New Songdo City and the Value of Flexibility: A Case Study of Implementation and Analysis of a Mega-Scale Project

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Abstract

In the modern real estate industry, mega-scale developments have been a notable feature. The distinctiveness of these projects is that they are enormous in scale and thus require many years to develop. Unlike regular sized projects, they have greater opportunities to alter strategies, plans or designs during the multiple years of development. This provides the developer with alternative options to mitigate potential risks or seize upside opportunities. The "Real options" theory is especially applicable for valuation and decision-making of mega-scale real estate development projects. Relying on the dynamic decisions of the developer, for example, the project can proceed, be delayed or be abandoned. Either way, the developer can avoid downside risks and attain a more optimal value for the project.

The New Songdo City (NSC) project in South Korea is an archetype of the mega-scale development phenomenon. "New Songdo City" is a massive city development project on 1,415 acres of reclaimed land in Incheon, near Seoul. The project features innovative and valuable aspects that are milestones for the real estate industry. Not only is NSC of mega-scale and multi-phase, but it is highly international in nature (foreign lead developer and architect, much foreign capital, and aimed at international world-class occupants). It also features imaginative conceptual planning, local and international developer partnership and sophisticated investment and financing techniques. The project highlights the importance of the interaction of local circumstances and other participants, helping to avoid risks and enhance the future values of the project.

New Songdo City thus provides an excellent laboratory to explore both the broader strategic and historical development of a Mega-Project and also the applicability of modern, cutting-edge analytical tools for valuing flexibility in project design and implementation. This thesis seeks to explore both of these aspects, including an in-depth review of the history and strategic prospects for the project as well as a specific quantitative model focusing on the value of phasing in the project. The quantitative model is innovative in that, while previous literature has developed classical economics-based real options models of NSC, this is the first application of the "engineering-based approach" advocated by Professor de Neufville and the MIT Engineering Systems Division. This approach allows the model to be more transparent and user-friendly to decision-makers, assisting the valuation of flexibility in the project in a manner more supportive for practitioners.

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Chapter I: Introduction

The late twentieth century saw a new trend in real estate industry: development of very large-scale, multi-phase projects. This refers to development projects of heretofore unprecedented scale for privately or publicly-financed endeavors, composed of a number of properties of various types such as residential, commercial, public facilities that are implemented in more than two phases over many years. Specifically, Dongtan in China, Al Zorah in Ajman, Downtown Burj Dubai in Dubai, Zuidas in the Netherlands and New Songdo City in Korea are such projects that are to be built into new cities.[1] In order to function as a complete city, each project is thoroughly planned to include all the required programs of a city, in contrast to traditional "Commuter town (Bedroom community)" projects, which merely supplemented residential units for nearby metro cities.

Since these large-scale projects are conducted over longer periods of time with more participants involved than traditional development projects, it is important to be aware of the numerous uncertainties and risks that may take place within the development period. Therefore, most of them are planned in multi-phases, providing flexibility for decision-making in development procedures. Developers can set a number of design elements and decision regulations so that they can dynamically react to unexpected situations. This flexibility allows developers to mitigate uncertainties and risks, giving more opportunities for completion of successful projects and increasing their value.

1.1. Background

Among the projects mentioned above, New Songdo City is a massive city development

[1] For detailed information on such projects, see Weikal (2008) and appendix A.

project located in the southwest coastline of Incheon, a western region in South Korea. The land, being about 1,415 acres, was reclaimed in the late 1990's to be developed into a world-class master planned community. The city of Incheon and the central government planned to transform the land into an international hub city for Northeast Asia and also to provide benefits for the Korean economy. In 2001, the city executed a Memorandum of Understanding with POSCO E&C, a local general contractor, as a joint venture partner, and Gale International, a U.S. developer headquartered in Boston, as a managing partner. The two partners formed a joint venture company, New Songdo City, LLC, in early 2003, which inherited the development rights and the land supply agreement from the city of Incheon.

Over the past five years, numerous factors have affected the execution of the New Songdo City project. Most of these factors were forecasted and identified, but some were not expected. Changes in the market for real estate industry led to supplementary changes in the initial plans in terms of schedule, profit structure, and financing of the project. The developer and related participants have reacted dynamically to the changing environment in order to maximize the value of the project.

1.2. Methodology

This thesis is divided into two sections. The first half focuses on the narrative of the New Songdo City project, looking into the past, present and future of the development project. The second half develops a quantitative valuation of the flexibility provided by the phasing of the New Songdo City project. This quantitative analysis is aimed at illustrating a Monte Carlo simulation analysis technique, employing a simplified, relatively transparent EXCEL®-based procedure designed to facilitate use by practicing decision-

makers such as real estate developers.[2]

In Chapter 2, we review the preliminary development stage of the New Songdo City project by observing background information on planning and structuring of the project. We also highlight on insights and opinions from participants involved in initiating the project.

Chapter 3 examines the present condition and prospects of the project. We describe the obstacles and barriers that occurred during the development process, and analyze how they affected the original scheme and, thus, caused changes in plans or schedule. We also discuss forthcoming events that may have influence over the project.

In Chapter 4, we briefly review the general academic framework of the real options theory developed in the financial field, and introduce the real options research in the real estate field. Then to evaluate a valuation model for the New Songdo City project, we explore the "engineering-based" real options model applicable to the real estate industry in terms of its methodology. Criteria and factors that need to be considered are clarified and adjusted to be used as parameters to create a simplified and transparent, yet useful, engineering-based model applicable to large-scale, multi-phased development projects.[3]

For the 5th Chapter, we focus the model on New Songdo City. We apply an "engineering-based" Monte-Carlo simulation model developed in Chapter 4 to the New Songdo City using design elements and decision rules identified. Finally, we compare the result with the "economic-based" real options model developed by Geltner (2005) and Kang (2004).

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[2] The Excel-based Monte Carlo framework illustrated in this thesis was developed by Richard de Neufville and colleagues in the MIT School of Engineering. See, e.g., de Neufville et al (2006).

[3] The term "engineering-based" is used in this context to distinguish the simplified Monte Carlo decision-modeling and simulation framework from the classical economics-based "real options" model of development flexibility value and optimal phasing that has been developed in previous literature (see, e.g., Kang, 2004).

Chapter II: New Songdo City project: Initiation

New Songdo City (NSC)[4] is a master-planned city designated to become a business hub of the Northeast Asia region. The New Songdo City project (the "NSC project" or "Songdo International Business District project") is the centerpiece of New Songdo City. This project is initiated by the public sector, including the city of Incheon and the central government, and developed by the private sector, a first-ever US-South Korean real estate joint venture. The NSC project is estimated to cost in excess of $20 billion[5], ranking as the largest private development project ever undertaken in the world. It situated on 1,415 acres of reclaimed land on the western coast of Korea, 40 miles southwest of Seoul. It fronts the Yellow Sea between mainland China and the Korean peninsula. When it is completed in year 2015, NSC is estimated to be able to accommodate 65,000 residents and 300,000 workers in 45 million square feet of office space, 30 million square feet of residential space, 10 million square feet of retail space, 5 million square feet of hotel space, 10 million square feet of public space and a 100-acre central park.

Just like any other development project, the NSC project presents an enormous risk. Its unprecedented size, complexity and uncertainty due to lack of reliable market data has made the project even more risky and more challenging. On the other hand, if the project is implemented as planned, it would bring huge success and substantial profit to the parties involved. Its success largely depends on the dynamic decision-making of the developer, who

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[4] The NSC project developed by Gale International and POSCO E&C should be differentiated from New Songdo City as a whole. Out of 13,170 acres of New Songdo City, the NSC project refers to the 1,415-acre-"Songdo International Business District" project in Zone 1 & 3. For more information on New Songdo City and other two cities in Incheon Free Trade Zone, see appendix B.

5 This excludes another approx. $10 billion invested in the infrastructure by the city and the central government.

must respond to changes in the market and other issues related to the project.

In this chapter, we introduce the background of the NSC project and its initial development plan. This information is used in the following chapter to compare it with the reality that has occurred over the past five years.

2.1. Project Background

Over the last couple of decades, the trade within the Northeast Asian region has increased rapidly. Already in 1998, 27% of the world's trade took place in Northeast Asia. China as a "factory of the world" and Japan, one of the highly-developed technology leaders, have led this increase in trade. International capital and hi-tech industry have rushed into China, and foreign direct investment (FDI) has increased rapidly. Meanwhile, South Korea, located at the center of the Northeast Asian region, worried it could be isolated between those economic giants. Korea was (and still is) struggling to compete with Japan in major industries such as automobile, electronics and information technology. This concern finally led the Korean government to implement a long-term economic growth and development strategy for Korea based on turning Korea into a service and technology based global economy. As one means to achieve this goal, the central government decided to assign the "Free Trade Zone" by facilitating its geological advantage. In 2003, the government declared the formation of three Free Economic Zones (FEZs): Kwangyang, Pusan and Incheon.

Reclamation of Land

While New Songdo City achieved its international recognition after involvement of

Gale International in 2001, the land reclamation had already started in 1994. Based on the basic reclamation plan formed in 1979, new town projects in the Songdo area near Incheon had been underway since the 1980's by Daewoo, one of major conglomerates in Korea. As the construction of Incheon International Airport began in 1992, the reclamation of 3,000-acres for "Songdo IT city" or "Digital Valley" was underway. However, the Asian financial crisis and the International Monetary Fund Bailout of South Korea in 1997 forced the initial project to be delayed and later abandoned with the bankruptcy of the Daewoo.

Initiation of New Songdo City project

In early 2001, the city of Incheon decided to reinitiate the New Songdo City project with the motto of "New Songdo City, the Hub of Northeast Asia." In order to implement the project, the city invited several major construction companies to lead development. Unlike other major companies which were not willing to participate in such a large project with huge risk, POSCO E&C, a relatively young construction company founded in 1994, searching for a growth opportunity, decided to take the project. The city granted POSCO E&C with a 6-month developer designation to serve as the lead Master Plan Developer for the 1,415 acres of reclaimed land at New Songdo City.

The designation from the city required POSCO E&C to form a joint venture with a foreign developer that would take a majority interest. This condition aimed at achieving followings:

- Develop a new international city with a high quality that exceeds Korean standards.
- Manage this large-scaled, multi-phased project successfully with the help of the expertise of the international developer.
- Encourage foreign direct investors to participate in the development project.
- Attract international companies to the New Songdo City by bringing in a foreign

partner's expertise in international marketing.

In January, 2001, Stan Gale, president, and John Hynes, III, CEO of Gale International, were invited to Korea. After visiting the site and meeting with the city officials in April, Gale International submitted a Letter of Intent, and in July a Memorandum of Understanding was signed between the city, POSCO E&C, and Gale International. Gale International assigned KPF, a New York based architectural firm, to create the master plan. Based on KPF's preliminary master plan approved by the city, a Land Supply Agreement was made between the city and the New Songdo City Development, LLC ("NSC") in March 2002. Vigers, a brokerage and market research firm in Hong Kong, performed the initial feasibility study and submitted the report to NSC, LLC in June 2002. In March 2003, the District Unit Plan ("DUP", a zoning regulation) process started based on KPF's master plan approved by the city in November 2002.

The first financing of US$90 million was completed in October 2003. With the execution of first loan agreement and the purchase of Parcel 1, the business plan of the New Songdo City project was approved by the city of Incheon at the end of October 2003.

2.2. Opportunity

> *The reason we pursued it is twofold. One is we believed in it. … We saw some fundamental advantages to the opportunity that, we felt, could work, and I guess that kept us going. … Ultimately, it's not every day that you get to do something like this. We've never dreamed of doing something like this. (J. Hynes, III, 2008)*

The NSC project was the first international project of Gale International, a real estate development and investment company headquartered in Florham Park, New Jersey. When

they were approached by POSCO E&C, they quickly identified following opportunities within the project.

Strategic Location: "The Gateway to Northeast Asia"

Undeniably, its location plays the most important role in the New Songdo City project. Within three and a half hours by flight, sixty one cities with populations over one million, one-third of the world population in total, are located nearby New Songdo City and two billion people are reachable in a day (IFEZ, 2007). Especially, proximity to China shows a great potential for international demand.

When the 7.4-mile-long Incheon Bridge is completed in 2009, it will take 15 minutes from New Songdo City to the Incheon International Airport, the world's fourth busiest airport in terms of cargo and freight, and eleventh busiest airport in terms of international passengers (Airports Council International, 2007). Seoul, the capital of South Korea and a metropolitan area with a population of ten million, is one-hour drive distance from New Songdo City and is expected to be connected by subway transportation. Incheon, the fourth largest city with population of 2.5 million is also adjacent to New Songdo City.

Support from the Korean Government and the City of Incheon

The NSC project had the full support and complete endorsement from the city of Incheon and the Korean Government. In addition to the newly built Incheon International Airport and land reclamation, the government promised following benefits.

- The city would provide basic infrastructure, such as sewage, streets, electrics, to the site. The cost was estimated to be US$ 1 billion.
- The land could be bought at 25% to 50% of the potential future market value.
- Government was willing to create a special Free Economic Zone designation for the

area. Also other preferable regulations were expected to be applied to the project.

- Permitting process would be supported by the local and the central government.
- Since the land didn't have any zoning regulations yet, developer could design the initial zoning to be favorable to realize the vision.

Blue Chip Joint Venture Partner

POSCO E&C, the local partner of NSC, LLC, is the 6th largest construction company in Korea in terms of the construction revenue with $4.2 billion in sales in 2007. A subsidiary company of POSCO, the second largest steel manufacturer in the world, POSCO E&C achieved credit rate of BBB+ and Baa1 from S&P and Moody's, respectively, in 2007. Partnering with a very strong local representative like POSCO E&C would give credibility to the project and confidence to the lenders, mitigating financing risk. Also this partnership would ensure the quality of the projects and reduce the risk of delivery.

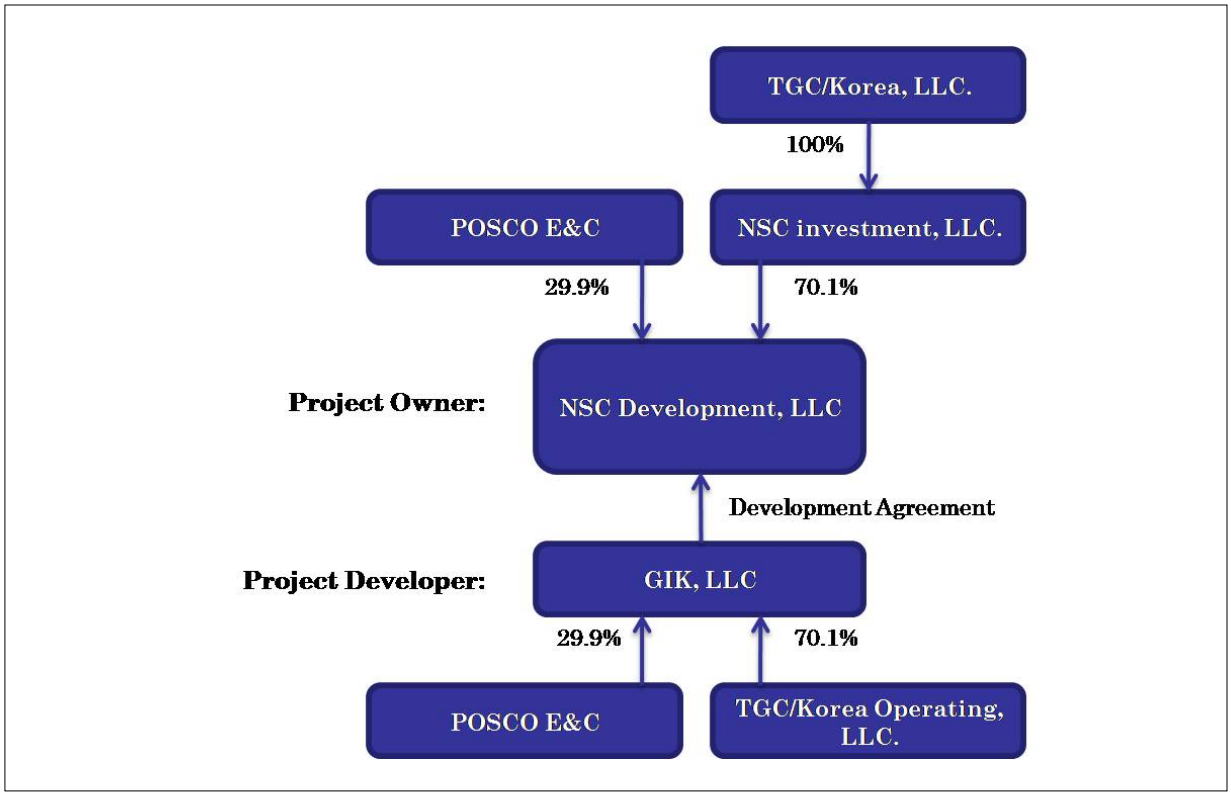
2.3. Initial Project Structure

2.3.1. Joint Venture Structure

In order to shield the partners from any possible downfalls, Gale International created several layers of special purpose companies as shown in the Figure 1. Among these companies, the New Songdo City Development, Limited Liability Company ("NSC, LLC", later changed to "NSIC" when the city was renamed as "New Songdo International City" in 2007), a Korean limited liability company that owned by the NSC Investment, LLC and POSCO E&C by 70.1% and 29.9% respectively, has an ownership of the total project. The

NSC investment, LLC, a Delaware limited liability company, is a subsidiary of Gale International. Gale International Korea, LLC is in charge of development and operation of the project under development agreement with NSC, LLC. POSCO E&C would be the construction manager and earn an additional 3% contractor's fee in the exchange of sole responsibility for all completion guarantees.

Figure 1 Project Company Structure



(Source: Gale International)

2.3.2. Financing structure

Traditionally in Korean real estate industry, the residential-for-sale properties are recognized to be the most profitable, while income producing properties, such as office and retail, are more risky and less profitable. Lack of reliable market data about commercial real estate also affected this perception since lenders couldn't assure the safety of

outstanding loan.[6] Almost all the lending for development projects were secured by land and supported by the credit of the general contractor that is usually a large construction company. Until then, there was virtually no project financing ("PF") that uses expected income from the project to support financing.

Recognizing this unique characteristic of the Korean real estate industry, Gale and POSCO E&C decided to fund the equity of commercial projects by the proceeds from the residential unit sales. With the help of Morgan Stanley as a financial advisor, the first round financing of $90 million was completed in October 2003. This syndicated loan, arranged by Woori Bank, a Korean commercial Bank, was reported to come from US$50 million split by Woori Bank and Industrial Bank of Korea, and US$40 million from ABN Amro, the Bank of Nova Scotia and other investors. The capital was raised for the initial land purchase of 82 acres and working capital needs. As is common for development projects in Korea, the land was collateralized and POSCO E&C and the city of Incheon provided the required credit support. In addition to the financing, Morgan Stanley, ABN Amro and Woori bank agreed to act as financial advisors for the future financing of the project.

Due to the sheer size and complexity of the project and uncertain market condition, initial valuation by the developer was performed under simplified assumptions. Financing expenses and taxes were excluded and hard costs were included in the land cost.

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[6] According to Kang (2004), for-sale residential properties in the project would generate profit margins in the range of 22 to 39% in a relatively short period, while income producing properties would generate 9 to 14% annual income yield. For more details, see Kang (2004).

2.3.3. Execution Planning

Conditions Required by the City of Incheon

The city of Incheon required the developer to fulfill conditions in the Land Supply Agreement and following detailed agreements. The conditions included followings.

- Build a convention center in the first phase and donate it to the city with additional land for future expansion. The "value" of the convention center should exceed US$100 million, but the detailed program and the size were to be negotiated.[7]
- Build a central park; size of the park is to be negotiated when the master plan is created. The park will be built above an underground parking garage that will contain 6,000 spaces.
- Provide main infra structure.[8]

The balance between profitable residential development and less profitable commercial development was one of the city's main concerns. To make sure that the New Songdo City project was created to be a full functioning city with both commercial and residential projects, the city of Incheon required the developer to build certain amount of commercial properties when it developed residential buildings.

Design of the phases

As a way to overcome the complexity of the project, as well as fulfill the city's

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[7] In the initial agreement in 2002, the convention center was planned to be developed as one of the main infrastructures by the city and Gale International was supposed to develop the center as a fee developer. This term was amended in 2003 after further negotiations with the new mayor of Incheon.

[8] Initial condition was that the city would provide the physical infrastructure, such as roads and sewerage. This term was also amended later that Gale would cover the construction cost of infrastructure for the residential blocks.

requirements, Gale classified all the properties into two categories: profitable projects and unprofitable projects. Profitable projects comprised residential buildings for sale, neighborhood retail and some of commercial retail. Other than those were classified as unprofitable projects. Based on market research, the developer estimated market demand for residential units. Considering the absorption rate with the demand level, Gale then determined the residential supply in the New Songdo City project in each phase per annum. Then the developer decided the supply schedule for commercial projects. Proceeds from the presale of residential units and external funding would cover the construction cost of both residential and commercial projects.

Development of Each Property in the New Songdo City Project

According to the agreement between the city and NSC, LLC, is obligated to participate in every project of New Songdo City. Therefore, an investor seeking for sole ownership of a specific project should agree on a ground lease term or form a Joint Venture partnership with minimum 1% interest for Gale. The investor should meet the criteria set by the master developer and the needs for design and planning to pass the review process for both the company and the development proposal.

2. 4. Vision and Challenges

2.4.1. "The Quality of Life"

> *New Songdo City is a city designed around one thing: the people who will live and work here. People who will experience an unparalleled Quality of Life as technology, resources and innovation all come together to create the ideal environment. (Gale*

International, 2006)

Gale International envisioned the New Songdo City project providing "the Quality of Life" to its residents and workers. In addition to lower rents, taxes benefits and other incentives, "the quality of life that doesn't exist anywhere in Korea and maybe anywhere in the world" (J. Hynes, III, 2008) would give companies that relocate in New Songdo City huge benefits. To achieve this goal, Gale International and KPF, a world-famous architectural firm that designed the master plan of New Songdo City, focused on creating quality-of-life projects such as the canals, the art center and the 100 acre Central Park. Creating a brand new city with every function fabricated intensively from scratch was challenging. KPF blended aspects of other world-known cities such as Paris, London, and Beijing, so that the city would have a heterogeneous structure and the residents would feel as if the city had evolved over many decades. [9]

In terms of programs, Gale International proposed three major setups in order to attract international companies to relocate in New Songdo City: the Central Park, international school and world-class hospital. Combined with the art museum and the *Ecotarium*, the Central Park would fulfill the cultural needs of all residents. Through the FEZ law, the Korean government would support the implementation of the projects by deregulating statues on both international school and hospital.

2.4.2. Identifying Challenges and Risks

In terms of executing the idea, Gale International faced risks not only associated with location, finance, market or permit, but also risks coming from its unique characteristics as

[9] For more detailed master plans including initial zoning plans and images, see appendix of Kang (2004). For a recent zoning plan modified in 2007, see appendix C.

an international project.[10]

Cultural Challenge

> *Songdo became a bigger challenge for variety of reasons. On top of these reasons, we have cultural risks. … How are we actually going to implement this idea? … There wasn't anybody else foreign who had developed anything in Korea. (J. Hynes, III, 2008)*

Gale International quickly learned that the business environment in Korea is totally different from that in USA. In addition, there was no international real estate investor or developer in Korea, and credible information on market and development process was scarce. Gale International needed to learn the business culture and market environment. This was a process of trial and errors that would clearly be time consuming and cost a great deal of money.

Execution Challenge

With a 13 hour time difference, New Songdo City is 6,800 miles away, 14 hours' flight from Boston. On the other hand, all the projects need hands-on operation in order for proper implementation. Unless Gale could assemble the right team to work the same way as they do in the states, the operation would require extra time and money in additional to the opportunity cost of projects executed in the US.

[10] Kang explained the risks associated with the New Songdo City project in detail in his thesis (Kang, 2004).

Chapter III: New Songdo City project: Implementation

Seven and a half years have passed since Stan Gale and John Hynes first paid a visit to Seoul in 2001. As usual in large development projects, the New Songdo City project has bumped into many roadblocks; sometimes the developer managed to overcome the obstacles, but other times they needed to change the initial plans.

3.1. Chronology

In February, 2004, NSC, LLC opened its Seoul office, and in June, and Gale International Korea, LLC was formed. In June the zoning regulation was amended based on KPF's completed master plan. In the prior regulation, average FAR was between 1.5 and 1.75. Under the new zoning codes, FAR varied up to 3.75.

The second round financing

Due to delay of permitting and construction, NSC raised a bridge capital. The second round financing of US$180 million was used to repay the first round financing of US$ 90 million and to fund working capital needs. Arranged by Woori Bank and executed in June, 2004, the syndicated loan was secured by the land and the proceeds from "the #: 1st World", the first residential project in the New Songdo City.

Direct investment and Joint Venture

In October, 2004, Taubman Centers, Inc., a USA real estate investment trust which specializes in shopping centers, created a Letter of Intent to invest US$ 477 million in the retail center project in New Songdo City. This shopping center is its first project to be

completed in the Asian region. This 1.1 million-SF shopping center will include a department store, a hypermarket, a multiplex cinema, a food court, an ice rink, and approximately 150 specialty stores.

In October, 2005, International School Service (ISS), a nonprofit corporation which provides a comprehensive range of quality educational services for schools, educators, families and corporations, signed an MOU with NSC, LLC to act as a founder and operator of the New Songdo City International School (NSCIS). In addition, Milton Academy signed an agreement with New Songdo City International School ("NSCIS"), forging an International School Partnership.

Kitson & Partners, LLC develops the Jack Nicklaus Golf Club community in conjunction with Gale International, POSCO E&C and the Jack Nicklaus Company. The community will feature approximately 400 residences, including single-family golf villas and condominiums, with the Nicklaus Signature Design 18-hole golf course.[11]

Ground-breaking of the projects

Five years of effort led to the ground-breaking of the first project in New Songdo City International Business District in May, 2005: the convention center ("Convencia".) In the following month, the first residential towers started construction.

The pre-sale of the first residential project, "the #: 1st World", was phenomenal. It was reported that "the application line stretched for 2 miles" (Forbes, 2008), and "two thousand one hundred forty-five residential units were sold for a total of $1 billion U.S. Ninety-two percent of the apartment units were sold to approved buyers during an initial three day presale. Within an additional two days, 100% of the apartments were sold to approved

[11] For a list of joint venture partners and other participants, see appendix D.

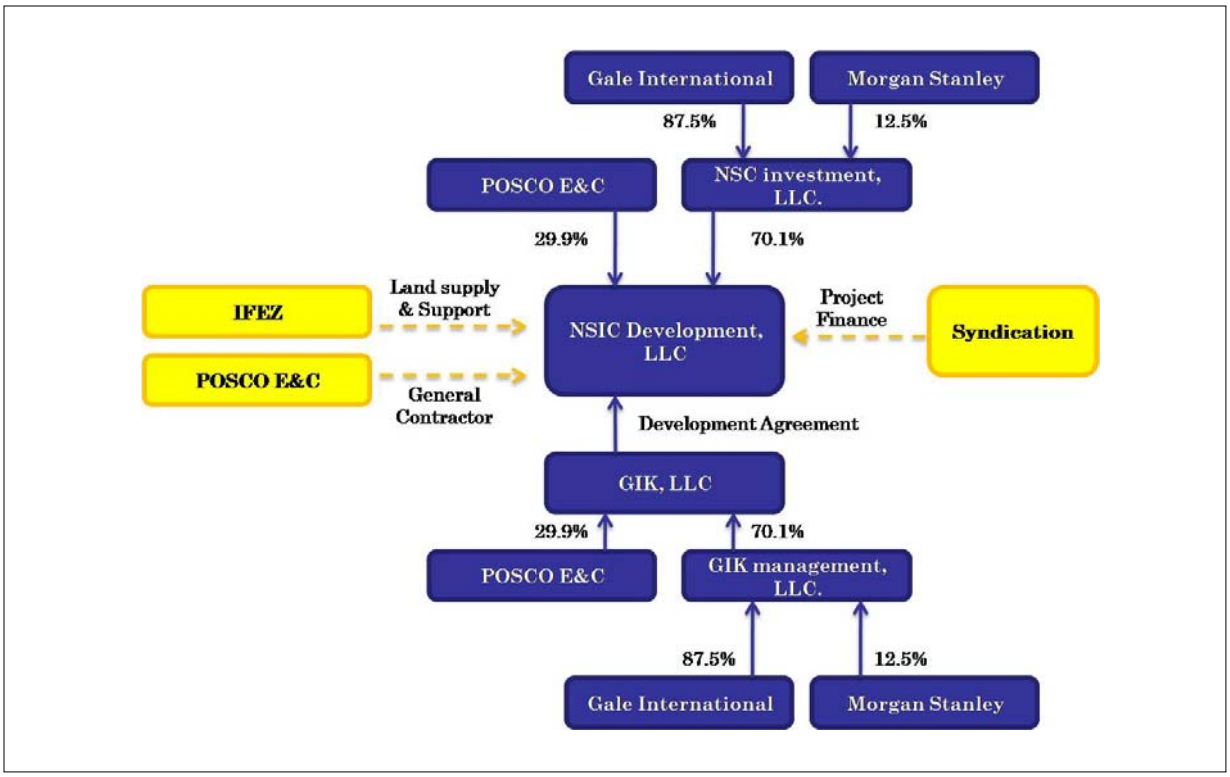
buyers." (PRNewswire, 2008)

Following residential projects were also successfully sold out in spite of relatively high prices. For example, the second residential project, "the #: Central Park", had 26,700 applicants for 677 units, with 1:40 competition in January 2007.[12]

Equity investor: Morgan Stanley

Such success of residential presale gave Morgan Stanley confidence on the potential of the NSC project. In May, 2003, Morgan Stanley announced to invest US$ 15 million to NSC Investment, LLC, taking 12.5% of interests in equity. (Figure 2)

Figure 2 Current Project Structure



[12] The pre-sale price of "The #: Central Park" was US$ 492 per SF excluding common area, an amount close to the price in Seoul. In 2006, average pre-sale price in the city of Incheon was reported to be US$ 255 per SF, almost half of the Songdo area. This was prior to the pre-sale cap regulation.

The third round financing

In June, 2005, NSC completed the third round financing, which in fact is the first main financing, of US$1.5 billion in syndicated loan from 26 financial firms. Three key arrangers include Woori Bank, Kookmin Bank, and ABN Amro, with Morgan Stanley as the financial advisor. This capital was used to purchase the parcel 2 of 600 acre for US$250 million in December, repay the second financing, fund the working capital needs and cover the construction cost of projects such as Convention center, Central Park, and other infra structure. The loan was collateralized by the land and cash flow from the commercial projects in the form of project financing. In the following December, Parcel 2 was acquired for US$ 250 million.

Final DUP and business plan approval

In November, 2005, final District Unit Plan ("DUP", a zoning regulation) and business plan were approved by the Ministry of Strategy and Finance (former "Ministry of Finance and Economy (MOFE)"). With this approval, zoning regulations on usage and FAR were finalized. In addition to former business plan, MOFE required NSC to develop 30% of residential and commercial projects until 2009 in order to keep balance in program. With this approval and the third round funding completed, NSC could accelerate the development process.

Linkage program and Additional Investment of MSREF

As a way of hedging risk and attracting investors, NSC introduced the "Linkage program". With this program, NSC granted development rights for residential projects in exchange with investment in commercial projects. The first linkage program was to combine the proceeds of "the #: 1st world" residential towers with the development cost of

the convention center. In August 2006, NSC announced seven additional linkage programs, which led to conflicts with the city and POSCO E&C. The city and the IFEZ authority did not regard to these programs as foreign direct investment which they had expected NSC to attract. On the other hand, POSCO E&C strongly opposed because they could not assure the construction contracts for projects within the linkage programs.

At the moment, Gale International and Morgan Stanley Real Estate ("MSREF") announced an agreement to fund US$350 million in new foreign direct investment. This capital would serve as the financial foundation for US$ 3 billion in construction of NEATT, hotel, and other commercial facilities along with residential blocks. In the following December, Linkage 2 Joint Venture Agreement was completed, and MSREF executed US$ 150 million investment. MSREF would invest another US$ 200 million in the Linkage 3 program which included the golf community, residential buildings and retail projects.

Regulatory amendment: Pre-sale price cap

As a way of controlling the housing price appreciation, in January 2007, government enacted a law on housing pre-sale price cap. Prior to this policy, developers and construction companies could freely decide pre-sale prices of housing units based on the actual development cost and market value associated the development profit, which consequently led to the appreciation. With the new regulation, the government attempted to control the pre-sale prices by deciding the standard price based on average construction costs, premiums and the land prices.[13]

For the NSC project, each round of financing was secured by the value of land and

[13] The land price used for the price cap is the appraisal value of the land, not actual transaction price. The appraisal value of the land in urban area is usually considered to be approximately 63% of the transaction price.

revenue from condominium pre-sales based on the price determined by NSC. Therefore, price cap could affect the value of collateral, making lenders nervous. Since buildings were to be built on reclaimed land, unstable soil condition required more reinforcement and special foundations system. Furthermore, the quality of residential buildings in the New Songdo City was above Korean standards. These conditions caused higher construction cost than other projects in Korea. Inevitably, the pre-sale price cap law harmed the profitability of the whole project given that the revenue from the residential development was planned to fund the construction of commercial development. This led to project delays and consequently more funding needs.[14]

More ground-breaking followed

In February 2007, construction of the Central Park, NEATT and Hotel started. Other major ground-breakings included the construction of POSCO E&C headquarters in January 2007 and the Jack Nicklaus Golf Course in March, 2008.

While NSC project was pushing forward, the city was having trouble with funding for its infrastructure completion, which led to its delay, as shown in Table 1, as well as the delay of the NSC project delivery.[15]

The fourth round financing

In November, 2007, New Songdo International City Development, LLC concluded a $2.7 billion syndicated financing agreement with arranger Shinhan Bank and 12 other

[14] This policy affected the whole construction industry which accounts for 18.8% of total GDP in 2005. New government is now trying to modify the regulation.

[15] For instance, in November 2004 the city and MOFE requested the funding of US$21.2 million for infrastructure construction, only US$5.6 million of which was included in the national budget by the National Assembly.

Table 1 IFEZ Metropolitan Infrastructure Plan Update

	Details	Initial schedule	Current status
The 2nd Airport Bridge	Direct connection of Songdo to Incheon International Airport. Project cost: US$ 774.8 million (10.25 km, 6 lanes) Developer: AMEC (UK)	2008	To be completed by 10 / 2009
The 2nd Seoul Belt Expressway	Initial opening between Songdo to Cheongna(21.5km) Project cost: US$ 639 million Developer: POSCO, E&C	2008	To be completed by 11 / 2012
The Gyeongin Express Bridge	Direct connection of Songdo to southern part of Gyonggi province. Project Cost: US$ 448.3 million Developer: The 3rd GyungIn Corp.	2008	To be completed by 2011
Gyeongin Expressway extension line	Direct connection of Cheongna to West Incheon IC. Project Cost: US$ 218.1 million	2008	To be completed by 2013
Airport Railway	Phase 1: Incheon International Airport to Gimpo airport(to be complete by 2005) Phase 2: Gimpo airport to Seoul Central Train Station.	completed 38% of the 1st Phase	Phase 1: 03 / 2007 Phase 2: 12 / 2009
Incheon Subway NSC extension	Project Cost: US$ 721 million 6.54km		To be completed by 09 / 2009

(Source: Kang (2004) and IFEZ (2007))

participating banks. This loan agreement was the largest real estate financing in Korean history. Shinhan Bank directly funds nearly $1.7 billion of the $2.7 billion financing. Other participants in the syndication include the Industrial Bank of Korea (IBK), Hana Bank, and Kumho Life Insurance.

The financing was used to purchase an additional land parcel as well as fund construction and the development of additional Songdo IBD facilities. It also was used in part to consolidate and repay prior financing.

Successful implementation of previous projects made it possible to support the loan with the expected income from commercial projects in the form of the project financing. By

excluding several parcels from collateral, NSC obtained more flexibility to development.

The fourth round financing was planned to be the last. However, due to the delay of projects, additional financing may be needed.

SIBD Global Marketing Campaign

Gale International, along with Jones Lang LaSalle, an exclusive leasing agent for the Northeast Asia Trade Tower, held a Global Marketing Campaign Event for domestic and international investors in January, 2008.

3.2. Major Issues of New Songdo City project

Political and Regulatory Jurisdiction

Political landscape is more volatile than USA. Gale International has engaged with three Presidents of Korea and two mayors of Incheon. New politicians with different outlooks and interests over the project made attempts to change initial plans and schedules, and to renegotiate conditions, most of which led either projects delays or profit decrease. For example, in 2006, the city requested to accelerate the completion of the convention center and hotels for the Global Fair & Festival 2009 Incheon, while the developer couldn't execute projects without proceeds from the residential building development. The local media would often stir up issues based on unconfirmed information or misunderstanding that pegged Gale as a "slash-and-burn opportunist" or a "typical American capitalist".[16]

[16] This issue was specifically provoked by Lone Star Funds' deal on Korea Exchange Bank. The Lone Star Funds, a private equity firm that specializes in purchasing distressed companies and assets,

Huge success of residential projects led to misunderstanding that NSC was only conducting profitable residential projects and none of commercial projects. NSC was also criticized because they purchased the land at the "fixed price a lot lower than the fair market price", which, however, is not exactly true because the value of land varies in terms of FAR and usage.[17] Along with a public long wary of foreign investors, these issues brought conflicts on development plans and permitting issues with local government city council, which became unavoidable as the project moved onward.

Gale also confronted a lot of red tapes involved in Korea. In Korea, which now is a leader in many high-tech industries, rigid hierarchy and bureaucracy still exists. New concepts which NSC introduced for the project were welcomed at first, but actual implementation of these ideas was sometimes hard to achieve because of conflicts with the authorities. Deregulations for the international school[18] have been finally established after long discussions and disputes, but regulations associated with the international hospital still need to be modified in terms of entity structure and health insurance issue.

For a project of this size and complexity that is considered of national level importance, the central government should be in charge of the overall development planning. However, two governments following President D. Kim, who initiated the plan, were not fully supportive to the project. The legislated statue of the Free Economic Zone was not enough to provide actual incentives for domestic and international companies to relocate.

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acquired the bank in 2003 following unrest in Korean credit markets, for US$ 1.4 billion. After three years, Lone Star attempted to sell it to Kookmin Bank for US$ 6.4 billion, but is facing criminal investigations from Korean regulators for stock manipulation and tax evasion, among other charges.

[17] For instance, market value of the land for the commercial project with FAR 3 would be much higher than the land for golf course. However, NSC purchased the land at the single, fixed rate.

[18] In Korea, international schools are regulated to accept students who lived in a foreign country for more than five years with foreign citizenship. However, the NSC international school can accept up to 30% of total students without foreign citizenship.

Inexperience in international development resulted in unfulfilled establishments of social support and tax benefits. In addition, incoming companies had to deal with not only the Incheon Free Economic Zone Authority but also with each ward office.

Lack of Social Infrastructure

Let alone the local participants that are engaged in the development of the project, the Korean real estate industry had not experienced and was unfamiliar with the role of a developer or development concept neither institutionally nor socially. In Korea, there was no speculative, third party developer. Most of the projects were developed either by corporate or by collaboration of small-size developers who would secure land with their equity, and then general contractors would provide credit for the financing and build the project. Korean officials had a hard time understanding the role of the developer who "arranges architects, contractors and institutional investors to come together in a location and collaborate on a project and who is in the middle of all." (J. Hynes, III, 2008)

The city officials' lack of experience and knowledge in development process also brought conflicts from time to time. For example, to eventually bring the tenants into NSC, first the master plan and design should be completed, and then the permit process. However, the government officials often insisted that, without tenants and investors, they couldn't give out permits. Longing to see the tangible results, the officials became impatient about the prudent and step-by-step process going on for many years. Therefore, educating the government officials took much time and effort.

Partnership and Position of Gale International

As a partner in NSC, LLC and also a general contractor who is solely responsible for all completion guarantees, POSCO E&C's interests would sometimes conflict with the NSC's

interests. POSCO E&C wanted to participate in less-risky residential projects while NSC needed to balance both residential and commercial projects. Moreover, the linkage programs which associate residential projects with commercial projects caused disputes, because, with projects under the linkage program, POSCO E&C couldn't secure construction contract with outside investors, while still solely responsible to the completion. In addition, given the privileges as a master contractor in the bidding process more than often increased construction costs.

As mentioned earlier, to understand the local real estate industry and to work harmoniously with the local partners Gale had made an effort to launch a local office in June 2004. Establishment of a local organization was essential for prompt actions and approvals. Earlier commitment would have provided Gale with advantages in negotiating with local partners and also to hedge against unpredicted situations.

3.3. Innovative Development

To meet with the needs of tenants and residents and to successfully promote the project, NSC adapted two concepts in terms of innovation: the Green City and the Ubiquitous City concept.

Sustainability: The Green City

NSC was announced as the "Green Urbanism" Pilot Project by U.S. Green Building Council in July 2007. The project was accepted as a partner for LEED for Neighborhood Development ("LEED-ND") certification, the first national standard for neighborhood design. The NSC project is one of only three LEED-ND projects in Asia with two smaller

projects in China, and one of only five outside the United States and Canada. Indeed, it is by far the largest project outside North America to be included in the 18-month pilot program.

With the implementation of modern green technologies such as recyclable irrigation system, gearless elevator system with 75% less energy consumption, NSC will become one of the world's "greenest" cities. Moreover, NSC will play a pioneering role in helping to set this standard for sustainable urban planning and smart growth based on criteria such as density, proximity to transit, environmental preservation, mixed housing type, and pedestrian-friendly design.

In order to implement this idea, NSC and GE Korea signed an MOU to cooperate on development and marketing of sustainable development. GE Korea, under the GE's "*Ecomagination*" initiative[19], will provide its expertise in environmental-friendly products and development solutions.

IT test bed: Ubiquitous City

Utilizing Korea's advanced IT industry was one of the strategies for NSC. With the motto "Ubiquitous City", NSC will become a place where most recent and future technology is experimented and tested. Inside the New Songdo City, wireless networks and radio-frequency identification will link all information systems- from the building's heating system to every cell phone and even toaster. "Residents, it's hoped, will be able to time their commute out the door with the changing walk signals on the street 50 stories below." ("A Brand New City", 2007)

[19] The *"Ecomagination"* initiative launched in 2005 represents GE's attempt to position itself as a "green" company. GE is focusing on development of new environment-friendly products such as hybrid locomotives, desalination and water reuse solutions, and photovoltaic cells.

To realize this goal, NSC LLC and LG CNS established "Songdo U-Life, LLC," a joint venture which will play a key role in constructing a U-city in New Songdo City, in June 14, 2005. Furthermore, in May 2008, Microsoft signed an MOU with Gale to collaborate to deliver technology and infrastructure and create a cutting-edge, digitally connected and environmentally sustainable city. This is a more extensive agreement of former collaboration on the integration of the MS service into the Songdo International School. MS will also provide a common interface to connecting to government services via its platform.

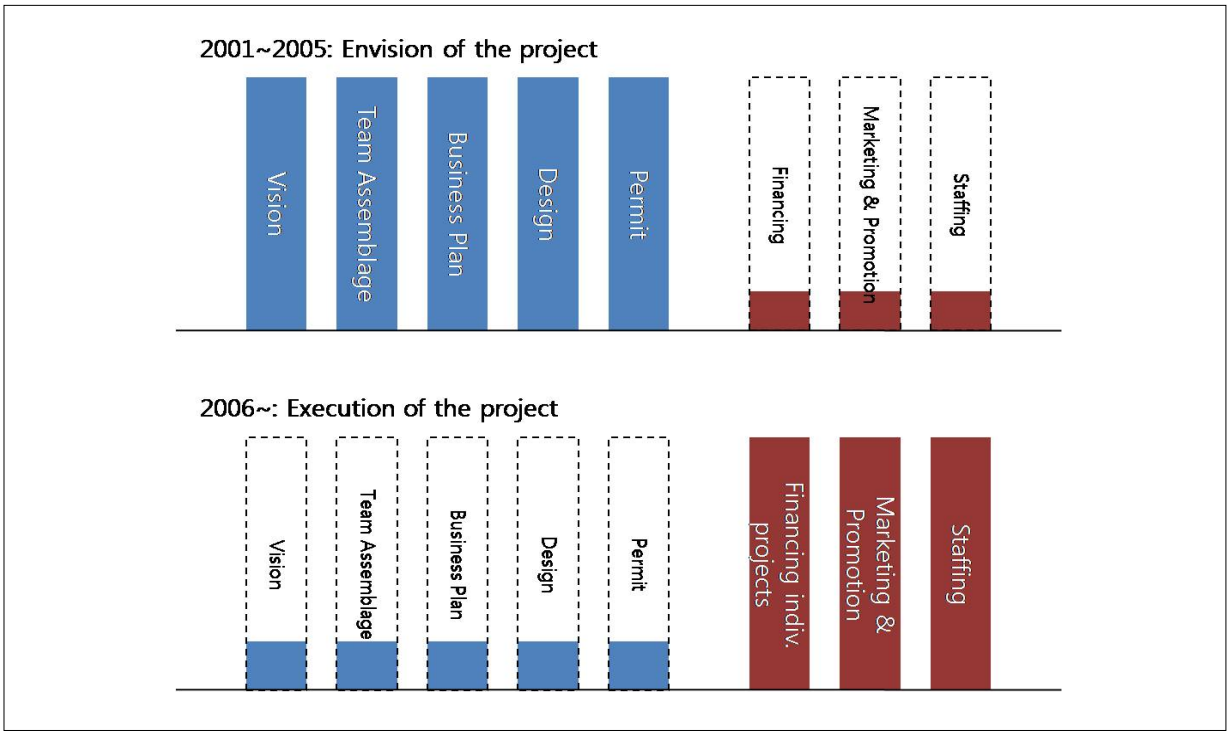
3.4. Now and Future of New Songdo City project

> *We are now starting to see the fruits of our labor. Where there's enough momentum now, we are finally able to attract some serious dialogue with international corporations and domestic corporations. Now we can finally say that this is real. … It's going to be a great project. You'll see it next summer. In August 2009, Songdo will look like a real place. (J. Hynes, III, 2008)*

Gale International explains that since 2006, the project has passed the first phase of strategic master-planning and now is going through the second phase of its whole process. From 2001 to 2005, this was a period for creating the vision, assembling the right team, setting the business plan, processing the design and permitting the projects. Since 2006, Gale International has focused on financing each project, executing construction, marketing and leasing, and staffing. (Figure 3)

With the infrastructure on the way —the Incheon Bridge opening in August 2009, subway in 2010, and third highway in 2009—, the first project completed in the New Songdo International Business District will be the convention center in November 2008, followed by the first residential towers in April 2009, the international school in September

Figure 3 "Silos" of Development Process



(Source: Interview with John B. Hynes, 2008)

Figure 4 Satellite images of NSC in 2002 and 2007 (Source: IFEZ, 2007)

2009 and many other buildings in 2010. By June 2008, 20 projects are under construction, with additional 15 projects expected to start construction in late 2008.

The merit of New Songdo City for the local Korean market can be summarized as the "quality product at the low price." The quality of the city, with its Central Park, canal, and

Figure 5 Site Photo on June 3, 2008

(From left, clockwise: NEATT, Residential towers ("#1: the 1st world"), Convention Center ("Convencia"). Source: authors)

other amenities, is extraordinary, while the price is still lower than in Seoul. The quality of products they deliver in New Songdo City is far superior in terms of their designs, materials and functions. Due to many flagship projects conducted by GE, MS or other global companies, the residents and workers can enjoy the most recent technology prior to anyone else in the world. Already large companies such as POSCO E&C and LIG decided to move their headquarters to New Songdo City and other domestic and international companies are expected to follow them.

Chapter IV: Real Options in Real Estate

Since large-scale, multi-phase "mega" real estate development projects such as the New Songdo City project, are conducted over many years, the due diligence process cannot be the same as in other smaller projects. As shown in previous chapters, the New Songdo City project has encountered various obstacles, some of which were never expected. Due to the complexity and high uncertainty, large-scale, multi-phase projects bear more risk. On the other hand, when circumstances around the project change during the development process, developers can manage the project actively by changing the initial plan. By facilitating their expertise, they can modify initial programs, change sequences, delay phases, or even abandon the rest of the project, eventually maximizing profit.

In this chapter, we introduce the concept of real options and its application in the real estate industry. In addition, we explain the real options "engineering-based" model and its methodology, which we apply to the valuation of the NSC project in the following chapter.

4.1 Overview of Real Options in Real Estate

A real option refers to an option whose underlying assets are real assets, i.e. product lines, plants, buildings and land. The term was first used by Myers (1977) in the context of strategic corporate planning in order to apply the "option" valuation method to real projects such as R&D and property investment. Based on the option theory—i.e. a financial notion that, with an option, one can choose to take the upside of the project and refuse to take the downside–, the notion of the real option is that flexibility of decision generates value and, therefore, the option value should be added to the value of the project.

The notion of options in development projects has been intuitively accepted by both

developers and investors. Many researchers have attempted to identify the options embedded in real estate development projects. Titman (1985) introduced option theory to explain the value of a vacant lot. If the value of a completed project exceeds the development cost, the option is worth exercising, i.e., buying the land and developing the project. In this case, the land price can be considered as an option price. Titman argues that if the speculative developer is uncertain of the project value due to volatile market conditions, it is better to wait than to exercise the option so that they can build the most appropriate building given economic conditions at that time.

Geltner et al. (2007) defined the land value as a "call option"—i.e. the right without obligation to purchase at a stated price per share, a specified number of shares of the stock, before or on a certain date. In order to quantify the value of the call option of land, he applied the binomial model and the Samuelson-McKean formula—both are "economic-based models"—to a simple development projects. He demonstrated that, by taking into account the landowner's option to avoid negative consequences, the expected value of the land would increase.

Kang (2004) developed the "economic-based" binomial model applicable to large-scale, multi-phase projects. Using the binomial model, he evaluated the option value of a real world case: the New Sondo City project in Korea. In addition, he applied the Decision Tree Analysis (DTA) to the project as a way to identify project-specific risks. Kang showed that when option value is added to the valuation, the NPV was positive, while traditional DCF valuation showed negative value. Based on Kang's data and methodology, Geltner (2005) developed a case on New Songdo city and refined the model.

Hengels (2006) challenged the idea that a universally practical financial model using real options could be developed. Using categorized EXCEL® worksheets, he proposed a more practical, transparent and instructive "workbook" which could be applied to smaller

development projects.

The limits of the "economic-based" model have directed researchers' interests toward another type of real options model: the "engineering-based" model.[20] In the field of engineering systems, academic researchers as well as practitioners have developed real options models in decision-making for optimal systems. De Neufville et al. (2006) presented three advantages of the engineering-based model compared to other valuation approaches. First, they use standard, readily accessible spreadsheet procedures. Second, they use data available in practice. Finally, they provide graphics that explain the results intuitively. De Neufville also defined four steps for analysis procedure. Cardin (2007) further developed the methodology of de Neufville. He explored the potential of flexible design and development strategies that maximizes the expected value of engineering systems. As a more practical way to develop and operate a system, he proposed catalogs of operating plans based on the Monte-Carlo simulation and applied them to two hypothetical real estate development projects. Using this model, he demonstrated that flexibility of a project would increase the results of Expected Net Present Value (ENPV) and Value at Risk and Gain (VARG) curve[21]. Based on previous studies of various real option models, Masunaga (2007) combined the "economic-based" model and the "engineering-based" model. Applying both the binomial model and the Monte-Carlo simulation model to a hypothetical project developed by Geltner et al. (2007), he identified a critical problem of the engineering-based model: the usage of a single risk-adjusted discount rate would lead the model either to underestimation or overestimation of the real option value. He then proposed to use the

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[20] For the description of the terms "engineering-based model" and "economic-based model", see footnote 3 in Chapter 1 (p.11).

[21] The ENPV is the mean of NPV values generated from the simulations and the VARG curve is the cumulative distribution of NPV value probabilities.

engineering-based approach with the economics-based approach together.

Barman and Nash (2007) conducted interviews with developers on their decision-making process and revealed that developers implicitly value real options via intuition and judgment and often adjust the hurdle rates or return requirements depending on the amount of options available; with more options to reduce risk, they lower return requirements. They also conducted a case study by combining the economic and engineering real options methodologies. The broad framework was based on the engineering-based Monte-Carlo simulations and the decision rules of hurdle rate and abandonment value were derived by the economic-based Samuelson-McKean formula.

4.2. Real Options Engineering-based Model: Analysis Methodology

The "engineering-based" model we focus on is based on EXCEL® software, which is easy to access and used widely by practitioners in the real estate industry. This method was originally developed by de Neufville et al. (2006). The approach method we use consists of four steps.

4.2.1 Step 1: Build an initial cash flow Pro forma

We start out by creating a cash flow projection of the project. The cash flow stream is built in accordance with market specifications, construction costs, project scale and schedule. We then discount these cash flows with a specific discount rate to calculate the Net Present Value. This NPV method is commonly used in the real estate industry to analyze projects and to make decisions as well. However, the stream of cash flows is based on deterministic projections without incorporating uncertainty and, moreover, flexibility.

Thus, as a base case to compare with results from incorporating uncertainty and flexibility, we will call it the “base case.”

4.2.2 Step 2: Identify uncertainty factors and incorporate into cash flow

The initial Pro forma is based on deterministic cash flows and, therefore, in order to recognize uncertain conditions of the overall real estate market we need to identify these uncertainty factors and incorporate them into the Pro forma. This procedure, the Monte Carlo simulation, can be conducted effectively by using the data table function in the EXCEL® program. The thousands of Monte Carlo simulations provide diverse outcomes of cash flows. We review the initial model based on these uncertain variable scenarios and examine how uncertainty affects the value and performance of the project. This case offers recognition of uncertainty before having the flexibility of decision-making. We call it the “inflexible case”.

4.2.3 Step 3: Determine criteria for decision rules and implement flexibility

By examining the cash flow developed in step 2 and considering real world development situations, we determine decision rules that respond to the uncertain variables. For development projects, possible decision options would be immediate development, waiting to develop, or abandonment of development in response to uncertain variables e.g., the market demand or project return. The criteria for these rules can be established depending on what the priorities or concerns of the project are for the decision-maker. The ability to make decisions introduces flexibility in the project, and thus we will call this the “flexible case”.

4.2.4 Step 4: Search decision combination to achieve optimal NPV

The fundamental of flexibility implementation is the accessibility to conduct several combinations of decision rules to achieve better results. We should mention that this procedure would rely on the principles of the decision-maker. For example, the principles could be based on expected NPV, initial CAPX minimization, etc. By experimenting different decision combinations, we can see how decision rules and design factors affect the project value, and determine the best combinations based on developer's criteria.[22]

[22] As a way of searching for the optimal decision combination, Cardin (2007) suggested an algorithm called "Adaptive One-Factor-At-a-Time (OFAT) which was developed by Frey and Wang (2006) and Wang (2007). With this method, he observed the system's responses to a limited set of uncertain variable scenarios and concluded that, though it is quite difficult to get the best combination through OFAT algorithm given time constraints, it is an efficient way to generate the optimal decision combination. For details, see Cardin (2007).

Chapter V: Valuation of NSC with Real Options Engineering-based Model

The valuation of the real options "engineering-based" model for the New Songdo City is inspired by and based on data information and assumptions applied in researches done by Kang (2004) and Geltner (2005). It should be noted that the numbers and detailed specifications of the model examined in this thesis do not correspond exactly to the actual real-world NSC project. This is done both to protect proprietary information and to simplify the analysis to facilitate its illustrative value. While the specifics differ slightly from the actual reality, the model well represents the essential characteristics of the NSC project as it is relevant for the present research.

Our approach starts out by analyzing the project using the traditional Discounted Cash Flow (DCF) method, like the type of analysis that was probably done by the actual project decision-makers at the time of the initial strategic investment decision. We then we develop an engineering-based real options model applicable for the project by identifying uncertainty factors and then incorporating these factors into the Pro forma, and then analyzing possible future outcomes of the uncertainty using Monte Carlo simulation.

Finally real options valuation model is built by determining the criteria for decision rules (in this case for the start-timing or possible abandonment of project phases) and applying these decision rules in the future simulation so as to quantify the value of the phasing flexibility in the development process.

5.1 Data and Assumptions

As stated earlier, the Pro forma cash flow used for our analysis is based on previously

developed research material. We utilize this Pro forma information to structure our model. The initial inventory plan is shown in Table 2 and the Pro forma in Table 3. Other information and assumptions were also used from these references in order to maintain consistency and to compare results.[23]

Table 2 Summary of Project Inventories (in SF)

Phase	I	II	III	IV	V	VI	Total
Land (sf)	3,519,000	9,846,000	14,451,000	11,355,000	4,488,000	6,755,000	50,414,000
Residential	5,515,220	10,915,664	5,650,451	15,090,462	5,289,300	246,000	42,707,097
Office	648,000	1,931,000	0	9,998,775	13,711,970	10,834,234	37,123,979
Retail	1,751,640	1,166,955	340,000	2,342,386	2,004,071	919,630	8,524,682
Hotel	1,019,200	656,973	0	0	0	0	1,676,173
Hospital	0	1,849,138	0	0	0	0	1,849,138
School	0	279,513	0	279,513	0	0	559,026
Government	1,000,000	0	0	0	0	0	1,000,000
Golf	0	0	9,822,774	0	0	0	9,822,774
Park	0	3,017,600	1,397,000	2,803,000	539,000	4,025,000	11,781,600
Total	9,934,060	16,799,243	5,990,451	27,711,137	21,005,341	11,999,865	93,440,096

The information and assumptions are addressed below:

- The project is planned and designed in six sequential phases, each phase including various product types. Much of the product is residential, which would be sold upon completion of construction.
- Each phase involves several years of construction and several years of sales of the development in that phase. The length of construction phase and sales phase varies in every phase.

[23] For detailed project pro forma and inventory list, see Geltner (2005) and Kang (2004). Geltner, in his case, simplified Kang's assumption furthermore for academic uses. In this thesis, we use Geltner's pro forma cash flow and assumptions.

- A single developer is being offered exclusive development rights (exclusive rights to purchase the land) for the entire project, with a guaranteed price for the land for each phase. The pre-agreed guaranteed land prices, which include land purchase price and associated fees are indicated in the "Cash Flow Pro forma".
- The construction schedule for the project is planned so that each phase can start construction one year after the preceding phase unless the decision rule indicates execution is unfavorable and an option to delay exists.
- The first phase includes the requirement that the developer initially construct a world class convention center (whose construction costs are estimated at $200 million).
- The developer shall proceed intentionally on developing the first phase at year 2003 ("time 0") regardless of circumstances.
- Taking on a phase of the project gives the developer the right without obligation to take on the next sequential phase.
- The land price for each phase is not due and payable unless or until development is committed to for the given phase.
- One year of construction is required to demonstrate commitment to any given phase before the developer obtains the option on the next phase.
- A 30% hurdle rate is applied to analyze the Net Present Value for each phase, a rate commonly used for practitioners in the real estate industry.[24]

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[24] Gelter (2005) explains that, given the risk of a pioneering development project like the NSC project, the lead developer with the exclusive development rights would probably require a very high hurdle rate and concludes that a hurdle rate of 30% per annum might well be required in a conventional DCF valuation of the NSC project. For comparison with the economic-based binomial model, we applied 30% to the model.

5.2 Real Options Engineering-based approach

5.2.1 Step 1: Build an initial Cash Flow Pro forma

A summary of the Discount Cash Flow Pro forma based on information provided by Kang (2004) and Geltner (2005) is shown in Figure 3. Since this initial cash flow is based on deterministic projections which do not incorporate uncertainty of any sort we call it the "base case" in our thesis. We have calculated the NPV of the basic cash flows at a discount rate of 30%. The results from the Pro forma are as follows:

NPV at 30% Discount Rate: $ -52,311,000 Overall Project IRR: 29.35%

Though the project shows negative NPV, overall IRR shows 29.35%, quite close to the hurdle rate of 30%. Given the scale of project with estimated cost of US$ 20 billion, we can say that the NPV is effectively zero.

5.2.2 Step 2: Identify uncertainty factors and incorporate into cash flow

In the real estate industry, the most critical factor that drives the decision-making is the return of the projects, which is the present value of revenues minus present value of cost. Of these two factors, the value of the underlying asset is more volatile than the cost.

Each phase of the New Songdo City project includes various types of properties with different target returns and volatility. In order to simplify the model, we assume that all product types in a certain phase move concurrently with the overall market, meaning that the volatility of the market will project its influence directly on the income and sales for our project. Also we assume that the development cost doesn't change even if the project is delayed for up to three years.

Table 3 Pro-forma of the NSC project

	PV @ Time 0	Undisc Sum	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
PHASE I (begin date 2003)														
Projected Costs:	**1,459,647**	**1,620,366**	**256,550**	**195,399**	**559,881**	**532,424**	**76,113**	-	-	-	-	-	-	-
Land + Fee	56,550	56,550	56,550	-	-	-	-	-	-	-	-	-	-	-
Convention Ctr	200,000	200,000	200,000	-	-	-	-	-	-	-	-	-	-	-
Building construction	1,203,098	1,363,817	-	195,399	559,881	532,424	76,113	-	-	-	-	-	-	-
Projected Income & Sales	**1,393,454**	**2,121,591**	-	**406,145**	**406,145**	**541,526**	**29,408**	**525,605**	**9,741**	**12,664**	**16,885**	**173,473**	-	-
Net Cash Flow:		**501,225**	**(256,550)**	**210,746**	**(153,736)**	**9,103**	**(46,705)**	**525,605**	**9,741**	**12,664**	**16,885**	**173,473**	-	-
Projected IRR as of begin date:		**25.3%**												
PHASE II (begin date 2004)														
Projected Costs:	**2,795,515**	**3,281,304**	-	**158,223**	**825,604**	**1,210,381**	**979,585**	**107,511**	-	-	-	-	-	-
Land + Fee *	149,975	158,223	-	158,223	-	-	-	-	-	-	-	-	-	-
Building construction	2,645,541	3,123,081	-	-	825,604	1,210,381	979,585	107,511	-	-	-	-	-	-
Projected Income & Sales	**2,935,180**	**5,287,178**	-	-	**434,688**	**1,075,547**	**1,063,334**	**1,122,607**	**1,157,993**	**9,135**	**12,789**	**411,084**	-	-
Net Cash Flow:		**2,005,874**	-	**(158,223)**	**(390,916)**	**(134,835)**	**83,749**	**1,015,096**	**1,157,993**	**9,135**	**12,789**	**411,084**	-	-
Projected IRR as of begin date:		**42.5%**												
PHASE III (begin date 2005)														
Projected Costs:	**1,302,781**	**1,588,221**	-	-	**232,225**	**372,612**	**579,703**	**403,682**	-	-	-	-	-	-
Land + Fee *	208,643	232,225	-	-	232,225	-	-	-	-	-	-	-	-	-
Building construction	1,094,138	1,355,997	-	-	-	372,612	579,703	403,682	-	-	-	-	-	-
Projected Income & Sales	**1,127,355**	**2,157,733**	-	-	-	**170,845**	**545,882**	**599,366**	**736,217**	**105,422**	-	-	-	-
Net Cash Flow:		**569,511**	-	-	**(232,225)**	**(201,767)**	**(33,821)**	**195,684**	**736,217**	**105,422**	-	-	-	-
Projected IRR as of begin date:		**26.9%**												
PHASE IV (begin date 2006)														
Projected Costs:	**4,528,310**	**5,871,072**	-	-	-	**521,350**	**1,413,366**	**2,221,258**	**1,715,098**	-	-	-	-	-
Land + Fee *	443,989	521,350	-	-	-	521,350	-	-	-	-	-	-	-	-
Building construction	4,084,321	5,349,722	-	-	-	-	1,413,366	2,221,258	1,715,098	-	-	-	-	-
Projected Income & Sales	**4,435,846**	**11,642,066**	-	-	-	-	**469,958**	**1,435,072**	**1,459,644**	**1,690,512**	**1,072,174**	**5,514,705**	-	-
Net Cash Flow:		**5,770,994**	-	-	-	**(521,350)**	**(943,408)**	**(786,186)**	**(255,453)**	**1,690,512**	**1,072,174**	**5,514,705**	-	-
Projected IRR as of begin date:		**33.2%**												
PHASE V (begin date 2007)														
Projected Costs:	**3,120,644**	**4,304,551**	-	-	-	-	**72,121**	**1,110,223**	**1,762,460**	**1,359,746**	-	-	-	-
Land + Fee *	58,217	72,121	-	-	-	-	72,121	-	-	-	-	-	-	-
Building construction	3,062,426	4,232,430	-	-	-	-	-	1,110,223	1,762,460	1,359,746	-	-	-	-
Projected Income & Sales	**2,596,782**	**8,491,137**	-	-	-	-	-	**169,665**	**508,995**	**530,648**	**783,796**	**983,328**	**5,514,705**	-
Net Cash Flow:		**4,186,587**	-	-	-	-	**(72,121)**	**(940,558)**	**(1,253,465)**	**(829,098)**	**783,796**	**983,328**	**5,514,705**	-
Projected IRR as of begin date:		**25.6%**												
PHASE VI (begin date 2008)														
Projected Costs:	**2,023,163**	**2,913,545**	-	-	-	-	-	**310,730**	**685,190**	**1,087,107**	**830,518**	-	-	-
Land + Fee *	237,750	310,730	-	-	-	-	-	310,730	-	-	-	-	-	-
Building construction	1,785,413	2,602,815	-	-	-	-	-	-	685,190	1,087,107	830,518	-	-	-
Projected Income & Sales	**1,314,455**	**5,363,773**	-	-	-	-	-	-	**8,128**	**24,383**	**34,618**	**233,250**	**575,343**	**4,488,052**
Net Cash Flow:		**2,450,229**	-	-	-	-	-	**(310,730)**	**(677,062)**	**(1,062,724)**	**(795,900)**	**233,250**	**575,343**	**4,488,052**
Projected IRR as of begin date:		**16.7%**												

Market Volatility (ε)

Considering the scarcity of reliable data, Kang (2004) used several data sources in order to calculate the volatility of the Korean real estate market. Using the housing sales price index from Housing and Commerce Bank of Korea, he estimated 19.1% as the annual return volatility of the housing market, which, he comments, was somewhat understated. Based on the "Office Sales Price and Rent Index, Seoul (1993~2003)" published by BHP Korea, a brokerage firm, Kang estimated 7.9% as the annual return volatility of the commercial market, which is much lower than that of the housing market. The portfolio weights of residential and the office components are 61.9% and 38.1% respectively. Combining these return volatilities with the portfolio weights and the 35.1% correlation between the return data, a volatility of 13.2% was calculated, which is relatively low.

In the US market, volatility of returns for typical properties has been in the range between 15% and 20%. Considering that the market is usually more volatile in smaller and fast-growing markets, the actual Korean real estate market returns would show more volatility. Moreover, compared to the market in Seoul, the market in New Songdo City would be more volatile in terms of returns and value of the properties. With 13.2% as the lower bound, Kang used 25% as the market volatility in his thesis and Geltner used 20%. To keep the consistency, we assume 20% for market volatility.

Noise factor range (η)

Geltner et al. (2007) explains that the informational inefficiency of real property market brings random noise into the asset valuation and pricing process. As opposed to the commodities market, real estate products are unique and deals are infrequent and privately negotiated. Therefore, it is hard to assure that the individual transaction prices actually

represent the precise market values.

Though it is hard to clearly differentiate what proportions of transaction prices actually are driven by true market values or by random noise, several academic research papers report a possible range of noise factors. For instance, statistic analysis of NCREIF Property Database suggests an average magnitude in the range of 5% to 15% (Diaz and Wolverton, 1998, as cited in Geltner, 2007, p.273). Therefore, we use a 10% as the noise factor range for our research.

Volatility and Random Realization of the Underlying Asset Value: V*(t)

By using two random factors, the market factor (σ) and noise factor (N), based on ε and η described above, we can simulate the market volatility and the random component of realizable asset values. We generate two random numbers between -1 and 1 from triangular distribution using the RANDOM function in the EXCEL® program, multiply those with ε and η, respectively, and use the results as the market factor (σ) and noise factor (N) to structure the asset value equation.

First, we must realize that market conditions move in consecutive movements. To represent the continuous movement from year t to year t+1, we calculate the market value relative, V(t + 1) by multiplying previous year's market value, V(t) with the newly generated market factor component. The asset realized value, V*(t + 1) at year t+1 is then calculated by the market value realized, V(t + 1) times the randomly generated noise factor. The asset realized value V* simulates the effect of the overall real estate conditions regarding economic, construction, political, regulatory and other issues. We apply the asset realized value to the 'Projected Income and Sales' cash flow in order to reproduce the market condition.

To sum up, formulas used in the model are as follows.

Market Factor: $\sigma = \{ \text{Random}( ) + \text{Random}( ) - 1 \} \times \varepsilon$, $\varepsilon = 20\%$

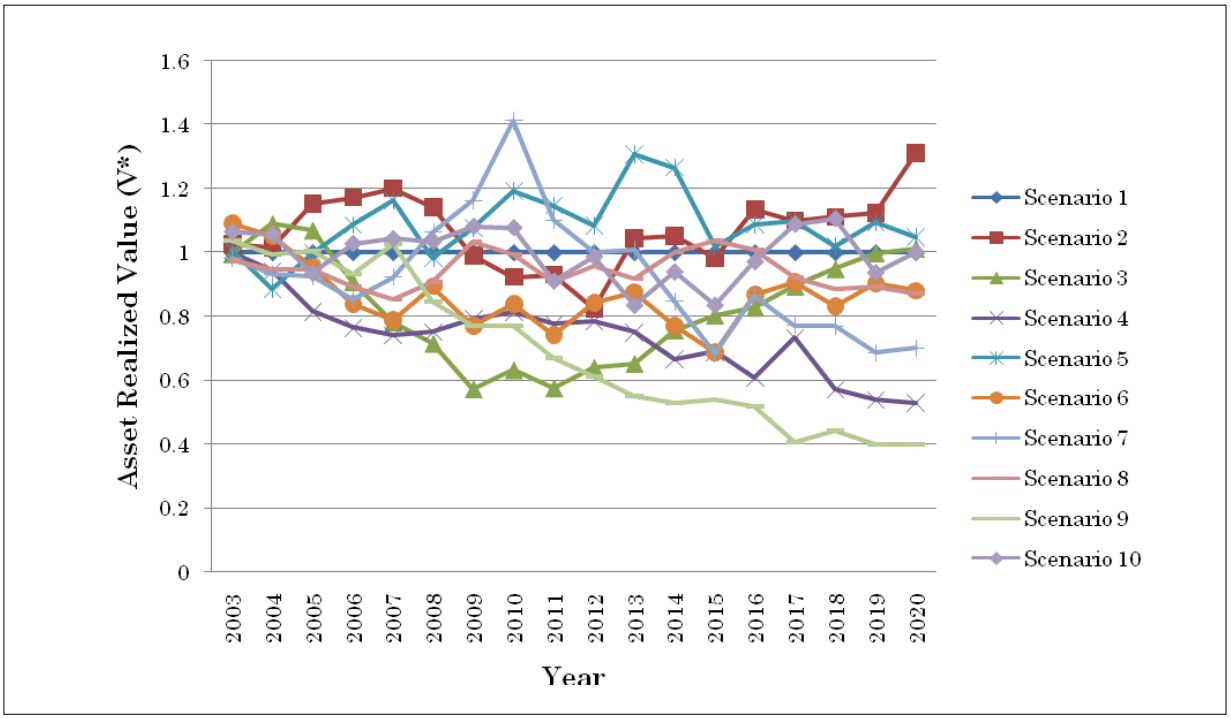
Noise Factor: $N = \{ \text{Random}( ) + \text{Random}( ) - 1 \} \times \eta$, $\eta = 10\%$

Market Value Relative: $V(t + 1) = V(t) \times (1 + \sigma)$, $V(0) = 1$

Asset Realized Value : $V^*(t + 1) = V(t + 1) \times (1 + N)$

Figure 6 shows ten examples from simulations of the market fluctuation based on 3,000 Monte-Carlo simulations. For reference, scenario 1 shows a horizontally straight line with a asset value of 1, since this scenario uses only deterministic cash flows, i.e. without uncertainty.

Figure 6 Example of simulation of the uncertain Asset Realized Value



Using the newly projected cash flows we reanalyze the value of the project. Also by conducting Monte Carlo simulations we create 3,000 NPV results from the randomly projected income and sales cash flows. In Table 4 we see that by incorporating uncertainty,

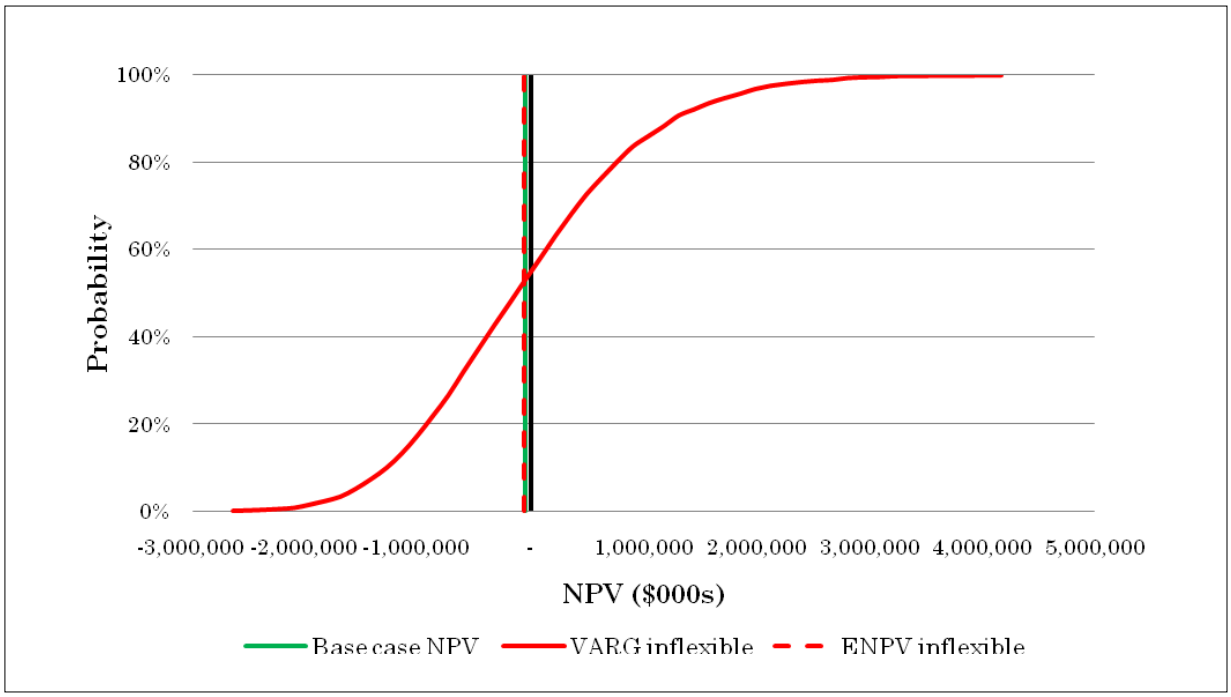
NPVs are widely dispersed. The ENPV for the inflexible case is lower than the NPV in for the base case, yet the difference is insignificant considering the project scale.

Table 4 NPV from base case and inflexible case (in $000s)

NPV in base case	NPV in inflexible case	
- 52,311	ENPV	-74,706
	Max	4,054,610
	Min	- 2,627,681

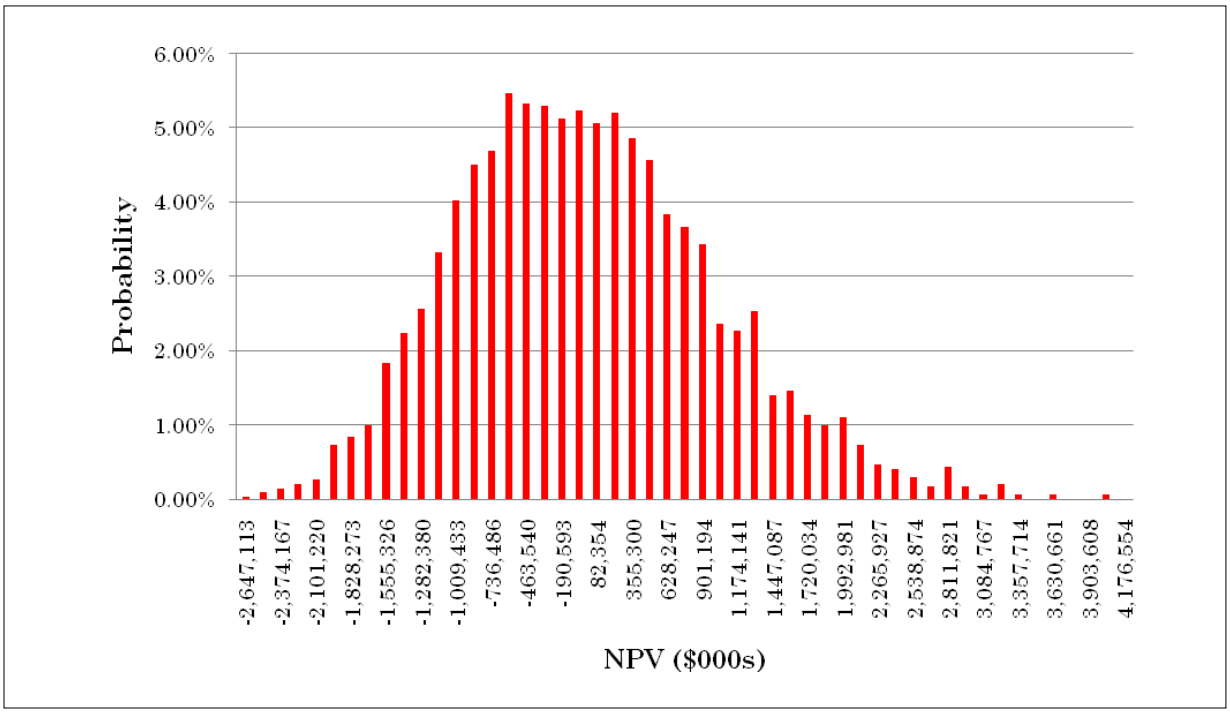
Conclusively, by examining the ENPV and cumulative NPV from the VARG (Value at Risk and Gain) curve in Figure 7, there are opportunities as well as risks when unpredicted situations occur.

Figure 7 Example of Value at Risk and Gain (VARG) curve



The frequency distribution in Figure 8 shows that volatility of the market can generate various outcomes. This step incorporates uncertainty into the Pro forma, but does not have the capability to avoid unfavorable market conditions. In other words, it lacks the flexibility of decision-making to eliminate the downside of NPVs.

Figure 8 Histogram of ENPV from inflexible case



5.2.3 Step 3: Determine criteria for decision rules and implement flexibility

Since we created randomly projected market cash flows we can employ decision rules to implement flexibility. We set up target hurdle IRRs for each phase and if the projected cash flows do not meet with the target standards, we assume that the developer has the right to wait until conditions become favorable, that is, when the hurdle IRR is expected to be achieved for that phase. We assume that the developer has a commitment to develop each phase within 3 years, otherwise after the third year they must abandon the project. This assumption may be somewhat subjective but considering the scale and length of the project, delay period of 3 years will be critical for the developer and the other participants. The model is structures in a way, so by observing yearly projected IRRs (based on the Monte Carlo realizations) for each phase with the hurdle rates, we can decide whether to develop in a specific year or to move on to the next year, unless after the 3 years of delay it becomes inevitable to abandon. And when a previous phase makes a decision to proceed, the next

phase may automatically start the same observation. Using the IRR as a criteria rule is intuitive and straightforward, in some sense reasonable for practitioners when making decisions. The criteria for flexibility and decision rules are summarized in Table 5.

Table 5 Decision Rules

Decision Options	Decision Rule
Start	If IRR ≥ Hurdle IRR at year t for phase n
Wait	If IRR < Hurdle IRR at year t for phase n
Abandon	If IRR < Hurdle IRR for 3 consecutive years at phase n

After conducting three thousand Monte Carlo simulations for the flexible case with a target hurdle IRR of 30% to all the phases, we compare the results with the previous inflexible case as shown in Table 6.[25]

Table 6 Results from Monte Carlo simulations

	Inflexible decision	Flexible decision
ENPV	- 74,706	925,973
Max	4,054,610	5,265,334
Min	- 2,627,681	- 491,775

The VARG and ENPV of Monte Carlo simulations are illustrated in Figure 9. We see that the ENPV and cumulative VARG curve have both made positive changes.

The distribution in Figure 10 also shows that NPV results from flexible case are skewed to the right compared with the inflexible case where NPV results are almost normally distributed around ENPV. This result supports the statement that, by implementing flexibility we are able to avoid and minimize the downside and enhance the value.

[25] Here, we set the initial target hurdle IRR of 30%, same as the discount rate used in the DCF analysis. Barman and Nash (2007) used the Samuelson-McKean formula to determine the optimal development hurdle rate, as well as the abandonment value of the land. However, given market characteristics such as noise (or friction) and developer's convention, we assume 30% of hurdle rate to be reasonable to use.

Figure 9 Example of VARG curve and ENPV from inflexible versus flexible case

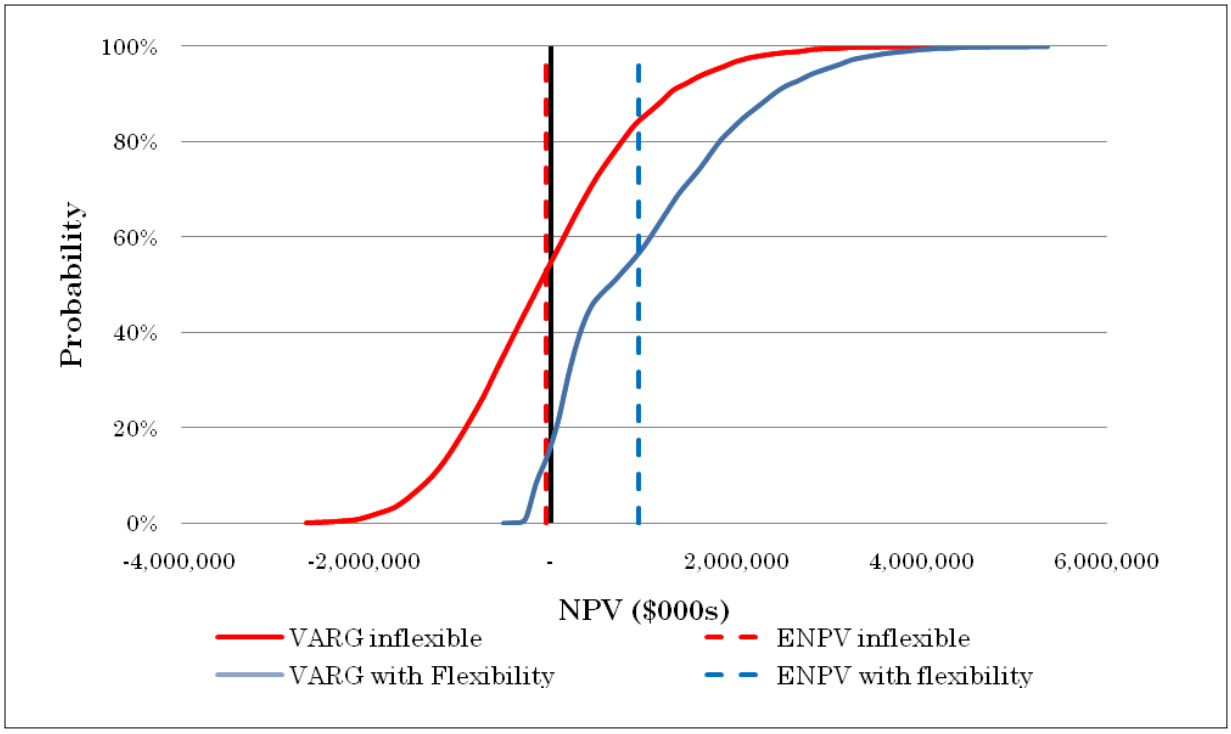
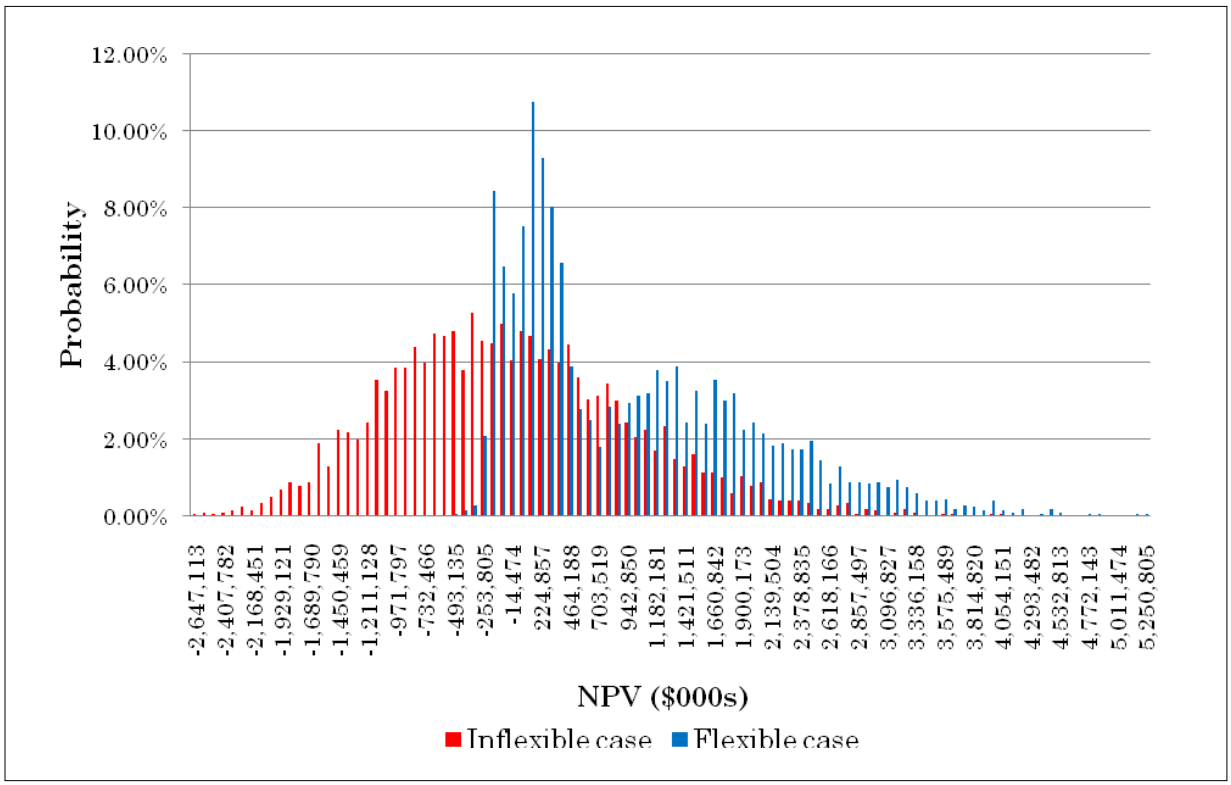


Figure 10 Histogram of ENPV from inflexible versus flexible case



4.2.4 Step 4: Search decision combination to achieve optimal NPV

The initial demonstration of engineering-based real options model shows that by implementing flexibility into the valuation model we recognize value that exists in flexible management and operations, which are actually happening in the real world. . We now experiment with several other decision rule combinations in effort to achieve optimal results. The experiment is done by conducting 4 trials of different target hurdle IRRs combination. A catalog of trial scenarios is summarized below:

- Trial 1 : Uniform application of a 30% IRR
- Trial 2 : Split phases into 2 groups, first group of phases 2,3,4 at target IRR of 40%, latter group of phases 5,6 at target IRR of 20%
- Trial 3 : Fix first group with target IRR of 40% and change latter group back to initial target IRR of 30%
- Trial 4 : Fix latter group with target IRR of 20% and change first group back to initial target IRR of 30%

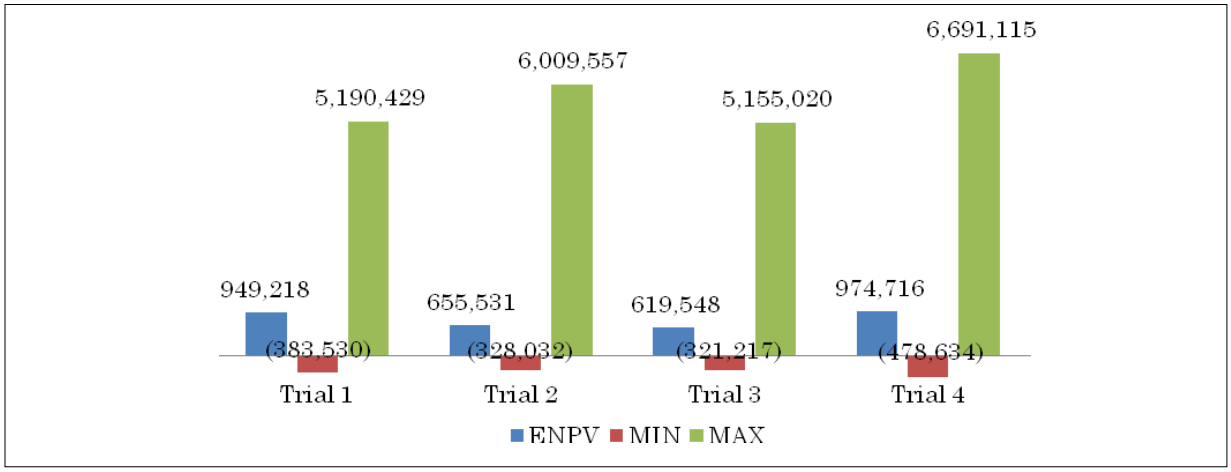
The results of the combinations trials are presented below in Table 7 and Figure 11. As we see from the results, trial 4 shows the highest ENPV as well as highest maximum NPV. Intuitively, we might consider trial 4 as the most favorable combination. Note that the preferred hurdle IRR for each phase depends on sheer will of the decision-maker. Thus it is ineligible to say that any particular trial has priority over another. For instants, the decision-maker's they are aiming for higher NPV and believe that they can beat the market, they will choose trial 4 with higher ENPV and maximum NPV. If they are highly risk adverse and don't want to take the risk of downturn, they will choose trial 3 with higher minimum NPV.

However, by analyzing the 4 trials using a different approach we realize that trial 4 is

Table 7 Decision Rule Combinations and Results

Phase	1	2	3	4
I	-	-	-	-
II	30%	40%	40%	30%
III	30%	40%	40%	30%
IV	30%	40%	40%	30%
V	30%	20%	30%	20%
VI	30%	20%	30%	20%
ENPV	949,218	655,531	619,548	974,716
MIN	- 383,530	- 328,032	- 321,217	- 478,634
MAX	5,190,429	6,009,557	5,155,020	6,691,115

Figure 11 Decision Rule Combination Results



the most competitive among the combinations considering NSC's situation. Figure 12 shows when the abandonment option is exercised for each trial.[26] It is noticeable that in phase 3, frequency of abandonment is extremely higher than any other phase across all trial combinations. This is because the expected IRR of phase 3 under the base case is 26.9%, lower than 30% so the possibility of achieving IRR higher than 30% is relatively low.

The competitiveness of trial 4 is best emphasized in Figure 13. The bold line indicates

[26] For example, with trial 3, possibility to abandon the project after phase 3 is approximately 45%, and probability to complete whole 6 phases is 21%. We assumed that the phase 1 would be built regardless of the market condition because of the contractual agreement.

Figure 12 Timing of Abandonment option exercise

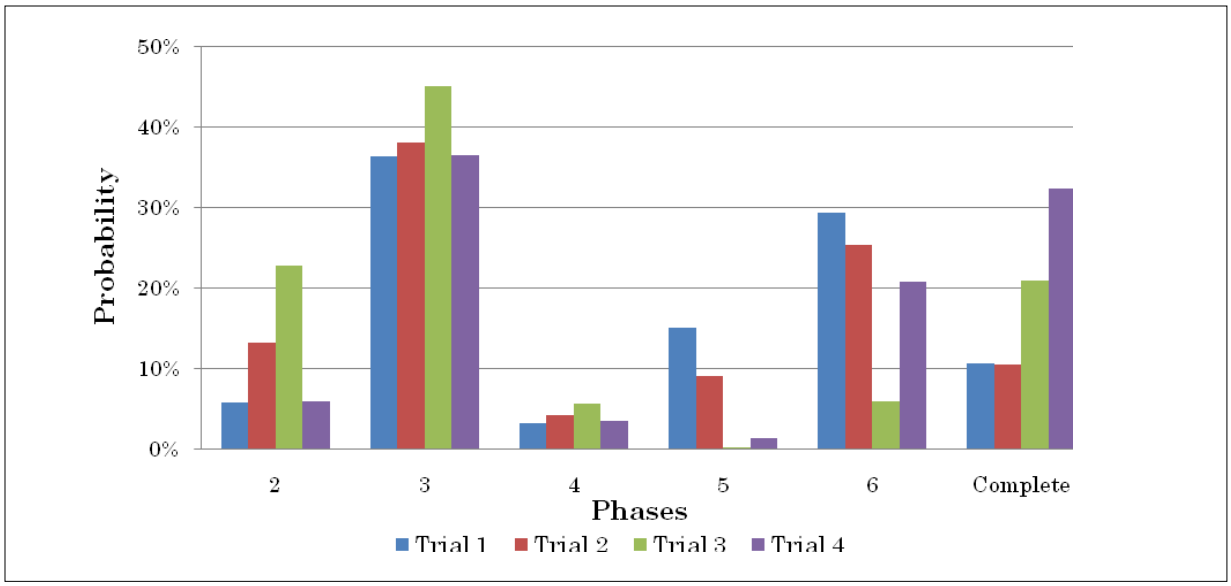
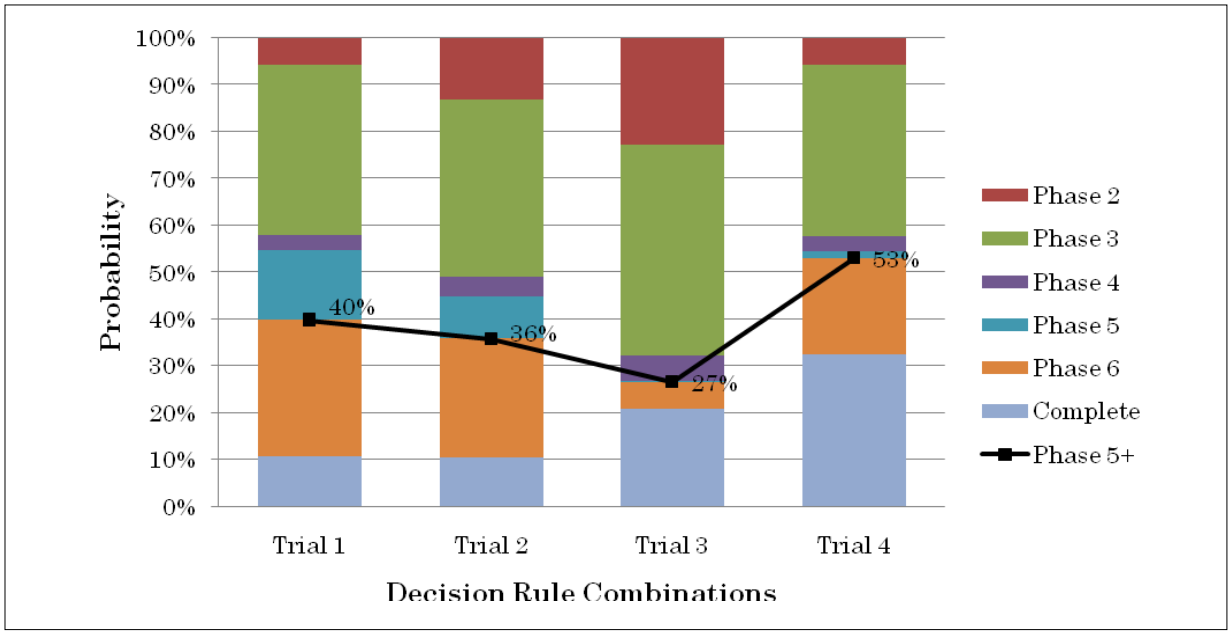


Figure 13 Percentage of Phase Completion



that trial 4 has the highest probability to reach the later phases or completion of the project.

Among the four decision combinations, trial 4 seems to be the best choice because of the following reasons:

1. ENPV is the highest, and while the min NPV is the lowest, it is a minor difference and not nearly as much as the increase in the upside maximum potential

2. Once the first four phases are completed successfully, the risk of the last two phases will be lower than 30%. Therefore, the hurdle IRR of 20% for the last two phases which is lower than IRRs for other phases makes sense and is consistent with rational NPV-based decision-making.
3. After the volume of project completions in NSC reach a certain level, economy of scale would bring synergy effect as a whole new city, such as agglomeration and amenities. Therefore, we can expect more upturn as well as lower risks in several years of the later phases, which will increase the asset value.
4. Due to reputational risk of abandonment, the developer will be willing to proceed with the project in spite of relatively lower IRR. The experience and reputation from NSC will assure them a world class developer position and will bring in more opportunities. Such immeasurable benefits will drive the developer to continue the project.

Since the resulting value is based on a simplified case and numerous assumptions, we conducted sensitivity analysis to observe a range of potential values from the model. Table 8 is the result of the sensitivity analysis, and Figure 14 plots the ENPV in relation to volatility and initial asset prices. The results show that, even under zero volatility with 0% noise and 0% market factor, flexibility improves the ENPV, meaning that the options embedded in the project increase the value of the project. And when the market is more volatile, the value added by the options is greater, showing higher ENPV.

Moreover, even when the asset values do not reach the expectation because of unexpected downturn or initial underestimation, still the options increase the value of the project as shown in row (4) of Table 8. Moreover the lower the realized asset value, the higher the option value. Apparently the option is valuable because it helps to protect the

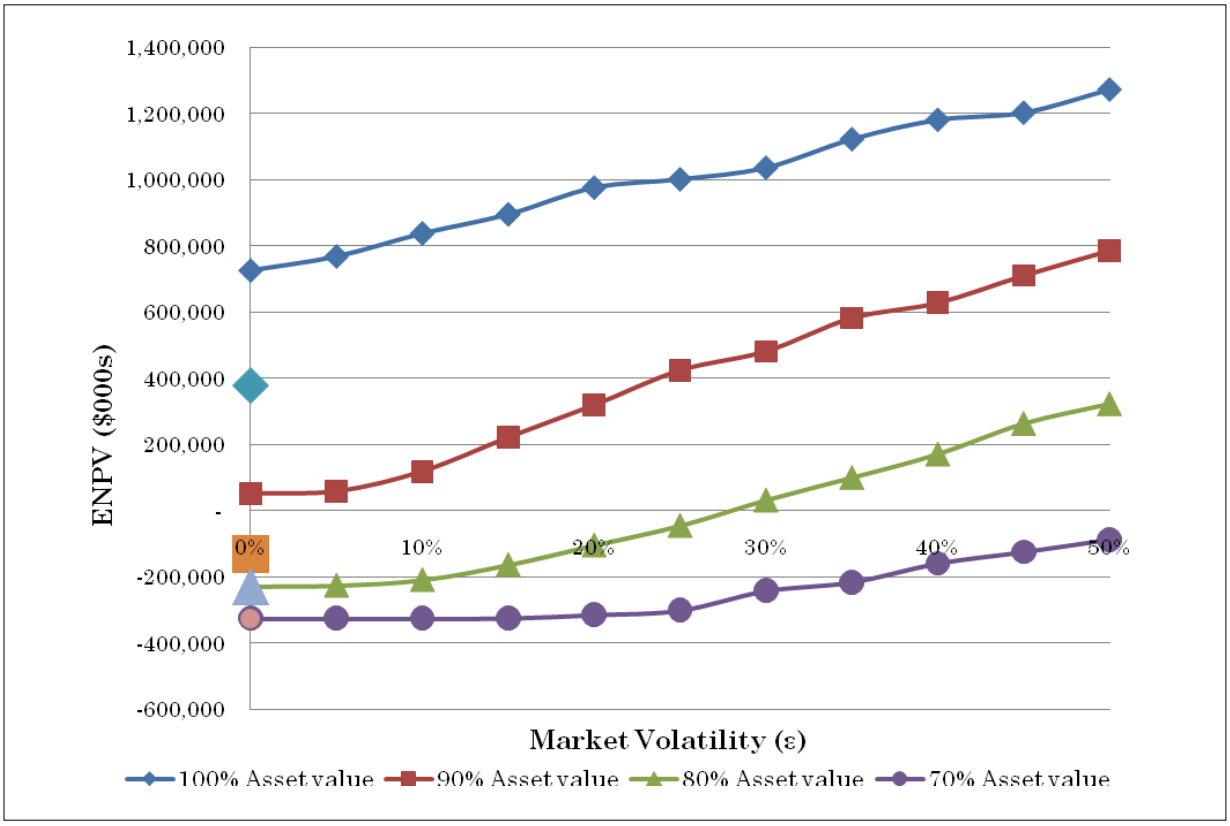
Table 8 Sensitivity of ENPV on Market Volatility (ε) and Asset Value (S)

Volatility		100% Asset value	90% Asset value	80% Asset value	70% Asset value
(1) Inflexible		- 74,706	- 679,727	- 1,292,145	- 1,923,882
(2) Noise 0% Market 0%		379,852	- 130,944	- 228,299	- 325,654
(3) Difference (2)-(1)		454,558	548,783	1,063,846	1,598,228
Noise	Mkt	100% Asset value	90% Asset value	80% Asset value	70% Asset value
(4) 0%	10%	784,259	104,577	- 219,922	- 325,927
10%	(5) 0%	726,487	51,942	- 228,343	- 325,170
	5%	769,034	58,147	- 225,835	- 325,381
	10%	838,561	118,807	- 208,854	- 325,494
	15%	896,417	221,653	- 163,356	- 323,944
	20%	977,262	319,124	- 103,749	- 314,026
	25%	1,002,458	424,153	- 44,496	- 300,297
	30%	1,037,582	481,548	32,990	- 241,310
	35%	1,123,889	582,025	101,500	- 215,065
	40%	1,182,389	628,043	172,568	- 158,138
	45%	1,204,071	710,545	265,162	- 123,567
	50%	1,274,167	785,788	324,986	- 85,984

developer's return from the downturn. However, in the case with 70% asset value, the graph shows a flat curve with volatility less than 25%, indicating that, when the realized asset value is too low, increasing volatility does not add much value.

We also examined the effects of the noise factor and the market factor on ENPV. Comparing values of row (4) and row (5) in Table 8, we observe that the market factor increases ENPV more than does the noise factor. This is because the market factor is accumulated over time, while the noise factor affects the volatility at that time only.

Figure 14 ENPV Sensitivity Graph on Market Volatility (ε) and Asset Value (S)[27]



4.3. Comparison with "Economic-based" Real Options Model

Kang (2004) and Geltner (2005) developed an "economic-based" binomial model and applied it to the New Songdo City project. The term "engineering-based" is used in this context to distinguish the simplified Monte Carlo decision-modeling, and simulation framework from the classical "economics-based" real options model of development flexibility value and optimal phasing.

The input parameters for a binomial model of Geltner (2005) are as follows:

[27] The sole dots on the Y axis with Market Volatility of 0% are NPVs under no uncertainty scenario with 0% noise factor, (2) in Table 8.

- Risk-free interest rate = 5.50%
- Underlying Asset Cash yield = 6%
- Underlying Asset Total Return = 14%
- Volatility = 20%
- Development Cost growth rate = 4%

By combining these with the Pro-forma cash flow, the binomial model illustrates the option value of the NSC project as US$ 1,590,150,000. This result is higher than the US$ 977,262,000, ENPV from the "engineering-based" model.[28] However, considering the size of the project, the difference is not great.

Needless to say, the economic-based model and engineering-based model are using different parameters and methodologies. Therefore, it would be somewhat unreasonable to compare the results as an "apples to apples" comparison. However, the similarity of results still implies that the option embedded within the project has a prominent value, and this finding is strengthened by the two different models giving similar results.

In order to observe the relation between the results and the effects of volatility in both models, we conduct a sensitivity analysis. Additionally, since the binomial model does not accommodate the noise factor, we also add a series of simulated ENPVs with the noise factor of zero for the engineering model, as shown in Table 9.

As shown in Table 9 and Figure 15, increase in volatility brings higher option value for both models. However, when the volatility is lower than 13%, the economic-based model shows lower NPV than the engineering-based model. With a noise factor of zero, ENPV of the engineering model draws closer to the results of the economic model, which is consistent with the fact that the binomial model assumes no noise. As the market volatility rises, the

[28] For the comparison, we used the decision combination of trial 4 in step 4.

Table 9 Sensitivity of NPV on Market Volatility (ε) from different models

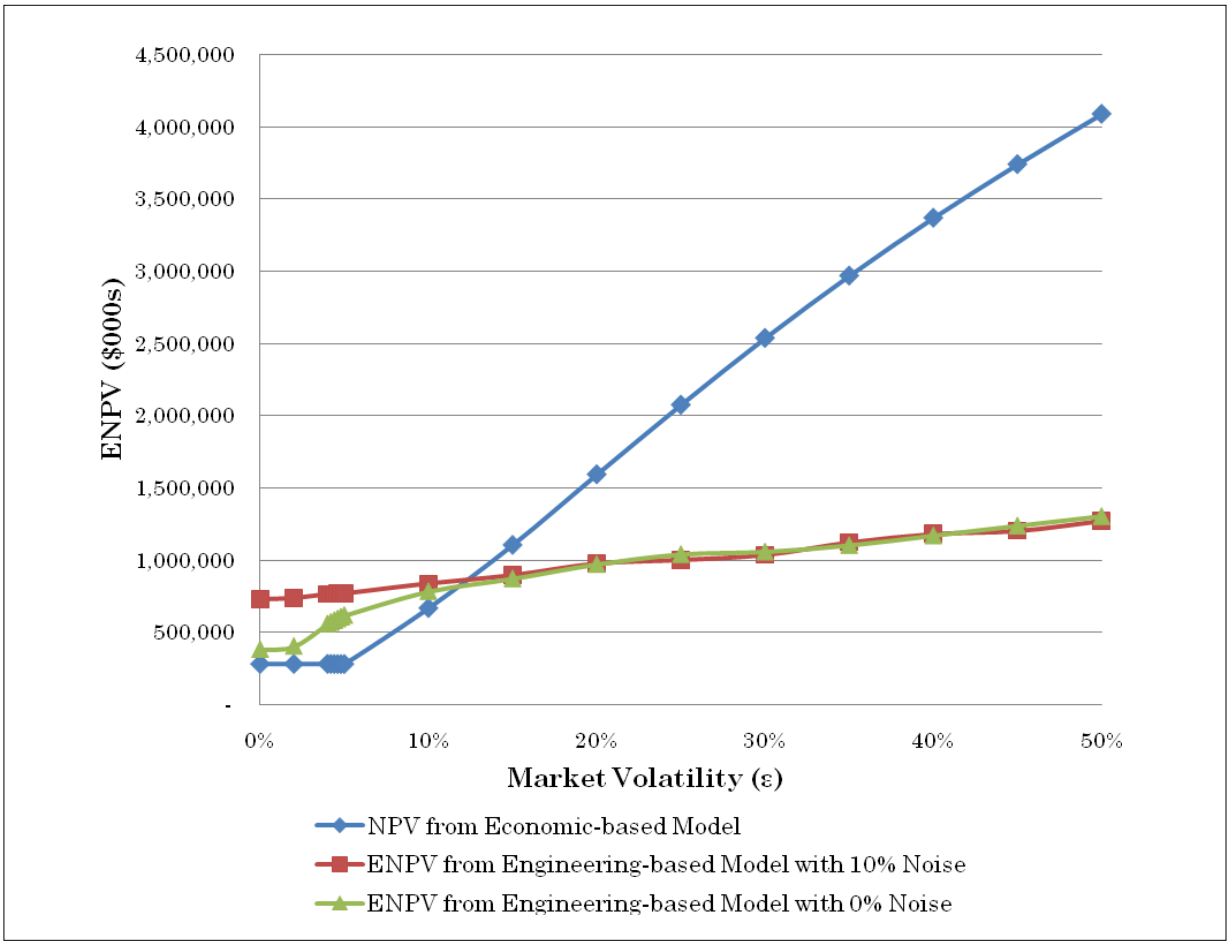
Volatility (ε)	Option value from Economic model	ENPV from Engineering model (Noise factor=10%)	ENPV from Engineering model (Noise factor=0%)
0%	277,680[29]	727,879	379,852
2%	277,680	738,031	402,014
4%	277,680	765,655	557,829
4.20%	277,135	766,330	569,543
4.40%	276,547	767,006	581,257
4.60%	276,252	767,682	592,970
4.80%	276,213	768,358	604,684
5%	276,399	769,034	616,398
10%	663,924	838,561	782,326
15%	1,101,624	896,417	871,301
20%	1,590,150	977,262	970,900
30%	2,534,857	1,037,582	1,056,796
40%	3,366,953	1,182,389	1,169,647
50%	4,086,414	1,274,167	1,303,383

two engineering models present similar values as shown in Figure 15. This indicates that in a highly volatile market, the noise factor does not affect the value significantly.

As the market volatility factor becomes greater, the difference of results from two models becomes greater. The binomial model was created in the finance field to calculate the value of option in security markets. The model assumes that the market is efficient and transparent with no noise, and that all the participants make the optimal decision in order to increase the value of the project. On the other hand, the engineering-based model simulates different results in terms of combinatory decision rules and design factors. The decision combination we point out in step 4 from the engineering based model would not be the "ultimate" optimal decision combination which maximizes the value, since we can try more various combinations and possibly obtain higher ENPVs.

[29] The "economic-based" binomial model cannot calculate NPV when volatility is zero. Therefore, we use 0.001% to approximate the option value.

Figure 15 NPV Sensitivity Graph on Market Volatility (ε) from different models



In reality, there are many factors that drive the developer's decision other than the project returns, such as legal issues, political issues, contractual terms, or developer's capability and, therefore, optimal decisions are practically hard to be made. By combining various factors into the model, the engineering-based model provides more realistic and achievable value of the project.

Chapter VI: Conclusion

People say that successful developers possess the gift of foresight. They see opportunities that others never noticed or attempted, and envision, then realize the development project. However, in order to realize the vision and maximize returns, developers need to analyze the opportunities and identify and mitigate the risks by making right decisions. Whether a project is a single-family housing or a large mixed-use complex, developers must undergo the same process of defining the opportunities and mitigating the risks.

When it comes to mega-scale, multi-phase, international projects, developers face a tremendous amount of challenges. Even though they analyze the same factors such as market conditions, permitting process, development program, financing and project executions, every detail of these factors is different. Most of all, they need to understand the local culture, which governs all the differences.

As a "first mover", the first sole international developer entering the Korean real estate market, Gale International has confronted many challenges since the launch of the New Songdo City project. They have been through many trials and errors due to lack of international experience of parties. Its unprecedented scale and scarcity of credible market data made it impossible to analyze the market in the traditional manner. Occasionally, the perceptions of the developer caused disputes between the city, media and the developer. The developer spent a large amount of time and effort to educate and convince the Korean participants about the role of a developer, as the coordinator of the entire project. They formed a joint venture with a blue-chip local partner; however, sometimes their interests did not align.

Soon now Gale International and the other participants will see the fruit of all their

efforts. The convention center opens in November 2008, followed by completion of many other projects. With the high-quality and the innovative concepts such as the ubiquitous city and green city, the New Songdo City project is expected to provide "the quality of life" to its residents and workers.

Since traditional DCF valuation cannot capture the value of dynamic decisions that occurs during the development process of a mega-scale, multi-phase project, we applied the real options valuation model to the New Songdo City project. By combining decision factors, the "engineering-based" model clearly shows that flexibility of decision-making improves the value of the project. This value is considerably a more accurate value than the NPV from a traditional DCF analysis because it incorporates the effect of decision-making flexibility that the developer can actually take advantage of.

Though the "economic-based" binomial model is more accurate as a pure valuation tool, the "engineering-based" model is more transparent and more intuitive, and has more ability to represent different types of design and construction decisions and components, and in a manner that developers can more easily understand and relate to. In any case, the two models arrive at broadly similar valuation results in our example. By using formulas and data table functions from EXCEL®, the Monte Carlo simulation of the engineering approach illustrates thousands of possible scenarios which can easily be described graphically. Moreover, unlike the economic-based model in which asset values play the main role, the engineering-based model can use various factors such as market rents or demand, or permitting schedules, for uncertain variables. After combining all the uncertainties, developers can structure the decision rules so that they well represent real world situations.

One significant advantage of the "engineering-based" model is that it is easy to analyze

the decision combination results in a quantitative manner. As shown in section 5.3 in Chapter 5, trying different combinations of decision rules and design factors can help developers to compare the values of each set of decision rules. Various parameters such as maximum NPV, minimum NPV and Expected NPV can also be provided to developers, which they can relate to their decision criteria and risk preferences.

Finally, our analysis directly compared the engineering and economics models on a more or less "apples-to-apples" basis for the NSC application. As noted, both models arrive at similar valuations, and valuation results that respond similarly to the key uncertainty parameters. This helps to confirm the finding that decision flexibility, such as the phase start-timing and abandonment flexibility examined in this thesis, can add a vast amount of value to a mega-scale project. By recognizing the value of decision flexibility, developers and financial backers and policy makers can avoid underestimating the value of the project. Developers may be able to bid higher prices and recoup the cost by managing the project properly, avoiding negative outcomes and seizing positive opportunities. Moreover, developers can negotiate terms and conditions with the land owner or public sector and implement flexibility upfront, in favor of higher possibilities to increase project value.

Simplified engineering-based real options analysis as demonstrated in this thesis provides a capability that traditional DCF cannot, to quantify and specify both valuation and design, and to do so in a way that decision-makers can relate to and use better than the classical economics-based options models, and all of this can be of "mega-importance" in a world of mega-projects!

Appendix A: 21st Century Mega-scale Development Projects

Project Name	Country or Region	City	Budget (billions)	Population	Land Area (sq km)	Expected Completion	Description
Liverpool Waters	United Kingdom	Liverpool	10.8		0.6	2038	50 highrise buildings; 23,000 homes, office, retail, 4 hotels.
Zuidas	Netherlands	Amsterdam		14,000	2.4		
Al Zorah	Ajman, UAE	Ajman	60	200,000	12	2018	
Downtown Burj Dubai	Dubai, UAE	Dubai	20		2	2008	Include Burj Dubai, Burj Dubai Lake Hotel, Burj Dubai Old Town, Burj Residences E, Burj Residences T, Burj Residences W, South Ridge, Burj Views, Boulevard Walk and The Lofts.
Dubai World Central	Dubai, UAE	Jebel Ali	33	900,000	140	2015	Comprises six specialized clustered zones: Dubai World Central International Airport (JXB), Dubai Logistics City (DLC), DWC Commercial City, DWC Residential City, DWC Aviation City and DWC Golf City. 850 towers
Madinat al-Hareer - "City of Silk"	Kuwait	Kuwait	86	700,000	250	2033	Four major zones - a city of commerce, a city of leisure and recreation, a city of ecology and a city of diplomacy and education
Al Wasl	Saudi Arabia	Riyadh	12	200,000	14.11		55,000 homes; offices; hotels; mosques; health and educational facilities; shopping malls, sports amenities and over 300 hectares of green, open space.
Bled El Ward	Tunisia	Tunisia	10		50	2028	International Health city, water channels in addition to tourist resorts, residencies, sport facilities, golf courses, along with areas for shopping, entertainment and open space.
Mumbai Manhattan	India	Mumbai	10		81	2010	
Wuhan CBD	China	Hubei Province	14.6	100,000	2.7	2023	City of Accessibility, City of Greenery, City of Vitality, City of Information , City of Fortune,
Dongtan	China	Shanghai	1.3	500,000	86	2040	China's first sustainable eco city will define the future of sustainable urban development in China and beyond.
New Songdo City	South Korea	Incheon	25	500,000	6		

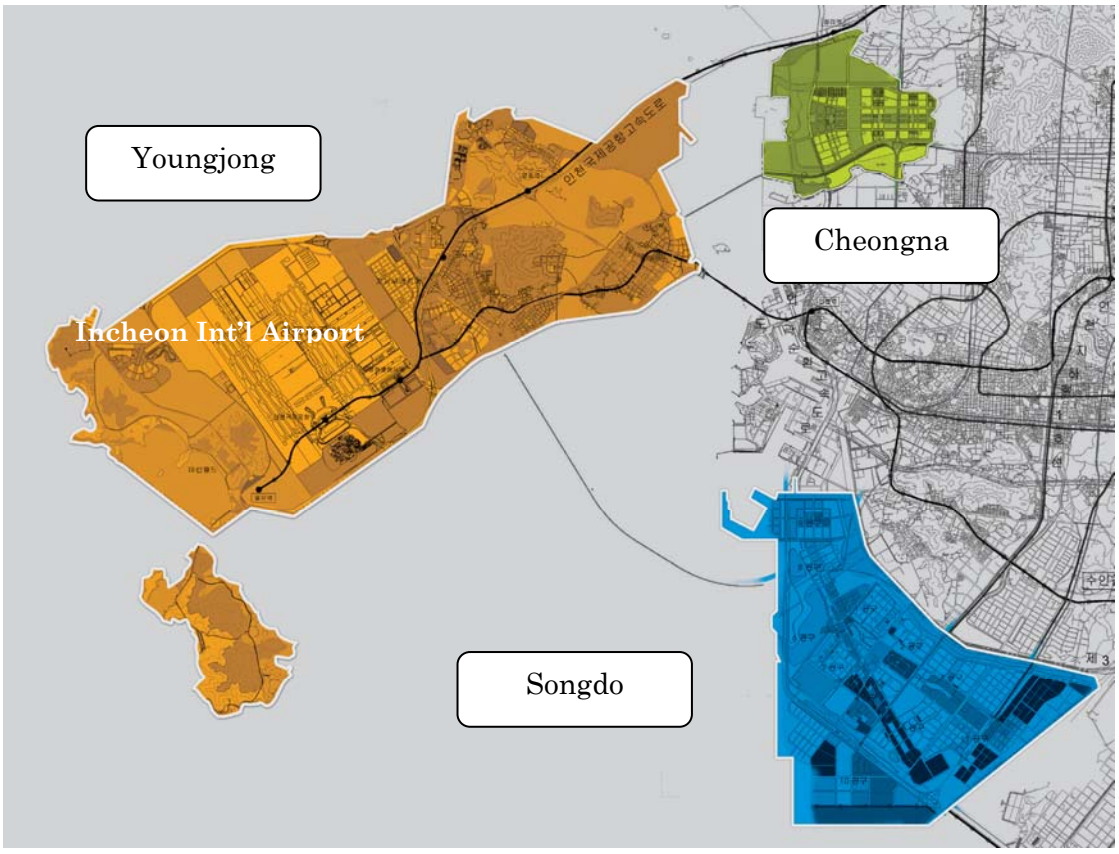
(Source: Weikel, 2008)

Appendix B: Incheon Free Economic Zone and New Songdo City

(Source: "IFEZ: White Paper 2007")

1. Incheon Free Economic Zone

	Songdo	Youngjong	Cheongna
Main function	International business Knowledge-based industry Bio-tech cluster Songdo Landmark city New Incheon Port	Airport & support Logistics Tourism	International finance Leisure, sports High-tech industry
Area	53.3 km2 13,170 acre	138.3 km2 34,170 acre	17.8 km2 4,400 acre
Development schedule	2003~2014	2003~2014	2003~2012
Estimated population	253,000	169,000	90,000



2. New Songdo City

Zone	Title	Size	Major projects	Devel'nt cost	Schedule
				Main Developer	
1,3	International Business District	5.7 km2 1,415 acre	Convention center NEATT, Office Golf course	US$ 24.4 b	2003~14
				NSIC, LLC	
2,4	Knowledge-base Industry Cluster	2.6 km2 640 acre	Technopark U-IT Cluster	US$ 399 m	2000~09
4	Bio-tech Cluster	0.3 km2 74 acre	Research, Hospital	US$ 48 m	1994~2011
				JV with VaxGen (USA)[30]	
5,7,11	High-tech Cluster	16.8 km2 4,150 acre	Joint research institutes (IT, BT)	US$ 893 m	2003~14
5,7	Songdo International Cluster	0.6 km 148 acre	University-related R&D center	-	2005~10
6,8	Songdo Landmark City	5.84 km2 1,440 acre	Incheon Tower(151F) Leisure Residential	US$ 1.7 b	2005~14
				JV w/ Portman Holdings[31]	
9,10	Incheon New Port		Port facility	US$ 4.3 b	2006~15

30 VaxGen is a biopharmaceutical company based in South San Francisco, California.

31 Portman Holding, LLC, a US full-service real estate development company, formed a Joint Venture with Hyundai E&C and Samsung C&T, two top construction companies in South Korea

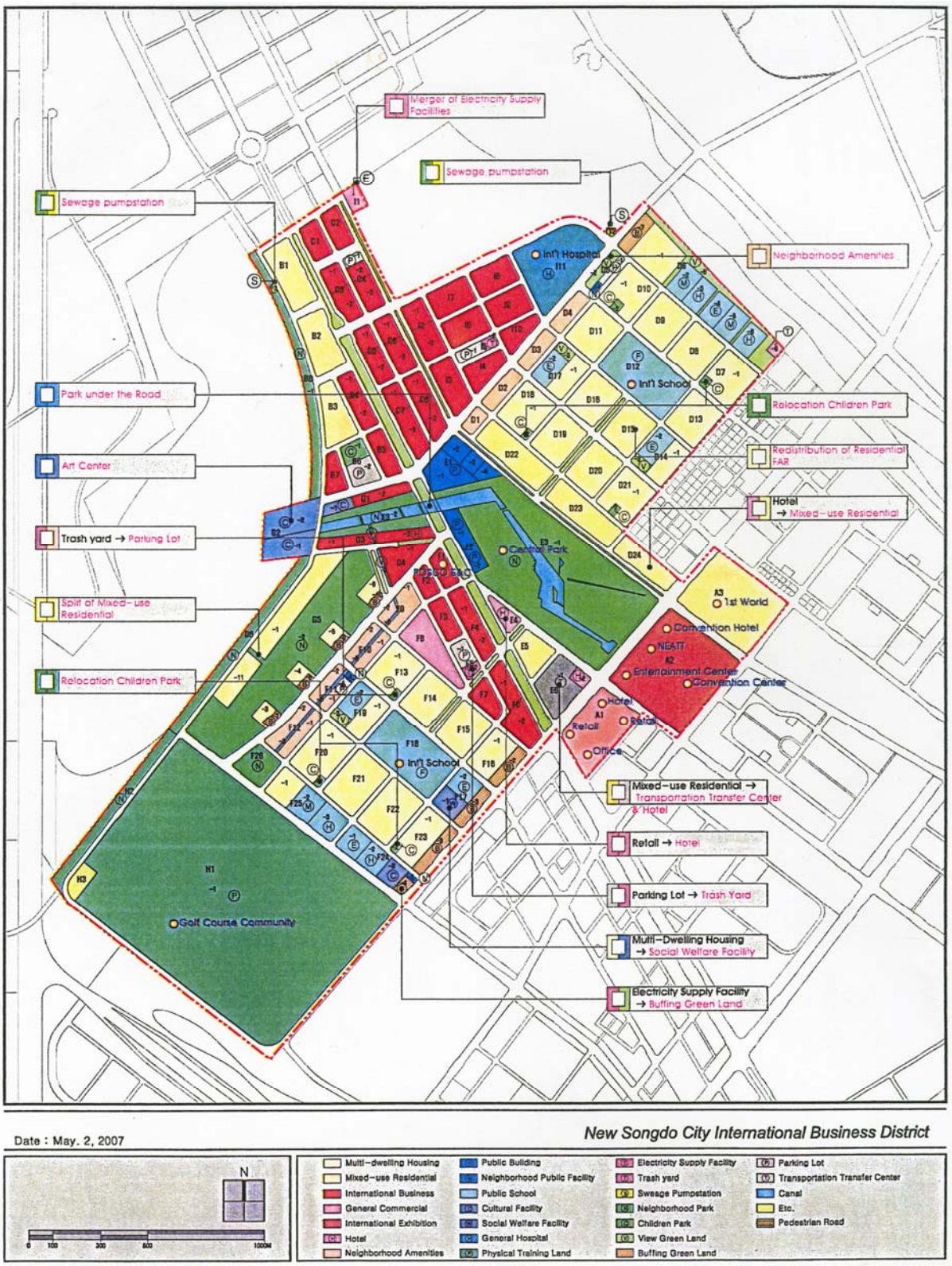
Zone 1 & 3: Songdo International Business District (the NSC project)

Zone 6 & 8: Songdo Landmark City

Zone 5 & 7: Songdo International Cluster

Appendix C: DUP Modification Items

(Source: Gale International)



Appendix D: Joint Venture Partners and Participants

1. Real estate property development

Partner	Character	Type	Projects
Morgan Stanley	Real estate fund (US)	JV (Linkage)	Northeast Asia Trade Tower (NEATT, open in 2010), hotel, retail mall, residential
Kitson & Partners	Developer (US)	JV	Jack Nicklaus Golf Course and Golf Villa
Taubman	Developer & operator (REIT/US)	JV (Linkage)	Retail mall complex
ISS	Educational service provider (US)	JV	International School Founder and operator of NSCIS JV with Milton Academy
New York Presbyterian Hospital	Hospital operator (US)	MOU	Hospital (JV with Yonsei University Hospital)
LIG	Conglomerate (Korea)	JV	Office (New headquarter, open in 2012)
IDEA	Manager & operator (US)	JV	Ecoterium US $48 m in equity US $72 m in debt financing
United Technologies Corp / Hanjin group	High-tech service provider (US) / Conglomerate (Korean Airline/ Korea)	MOU	Sustainability and technological innovation Two office buildings (U-Life Northeast Asia Headquarters and the Sustainable International Business Center)
Daewoo	Construction company (Korea)	JV (Linkage)	Hotel, residential, office

2. Infrastructure and operation

Partner	Character	Type	Projects
LG CNS	IT service provider (Korea)	JV	Songdo U-Life, LLC. (June 2005) Installing and building IT infrastructure
Microsoft (MS Learning)	Product group of MS (US)	MOU	Integration of the MS Digital Literacy curriculum and MS IT Academy into the Songdo International School as well as technology skill training for workers
GE Korea	Technology & services conglomerate (Korea/US)	MOU	Provide sustainability product and service

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