Application of the Design Structure Matrix (DSM) to the Real Estate Development Process

By

Benjamin Bulloch AND John Sullivan

B.Sc., Social Sciences, 2002

B.A., Engineering Studies, 2004
B.A., Economics and Business, 2004

University of Edinburgh, Scotland

Lafayette College

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Massachusetts Institute of Technology

Signatures of authors _____

Benjamin Bulloch & John Sullivan
Center for Real Estate
July 24, 2009

Certified by _____

David Geltner
Professor of Real Estate Finance, Department of Urban Studies and Planning
Thesis Supervisor

Accepted by _____

Brian A. Ciochetti
Chairman, Interdepartmental Degree Program in Real Estate Development

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Abstract

This thesis presents a pioneering application of an engineering systems framework, the Design Structure Matrix (DSM), to model the real estate development (RED) process. The DSM is a process modeling tool that originated recently in the branches of engineering systems and management science, and is primarily used to study product development processes. The DSM is an n-squared graphical matrix representation of a process that is particularly well suited to model both the sequential and iterative informational relationships between tasks in a product development process. The similarities between product development and the real estate development process make DSM an excellent fit for applying the DSM.

The thesis first reviews existing models of the RED process but finds them lacking a combination of granularity and ability to model the highly iterative nature of the RED process. This limits their effectiveness for conveying information useful to practitioners. No previous RED model describes the process at a task level or has the ability to model iterative or sequential information flows between tasks.

The DSM developed in this thesis first presents a normative or baseline model of a RED project. The model was developed through the participation and assistance of MIT/CRE industry partner, Jones Lang LaSalle (Boston Office). Through a series of interviews and meetings, the authors first developed a Six Stage Event Sequence model of RED with decision-gates found to occur during the process. The six stages were then expanded with JLL's assistance into a table of 91 individual tasks necessary for successful completion of a RED project. Finally, again with JLL's engagement, the 91X91 'Baseline' RED process DSM was constructed, identifying 1,148 planned informational inter-task interactions (out of 8,281 potential interactions). The 'Baseline' DSM model was then manipulated to highlight important aspects of the RED process including the iterative and interdisciplinary nature of RED. Several typical development scenarios are then modeled to highlight the utility of DSM as a management tool in practice. The models show how unplanned iteration can become a significant cause of project risk and failure. They also highlight the risks and opportunities that task re-sequencing can have on a project.

This thesis demonstrates the DSM to be a useful and effective model of the RED process enabling new insight and understanding. The highly complex and iterative RED process can be graphically modeled in great detail in a visually appealing manner. Additionally, the RED DSM proves to be an adaptive and manipulative tool that allows for a multi-layer grasping of the RED process, able to assist in project management, change management, identification of risks and opportunities, and firm-level organizational structure and procedures. Additionally, the RED DSM model proves to be a useful pedagogical device for teaching real estate students.

Thesis Supervisor: David M. Geltner
Title: Professor of Real Estate Finance

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Jones Lang LaSalle was an incredibly gracious research host. We had unfettered access to managers including Kirstin Brown (MIT MSRED 1998), John Myers, Anthony Warren, Chip Weintraub (MIT Sloan 2006) and Nat Wysor. Our research would have been impossible without these gifted real estate development practitioners guiding our way.

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Ben would like to thank his wife and partner Dr. Christine Sylvest for her love and encouragement.

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When we mean to build,
We first survey the plot, then draw the model;
And when we see the figure of the house,
Then must we rate the cost of the erection;
Which if we find outweighs ability,
What do we then but draw anew the model
In fewer offices, or at last desist
To build at all?

William Shakespeare
Henry IV, Part II
Act 1, Scene 3

"Someone rolled a rock to the entrance of a cave and created an enclosed space for his family – a warmer and more defensible shelter, distinct from the surrounding environment. This can be called the first real estate development."

James Graaskamp
Fundamentals of Real Estate Development

Preface

Real estate development is the process of creating value by making tangible improvements to real property. The development process ranges from land speculation and new construction to the renovation of existing buildings. The development of real estate is the process by which physical products where we live and work are conceptualized, refined, constructed and managed. Successful implementation of this process is crucial to our economy along with our everyday lives. As Winston Churchill has famously stated, "We shape our buildings, and afterwards our buildings shape us."

The real estate developer, whether in the public or private sector, is responsible for coordinating the tasks required to deliver a real estate product. This is done through the management of thousands of individual tasks. While each task involves numerous players and information, it is the developer's job to ensure that information generated in individual tasks is efficiently being shared between all the parties involved. Throughout this process, the developer manages the information being generated with the intention of ultimately delivering a product intended to meet a specific market demand.

Throughout the development process, tradeoffs are made as information is developed. For example, a high quality building may achieve the highest rents, but it will most likely come at a higher costs. These types of tradeoffs make the real estate development process iterative as well as multi-disciplinary. The process can also take years to complete, leaving it subject to many internal and external changes along the way. Additionally, the location and timing of each product differs as well. This uniqueness leads practitioners to often believe each development process is unique. While the real estate development process from one project to the next is not identical in every step or in all details, we believe that important commonalities can be observed across most projects and can be captured in a general framework. Such a framework can be useful both in learning about the process and helping improve standard operating procedures of development firms.

A review of real estate development literature to date provides scant useful insight for a developer to identify and understand the tasks and the relationship to one another. This approach would provide a developer with a true understanding of how the process works. The

current literature is usually done at too broad, or too specific of a level. The broad work identifies stakeholders and explains the many reasons why real estate is developed. On the opposite end of the spectrum, much work has been done to explain specific parts of the process, such as the design, construction, determining product types, etc. Our understanding of the real estate development process needs something in-between that identifies specific tasks in the process, but also explains characteristics of the process and how they are all tied together. This, however, is no easy task. Illustrating or explaining how numerous tasks are related in a long and complicated process is confusing and may leave the reader no better off than when he began.

This problem of modeling and explaining complex development processes is not unique to real estate. In the industrial arena, product development projects are often as long, iterative and complex (rockets, satellites, microchips, fighter planes, automobiles, etc). Decades ago, engineers in these fields faced similar problems with trying to model and understand the process of their complex development projects. They discovered that information generated during the development process was unique and specific for each product, however the method they went about developing products was similar each time. This discovery allowed for the creation of frameworks and tools to analyze these processes. One of the most successful tools established to model these product development processes and the flows of information is the Design Structure Matrix (DSM). By buildings and using a DSM, engineers created a simple way to visually demonstrate the information flows between tasks in a product development process. Over the last 20 years, this framework has been continuously enhanced and has become accepted as a tool in the product development industry.

The issues that the engineering and manufacturing industries faced decades ago are very similar to those currently faced in real estate development. While the products are very different, both include the general stages of coming up with an idea, refining that idea, committing to the idea and finally executing. Along the way, information is shared between tasks to get to milestones where a decision is made whether or not to move forward. We believe that, because of the similarities between the two fields, there is room to use engineering techniques, specifically DSM, to analyze the real estate development process.

Before applying the engineering systems DSM tool to the real estate development process, we first review existing academic models and conceptualizations and highlight

weaknesses of current approaches (Chapter 1). Then, we examine the engineering systems and product development analysis to understand the similarities and differences between their disciplines and real estate development (Chapter 2). Chapter 3 then focuses on the history, applications and mechanics of the DSM.

These first three chapters give us a framework for applying DSM to the real estate development process. In Chapter 4, we outline our methodology for constructing the real estate development DSM and describe our findings from analysis of this Baseline scenario. Chapter 5 then puts the DSM to work and demonstrates how DSM can graphically illustrate and highlight valuable information for the developer. Chapter 6 explains and summarizes the benefits of the DSM to the developer as well as to academia. Finally, Chapter 7 outlines future research topics that the authors believe have potential to yield further insights into real estate development.

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Chapter 1: The Real Estate Development Process

Chapter Summary: In this Chapter, we review historical and contemporary frameworks that conceptualize the process of real estate development. These approaches are drawn from many academic disciplines and contribute to our understanding of the actors involved in real estate development and the political, social, financial, physical and economic contexts in which development occurs. While interesting from an academic perspective, we ultimately find these frameworks offer scant practical advice for improving the delivery process of "real-world" development projects. Readers with advanced knowledge of the real estate development process may skip this Chapter and to proceed directly to Chapter 2 where we propose adapting Engineering Systems approaches to real estate development.

The real estate development process is a lengthy and complex process that starts with an idea for a physical product to serve a need. This then initiates a process that may or may not lead to a product being built. Throughout the process of developing real estate, questions are being asked and answered and information is being gathered and analyzed by the developer. As the specific project starts to take shape and information is generated, the unknowns are reduced. As with any investment, as the uncertainties are reduced, so too is the risk. This can be seen simply by looking at how the market prices the investment in real estate development. In the early stages, the opportunity cost of capital (OCC) can be as high as 40% (Geltner et al. 2007, p. 759). It is the developer's job to navigate the process and eventually deliver a stabilized, cash-flowing asset, with lower risk and a much more modest OCC of approximately 8%. As information is gathered during the early stages of the development process, risk is significantly reduced, even though the amount of capital being invested is relatively small relative to the total investment. This high capital cost of development suggests that any reduction in uncertainty (and therefore OCC) can have a significant impact of the returns and viability of a project. This concept can be shown graphically in Figure 1.

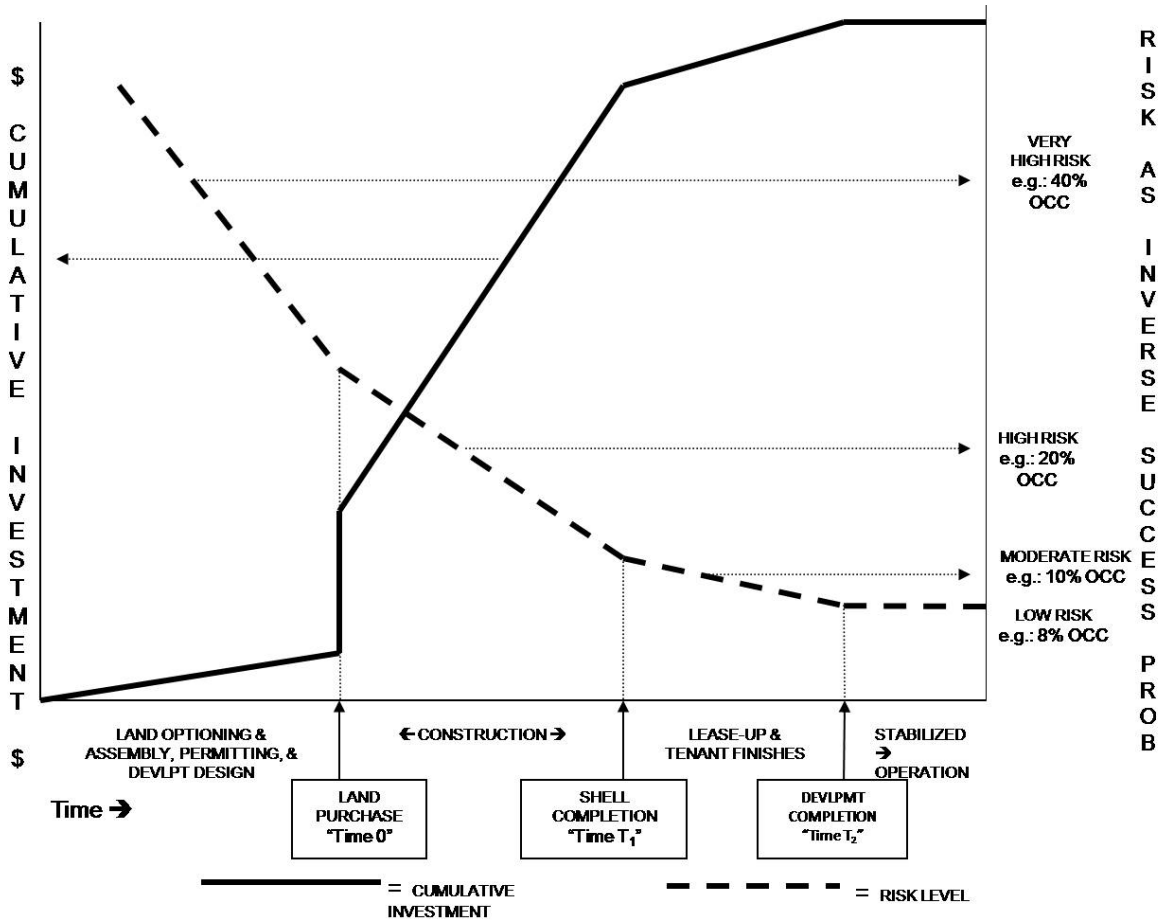

Figure 1 - RED Investment vs. Risk (Geltner *et al*, 2007)

One way to lower the risk of development is to model it and improve the way in which the process is managed. By efficiently gathering and sharing information, the developer can lower these risks, speed the process up and spend less capital before the land acquisition and construction occur. The rest of the chapter attempts to identify and explain some of the models that have been created to model the development process.

James Graaskamp on Real Estate Development

Real estate development has been described by celebrated Wisconsin real estate professor James Graaskamp as the creation and management of "space-time units". Any improvement of real property has the three dimensions of space (length, width, and height). Real estate has a fourth dimension of time for possession and benefit. Individuals, businesses or

institutions can control the created space unit for a period of time in exchange for a corresponding monetary value. (Jarchow, Stephen P., ed., 1991, p. 230)

The creation of these space-time units is a highly creative process in which physical ingredients such as land and buildings are combined with financial and marketing resources to create an environment where people live, work, and play. (Peca, 2009, p. 8) A real estate developer brings together a variety of physical, financial and marketing resources to create a development plan. The implementation of the development plan is an iterative process often lasting many years where the developer combines financial resources with physical resources to determine costs; financial resources with market resources to determine revenues; and physical resources with market resources to determine design as shown below in Figure 2. (Peca, 2009, p. 13) This creative process occurs in the context of complex relationships between the participants and the economic, political, financial, and social institutions of the environment in which they operate.

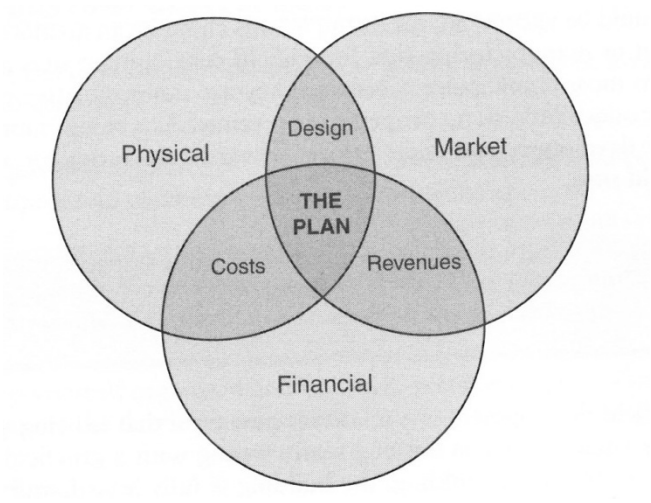

Figure 2 - The Development Process (Peca, 2008)

Graaskamp (Jarchow, Stephen P., ed., 1991) believes that a critical component of understanding real estate development is the *enterprise concept* which portrays development and its operations as a business unit primarily concerned with cash solvency, requiring active and aggressive management to achieve its goals. Each individual real estate development has all the critical attributes of an enterprise such as revenues, expenses, income, employees and taxes. As such, a real estate development enterprise begins with financial resources to purchase raw

materials and services (land and consultants), adds value through expertise and management, and converts finished products (buildings) into inventory which it sells for accounts receivable and back to cash. A full cash cycle is complete. All enterprises must maintain cash solvency as a prerequisite for continued survival. A surplus of cash above that required for enterprise survival is profit which owners (or investors) can appropriate for their personal use.

A real estate development in this framework is the result of continuous feedback between *space users, space production entities, and public infrastructure entities.* These relationships are defined and constrained by exogenous systems that give meaning and context to each entity: *political systems, social systems and enterprise systems.* This is illustrated in Figure 3.

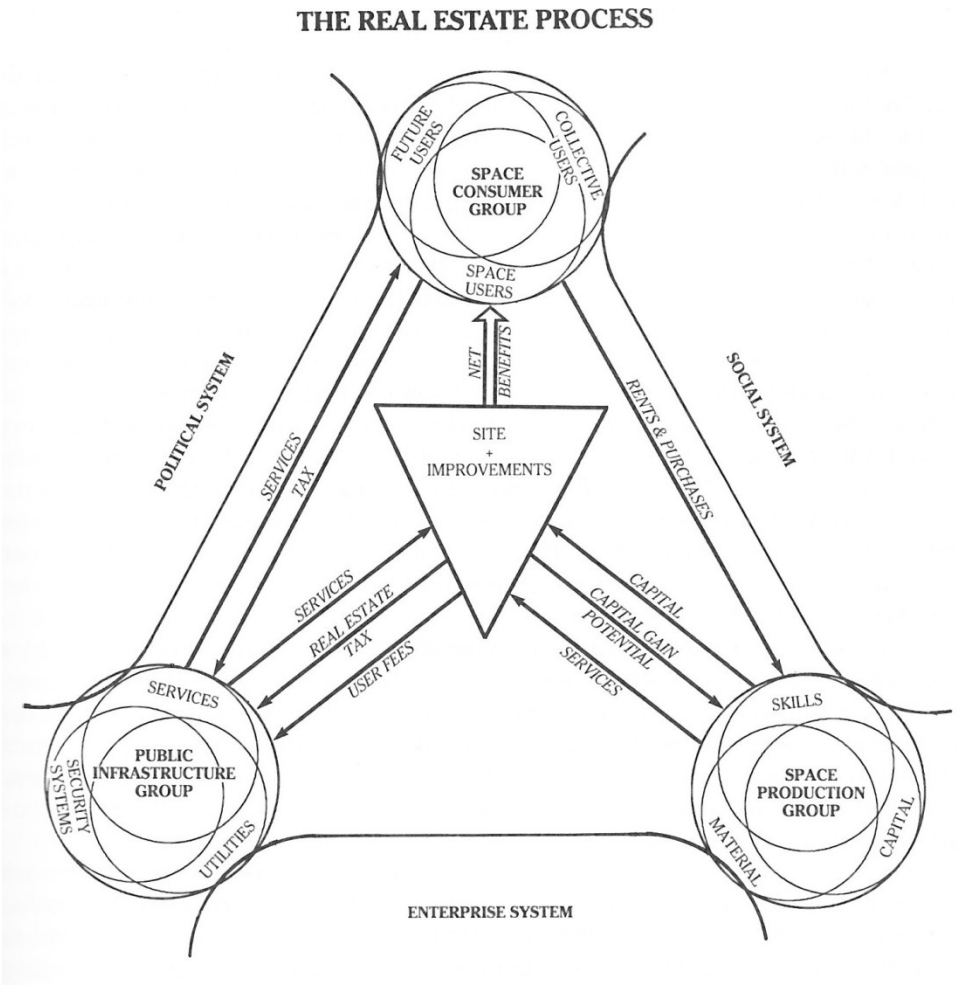

Figure 3 - Graaskamp's Real Estate Process (Jarchow ed., 1991)

In the conceptualization illustrated in Figure 3, the process of real estate development is the highly iterative outcome of analysis from four distinct disciplines: *urban economics* drives decisions about space markets, *architecture and engineering* guides physical design, *legal and political analysis* defines the permissible potential outcomes, and *financial economics* drives decisions about capital markets and real estate asset markets. The function of the space production group is to synthesize information from each of these four disciplines. Graphically, this has been illustrated in Figure 4, where each quadrant represents one of the four disciplines. The iterative manner, illustrated by the black line, shows that a balance of these four aspects is required to create a feasible cash-solvent enterprise. Each iteration represents a balancing of the issues from the four quadrants to refine the plan and move closer to reality. Though out the process *go, no go, and go back* decisions are being made based on the information generated in the process. (Geltner, Miller, Clayton, & Eichholtz, 2007, pp. 758-759).

Figure 4 - Graaskampian Decision Making Process (Geltner *et al*, 2007)

Graaskamp's approach to the real estate development process is intuitively satisfying because it abstracts and synthesizes a wide range of complex interactions and processes into a concise framework that appears to mesh well with reality. Graaskamp's writings can be described as eclectic because he freely adopts a variety of disciplinary approaches to the real estate development process. Graaskamp was a phenomenally prolific thinker on almost all aspects of real estate but he rarely published or applied intense academic rigor to his

pronouncements. His published analysis of the development process, while useful and intuitive, lacks academic depth and rigor. Writers such as Zuckerman have expanded upon Graaskamp's basic concepts to develop practically focused 'manuals' that outline the procedures to develop a successful real estate development. (Zuckerman & Blevins, 2003) By reviewing other literature on the real estate development process, we can understand the context of his analysis and gain an appreciation for his intellectual predecessors and contemporaries and the evolution of real estate development academic analysis.

Five Contemporary Approaches to the Real Estate Development Process

Many author besides James Graaskamp have developed models to analyze the property development process from a particular theoretical perspective. The models described below are intended to provide theoretical frameworks for understanding and conceptualizing the real estate development process. These varied approaches seek to address the notion that the real estate development process is a complex and adaptive process and the participants are not autonomous entities. On the contrary, developments and developers exist in a wider context of fact patterns that influence or, in some cases, determine the process of development and the eventual outcome. These perspectives and models synthesize a variety of academic disciplines and draw insights from established fields of enquiry such as sociology, economics, finance, management, and engineering.

Each model of the real estate development process provides unique insights that vary depending on the academic discipline of origin. For simplicity, we have categorized the models, frameworks and approaches that exist in the literature on real estate development processes into five major groups. (Healey, 1991; Trevillion, 2002)

- **Agency models** – deal with the actors in the development process and their relationships. These models attempt to describe the development process by focusing on sociological or behaviorist perspectives.
- **Structure models** – focus on the forces, institutions, and conventions that organize and constrain relationships in the development process. These models are generally informed by political economics.
- **Economic models** – primarily econometric in nature and deal with supply and demand as a driver for the development process as reflected in rents, costs, occupancy, investment yields, etc.

- **Event sequence models** – focus on the management and sequencing of the stages and processes of real estate development. These models are practical and industry focused and historically the least theoretical in nature.
- **Systems models** – view the real estate development process holistically and attempt to synthesize and reconcile the practicality of event sequence models, the actor focus of agency models, and the impact of institutions and power relations of structural models.

Agency models

Agency models are concerned with the participants ('actors') in the development process and the networks of interests and events that inform their strategic decisions. The distinguishing characteristic of agency models is a concern with the roles of agents in the development process, the networks of interests that influence their actions and decision-making, and the characteristics of the actors themselves. (Healey, 1991, p. 225) Agency models allow insights into the complexity of the development process by highlighting how actors and agents in the development process tend to cluster together and interact.

William Form (1954) from Michigan State University was one of the first writers to study the development process in the US. Form was a "social ecologist", a precursor to modern academic sociology, and was concerned with identifying and understanding the social forces and relationships that affect land use decisions and the land market. Form posited that the land market was highly organized and dominated by four interacting "social congeries" with a discernable "ecological" structure that reacts over time to institutional pressure. Form's four "social congeries" were: real estate and building businesses; large businesses and utilities; homeowners; and government agencies. Form believed the land development process was the result of a process of "struggles" between these groups and the process of negotiation and concessions among these groups. He proposed analyzing the real estate development process in terms of each congeries' available economic resources, functionality, internal organization, accountability pattern, and image of the city the groups are operating within. (Form, 1954, pp. 319-320)

University of North Carolina researchers Edward Kaiser and Shirley Weiss (1970) began to look at the real estate development process in the context of neo-classical economics. Kaiser and Weiss looked at residential land conversion and the decision-making process that led actors to their actions in each stage of the development sequence. They focused on the pre-

development landowner, developer, and household purchasing the end product and the rational decision process each party undergoes in response to their contextual conditions. Weiss and Kaiser proposed a "linked decision agent model" to quantitatively predict the likelihood that specific undeveloped parcels in North Carolina suburbs would convert to suburban residential development. The qualitative portion of their analysis was among the first to highlight the complex, highly-interdependent decision processes of owners, producers and consumers of residential land. They argued that the "three-dimensional spider web can be moved by impact in any corner" of the chain of decisions that culminates in a real estate development. (Kaiser & Weiss, 1970) This model of contextual decision-making is in contrast to Form's model of actors constrained by social relations which circumscribe and direct their actions.

Goodchild and Munton (1985) extend the analysis of Kaiser and Weiss by explicitly relating actors involved in a decision process to the actions they can choose. By identifying three key stylized roles in the development process (landowner, developer, and planner) and two key stages (identification and initiation), Goodchild and Munton describe alternative event sequence 'routes' and the roles and relationships that characterize these 'routes'. This work also acknowledges that sites vary and that events do not follow a set sequence. In Figure 5 Goodchild and Munton outline six possible "routes" for a property to traverse prior to construction commencing. Each development "route" must interact with a landowner, developer and planner in some fashion and must pass through the universal stages of "identifying" the property and "initiating" the development process. Routes 1 through 3 are typically associated with land development in Western capitalist contexts (Goodchild & Munton, 1985, p. 90).

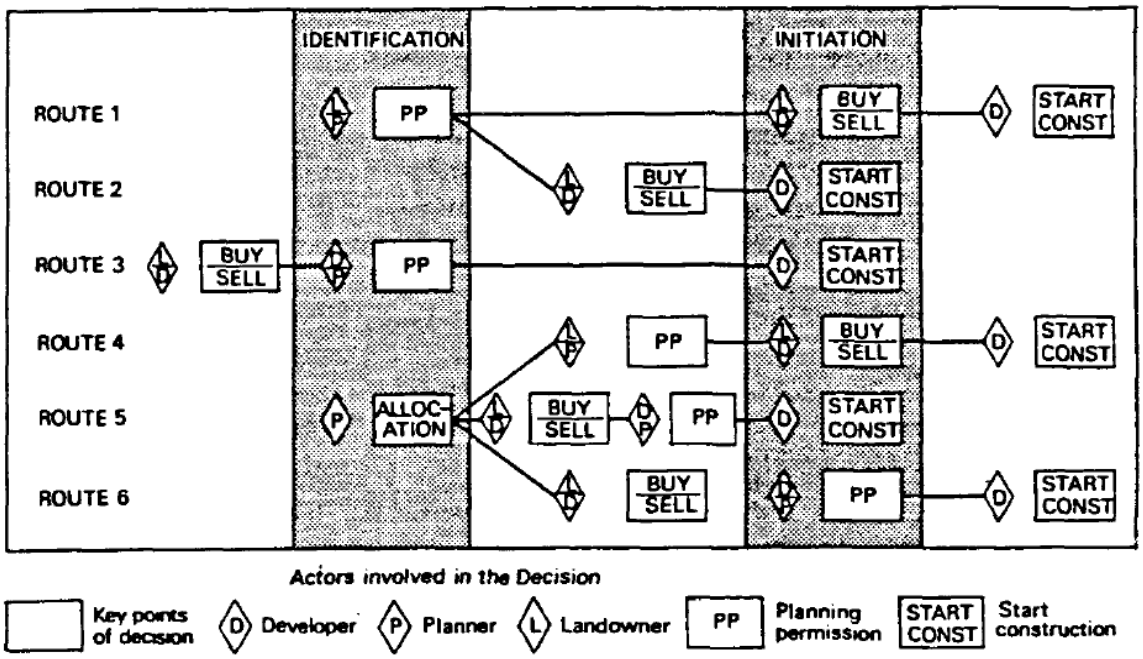

Figure 5 - Agency model of the development process (Goodchild et al., 1985)

Barrett, Stewart and Underwood (1978) assume the roles in the development process are more varied and the relationship between roles and actors are more complex. They describe a "dynamic pipeline" of structured event sequences that display iterative characteristics. Barrett *et al.* place events within the development process in a broad context of demographic, political, and economic change similar to the assumptions of the econometric models but emphasize the sequencing of events can be parallel or linear. In Figure 6, Barrett *et al.* outline their conceptualization of real estate development as a series of events and interactions anchored by 'development pressure and prospects'. This leads a developer to determine 'development feasibility' which can lead to 'implementation' if all tasks and conditions are successfully concluded. This concept of progression through time is an interesting connection to the Event Sequence models to be discussed later in the chapter.

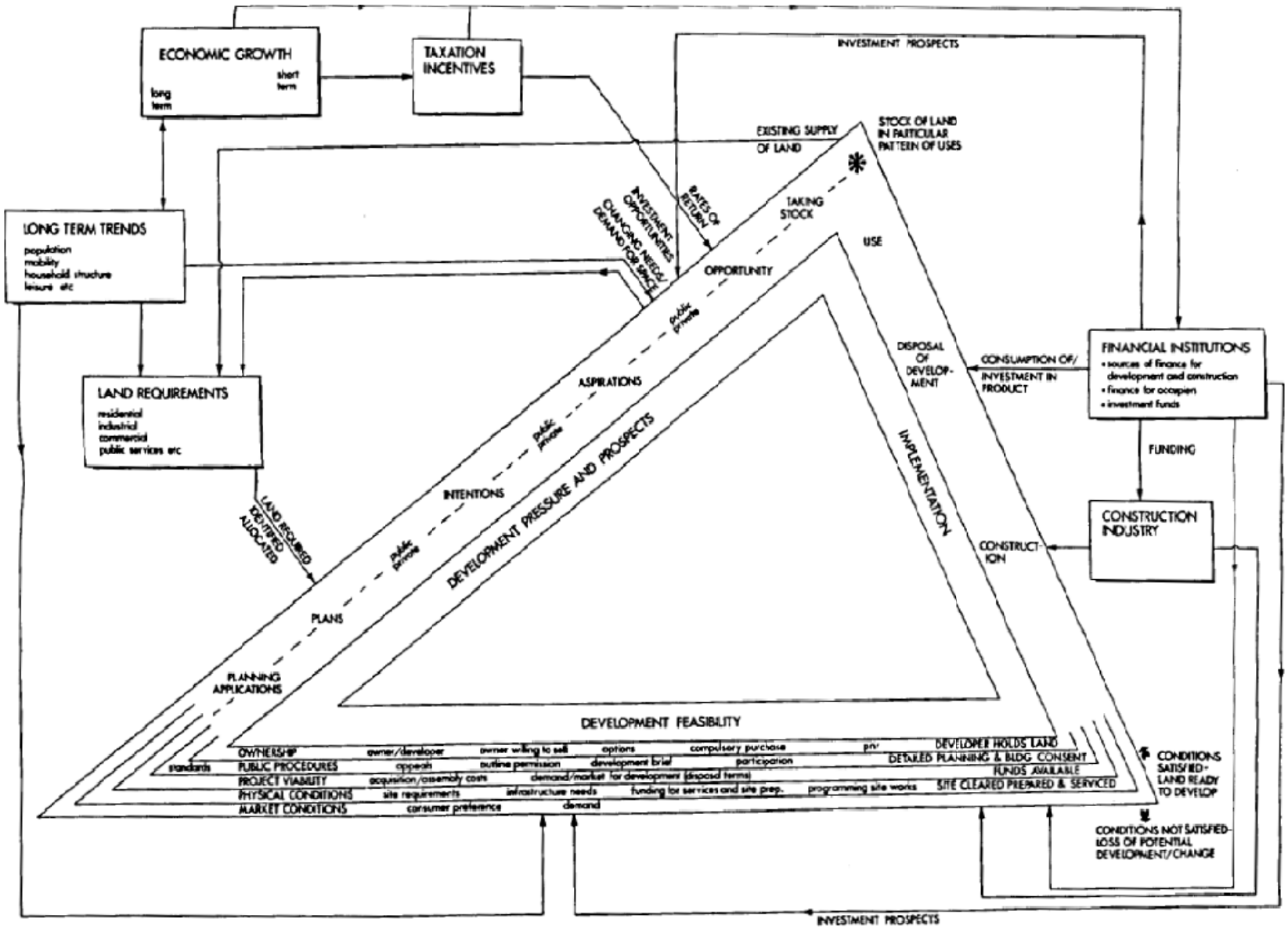

Figure 6 - The development process (Barrett, et al., 1978)

Agency models of the real estate development process are contributions to our understanding because they articulate and explicate important information about participants in the process and how they are connected. A major shortcoming of agency models, however, is the difficulty they have in clearly and concisely conveying exactly who is interacting with whom and why that interaction is important. The diagrams that accompany these models are clear examples of the shortcomings of agency models. The diagrams purport to elucidate the RED process and illuminate the complexity inherent to the development process but do little in practice to accomplish that goal. These diagrams are difficult to understand, provide limited opportunities for analysis, and cannot dynamically adjust to changing conditions. They provide a glimpse of the relationships between participants but little of the context and complexity found in reality. Additionally, agency models are focused at a high level of abstraction and therefore do not provide specific guidance or understanding at the project or firm levels.

Structure models

Structure models of real estate development are generally derived from the Marxist school of political economy which analyzes the processes of production from the perspective of power relationships between capital, labor and landowner. This is a distinct theoretical perspective from the neo-classical school of economics which is more concerned with the processes and consequences of supply and demand in response to market signals (Healey, 1991, p. 232).

The most influential structural theorist of real estate development is David Harvey (1985, pp. 59-89) who has written several books on real property in the context of market-based, communist, statist, and socialist economic systems. Harvey argues that the links between production (land and property for use), finance capital (land and property for investment and the state (public policy) can be viewed through the Marxist (as adopted by Keynes) 'circuits of capital' framework. The Marxist circuits of capital (Figure 7) are the Primary or Production Circuit where capital is produced by labor; the Secondary Circuit where capital flows into fixed assets and consumption assets; and the Tertiary Circuit where capital flows into science/technology and social expenditure. This focuses attention on linking events and agency behavior to the varied ways that different types of economies regulate their modes of production as structured by relationships between capital-labor, capital-landowner, and state-

market. Harvey believes that the historical/geographical politics of "accumulation" give rise to "class struggles" between those who control capital and those who contribute their labor. These tensions are resolved by cycles of prosperity and crisis and mediated by the state.

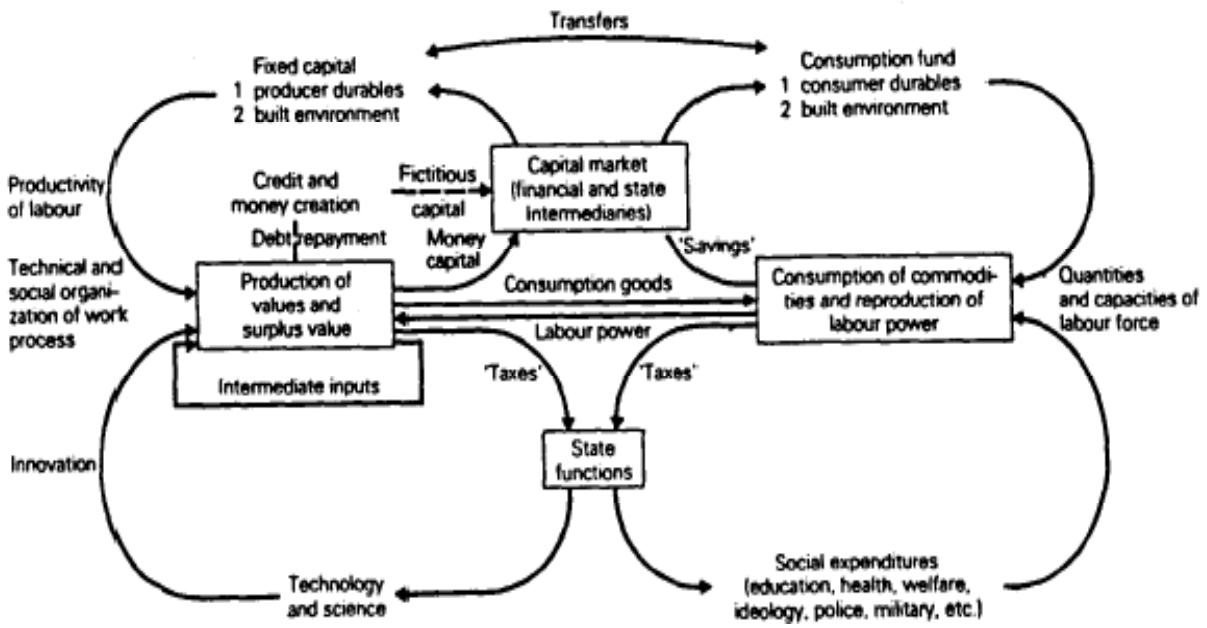

Figure 7 - RED in Marxist 'circuits of capital' (Harvey, 1985)

Like all structural analysts, Harvey essentially believes that all details of real world real estate developments are dependent variables of the structural relationships that surround each project. Structural models like Harvey's do not postulate many of the core assumptions Western developers believe are axiomatic. As such, structural models can be useful tools for decomposing the underlying assumptions implicit in a particular geography at a particular time. While an interesting framework for conceptualizing development in varying economic contexts, this model fails to give an actor in a US-based, capitalist context any useful information about how to proceed with the conceptualization, production and management of a real-world project.

Event sequence models

The most practical descriptive models for developers to conceptualize the development process are event sequence models that break the land development process into a discrete set of events and activities. Lichfield (1956) was the first contemporary author to conceptualize the real estate development process in terms of its constituent activities. Goodchild and Munton

adapted Litchfield's work to derive the following widely referenced seven step real estate development process:

The development process begins when a parcel of land is considered suitable for a different or more intensive use and it is completed when the necessary changes have taken place and the land is re-occupied.

1. *The 'maturing of circumstances' that makes possible a change in the use of land.*
2. *Purchase of the land by a person prepared to develop it.*
3. *Preparation of the land for development including both 'physical' construction work and 'abstract' operations such as establishing legal title.*
4. *Preparation of the development scheme including obtaining all necessary consents, especially planning permission.*
5. *Arrangement of finance to carry out the development.*
6. *Construction of the development scheme.*
7. *Its occupation by the developer, a new owner, or tenant.*
   (Goodchild & Munton, 1985, p. 65)

This event sequence model suggests the level of complexity that successful completion of a real estate development process must undergo to reach a conclusion. It also illustrates the temporal dimension as projects move from one phase to the next.

Mike Miles *et al.* propose an eight-stage framework that represents a typical sequence for a real estate development (Miles, Berens, Eppli, & Weiss, 2007) that has been widely adopted by the development community in the United States and advocated by the Urban Land Institute as a practical guide for developers. While Miles *et al.* accept that specific developments and developers are highly idiosyncratic his eight-stage framework details a sequence of activities that adequately characterizes a majority of real estate projects. Miles acknowledges that the sequence is not always followed exactly and the activities within each stage are often occurring concurrently or iteratively but argues that conceptualizing development as a series of stages provides a practical framework for evaluating individual projects.

1. **Idea inception** – A developer generates an idea for a particular project in terms of size, scope, product type for a particular geographical area. This is conceptualized by Graaskamp as "a site looking for a use" or "a use looking for a site". The developer begins to conceive the type of users that the project would serve and the rough income streams that user could generate. This income stream can generate a potential capitalized

value of the project which compared to cost, quickly allows the developer to determine viability of the idea.

2. **Idea refinement** – The developer begins to identify sites with appropriate locational characteristics and economics and attempts to gain control of the site. Preliminary physical feasibility is evaluated in terms of soils condition, environmental mitigation, and ability of the site to physically contain and legally construct the envisioned project. Financial feasibility is further tested in terms of potential income, cost of complete, and availability of financing.
3. **Feasibility** – A formal feasibility process is started where the developer hires consultants to conduct market and marketability research, begins a formal design process, initiates entitlements and approval negotiations, arranges debt and equity financing, and evaluates costs and constructability.
4. **Contract negotiations** – Written contractual agreements are initiated with all key participants. Construction and permanent debt and equity are negotiated and structured. A contractor is retained to build the project. Government approvals are negotiated and finalized.
5. **Commitment point** – All the contracts negotiated in Stage 4 are ratified and come into effect.
6. **Construction** – The project is constructed by the contractor and the developer manages the process.
7. **Initiation of operations** – The construction is completed and operating managers begin the process of preparing the building for occupancy.
8. **Asset management over time** – All aspects of managing the capital improvements over their economic lifecycle are initiated. These include maintenance, releasing, refinancing, and disposition.

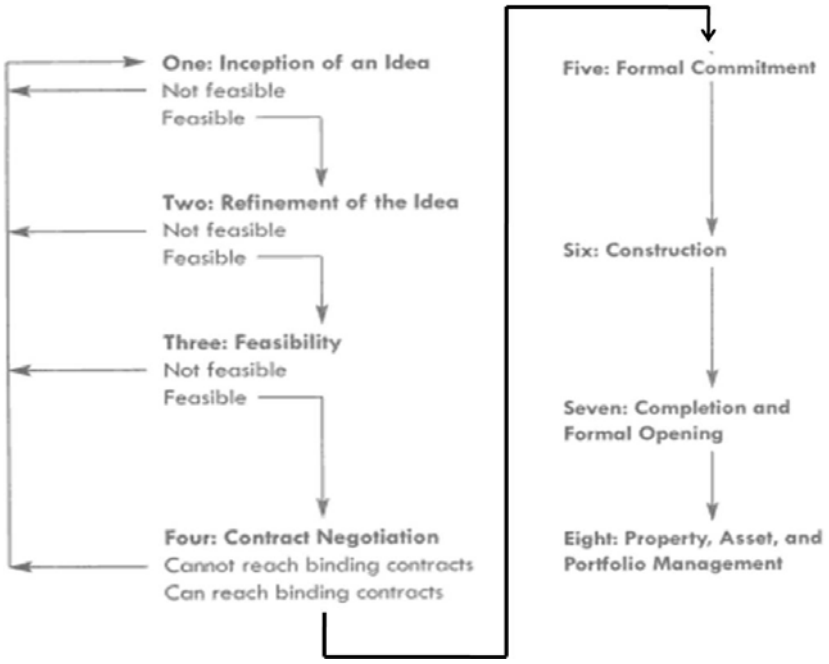

Figure 8 - Miles' 8 Stages of the RED Process (Miles, et al., 2007)

Event sequence models are often criticized for offering little more than a vocabulary for describing the development process (Healey, 1991, p. 224) without a specification of the participants in the process and the conflicts interests they represent. Additionally, it is contended, that there is no description of the development process that can manage the level of complexity and iteration that actually occurs during a development process. Miles implicitly accepts this criticism but contends that some framework for understanding the real estate development process in terms of its constituent events and activities is better than none at all. While the eight stages are not a completely satisfactory model of the real-life complexity of a real estate project, they are a useful framework for conceptualizing events and activities from a developer's perspective.

Economic models

Economic models of the real estate development process are primarily econometric in nature and utilize rigorous quantitative analysis to understand supply and demand equilibriums and the endogenous and exogenous changes to the system driving the occurrence of development processes. Economic models are highly data driven and are often combined with advanced statistical techniques to project variables such as future prices, rents, returns, activities, etc. Real estate econometric modeling is equally adept at microeconomic analysis at the property level or macroeconomic analysis at the city, regional or national levels. These models and analyses are very well established in Urban Economics literature. Many concepts illuminated by econometric models are articulated using financial analysis grounded by the "time value of money".

Economic models are generally concerned with the supply and demand equilibriums of built real estate and the effect that urban spatial theory has on land availability and pricing. Economic models of the development process generally posit that new developments are spurred by the value of existing stock exceeding the cost of new construction. Disequilibrium occurs and development happens to bring the system back into balance. (DiPasquale & Wheaton, 1996, pp. 7-10)

The DiPasquale-Wheaton 4-Quadrant Model (Figure 9) is a succinct summary of real estate property and asset markets viewed from an economics perspective. Demand (D) is a

function of rent and macroeconomic conditions prevalent at the time. Supply and demand for built space determines market-determined rents for space in the "space-market" depicted in the upper-right quadrant. The upper-left quadrant takes those rents and via the ratio of rents to market-determined asset prices determined in the asset markets establishes current property values. The line in the upper-left quadrant is the current yield (capitalization rate) or valuation that investors are requiring for real property assets as a function of their current rents. When prices for existing assets are greater than or equal to replacement cost, new development and construction will occur in accordance with a supply function in the lower-left quadrant. Passing through the lower-right quadrant, this new inventory of real estate space is now long-run stock (Q) and part of the supply-side in the market's determination of rents in the upper-right quadrant. This framework allows sophisticated quantitative analysis and makes forecasting possible. As rents, prices, and construction changes, the model adjusts to model the new equilibrium levels. (DiPasquale & Wheaton, 1996).

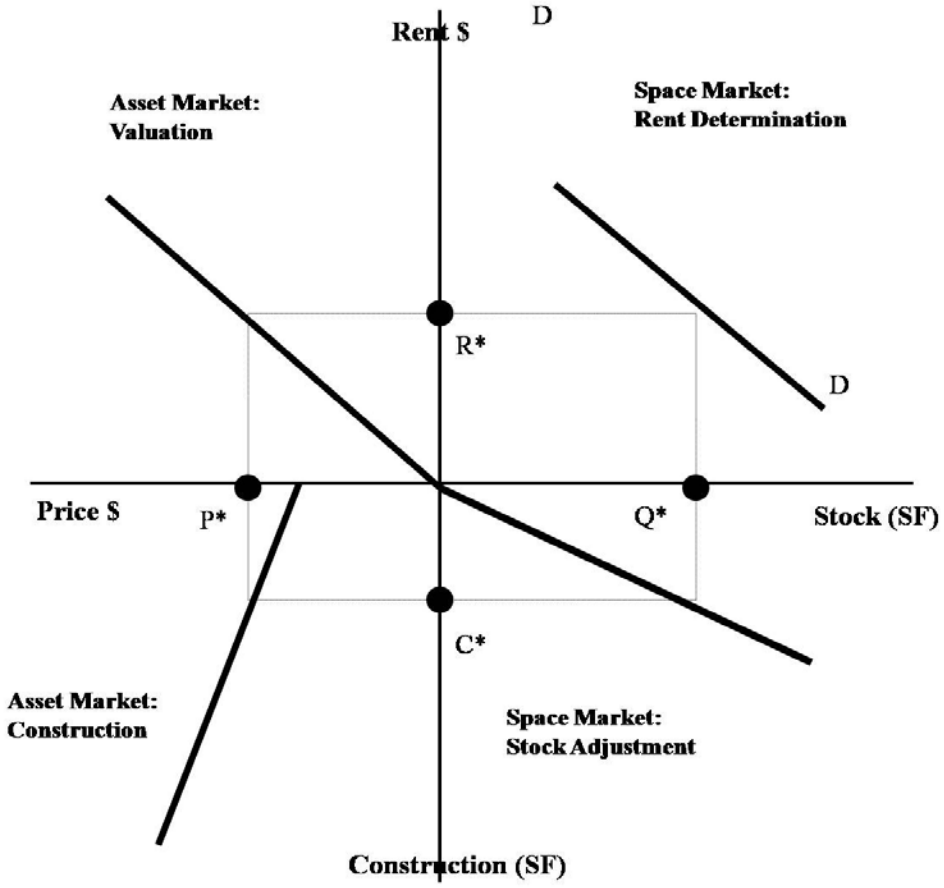

Figure 9 - DiPasquale-Wheaton 4-Quadrant Model (DiPasquale & Wheaton, 1996)

In this 4-Quadrant framework, real estate development occurs in the lower-left quadrant as a result of market disequilibrium. The slope and shape of the supply function in this quadrant depict the realization of real estate development projects in the market. Developers (and their financial backers) employ financial analysis tools to determine the costs of new development and the value they can attribute today to the stream of future cash flows based on the asset market in the upper-left quadrant. Development occurs to maximize the residual value between the value of the capitalized stream of rents and the cost of development and construction. The residual is the land value. A rational developer will build a project that maximizes the residual (land) value, typically by generating the largest stream of rents. He will choose a development program that maximizes the risk-adjusted *net present value* (NPV) of the future cash flows over all other mutually exclusive alternatives (Geltner *et al.*, 2007).

If the developer owns the land, one alternative is to wait for a more advantageous time to build in the future (speculating that conditions will improve). In this formulation, the development of land into a real estate project is the exercise of a real option. A developer can choose to incur high capital costs and significant risk now in order to capture an income stream, or he can wait to exercise the option later. (Geltner *et al.*, 2007)

While economic models of the development process are very useful in understanding where to build a new project, how much to pay for land, or how much rent is justifiable, they do not provide much useful project level information to the developer about the process of identifying property in the real world and navigating the contentious and politicized entitlement and design process that ultimately leads to construction and tenant turnover.

Systems model

Recently scholars have begun to view real estate development as a complex and adaptive system whose participants and processes exist in specific contexts of economic and political meaning. Viewed through this lens, real estate development can be analyzed by observing and measuring the system dynamics of development and developers.

Edward Trevillion (Trevillion, 2002) is the leading proponent of approaching real estate as a system of interacting components. Trevillion argues that real estate development is a highly dynamic and adaptive system that responds to changes in the surrounding cultural, political and

economic environment. In order to understand the adaptations of the system, one must understand the underlying structural relationships that shape and constrain the components of the system and mold the development process. These underlying relationships give rise to dynamic feedback loops that influence behavior of participants and the evolution of process and behavior. In this systems model, the reaction of a system component to an exogenous force is not entirely deterministic. The system's evolving structure will influence and control the action of the component part through transmission of information. The real estate development system will demonstrate emergent properties that individual components of the system do not display individually. Thus real estate development can be viewed from a systems perspective as a structure of elements, interconnections and feedback loops that characterize and describe the behavior observed in reality. This is illustrated in Figure 10.

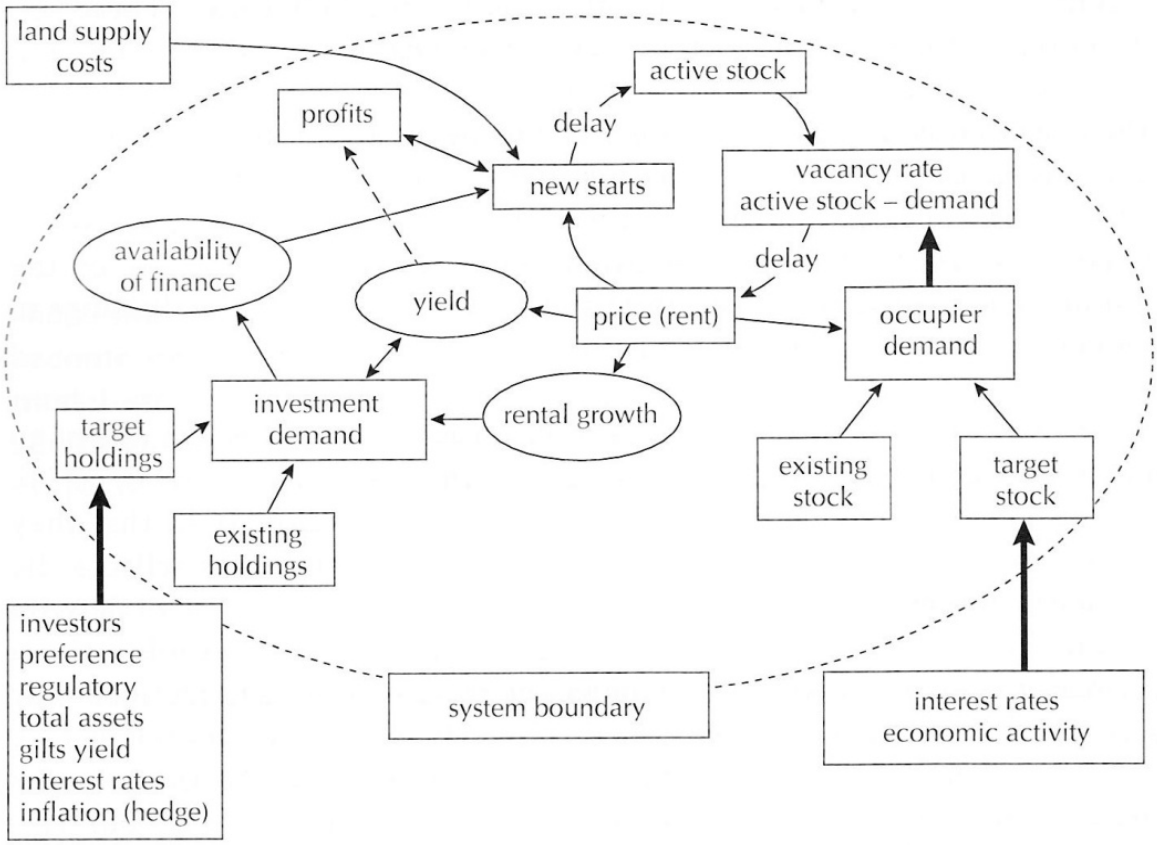

Figure 10 - System Structure Diagram (Trevillion, 2002)

In the System Structure Diagram above (Figure 10), Trevillion highlights the notion of a distinct boundary for factors endogenous to the real estate development system (supply and demand cycles, stocks and flows) and those which are exogenous (interest rates, investment yields, economic activity). The arrows indicate the communication of information from one factor to another or the transmission of behavioral influence. System dynamics are demonstrated by the feedback loops (positive or negative) that reinforce or compensate the internal activities of the sub-systems (Trevillion, 2002, pp. 181-193). This System Structure Diagram conveys a great deal of information however the presentation is rather confusing and offers limited opportunities for modeling system dynamics or process change.

Chapter Summary

This chapter has presented a series of frameworks for understanding the real estate development process. Each perspective contributes to our comprehensive conceptualization of the actors, relationships, structures and systems that impact a real estate development and the process by which Graaskamp's "*space-time units"* are conceptualized, analyzed, constructed, and managed. However, all of these models of the development process lack a level of granularity regarding the specific micro-level tasks required to develop real estate and the relationships between the tasks. If we stipulate a particular conglomerate of economic, political, financial, social, and physical systems, what does a useful and practical task-oriented process look like for a real estate development project? Existing models lack the ability to analyze or articulate the level of detail necessary to be a real world aid to development decision-making. We believe that tools adapted from the field of engineering systems can explicate these tasks and relationships, contribute to enhanced understanding of the real estate development process and aid decision-making that can reduces cost, shorten schedules, and lower risk and uncertainty.

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Chapter 2: Systems Thinking in Real Estate Development

Chapter Summary: In this chapter we introduce the interdisciplinary fields of systems engineering (engineering & management) and engineering systems (engineering, management & social sciences) and discuss insights from these fields that contribute to understanding the product development process. We then review the applicability of these analytical perspectives to the real estate development process. We describe the applicability of these insights to the real estate development process and review tools currently used to manage real estate development. The many shortcomings of existing tools used in real estate development sets the stage for applying DSM.

Real estate development is a process. As we saw in the Graaskamp spiral (Figure 4), the process starts with an idea. Then, as information is gathered and tasks are completed, the idea becomes further defined, and moves closer to reality. None of these tasks, however, can be completed in isolation, or in a prescribed linear sequence. Each relies on information from another. This results in a complicated web of linked information that must be managed by the real estate developer. This cyclical, interdependent nature of development is not unique to just real estate. The same can be said for the development of any product where information is being shared between tasks and across disciplines in the process. While the products we have developed over the last century have grown increasingly more complicated, so too has the task of managing how they are developed.

Systems Engineering – Engineering & Management Disciplines

The increased complexities of products and how they are developed have led to the demand for innovative methods of managing and modeling these processes. Prior to World War II, most industrial engineering "was carried out by a small group of designers or a single generalist designer. The products were simpler; the production processes were simpler." The period after WWII, "was characterized by the diffusion and further development of methods originated in wartime production of weapons." (Anumba, Kamara, & Cutting-Decelle, 2007) Engineers and managers began to realize that, "in a complex system it is often found that even though individual components satisfy all specifications, the system as a whole will not work." (Schlager, 1956) In response to these issues, a field of study known as *systems engineering* developed to solve the interdisciplinary problems that were occurring in complex development projects. Systems engineering became concerned with integrating disciplines and specialists into

teams that develop a structured development process in all stages of development from design to operation. Systems engineering approaches synthesize business needs with technical requirements to provide customers with quality products that meet user needs.

One accepted definition of systems engineering is:

> *'Systems engineering is a rational approach to decision-making related to the solution of complex problems in engineering, planning, design and operation." (Boardman, 1990, p. 2)*

By integrating engineering and management techniques, systems engineering looks to improve the way individual parts of a system work as a whole. Since the name was first coined at the Bell Telephone Laboratories almost 70 years ago, the concept has matured to become an accepted interdisciplinary engineering field of study. Today, product development industries ranging from computer chip design, software integration, and building construction are utilizing systems engineering techniques to improve the development process.

Systems engineering is a practically oriented subject that allows for problem solving and management through the use of models as a tool to visualize and analyze a process. These models can show how subsystems are related and how information is shared between tasks, showing both qualitative and quantitative aspects of the process. The idea of using models to describe a process came before any formal recognition of the field itself. As Boardman states, "systems engineering may not be anything new, but is just good engineering dressed up in new clothes." (Boardman, 1990, p. 3). The creation of the subject, however, has allowed for people to formally study the way these models are being used. Over the years, the field has been able to provide tools and techniques to aid in the development of different products.

The need for systems engineering tools has increased with the development of new technologies over the last half century. Technological improvements have led to the increased complexities of our products and their development, but at the same time, have also given us effective tools to manage those processes. These tools, such as computers and the models they generate, however, cannot improve the system alone. Proper management must also be in place to oversee and execute based on their output. "There is no guarantee for success unless the proper organizational environmental has been created and an effective and efficient management structure is in place." (Blanchard, 2008, pp. 45-46) This is further illustrated by Blanchard in Figure 11 below.

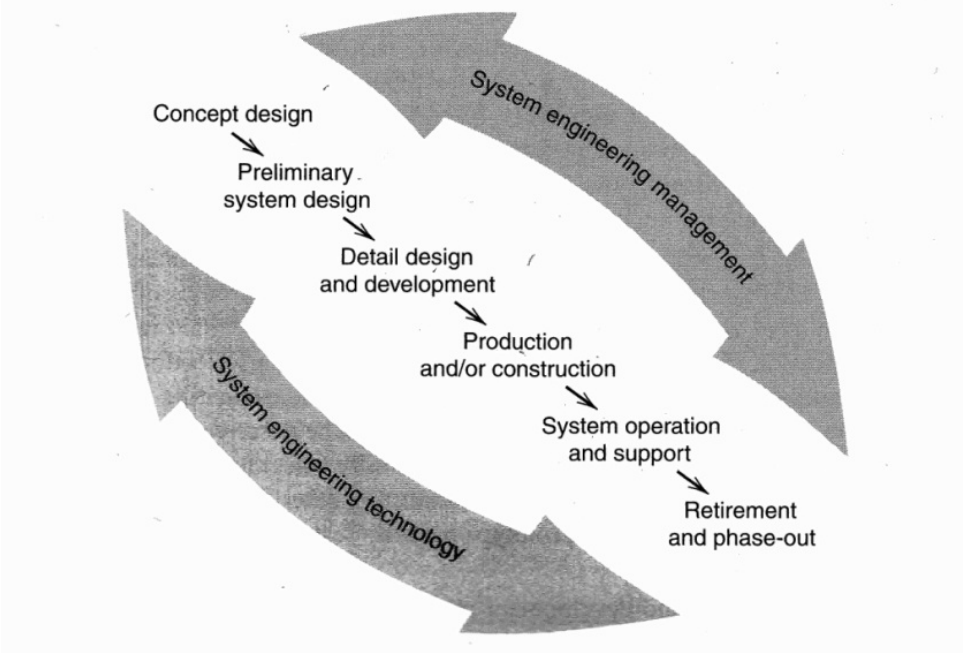

Figure 11 - System engineering process (Blanchard, 2008)

The framework of systems engineering discussed above can be applied to any type of development system, including that required to create real estate. While a review of the literature indicates that system engineering has never been formally applied to real estate development, the currently practiced process of real estate development embodies many characteristics of contemporary systems engineering and product development practice. The development of real estate, similar to any product, starts with an idea looking to meet a demand. Once that demand has been understood, a feasibility analysis is completed to further investigate and refine how this demand can be met in a profitable way. If it appears the demand can be met profitably, the plan is finalized, and financing is procured and structured. The product is then constructed to meet the requirements that were determined in earlier stages. Throughout the development process, the business entity gains knowledge of the product being developed. This knowledge can be further refined on subsequent projects as well, improving the delivery process.

Engineering Systems – Engineering, Management & Social Sciences Disciplines

Systems engineering is the integration of management and engineering disciplines to build successful technological systems, but the field generally ignores the rich interactions

between these systems and their social, environmental, political and technological context. The new field of Engineering Systems initially conceptualized by the MIT Engineering Systems Division (ESD) seeks to build upon the insights of systems engineering by integrating approaches and methodology from social sciences. Engineering systems has become a distinct field of enquiry with graduate-level programs at over 30 universities internationally. Engineering systems analysis complements systems engineering by expanding the field of examination beyond the micro-level analysis of specific systems to incorporate macro-level analysis of the system's socio-technical context. Scholars have devised two key meanings of engineering systems:

1. A class of systems characterized by a high degree of technical complexity, social intricacy, and elaborate processes, aimed at fulfilling important functions in society
2. An emerging field of scholarship that seeks solutions to important, multi-faceted socio-technical problems.

Engineering systems approaches analysis of complexity through perspectives and methodologies that balance quantitative rigor with qualitative insights while always examining systems from a multiplicity of stakeholder perspectives. The primary engineering systems approaches currently advocated by MIT's ESD include:

1. "**The Interface of Humans and Technology:** Examining the ways in which human attitudes and behaviors affect the successful use of technologies, as well as design methodologies that explicitly account for the human interface.
2. **Uncertainty and Dynamics**: Including modeling the sources of uncertainty and dynamics of complex systems as well as the effects of uncertainty in each domain area.
3. **Design and Implementation**: Applying life-cycle concepts to capture the value and cost of flows over time, as well as analyzing enterprise architectures and developing change management processes that are required for successful implementation.
4. **Networks and Flows**: Representing, analyzing and designing systems as interdependent multi-layered networks with multiple types of flows.
5. **Policy and Standards**: Taking into account the role of government policy, industry standards, and other factors, which traditionally have been taken as external constraints, but instead are treated as design variables by ESD researchers."

(MIT Engineering Systems Division, 2008, p. 6)

Engineering systems researchers currently focus on domains that highlight the complex relationships between people and technology such as critical infrastructure (electrical grid, transportation, information, communication); extended enterprises (product & service design-

manufacture-delivery, flows of goods/information/money/knowledge); and energy & sustainability (energy production-distribution-use, resource availability & conservation, policy).

The real estate development process incorporates and synthesizes most key programmatic interests of engineering systems which makes it ideally suited for extending the approaches outlined above. Real estate technology is always progressing and adapting and humans interact with building technology at work, home and during recreational pursuits. The real estate development process is fraught with many types of risk and uncertainty that can be quantified and analyzed. Complex organizations design and build real estate projects in response to customer demand. In the United States, efficient and environmentally sensitive buildings are crucial to sustainability and conservation efforts. The real estate development process is highly regulated at local, state and federal levels and is the outcome of networks of stakeholders and policy decisions. It is also vital to economic development and our social interactions. Enhanced understanding of real estate development is crucial to our continued progress and success as a species, society and culture.

We believe real estate development is a legitimate and important focus of engineering systems approaches. The applications of engineering systems tools and methodologies to real estate development processes will lower risks, lower costs (financial, environmental, social, etc.) and improve the long-term viability of our society. Our understanding of real estate development will benefit from engineering systems analysis and the nascent field of engineering systems will benefit from studying a complex socio-technical system such as the real estate development process.

Product development

One way to apply systems thinking to real estate development is through analysis of the product development process. Systems approaches are applicable to all stages of a product's lifecycle. Real estate is a product that is developed in a rich context over time and is thus suitable for analysis using established product development systems methodology.

Early in a product development process, the focus is on conceptualizing a design that meets the anticipated demands of the consumer or user of the product. Once these initial requirements have been established, the focus becomes internal, as a product is designed to

efficiently meet these demands. "Trade-off studies are conducted, with the objective of providing a well-balanced system design. There are many different design objectives that must be met, some of which may be somewhat conflicting." (Blanchard, 2008, pp. 30-32) As information is gathered and interpreted, "the role of system engineering is to identify, prioritize, integrate, and to cause the development of a system configuration that will meet all customer requirements in a timely, effective, and efficient manner." Throughout the production stage, systems techniques are utilized to ensure that the product still meets the original specified requirements. Throughout the process, "there is a continuous product/process improvement feedback loop…which is critical in the implementation of system engineering." (Blanchard, 2008, pp. 30-32)

By reviewing the work done in product development, we can observe many similarities between generic product development processes and those of real estate development. Therefore, by taking a systems approach to real estate development, one is able to apply proven tools and methodologies to improve the practice and knowledge of the real estate development industry. As a result of evaluating and understanding the process in which development is conducted, the developer is able to reduce the number of uncertainties and rework that takes place in the process. This creates value for users and consumers by reducing risk, lowering costs, and improving product quality.

The risks associated with product development can be put into four main categories: **technical risk, market risk, schedule risk** and **financial risk**. A product development process can be deemed successful if it is capable of identifying, managing and mitigating these risks. (Unger & Eppinger, 2009) These risks can be viewed and measured from an outcome distribution perspective as the possibility the realized *ex post* outcome deviates from the intended *ex ante* outcome. This view of risk highlights the dynamic nature of product development processes and the inherent uncertainty of the new product development process.

To improve a product development process, models are created to visualize, conceptualize and manage the process. "By listing the activities to be done and their dependencies, planners can get an idea of a project's critical path, duration, etc." and can "explore opportunities to reduce duration." An attempt to model a product development process can be extremely difficult and should not be taken lightly. "Ambiguities, uncertainties,

and interdependencies of activities, their results, their assigned people, and their tools make the product development process extremely complex and challenging to model." (Browning, Fricke, & Negele, 2006, p. 105). "Given the uncertainties inherent in product development, iteration is inevitable and must be managed effectively." (Unger & Eppinger, 2009, p. 389)

Numerous product development process models have been established that depict business processes. To successfully manage a development process, one first needs to understand the differences and similarities between product development and other business processes. Most business processes, "strive to do the same thing repeatedly, whereas product development projects seek to do something new, once." As a result, "conventional business processes tend to be more sequential, driven by firm dependencies on specific materials and data, whereas product development processes tend to be more parallel[1], since dependencies on information are 'softer' in the sense that they can be replaced (for better or worse) by assumptions and early estimates." (Browning, Fricke, & Negele, 2006)

It is evident in systems engineering that iteration is necessary to develop products. The back and forth of ideas between tasks allows for innovation to efficiently solve problems. Too little iteration leads to no new ideas or a sub-optimal product whose design is not sufficiently honed. Too much iteration, however, can be highly resource consuming and deliver small incremental value per iteration. There must, therefore, be a balance between too little iteration and too much. A product developer must constantly manage iteration in the development process to ensure that balance is maintained between iteration that improves the product in a time-efficient, cost-effective manner and iteration whose improvements are marginal (or negative) and simply consume limited resources. These concerns are particularly appropriate for real estate developers who must carefully balance development cost, project timeline, and product characteristics in order to deliver a viable product to market that maximizes value over time.

[1] In DSM terms, "parallel" means *independent* tasks (no information flow between tasks is required) however it is clear that Browning *et al* are referring to *interdependent* or coupled tasks as shown in Figure 12.

Process Management Tools Currently Used in Real Estate Development

Real estate developers use a variety of project management software tools to manage the flow of information, control schedules and track costs. Most commercially available project management software tools are designed for coordinating design and construction activities which forces developers to attempt to adapt this software to their more complicated reality. Much of the value created by real estate developers comes from conceptualizing a deal, assembling land, designing the project and getting the project entitled through the political system all of which is outside the functionality offered by commercial software systems. Other software systems focus on managing real estate development accounting and financial analysis but this offers little help to project management or information flow activities.

MS Project is an example of an "off-the-shelf" generic project management system that manages tasks and timelines with limited cost management functionality. MS Project has some utility but tasks and durations must be input manually and it must be adapted to the particular project. MS Project has no ability to handle iterative tasks which severely lowers its utility for use in the real estate development process.

Some software tools are specifically designed to manage and coordinate development and construction activities and costs.[2] Most of these tools used in real estate development come from the construction industry, where tasks are completed in a sequential order. Some software packages are based on PERT/CPM[3] analysis and Gantt charts (Primavera, Virtual Premise, Buzzsaw), and display graphical descriptions of the sequence in which tasks are completed. PERT/CPM and Gantt are not well suited to modeling the real estate development process because they are very poor at representing iteration in tasks. Additionally, the diagrams generated using these techniques can rapidly get so complicated that they tend to overwhelm

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[2] **Primavera P6 by Oracle** – Project & Portfolio Management (www.oracle.com/primavera/index.html)
Timberline Office by Sage -Suite integrates with accounting systems (www.sagecre.com)
Virtual Premise – Real Estate Portfolio Management with PM module (www.virtualpremise.com)
Quickbase by Intuit – Project Management integrates with financial analysis and accounting (quickbase.intuit.com)
ProjectCenter by Bricsnet – Project Management integrates with portfolio management (www.bricsnet.com)
Constructware by Autodesk – Project Management integrates with Design Suite (usa.autodesk.com)
Buzzsaw by Autodesk – Project Management integrates with Design Suite (usa.autodesk.com)
Developer by ARGUS – Limited project management integrates with financial analysis (www.argussoftware.com)

[3] The Program (or Project) Evaluation and Review Technique (PERT), Critical Path Method (CPM)

users with detail rather than provide practical information about problems. Many newer systems such as Buzzsaw or Primavera are web-based and have functionality to store and exchange project documents over the internet. These types of systems tend to be "document-based" rather than "task-based" and excel at managing a process of drawing review and approval. Other software systems offer project management functionality and closely integrate with budgeting and accounting platforms (Timberline and Quickbase). None of these systems are useful to a real estate developer attempting to gain a big-picture overview of the real estate development process and the network of information flows within tasks. These project management software packages are interesting and useful at certain points of the development process, but none focus on the real estate development process from the holistic and integrated perspective that this thesis advocates.

The problem with applying these software tools to the real estate development process is that development, unlike construction, is not a sequential process. Graaskamp describes a real estate development process with continuous refinement of an idea spanning over many disciplines and domains. Tasks are occurring simultaneously and information is rapidly flowing between tasks. The methods and tools currently used to manage the development process can't adequately show the iteration and structured learning that takes place during development processes. (Eppinger, 2001) Existing software tools are too unwieldy to explicitly model the multitude of tasks occurring in a development process and the information flowing between them, especially given the iterative nature of the process.

Further, the approaches and models of the real estate development process described in Chapter 1 are at a general and abstract level that does not provide sufficient detail for practical insights to a real estate developer. The missing piece is a concrete and detailed model of the real estate development process that provides detail-level insights into tasks and their informational and disciplinary relationships yet remains easy to understand and apply in practice.

New tools and methodologies are necessary to synthesize the systems thinking described in this chapter with the real estate development process described in Chapter 1. The next chapter introduces the Design Structure Matrix (DSM) as a method of modeling the complex tasks in a real estate development project and the informational relationships between tasks. DSM is a very powerful tool for graphically and concisely conveying a huge amount of

information in a fairly simple framework that allows for many practical insights into the real estate development process.

Chapter 3: Introducing the Design Structure Matrix (DSM)

Chapter Summary: This chapter begins by discussing the information flows that occur in a product development process. We introduce the DSM as a tool for modeling complex processes and the informational flows between tasks. A primer on DSM fundamentals allows the reader to interpret a DSM diagram and understand the history, applications and analysis of DSM diagrams. Readers with prior knowledge of DSM are invited to skip this chapter and proceed directly to Chapter 4 where we apply DSM to the real estate development process.

Most product development industries view tasks as linear and sequential and assume that information flows smoothly and completely from one task to the next. The real world, however, exhibits more complexity. Many tasks, especially at a high level of abstraction, require information from many other tasks to fully complete the task. Likewise, many tasks feed information forward into many tasks further forward in the sequence. In these scenarios, the inputs and outputs of each of these tasks and how they relate to each other is of critical importance. Information (its quality and relationship to other information) is the key to product development, not necessarily the tasks themselves. Feeding a task accurate assumptions and information determines how effectively the task can be performed. "To find dependencies between activities, we need to find what information and other deliverables they require to do their work." The methods discussed in the previous chapter fail, "to capture the full information flow, and the noted iterations are often poorly understood." (Browning, Fricke, & Negele, 2006)

Informational relationships between tasks

In the product development process, we know that some tasks share or depend on information from other tasks and some tasks can be done independently. There are, in fact, three basic types of relationships that tasks can have with each other. An example of the different possible relationships between two activities, A & B, is shown in Figure 12. If Activity B requires information from previously completed Activity A, then they typically occur sequentially, and are referred to as *dependent*. If Activity A and Activity B can be done in parallel without information from each other, they are referred to as *independent* and can potentially be done at the same time (or different times in any order). If successful completion of Activity A

requires information from Activity B and Activity B also requires information from Activity A, the activities are *interdependent* or "coupled". Interdependent tasks are iterative due to feedback relationship the tasks share. The first two types of relationships are relatively straight forward to model and manage in practice and are prevalent in the construction and manufacturing industries, where tasks can be completed in a prescribed sequential order. Modeling and managing coupled tasks, which describes much of the real estate development process and product development industries, is much more challenging because this arrangement implies iteration and feedback loops. (Eppinger, Whitney, Smith, & Gebala, 1994)

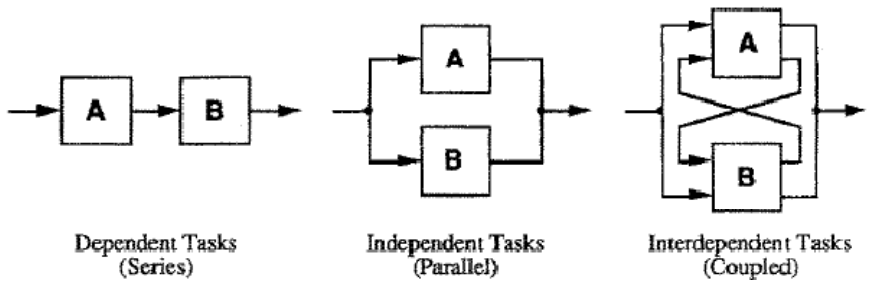

Figure 12 - Three possible sequences for two design tasks (Eppinger et al., 1994)

Design Structure Matrix (DSM)

Tools and models in systems engineering have been created to address the issue of modeling coupled tasks and how information flows. One tool finding increasing acceptance and use in product development industries is the design structure matrix which came out of research into applied graph theory[4]. Steward (1981a and 1981b) uses an N-square matrix to represent information exchanges and dependencies within a system. In the DSM, N units are listed identically in the rows and columns of a matrix to represent the design tasks. The marks represent the information flow between tasks. Revisiting the example from Figure 12, the same three patterns of relationships between two tasks are shown in the N-square matrix below (in this case 2x2) in Figure 13.

[4] Leonhard Euler's famous *Seven Bridges of Konigsberg* written in 1736 is considered the first graph theory paper. Graph theory is closely related to topology and widely used to model network and routing problems. A DSM is a 2D relational matrix representation of a transaction graph. The nodes of the graph (the tasks in the system) correspond to the column and row headings in the DSM. The graph arrows correspond to the "X" marks in the DSM. For further information see (Diestal, 2005).

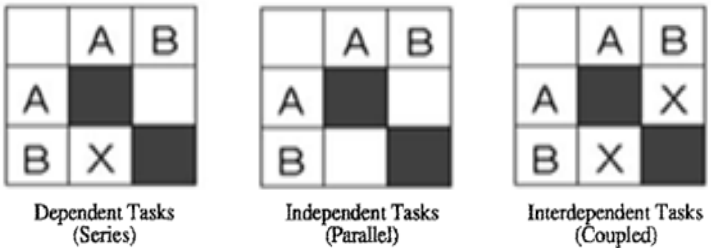

Figure 13 - Possible sequences for two design tasks (in DSM) - (Pektas & Pultar, 2006)

An "X" in a row indicates that the task labeled on the left in that row requires information or input from the task labeled at the top of the column in which the "X" is located. This two task example can be expanded to include the multiple tasks that occur in real life processes, at many different levels of analysis. Whether there are 10 or 500 tasks listed along the rows and columns, the DSM can provide graphic insights into the relationships between tasks.

To further expand understanding of DSM mechanics, Figure 14 provides an example with seven tasks (or elements). The activities are listed on the left of the matrix, one for each row. The order, in which they are listed in the rows, is repeated in the same order across the top of each column. The cells on the diagonal of the matrix are tautological (each task obviously uses its own information, thus it is meaningless to say that information flows to and from the same task). The off-diagonal cells in the matrix are then filled in to show from where tasks get their information and to where they send information. Looking across a particular row shows the tasks which the current task depends on for information. Reading down the column lists where a task sends information to.

Figure 14 depicts a hypothetical DSM scenario for designing a suspended ceiling system in a commercial office building. In order to design task B, "Floor to Ceiling Height", you will need information from task A (Floor Area)[5] and task G (Plenum Depth). Reading down the columns shows where the task provides information to. Task D (Air Duct Depth), for example,

[5]In large open floor plate buildings, occupants are more "comfortable" with higher ceilings because they report feeling less "boxed-in" and cramped. Conversely, small rooms often "feel" better with floor to ceiling height matched to the length or width dimension.

generates information that is required for tasks E (Beam Integration) and G (Plenum Depth) to be completed.

	A	B	C	D	E	F	G
Floor Area **A**	1						
Floor to Ceiling Height **B**	X	2					X
Beam Depth **C**	X		3		X		
Air Duct Depth **D**	X			4			
Beam Integration Scheme **E**			X	X	5		
Lighting Fixture Depth **F**	X					6	
Plenum Depth **G**			X	X	X	X	7

DEPEND

PROVIDE

Figure 14 - Suspended Ceiling Design – Initial DSM (Pektas & Pultar, 2006)

The matrix also reveals where iteration takes place. All X's below the diagonal line represent *feed-forward* information flows, where information created in earlier tasks can be used in later tasks. This is a classical *sequential* process. When X's are above the line, however, there is a *feedback* where information from later tasks may require rework or refinement of work done or decisions made in previous tasks. In the example above, task B depends on information from task G, which is completed after B. Therefore, the designer must make assumptions in order to complete B, without G being completed. If these assumptions are subsequently found to be incorrect when task G is completed, rework will be required to fix the problem or adverse consequences may ensue. This would require the process to move back to task B and repeat itself, which could prove to be costly and time consuming. (Eppinger, Innovation at the Speed of Information, 2001)

With the matrix completely filled in, the initial sequence of tasks can be reorganized to minimize the amount of potential rework; a process known as partitioning. To optimize the process, tasks are organized in a way in which the most number of X's as possible are below the diagonal, minimizing feedback. In the development process, with known iterations, it is impossible to move all of the activities below the diagonal. In this case, tasks are ordered to get the X's to as close to the diagonal as possible. By partitioning the example shown in Figure 14, we can see a new process, with less iteration in Figure 15. (Pektas and Pultar, 2006) There is

now only one coupled pair (tasks C & E) and the reordered tasks are close to each other in the work flow. These tasks can be completed together (as a single "phase" or "cluster"), rather than at different stages of the process, minimizing the impact of rework. The relationships between the tasks remain the same, but a new order minimizes the impact of iteration.

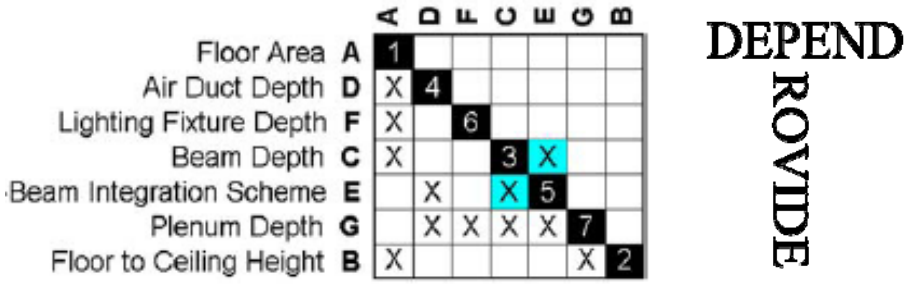

Figure 15 - Suspended Ceiling Design – Partitioned DSM (Pektas & Pultar, 2006)

Steward applied graph theory mathematics to the matrix structure of DSM that represents the DSM as a system of equations and thus amenable to quantitative analysis to identify inefficiencies and redundancies (Steward, 1981). A Task-based DSM was refined to analyze design tasks and activities (Eppinger, Whitney, Smith, & Gebala, 1994). DSM was adapted to analyze the relationships between physical components in a technical system using component-based DSM (Pimmler, 1994). DSM was further extended by Eppinger (1998) to analyze relationships in teams and organizations using team-based DSM. Browning (2001) proposed many sophisticated algorithmic methods to further analyze, cluster and optimize DSM matrices. The internet website **www.dsmweb.org** is an excellent repository of DSM related information and contains a database of almost 500 articles and monographs.

As seen in the examples above, DSM addresses many of the problems faced when modeling product development processes. The matrix is a tool that allows one to see not just the tasks themselves, but more importantly, the relationships between them. This allows participants in the process to easily see the tasks they depend on to complete their work, as well as the tasks to which they provide information. DSM also helps identify, plan for and manage iteration, which is prevalent in development processes. Partitioning the tasks can re-sequence

the process and minimize iterations. Additionally, the DSM can show which dependent tasks are affected in the event of a change to a preceding task.

Organizations have discovered learning value by undertaking the exercise of constructing a DSM for their product development process. By asking managers to detail their conceptualization of their tasks, the informational requirements of these tasks, and then representing this information visually in the DSM, linkages are made explicit and managers gain insight into the roles and functioning of the entire process. The construction of a DSM is an important learning experience that creates value for an organization and builds institutional knowledge.

Most importantly, a DSM can graphically convey an extremely complex process on a single page. This proves to be a valuable and easy to use management tool. In complex projects, typical PERT and CPM network diagrams can run hundreds of pages long, making it nearly impossible to understand all the relationships taking place. Where DSM has been found to be useful in practice, it is often due to the *visual* quality of the matrix. Decision-makers and managers can visually see the nature of relationships between all tasks at a quick glance.

Recently, work by Oloufa, Hosni, Fayez, & Axelsson (2004) and Pektas & Pultar (2006), and others have applied the DSM to other fields, including building design and construction. To date, however, there has been no attempt to model the real estate development process as an integrated process from idea Inception through final disposition of a completed real estate product. From the work by Graaskamp, we know that real estate is an iterative process as an idea is refined. Throughout this refinement, tasks share information, with many of them being completed simultaneously. This is a key problem the DSM aims to address. Based on the success DSM has achieved in modeling other iterative product development processes, the DSM tool should have useful applications to the real estate development process.

Chapter 4: The Real Estate Development Process DSM

Chapter Summary: This chapter develops a real estate development process DSM which synthesizes 91 tasks (each allocated to a Graaskampian function) into a "6 stages of development" framework. A hypothetical real estate development deal is described using the "6 Stages". The 91x91 DSM is rigorously evaluated for information flows between tasks based on field research. 1,148 information flows are identified between the 91 tasks. This generates the Baseline DSM which is analyzed and discussed as a new model of the real estate development process which addresses the shortcomings of other models introduced in Chapter 1.

Methodology

To construct a DSM for the real estate development process, we conducted interviews with global real estate services firm, Jones Lang LaSalle (JLL). Through a series of group meetings with senior managers in JLL's Product Development Services team, we created a list of the stages and tasks that occur in a typical development project. This was then followed with individual meetings to discuss the tasks and information flows that occur between the tasks. These information flows are then represented by the off-diagonal X's in the DSM. It should be noted that the modeling process to date does not represent a specific project, but rather a stylized or planned development process. Therefore, this DSM can be taken to represent a normative real estate development process; the way development is planned to occur, not necessarily the way it always does occur in the real world. The following chapter will then add to this to model how unplanned events and information flows affect the process.

Stages of Development

The first series of interviews was conducted to determine the major stages or phases in the real estate development process. After meetings with five senior managers, the group came to a consensus that tasks in the real estate development process can be organized into six stages:

1. Idea Inception
2. Feasibility
3. Preconstruction
4. Construction
5. Stabilization
6. Asset Management and/or Sale

Most real estate development ideas generated in stage one never survive to stage six. At the end of each stage a decision must be made above the future viability of the potential project. Scarce resources are allocated at each stage and the process gets more expensive as time moves forward. A developer's ability to affect change is greatest at the beginning of a project and the cost initiating a change is minimal. As a project moves forward, a developer's ability to affect change decreases and the cost of implementing any significant change can be exorbitant. This concept was introduced in Figure 1 of Chapter 1.

At the end of each Stage, information is collected, synthesized and reviewed to determine whether the developer should:

- *Move forward* and expend further resources on the project
- *Stop* and give up (losing the investment made to date)
- *Go back* to an earlier phase and reexamine assumptions and decisions in a effort to create a more viable project

These *Decision Gates* are crucial steps in the development process and can assume a variety of forms. In many development firms an internal Investment Committee will serve this function. Sometimes an independent Board of Directors is required to approve certain stages of a project or expenditure of resources. At the simplest level, the project's General Partner may make the decision completely independently. In many development projects and organizations, the process for reaching the *Decision Gate* drives the order and relative importance of tasks within a Stage. In our framework, we denote this as an explicit *Review and Approve* task that feeds-forward into the subsequent **Stage** (if approved).

At the beginning of each **Stage's** discussion which follows, we will describe a hypothetical, but typical "best-case-scenario" real estate development moving through these six stages to illustrate key points about each stage in practice. This is done to set a context for the reader to experience each of these stages. A complete glossary the real estate development tasks used in this DSM exercise can be found in **Appendix A**, "Stages and Tasks". The tasks are briefly described and categorized by their **Stage** and Graaskampian functional discipline.

Idea Inception

> *January 1, 2000 – Nicholas is a real estate developer and investor with an extensive track record of developing medical office buildings in suburban infill locations. He recently noticed that a local garden center went out of business on a five acre parcel on a well-travelled street. He knows his other medical office buildings are doing well. He believes the market can take another medical building at competitive rents and is pretty sure he can attract investors for equity and appropriate debt financing. He believes the master plan for the City would allow for up to 150,000 sq ft of medical office at this location with a zoning change. Nicholas runs some preliminary financial analysis on costs and rents and believes he can build a positive NPV building and earn a decent yield on his capital deployment. Nicholas calls the owner of the parcel to determine if he is interested in selling the property. After much negotiation, the owner agrees to sell the parcel for $5 million with settlement subject to final site plan approval expected three years from contract ratification. Nicholas signs the land purchase contract and sends the seller a $300,000 check as a refundable deposit to enter a 60 day feasibility study period. The deposit becomes non-refundable at the end of 60 days unless Nicholas informs the seller he is exercising his right to cancel the contract. Time to get to work on his new project, Hemingway Hills…*

As illustrated above, a project first starts with an idea. In this stage of the development project, the developer looks to provide a product that meets a certain demand that he observes in the marketplace. This process is initiated based on one of two different scenarios, *a site looking for a use* or a *use looking for a site* (Jarchow, Stephen P., ed., 1991). With a site looking for a use, the developer has a piece of land identified and is trying to maximize value creation on the site by evaluating the *highest and best use* of the site in terms of current and forecasted market conditions. With a use looking for a site, a space user has a demand for a real estate product and needs to identify an appropriate land parcel to satisfy their needs. While much of the development process is the same for either scenario, certain market analysis and leasing tasks are required for speculative development typified by a site looking use scenario. We have chosen to model the development process assuming that we are speculatively developing a site looking for a use.

During the Idea Inception stage, the developer is evaluating what to develop for one, or one of many potential sites. This initial, high level approach is typically done in house by the developer. If outside information is needed, consultants are generally willing to spec time in hopes of getting the work if the project moves forward. The developer is attempting to get an idea of the major factors that will affect the development and the general parameters that constrain his activities. These include the market conditions, design possibilities, zoning and

political restrictions and financial possibilities; the same noted in the four quadrants of the Graaskamp spiral. These four major issues are evaluated and balanced to determine if the project is feasible. The potential outcomes, which may include multiple possibilities at this point, will also need to match the developer's organizational strategy and capabilities, including timing, location, product, size and complexity.

The tasks in this stage will iterate several times as different ideas are proposed and evaluated for a particular parcel of land. The stage ends when an idea (or ideas) for the development of the land is viable enough to invest in an extensive series of feasibility studies. In practice this often means attempting to negotiate with the current owner of the land some form of site control agreement. If satisfactory terms can be reached on a land deal, the developer typically must put down a refundable deposit totaling 5-10% of the final purchase price of the property upon ratification of the land contract. This deposit, while refundable at this point, demonstrates a level of commitment to the seller and gives the buyer time to initiate resource intensive feasibility studies without concern that another buyer will purchase the property.

Feasibility

> *April 1, 2000 – Nicholas talks to the brokers that handle his leasing and talk to his doctor friends about his idea for a new medical office building. They appear optimistic but believe that only 100,000 sq ft is necessary in the market right now. The planning/zoning/permitting process in this town is notoriously difficult to navigate and Nicholas knows it will take a lot of citizen input and political work to get this project put together. He hires a team of architects and planners to prepare some preliminary sketches and evaluate some scenarios for building location and massing. Other consultants are engaged to review utility availability and evaluate the site's environmental characteristics. He calls a general contractor he has worked with on a previous project to get advice on approximate construction costs for this type of project. Nicholas calls several banks he works with to discuss the project and get input on availability of financing. He also calls his financial partners to gauge their interest in investing in this type of project. Sixty days goes by very quickly. Nicholas must decide whether to move forward and put his deposit at risk to fully control the site. He determines that all of the information he has received so far is positive and decides to move forward. The real work starts now.*

In this stage, the developer is will now working towards determining the highest and best use for the site within the constraints he identified in the Idea Inception stage. This is done by conducting a full feasibility analysis. Similar to the previous stage, the developer is evaluating and balancing the issues from Graaskamp's four quadrants. These tasks, however, are being

completed at a more detailed analysis than the previous stage, as the ideas become further developed.

To determine the highest and best use, the developer engages feasibility consultants to further develop the issues identified in the previous stage. They will work to develop preliminary market studies, massing studies, conceptual designs and an outline of the legal process involved in permitting the project.

In this stage, the developer is gathering the information necessary to settle on a single plan for development. While all the issues have not been resolved, they are being identified, and a plan for development is underway. The feasibility stage will come to an end once a single, highest and best use product has been determined. Additionally, the plan must meet all financial and organizational objectives. Once the feasibility review has been completed the developer must decide whether to move forward with the costly preconstruction stage. Additionally, his deposit typically becomes non-refundable at the end of the feasibility period. Although the developer may not own the property at this point, he gains full control of the site.

Preconstruction

November 1, 2000 – Nicholas has the land under a firm contract and now must begin the process of making his idea real on paper. He engages a full design team to complete the planning, engineering and architecture work to bring the project to fruition. He works with attorneys and consultants to navigate the treacherous entitlement and permitting process. Nicholas talks to his doctor friends about taking space in the new building. He engages marketing consultants and brokers to find prospective tenants. Nicholas must come to final agreements with his equity partners and negotiate construction loan financing agreements. Nicholas must interview and engage General Contractors who will execute the construction documents ultimately generated by the design team. The budget and schedule are constantly updated to reflect new information coming from his team. Nicholas continually updates his project proforma to evaluate the finished project's financial performance against his required return and partners' expectations. After two years of work, Nicholas finally has entitlements and final design documents but leasing the space has been rather disappointing. He cannot seem to get a commitment from a large doctor's group to anchor the building. He has several expressions of interest from small specialists but they won't commit until they know what kind of medical practice will dominate the building. Nicholas realizes his rent expectations are too high. Something needs to give. He decides to reexamine the design and eliminate several expensive building options. This enables him to lower the asking rent but does it damage the credibility of the building? Out of the blue he gets a call from the office manager of a large doctor's cooperative looking for 65,000 square feet. A deal is put together and construction is scheduled to commence.

With an initial plan established in the feasibility stage, the preconstruction phase resolves the design and development of the project so that construction can commence. The developer is again simultaneously working in the four Graaskampian quadrants to refine the idea to a point where is can be physically delivered to the market.

On the design side, various consultants are working together towards multiple design milestones. Common names for these milestones include, but are not limited to: schematic design, design development and construction documents. These designs generate information that will allow for the public approval process to be completed as well as various levels of construction estimates of quantities and costs. As the information is evaluated by various groups, feedback will result in changes and refinement. If certain aspects of the design result in budget overruns, the developer will need to revise the budget or request the design team make changes to the design.

The public approval process is also completed during preconstruction. The length and complexity of this process will vary depending on the governing authorities as well as the size and complexity of the specific project. The developer's pre-existing "human capital" and ability to work with relevant governing political/regulatory authorities and citizen stakeholders is a significant source of value creation for the real estate development and developer.

The developer will also conduct formal market studies and marketability plans to verify the design, product and schedule have a high likelihood of market success and minimize downside risk. Ideally, but not always, the developer will have lease commitments for a significant portion of the building prior to construction. The information from the updated marketing plan will then be used to update the project financials throughout the preconstruction phase.

The developer will also need to identify and secure all sources of capital. Most likely, the early soft costs will be paid for with the developer's own equity. The remaining development budget will likely be financed with a construction loan and other sources of external equity capital. This equity capital can come from many sources (private equity funds, high-net-worth families, or REITs) and can sit at several senior positions in the project capital structure (mezzanine debt, preferred equity, etc.) The developer will work with multiple debt sources to

negotiate a construction loan. The construction loan is not usually committed until the developer has fully drawn down his equity and needs reimbursement for work already completed.

Many of the activities described above are occurring simultaneously. There is a constant balance taking place between all the issues to develop a single, cohesive plan. This is done through constant information sharing. At the end of this stage, the developer will be faced with the biggest decision in the development process: Proceed with construction? Wait with the existing plan? Go back and revise the development plan? Or (in an extreme case) cancel the project altogether?

Construction

June 1, 2003 – 3 ½ years after identifying a property, Nicholas is finally ready to begin construction. The design is finalized and approved. The contractor is ready to begin work. While inevitable construction or design problems will arise that require his attention, most of the hard development work is finished. The contractor breaks ground and constructs the building infrastructure and core and shell. Nicholas must keep a close eye on the development budget and schedule to ensure that cost and schedule overruns are minimized. As part of his financing agreements, Nicholas will also be required to constantly update his equity partners and the bank on the status of construction. His anchor tenant is secure but he needs to fill in the rest of the space as quickly as possible to start generating positive cash flows to pay off his investors. After the building core and shell is complete, work starts on the interior fit-out for the doctor's co-op and other tenants. After 16 months of construction, the building is substantially complete and obtains its temporary certificate of occupancy.

To begin construction, the developer must get his construction loan funded and finally acquire title to the property. During the construction phase, the contractor and subcontractors are responsible for constructing the building based on the design and specifications which were finalized in preconstruction. Throughout the construction process, which can take months or years to complete, the market and financial assumptions are continuously being evaluated and updated. The developer is also looking to find tenants or purchasers as well.

Stabilization

October 1, 2004 – Nicholas takes a deep breath. The riskiest part of the real estate development process is behind him. Construction has finished on the building interiors except for some fairly small issues still getting cleaned up. Tenants are occupying the building and starting to

pay rent. Twenty percent of the building is still vacant so leasing efforts continue, but the building is starting to look like it will meet its financial performance expectations.

Once construction has been substantially completed, the building will obtain some sort of certificate of occupancy, allowing the building to start being used for its intended purposes. Tenants will start moving in during this stage as well. This signifies the first opportunity for the developer to start collecting rents[6]. As a result, the financial underwriting will be updated to reflect what is actually occurring. Stabilization continues until construction and punchlist activities are complete and the building achieves a consistent level of occupancy and cash flow.

Asset Management and/or Sale

October 1, 2004 – The building is fully leased and is performing slightly better than expectations. Nicholas must decide whether he wants to refinance the building with a permanent amortizing loan (and pull out some of his equity) or sell the building in its entirety to an investor interested in buying the stable cash flows the building now consistently generates. Nicholas decides to sell. He had so much fun with this project, he decides to cash out entirely and start another project, hopefully utilizing the information he learned on this development.

At some point after the project has become financially stabilized, the developer will seek to take out the construction loan and replace it with a permanent loan. The developer will also be faced with a decision on what to do with the property. If, in the case of a condominium situation, once a majority of the condos are sold, the developer will turn the property over to some sort of association. In a rental situation, the developer has two options; manage the asset and collect the cash flows, or sell the property and (hopefully) create a liquidity event for the ownership structure. There are many factors that go into this decision. They include the value of the property in the market, the developer's particular financial objectives and the organization's long term business plan and strategy.

[6] In the case of for-sale product, purchasers will take ownership and the asset will begin to be sold.

Tasks and Interactions

As is obvious from our discussion of the Stages in the real estate development process, many individual tasks occur within each Stage. Our interview process with Jones Lang LaSalle focused on gaining consensus on which tasks occurred within each stage. As previously discussed, we found that within each stage, many of the tasks were being repeated from the previous stage, just with more refinement. This concept is consistent with Graaskamp's "refinement of the idea" and represented by the spiral iterating through and across the four major disciplines, illustrated in Figure 4. Indeed we observed that the tasks typically fell into one of Graaskamp's four functional groups: *Market and Competitive*; *Physical and Design, Political and Legal and Financial*. There were a few tasks, however, that spanned a few of these classifications and were primarily firm level tasks that we categorize as *Project Management* tasks and add as a fifth functional sector to Graaskamp's spiral. Our Five Sector Functional Model can be seen below in Figure 16 and it located in the upper left of every DSM for reference.

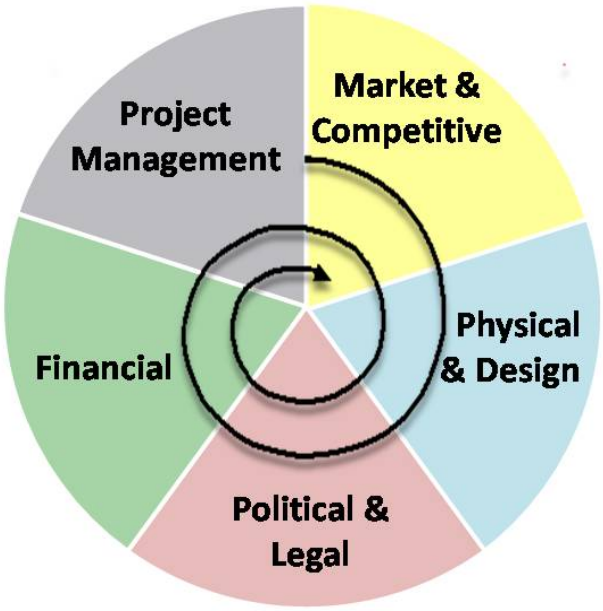

Figure 16 - Five Functional Sector Model

The 91 tasks categorized by stage and discipline can be viewed in **Appendix B**. In Figure 16, Appendix B and the subsequent DSMs we used colors to denote to which functional

group a task belongs (*Market and Competitive* (yellow); *Physical and Design Analysis* (blue)*, Political and Legal (*red) *Financial* (green) and *Project Management* (grey)).

Our interviews utilizing the tasks outlined in Appendix B had the interesting result of uncovering how people conceptualize and categorize their job responsibilities. Some development managers specialize in one Graaskampian functional group (vertically) almost exclusively across all stages in the development process. For example, one interviewee had responsibility for financial analysis through all stages of the real estate development process. Other development managers specialize in a particular stage of the development process (horizontally) but manage all functional groups. For example, one interviewee specialized in the Feasibility stage analysis of all the firm's potential development opportunities. Other development managers viewed themselves as generalists who were competent across both functional groups and stages. As noted earlier, a complete glossary of real estate development tasks used in this DSM exercise can be found in **Appendix A**, "Stages and Tasks".

Interactions between tasks

The tasks were then placed in a rough chronological order in the DSM matrix by stage. We determined the chronological order based on our field interviews and the authors' knowledge and experience of a typical real estate development event sequence. It is important to note that within a Stage, many tasks are occurring concurrently at various levels of completeness. Information is moving to and from tasks in an iterative manner to drive a task to completion.

With the tasks and stages inputted into the DSM, we then marked the informational interactions with an "X" per the discussions in Chapter 3. We decided where to place "marks" based on our interview process with JLL and the authors' knowledge and experience with the development process. When determining how tasks were related, interviewees found it significantly easier to think about where there got their information from than where the information they developed subsequently went.

It should also be noted that further refinement of this model is still possible. With more time and research, actual projects should be studied to observe actual informational flows. More participants in the process (consultants, contractors, attorneys, bankers, etc.) should be

interviewed as well. The shortcomings and future opportunities of this model are further outlined in Chapter 7.

This DSM is not a representation of every real estate development. It is intended to be normative for a "best case scenario" commercial real estate development deal, illustrating only the planned interactions and iterations that occur. Since unexpected events will most undoubtedly occur, it should not be construed as a universal model. This DSM can, however, be used as a template for many common types of real estate development. Additionally, as described in the next chapter, the DSM can be a powerful project management tool for the developer.

Reading the Baseline DSM

The Baseline real estate development DSM in Appendix C-1 visually conveys a vast amount of information about the tasks and informational interactions in the process. For example, the *Estimate Rent* task from **Idea Inception Stage** (task #106) depends on information[7] from the preceding task, *Local Supply & Demand Analysis* but also depends on information from tasks that haven't occurred yet: *Estimate Costs, Back of the Envelope Proforma, Evaluate Programmatic Options,* and *Financial Underwriting*. As these subsequent tasks are started, information will feedback into *Estimate Rents* and update the initial rent assumptions.

The Estimate Rent task (#106) also provides information[8] to tasks within the **Idea Inception Stage** (*Estimate Costs, Back of the Envelope Proforma, Estimate Project Scope, Evaluate Programmatic Options, and Financial Underwriting*), as well as a number of tasks in subsequent Stages. This is expected because information developed in an earlier stage should feed-forward into subsequent stages and tasks.

The DSM also shows that some tasks, *Financial Underwriting* for example, depend on information from almost every other task in their Stage. It is clear from viewing the DSM that *Financial Underwriting* is an extremely iterative activity that is constantly updated as new information emerges. This insight is true in reality and the DSM is an excellent method of graphically depicting this information relationship.

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[7] Read across the 106 row to see the tasks that provide information to *Estimate Rents*.
[8] Read down the 106 column to see the tasks that depend on information from *Estimate Rents*.

The Baseline Real Estate Development DSM – A New RED Process Model

In this "stylized" or "planned" real estate development, we modeled 1,148 informational exchanges between the 91 tasks in the Baseline DSM as shown in Appendix C-1. This Baseline DSM reveals many interesting traits of the real estate development process. The development process outlined by our Baseline DSM model is characterized by containing many coupled tasks that cause iteration. These feedback loops are easily identified in the DSM because the mark lies above the diagonal line. This feedback mark denotes that information from subsequent tasks may force rework of a prior task. As previously discussed, this feedback is where learning occurs as issues are balanced and resolved. This iterative characteristic is familiar not just to real estate, but to all sophisticated product development processes.

Additionally, while this Baseline DSM clearly demonstrates significant iteration within a stage, the task feedback loops in this DSM do not extend past the task's present stage (indicated by the gray boxes of the DSM). This means that a task does not require information from a stage that has not yet been initiated in our Baseline scenario. This matches the author's intuition because we are modeling a normative real estate development with *planned* iteration. As we will see in the next chapter, *unplanned* iteration will frequently result in extra-stage feedback loops.

The DSM also confirms that the development process is highly multidisciplinary. By using colors to indicate disciplines, the DSM shows that information is being shared between all of the five functional groups. As a result, when these different groups interact, parties with different expertise and goals are required to work together. A developer must understand the interdisciplinary nature of development to effectively balance and coordinated these complicated informational interactions. This characteristic of real estate development contributes to its conception as a highly intricate process.

It is also interesting to note that the early stages up to and including **Preconstruction** are typified by an extraordinary number of planned feedback loops (marks above the diagonal). Tasks that occur in the **Idea Inception, Feasibility, and Preconstruction Stages** of the project demonstrate a much greater degree of informational connectivity than the generally sequential **Construction, Stabilization and Asset Management Stages**. While the majority of the financial capital is deployed and converted to physical capital in the later stages, the earlier stages actually appear to require much greater management in order to achieve desired results.

The earlier stages also have a much higher probability of unplanned iteration due to the interconnectedness of tasks and the required rework if incorrect assumptions are fed-forward in the process. In contrast, the **Construction, Stabilization, and Asset Management/Sale Stages** have practically no planned iteration. These tasks can be substantially accomplished by proceeding in a linear, sequential manner. This substantially matches the author's expectations and intuition.

This Baseline DSM is a significant addition to our understanding of real estate development because it makes the relationships between the input and outputs of individual tasks explicit and visually organized. The DSM also clearly outlines many of the overall characteristic of the real estate development process. Its usefulness, however, does not stop here. This model, as outlined in the subsequent chapters, is highly adaptive and can be used to display different types of information flows and measure the impact of changes to the process. The following chapter leverages the Baseline DSM to model change in this "best-case" or normative DSM scenario and further analyzes the relationships between different types of tasks.

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Chapter 5: Applications of the Real Estate Development DSM

Chapter Summary: This chapter takes the Baseline DSM introduced in the previous chapter and manipulates it several ways to prove its usefulness as a tool and to gain additional insight into the real estate development process. First, we modify the Baseline DSM to highlight the interaction between tasks of different functionality. Secondly, we modify the Baseline DSM to highlight how tasks are being completed between the developer and consultants. Thirdly, we model four scenarios where unplanned iteration occurs in the process and show the effect on the overall development process. Last, we model three scenarios where tasks are initiated out of the baseline sequence and highlight the risks and opportunities of unplanned iterations.

The Baseline DSM developed in the previous chapter models the planned information flows and task sequence of a stylized real estate development process in a visually intuitive, information-rich format. The Baseline DSM model, however powerful on its own, can be further manipulated to gain additional insights into the real estate development process. It should be no surprise that the real estate development process is unique for every project. For the DSM to be useful in practice, it must be capable of modeling real-world issues that occur in the development process and provide insights that identify potential risks and opportunities. This chapter will describe several manipulations of the Baseline DSM that allow for a deeper understanding of the real estate development process. We will also model typical real-world development scenarios and their impact on the development process, demonstrating how the DSM can be used as an effective management tool. .

The stylized real estate development DSM we have describe in the Baseline DSM is one example of a typical development process which highlights the planned iterations in a "stylized" scenario. This thesis is not arguing the Baseline DSM represents the "ideal" process for real estate development. There are two reasons why this cannot be done. First, the Baseline DSM assumes that tasks and information flows are static and not subject to change. We know this is not the case. The rents can change, soils could be found to be contaminated, design flaws can be discovered, etc. This requires the process to continuously change and adapt to new and unplanned iteration cycles. Secondly, the Baseline DSM does not attempt to represent the costs (time and resources) and benefits (improved task result or greater certainty of result) of repeating tasks iteratively. Speeding up the development process to bring the product to market

quickly may outweigh the risk of cutting out iteration cycles. Or the reverse could be true. Additionally, the Baseline DSM does not attempt to model the optimal number of iterations that occur before a stage is complete. We simply represent that iteration should occur between coupled tasks without optimizing the number of cycles that occur in reality on a specific project. The optimal number of iterations will vary from project to project as the developer weighs the balance between innovation and certainty generated by iteration and the costs associated with a longer, more detailed process.

Because each real estate product possesses its own budget, schedule and risks, the specific process to create a development project will always be unique. The Baseline DSM can serve as a starting point and a guide for the developer to navigate an extremely complex process. With a Baseline DSM established, a developer can use the matrix in many different ways to model his unique process or the unexpected changes that occur. Above and beyond the project level benefits, the DSM has potential to help a real estate development firm examine its entity-level organization processes. A firm, for example, can use a DSM to understand how they manage their projects to understand the firm's strengths and weakness. In the rest of this chapter we will outline some examples of how the DSM can be utilized to address both project and firm level issues. In doing so, we will demonstrate the DSM's effectiveness in the real estate development context for modeling the following:

- Different types of information flow interactions and how a firm can understand how they develop at the entity level
- Unexpected changes to the planned development process, resulting in unplanned iterations
- Positive and negative effects of task re-sequencing

Modeling Different Types of Information Flows

In the DSM, information flows between two tasks are indicated by X's. In the Baseline DSM, however, the type of relationship, or a description of each type of X, is not indicated. Instead, all information flows are treated as the same.

By simply coding[9] tasks into different categories, one can quickly gain additional insight about the relationships between tasks, which can help characterize the development process, as well as act as a useful from a management perspective . To illustrate this, we've chosen two separate analyses. First, we've modeled whether or not information is being shared between tasks within the same functional group (or "discipline" meaning: Market, Financial, Physical, Political or Project Management), or alternatively whether the information exchange is between tasks in a different functional groups resulting in a cross-discipline information flow. The former would typically involve individuals with relatively similar professional backgrounds and formation, while the latter requires individuals of different professional focus to interact "across cultural lines". Secondly, we analyzed information generation and transmission between the developer and external parties. This implies three potential communication/information flow scenarios: a) developer task to developer task b) developer task to 3rd party task c) 3rd party task directly to different 3rd party task. Obviously these three types of interaction involve greater and lesser control by the developer, and hence imply different project management strategies.

Functional Interaction DSM

We have previously discussed James Graaskamp's four quadrant model of the real estate development process. We argue that there is a fifth group of tasks that affect the developer's project management decisions, but does not fit into these four quadrants. We identify these as *Project Management Tasks*.

In this *Functional Interaction DSM*, (Appendix C-2) we've grouped the interactions between tasks into two groups. The green boxes represent tasks that interact with tasks from the same functional group (i.e. two *Market* tasks or two *Political* tasks). The yellow boxes represent tasks that interact across functional disciplines (i.e. *Market* task feeds-forward information to a *Financial* task).

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[9] Coding and formatting was done in Microsoft Excel 2007. Tasks were coded according to the desired characteristic. Conditional Formatting routines were applied to illustrate and visualize the desired relationships or changes to the process. The Excel file is an attachment to the PDF version of this thesis available from MIT's DSpace (http://dspace.mit.edu/). Alternatively email the authors at benbulloch@gmail.com or mrjohnsullivan@gmail.com for a copy of the Excel.

As noted, green task interactions are likely to occur between groups that "speak the same language" or have disciplinary affinities. These tasks may be completed by the same consultant or internal development team so the information flow is likely to be smooth with less likelihood of miscommunication or misinterpretation.

Yellow task interactions represent multi-disciplinary interactions. Information from one discipline is an input to a task of a different discipline. This interaction is likely between teams that have less in common or are less familiar with each other's professional work. For example, a zoning attorney may have difficulty communicating an arcane (and often arbitrary) Zoning Board decision to the architecture team who must then translate this information into design drawings. This type of information flow may be an indication that heightened management by the developer is required to successfully synthesize information across the functional boundary. These may be "riskier" or more costly interactions with a higher likelihood of many iterative cycles (the architecture team may draft 10 versions of design element until it finally matches the Zoning Board's demand).

The *Functional Interaction DSM* provides a tool for the developer to visualize this type of risk. For example, at a glance the DSM reveals the relative frequency of intra- (green) versus inter- (yellow) disciplinary interactions, as well as the pattern these interactions have in the overall process (e.g., some tendency for intra-disciplinary interactions to cluster near the diagonal, which means roughly in temporally adjacent tasks). Quantitatively, by counting the yellow and green X's, the DSM shows that 350 (30.5%) of the interactions are green and 798 (69.5%) are yellow. This DSM adds to the understanding of the development process by showing in a quantitative fashion that the real estate development process is quite multidisciplinary, as more than two thirds of the interactions are occurring between different disciplines.

Internal vs. External DSM

In the real estate development process, a very large amount of information is generated by consultants, contractors and other external parties or advisors to the developer (e.g., the zoning approval board is an entity in the RED process). The amount of work that is outsourced, compared to the amount done "in-house" varies from project to project and from

developer to developer. It is rare, for example, for a developer to perform legal work, construction work, or design work himself. Conversely, it is quite common for large development projects to be managed by one or two individuals (usually the owners or equity partners) who coordinate the work of dozens of outside consultants and contractors. Outsourcing tasks allows the developer to remain flexible and save on overhead expenses. Completing work in-house, however, helps the developer align interests and maintain better control over progress and work quality. Some balance must be maintained based on an organization's internal strategy and competencies.

While all parties to a development project (at least if the bills are paid on time) hope to achieve a successful project, each one's definition of success may be different. The developer may define success as a building built under-budget and ahead of schedule that exceeds financial projections, while the architect may define success as a project that wins design awards. While the developer hopes all his consultants are acting in a fiduciary manner, he is responsible in monitoring the process and progress to confirm that is the case. One way to do this is to determine which information flows are being completed in-house, and those which have been outsourced. The *Internal vs. External DSM* (Appendix C-3) graphically illustrates whether the interactions between tasks are occurring internally (within the development organization) or externally to the development firm (with consultants). To do so, each task first needed to be categorized based on whether the task was primarily accomplished in-house or outsourced to consultants or contractors.[10]. This results in three potential information flows:

> <u>Both tasks are accomplished internally</u> - These interactions are presumably the easiest for a development firm to manage because they are done in-house. Information only needs to flow efficiently within the organization. An example of this would be a developer asking his sales team estimated rents for his financial underwriting. These interactions are highlighted in green.

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[10] As discussed, the tasks that are outsourced vs. those that are done in-house will vary from developer to developer and from project to project. We developed one hypothetical (yet typical) division of tasks as denoted in the horizontal and vertical axes of the *Internal vs. External DSM* (Appendix C-3). A **0** on the axis codes for an *Internal Task* while a **1** codes for an *External Task*.

One task internal and one task outsourced - These tasks carry an increased amount of risk because of the complexity of transmitting and transferring information to teams outside the development firm. An example of this would be the contractor providing construction estimates for the developer's development budget. These are highlighted in yellow.

Both tasks are outsourced - These tasks are the most difficult for a development firm to manage because both tasks are the responsibility of 3rd parties. While the developer is responsible for directing and supervising (and paying for) these tasks, he has little direct role in either task's completion. Information is flowing directly between 3rd party consultants or contractors. Unless the developer is fastidious in reviewing and assessing the quality of work and suitability to the project objectives, expensive and time-consuming mistakes may be made. One example of this would be a design package being completed by the architect for the contractor to estimate its cost. Unless the developer carefully reviews the design package for compliance with his intentions, the contractor may provide a grossly inaccurate estimate. These interactions are highlighted in red.

This is just one hypothetical scenario based on a hypothetical development firm's internal competencies and capabilities. Every firm is going to have some tasks they do "in-house" and some which are "outsourced." Different scenarios can be quickly run by changing the coding of tasks.

Modeling Change in the RED Process

As anyone familiar with the real estate development process knows, effectively managing change is one of the most important roles of the developer. Because the process to develop real estate takes years to complete, the chances are high that information developed early in the process will change many times before the process is complete. Significant changes will require the developer to reassess tasks later in the process, even though they were originally thought to be complete. By creating reviews of previous tasks in the development process, the developer can quickly see how the process is affected. To illustrate this type of analysis, we have four scenarios where unexpected events occur that provide new information to the process, resulting

in unplanned iteration. The examples start with the baseline DSM and represent a task from each of Graaskamp's four quadrants. As a result of the changes, new stages are created and there is a cascading impact on other tasks that require the new information as well. We will illustrate these change scenarios by revisiting the hypothetical *Hemingway Hills* development developed in Chapter 4.

Market Change DSM

> ***Financial Crisis 2008 Scenario*** *– Nicholas has slowly but surely moved his Hemingway Hills development through the entitlement and design processes to the end of the Pre-Construction Stage. Nicholas has been negotiating with a large doctors' cooperative as an anchor tenant for his medical office building and believes that everything is on track to start construction eminently. A financial crisis ensues (a la late-2008) which may significantly change the information generated in the previous tasks titled Capital Markets, Macroeconomic conditions and Local Supply and Demand tasks at the beginning of the Idea Inception Stage. Nicholas is worried that his previous assumptions on the economy and availability of construction financing are no longer true. The doctors' co-op has starting acting skittish and isn't returning his phone calls. Although painful, Nicholas puts the project on hold, and conducts a review of what has been completed to date.*

With this drastic change in the economy, the developer creates a new task to review the potential impact to the project. On the *Market Change DSM* (Appendix C-4) this is highlighted in red and called "FINANCIAL CRISIS REVIEW." To understand the impacts to the project, the developer needs to determine which activities this financial crisis event and subsequently the new "review" will affect. This is done by going down the column for this new task and adding X's to every task that will be receiving new information. For this scenario, 36 tasks will receive new information in an unplanned iteration. As a result, this review creates a new stage in the development process, highlighted in yellow. The information that flows within the yellow box should be repeated to revaluate the project. The level of analysis that is repeated will depend on the developer's preferences and findings. If economic conditions are poor enough, the project will stay in a new Idea Inception stage or be put on hold all together. It is obvious that an event of this magnitude can seriously impact the entire process and look very different from the baseline example.

Physical / Design Change DSM

> ***Negligent Geotechnical Consultant / Inadequate Design Review –*** *Nicholas fully completed all Preconstruction Stage tasks and broke ground on building construction*

one month ago. The last few months before he broke ground were pretty hectic. So many design documents and consultant reports were flying through the door that Nicholas sometimes barely glanced at documents that cost him $20,000+ to generate. Nicholas knew he should be more diligent about checking up on his consultants to ensure they were accurate and met his expectations but he was just too busy.

The excavation contractors started reporting anomalies when they first arrived on site. The ground was much easier to work with than the geotechnical reports indicated. The core samples indicted a layer of unstable (non-load-bearing) expansive clay eight feet below the surface that needed to be removed (expensive and time-consuming) and necessitated an expensive foundation system. The excavation team wasn't hitting that at all. They were reporting beautiful loam over bedrock. What was going on? Nicholas called his geotechnical consultant who sheepishly admitted the lab team had inadvertently swapped the samples for his project with a completely different project across town. The actual soil report indicated that cheap and fast slab-on-grade foundation system would actually be perfectly adequate for a savings of $2 million. Nicholas wasn't sure if he should be furious or ecstatic. It would take 4 months to revise the design for the cheaper foundation but it would save him a ton of money and might actually be faster in the long run. Nicholas initiates an emergency design review and shuts down construction.

With a significant design issue, the developer has created a new task titled "EVALUATE DESIGN CHANGE", as shown in the *Physical / Design Change DSM*, (Appendix C-5) to measure the impact of this change. The severity of the issue may result in significant changes to the overall product. The developer will first determine the tasks that may be affected by the change, adding X's to the new, red column. During the design process, the current foundation was designed during the schematic design stage (task #311). As a result, this task will need to be revisited. Additionally eight other subsequent tasks will be directly impacted as well. This results in a new iteration stage in the development process, highlighted by the yellow box. Repeating this stage and revisiting the tasks within will allow the developer to understand the complete impact of the change. With construction already underway, this change could be very expensive (or reduce the cost as in this example) depending on the new information and what the new unplanned stage discovers.

It is important to note in this example that the change was the result of internal mistakes the developer's team made, not an exogenous event outside the developer's control. The developer should have been more diligent checking documents and the consultant should not have made such a grievous mistake. Additionally, unexpected iterations can occasionally have positive effects on the project, as seen in this example. Increased project risk implies increased

volatility and unpredictability of the result probability distribution. This volatility and risk can have results that improve OR impair the project's performance parameters.

Legal / Political Change DSM

> ***Cranky Citizens Scenario –*** *Nicholas has spent two years battling his way through the City's convoluted entitlement review process for his Hemingway Hills medical office building project. The entire Preconstruction phase has been completed. Construction is to begin shortly. One day Nicholas unexpectedly receives a letter from the City stating that a Notice of Public Hearing was filed incorrectly by a clerk in the City's Development Department. Some citizen and interest groups were not properly informed about the development proposal and a new hearing must be called. Even though it isn't Nicholas' fault, he has significant uncertainty about all the tasks that relied on his belief that all necessary Public Participation tasks had been successfully negotiated.*

By repeating the public review process, certain tasks, which were originally thought to be completed, are now brought back to the fore. As in the previous scenarios, a new task has is created entitled, "REVIST PUBLIC PARTICIPATION". (Appendix C-6) By marking the tasks that will be directly impacted, we can see the new, unplanned iteration. As a result, a new stage occurs in the development process, shown in yellow. The new public review has the potential to impact all the information flows within this new stage. The developer will therefore want to revisit and potentially repeat the previous tasks to understand the full impact of this change. Because this task generates the same information as the previous public participation task (#308), the information flows in the two columns are identical. It should also be noted that this new stage is being completed within the original preconstruction stage. Because there is already a certain level of expected iteration in this stage, the impact may prove to be less severe than if it were to cross multiple stages (if *Construction* had started for example).

Financial Change DSM

> ***Flaky Partner Scenario –*** *Nicholas has been through a pretty rough time by this point but he finally thinks he is ready to close his construction loan and start moving dirt. The entire Preconstruction phase has been completed and the lender is ready to fund the loan. Nicholas calls his equity partner Sal who has promised to supply a large portion of the project's equity in return for a significant ownership position. Nicholas tells Sal that the escrow account needs to be funded to finalize the construction loan. To the Nicholas' chagrin, Sal sheepishly informs him that he just lost all his money betting on horses in Atlantic City. The project's future is called in serious jeopardy as the capital stack has collapsed. All decisions and tasks which relied on his equity partner performing his obligations are in question.*

With the equity partner gone, the developer must identify new equity options. This process will require a reevaluation of potential equity options, a task titled, "IDENTIFY NEW EQUITY OPTIONS". (Appendix C-7) This new task will inform the same tasks as the original one (#214). These thirteen information flows can be copied from the previous task. As a result, a new stage is created and the 35 previous tasks will need to be revisited. The impact of this new stage will depend on how different the new information is from the original. If there are numerous equity partners looking for similar investment options, the impact will be minimal. Alternatively, if new equity partners are looking for a completely different type of deal, this new stage could result in significant rework.

Overlapping Change DSM

> ***Disastrous Project Scenario -*** *Nicholas just cannot catch a break. Almost anything that can go wrong has gone wrong on this project. It appears a recession is right around the corner. He has had horrific design and entitlement problems. And his equity partner is not responding to a capital call. He feels like he is chasing his tail… Everything keeps getting repeated and nothing gets finalized. Maybe he should have listened to his mother and become a doctor…*

This DSM scenario details the effects of many phases of unplanned iteration. (Appendix C-8) Each exogenous event forces the developer to, at a minimum, re-examine conclusions from certain tasks and, worst case, completely re-do a number of tasks as illustrated on the DSM by the marks denoting feedback for the new 'crisis review' tasks. These crises cause iteration both inter and intra stage and can lead to tremendous cost and schedule overruns as well as lower quality product if not carefully managed. While this is a rather extreme scenario in the scope of problems encountered in a typical development deal, the number of unplanned crises is probably too low.

Re-sequencing Tasks in the RED Process

In the baseline DSM, we modeled a process that attempts to minimize the iteration (X's above the diagonal) in each stage and eliminate extra-stage iteration. Depending on the circumstances of a particular developer or deal, however, this may not be the most ideal process for the developer. By re-sequencing tasks, the developer may be able to speed up the entire process. In the examples below, we show how this re-sequencing will result in more iteration and added risk due to the increase in potential rework. This risk of possible rework must be

compared to the benefit to shortening the overall project schedule or other project benefits. Each information flow represents a different level of importance in the process. If a certain task is less important to the process as a whole, the developer may not mind if the task is above the diagonal, risking iteration. Additionally, the developer may be able to predict the outcome of certain interactions based on his experience or expertise. If there is a high probability of an expected outcome, the developer may be comfortable with potential iteration if it results in an expediting of the process or significant reduction in cost. These costs and benefits leave the developer with many decisions of how to best sequence the process for each individual project.

Construction before Design Complete DSM

> ***Beat the Competition Scenario –*** *Nicholas is under time pressure to deliver Hemingway Hills. A potential anchor tenant is interested in two buildings: Hemingway Hills and a competitor's building currently under development down the street. The tenant says he will award the lease to Nicholas but he must deliver the building 6 months ahead of his current schedule. It will be difficult and risky but Nicholas decides not having an anchor tenant is even more risky. He decides to engage his general contractor to start construction without a full set of construction drawings. His contractors will begin to work on infrastructure and site work off a Design/Development set of documents and the building construction drawings will be done as construction is underway. Nicholas risks a significant amount of rework by starting without final drawings. The developer is unlikely to obtain a construction loan when construction starts and will be paying out of pocket. Additionally, his contractor is unlikely to agree to a GMP without real drawings. He risks rework in multiple phases.*

To speed up the development process, the developer has chosen to start certain tasks earlier than in the baseline example. (Appendix C-9) This adds risk by creating potential for rework but could also result increased profitability if the schedule is compressed, or as in this case it provides competitive advantage. The developer has chosen to start construction after Design Development (task #312) in this example. To do so, there are some other related tasks that need to be reordered as well. We have assumed that equity agreements (#322) must be secured earlier and property must be acquired sooner (#403). The developer will also need to obtain a building permit (#405) and develop a procurement strategy (#324) as well. Construction can then commence (#406 and 407).

To model this change in the DSM, the rows and columns of each task are cut and pasted into their new order. Because the information flows between the tasks remains the same, there

is no need to add, delete or change any of the X's. As a result of re-sequencing the tasks, the developer has moved 35 information flows above the line, signifying potential rework. In this DSM, the new potential feedbacks are highlighted in red, orange and yellow. The yellow represents the 26 information flows that are now above the diagonal and occur in the preconstruction stage. Because there is a certain level of planned iteration within the preconstruction stage, these iterations will be less of an issue than if occurred outside the stage. The two orange boxes represent tasks that were previously above the line in this stage, but have moved further away.

The nine iterations outside of this stage, highlighted in red, represent potentially riskier events. These information flows occur during construction but may require the developer to go back into preconstruction. The DSM indicates that the execution of the GMP Agreement (#401), securing of the construction loan (#402) and the procurement of the major trade buyouts (#404) provide information to the previous tasks and could result in rework. These earlier, potentially impacted tasks include how the property is acquired (#403), the building permit (#405), and what is actually constructed (#406 and 407). For example, if the developer is unable to secure a construction loan (#402) after construction has begun, property acquisition, the building permit and the ability to construct the building are all in jeopardy. This can be seen by reading down the column for task #402.

If the developer is comfortable with his expected outcomes and ability to manage the potential rework, then this re-sequencing can prove to be advantageous. But the DSM is clearly warning him that he is taking on additional risk and the potential for costly and time consuming rework if things do not work out in his favor. This is for the developer to determine and will vary from project to project. The DSM quickly and graphically illustrates the potentially problematic issues and provides a useful tool to manage the process of starting construction early.

Design before Entitlements DSM

> ***Itchy Trigger Finger Scenario*** *– Nicholas was getting impatient. The planning process was dragging on forever. His design team was starting to get anxious about waiting for the go-ahead to start the full construction drawings. They even had the temerity to suggest they would have to start working on other projects if the billings didn't ramp up soon. Nicholas liked his designers and they knew the project from its inception but he didn't have final approval on his plan*

from the City. Against his better judgment, Nicholas reluctantly gave his approval for the designers to start the time-consuming and expensive construction drawing set. Nicholas rationalized, "I'll get the approvals any day now. Any changes or comments from the City will be small anyway."

While the reordered tasks in this scenario are occurring within the same stage, the developer risks significant rework once the City reviews his documents. (Appendix C-10) If design changes are required, some of these design packages will need to be redone. Alternatively, if the approvals had come in with no or little required design changes, construction could have started faster than in the Baseline case.

In this DSM, the iteration associated with these tasks is highlighted in yellow and orange. The 24 orange boxes represent information flows that were above the line to begin with, but have now been shifted further away, potentially increasing the impact of rework to these tasks in this stage. The six yellow boxes represent previously feed forward flows that are now above the diagonal and can now potentially result in feedback.

With this information available, the developer may or may not decide to reorder the tasks to minimize potential rework. If there is a high probability that the public approval process will require significant design changes, the developer will want to eliminate the iteration, slowing the process down. Additionally, if the design packages are extensive and expensive to redo and any threat of rework could pose significant schedule and cost implications, the developer should be reluctant to complete them early. However, if the public approval process has a highly expected outcome, or the cost to redesign is minimal, then it may be advantageous for the developer to sequence the tasks in this order. Again, this sequence choice will vary depending on the project and the developer.

Construction before Tenants DSM

Speculative Office Scenario *– After 9 months of chasing potential tenants but not quite closing the deal, Nicholas is getting restless. Soon he is going to have to decide to whether to put his project on hold because he doesn't have any tenants or move forward and put his faith in the market. Nicholas looks around him and everything looks and feels positive: the office market is booming, rents are rising, and there appears to be a high demand for new office space. He has just had bad luck with difficult prospective tenants, he tells himself. His bank appears willing to fund the construction loan so Nicholas decides to move forward. "If the bank is still willing to give me the money, they must know something!"*

By signing tenants later in the process, the developer is moving tasks #319 (*Sign Tenant Agreements*), 326 (*Secure Anchor Tenant*), 323 (*Evaluate Tenant Improvement Requirements*) and 408 (*Build Tenant Improvements*) down in the process sequence. (Appendix C-11) In this DSM, this creates potential iteration, and is highlighted in yellow, orange and red as before. The yellow tasks were originally feed forward interactions, but are now feedback. The orange have remained feedback, but have moved to different locations in the DSM. The red are potential iterations outside the preconceived stages.

Similar to Scenario #5, there is now iteration occurring outside the predetermined stages. This should be expected. The tenant tasks are typically completed during preconstruction because they interact with many other preconstruction activities. Moving them down into construction does not eliminate these interactions, but instead, just moves them further out in the process. By doing so, there is the potential for iteration to occur between stages which can increase the risk of unforeseen outcomes and the potential for rework.

The developer risks designing and constructing a building that does not meet the needs of potential tenants. This would result in costly rework or a failed project as the developer would need to repeat some of the preconstruction activities, even after construction has begun or been completed. If the developer is able to find a tenant and market conditions remain favorable, the building can be delivered to the market earlier and potentially earn the owners and investors a higher return. The DSM acts as a tool for the developer visualize the consequences of his important decisions at all stages of the process.

Summary

The scenarios described in this chapter highlight some of practical applications of DSM in real estate development practice. The Baseline DSM attempts to minimize iteration and describe a normative, "best-case" development process. From here, a developer can model different types of information flows, observe and manage inevitable changes that in the process and understand the impact re-sequencing can have on other tasks and the entire process. These examples were meant to be simplistic to allow the reader to clearly understand DSM mechanics. Scenarios with additional complexity can be modeled with similar effectiveness.

It should be noted that the DSM does not tell a developer the "correct" way to set about a real estate development project. Instead, in this Chapter, we've outlined how the DSM can act as a tool for the developer to use to understand the information flows that are occurring in the process and manage and model potential changes and risks. This will allow for a fuller understanding of the potential costs and benefits of a particular course of action and help the developer to optimize his decision-making.

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Chapter 6: DSM in Real Estate Development: Observations & Takeaways

Chapter Summary: This chapter expands on the preceding chapters to detail practical applications of the DSM for a development entity. These conclusions were reached through analysis of the Baseline and Scenario DSMs (Chapters 4 & 5), and our presentation and discussion of results with industry partner Jones Lang LaSalle. The real estate DSMs are found to be useful tools for understanding development issues at the firm and project levels. The DSM promises to be a useful project management tool that surpasses previous academic RED models and many commonly used project management tools used by industry.

In Chapter 4, we detail a list of Stages and Tasks and model their informational flows to derive a normative or stylized DSM. This baseline DSM established a model that outlined many characteristics of the development process. Chapter 5 then explored hypothetical scenarios where the DSM could be applied by a developer. This exercise used the DSM in three distinct ways. First, the Baseline DSM was colored to illustrate different types of information flows in the process. Secondly, the DSM demonstrated change in the development process modeled through the functional sectors. Finally, the DSM modeled the effect of re-sequencing tasks in the real estate development process. These exercises helped to illustrate ways the authors believed DSM could be useful in practice. The results were presented to a panel of senior project managers at Jones Lang LaSalle to stimulate conversation about their perceptions of DSM's applicability to their projects and project management practice. This meeting concluded with a discussion of future DSM research opportunities in the real estate development industry.

Using DSM to Understand the Development Process

Before reviewing the DSMs from Chapter 4 and 5 in our presentation, we reviewed the Stages and Tasks worksheet (Appendix B). This worksheet, as a standalone document, was found to be useful in understanding the development process in an organizational context. Articulation of Six Development Stages with a 'Decision' or 'Approval' gate as the final task proved to effectively model reality at Jones Lang LaSalle. The group also gained organizational insights from viewing tasks organized vertically by the Graaskamp-adapted five functional sectors framework. The concept that all tasks were iterating within and across these five groups

at each Stage of the process as the development product is refined proved intuitive to our panel and an accurate model of reality. A final take-away was that Jones Lange LaSalle could manage projects and project staffing by deconstructing a project into Stages and Functionality. Some managers found themselves approaching the process vertically, where they specialized in a specific functional group throughout the process (i.e. financial tasks). Other managers viewed themselves as horizontally-oriented; associated with a specific stage in the process.

Our panel's feedback noted that DSM can be useful at many levels of analysis. From a purely graphical perspective, without focusing on specific tasks, the DSM offers some interesting revelations. One panel member remarked that the DSM clearly pointed out where iteration was occurring in the process. The DSM illustrated that early stages of the development process (Stages 1-3) were far more iterative that the final three Stages. Further, the concept of iteration (planned versus unplanned) was a new concept for our panel members. They knew tasks were being completed incrementally and repeatedly with new information improving previous results, but they had never conceptualized the iteration process as explicitly part of the real estate development process or ever seen a description of their work that clearly and visually demonstrated this iteration. As a result, they found it to be very useful in enhancing their personal understanding of their profession and the broader real estate development process.

Our panel also agreed with the concept of "Approval Gates" that restrict access to further Stages of the development process. They generally viewed this gate as Investment Committee approval (or rejection) in response to a request for more funding. To get to the Investment Committee, they completed a series of tasks that were consistent with the DSM-modeled process. They did, however, note that the task list completed prior to reaching a "gate" or the order of task completion would vary depending on the project or particular Stage. If the team was confident that investment committee approval was forthcoming, they would often go ahead with future tasks without explicit approval. We learned that the primary interest of the investment committee was financial performance data and projections. It is our belief that getting to and through the decision gates will differ for each project and each developer. If the project is perceived to be risky or capital intensive, the gates may be more stringent and information intense. In any project, however, there are gates in the process where the project is evaluated and its fate is determined by a "go," "no-go," "go back" decision.

DSM at the Firm Level

The DSM was found to be useful for understanding and analyzing development firm level issues. Job roles and responsibilities are clearly understood by viewing a DSM. A quick review of a task in the horizontal row of the DSM will reveal the source of information critical for task completion. A quick view down the column will reveal the tasks that are fed information from the present task. This understanding allows managers to more accurately plan and understand necessary internal staffing and consultant requirements. As information flows increase and/or become more complicated, it may be necessary to add staff or consultants to successfully complete a task. The DSM shows the tasks that are being completed, and therefore the expertise that is required from the project team.

The *Functional Interaction* and *Internal vs. External* DSMs (Appendix C-2 & C-3) both point out interesting applications for the developer at the firm level. The *Functional Interaction* DSM, through the use of green and yellow boxes, visually displays relevant information about the nature of the interactions between tasks. Some information exchange is between tasks of matching discipline and others are not. This knowledge could be used when making staffing decisions. It was noted in our meetings that a junior person or someone with a more specific background would be better off handling like tasks (the green tasks) where a senior person would be better off managing the multidisciplinary tasks (the yellow tasks).

The *Internal vs. External* DSM visually conveys information about whether a task is primarily and substantially completed by someone internal to the development organization or outsourced to consultants and contractors. It was obvious to our panel that the different types of interactions necessitated different management techniques and responsibilities. Tasks being completed by consultants and handed off directly to another consultant, for example, could pose a greater risk since most work is being done without the developer's direct oversight. This DSM allows the developer to understand the information flows between these parties, and manage them accordingly based on a firm's expertise.

The DSM was also stated to be a useful tool to understand and track the lessons learned in the development process. By tracking the actual information flows in the process for a specific project versus how the information flows were planned, the developer can experimentally learn management successes and failures. Successes can be made repeatable and

failures can be mitigated. The developer can learn more about the risks that occur and determine how to better manage them in the future. The developer may also choose to focus on projects with attributes that specifically match areas of firm expertise. This matches a critical concern of real estate development: Appropriately matching project risk with the entity best positioned to manage and mitigate this risk.

The participants also believed that DSM could be useful in their client interactions. A majority of JLL's work is done as a service provider to investors and corporate entities. JLL project managers are often interacting with people unfamiliar with the real estate development process. The DSM provides a useful way to explain the process and understand the impact of potential changes. Additionally, the DSM could be used as a marketing tool, helping to explain one way in which JLL understands and manages the complicated development process.

DSM at the Project Level

In addition to utility at the firm level, the DSM proves to be useful at the project level. The DSM allows a developer or project manager to quickly model development scenarios and evaluate potential risks and outcomes. If a client, for example, was interested in making a significant change to the project, the team could use the DSM to model impacts and effects. Without the DSM, it is difficult to fully comprehend the specific effects that a changed task has on the entire process.

The DSM is also a useful tool for coordinating all project team members to establish standard project management procedures. In our Jones Lang LaSalle panel meetings, the one page DSM instigated useful and interesting discussions about the real estate development process. Project level issues such as sequencing, staffing, management and information flows are easily visualized, analyzed and discussed. The DSM can also make the project approval process explicit through the approval gates throughout the process.

DSM as a Teaching Tool

Finally, DSM is useful to both industry practitioners and academia as a pedagogical tool for students and teacher of real estate. Real estate is a rich and interdisciplinary field, and it can be difficult to understand or explain the intricacies of the development process. As discussed in Chapter 1, many have attempted to model real estate development, but have come up short in

providing a model that explains both the nature of development (multidisciplinary and iterative), the tasks that must be completed in the process, and how these tasks interact with each other. The DSM addresses all of these issues. DSMs can help students and teachers illustrate the characteristics of the real estate development process.

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Chapter 7: Future Research Opportunities

Chapter Summary: This chapter outlines some potential future research that the authors believe worth pursuing. We have uncovered a plethora of opportunities to apply DSM to the real development process at many levels of analysis. Additionally, we believe many opportunities exist to apply engineering systems techniques and frameworks, other than DSM, to real estate development. At the same time, real estate development offers the engineering systems field an excellent opportunity for inquiry and analysis.

This thesis was written with the intent to investigate applying the design structure matrix to models of the real estate development process. The real estate development and engineering systems disciplines had not previously been integrated and synthesized in depth. This thesis explored the two fields in an attempt to apply an engineering systems tool, the DSM, to real estate development. This required a broad and occasionally simplistic view of both subjects. While the authors believe to have successfully modeled a normative real estate development process using DSM, we believe significant opportunities exist to extend this analysis through further research. We will suggest some areas that we believe are fertile ground for further exploration in this chapter.

Case Study Approach

To apply DSM to the real estate development process, we conducted interviews and developed scenarios, in an attempt to model a stylized or ideal development. These scenarios, however, are not as complicated as real world projects. We believe that real-world projects can be investigated and modeled in the DSM to determine both planned and unplanned informational flows. This, however, will not be easy. Projects take years to complete, requiring the investigator to understand how tasks interact over a long period of time. One way to circumvent this issue is to focus on a certain stage of the development. This would allow the participants to discuss current topics and issues. The results of a case study could then be compared to the DSM developed in this thesis, providing interesting comparative results. It would also be interesting to develop an *ex ante* real estate development DSM modeling how a developer believes a specific project will happen. An *ex post* DSM could be constructed modeling the actual development process and the two DSMs can be compared. A case study

approach will clearly benefit our understanding of real estate development and the applications of DSM.

Finer Granularity

One major issue that the authors struggled with during this thesis was the level of granularity for our analysis. While we catalogued 91 real estate development process tasks, this number could be summarized and reduced to fewer tasks or expanded exponentially to thousands of tasks. As an example, the physical construction of the development in our model is comprised of just three tasks when obviously thousands of micro-level tasks are happening in reality.

Future research could model the development process at a more detailed level. By focusing on certain stages of the process, a more thorough analysis could be conducted to understand the information flows within the process. Valuable DSM analysis has been done in other industries with just a few tasks, or with hundreds of tasks.

Quantitative Analysis

Much contemporary DSM research has focused on rigorous quantitative analysis of DSM models. One way to analyze DSMs is to quantify the information flows from the model. The "marks" in a DSM matrix can have a numeric value to denote additional information about the type of informational interaction. This information could be based on attributes such as importance, duration, cost, or predictability of the task. Once the DSM is coded, one can analyze the relationships numerically. If an outcome is highly predictable, for example, the developer may be comfortable with its potential iteration. Monte Carlo simulation could then be utilized model the likelihood of potential outcomes. DSMs can be manipulated, optimized and analyzed using linear equations and matrix algebra techniques.

There has also been work to determine a project's schedule through the design structure matrix. By adding durations to different tasks and quantifying their relationships, researchers can create outputs that can be transformed into traditional CPM and Gantt charts by software like MS Project. This allows for new schedules and sequencing to occur, allow for participants to critique the current way tasks are completed. Several firms offer commercial DSM software

and some researchers have developed free Excel-based DSM analysis packages. These resources can be found at **www.dsmweb.org**.

These are just a few of the ways that quantitative DSM analysis can benefit real estate development. A review of the literature referenced in this thesis, along with other work in the DSM field, provides a more complete understanding of the potential for quantitative DSM analysis. As mentioned, **www.dsmweb.org** has an excellent database of DSM research.

Other Engineering Systems Opportunities

The field of engineering systems, as previously mentioned, is, "an emerging field of scholarship that seeks solutions to important, multi-faceted socio-technical problems." Within this academic discipline, new techniques, tools and frameworks are continuously developed to address or resolve these socio-technical problems. It is clear that the real estate industry field could benefit immensely from this work. The buildings that we develop shape communities, spur economic development, and most important shape the way people live and interact. Because of this importance, there is no shortage of debate, struggle and conflict that occurs when one attempts to develop real estate. Engineering systems provides an opportunity and a framework to understand and address these complex issues.

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Chapter 8: Conclusion

The production of real estate creates places for people to live, work and play and defines the cities in which we live. The real estate development process is complex and multidisciplinary. To visualize this process, we have developed a model for the real estate development process that utilizes the design structure matrix (DSM) developed in the field of engineering systems. This DSM-based model of real estate development teaches us many interesting and valuable lessons.

We initiated this thesis by reviewing and analyzing previously published models of the development process. We began by looking at Graaskamp's eclectic models. We continued with agency, structure, event-sequence, economic, and systems models of the real estate development process. We found all of these models offered broad frameworks and characterizations of the development process. No existing model, however, provided the developer with a practical model that could adequately describe the development process with the level of detail necessary to execute a project.

To model and understand the complex process of real estate development, this thesis looks to the young field of engineering systems to provide insights. We found that many tools used to model and efficiently manage product development are applicable to real estate. One tool which has been used with great success to model complicated and iterative processes in other industries is the DSM. The thesis then introduces the DSM and details its mechanics and previous applications.

We then describe the process of creating the real estate development DSM model. We start by working with a panel of development professionals from our industry partner, Jones Lang LaSalle, to determine and categorize the six stages and ninety-one tasks that constitute the development process. Our panel also gained insight from James Graaskamp's "refining the idea" concept by iterating through four functional development sectors (market, legal / political, physical / design and financial). We argue for the creation of a fifth functional sector, project management, which incorporates project and firm level tasks that occur throughout the development process. With the stages and tasks determined, we conducted a series of interviews with our industry panel to document the information flows between tasks in the

development process. These were transcribed this onto the DSM by marking an "X" on each information flow between tasks. This stylized and normative development process is captured in a visually intuitive model which we designated the Baseline DSM. Several interesting insights into the development process are gained by an analysis of the Baseline DSM.

Through the Baseline DSM, we first confirmed that real estate development is a highly iterative process. The DSM model provides visual validation for this premise. The DSM model also shows that the process is very multidisciplinary. The model also proves to be a useful tool that developers and development firms can use at many different levels. The DSM can be used at the firm level to get organizational insights. It can also be used at the project level as a management tool. Lastly, the DSM model appears to have potential as a pedagogical tool to teach students about the process of real estate development.

To test the usefulness and capability of DSM as a tool, we describe several scenarios that model typical development issues. We add a level of information to the DSM by utilizing color to model the interactions between tasks across functional boundaries. Another colored DSM demonstrates the interaction of internally completed tasks versus those completed by external consultants and contractors. We then model typical changes to the development process and the effect of re-sequencing tasks.

We presented these results to our industry panel to gain insight into the application of the DSM in practice. Jones Lang LaSalle executives found our DSMs to be a useful and intuitive model of their real-world development processes. They also believe that the DSM is a useful tool to understand and model both firm-level and project-level issues.

This thesis demonstrates that tools adapted from the discipline of engineering systems, specifically the DSM, have a useful application to understanding and improving the real estate development process. We believe that future research further integrating the DSM with the real estate development process will be a major contribution to our body of knowledge and offer significant improvements to the practice and pedagogy of real estate development.

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Appendix A: Stages and Tasks Glossary

Idea Inception

Market and Competitive Analysis

Macroeconomic Analysis – This task includes evaluating national macroeconomic indicators, such as unemployment rates, demographic changes, and interest rates. Certain factors may indicate a demand in the marketplace.

Evaluate Capital Markets – An understanding of the capital markets is conducted to understand the cost of capital and the level of risk that the market will tolerate.

Local Supply and Demand Analysis – Local market conditions will play a significant role in how a development is developed if at all. It will show projects that are in the pipeline, expected absorption rates and the demand for new space.

Estimate Rents – By looking at comparable projects and market conditions, the developer will seek to understand what type of rents the project will be able to achieve. This will ultimately be used to calculate the initial financial assumptions. These rents will be rough estimates, as the final timing, product mix and design of the project is unknown.

Estimate Costs – Development costs, including both soft and hard costs, will need to be estimated to compare with the estimated rents. These numbers will be rough as the timing and design of the project have not yet been determined. The balance between the two will ultimately determine whether or not the project is achievable.

Physical and Design Analysis

Estimate Project Scope – This is a broad attempt to determine that the size of the project will be. This is on the magnitude of number of buildings, height, floors, square footage, etc. This will based on information gathered from other tasks in the *Idea Inception* stage.

Evaluate Programmatic Options – Here different uses are evaluated to determine the possibilities. These would include residential (for sale or lease), commercial, hotel, industrial, mixed use, etc. There may be multiple options still feasible after this task has been completed.

Political and Legal Analysis

Evaluate Zoning/Planning – Evaluation of how the entitlement process generally works, as of right restrictions and likelihood of changes or variances to the current zoning requirements.

Evaluate Local Politics – An understanding of the political acceptance of development is required to understand what is to be expected. Some projects are encouraged by the public, while others can face years of opposition. This will affect the costs and timeline of the project.

Financial Analysis

Back of the Envelop Proformas – With some of the market information determined, the developer will conduct various types of "back of the envelope" calculations. This quick, unscientific calculation will help determine a high level feasibility test.

Evaluate Investment Thresholds – The developer will need to determine the investment thresholds and risk tolerances of the organization.

Financial Underwriting – 1st Draft – With the tasks above completed, the developer can complete an initial underwriting of the project. Based on our discussions, a majority of the projects evaluated do not pass this initial test.

Project Management

Identify Land Opportunities – Potential project sites are determined and evaluated at this point.

Evaluate Land Control Options – Each site will require different steps for the developer to gain control. The developer will need to evaluate each of them and determine the risks and return for each.

Evaluate Organization Strategy – During the idea phase, the developer will need to determine the organization's strategy. They may have types of projects they specialize in (size, program, etc.) as well as the level of risk they are willing to take on.

Estimate Project Timeline – The developer will need to evaluate the timeline of development for the possible projects and compare that with the organization's strategy.

Approval to Proceed – After all the tasks in the *Idea Inception* group have been completed, some form, whether formal or informal, of approval must be granted to allow the development process to proceed to the next stage.

Feasibility

Market and Competitive Analysis

Perform Preliminary Market Analysis – This task is similar to the task in the previous stage, yet at a more detailed level. The developer now has one or maybe a few sites in mind. The market analysis is conducted with these specific sites and their potential uses.

Evaluate Marketability Options - This task evaluates how the specific project would be introduced into the marketplace. How long would absorption take, how the market will respond to the product, etc?

Determine Highest and Best Use – This task allows the developer to determine the best product for a specific site. From this point on, the highest and best use will be further refined to a final product.

Physical and Design Analysis

Engage Feasibility Consultants - Here the developer evaluates and engages in consultants necessary to complete tasks within the feasibility stage. This will include design consultants, contractors and legal counsel.

Perform Massing Study – The design consultant will perform a massing study to determine what a site can hold physically and how the uses layout. This will be based on other factors such as costs, zoning, supply/demand, political will, etc.

Develop Conceptual Design – With a massing study complete, one or multiple conceptual designs need to be completed to get an idea of a possible product. If approved, this design will be further developed later in the process.

Complete Phase 1 Environmental Site Assessment (ESA) – Environmental conditions pose a significant risk the profitability of a development, especially on redevelopment sites. An initial analysis is conducted at this stage to identify these risks. This is a due diligence stage, and physical sampling is not usually collected at this stage.

Evaluate Consultants and Contractors – As the idea becomes more of a reality, the developer will start evaluating and meeting with potential consultants and contractors for the

preconstruction and construction phases. These consultants may or may not be the same as those completing some of the feasibility tasks.

Obtain Rough Construction Costs – With massing and conceptual designs complete, the developer is able to get initial estimates on the product. While still budgetary, it will help the developer identify significant issues that may require rework.

Political and Legal Analysis

Evaluate Planning and Zoning Process – Here the entitlement process is fully understood to determine potential risks, costs and timing. Much of the design will be completed in stages based on this process.

Identify External Stakeholders – The stakeholders need to be determined to understand who will play a role in the development of the project. This will include neighbors, the public, politicians, competitors, etc.

Identify Permits and Approvals - These approvals will determine a lot of the work that is required to be completed in the second and third stages of development. They will play an important role in the design, cost and timing of development.

Financial Analysis

Identify Debt Options – With a general understanding of a product, schedule and budget, the developer can begin to evaluate what the options are for debt financing, including certain terms, loan to value ratios, etc.

Identify Equity Options - The developer will need to identify where the remaining funds will come from. The funds will most likely be required during the preconstruction phase before any money from the construction loan can be used.

Update Financial Underwriting – With further information on rents and costs now available, the financial underwriting can be updated to get a better understanding of the project's financial feasibility.

Project Management

Reevaluate Organization Strategy – The developer will need to evaluate the organization's strategy now that a formal plan is starting to take shape. This plan may or may not be acceptable to the developer.

Estimate Schedule – Throughout this stage, the developer will want to continuously evaluate the project's schedule.

Gain Control of Site and/or Client - Near the end of the *Feasibility* stage, the developer will be faced with a decision of whether or not to proceed with preconstruction. Before starting with preconstruction, which requires a significant amount of soft cost expenses, the developer will want to ensure that the site is under control.

Approval to Proceed – Once these tasks have been completed, a decision will need to be made of whether or not to proceed with preconstruction.

Preconstruction

Market and Competitive Analysis

Perform Formal Market Analysis – A formal market study is conducted to completely evaluate all market conditions. The size and cost of the market study will vary depending on the size of the project and the preferences of the developer.

Develop Marketing Strategy – A full marketing plan is developed to determine how the property will be leased and or sold. The market analysis will determine much of this strategy.

Leasing Process – During preconstruction, the leasing process can begin. This includes looking for an anchor tenant, along with other tenants. Many banks (market depending) will want to see formal commitments before committing to a project.

Sign Tenant Agreements – In most incidences, tenants will need to be secured during preconstruction to guarantee cash flow after construction. This may not be necessary if equity and debt sources do not require it. That will most likely be determined by the liquidity and risk tolerances in the capital markets.

Secure Anchor Tenant – In many projects, a majority of the space will be taken by a single tenant, known as the anchor tenant. The anchor tenant is obviously the most important tenant and is usually signed during preconstruction. This minimizes much of the lease up risk that occurs after the project has been completed.

Physical and Design Analysis

Initial Contractor Discussions – During preconstruction, the developer will want to work towards securing a contractor to build the project. This will first require a lengthy descope process to minimize the amount of uncertainty. The developer may prefer to sign a contractor early to take advantage of preconstruction services and a fiduciary construction partner.

Engage Full Consulting Team – All consultants will need to be signed up to get through the *Preconstruction* stage. This includes lawyers, designers, preconstruction contractors, etc.

Execute GC and Fee Agreement – The developer will most likely want to first execute a general conditions (GC) and fee agreement with a contractor. This will lock in the overhead costs of construction and allow the contractor to act in a fiduciary manor with the developer during preconstruction and value engineering activities. While this is a popular delivery method, many other factors will go into determining how the developer will proceed.

Contractor Estimating – As the design becomes further established, the developer will want to maintain some level of check against the original budget. The design stage may take a significant amount of time, and updates to the budget are necessary to ensure no drastic changes occur late in the process.

Phase 2 ESA – With the site under control, the developer will want to engage an environmental consultant to complete a Phase 2 ESA. This will determine whether or not the site is contaminated and if necessary, remediation requirements.

Schematic Design – One of the conceptual designs will be further refined to eventually become a final design. The first incremental milestone on the design timeline is typically referred to as the schematic design. The schematic design will be used for the entitlement process. Depending on the likelihood of changes to design during the approval process, the developer may or may not choose to proceed past this step without some level of consensus.

Design Development – The design is further refined after schematic design. The level of design between this stage and the previous will depend on the developer's preference, the demands of the approval agencies, etc.

50% Construction Documents – With design approvals mostly complete, full design is underway to get towards constructible documents. Some parts of the building may be completed sooner than others to allow for early procurement of certain trades.

100% Construction Documents – Design is finalized to allow for a construction agreement to be completed.

Evaluate TI Requirements – The cost and complexity of tenant requirements will need to be determined in this stage. The developer will need to determine what is being built under the classification of base building, and what is being built as part of tenant fit up.

Procurement Strategy – A procurement strategy will need to be conducted to determine how the construction GMP and subcontractors are awarded.

Political and Legal Analysis

Clear Title Report – The developer will need to ensure that the title on the property is free and clear from any encumbrances.

Public Participation – The zoning and approval process will outline if public participation is required for approval of the project. This will vary depending on the local entitlement process.

Obtain Planning and Zoning Approvals – All necessary planning and zoning approvals will be obtained during this stage.

Obtain Miscellaneous Permits and Approvals – All other necessary permits and approvals will be secured in this stage.

Financial Analysis

Negotiate Debt Agreements – The construction loan will be negotiated during this stage. This will most likely include multiple banks and a comparison of multiple terms.

Determine Exit Strategy – The developer will want to establish an exit strategy and ensure they comply with the debt and equity agreements, along with the expected market conditions.

Finalize Development Budget – With near complete construction documents and a significant amount of soft costs spent, the development budget will need to be updated for the bank, equity partners and the developer to ensure project feasibility.

Update Financial Underwriting – With most information finalized, all financial information is update before construction.

Secure Equity Agreements – Equity will need to be secured during preconstruction to pay for much of the upfront soft costs.

Project Management

Develop Project Schedule – After most of the preconstruction tasks are complete, a project schedule can now be finalized.

Approval to Proceed – Once all these tasks have been completed, a decision is made as to whether or not to proceed with construction, the most financially significant decision made during the process.

Construction

Market and Competitive Analysis

Update Market Conditions – Throughout the construction process, the developer will want to monitor the market to ensure their assumptions made during preconstruction hold true during this lengthy stage.

Physical and Design Analysis

Execute GMP Agreement – With a final design and an approval to start construction, the developer will most likely choose to lock in a guaranteed maximum price with a contractor.

Procure Major Trade Buyouts – Depending on market conditions, schedule and risk tolerances, the developer may or may not choose procure the major trades prior to a GMP being signed.

Build Project Infrastructure – This includes any work, outside of the building(s) itself, that may need to be built before full construction begins.

Build Core and Shell – This includes building of the structure and exterior of the building. This usually includes life safety systems. Some work to facilitate tenant improvement work may be included as well.

Build Tenant Improvements – This includes all interior construction. When and what is built will depend many factors, including the product, the market, leasing progress and specific tenants.

Construction Inspection – Throughout the construction project, the developer will need to ensure that construction complies with the contract documents.

Building Turnover – After substantial completion, the developer and/or the tenants will take control of the space from the contractor.

Political and Legal Analysis

Obtain Building Permit – A building permit will need to be obtained prior to any construction activities commencing.

Obtain Temporary Certificate of Occupancy – Once the building is substantially complete and all life safety systems are online, the local authorities will grant a certificate of occupancy. This may only be temporary if there is a substantial amount of construction activities still left to be completed.

Financial Analysis

Secure Construction Loan – A construction loan will most likely be obtained near the beginning of construction to pay for the work as it is completed.

Construction Loan Administration – The bank will need to inspect the project, usually on a monthly basis, to ensure the correct funding is taking place throughout construction.

Update Development Budget – The development budget will need to be updated throughout this phase as buyouts are completed and as construction progress. Scope changes and unanticipated design flaws will be paid for out of a predetermined contingency budget. This will need to be monitored throughout the project.

Update Financial Underwriting – As costs are updated and leases are signed, the developer will want to update the projects operating proforma.

Project Management

Acquire Property – The formal acquisition of the property (if not already done so) will need to take place prior to any construction activities.

Monitor Schedule – The schedule will need to be continuously updated throughout construction as tasks are completed. The duration of the project will affect borrowing costs, future rents and tenant activity.

Stabilization

Market and Competitive Analysis

Update Marketing Plan – With space now available (if applicable) the marketing plan will need to be updated. The marketing plan will also be based on the amount of space that is available.

Physical and Design Analysis

Move Tenants In – The moving in of tenants signifies substantial completion of construction and the beginning of cash flows.

Punchlist – As construction nears completion, a list of work to complete items will be generated. Completion of all punchlist tasks will signify construction completion.

Project Closeout – This task represents closing all of the contracts with consultants and contractors.

Political and Legal Analysis

Obtain Certificate of Occupancy - Once the building is mostly complete and all life safety systems are online, the authorities will grant a certificate of occupancy. This may occur at the time of temporary certificate of occupancy if the construction is far enough along.

Financial Analysis

Collect Rents – Tenants will start paying rent (or purchase part of the property) once they move in.

Update Financial Underwriting – With all construction costs known and tenants moving in, the financial underwriting will need to be updated to reflect the updated numbers.

Project Management

Implement Property Management – The property manager will need to start operating the building as the construction team begins to leave. There will most likely be an overlap as all issues are resolved.

Asset Management and/or Sale

Market and Competitive Analysis

Evaluate Capital Markets - The capital markets will determine if and how the property can be refinanced and/or sold once it becomes a stabilized asset.

Financial Analysis

Refinance / Obtain Permanent Loan – The developer will need to refinance the construction loan to a permanent loan. The terms and rates will depend on the capital markets and the amount of space remaining in the building.

Sell Property – The developer may choose to sell the property depending on the organization's strategy and the value of the property in the market place.

Project Management

Evaluate Organization Strategy – Different companies will have different strategies on whether to hold or sell an asset. This may depend on the value of the property, other development opportunities, etc.

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Appendix B: Tasks by Stage and Quadrant

See page 59 for narrative discussing Appendix B.

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Appendix B: Tasks by Stage & Quadrant

1. Idea Inception

Market & Competitive Analysis	Physical & Design Analysis	Political & Legal Analysis	Financial Analysis	Project Management
Macroeconomic Analysis Evaluate Capital Markets Local Supply & Demand Analysis Estimate Rents Estimate Costs	Estimate Project Scope Evaluate Programmatic Options	Evaluate Zoning/Planning Evaluate Local Politics	Back of the Envelope Pro Formas Evaluate Investment Threshold Financial Underwriting - 1st Draft	Evaluate Organization Strategy Identify Land Opportunities Evaluate Land Control Options Est. Project Timeline **Gate** Review and Approve

2. Feasibility

Market & Competitive Analysis	Physical & Design Analysis	Political & Legal Analysis	Financial Analysis	Project Management
Perform Prelim. Mkt Analysis Evaluate Marketability Options Determine Highest & Best Use	Engage Feasibility Consultants Perform Massing Study Develop Conceptual Design Complete Phase 1 ESA Evaluate Consultants & Contractors Obtain Rough Construction Costs	Evaluate Planning & Zoning Process Identify External Stakeholders Identify Permits & Approvals	Update Financial Underwriting Identify Debt Options Identify Equity Options	Reevaluate Organization Strategy Gain Control of Site and/or Client Estimate Schedule **Gate** Review and Approve

3. Preconstruction

Market & Competitive Analysis	Physical & Design Analysis	Political & Legal Analysis	Financial Analysis	Project Management
Perform Formal Market Analysis Develop Marketing Strategy Leasing Process Sign Tenant Agreements Secure Anchor Tenant	Initial Contractor Discussions Engage Full Consulting Team Contractor Estimating Phase 2 ESA Schematic Design Design Development 50% Construction Documents 100% Construction Documents Procurement Strategy Evaluate TI Requirements Execute GC and Fee Agreement	Clear Title Report Public Participation Obtain Zoning and Planning Approvals Obtain Misc. Permits and Approvals	Finalize Development Budget Update Financial Underwriting Determine Exit Strategy Negotiating Debt Agreements Secure Equity Agreements	Develop Project Schedule **Gate** Review and Approve

4. Construction

Market & Competitive Analysis	Physical & Design Analysis	Political & Legal Analysis	Financial Analysis	Project Management
Update Market Conditions	Execute GMP Agreement Procure Major Trade Buyouts Build Project Infrastructure Build Core and Shell Build Tenant Improvements Construction Inspection Building Turnover	Obtain Building Permit Obtain Temp. Certificate of Occupancy	Secure Construction Loan Update Development Budget Update Financial Underwriting Construction Loan Admin.	Acquire Property Monitor Schedule

5. Stabilization

Market & Competitive Analysis	Physical & Design Analysis	Political & Legal Analysis	Financial Analysis	Project Management
Update Marketing Plan	Move Tenants In Project Closeout Punchlist	Obtain Certificate of Occupancy	Update Financial Underwriting Collect Rents	Implement Property Management

6. Asset Mgmt and/or Sale

Market & Competitive Analysis	Physical & Design Analysis	Political & Legal Analysis	Financial Analysis	Project Management
Evaluate Capital Markets			Refinance / Perm. Loan Sell Property	Evaluate Organization Strategy

Appendix C: Real Estate Development Process DSMs

The DSMs referenced in the thesis have been attached in Appendix C. For reference to the DSM in the text of the thesis, please refer to the chart below.

Appendix	Description	Reference in Text (pp. #)
C-1	Baseline DSM	61
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C-5	Physical / Design Change DSM	72
C-6	Legal / Political Change DSM	73
C-7	Financial Change DSM	74
C-8	Combined Change DSM	74
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C-10	Design Final before Entitlements Final	77
C-11	Construction Started Before Any Tenants Signed	78

The Excel file that contains the following DSMs is an "attachment" to the PDF version of this thesis available from MIT's DSpace (http://dspace.mit.edu/). Alternatively email the authors at benbulloch@gmail.com or mrjohnsullivan@gmail.com for a copy of the Excel.

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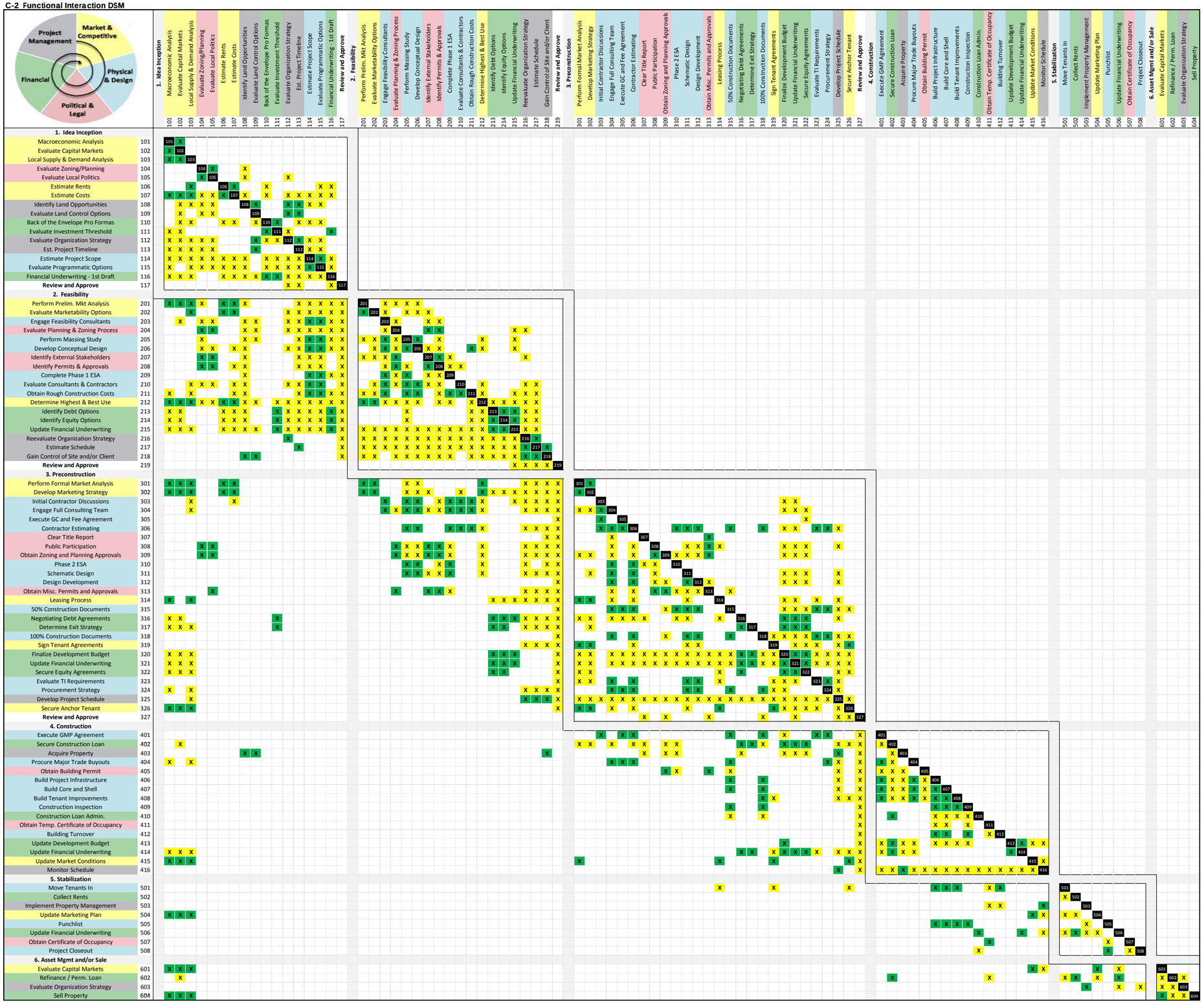
C-1 Baseline DSM

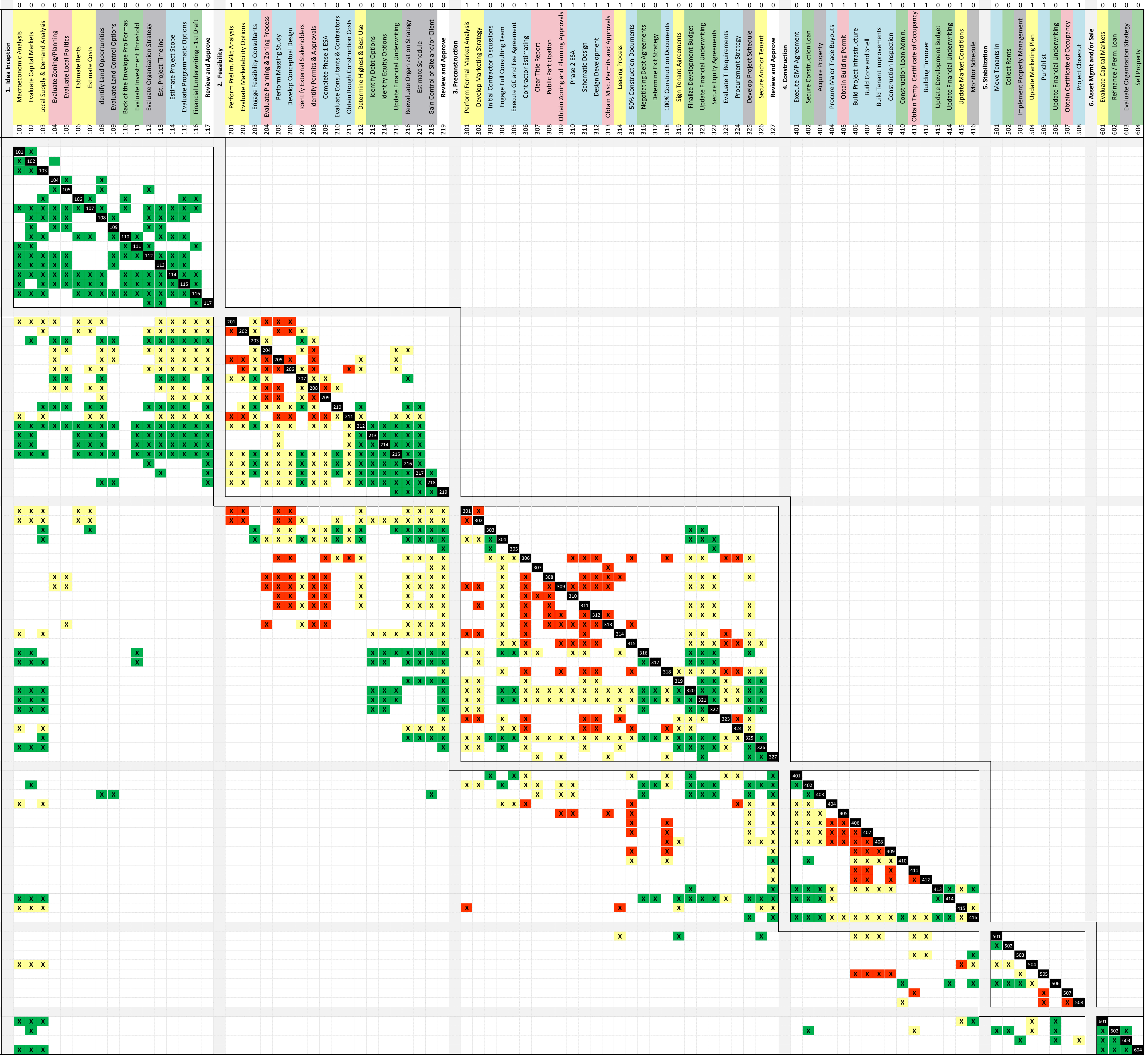
No.	Activity
	1. Idea Inception
101	Macroeconomic Analysis
102	Evaluate Capital Markets
103	Local Supply & Demand Analysis
104	Evaluate Zoning/Planning
105	Evaluate Local Politics
106	Estimate Rents
107	Estimate Costs
108	Identify Land Opportunities
109	Evaluate Land Control Options
110	Back of the Envelope Pro Formas
111	Evaluate Investment Threshold
112	Evaluate Organization Strategy
113	Est. Project Timeline
114	Estimate Project Scope
115	Evaluate Programmatic Options
116	Financial Underwriting - 1st Draft
117	Review and Approve
	2. Feasibility
201	Perform Prelim. Mkt Analysis
202	Evaluate Marketability Options
203	Engage Feasibility Consultants
204	Evaluate Planning & Zoning Process
205	Perform Massing Study
206	Develop Conceptual Design
207	Identify External Stakeholders
208	Identify Permits & Approvals
209	Complete Phase 1 ESA
210	Evaluate Consultants & Contractors
211	Obtain Rough Construction Costs
212	Determine Highest & Best Use
213	Identify Debt Options
214	Identify Equity Options
215	Update Financial Underwriting
216	Reevaluate Organization Strategy
217	Estimate Schedule
218	Gain Control of Site and/or Client
219	Review and Approve
	3. Preconstruction
301	Perform Formal Market Analysis
302	Develop Marketing Strategy
303	Initial Contractor Discussions
304	Engage Full Consulting Team
305	Execute GC and Fee Agreement
306	Contractor Estimating
307	Clear Title Report
308	Public Participation
309	Obtain Zoning and Planning Approvals
310	Phase 2 ESA
311	Schematic Design
312	Design Development
313	Obtain Misc. Permits and Approvals
314	Leasing Process
315	50% Construction Documents
316	Negotiating Debt Agreements
317	Determine Exit Strategy
318	100% Construction Documents
319	Sign Tenant Agreements
320	Finalize Development Budget
321	Update Financial Underwriting
322	Secure Equity Agreements
323	Evaluate TI Requirements
324	Procurement Strategy
325	Develop Project Schedule
326	Secure Anchor Tenant
327	Review and Approve
	4. Construction
401	Execute GMP Agreement
402	Secure Construction Loan
403	Acquire Property
404	Procure Major Trade Buyouts
405	Obtain Building Permit
406	Build Project Infrastructure
407	Build Core and Shell
408	Build Tenant Improvements
409	Construction Inspection
410	Construction Loan Admin.
411	Obtain Temp. Certificate of Occupancy
412	Building Turnover
413	Update Development Budget
414	Update Financial Underwriting
415	Update Market Conditions
416	Monitor Schedule
	5. Stabilization
501	Move Tenants In
502	Collect Rents
503	Implement Property Management
504	Update Marketing Plan
505	Punchlist
506	Update Financial Underwriting
507	Obtain Certificate of Occupancy
508	Project Closeout
	6. Asset Mgmt and/or Sale
601	Evaluate Capital Markets
602	Refinance / Perm. Loan
603	Evaluate Organization Strategy
604	Sell Property

C-2 Functional Interaction DSM



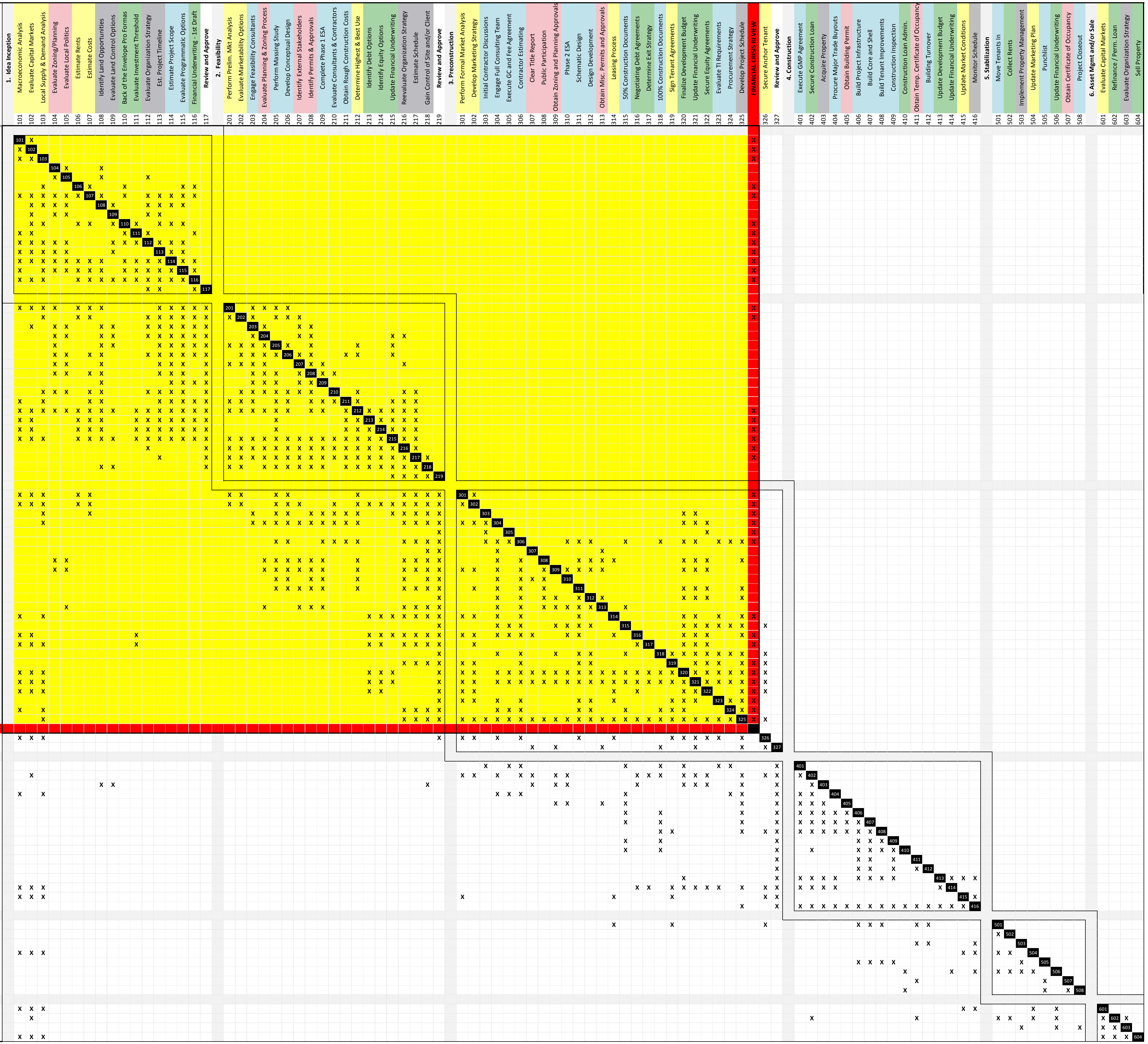
C-3 Internal vs. External DSM

Coding 0 = Internal Task 1 = External Task



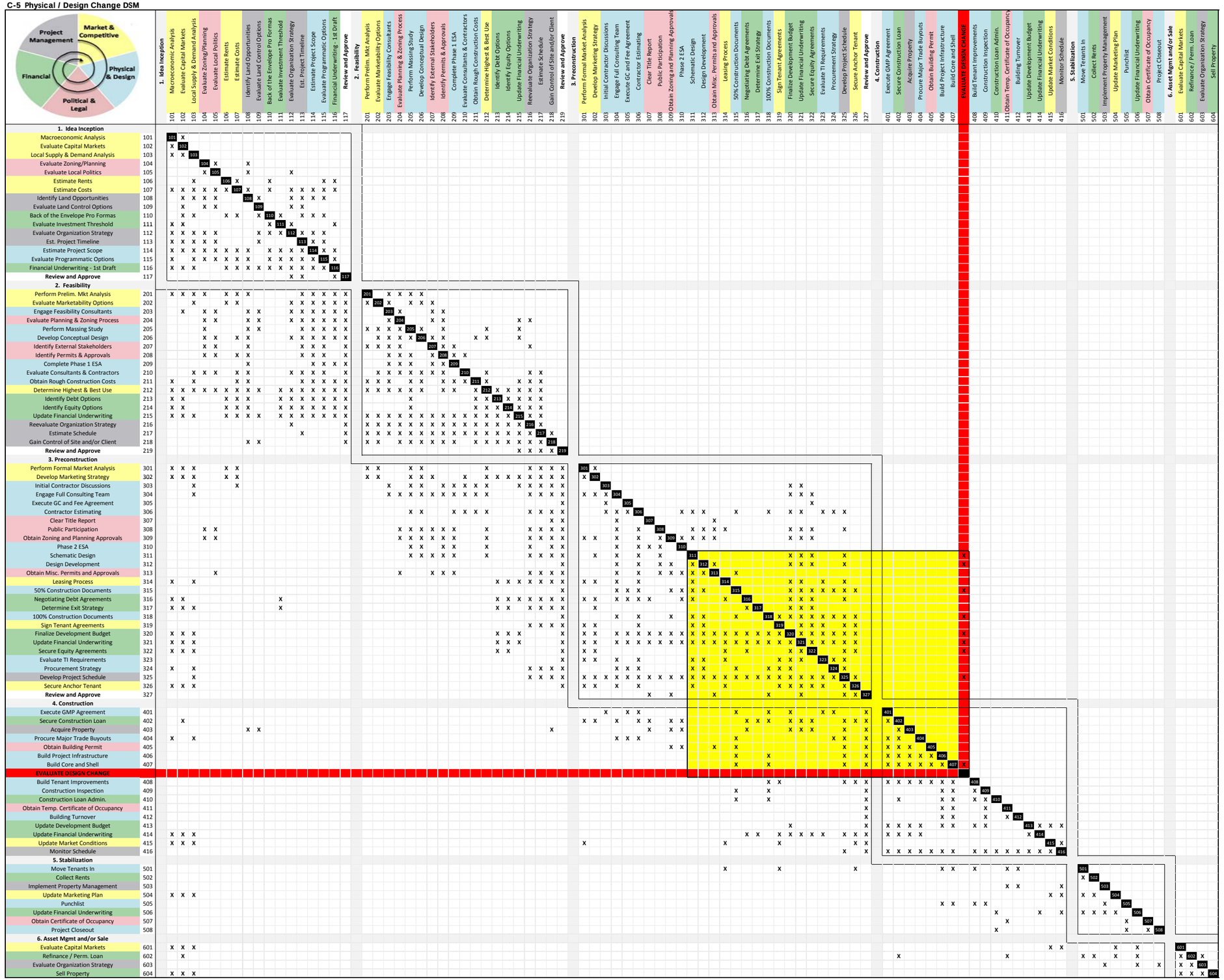
Coding	Task	No.
	1. Idea Inception	
0	Macroeconomic Analysis	101
0	Evaluate Capital Markets	102
0	Local Supply & Demand Analysis	103
0	Evaluate Zoning/Planning	104
0	Evaluate Local Politics	105
0	Estimate Rents	106
0	Estimate Costs	107
0	Identify Land Opportunities	108
0	Evaluate Land Control Options	109
0	Back of the Envelope Pro Formas	110
0	Evaluate Investment Threshold	111
0	Evaluate Organization Strategy	112
0	Est. Project Timeline	113
0	Estimate Project Scope	114
0	Evaluate Programmatic Options	115
0	Financial Underwriting - 1st Draft	116
0	**Review and Approve**	117
	2. Feasibility	
1	Perform Prelim. Mkt Analysis	201
1	Evaluate Marketability Options	202
0	Engage Feasibility Consultants	203
1	Evaluate Planning & Zoning Process	204
1	Perform Massing Study	205
1	Develop Conceptual Design	206
0	Identify External Stakeholders	207
1	Identify Permits & Approvals	208
1	Complete Phase 1 ESA	209
0	Evaluate Consultants & Contractors	210
1	Obtain Rough Construction Costs	211
0	Determine Highest & Best Use	212
0	Identify Debt Options	213
0	Identify Equity Options	214
0	Update Financial Underwriting	215
0	Reevaluate Organization Strategy	216
0	Estimate Schedule	217
0	Gain Control of Site and/or Client	218
0	**Review and Approve**	219
	3. Preconstruction	
1	Perform Formal Market Analysis	301
1	Develop Marketing Strategy	302
0	Initial Contractor Discussions	303
0	Engage Full Consulting Team	304
0	Execute GC and Fee Agreement	305
1	Contractor Estimating	306
1	Clear Title Report	307
1	Public Participation	308
1	Obtain Zoning and Planning Approvals	309
1	Phase 2 ESA	310
1	Schematic Design	311
1	Design Development	312
1	Obtain Misc. Permits and Approvals	313
1	Leasing Process	314
1	50% Construction Documents	315
0	Negotiating Debt Agreements	316
0	Determine Exit Strategy	317
1	100% Construction Documents	318
0	Sign Tenant Agreements	319
0	Finalize Development Budget	320
0	Update Financial Underwriting	321
0	Secure Equity Agreements	322
1	Evaluate TI Requirements	323
1	Procurement Strategy	324
0	Develop Project Schedule	325
0	Secure Anchor Tenant	326
0	**Review and Approve**	327
	4. Construction	
0	Execute GMP Agreement	401
0	Secure Construction Loan	402
0	Acquire Property	403
1	Procure Major Trade Buyouts	404
1	Obtain Building Permit	405
1	Build Project Infrastructure	406
1	Build Core and Shell	407
1	Build Tenant Improvements	408
1	Construction Inspection	409
0	Construction Loan Admin.	410
1	Obtain Temp. Certificate of Occupancy	411
1	Building Turnover	412
0	Update Development Budget	413
0	Update Financial Underwriting	414
1	Update Market Conditions	415
0	Monitor Schedule	416
	5. Stabilization	
0	Move Tenants In	501
0	Collect Rents	502
0	Implement Property Management	503
1	Update Marketing Plan	504
1	Punchlist	505
0	Update Financial Underwriting	506
1	Obtain Certificate of Occupancy	507
1	Project Closeout	508
	6. Asset Mgmt and/or Sale	
0	Evaluate Capital Markets	601
0	Refinance / Perm. Loan	602
0	Evaluate Organization Strategy	603
0	Sell Property	604

C-4 Market Change DSM

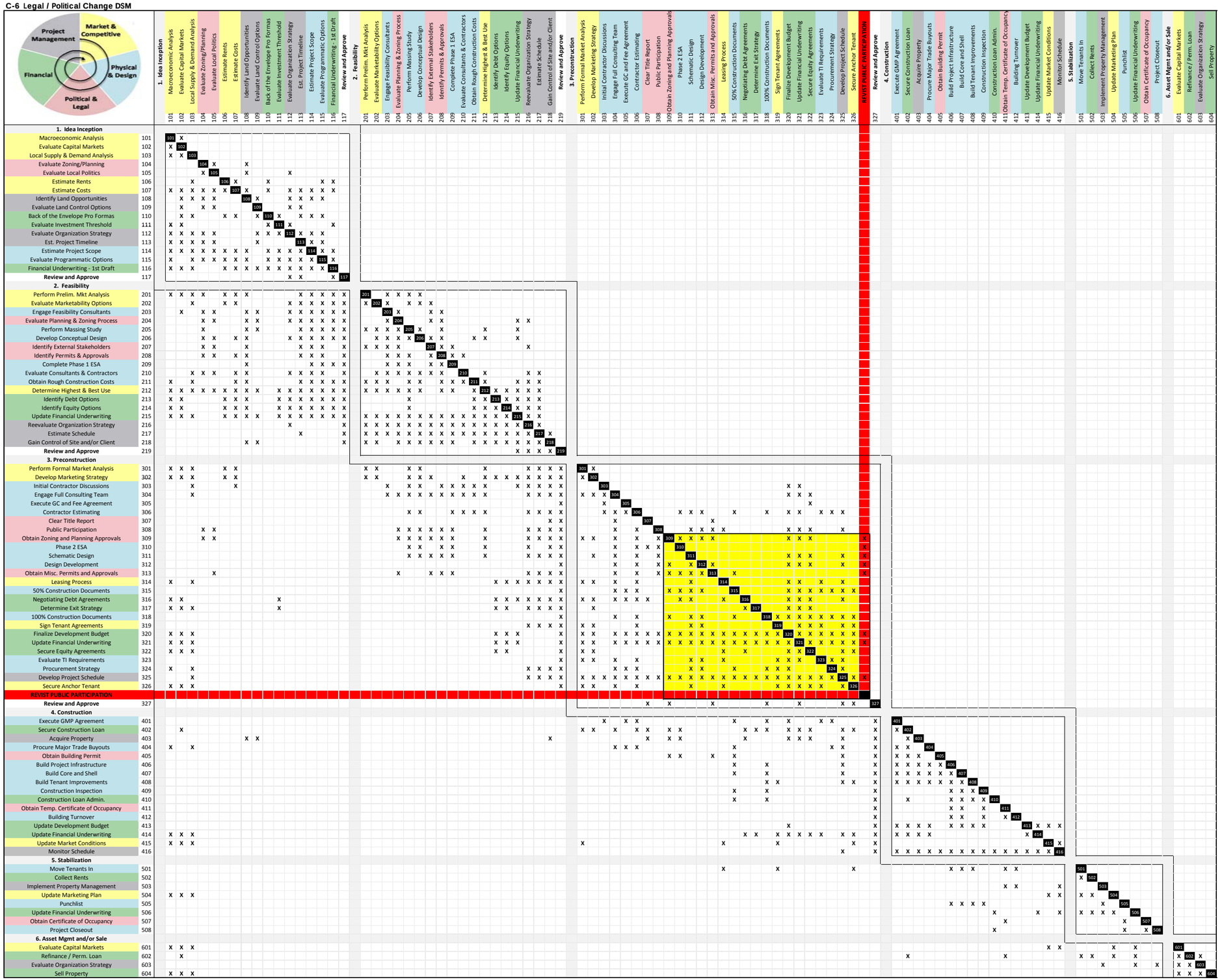


No.	Activity
	1. Idea Inception
101	Macroeconomic Analysis
102	Evaluate Capital Markets
103	Local Supply & Demand Analysis
104	Evaluate Zoning/Planning
105	Evaluate Local Politics
106	Estimate Rents
107	Estimate Costs
108	Identify Land Opportunities
109	Evaluate Land Control Options
110	Back of the Envelope Pro Formas
111	Evaluate Investment Threshold
112	Evaluate Organization Strategy
113	Est. Project Timeline
114	Estimate Project Scope
115	Evaluate Programmatic Options
116	Financial Underwriting - 1st Draft
117	**Review and Approve**
	2. Feasibility
201	Perform Prelim. Mkt Analysis
202	Evaluate Marketability Options
203	Engage Feasibility Consultants
204	Evaluate Planning & Zoning Process
205	Perform Massing Study
206	Develop Conceptual Design
207	Identify External Stakeholders
208	Identify Permits & Approvals
209	Complete Phase 1 ESA
210	Evaluate Consultants & Contractors
211	Obtain Rough Construction Costs
212	Determine Highest & Best Use
213	Identify Debt Options
214	Identify Equity Options
215	Update Financial Underwriting
216	Reevaluate Organization Strategy
217	Estimate Schedule
218	Gain Control of Site and/or Client
219	**Review and Approve**
	3. Preconstruction
301	Perform Formal Market Analysis
302	Develop Marketing Strategy
303	Initial Contractor Discussions
304	Engage Full Consulting Team
305	Execute GC and Fee Agreement
306	Contractor Estimating
307	Clear Title Report
308	Public Participation
309	Obtain Zoning and Planning Approvals
310	Phase 2 ESA
311	Schematic Design
312	Design Development
313	Obtain Misc. Permits and Approvals
314	Leasing Process
315	50% Construction Documents
316	Negotiating Debt Agreements
317	Determine Exit Strategy
318	100% Construction Documents
319	Sign Tenant Agreements
320	Finalize Development Budget
321	Update Financial Underwriting
322	Secure Equity Agreements
323	Evaluate TI Requirements
324	Procurement Strategy
325	Develop Project Schedule
	FINANCIAL CRISIS REVIEW
326	Secure Anchor Tenant
327	**Review and Approve**
	4. Construction
401	Execute GMP Agreement
402	Secure Construction Loan
403	Acquire Property
404	Procure Major Trade Buyouts
405	Obtain Building Permit
406	Build Project Infrastructure
407	Build Core and Shell
408	Build Tenant Improvements
409	Construction Inspection
410	Construction Loan Admin.
411	Obtain Temp. Certificate of Occupancy
412	Building Turnover
413	Update Development Budget
414	Update Financial Underwriting
415	Update Market Conditions
416	Monitor Schedule
	5. Stabilization
501	Move Tenants In
502	Collect Rents
503	Implement Property Management
504	Update Marketing Plan
505	Punchlist
506	Update Financial Underwriting
507	Obtain Certificate of Occupancy
508	Project Closeout
	6. Asset Mgmt and/or Sale
601	Evaluate Capital Markets
602	Refinance / Perm. Loan
603	Evaluate Organization Strategy
604	Sell Property

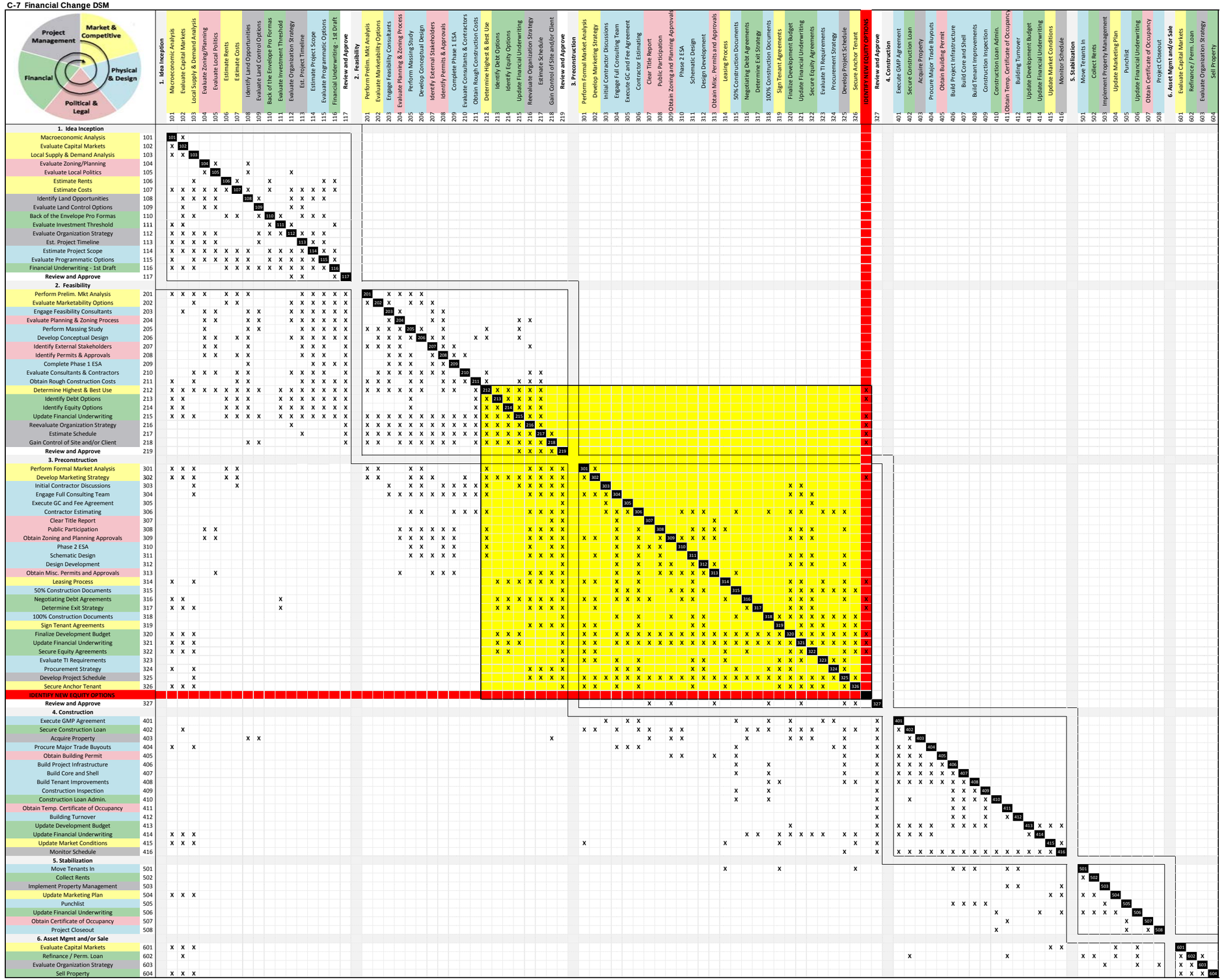
C-5 Physical / Design Change DSM



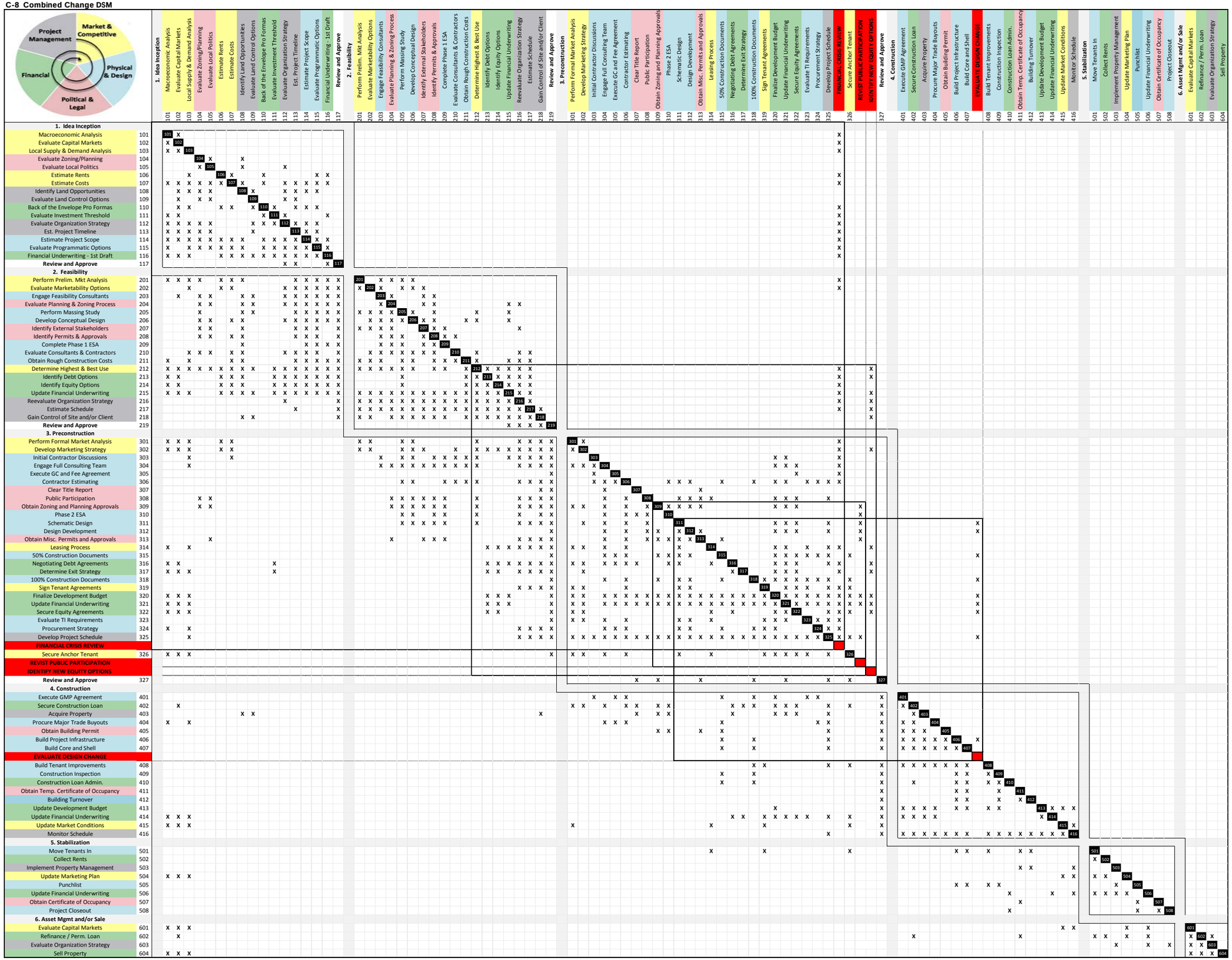
C-6 Legal / Political Change DSM



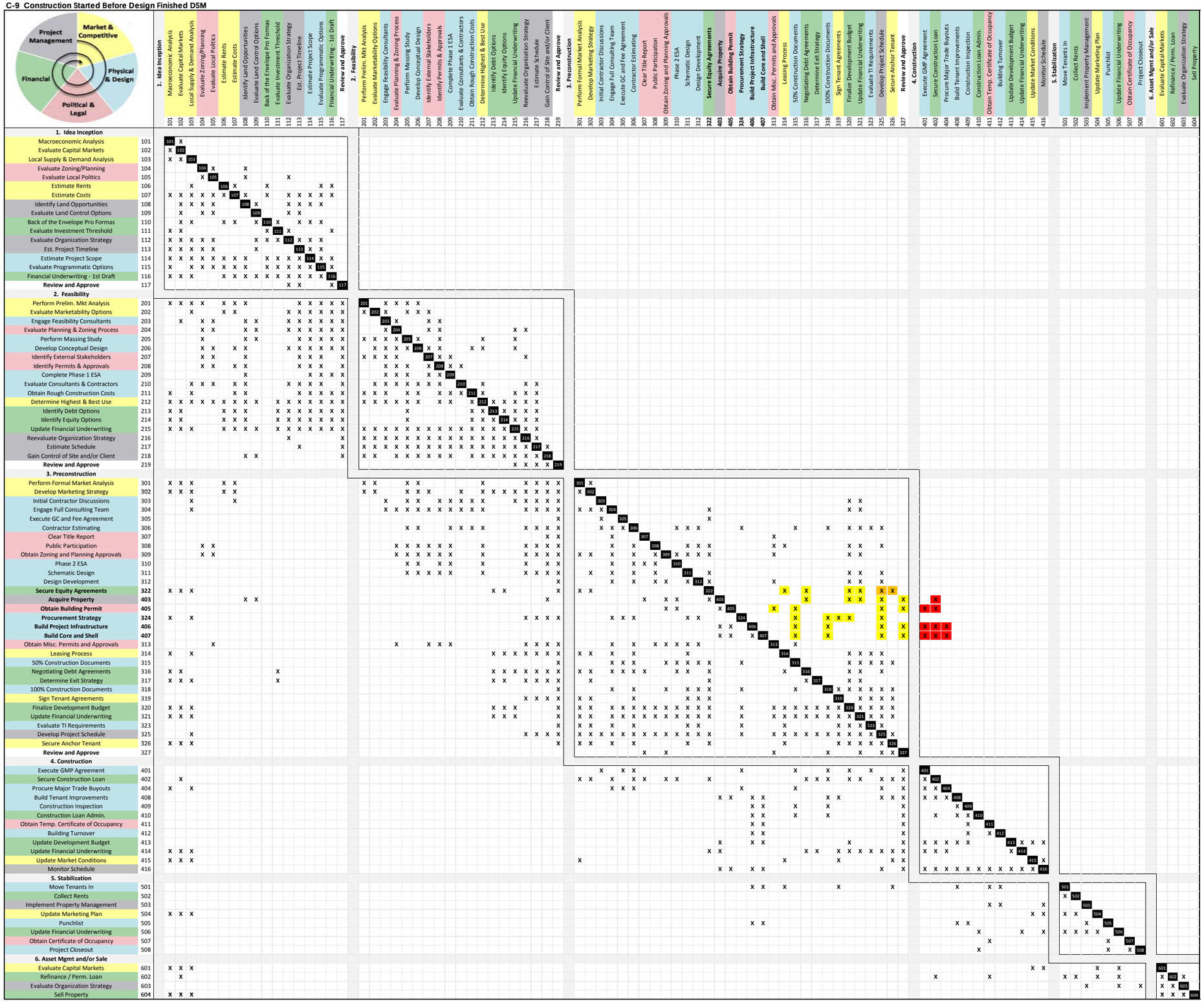
C-7 Financial Change DSM



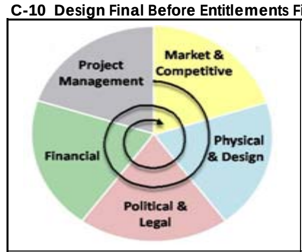
C-8 Combined Change DSM

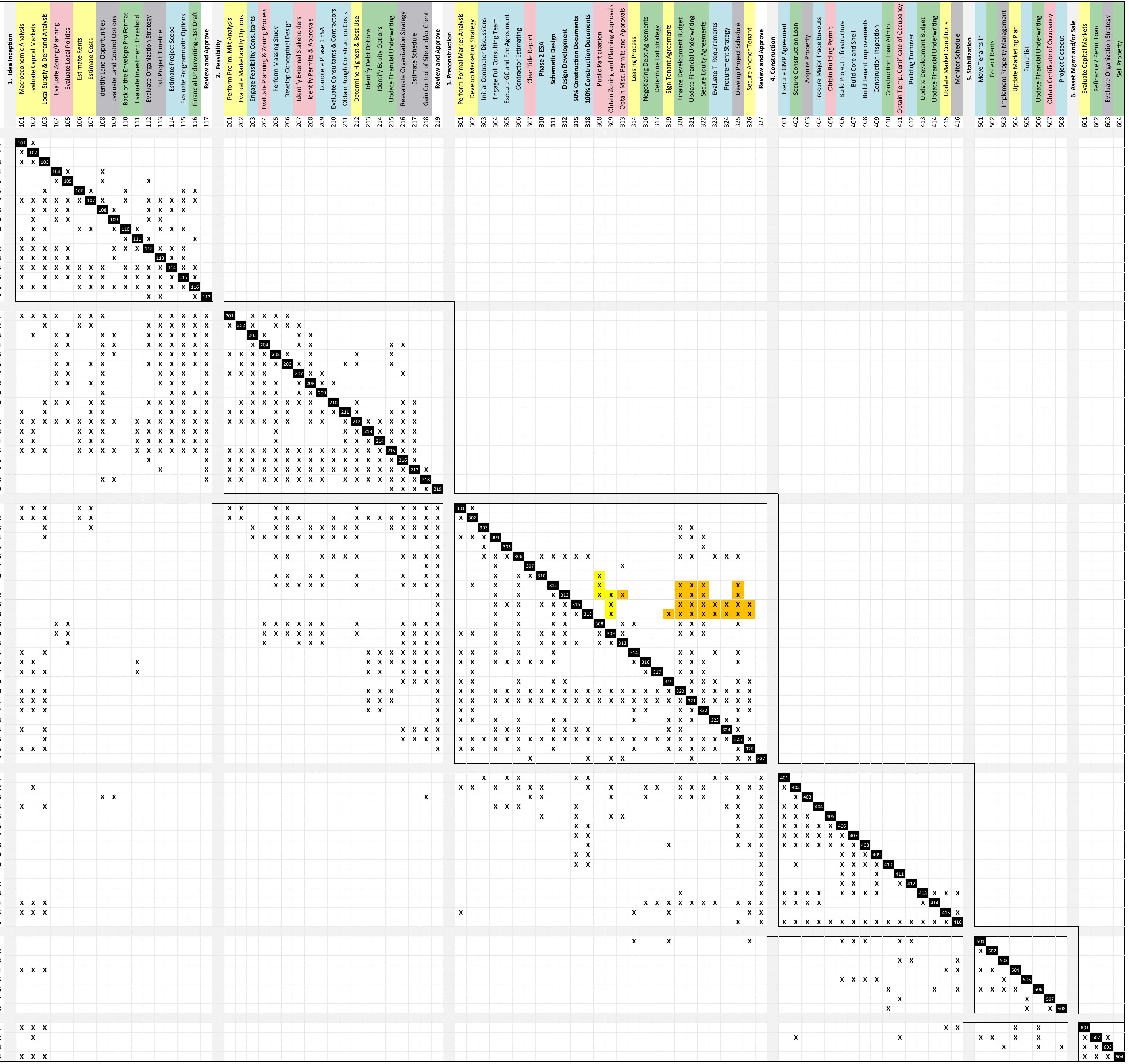


C-9 Construction Started Before Design Finished DSM



C-10 Design Final Before Entitlements Final





No.	Task
	1. Idea Inception
101	Macroeconomic Analysis
102	Evaluate Capital Markets
103	Local Supply & Demand Analysis
104	Evaluate Zoning/Planning
105	Evaluate Local Politics
106	Estimate Rents
107	Estimate Costs
108	Identify Land Opportunities
109	Evaluate Land Control Options
110	Back of the Envelope Pro Formas
111	Evaluate Investment Threshold
112	Evaluate Organization Strategy
113	Est. Project Timeline
114	Estimate Project Scope
115	Evaluate Programmatic Options
116	Financial Underwriting - 1st Draft
117	**Review and Approve**
	2. Feasibility
201	Perform Prelim. Mkt Analysis
202	Evaluate Marketability Options
203	Engage Feasibility Consultants
204	Evaluate Planning & Zoning Process
205	Perform Massing Study
206	Develop Conceptual Design
207	Identify External Stakeholders
208	Identify Permits & Approvals
209	Complete Phase 1 ESA
210	Evaluate Consultants & Contractors
211	Obtain Rough Construction Costs
212	Determine Highest & Best Use
213	Identify Debt Options
214	Identify Equity Options
215	Update Financial Underwriting
216	Reevaluate Organization Strategy
217	Estimate Schedule
218	Gain Control of Site and/or Client
219	**Review and Approve**
	3. Preconstruction
301	Perform Formal Market Analysis
302	Develop Marketing Strategy
303	Initial Contractor Discussions
304	Engage Full Consulting Team
305	Execute GC and Fee Agreement
306	Contractor Estimating
307	Clear Title Report
310	**Phase 2 ESA**
311	**Schematic Design**
312	**Design Development**
315	**50% Construction Documents**
318	**100% Construction Documents**
308	Public Participation
309	Obtain Zoning and Planning Approvals
313	Obtain Misc. Permits and Approvals
314	Leasing Process
316	Negotiating Debt Agreements
317	Determine Exit Strategy
319	Sign Tenant Agreements
320	Finalize Development Budget
321	Update Financial Underwriting
322	Secure Equity Agreements
323	Evaluate TI Requirements
324	Procurement Strategy
325	Develop Project Schedule
326	Secure Anchor Tenant
327	**Review and Approve**
	4. Construction
401	Execute GMP Agreement
402	Secure Construction Loan
403	Acquire Property
404	Procure Major Trade Buyouts
405	Obtain Building Permit
406	Build Project Infrastructure
407	Build Core and Shell
408	Build Tenant Improvements
409	Construction Inspection
410	Construction Loan Admin.
411	Obtain Temp. Certificate of Occupancy
412	Building Turnover
413	Update Development Budget
414	Update Financial Underwriting
415	Update Market Conditions
416	Monitor Schedule
	5. Stabilization
501	Move Tenants In
502	Collect Rents
503	Implement Property Management
504	Update Marketing Plan
505	Punchlist
506	Update Financial Underwriting
507	Obtain Certificate of Occupancy
508	Project Closeout
	6. Asset Mgmt and/or Sale
601	Evaluate Capital Markets
602	Refinance / Perm. Loan
603	Evaluate Organization Strategy
604	Sell Property

🟨 Moved above the Diagonal

🟧 Moved Further from Diagonal

🟥 Outside Planned Stage

C-11 Construction Started Before Any Tenants Signed

1. Idea Inception
101 Macroeconomic Analysis
102 Evaluate Capital Markets
103 Local Supply & Demand Analysis
104 Evaluate Zoning/Planning
105 Evaluate Local Politics
106 Estimate Rents
107 Estimate Costs
108 Identify Land Opportunities
109 Evaluate Land Control Options
110 Back of the Envelope Pro Formas
111 Evaluate Investment Threshold
112 Evaluate Organization Strategy
113 Est. Project Timeline
114 Estimate Project Scope
115 Evaluate Programmatic Options
116 Financial Underwriting - 1st Draft
117 **Review and Approve**

2. Feasibility
201 Perform Prelim. Mkt Analysis
202 Evaluate Marketability Options
203 Engage Feasibility Consultants
204 Evaluate Planning & Zoning Process
205 Perform Massing Study
206 Develop Conceptual Design
207 Identify External Stakeholders
208 Identify Permits & Approvals
209 Complete Phase 1 ESA
210 Evaluate Consultants & Contractors
211 Obtain Rough Construction Costs
212 Determine Highest & Best Use
213 Identify Debt Options
214 Identify Equity Options
215 Update Financial Underwriting
216 Reevaluate Organization Strategy
217 Estimate Schedule
218 Gain Control of Site and/or Client
219 **Review and Approve**

3. Preconstruction
301 Perform Formal Market Analysis
302 Develop Marketing Strategy
303 Initial Contractor Discussions
304 Engage Full Consulting Team
305 Execute GC and Fee Agreement
306 Contractor Estimating
307 Clear Title Report
308 Public Participation
309 Obtain Zoning and Planning Approvals
310 Phase 2 ESA
311 Schematic Design
312 Design Development
313 Obtain Misc. Permits and Approvals
314 Leasing Process
315 50% Construction Documents
316 Negotiating Debt Agreements
317 Determine Exit Strategy
318 100% Construction Documents
320 Finalize Development Budget
321 Update Financial Underwriting
322 Secure Equity Agreements
324 Procurement Strategy
325 Develop Project Schedule
327 **Review and Approve**

4. Construction
401 Execute GMP Agreement
402 Secure Construction Loan
403 Acquire Property
404 Procure Major Trade Buyouts
405 Obtain Building Permit
406 Build Project Infrastructure
407 Build Core and Shell
409 Construction Inspection
410 Construction Loan Admin.
411 Obtain Temp. Certificate of Occupancy
412 Building Turnover
319 **Sign Tenant Agreements**
326 **Secure Anchor Tenant**
323 **Evaluate TI Requirements**
408 **Build Tenant Improvements**
413 Update Development Budget
414 Update Financial Underwriting
415 Update Market Conditions
416 Monitor Schedule

5. Stabilization
501 Move Tenants In
502 Collect Rents
503 Implement Property Management
504 Update Marketing Plan
505 Punchlist
506 Update Financial Underwriting
507 Obtain Certificate of Occupancy
508 Project Closeout

6. Asset Mgmt and/or Sale
601 Evaluate Capital Markets
602 Refinance / Perm. Loan
603 Evaluate Organization Strategy
604 Sell Property

🟨 Moved above the Diagonal
🟧 Moved Further from Diagonal
🟥 Outside Planned Stage