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STRATEGIC TAKT PLANNING

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ABSTRACT

Reports on the use of takt tend to focus on applications aimed at so-called operational takt planning. Instead, this paper focuses on strategic takt planning. Strategic- and operational takt planning must go hand in hand. Specifically, strategic takt planning is required upfront in project delivery as it informs prospective contractors what is expected of them regarding their capacity allocation, and supply chains must be lined up to meet the crews' just-in-time delivery needs to meet customer demand. Without a strategic takt plan that spells out assumptions embodied in the procurement schedule, it may be difficult (without later requiring contract adjustments) to onboard specialty contractors and suppliers who are then willing and able to jointly develop their operational takt plans and execute their work accordingly. This paper describes how, during strategic takt planning, project execution strategies can be explored based on alternative choices of a takt and the number of takt zones, and how plan options can be evaluated without requiring many project specifics. The computation and exploration of the merits of alternative options contribute to the body of knowledge on takt planning. They lead to better alignment between contracting- and operational strategies when maximizing flow is the objective.

KEYWORDS

Strategic takt planning, operational takt planning, takt production, project execution strategy.

INTRODUCTION

The use of takt planning in the construction industry varies in terms of the types- and phases of projects where it is used, the methods for choosing which steps to include in a process, how to zone the work space and level step cycle times, zone by zone, so that process flow, crew flow, and other flows are balanced and the takt will be met. But how does one know what the takt should be at which to deliver a process or project, and when can one define takt targets?

Many reports on the use of takt tend to focus on applications that are aimed at so-called operational takt planning. This term refers to takt planning at the level of information availability and detail corresponding to the Phase Planning level of planning in the Last Planner System® (Ballard & Tommelein 2021) (Figure 1). That is, operational takt planning requires the engagement of those specialists already involved and committed to performing the work themselves. It takes place after specialty contractors and key suppliers have been procured and by then the project is well underway. When takt planning is done without the benefit of strategic foresight, the process

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must be highly collaborative and enabled for example by commercial terms that spell out shared risks and rewards (e.g., Tommelein 2017).

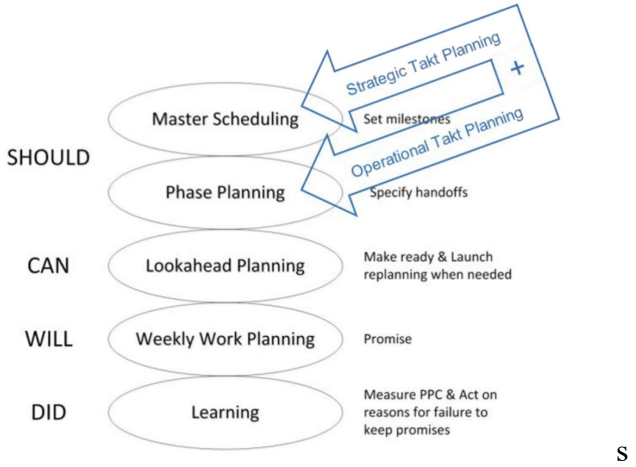

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Figure 1: Strategic- and Operational Takt Planning Relative to Levels in the Last Planner System® (Figure 6 in Tommelein & Pak 2019).

For an operational takt plan to serve its purpose, which is to document an agreed-to plan that can be made ready for execution, specialty contractors must previously have committed their willingness to coordinate their work by means of a takt plan and allocated their capacity accordingly, and supply chains must previously have been lined up to meet their crew's just-in-time delivery needs, zone by zone, etc. (Figure 2). Therefore, before engaging in operational takt planning, another takt planning process must be initiated much earlier in time, e.g., during validation or the early schematic design phases of the project life cycle. This earlier takt planning process must take into account the availability of information and detail corresponding to the level of Master Scheduling in the Last Planner System®, so-called strategic takt planning (Figure 1). This distinction between strategic- and operational takt planning is not articulated clearly in the literature.

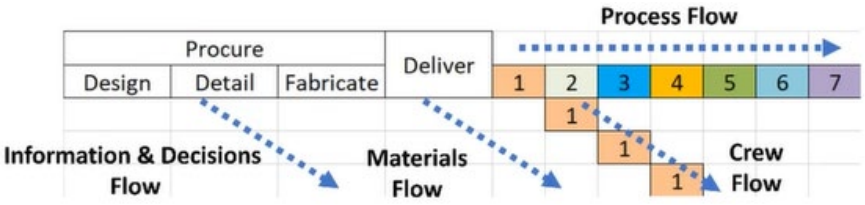

Figure 2: Alignment of Design and Supply Flows to Match the Takt of the Construction Process

This paper starts with a brief literature review. It then offers a set of definitions that distinguish strategic- from operational takt planning and customer- from operable takt, and that explain how work phases relate to sequences of operation steps (processes). Focusing on strategic takt planning rather than operational takt planning, the main section of this paper presents computations that make it possible to rapidly articulate alternative project execution strategies and then to assess the qualities of each one so that a suitable strategy can be chosen early on in project delivery. These computations demonstrate how takt and zoning choices can be decided without as-of-yet knowing many specifics of the project.

LITERATURE ON TAKT IN CONSTRUCTION PLANNING

Takt planning is a work structuring method used in the Last Planner System® (Ballard et al. 2001, Emdanat et al. 2016). The term takt planning can also refer to related methods used in other multi-tiered planning systems (e.g., Dlouhy et al. 2016, Binninger et al. 2017).

Takt planning is an enabler for Lean Construction (e.g., Tommelein & Emdanat 2022). It has been used to plan production on projects in various industries including healthcare (e.g., Frandson et al. 2013, Linnik et al. 2013), manufacturing (e.g., Dlouhy et al. 2018), pharmaceuticals (e.g., Tommelein & Pak 2019), infrastructure (e.g., Fiallo & Howell 2012), housing (e.g., Vatne & Drevland 2016, Lehtovaara et al., 2019, Barth et al., 2020), and many more (e.g., Heinonen & Seppänen, 2016, Tommelein et al., 2024, Tommelein & Lerche, 2023).

An appeal of takt planning is that the duration of a project can be reduced and made more predictable when effort is devoted to reducing variability and then judiciously buffering to prevent variability from being passed on and reverberate through the remainder of the schedule.

Takt planning methods make use of various types of buffers to achieve shorter durations and greater schedule predictability (e.g., Horman & Kenley 1998, Horman 2001, Frandson et al. 2015). In particular, the calculated end buffer is of strategic importance. Dlouhy et al. (2019 p. 431) define it as "the total cumulative time that can be saved from an optimized process flow. While this buffer may seem unnecessary at first glance, in reality it is deliberately planned. It communicates a general reserve of time that is at the project's disposal and which can be used, if the project requires it. If there is no need for its usage, it can be accounted for as time gained. This makes it the most effective type of buffer." They do not, however, describe when in the delivery process this calculated end buffer can be established. It can be established during strategic takt planning, as will be illustrated in this paper.

In practice, takt planning practices in the construction industry vary in terms of the types of projects and phases where it is used, the methods for choosing which steps to include in a process, and how to level step cycle times, zone by zone, so that the takt will be met. But what is the takt to be met?

This paper highlights the notion that the takt to be met is a calculated value. Per definition, takt is the unit of time within which a product must be produced (supply rate) to match the rate at which that product is needed (demand rate). To compute a takt, the customer's demand rate must be understood. In part due to the relative novelty of takt planning concepts, all too often it is not obvious to project owners how to specify it. It is more typical for owners to articulate their demand based on past project experience and accordingly specify what their expectation is for the project's completion time.

DEFINITIONS

CUSTOMER DEMAND

Customer demand is defined as the overall duration of a project chunked into overlapping work phases (this definition is more specific than the definition of phases in the Last Planner System®). Work phases identify related process steps and, correspondingly, each work phase has well-defined boundaries in space and time (milestones). Strategic takt planners will likely estimate the duration of each work phase based on their experience with work of similar scope and size, and then adjust and validate that estimate in the course of further planning. The overlap between work phases is determined by the strategic takt analysis process and may subsequently be adjusted when production planners consider various zoning strategies (e.g., delineating the spatial boundaries of

each zone). Generally speaking, fewer zones will result in a longer duration of a work phase and that work phase would require more overlap with other work phases in order to meet customer demand; in contrast, more zones and the resulting shorter work phase duration may reduce the need to overlap work phases.

STRATEGIC- AND OPERATIONAL TAKT PLANNING

Strategic takt planning is done upfront in a project's delivery process when the structure of the project production system is to be determined (Emdanat 2024). At that time only a limited amount of project information will be available, yet, as is described in this paper, it can be meaningfully done to explore alternative project execution strategies that will shape the takt planning process. The goal is to design a production system that flows from the beginning (e.g., Figure 2).

In contrast, operational takt planning is done later during the design or the detailing phases of a project, or possibly even later, when enough information has become available about quantities and locations of items as well as crew production rates so that these can be included in the takt analysis. This increasingly detailed information will allow teams to refine the areas and shapes of their takt zones, for example by taking work density into account (Tommelein 2022).

Strategic takt planning and operational takt planning must go hand in hand. A strategic takt plan informs owners about the feasibility of their project, and designers, suppliers, and contractors what is expected of them regarding their allocation of capacity and work timing, the nature of handoffs, just-in-time delivery needs, etc. to meet customer demand. It helps clarify the expectations of those who will be contracted to perform the project. In contrast to strategic takt planning, operational takt planning involves signatories to the contract who will be delivering the project and engages them in collaborative planning sessions, so that they can develop shared understanding and agree on a plan to execute and control the work (Tommelein 2017).

CUSTOMER TAKT VS. OPERABLE TAKT

As mentioned, the calculated value of takt as defined by a customer's demand may be called the customer takt. In contrast, rather than looking 'outside' at the customer, one can also look 'inside' a process and refer to a so-called operable takt. Customer takt, as will be illustrated in this paper, can be calculated with fewer parameters than operable takt and this calculation can be done earlier in the project, well before the operable takt can be ascertained.

Considering the sequence of steps that make up a process, a duration can be determined (likely with some degree of variability) for each step. This duration is called the workload or step cycle time. In any process, it will always be the case that at least one step's workload is larger than every other step's workload. That workload peak defines the "Operable Takt Time [which is] the pace you can actually achieve with your current process and equipment. This is a manufacturing-focused metric." (Moran 2022).

To meet the customer demand, the operable takt must be less than the customer takt. The difference between the two serves as a capacity buffer that is needed to absorb duration variability. Protecting the takt plan from such variability is commonly done by underloading resources (i.e., creating a capacity buffer) or by allocating time- or space buffers (Frandson et al. 2015).

WORK PHASES AND SEQUENCES OF OPERATION STEPS

Work phases refer to distinct scopes of work in a project and are bound by well-defined handoffs from and to other work phases. They comprise clearly identifiable sequences of operation steps. These steps define processes that will be takted. An objective of takt planning is to create process flow (Figure 2).

So, a process comprises steps, each of which is performed by a trade, and that trade typically differs from the trade performing an adjacent step (e.g., Figures 2 and 3 depict each trade using a different color). Any given trade typically must perform several steps to complete its operation. Combined, the sequences of operation steps and their associated work phases are the foundations for strategic takt planning calculations.

STRATEGIC TAKT PLANNING

THEORETICAL CALCULATION

The duration D of a work phase may be expressed, as shown in Equation 1, in function of the number of steps (S) in a process that will be repeated on multiple floors (F) in that work phase, the number of zones (Z) dividing the work space on each floor, and the takt T(Z). Here T is written as a function of Z because generally speaking—but not always (e.g., see Jabbari et al. 2020)—a lower customer takt will be within reach when a work space is divided more (i.e., the number Z increases). The latter is an assumption made during strategic takt planning and to be ascertained later during operational takt planning. Equation 1 can be inferred from Figure 3, where the work phase comprises three floors (F =3), each floor is divided onto two zones (Z = 2), and a process with five steps (S = 5) must be completed in each zone within the allowed time-to-complete referred to as the takt T(Z).

$$D = (S + (F*Z) - 1) * T(Z) \qquad \text{(Equation 1)}$$

This equation can be rewritten to compute the takt when all other variables are (or are assumed to be) known:

$$T(Z) = \frac{D}{S + (F*Z) - 1}$$

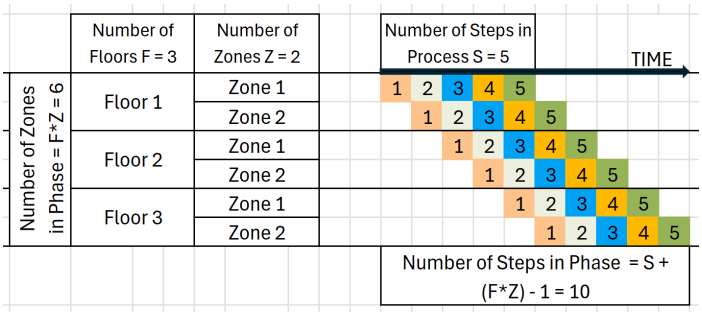

Figure 3: Work Phase Duration D of 10 * T(Z)

In the case of strategic takt planning, the duration D of a work phase will be informed by the customer demand for the project. Defining work phases and associated processes are the first steps for identifying customer takt. The duration of a work phase can be identified through a combination of past experience, production rates, historic data, or experimentation. A project will have various work phases that can have different durations, and work phases can overlap. The start of the first work phase and the end of the last work phase is the customer demand for the project (i.e., the project duration).

Assuming that the duration D of the work phase being planned is a given (e.g., the work phase must be completed in 50 work days), a planner can define a sequence of steps (process) and then explore how a change in the number of zones changes the value of the computed takt.

EXAMPLE EXECUTION STRATEGIES WITH VARYING TAKT DURATIONS

An example will illustrate the calculations that can be performed to explore alternative project execution strategies. Assume you are planning a three-step process (S = 3) that will be repeated on each of three floors (F = 3). The total duration D for that work phase is not to exceed 50 days. Table 1 expands on options according to the number of zones (Z shown in column [1]) in which to divide the work space available on a single floor. Given the stated assumptions and each one of several values for Z, the total number of steps in the work phase is computed (column [2]).

Using Equation 1, a takt is then calculated (column [3]). As decimal fractions of a work day are not practical, the computed takt is rounded down to an integer value (column [4]) (note that a planner may apply a different rationale for rounding numbers to suit their project). Now the takted duration per floor can be computed (column [5]) by multiplying the number of zones by the takt. This describes how much time each trade will have to complete their work on a floor, assuming the trade is responsible for only a single step in the process. Next, the takted phase duration is computed (column [6]) by multiplying the total number of steps in the work phase by the takt. Finally, when the takted phase duration is shorter than the allotted duration D = 50 days, a phase buffer can be computed by subtracting the former from the latter (column [7]).

Number of Zones Z [1]	Total Steps in Phase S + (F*Z) – 1 [2]	Calculated Takt [days] (equation 1) [3]	Takt [days] (rounded down) [4]	Takted Duration Per Trade (Step) Per Floor [days] [5]	Takted Phase Duration [days] [6]	Phase Buffer [days] [7]
1	5	10.00	10	10	50	0
2	8	6.25	6	12	48	2
3	11	4.55	4	12	44	6
4	14	3.57	3	12	42	8
5	17	2.94	2	10	34	16
6	20	2.50	2	12	40	10
7	23	2.17	2	14	46	4

Table 1: Strategic Takt Calculations

Figure 4 illustrates three of the options shown in Table 1, namely those calculated when dividing the work space into 4, 5, or 6 zones. Step 1 is shown in turquoise, step 2 in golden yellow, and step 3 in dark blue. The green cells on the right illustrate the phase buffer. The cell marked by an ‘x’ shows the total amount of time each trade will have on each floor, which is highly relevant when trades are planning the resources they will need to complete their work. Note that this duration does not vary linearly with an increase in the number of zones.

DISCUSSION AND PRACTICAL IMPLICATIONS

LOGICAL APPLICATION OF STRATEGIC TAKT PLANNING

Considering takt calculations such as those illustrated by data in Table 1, a planner can strategically decide on an execution strategy. Having only 1 zone per floor is risky because the takted work

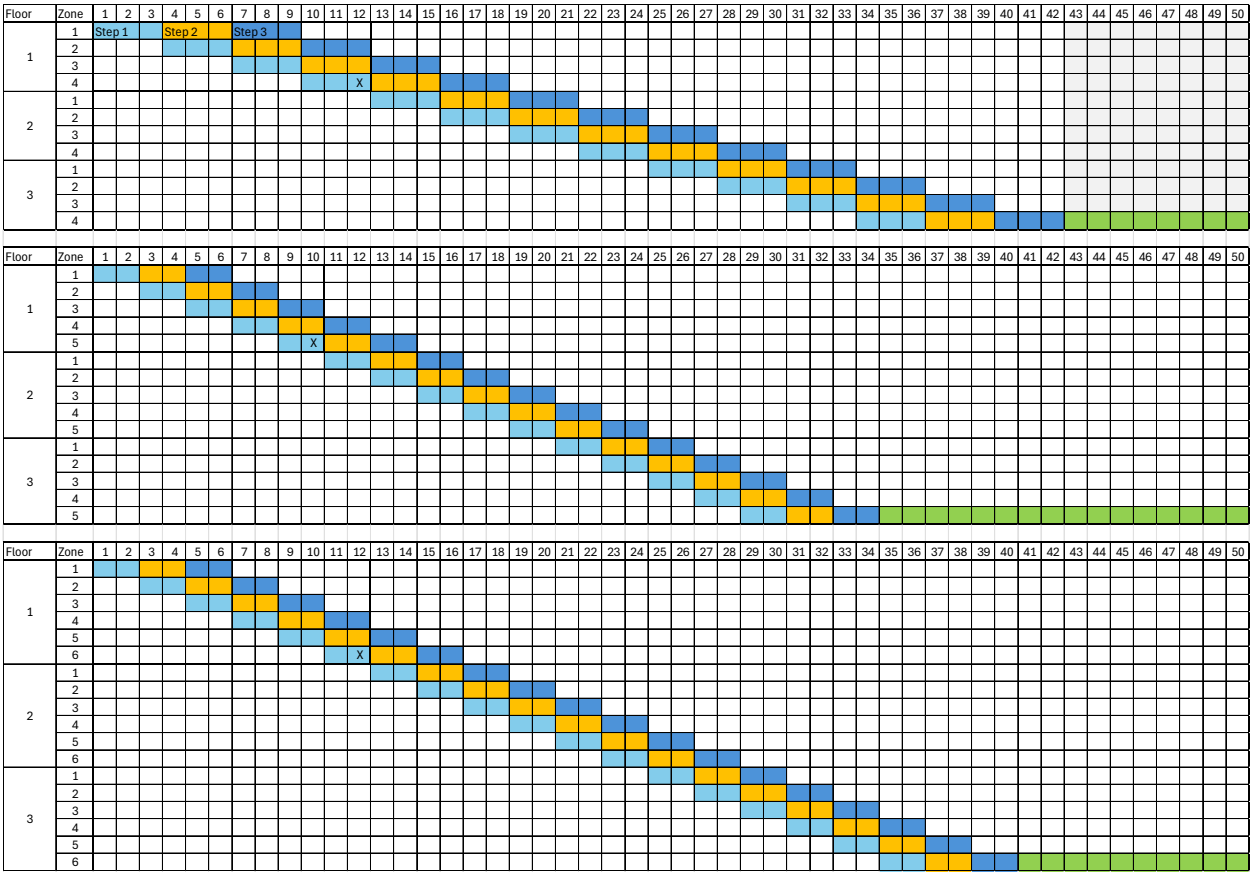

Figure 4: Illustration of the 4-, 5-, or 6-Zone Options

phase duration would be precisely 50 days, leaving no time buffer to absorb any duration variability. Furthermore, each trade will have only 10 days to complete their work on a given floor, whereas other options offer them more time on each floor.

Alternatively, dividing each floor into 3 or 4 zones yields a calculated takt of respectively 4 or 3 days. In either case, a trade will have the same amount of time (12 days) to complete their work on each floor, and a reasonable amount of time buffer remains at the end of the phase. This logic can be applied to assess the qualities of each option and then to choose the options most appropriate to share with potential trade partners. Once trade partners have joined the project, the chosen strategic takt plan will form the basis of the operational takt planning efforts they will engage in next.

In practice, teams can perform strategic takt planning as soon as they can define work phases and processes within those phases and have an idea about the overall building footprint and number of floors and functions within each floor. Note that the quantity of the work is constant in all options, but it does not need to be known ahead of time.

The primary variables for identifying the options are the sequence of operation steps and the assumed number of zones per floor. The sequence of operation steps is the most important from a practical point of view in determining the various takt strategies. The steps and their sequence are determined by the systems that need to be built and their composition. Teams can explore design options that produce different sequences of operation steps (e.g., stick build vs. prefabrication) and assess them during strategic takt planning. Performing this analysis earlier in the design can inform the design process and guide it to produce outcomes that meet customer demand.

Additionally, strategic takt planning calculations will identify the possible zoning options, specifically the number of zones, but not the actual size (area) or shape of the zones. Zone boundaries (and thus the size and shape) will be determined later during operational takt planning based on work density (Singh et al. 2020, Tommelein 2022) so that the crews can spend more-or-less the same amount of time per zone. Nevertheless, during strategic takt planning, impractical zoning options (i.e., zones that are too small) would be dismissed.

EXAMPLE EXECUTION STRATEGIES WITH VARYING RESOURCE ALLOCATIONS

Work phases may have different takt targets depending on the processes they comprise (each process with its sequence of operation steps) and their zoning assumptions. When work phases are combined into the overall project execution strategy, planners can take advantage of opportunities that emerge as a result of this variation. Figure 5 illustrates such an opportunity for a takt plan with time (expressed in weeks) on the horizontal axis and four floors each divided into three zones on the vertical axis. The last work phase (the Finishes starting after Water Tight in week 28) has a takt of 4 days per zone but it is progressing at a slower pace than the previous work.

Planners can explore variations of increasing crew size in the same area as shown in Figure 6, they can plan on adding another set of crews while maintaining the same takt per zone as shown in Figure 7, or they may choose to do nothing and slow down the preceding work if there is no benefit to speeding up the work phase due to constraints of a subsequent work phase.

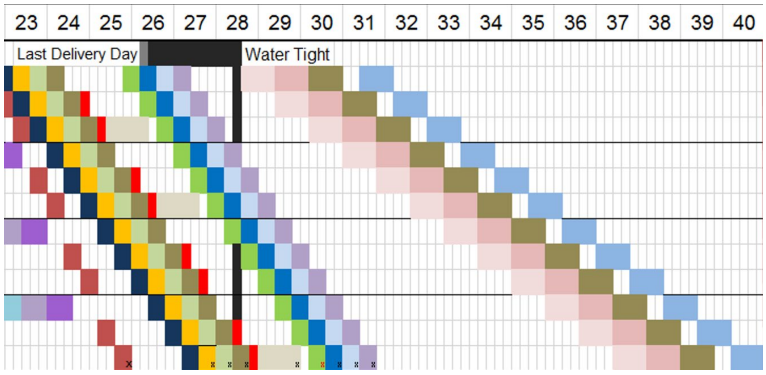

Figure 5: "Finishes" Work Phase Starting from "Water Tight" to Day 40 with 1 Crew per Step

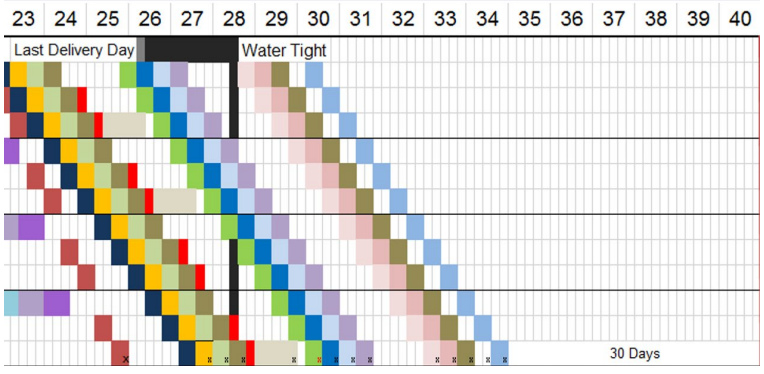

Figure 6: "Finishes" Work Phase Starting from "Water Tight" to Day 34 with 2 Crews per Step

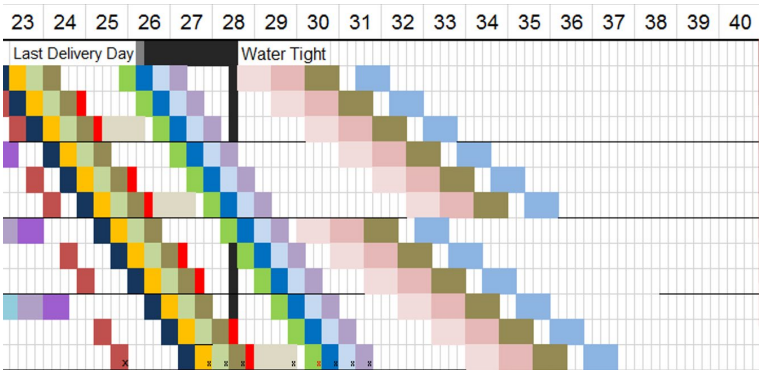

Figure 7: "Finishes" Work Phase with 2 Crews and Staggered Starts at Different Locations

Strategic takt planning produces alternative ways of approaching project execution that teams can reference as the design develops and the project progresses from design to construction. Teams can keep those as viable options while they advance the design. The strategic takt planning focus on identifying the sequence of operations steps earlier in the design creates an environment for the design teams (and the trades to the extent they can be involved at that time) to improve supply chain alignment. The process results in clear handoffs between work phases and thus better work structuring when the team begins to identify major project milestones and milestone targets for construction. This drives procurement strategies so that when trades are procured their scopes are aligned with an execution strategy that is designed for flow. Strategic takt planning should be validated at various points of the design evolution through operational takt planning once more information about the design is available to perform detailed process analysis and perform the work density analysis. It is only in rare, extreme cases when work density is highly concentrated that a strategic takt plan may turn out to be infeasible.

PROJECT APPLICATIONS

Strategic takt planning was applied in a number of real-world project situations and some of those are presented in the following paragraphs.

Project 1

A developer was interested in validating their business case to invest in a project that needed to open within a specific timeframe. Process analysis was done based on schematic design information and involving the key trade contractors (mechanical, electrical, plumbing, and framing) at a time when not all subcontractors had been onboarded yet. The strategic takt planning analysis led the project team to conclude that a concrete frame option proposed as work to be self-performed by the general contractor would not be an appropriate solution for this project as it would have strained the resources required to construct the interior spaces. The developer abandoned the project because the project could not be built in the desired time.

Project 2

A manufacturer was interested in opening Phase 1 of a manufacturing plant to receive early equipment deliveries. The delivery dates could not be changed. Strategic takt calculations were performed with input from the key trades and the general contractor based on design development information. The process analysis led to several design improvements and to the allocation of additional crews to specific process steps (to alleviate bottlenecks and to implement what was needed after crew assumptions had to be modified) and thus to align operational takt with customer takt and finish the phase within the required time. That is, strategic takt planning calculations

resulted in defining the takt targets and subsequent operational takt planning (including color-ups done by the trades involved) resulted in the quantities, in turn informing adjustments necessary to align the operational- with the strategic takt plan. As mentioned previously in this paper, strategic and operational takt planning must go hand in hand.

Project 3

A contractor committed to delivering a project to a pharmaceutical manufacturer within a specific timeframe based on a critical path method schedule. During design development, strategic takt planning was applied to validate the construction schedule assumptions. The analysis revealed that for the team to finish the project as promised they would need a calculated takt of 1 day per work zone; this was unrealistic for the type of work being installed. The team dismissed the takt analysis outright as it was at odds with what they had committed to deliver. As they advanced through construction, they found out that the project could not be delivered as promised (and offered many reasons why this was so). They finished the project several months later.

Project 4

Strategic takt analysis was used during the validation phase of a project that used an integrated project delivery method. This analysis was performed with input from the trades and the general contractor during the early design development phases. The process analysis used conservative assumptions regarding how many process steps would be needed per work phase and made use of buffers between the work phases to further account for risk of unknowns. The strategic takt analysis revealed that the project could be delivered months earlier than indicated by the critical path method schedule developed in parallel by the general contractor. However, being new to the concept and wary, the general contractor dismissed the takted approach and opted to continue their negotiations with the project owner based on the critical path method schedule even though it would force the owner to compromise their program requirements for the project.

CONCLUSIONS

This paper focused on strategic takt planning as distinct from operational takt planning. It described how teams can leverage takt planning to quickly develop options for project execution strategies very early in the project life cycle (e.g., during validation, or the early schematic design phases). An equation was provided to calculate a takt target for a certain work phase. The results of using this equation can be applied to articulate alternative project execution strategies and options can then be compared and assessed.

The strategic takt planning approach has been used in various project contexts. Several use cases from actual projects were described. Project teams that have never used takt planning before often opt to dismiss the results of the calculations. They may be more comfortable continuing with their conventional critical path method schedules as the basis for contract negotiations even though the takt calculations show that, based on takt, they could have a conservative path to completion that yields a shorter overall project duration. However, as project participants gain exposure and become more accustomed to using operational takt planning, those with takt experience can explore how to improve their next implementation by starting with strategic takt planning and then moving into operational takt planning at the appropriate time.

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