GO OR NO-GO DECISIONS AT THE CONSTRUCTION WORKFACE: UNCERTAINTY, PERCEPTIONS OF READINESS, MAKING READY AND MAKING-DO

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ABSTRACT

Construction work is performed at the end of a chain of decisions made by the individuals involved in planning the work at increasingly detailed levels of resolution. At each step planners make decisions based on their perception of the state of readiness, or maturity, of the work, but there is always, by definition, some residual uncertainty. Therefore, fine-grained planning decisions are often required even after commitments are made in weekly work planning using the Last Planner® System. These decisions can result in abandoning (or stopping) the planned work or improvisation or 'making-do'. However, the motivations and context of these decisions are not well understood. Empirical data collected over eleven weeks at a large residential construction project enabled synthesis of a taxonomy of scenarios and proposal of a candidate flow chart of the decision-making process at the operational level. In doing so, we define questions for future research concerning the impact of uncertainty on decision-making in this context.

KEYWORDS

Last Planner® System, make-ready, making-do, decision making, individual behavior and motivation, task maturity, uncertainty.

INTRODUCTION

Much of lean construction research and practice has focused on creating reliable and stable workflows. Koskela's introduction of the flow view of production in construction, within the Transformation-Flow-Value theory (Koskela 1992; Koskela 2000), together with the work of Howell et al. (Howell, Laufer et al. 1993), paved the way for research of the impact of instability on construction flows. The subsequent work of Tommelein et al. (Tommelein, Riley et al. 1999), Bertelsen et al. (Bertelsen, Henrich et al. 2007; Bertelsen and Sacks 2007), Sacks et al. (Sacks, Esquenazi et al. 2007) and others exposed the direct link between instability in production and measures of throughput, work-in-process and cycle times. The parallels with the theory of production in manufacturing, as set out by Hopp and Spearman (Hopp and Spearman 1996), with special emphasis on Little's Law, were drawn.

The Last Planner® System (LPS) (Ballard 2000) was devised for the purpose of achieving reliable and stable workflows, and many in the construction industry

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perceive it to be the primary practical tool of lean construction. Construction work actions are performed at the end of a chain of decisions made by the people involved in the planning of the work at increasingly detailed levels of resolution. Originally, LPS® stages were defined as master planning, phase planning, look-ahead scheduling and weekly work planning (Ballard 2000). Subsequently, the daily 'huddle meetings' formalized by Toyota were adopted in construction to extend collaborative decision-making beyond weekly work planning (Liker 2003, Macomber 2006). However, disruptions to achieving smooth work flow still occur, such as when materials that were planned to arrive at a certain point in time are delayed, or defects in earlier work are discovered, or when equipment fails. Extensive evidence has shown that even under the best practice of LPS®, percent plan compete (PPC) measures do not reach 100% (Alarcon et al. 2005; Bortolazza et al. 2005).

Whether immediately prior to the start of work or after work has begun, any unforeseen events that prevent completion of the work as planned require adhoc decision-making. Decisions can result in desisting from starting the work, stopping the work if it is already in progress, or improvisation or making-do and continuing in either case. These fine-grained planning decisions on the operational level, made by the crew leaders (the last planners), are critical in determining the actual flow of work on site and its quality, but they are not well understood. The motivations of the last planners in making their decisions are dependent on many factors like perception of the state of readiness, or maturity of the work. Furthermore, last planners amd workers are individuals and their decisions are influenced by multiple factors, many of which are unrelated to the overall project goals, or even to the goals of the organization by which they are directly employed (such as maintaining profitability by using resources effectively).

Given that even in the best projects PPC measures do not reach 100%, we hypothesize that:

- Short term operational decisions concerning coordination, execution and control of work are required; that these decisions often result in making-do; that making-do can deliver full planned value in some cases; and that go/no-go decisions are often delayed while more detailed information is gathered.
- Decisions made at the workface by individuals are influenced by many 'soft' aspects, such as personal past experience, reputation, risk aversion, and/or other individual imperatives.

Our purpose is to define research questions concerning these issues, and to challenge the lean construction community to explore them with a view to improving our understanding of the ways in which managers at all levels deal with uncertainty when making decisions that have a fundamental impact on the stability of workflow. We propose to frame the issues and research directions that will lead to a theoretical map of the decision-making and working process, in the hope that such a theory will eventually enable improvement of the LPS® and development of additional methods, tools and techniques for improving reliability and stability of work processes. This requires close study of literature defining the state of the art understanding of decision-making and its processes, and empirical observations of real-life cases.

LITERATURE REVIEW

Construction projects are often characterized as complex and dynamic processes that have inherently high degrees of uncertainty. Uncertainty can be defined as gaps in that information required by a project team to perform a task, which is unavailable (Winch 2010). Furthermore, uncertainty can be divided into two categories, "*ends uncertainty*" (what to do) and *means uncertainty* (how to do it) (Laufer 2009, Winch 2010). The two are interdependent, i.e. the means facilitate the ends, and the ends dictate the means.

Simon (1973) distinguishes between *ill-structured* and *well-defined* problems. An *ill-structured* problem is one whose structure lacks definition in some respect; the goals to be attained by solving the problem may be vague or non-quantitative at the outset of the problem solving process, and it may not be clear what information is required for solving the problem. However, at the level of detail we are considering in this paper, where workers or crew leaders make short-term operational decisions concerning coordination, execution and control of tasks on site are more akin to *tamed* problems. The desired outcomes are known, but the methods are brought into question. The issues arise due to organizational and coordination complexity, and relate primarily to means uncertainty. Indeed, analysis of the root causes for 345 cases of 'making-do' observed on two projects in Brazil revealed that means uncertainty was responsible for more than 90% of the cases (Formoso et al. 2011).

When crew leaders are confronted with conditions that differ from those contemplated in the production plan (typically the weekly work plan), they must decide whether to pursue the task at hand or to abandon it. Numerous factors influence these decisions, and their motivations include personal as well as company or project goals. For example, Sacks and Harel (Sacks and Harel 2006; Sacks 2008) explored the motivations of subcontractors and project managers in assigning crews to projects, showing, using economic game theory, that uncertainty in planning leads to defensive lose-lose behavior patterns, where the decisions made are driven by risk-aversion rather than seeking optimal benefit for all.

However, Sacks and Harel's model was limited in that it assumed rational economic self-interest on the part of the project manager and subcontractors. It was also only capable of reflecting the interests of the companies, not of the individuals. Individuals' decision-making in essentially economically-driven situations, similar to the situations of the crew leaders we are concerned with here, has been the focus of extensive research in economics and psychology. The seminal work of Kahneman and Tversky (1979, 1992), known as 'Prospect Theory', highlights the differences between the influence of potential gains and the risk of loss in motivating people's decisions. For instance, when faced with open-ended situations that offer many possible courses of action, people tend to simplify the problem using heuristics. Others, such as Ariely (2008) have highlighted the irrational ways in which people approach what are apparently purely rational economic decisions.

'Making-do' waste (Koskela 2004) occurs when work is executed under sub-optimal conditions, i.e. before all of a task's preconditions have matured. Koskela (2000) defined the following prerequisites for performing a task correctly and smoothly: information (product and process), components and materials, workers, equipment, space, technically precedent works and external conditions. A conventional wisdom commonly encountered among construction professionals is that the differences from project to project, coupled with the uncertainty inherent in complex operations and coordination between multiple actors, make it a common occurrence that one or more prerequisites for a given task are not mature when its planned time arrives; and that in these conditions, the ability to improvise is a virtue. Telem et al. (2006) found that the most successful project managers were those who were most able to adapt to changing, dynamic conditions. However, while buildings and project organizations differ from project to project, at the operational level the work by its nature is typically very similar across most projects. Tiles are laid, pipes are installed, and walls are built in the same way. Lean construction principles suggest that improvisation as a rule reduces the productivity of construction operations, which should follow standardized work methods and techniques under properly planned and prepared conditions (Diekmann et al. 2004; Forbes and Ahmed 2011 p. 367).

METHOD AND RESULTS

The third author led an intervention in a large residential construction project, implementing a version of LPS® in the interior finishing works of two eight story buildings. Over a period of five months he observed all of the weekly work planning decisions. For the latter 11 weeks he also followed them up, recording not only whether they were completed as planned or not, but also any interim decisions that were made during the week. The data were then sorted according to the nature of the interim planning decisions and the actual outcomes, resulting in a taxonomy of typical work outcomes. The relative frequency of each of the typical outcomes in the taxonomy was then calculated. A flowchart was prepared to describe the process graphically.

Figure 1**: Data collection format with one example of each different category of task go/no-go decisions and their outcomes** shows the format used to record and analyze the data collected. The table includes columns for listing whether the tasks were completed as planned or not, whether there was any making-do, whether the decision to start was delayed, and what the outcome was (achieved full, partial or no value). The data was sorted according to the combinations of values of these properties. Each distinct set of values was defined an outcome scenario, thus compiling a taxonomy of all the different outcome scenarios that were observed. One typical row for each outcome scenario is shown in the table.

Table 1 shows the cumulative results for the different scenarios. As can be seen in the first row of data, 63 tasks were completed as planned, giving an average PPC of 63%. 13 more tasks yielded full value although they were completed late, while four had to be stopped. Thus 80% of the tasks in the sample were considered to be fully mature at the time they were due to begin. However, 21 of the tasks were recognized to be lacking prerequisites at their start. Of these, nine were abandoned (no-go decision) and some form of making-do was attempted in the remaining 12. In half of the cases of making-do full value was achieved, albeit some were completed late. A final observation is that in nine of the 101 cases, the go/no-go decision was postponed.

Thus the taxonomy of cases is as follows:

A. The task is mature at its planned start and full value is achieved, even if completed late. This corresponds to the path through nodes 1-5-8 in Figure 2.

Task number	Weekly Work Plan Dates	Description	Location (building - floor)	Were all constraints removed?						PPC	Remarks
				Yes		No					
				Finished (full value)	Stopped (partial value)	Performed work by making-do		Postoned decision	No- Go		
						Finished (full value)	Stopped (partial value)				
…	…	…	…	…	…	…	…	…	…	…	…
#9	3/15-3/21	Plumbing	11-May		80%					0	Finished only 80% of the work because some piping parts were missing
…	…	…	…	…	…	…	…	…	…	…	…
#18	3/15-3/21	Finishing concrete work	10-Aug						1	0	The task was not done because the crew did not arrive and was unavailable all week
…	…	…	…	…	…	…	…	…	…	…	…
#31	3/29-4/4	Drywall partitions	11-Aug	1						1	
…	…	…	…	…	…	…	…	…	…	…	…
#35	3/29-4/4	Plumbing	10-Jul			1		1 day		0	Electrical work in the apartment was not finished; they made-do by working together in the same space.
…	…	…	…	…	…	…	…	…	…	…	…
#82	5/3-5/9	Cleaning of laundry rooms	10	1						0	The task started in time but was completed one day late
…	…	…	…	…	…	…	…	…	…	…	…
#99	5/3-5/9	Drywall partitions	10-May				80%			0	A thte time the task began, the flooring work was not completed. Only 80% of the planned work could be performed.
…	…	…	…	…		…	…	…	…	…	…

Figure 1: Data collection format with one example of each different category of task go/no-go decisions and their outcomes

B. There is uncertainty at the start time, but gathering information resolves the issue and the task is delayed but completed successfully (path 1-2-3-1-5-8).
C. The task is judged to be mature and started, but in fact it cannot be completed (path 1-5-9).
D. There is uncertainty at the start, the deicsion is postponed, but even after presumed resolution the task cannot be completed (path 1-2-3-1-5-9).
E. The task is not mature at its start, but making-do leads to successful completion with full value achieved (path 1-2-3-6-5-8).
F. As for E, but only partial value is achieved (path 1-2-3-6-5-9).
G. The task is not mature, and the decision is 'no-go' (path 1-2-3-4).

Table 1: Cumulative values for the scenario outcomes for the whole data set

Outcomes	**Timing of Task Start or Decision**		**Total**	**Description or Example (Row No. in Figure 1)**
	On-time	Delayed		
As planned	63		63	#31
Successful, but completed late	9	4	13	#82
Achieved partial value	2	2	4	#9
Making-do				
Successful (achieved full value)	4	2	6	#35
Unsuccessful (achieved partial value)	6		6	#99
No-go	8	1	9	#18
Totals	92	9	101	

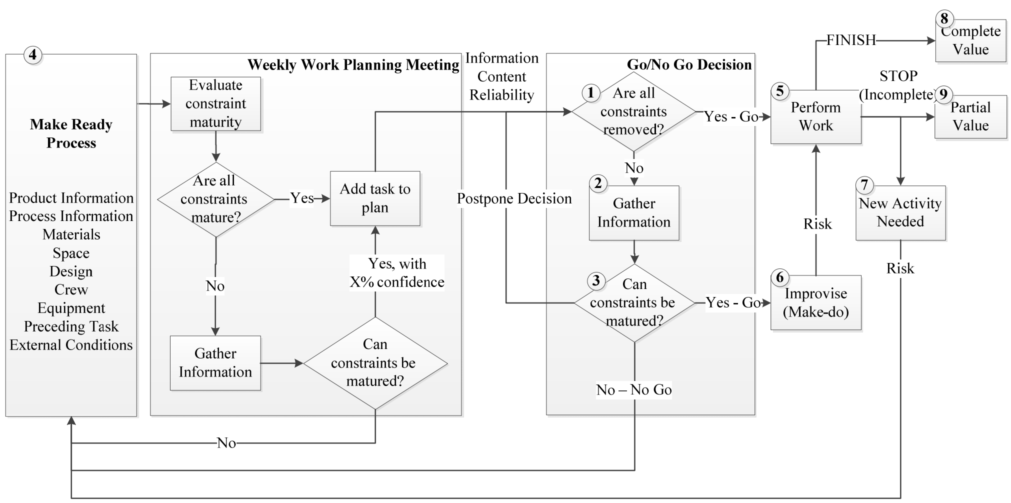

Figure 2: Candidate process map of the make-ready, weekly work planning and go/no-go decision process in construction

GO/NO-GO DECISION MAKING PROCESS

Figure 2 represents a hypothetical process map of the planning and decision-making process in construction operations. The left-hand side describes the flow of decision-making as tasks are planned in a make-ready process, checked for maturity, and promoted to a weekly work plan according to the LPS®. Crews commit to perform work in weekly work scheduling meetings on the basis of

a) their assessment of the information available to them concerning the maturity of the prerequisites for their work;

b) their level of confidence in other actors who are responsible for fulfilling prerequisites (such as previous work) that are not yet complete;

c) their personal experience and ability to foresee, assess and accept the risks that arise from residual uncertainty that cannot be completely eliminated

The right-hand side follows the task as it becomes due, and crews make decisions at the work face as actual conditions emerge. If the task is sound, work goes ahead (go); but if not, the crew may gather additional information and then make an assessment – to abandon the task (no go) or to proceed on the assumption that any immature preconditions can be fulfilled through some form of 'making-do' or improvisation (go with risk). Once a task is begun, it may be completed as planned (finished with full planned value), or it may need to be stopped, in which case some partial value may have been generated.

DISCUSSION

The taxonomy of scenarios illustrate the ways in which crews can respond to situations in which the context that emerges at the time that work was planned to begin does not conform to the context envisaged in the plan. It is at this point that making-do is introduced into the process. Making-do implies executing a task when one or more of its prerequisites are not mature, and in theory, it only occurs when the making ready process has not anticipated the conditions. In this sense, making-do complements making ready. As the top row of Figure 3 illustrates, in an ideal lean construction world, the make-ready process is complete, no making-do is needed, and work proceeds exactly as planned. In traditional construction, illustrated in the second row of Figure 3, the make-ready process is often minimal, and therefore a great deal of making-do, or fire-fighting, is needed. In many companies, fire-fighting skills are highly respected among project managers in traditionally managed projects.

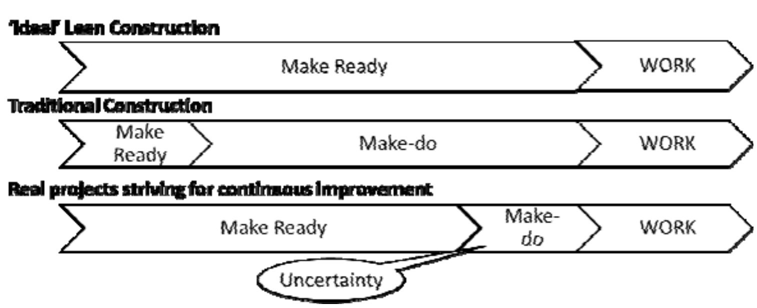

Figure 3: Relationship between making ready and making-do

Yet no projects function in 'ideal' conditions, so that even in lean projects, crews still confront situations where some pre-requisites remain unfulfilled. The bottom row of Figure 3 shows how uncertainty remains, necessitating some residual level of making-do. But even then, partial or even full value can be attained if making-do is successful. While it is intuitive to assume that a planned activity will always be more productive and safer than an activity that involves making-do, the make-ready process itself requires resources and time. The first question we raise, therefore, is:

- Is there an economic trade-off between the additional effort in making-ready versus the effort required for making-do? This must be answered at the systems level. For example: what is the right amount of time for a team of people to spend in planning meetings? How much planning is enough planning?[2]

Another question that arises is that of the semantics of 'making-do':

- Is 'making-do' a form of waste?

The scenarios show that where making ready is incomplete and the crews decide to 'make-do' and continue, there can be three distinct outcomes: 1) flow stops if work cannot be done, 2) flow is sub-optimal and only partial-value can be achieved in the product, or 3) work is completed and full product value is achieved. Thus making-do appears to be a sign of sub-optimal flow, much in the same way that work in progress inventory is a sign of sub-optimal flow.

Additional research questions concern the ways in which use of the LPS® might change or influence individuals' behaviors when they are confronted with the need to make 'go/no-go' and 'making-do' decisions. For example:

- Do people have less framing toward their individual interests when in a lean context than in a traditional context? What are the drivers that influence the decisions that people make in planning and executing work?

We hypothesize that the planning meetings, apart from their technical planning function, lead to development of a social system among the crews. As such, mutual commitment may rise and impact the framing of their decisions, leading to more collaborative behavior than in traditional settings. If this is indeed the case, then it leads to the possibility to pro-actively enhance the effect, for example by instituting a form of '*social subcontract*' among teams to complement the LPS®, with the aim of encouraging increased communication and coordination, and decisions that serve communal good and avoid waste.

Other issues that have been raised previously but remain unresolved include:

- Sacks et al. (2010) sought to establish metrics for the processes described in Figure 2. Is it possible to measure the degree of maturity (or, conversely, of uncertainty) of a planned task, and to track the development of that maturity over time? What units of measurement might be appropriate? Can such metrics be useful to help planners make better decisions? Can we measure the

[2] This question has been raised by authors in other contexts, specifically by Laufer, A. (2009). *Breaking the Code of Project Management.* New York, United States Palgrave Macmillan.

value of 'good' and reliable systems (robust/reliable supply chains, decoupled chains, correctly buffered systems, etc.)?

- To what degree do people's perceptions' of maturity differ (from those of other people in the process or from some objective measure)?
- Why is PPC generally low, and how high can (or should) it be taken? Can it reach 100%, in theory?

CONCLUSION

Due to the complexity of construction operations and residual uncertainty, unexpected contexts emerge in construction operations that require adaptive decision-making. These decisions are not only influenced by economic drivers (assumed for rational decision-makers) but also by the values, experience, and personal interests of each individual, and by their perception of the state of readiness, or maturity, of the work. The motivations and context of these decisions are not well understood but they impact on the project as a whole.

Empirical data shows that even where the LPS® and its enhancements are applied, there are limits to the level of detail and to the span of control to which the formal process can extend. At fine-grained resolution, responsibility is local, and each actor makes their own decisions, based primarily on their own interests, both as a representative of a company and as an individual.

The taxonomy of scenarios and the initial model of the 'go/no-go' decision making process presented in this paper are only a first step towards a more comprehensive theoretical model. However, they suggest that making-do is not necessarily wasteful, and help highlight a number of questions concerning the relationship between making ready and making-do. Further research is needed to establish how people behave within this context, as a basis for further development of lean construction approaches to improve the outcomes that depend on peoples' planning and decision-making at the operational level.

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