Mangement and Planning of a Collaborative Construction Planning Process

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ABSTRACT: Construction planning is performed in a multi-disciplinary environment in which it is crucial to explore interdependencies, manage the uncertainty of the information exchange and the understanding of the context. Current construction planning often works on a “throw over the wall” basis - plans are developed only or mainly for control purpose, and ignore the “how” aspect. Construction method planning is treated as a linear process and isolated from information and logistics management. Planners are often puzzled by information; they usually receive a large amounts of formal and informal communications with different formats, some of which are not relevant to their role. The quality of the information received is also often poor (i.e. incomplete design information). In order to deal with the uncertainty caused by insufficient information, guesses are frequently made in the planning process, which neither the initial planner, nor the downstream planner will later check. They are usually ignored and left until execution of the plan, when the problems reveal themselves. This paper argues the importance of effective management of information flow in a planning process and the need to improve the management and planning of construction planning. A collaborative planning process model using a dependency structure matrix tool to manage and optimize the construction planning process is presented.

Keywords: Construction, Construction Planning, Information Modelling

1. Introduction

Successful project management requires the effective control of the planner teams and the exchange of information between them for successful planning management.

Traditionally, the efforts to improve planning have often stressed the technical side of the planning process, such as planning models, tools and software (Laufer, 1987). Few researchers try to improve the management and planning of the planning process itself.

In recent times, there has been increased understanding of the importance of the effective management and planning of a collaborative construction planning process. For example, John (20002) recently interviewed 18 construction planners on their daily practices in order to explore the construction project planning process. Eknarin (2004) highlighted the problems of “separation of execution from planning”, and developed an integrated decision support system for multi-constraining planning and control. Koskela (2000) argued that traditional planning methods are based on traditional production and project management derived from the transformation conception of production, which focus on activities but ignore the dimension of flow and value. Ballard (2000) states that in a traditional approach, materials, information and labour are “pushed” upstream. It is assumed that 100% resources are available and 100% constraints are satisfied. He developed the “last planner system” in order to reduce uncertainty, and to improve the reliability of a plan. Chau (2003, 2004) highlighted the resources site logistics and site layout plan, he applied 4D technology as planning and scheduling tool in construction, and further, he extended 4D technology into the areas of resource management and site utilization. Kathleen and Fischer (1998) highlighted the problems of that in current planning, the planner finds it difficult to explain “why do make such decisions”, and applied the 4D annotator as a visual decision support tool for construction planner. David (2004) and Akinci (2002) both recognized the importance of the management of time-space conflicts, and David developed an analytical system for space planning on construction sites. Akinci developed 4D modelling for time-space conflicts identification, P.P.Zouein and Tommelein (1995) highlighted the dynamic space scheduling and developed MoveScheduling in order to solve time-space conflicts by changing activity scheduling. Riley (1998) classified site space into 12 categories, and investigated the relationship between the space availability and task execution.

However, these researchers only focus on one or two aspect of planning, for example, Eknarin (2004) highlighted the constraints in the planning process. Kathleen and Fischer (2000) focus on decision making aspect of planning. David (2004), P.P.Zouein (1995), Akinci (2002), and Riley (1998) highlighted the importance of space in construction, and developed efforts in order to identify and reduce time-space conflict. Ballard (2000) highlighted the importance of reliability, uncertainty, and variability in planning. None of them address the importance of management of information flow in a planning process in order to improve the management and planning of a collaborative construction planning process. This paper presents a collaborative planning process model using a dependency structure matrix tool in order to manage and optimize the construction planning process.

2. Problems in Current Construction Planning

Effective planning is influenced by things such as the project delivery method, contract procurement, management of the client and supervision of the planning team, and encompasses factors such as information exchange management and quality management. However, it can be argued that the fundamental activity in the planning is to manage, to control and to evaluate planning tasks. An early part of the research involved a literature review and informal interviews with the academic researchers and construction industry professionals to investigate current practice in planning management and its associated problems (Baiyi, 2004). These professionals, who included architects, building services designers and planners, and building services site logistics engineers, identified the main problems in current construction planning process as being due to: (1) an inadequate method for information gathering and management; (2) insufficient training ; (3) misunderstanding of the nature of planning process; (4) inadequate methods for planning coordination; and (5) the cumbersome work structure in planning practice. These five problems are discussed in more detail in the following sections.

2.1 Gathering information

Planners often experience information gathering problems and lack of method for the effective management of information flows. Information is often “pushed” from the upstream players. Planners usually do not know how and where to get information. On the other hand, it is difficult for the planners to select the required information from huge amount in different formats from a variety of supply chain organisations and disciplines. In addition, the quality of much of the information received is often poor. For example, the planners often receive incomplete design information, In extreme cases, the planner may even have to redrawing some drawings. The most common problems, mentioned by most of the interviewees , are that the designers showed a lack of understanding of the installation space requirements. making installation difficult or even impossible. As a result, planners have to prepare plans with incomplete information and in order to deal with the uncertainty caused by information deficiencies, a lot of guess work must be taken in the planning process. However, neither the initial planner, nor the downstream planner will check these assumptions later They are usually ignored and are simply left until execution of the plan, when incorrect guesses manifest themselves. It is very common in current practice that the planners often start a planning task earlier than anticipated based upon assumed information. Eknarin (2004) had the same findings and points out that current planning approaches isolate the role of planning from information and logistics management

2.2 Training

Planning is not a easy task. Becoming a good planner requires a long training process, which includes not only a lot of site work experience, but also the knowledge of detailed construction methods. In additional, planners should have good communication skills, be keen to learn and familiar with new techniques, materials and regulations. However, we currently do not have formal academic training for construction planners, or any code to guide planning works.

2.3 Concurrent working

Current construction planning often works on the “throw over the wall “ principle, i.e. information is pushed on to the next person with little interaction. The client, designers, main contractor and subcontractors often develop their own plans in isolation. The selection of the construction method, scheduling activities and scheduling space are interrelated and interdependent – they should not be undertaken independently. The interdependences are often ignored at the planning stage and until execution. As a result, in current construction practice, the construction space allocation often works on the principle of “first come, first served”, and the choice of construction method depends on the self-interest of individual organisations. This leads to dynamic, complex and uncertain time-space conflicts. We argue that a subcontractor’s planning decisions should not be undertaken in isolation but that selection of the work methods (including prefabrication) and site logistics can have important impacts on time-space conflicts and may hamper the performance of other subcontractors..

2.4 Who and when?

There are two dilemmas in construction planning: who should do planning and when should they do it? Laufer (1992) pointed out that project managers have the capability to plan but are often busy undertaking other management issues, such as communication with clients, negotiation with designers and organising staff. The operational engineers have enough time, but they often experience difficulties in decision making and information gathering.

2.5 Nature of the process

The planning process is not linear but iterative. For example, the selection of construction methods could have a very important impact on space scheduling, and in turn, space availability could affect the subcontractor choosing their construction method. However, current planning practice takes little account of the interdisciplinary , iterative nature of the process. This leads to a compromised planning process containing inevitable cycles of rework together with associated time and cost penalties in both planning and construction. Plans are often developed only or mainly for control purpose, and ignore the "how" aspect, which is the other main purpose of planning. In construction the terms planning and scheduling are often used synonymously. Planning often refers to using scheduling techniques, such as CPM, bar charts or networks to produce a time related schedule. Neale (1989) defines planning "as a creative and demanding mental activity of working out what has to be done, how, by why, by whom, and with what, i.e. doing the job in the mind". However, scheduling is the determination of the timing of activities and follows logically from the planning process. In other words, scheduling is the process of producing a time related schedule of the planning decisions.

The literature review and research interviews indicated some problematical information related events, including: starting a planning task earlier than anticipated based upon assumed information, gate keeping (or withholding of planning information) among planning team members; predicting the impact of changes in planning information; assessing the result of missing information; evaluating the variation in the quality of information exchanged between different planning tasks; and releasing the information from different planning tasks in packages or phases. By understanding and making allowance for such events, it should be possible to improve the management of information flow, and hence the collaborative planning process. Our proposed solution is to develop a collaborative planning by a planning team, which includes the main contractor's planners, the subcontractors' planners, the estimators, the project manager and the detail designers. It is proposed that the main contractor's planners first spends a few days to conduct a preliminary investigation and constraints analysis and then identify project objectives, breakdown project into work packages, and develop an outline schedule and budget for each work packages. The subcontractors' planners then develop the detail plans to suit their own methods, according to the main contractor's planner's proposals (outline schedule and budget) and tender documents. Once all the detail plans are developed, coordination planning is conducted in a 4D virtual environment involving all the planning team. (it is similar with the traditional design coordination process, the "lights table method"). In the coordination meeting, most of the conflicts, such as time-space conflicts will be identified Resolved by either changing the work method, scheduling, or compressing the space required to solving the identified conflicts. However, for this approach to work, the effective management of information flow during planning is crucial. Therefore, it is obviousl that any solution of these difficulties requires some model of the planning process and the information flow therein.

3. IDEFOp: a Modified Version of IDEFO

Many modelling methodologies have been examined in order to identify the suitability of representing information flow. A review of the IDEF0 methodology found that although the technique is suitable to model a process, and can well represent information flow (Austin, 1999), some modifications could be made to the notation in order to enhance its advantages. The purpose of modelling a collaborative planning process is to represent information requirements, such as constraints, and not to indicate how each planning task should be undertaken, and hence there is a little benefit to be gained from representing process controls in the model. Also the review of problems in current practice i(section 2) identified poor information gathering methods and ineffective management of information flow. Planners sometimes do not know how, what or where to get information. In this research, the scope is limited to the preconstruction stage, and focuses on the main contractor preparing the initial construction plan for bidding purpose. Therefore, better use could be made of the top and bottom arrow features of an IDEF0 diagram by distinguishing the information inputs that are from the construction team, from the upstream participants, such as the clients, project managers and designers, and from the downstream participants, such as fabricators, subcontractors, and specialist suppliers.

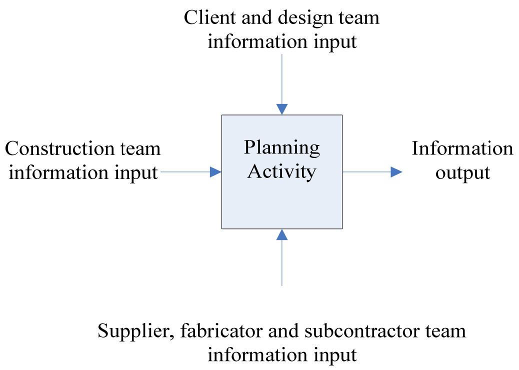

Figure 1: A Modified Version of IDEFO Technique

Figure 1 shows the notation implemented in our collaborative planning process model, termed IDEF0p, which varies from the standard IDEF0 notation in the following ways:

1. Construction team information inputs enter from the left – not Inputs;
2. Client and designers team information inputs enter from the top – not Controls; and
3. Suppliers, fabricators and subcontractors team information inputs enter from the bottom – not Mechanisms.

4. Modelling a Collaborative Planning Process

4.1 Creating a Planning process model

The collaborative planning process model was developed in two stages. Firstly, the activities within the overall process were identified and the hierarchical structure of them determined. At the highest level of the hierarchy is the process of collaborative planning which is then partitioned into the nine processes, as shows in Figure 2.

Once the highest level of the hierarchy was determined, discussion with planners then established how these nine planning processes should be divided into sub-processes, and how these can further divided into the bottom level individual planning tasks as shows in Figure 3.

Secondly, having established the hierarchy of the activities in the collaborative planning process, the information dependencies of each functional primitive tasks were determined so that the model could be constructed. This information was collated in tabular form, via input form practicing planners. Table 1 shows an example of an information dependency table.

4.2 Planning Process model Diagrams

The planning process model was compiled with Microsoft Visio 2003, by placing on to each diagram the activities identified in the process hierarchy and the information flows that each activity required. The source activity (whether construction team, client, designer, supplier, fabricator or subcontractor was then identified. and the information flows were attached to the appropriate tasks as either inputs or outputs using the IDEF0p notation described in Figure 1. Figure 4 shows examples of the collaborative planning process model diagrams.

The collaborative planning process model hierarchy can be traced for activity A4, “scheduling”, through activity A42, “activity scheduling” to planning tasks at the bottom of the hierarchy (activity A421, A422, A423). The detailed information flows are represented at the bottom level of the hierarchy, and at upper level, the information flows are grouped under headings that ensure the diagrams do not become confusing.

4.3 Planning Information Classification

Information classifications were allocated to each information flow by the practicing planners, which tabulated in the same form as was used to compile the information dependency table (Table 2 shows examples). In this research, the classification of the planning information adopted Austin’s method: information classifications were made on a three-point scale, A being the most critical information and C being the least (Austin, 2000)

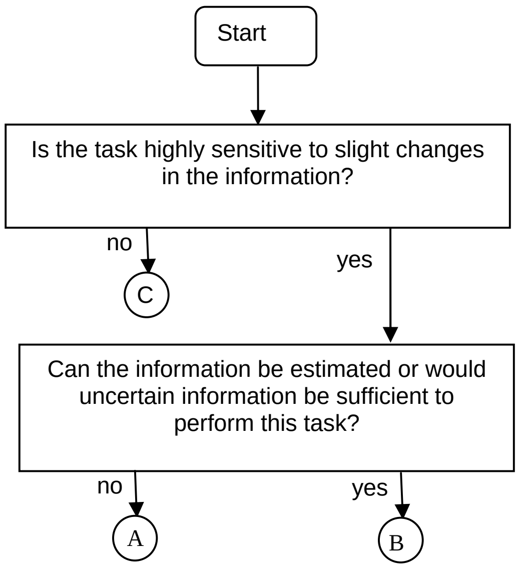

Figure 4: Allocation Classification on the Three-point Scale (Austin et al, 2000)

5. DSM Optimisation of Planning Tasks

Once the planning tasks and their information dependencies are represented in the process model, they can be analysed on the basis of their information requirement to identify an optimum order, This is achieved with a dependency structure matrix tool. Figure 5 shows an example of ordering of planning tasks. Figure 5a is the originally matrix developed directly from the information dependency table as shows in table 2. In a DSM the activities are undertaken in the order listed in the rows of the matrix,. Each mark in the matrix indicates that the activity on the left-hand side is dependent upon the activity in the column at the top of the matrix. This means that in the assumed order of activities, a mark below the diagonal show that an activity is dependent on the information which has been produced by the previous activity, whereas a mark above the diagonal indicates that an activity is dependent on the information that has yet to be produced. This can be overcome by estimating the information that is as yet unavailable and then verifying the estimate once the information-generation activity has been undertaken. In order to reduce the need for estimates, or latter evaluation and therefore iteration within the process, an algorithm reorders the activities within the matrix so the marks are below the diagonal or as close to it as possible, thus producing the optimal sequence of activities. The process of reordering the matrix is called partitioning. Figure 5 (b) shows the partitioned matrix.

5. Conclusion

This paper has described a collaborative planning process model using a dependency structure matrix tool in order to manage and optimize the construction planning process. This model has been developed through the production of a revised IDEFO process modelling notation termed IDEFOp, the implementation of a three-point information classification system and the formulation of an information location matrix. In order to reduce the need for estimates, or latter evaluation and therefore iteration the process is analysed using an algorithm to reorder the activities within the matrix so the marks are below the diagonal or as close to it as possible, thus producing the optimal sequence of activities.

The next stage of this research is to verify the content of this model by interviewing the practising planners and planning managers.and to validate this approach by applying to a live project.

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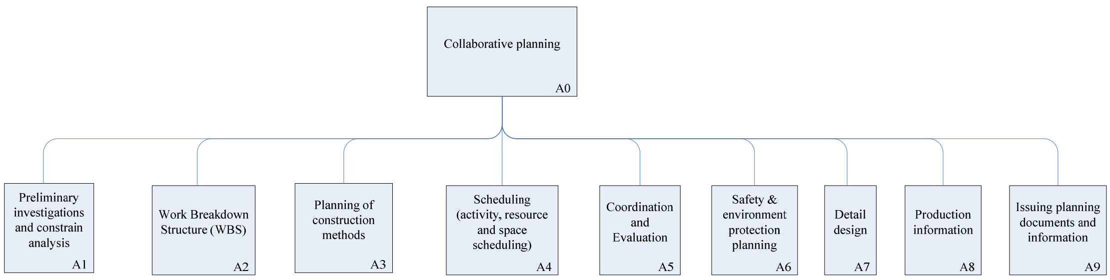

Figure 2: Planning Process Hierarchy

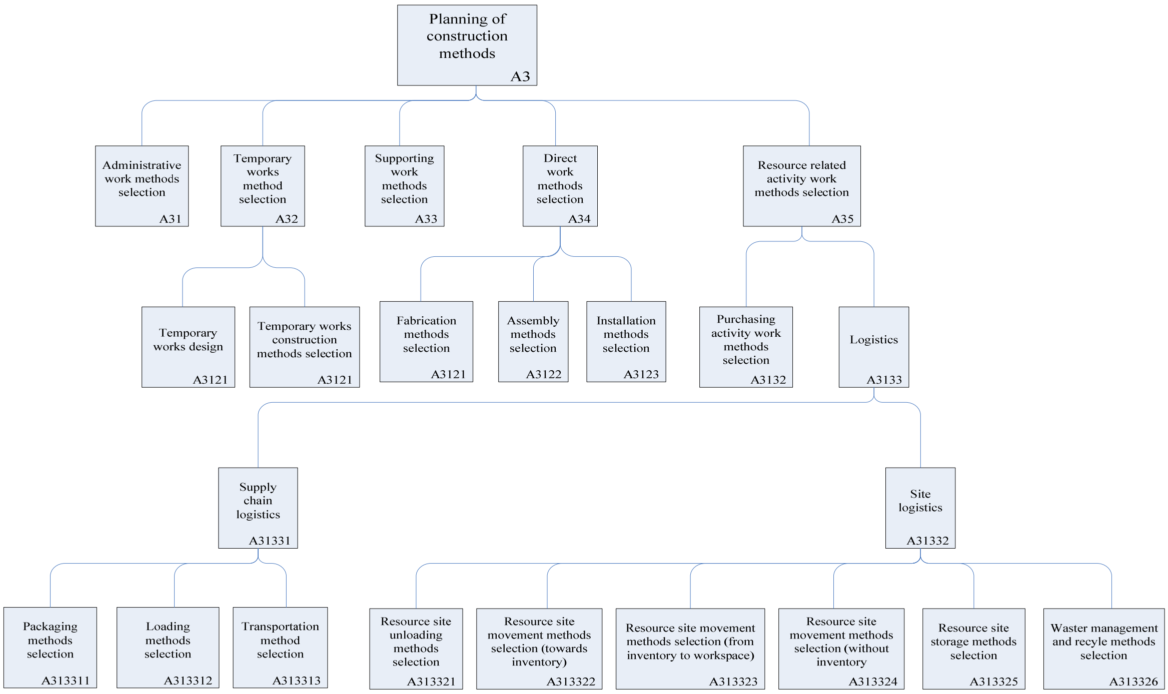

Figure 3: Planning the Construction Method Process Hierarchy

Table 1: Information Dependency Table

Task		Information Required		
Number	Name	Name	Type	Source Activity
A.3.4.1	Fabrication method planning			
		Preliminary investigation report	Constr	A.1.1
		Constraints analysis report	Constr	A.1.2
		Bill of components	Constr	A.2.1
		Outline schedules	Constr	A.2.2
		Cost plan	Constr	A.2.3
		Transportation system capability report	Suppli.	External
		Site resource moving system capability report	Suppli.	External
		Fabricators' feasibility report	Suppli.	External
A.4.1.4.1	Defining fabrication activity			
		Fabrication method statement	Suppli.	A.3.4.1
		Preliminary investigation report	Constr	A.1.1
		Fabrication instruction	Suppli.	External
A.4.2.1.4.1	Estimating fabrication activity duration			
		Fabrication method statement	Constr	A.3.4.1
		Fabrication activity defining	Suppli.	A.4.1.4.1
		Fabrication labour estimation report	Suppli.	A.4.2.2.2.4.1
		Fabrication plant estimation report	Suppli.	A.4.2.2.3.4.1
		Fabrication space estimation report	Suppli.	A.4.2.3.1.3
		Fabrication labour productivity	Suppli.	A.1.1.3
		Plant productivity	Suppli.	A.1.1.3
A.4.2.2.1.4.1	Estimating materials needed for fabrication activity			
		Fabrication method statement	Suppli.	A.3.4.1
		Fabrication activity defining	Suppli.	A.4.1.4.1
		Material consumed standard	Suppli.	External

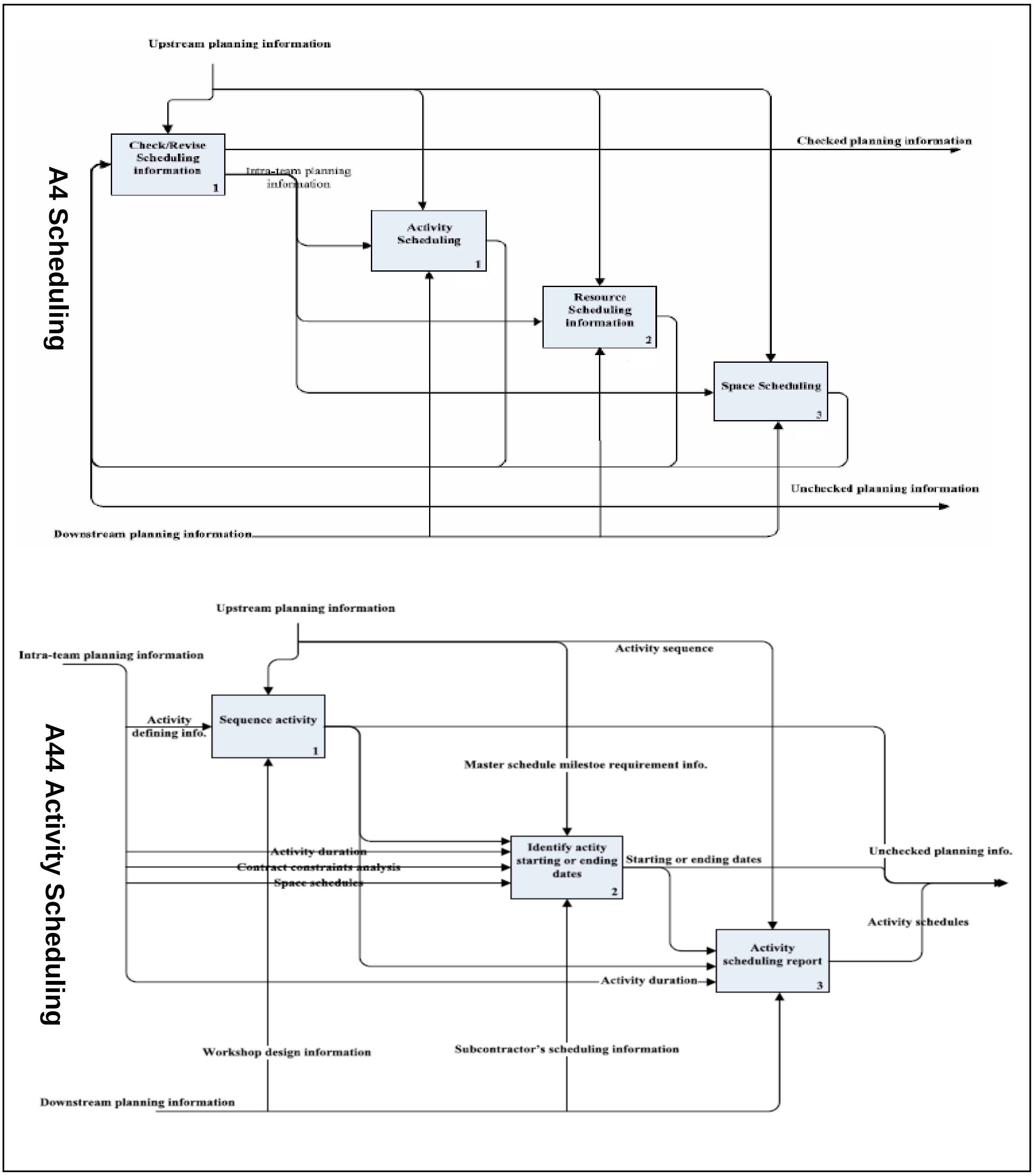

Figure 4: Planning Process Model Diagrams

Table 2: Dependency Table Formatted to Include Project-Specific Classifications

Task		**Information Required**			
Number	Name	Name	Type	Source Activity	Class
A.3.4.1	Fabrication method planning				
		Preliminary investigation report	Constr	A.1.1	B
		Constraints analysis report	Constr	A.1.2	B
		Bill of components	Constr	A.2.1	C
		Outline schedules	Constr	A.2.2	B
		Cost plan	Constr	A.2.3	B
		Transportation system capability report	Suppli.	External	A
		Site resource moving system capability report	Suppli.	External	A
		Fabricators' feasibility report	Suppli.	External	A
A.4.1.4.1	Defining fabrication activity				
		Fabrication method statement	Suppli.	A.3.4.1	A
		Preliminary investigation report	Constr	A.1.1	C
		Fabrication instruction	Suppli.	External	A
A.4.2.1.4.1	Estimating fabrication activity duration				
		Fabrication method statement	Constr	A.3.4.1	B
		Fabrication activity defining	Suppli.	A.4.1.4.1	A
		Fabrication labour estimation report	Suppli.	A.4.2.2.2.4.1	A
		Fabrication plant estimation report	Suppli.	A.4.2.2.3.4.1	A
		Fabrication space estimation report	Suppli.	A.4.2.3.1.3	B
		Fabrication labour productivity	Suppli.	A.1.1.3	A
		Plant productivity	Suppli.	A.1.1.3	A
A.4.2.2.1.4.1	Estimating materials needed for fabrication activity				
		Fabrication method statement	Suppli.	A.3.4.1	A
		Fabrication activity defining	Suppli.	A.4.1.4.1	B
		Material consumed standard	Suppli.	External	A

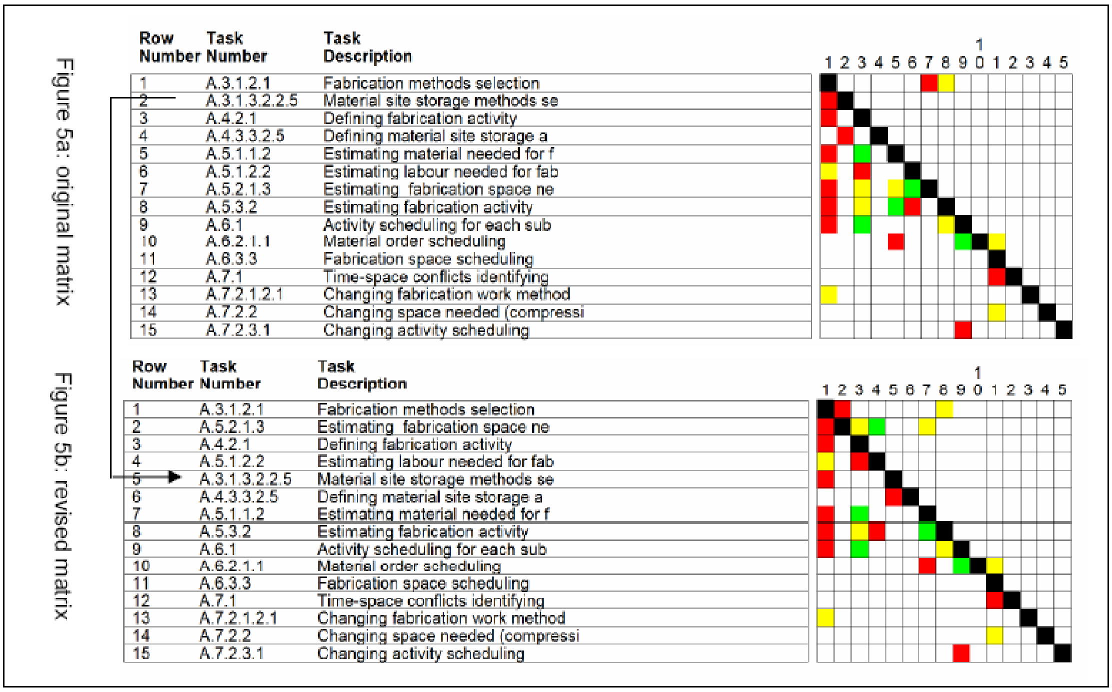

Figure 5a: original matrix

Row Number	Task Number	Task Description
1	A.3.1.2.1	Fabrication methods selection
2	A.3.1.3.2.2.5	Material site storage methods se
3	A.4.2.1	Defining fabrication activity
4	A.4.3.3.2.5	Defining material site storage a
5	A.5.1.1.2	Estimating material needed for f
6	A.5.1.2.2	Estimating labour needed for fab
7	A.5.2.1.3	Estimating fabrication space ne
8	A.5.3.2	Estimating fabrication activity
9	A.6.1	Activity scheduling for each sub
10	A.6.2.1.1	Material order scheduling
11	A.6.3.3	Fabrication space scheduling
12	A.7.1	Time-space conflicts identifying
13	A.7.2.1.2.1	Changing fabrication work method
14	A.7.2.2	Changing space needed (compressi
15	A.7.2.3.1	Changing activity scheduling

Figure 5b: revised matrix

Row Number	Task Number	Task Description
1	A.3.1.2.1	Fabrication methods selection
2	A.5.2.1.3	Estimating fabrication space ne
3	A.4.2.1	Defining fabrication activity
4	A.5.1.2.2	Estimating labour needed for fab
5	A.3.1.3.2.2.5	Material site storage methods se
6	A.4.3.3.2.5	Defining material site storage a
7	A.5.1.1.2	Estimating material needed for f
8	A.5.3.2	Estimating fabrication activity
9	A.6.1	Activity scheduling for each sub
10	A.6.2.1.1	Material order scheduling
11	A.6.3.3	Fabrication space scheduling
12	A.7.1	Time-space conflicts identifying
13	A.7.2.1.2.1	Changing fabrication work method
14	A.7.2.2	Changing space needed (compressi
15	A.7.2.3.1	Changing activity scheduling

Figure 5: A Example of Reordering Planning Tasks Using DSM