RTO model chooses the solution that can achieve RTO, $Z_{jk}X_{jk}$ takes the value of 1. Here, P_j is considered a priority. The right side of formula [1] calculates the number of solutions to be selected from RTO achievable solutions. In terms of the constraints conditions in formulae [2] through [7], formula [1] calculates the value of X_{JK} maximizing the value of F_1. Therefore, formula [1] is an objective function.

$$Max\ :\ F_1 = \sum_{j=1}^{m} p_j \sum_{k=1}^{n} Z_{jk} X_{jk} \qquad [1]$$

Table 2 Definition of Symbols

Symbols	Definition
i	Constant that indicates ID number of businesses. (i = 1,2, …, h)
j	Constant that indicates ID number of risk scenarios. (j = 1,2, …, m)
k	Constant that indicates ID number of alternative solutions. (k = 1,2, …, n) A solution is a set of component measures for shortening the Gap Time between RTO and CRT.
t	Component measures t included in each alternative solution. (t = 1,2, …, r)
j’	Other risk scenario j’ as seen from risk scenario j.
k’	Other alternative solutions k’ as seen from alternative solution k.
t’	Other component measures t’ as seen from component measures t.
X_{jk}	Binary variable determining whether the organization adopts the solution. If the organization adopts solution k for risk scenario j, the value of X_{jk} is “1.” If the organization does not adopt solution k for risk scenario j, the value of X_{jk} is “0.” (j = 1,2, …, m k = 1,2, …, n)
Z_{jk}	Binary constant including whether the organization can achieve RTO. If solution k for risk scenario j can achieve RTO, the value of Z_{jk} is “1.” If solution k for risk scenario j cannot achieve RTO, the value of Z_{jk} is “0.” (j = 1,2, …, m k = 1,2, …, n)
$U_{jktj'k't'}$	Binary constant for component measures. If component measures t contained in alternative solution k of risk scenario j is the same as component measures t’ contained in alternative solution k’ of risk scenario j’, $U_{jktj'k't'}$ is given the value “1,” otherwise “0.”
C_{jk}	The constant that indicates the costs required for each solution. Costs required for implementing solution k for risk scenario j. (j = 1,2, …, m k = 1,2, …, n)
E_{jkt}	Required cost for component measures t contained in alternative solution k of risk scenario i.
M_{jk}	Constant that indicates the amount of shortening of CRT by solution k for risk scenario j. (j = 1,2, …, m k = 1,2, …, n)
P_J	Constant that indicates the recovery priority of each risk scenario j. (j = 1,2, …, m)
R_j	Constant that indicates CRT of each risk scenario j.
Oi	Constant that indicates RTO for each business i. (i = 1,2, …, h)
B	Total budget prepared to implement all solutions to reduce Gap Time.

b) Constraint of One or Less Selection

Alternative solutions of the Twin Model are planned up to “n” cases for each risk scenario. The selection solution rule is one less than the same risk scenario. Formula [2] is the mathematical expression of those rules.

$$\sum_{k=1}^{n} X_{jk} \le 1 \quad \text{but} \quad j = 1,2, \dots, m \qquad [2]$$

c) Budget Constraints

Budget constraints formulae are important for the Twin Model. The left-hand side of formula [3] is calculated on the condition that the cost of all solutions can be adopted and this cost must not exceed the budget on the right-hand side. The first term on the left-hand side of formula [3] accumulates each cost of the solutions to be adopted. The second term calculates the overlapping expenses in case that each solution to be adopted includes the same component measures. If different solutions contain the same component measures, the value of $U_{jktj'k't'}$ is set to “1.” When both these solutions are selected simultaneously, each of the values of X_{jk} and $X_{j'k'}$ are set at “1” (X_{jk} = 1 and $X_{j'k'}$ = 1). This deducts the overlap amount equivalent to E_{jkt}. Formula [4] shows the relationship of component measures costs “E_{jkt}” and solution costs “C_{jk}” used in formula [3].

$$\sum_{j=1}^{m}\sum_{k=1}^{n} C_{jk}X_{jk} - \sum_{j=1}^{m}\sum_{k=1}^{n}\sum_{t=1}^{r} E_{jkt}X_{jk}\sum_{j'=1}^{m}\sum_{k'=1}^{n}\sum_{t'=1}^{r} U_{jktj'k't'}X_{j'k'} \le B \qquad [3]$$

$$C_{jk} = \sum_{t=1}^{r} E_{jkt} \quad \text{but} \quad j = 1,2, \dots, m \quad k = 1,2, \dots, n \qquad [4]$$

d) Constraint on Solutions that can Achieve RTO

Only RTO achievable solutions can be adopted. This constraint is expressed as formula [5]. Z_{jk} is defined in formulae [6] and [7].

$$X_{jk} \le Z_{jk} \quad \text{but} \quad j = 1,2, \dots, m \quad k = 1,2, \dots, n \qquad [5]$$

e) Binary Constant Indicating whether the Organization can Achieve RTO

The binary constant indicating whether the organization can achieve RTO is defined in formulae [6] and [7]. “Z_{jk}=1” indicates that CRT can achieve RTO, while “Z_{jk}=0” indicates that CRT cannot achieve RTO. If solution k for risk scenario j can achieve RTO, the value of Z_{jk} is set at “1,” otherwise “0.”

$$\text{If}\ \ O_i \ge R_j - M_{jk}\,,\ \ Z_{jk} = 1 \qquad [6]$$

$$\text{If}\ \ O_i < R_j - M_{jk}\,,\ \ Z_{jk} = 0 \qquad [7]$$

but, i = 1,2, …, h j = 1,2, …, m k = 1,2, …, n

f) Non-negative Constraint

The non-negative constraint on symbols that are used in the RTO model is expressed in formula [8].

$$X_{jk}, Z_{jk}, P_j, C_{jk}, E_{jkt}, B, O_i, R_j, M_{jk} \ge 0 \qquad [8]$$

(5) CRT Model

If CRT can be reduced by a solution, it is a useful solution. This is an important objective of BCM. This model derives the optimal set of solutions to maximize the amount of shortening of CRT from among the many solutions that can reduce CRT within a given budget. This model consists of an objective function and a four-constraint formula.

a) Objective Function that Maximizes CRT Reduction

The objective function that maximizes the amount of shortening of CRT is expressed by formula [9]. In terms of constraints conditions from formulae [2], [3], [4] and [8], formula [9] calculates a value of X_{jk} maximizing the value for the F2. The right-hand side of formula [9] calculates the total amount of CRT reduction by the selected solution. The right-hand side of formula [9] sums the reduction of CRT. However, this is the case only when the solution is selected with a value other than "0." In this case, priority level P_j is considered.

$$\mathrm{Max} : F_2 = \sum_{J=1}^{m} P_j \sum_{k=1}^{n} M_{jk} X_{jk} \qquad [9]$$

5. Numerical Experiment

The Twin Model is confirmed by using the hypothetical data in Tables 3 and 4. There are five risk scenarios, all of which have RTO as common. There are three alternative solutions in each risk scenario. Execution priority is given to each risk scenario, which contains four component risks. The shortening of CRT in Table 3 is derived as CRT-IRT balances. Shown in Table 4, it is assumed that there are overlaps in the component measures.

The optimal solution is derived by using one of the two components of the Twin Model, or by a combination of both models. The budget is assumed to have ten stages. The Twin Model solution is based on the branch and bound method.[14)]

6. Structural Characteristics of the Twin Model

The following Twin Model characteristics can be observed in terms of the structure. In addition, they are confirmed by this study's experiment. The Twin Model should be used only after thoroughly understanding these characteristics.

Table 3 Input Data (Basic data)

RTO (days)			14		
The number of risk scenarios			5		
Budgets (Interval JPY 1 million)			100-1000		
Scenario No.	Priority	Data of each risk scenario	Alternative solutions		
			1	2	3
1	1.0	CRT (days)	40	40	40
		CRT shortening (days)	25	20	10
		Cost (JPY 10,000)	200	150	100
2	1.1	CRT (days)	45	45	45
		CRT shortening (days)	39	15	5
		Cost (JPY 10,000)	500	300	80
3	0.8	CRT (days)	25	25	25
		CRT shortening (days)	12	10	5
		Cost (JPY 10,000)	100	70	30
4	0.9	CRT (days)	20	20	20
		CRT shortening (days)	18	13	10
		Cost (JPY 10,000)	50	40	20
5	1.2	CRT (days)	35	35	35
		CRT shortening (days)	22	10	2
		Cost (JPY 10,000)	300	200	100

a) The RTO model works to select preferentially economical solutions among achievable RTO solutions and maximize the number of RTO achievements. cf. Formula [4]

b) The CRT model works to select preferentially economical solutions among solutions for decreasing CRT and maximizing CRT reduction. This may improve the possibility of achieving the RTO. cf. Formula [8]

c) The RTO model may not choose a solution with a greater CRT reduction effect when compared with the solution it selects.

d) The CRT model may not select the solution of an achievable RTO.

e) In the case of equal budgets, the CRT model cannot realize multiple RTO achievements of more than one RTO model. Similarly, the RTO model cannot enhance the shortening the recovery time more than the CRT model.

f) If the budget is less than the required amount to achieve RTO, the organization is force to select the CRT model.

g) If the CRT model maximizes the recovery time shortening without considering the RTO, the organization may make an error and select overly effective and costly measures beyond its requirement to achieve the RTO for some scenarios.

h) The budget balance for the RTO model tends to become larger than the remaining budget for the CRT model. In such a case, a CRT model may apply within the upper limit of the budget remainder after applying an RTO model.

i) By changes in the budget because of estimating multiple budgets, it is possible to provide reference information for the budget decision on an alternative solution to be selected before budget determination.

Notably c) and d) imply that RTO and CRT models have an incompatible characteristic. It seems that the trade-off relationship arises from this.

Table 4 Input Data (Overlapped Component Measures)

Groups of common measures	Costs of measures
U_{114123}, U_{114512}, U_{114521}	50
U_{121133}, U_{121223}, U_{121311}, U_{121522}, U_{121533}	30
U_{122213}, U_{122522}	40
U_{131224}, U_{131234}, U_{131412}, U_{131422}, U_{131532}, U_{131534}	20
U_{232314}, U_{232324}, U_{232411}	15
U_{332424}, U_{332434}	5

† JPY 10,000 per unit.

Each line is equivalent to the same component measures.

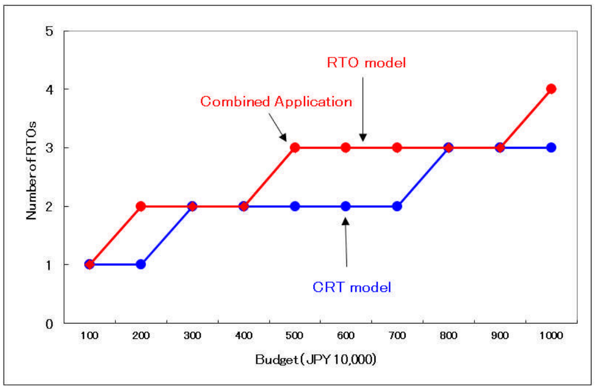


Fig. 7 RTO Achievement

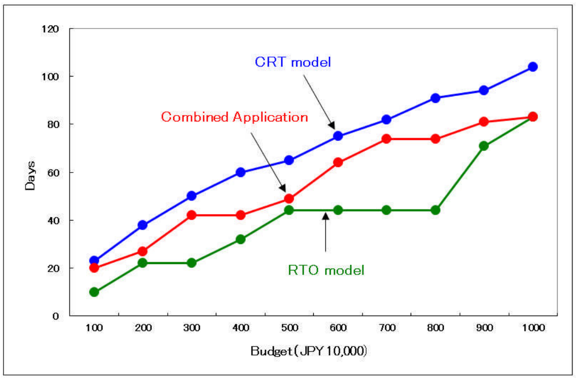


Fig. 8 CRT Shortening

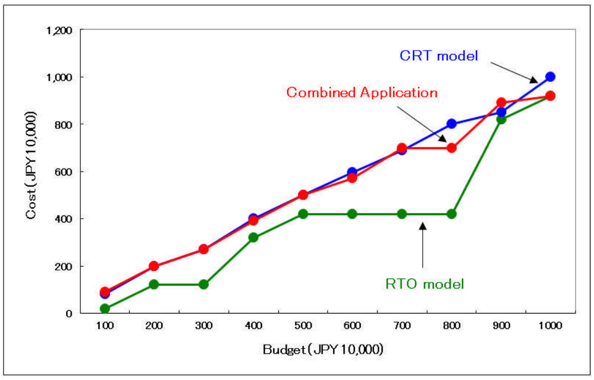


Fig. 9 Cost of Solutions

Table 5 Experimental Results (1)

		Budgets (JPY 10,000)	100	200	300	400	500	600	700	800	900	1000
RTO model		Costs (JPY 10,000)	20	120	120	320	420	420	420	420	820	920
		RTO achievement	1	2	2	2	3	3	3	3	3	4
		CRT shortening (days)	10	22	22	32	44	44	44	44	71	83
CRT model		Costs (JPY 10,000)	80	200	270	400	500	595	690	800	850	1,000
		RTO achievement	1	1	2	2	2	2	2	3	3	3
		CRT shortening (days)	23	38	50	60	65	75	82	91	94	104
Combined Application	CRT model	The budget remaining (JPY 10,000)	**80**	**80**	**180**	**80**	**80**	**180**	**280**	**380**	**80**	**80**
		Costs (JPY 10,000)	70	80	150	70	80	150	280	280	70	0
		RTO achievement	0	0	0	0	0	0	0	0	0	0
		CRT shortening (days)	10	5	20	10	5	20	30	30	10	0
	Total	Costs (JPY 10,000)	90	200	270	390	500	570	700	700	890	920
		RTO achievement	1	2	2	2	3	3	3	3	3	4
		CRT shortening (days)	20	27	42	42	49	64	74	74	81	83

† Combined Application applies CRT model after RTO model was applied.

The budget remaining after RTO model was applied is the budget for CRT model.

Table 6 Experimental Result (2)

Scenario No.	Solutions	100			200			300			400			500			600			700			800			900			1000		
		RTO model	CRT model	Combined Ap.	RTO model	CRT model	Combined Ap.	RTO model	CRT model	Combined Ap.	RTO model	CRT model	Combined Ap.	RTO model	CRT model	Combined Ap.	RTO model	CRT model	Combined Ap.	RTO model	CRT model	Combined Ap.	RTO model	CRT model	Combined Ap.	RTO model	CRT model	Combined Ap.	RTO model	CRT model	Combined Ap.
1	1											1			1			1				1			1		1			1	
	2					1			1	1									1		1			1							
	3																														
2	1																				1			1		1	1		1	1	
	2																														
	3						1					1				1		1				1			1						
3	1				1			1	1			1		1			1			1			1	1			1		1		
	2			1									1															1			
	3		1															1			1										
4	1		1			1			1			1			1			1			1			1			1			1	
	2																														
	3	1			1			1			1			1			1			1			1			1			1		
5	1										1			1	1		1	1		1			1			1			1	1	
	2																														
	3																							1							

Budgets (JPY 10,000)

† "1" means adoption of an applicable solution. "0" is replaced as blank space.

7. Conclusion

a) The use of hypothetical experimental data allowed the study to confirm that the model operated according to the specifications. Using examples, the following were confirmed: limitation on the number of alternative solutions, deduction of redundant component measures cost, and maximization of the objective function within budget limits, etc.

b) It was confirmed that RTO and CRT models each chose a different solution, and that there is individuality in a way that affects both models.

c) It was verified that the combined application that derives compromise solutions is another option.

d) To solve the problem of Gap Time between the RTO and CRT, one must address the trade-off problem of maximizing the CRT and RTO models.

8. Future Issue

In this study, the business of the organization is assumed to be interrupted by multiple hazards. On the other hand, the standard text of BCAO addresses “the need to consider the Recovery Level Objective (RLO) or Minimum Business Continuity Objective (MBCO) [(7)] that is inseparable from RTO.” The RLO is the same as MBCO.

However, the Twin Model has not been conducted in a MBCO context. Therefore, in addition to business interruption of the organization, it needs to be available to cope with the issue of rate-of-operation fall problem; the author believes this should be a topic for future research to improve the Twin Model. In addition, the compromise plan of the Twin Model can be tested in one or both of the following ways beyond the content of this experiment.

a) A budget allocated to two models; first being the RTO model with the remaining budget for a CRT model. The splitting ratio of the budget is decided by the organization’s policy change. This method can possibly correspond with the Twin Model.
b) To make the Twin Model evolve into a single model is a future issue. This requires identification of the minimum satisfying level of RTO achievements as an organizational policy. Within the budget, achieving a satisfying level of the number of RTO achievements is set as the first target. Subsequently, it can be used as a method to select the solutions that maximize the CRT reduction as a second target. To employ this method, it would be necessary to develop a new model different from the Twin Model.

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Appendix

(1) RTO (Recovery Time Objective)
Period following an incident within which product or service must be resumed, or activity must be resumed, or resources must be covered.[15)]

(2) MTPD (Maximum Tolerable Period of Disruption)
Time it would take for adverse impacts, which might arise as a result of not providing a product/service or performing an activity, to become unacceptable.[15)]

(3) CRT (Current Recoverable Time)
Time is the estimated time as current recoverable ability of the organization.

(4) BCM (Business Continuity Management)
Holistic management process that identifies potential threats to an organization and the impacts to business operations those threats, if realized, might cause, and which provides a framework for building organizational resilience with the capability of an effective response that safeguards the interests of its key stakeholders, reputation, brand and value-creating activities.[15)]

(5) BIA (Business Impact Analysis)
Process of analyzing activities and the effect that a business disruption might have upon them.[15)]

(6) RA (Risk Assessment)
Overall process of risk identification, risk analysis and risk evaluation.[15)]

(7) MBCO (Minimum Business Continuity Objective)
Minimum level of services and/or products that is acceptable to the organization to achieve its business objective during a disruption.[15)]

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