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Flexible Business System Design for Indoor and Outdoor Seamless Positioning System with GPS Technology

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Abstract

Indoor Messaging System (IMES) is an emerging technology which enables to provide location-based information service both indoor and outdoor seamlessly. The purpose of this paper is to analyze and design a flexible business system for the IMES to cope with uncertainty ahead, which is always the case with emerging technology. First, a simple business model was created for the simulation assuming the IMES service at a large outlet shopping mall. Second, the matrix-based analysis was introduced to categorize the uncertainty in the business and several scenarios were designed for conducting Monte Carlo Simulation for evaluating flexibility of the business. The proposed methodology enables to prevent emerging technologies such as the IMES from falling into 'valley of death' by designing flexibility of the business system.

Introduction

Indoor Messaging System (IMES) is a newly developed technology which enables to provide location-based information service both inside and outside building seamlessly. Among various existing technologies for the same type of service (Marco, A., Casas, R., Falco, J., Gracia, H., Artigas, J.I., Roy, A., 2008), the strength of the IMES is its compatibility with GPS protocol (Kogure, Maeda, Ishii, Manandhar and Okano, 2008). For example, with the IMES technology, a GPS-equipped cell phone does not require any additional equipment to receive location information even inside the building or underground, where GPS signal cannot reach today.

However, such an excellent technology does not always become the winner of the market (Polk, R., Plank, R., Reid, A. 1999). A feasible and sustainable business model must be designed beforehand in order for a newly developed technology to be a commercially successful in the end. Kim et al introduced a systematic approach to design a feasible business model for the IMES. They concluded that the IMES business "be designed based on the Business to Business (B to B) model so as to secure its profitability and sustainability" (Kim, Minato, Busser, Kohtake, 2010). However, the uncertainty of the IMES, both technical and commercial, was not fully considered in the business model simulation. Furthermore, the flexibility of the IMES business system was totally out of the scope in the previous research. Therefore, the purpose of this paper is to analyze and design the feasible business system for the IMES including consideration of ‘uncertainty’ and ‘flexibility’. The paper mainly discussed commercial aspects and the technical flexibility was fully discussed in another paper (Kohtake and Minato, 2010).

In this paper, the authors introduced the matrix-based approach as shown in Fig. 1 to analyze the sources of uncertainty in the business model. It was consisted of two axes of controllability and variability. ‘Fixed and uncontrollable’ parameters should be treated as constraints. Best guess could be reasonably used for the ‘fixed and controllable’ parameters. On the other hand, Scenario Analysis would be appropriate for ‘variable and controllable’ parameters. Assumptions must be set for ‘variable and uncontrollable’ parameters so as to reflect uncertainty. The benefit of the approach was the reduction of time and effort for the analysis by treating some parameter as predominantly given.

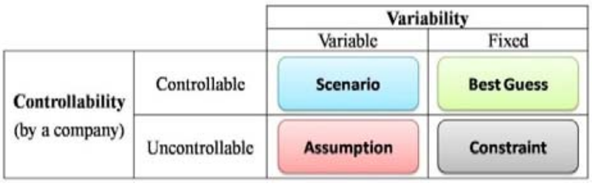

Fig. 1. Matrix-Based Approach

In the following, the authors firstly designed a simple business model for the IMES business simulation assuming that the service would be provided at a large outlet shopping mall. Secondly, the business model was evaluated based on the matrix-based approach in Fig. 1. In addition, Scenario Analysis and Monte Carlo Simulation were conducted so as to include the consideration of uncertainty in the IMES business. Finally, the authors evaluated the results and proposed the flexible business system design for the IMES technology.

Business Model Design

Location. The authors assume that the location-based information service with the IMES would be provided at one of the biggest outlet malls in Japan called Karuizawa Prince Shopping Plaza. Table 1 showed the installation plan for the IMES transmitters based on the analysis of the facilities of the mall. 1 IMES transmitter was assumed to be installed at each shop, corridor (in front of every shop), information centre, toilet, nursing room, entrance, exit, elevator, corner, coin locker, shuttle bus station, smoking room, public telephone, cash dispenser, car parking and bicycle parking. In total, 744 IMES transmitters were necessary at the outlet mall for the IMES service operation.

Table 1. IMES Transmitter Installation

Installation Spots in the Mall	Number
Shops	208
Corridor (in front of every shop)	208
Information Center	3
Toilets	10
Toilets for Disabled Person	8
Nursing Rooms	6
Entrances/Exits	9
Elevators	5
Corners	247
Coin Lockers	7
Shuttle Bus Stations	2
Smoking Rooms	8
Public Telephones	5
Cash Dispensers	2
Car Parking	11
Bicycle Parking	5
Total	744

Business Structure. Business to Business (B to B) model were adopted in the simulation as shown in Fig. 2. First of all, a company was assumed to purchase 744 IMES transmitters from the IMES transmitter manufacture to install them at the outlet mall. Then, the company would provide the location-based information service to the tenant shops inside the mall. In return, the shops would pay the IMES utility fee to the company in addition to the rent to the outlet mall manager. The outlet mall manager would receive profit margins from the company in return for permitting the IMES transmitter installation at the mall. Finally, consumers would be able to receive commercial information (e.g. free coupons for shopping) via the IMES environment. Customers would be stimulated to purchase more goods and services at the mall due to the information provided by the IMES.

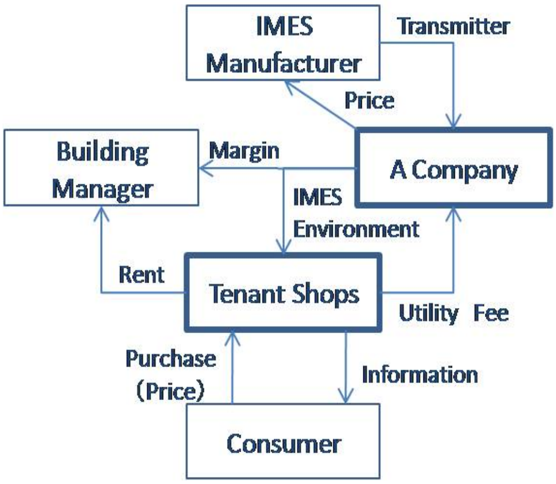

Fig. 2. Business Structure

Parameters. The authors designed the 18 parameters were for the simulation as shown in Table 2; Number of Tenant Shop, IMES Utility Fee, IMES Service Adoption Rate, Number of IMES Transmitter, Transmitter Unit Price, Transmitter Installation Cost, Transmitter Maintenance Cost, Transmitter Electricity Cost, System Development Cost, System Operation Cost, System Improvement Cost, Margin to Building Manager, Administration Cost, Project Duration, Discount Rate, Tax Rate and Depreciation.

Table 2. List of Parameters for Simulation

Number of Tenant Shop		Unit
IMES Utility Fee	Initial	USD (initial)
	Annual	USD/year
IMES Service Adoption Rate		%
Number of IMES Transmitter		unit
Transmitter Unite Price		USD/unit
Transmitter Installation Cost		USD/unit
Transmitter Maintenance Cost		USD/unit/year
Transmitter Electricity Cost		USD/unit/day
System Development Cost		USD (initial)
System Operation Cost		USD/year
System Improvement Cost		USD/year
Margin to Building Manager		USD/unit/year
Administration Cost		%
Project Duration		year
Discount Rate		%
Tax Rate		%
Depreciation		year

Calculation. First of all, annual revenue was calculated by multiple of the three parameters, 1) Number of Tenant Shop, 2) IMES Service Adoption Rate and 3) IMES Utility Fee. The calculation was shown in Eq. (1). The IMES Service Adoption Rate was the ratio of the IMES service utilizing shops divided by the number of total tenant shops in the outlet mall. The calculation was shown in Eq. (2). The ratio showed the average volatility of the service utilization, which in turn, would affect the revenue of the business. Since every shop would not necessarily use the IMES service throughout the 10 years due to economic downturns or simply reluctance, the authors introduced the concept.

$$\textbf{Annual Revenue} = f(R) = TS \times AR \times UF \quad (1)$$

TS: Number of Tenant Shops

AR: IMES Service Adoption Rate

UF: IMES Utility Fee

IMES Service Adoption Ratio

$$= \frac{\text{IMES Service Utilizing Shops}}{\text{All Tenant Shops in the Building}} \quad (2)$$

Second, annual cost was calculated by sum of all the cost factors. For example, transmitter purchase, transmitter installation, transmitter maintenance, transmitter electricity, system operation, system improvement, outlet mall manager margin, and administrations were considered to be the cost factors in the business model. System development cost was not included here since it was considered to be an initial investment. The calculation was shown in Eq. (3)

$$\textbf{Annual Cost}= f(C) = \sum(\mathrm{PC} + \mathrm{IC} + \mathrm{MC} + \mathrm{EC} + \mathrm{SO} + \mathrm{SI} + \mathrm{MB} + \mathrm{AC}) \quad (3)$$

PC: Transmitter Purchase Cost

IC: Transmitter Installation Cost

MC: Transmitter Maintenance Cost

EC: Transmitter Electricity Cost

SO: System Operation Cost

SI: System Improvement Cost

MB: Margin to Building Manager

AC: Administration Cost

Finally, annual Free Cash Flow (FCF) and Net Present Value (NPV) were calculated based on Eq. (4) and Eq. (5) respectively. System development cost was considered to be the initial investment in the NPV calculation.

$$\textbf{Annual FCF} = \{\mathrm{f(R)} - \mathrm{f(C)}\}(1-\mathrm{T}) + \mathrm{D} \quad (4)$$

$$\textbf{NPV} = \sum_{n=1}^{t} \frac{(\text{Annual FCF})^t}{(1+r)^t} - \mathrm{I} \quad (5)$$

FCF: Free Cash Flow

NPV: Net Present Value

T: Tax Rate

D: Depreciation

r: Discount Rate

t: Project Duration

I: Initial System Development Cost

Result of Analysis

Table 3 showed the result of the matrix-based analysis. Among the 18 parameters, 5 parameters were considered as uncontrollable and fixed and thus should be treated as Constraints. 1 parameter was considered as controllable and fixed and thus should be defined by Best Guess. 8 parameters were considered as uncontrollable and variable and thus should be defined by assumption. 3 parameters were considered as controllable and variable and thus should be analyzed based on scenario.

Table 3. Result of Matrix-based Analysis

	Fixed	Variable	Controllable	Uncontrollabl	**Results**
Number of Tenant Shop	X			X	**C**
IMES Utility Fee — Initial Annual		X	X		**S**
IMES Service Adoption Rate		X		X	**A**
Number of IMES Transmitter	X			X	**C**
Transmitter Unite Price		X		X	**A**
Transmitter Installation Cost		X		X	**A**
Transmitter Maintenance Cost		X		X	**A**
Transmitter Electricity Cost		X		X	**A**
System Development Cost		X	X		**S**
System Operation Cost		X		X	**A**
System Improvement Cost		X		X	**A**
Margin to Building Manager		X	X		**S**
Administration Cost	X		X		**B**
Project Duration	X			X	**C**
Discount Rate		X		X	**A**
Tax Rate	X			X	**C**
Depreciation	X			X	**C**

A: Assumption **B**: Best Guess **C**: Constraint

S: Scenario Analysis

The authors set the values for the Constraints and the Best Guess as shown in Table 4 and the values for the Assumptions in Table 5 for conducting the simulation.

Table 4. Constraint and Best Guess

Parameter	Value
Number of Tenant Shops	208
Number of IMES Transmitter	744
Project Duration	10 years
Tax Rate	40%
Depreciation (Uniform)	10 years
Administration Cost (% to Oper. Cost)	10%

Table 5. Assumptions

Parameter	Min.	Likeliest	Max.
IMES Service Adoption Rate	50%	70%	90%
Transmitter Unite Price	$20	$100	$500
Transmitter Installation Cost	$25	$50	$75
Transmitter Maintenance Cost	$10	$20	$30
Transmitter Electricity Cost	$0.1	$0.2	$0.3
System Operation Cost	$10,000	$20,000	$30,000
System Improvement Cost	$5,000	$10,000	$15,000
Discount Rate	7%	10%	15%

Finally, the authors could choose the 3 parameters which were appropriate for Scenario Analysis; System Development Cost, Margin to Building Manager and IMES Utility Fee. These parameters depend either on a company's investment decision or on pricing strategy and thus it is possible for a company to decide them at company's disposal. In the following, the authors evaluated the flexibility of the IMES business in two different aspects; 1) cash outflow, which would affect the cost of the business and 2) cash inflow, which would affect the revenue of the business.

Cash Outflow Analysis. Table 6 showed 9 different scenarios for the cash out-flow. The authors assumed that System Development Cost had 3 options ($50,000, $100,000 and $150,000) and it must be paid initially. Margin to Building Manager also had 3 options ($0, $10, $20) and to be paid annually per IMES transmitter.

Table 6. Cash Outflow Scenario

		System Development Cost		
		$50,000	$100,000	$150,000
Margin	$0	Scenario 1	Scenario 2	Scenario 3
	$10	Scenario 4	Scenario 5	Scenario 6
	$20	Scenario 7	Scenario 8	Scenario 9

First of all, the results of the NPV analysis were visually summarized in Fig. 3. It illustrated that when the initial investment for System Development Cost was as less as $50,000, all scenarios (Scenario 1, Scenario 4 and Scenario 7) showed positive NPV and also reached NPV breakeven earlier than 5th year regardless of the amount of Margin to Building Manager. In this case, a company could acquire more flexibility of decision making on how much it should pay to the building manager.

When the initial investment for System Development Cost was $100,000, all scenarios (Scenario 2, Scenario 5 and Scenario 8) still showed positive NPV regardless of the Margin. However, Scenario 8 (pays $20 to Building Manager per IMES Transmitter per year) cannot reached NPV breakeven in middle of the project. Therefore, paying $20 to building manager was slightly a risky decision making for a company.

When the initial investment for System Development Cost reached as much as $150,000, all scenarios (Scenario 3, Scenario 6 and Scenario 9) still show positive NPV regardless of the amount of Margin to Building Manager. However, Scenario 6 (pays $10 margin) and Scenario 9 (pays $20 margin) cannot reached NPV breakeven in middle of the project. In this case, a company was likely to be required to negotiate with building manager for exemption of the margin payment so as to design a feasible business model.

Furthermore, the authors implemented Monte Carlo Simulation for each scenario and the results were visually summarized in Fig. 4. In three scenarios, say, Scenario 6, Scenario 8 and Scenario 9, the certainty for acquiring positive NPV were less than 60%. In order words, if a company would like to keep the risk of negative NPV from the IMES business as less than 40%, then these options were not acceptable from the beginning. More concretely speaking, when a company invested $150,000 initially for System Development, then the only option for a company to take would be negotiation with the building manager for exemption of the margin. In the same way, when a company invested $100,000 initially, then the options to take would be either paying $10 for the margin or paying nothing to building manager.

In this way, it is possible to make decision on how much margin a company should pay to building manager so as to make the IMES business commercially feasible according to the amount of initial investment. Flexibility of the IMES business system can be evaluated and designed based on the proposed approach.

Cash Inflow Analysis. Table 7 shows 9 different scenarios for cash in-flow analysis. The authors assumed that IMES Utility Fee would have two different schemes for payment from tenant shops in the mall; 1) Initial Payment and 2) Annual Payment. The authors designed 3 options for each payment scheme. As for the Initial Payment, 3 options were $0, $1,000 and $2,000 per shop. As for the Annual Payment scheme, 3 options were $500, $1,000 and $1,500 per year per shop.

Table 7. Cash Outflow Scenario

		IMES Utility Fee (Initial Payment)		
		$0	$1,000	$2,000
IMES Utility Fee (Annual Payment)	S500	Scenario 10	Scenario 11	Scenario 12
	$1,000	Scenario 13	Scenario 14	Scenario 15
	$1,500	Scenario 16	Scenario 17	Scenario 18

First of all, the results of the NPV analysis were visually summarized in Fig. 5. Contrary to the Cash Outflow analysis, there were greater distinctions among the scenarios in the Cash Inflow analysis. It visually showed that the IMES business was less likely to be feasible when a company set the annual payment as $500 regardless of the amount of the initial payment. In fact, Monte Carlo Simulation (Fig. 6) also showed that positive NPV was hardly achieved in Scenario 1 through Scenario 3. However, the situation dramatically improved when a company would double the annual payment for the IMES Utility Fee up to $1,000. Fig. 6 illustrated that positive NPV was kept even without requiring any initial payment for utilizing the IMES (Scenario 13) and the certainty for positive NPV marked more than 60% for both Scenario 14 ($1,000 for initial payment) and Scenario 15 ($2,000 for initial payment). Furthermore, when a company would triple the annual payment for the IMES Utility Fee up to $1,500, the situation further improved. As illustrated in Fig. 6, Scenario 16 through Scenario 18 (requiring $1,500 for annual payment) resulted in almost 100% certainty for positive NPV. It meant that the business risk would extremely minimize when a company set the annual payment as much as $1,500 regardless of the amount of the initial payment.

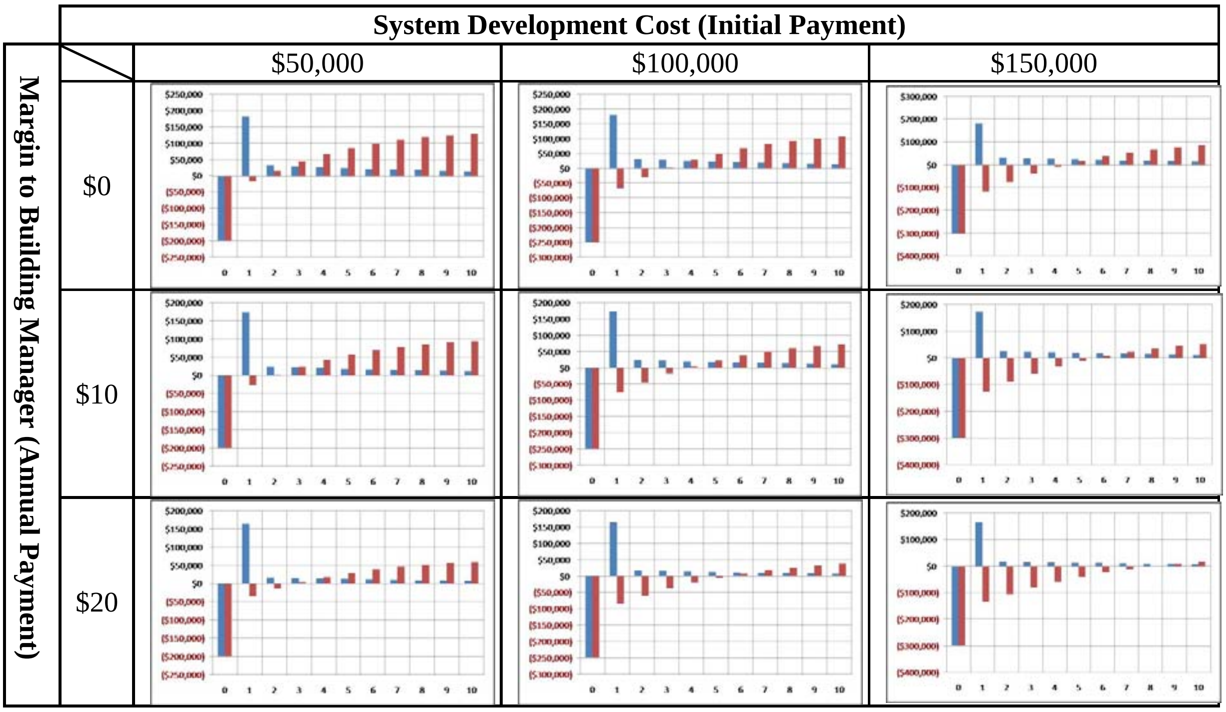

Fig. 3. NPV Analysis (Cash Outflow Scenario)

[Blue: Annual NPV, Red: Accumulated NPV]

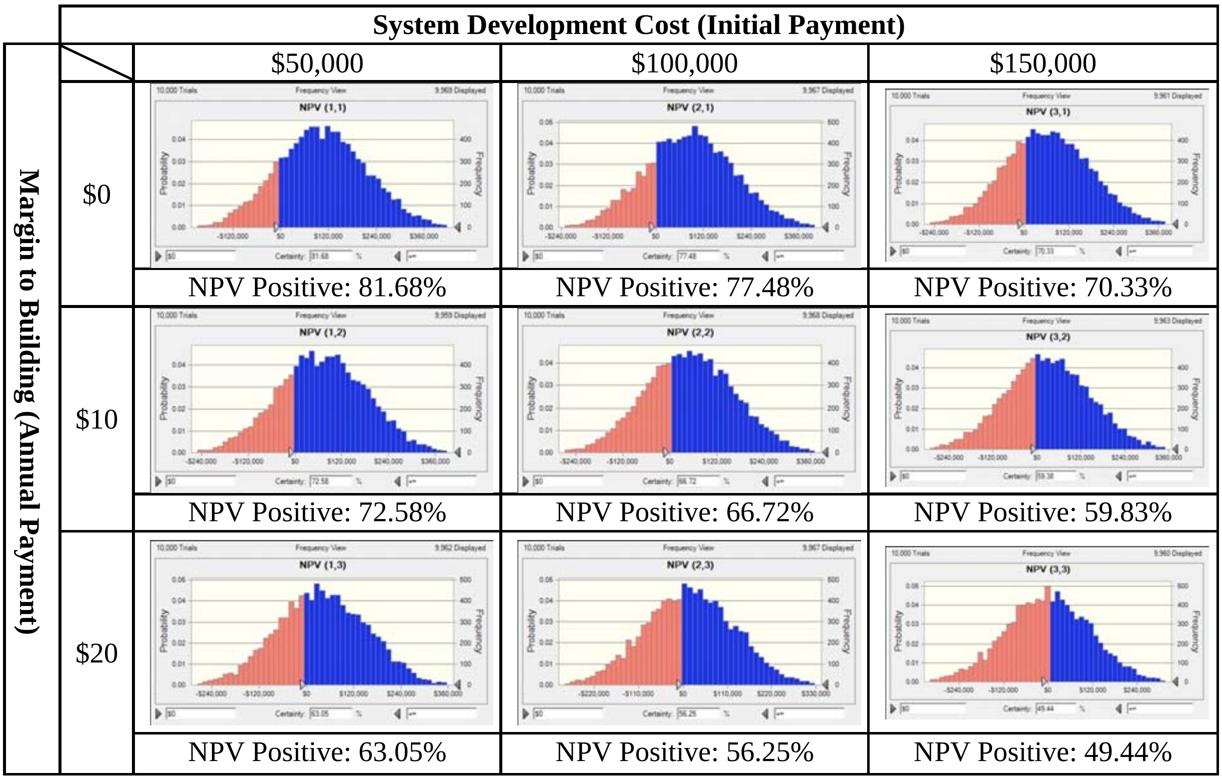

Fig. 4. NPV Distributions (Cash Outflow Scenario)

[Blue: Positive NPV, Red: Negative NPV]

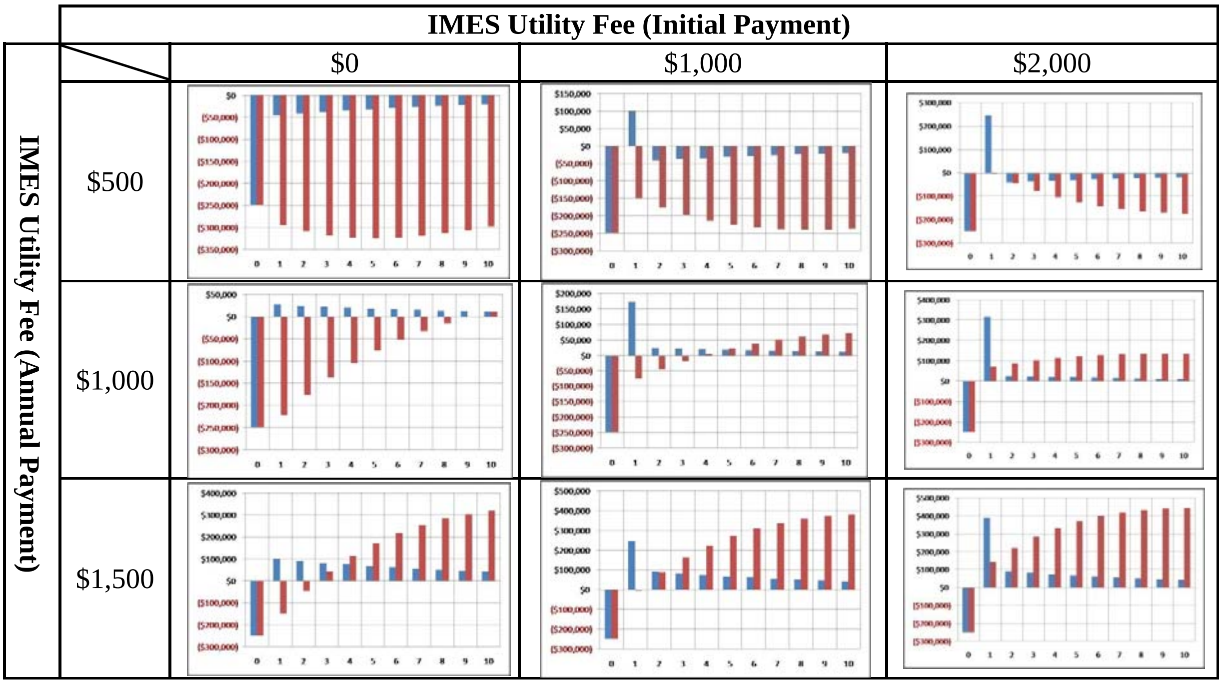

Fig. 5. NPV Analysis (Cash Inflow Scenario)

[Blue: Annual NPV, Red: Accumulated NPV]

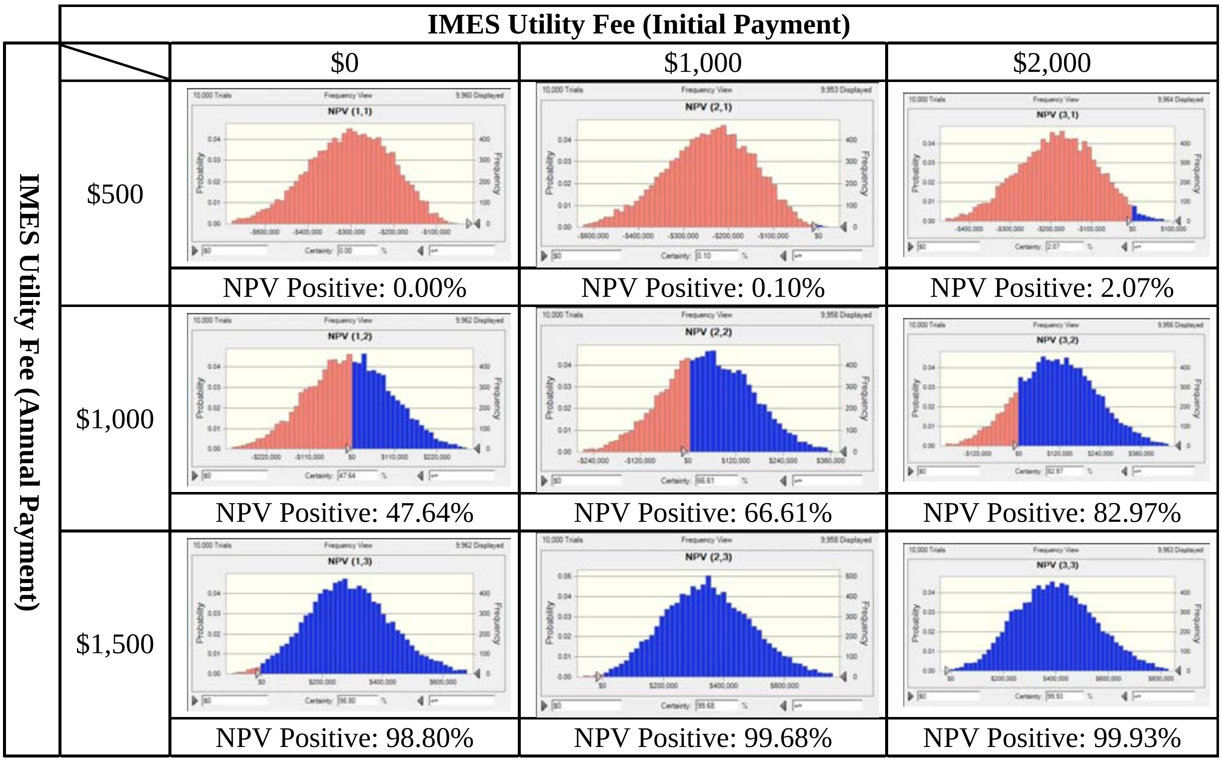

Fig. 6. NPV Distributions (Cash Inflow Scenario)

[Blue: Positive NPV, Red: Negative NPV]

Conclusion

The paper mainly discussed how to analyze and design flexibility of business system considering uncertainty in emerging technology. The proposed matrix-based approach made it possible to conduct scenario analysis of a new business more efficiently and effectively. As a result of Scenario Analysis and Monte Carlo Simulation, the authors could identify several key factors for designing a flexible business system for the IMES at a large outlet shopping mall. First, as for the cash outflow, a company should carefully design the amount of margin to building manager according to the initial investment. When the initial investment exceeded more than $150,000, then the exemption of the margin should be negotiated with building manager. Second, as for the cash inflow, design of the annually payment scheme was more critical than that of the initial payment. Designing the annual payment as $1,500 would provide more freedom for a company to design the initial payment from the tenant shops for the IMES service. It greatly affected the IMES service adoption rate in the beginning and the revenue in the end. The proposed methodology can be applied to any other fields under the various types of uncertainty. The authors believe that it contribute to design flexibility of business system, which in turn, prevent emerging technology such as the IMES from falling into 'valley of death'.

References

Brickley, J, Smith, C, Zimmerman, J, 2007, Managerial Economics and Organization Architecture, Forth Edition, P704

Kogure, S, Maeda, H, Ishii, M, Manandhar, D, and Okano, K. 2008, The Concept of the Indoor Messaging System, The European Navigation Conference (ENC-GNSS), Toulouse.

Kohtake, N, Minato, N, 2010, Flexible Technical System Design for Indoor and Outdoor Seamless Positioning System with GPS Technology, GLOGIFT2010, Japan.

Kohtake, N, Minato, N, and Makino, Y. 2010, Indoor and Outdoor Seamless Positioning System for a GPS-equipped Receiver, 22nd Annual Systems & Software Technology Conference (SSTC 2010), Salt Lake City.

Marco, A., Casas, R., Falco, J., Gracia, H., Artigas, J.I., Roy, A., Computer Communications, Volume 31, Issue 6, 18 April 2008, p1055-1066.

Polk, R., Plank, R., Reid, A. 1999. Technical risk and new product success: An empirical test in high technology business markets Industrial Marketing Management,Volume 25, Issue 6, p531-543.

Sun Kim, Minato, N., Busser, D., Kohtake, N., 2010, Transforming Seamless Positioning Technology into a Business using a Systems Design Approach-Scenario-based Amorphous Design, IEEE International Systems Conference 2010, San Diego, USA

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Biography

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