

INTEGRATING A STRATEGIC MILESTONE AND PHASE PLAN (SMPP) AS A NEW LEVEL OF THE LAST PLANNER SYSTEM (LPS): AN INVESTIGATION ON MEGAPROJECTS

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ABSTRACT

Megaprojects often struggle with their production planning. One of the reasons is a lack of common understanding of the project scope and goals within the project teams and stakeholders as the basis for reliable project delivery. The Last Planner System (LPS) is a well-known method for production planning and control. Nevertheless, the LPS has its limitations in megaprojects as the gap between the master schedule and the phase plan is vast. On the one hand, the master plan consists of the milestones, the phase durations, and overlaps only. On the other hand, the phase plan (also named milestone and phase plan [MPP]) already consists of specified handoffs and conditions between processes within a phase duration. Thus, the master schedule is too vague, and the phase plan is too detailed. To overcome this limitation, the authors propose integrating another level, on a monthly basis, between the master schedule and MPP in the LPS.

Based on two case studies, this paper describes and analyzes how a Strategic Milestone and Phase Plan (SMPP) can be integrated as a new level into the LPS and demonstrates the benefits based on the findings of the two cases. The authors finally conclude that the SMPP should be integrated into the LPS at a new and additional level.

KEYWORDS

Last planner system, strategic milestone and phase plan, megaprojects.

INTRODUCTION

Flyvbjerg (2017) defines megaprojects as “large scale, complex ventures that typically cost \$1 billion or more, take many years to develop and build, involve multiple public and private stakeholders, are transformational, and impact millions of people” (p. 2). Challenges often come with this: The development of a huge organization that contains constantly high employer fluctuation, unclear roles and responsibilities, a hierarchical decision-making process, long duration times when it comes to decision-making, lots of stakeholders with different expectations and interests, strong power relations, a lack of clearly defined goals and scope as well as unclear and undefined interfaces, a changing scope over time, technological innovation, a lack of common understanding within the project team, asymmetric information among the different stakeholders, a lack of transparency, a lack of seeing the overall project, working in silos, political interests, political decisions impacting the project (power games), and different financial funding (Flyvbjerg, 2017; Flyvbjerg et al., 2003; Merrow, 1988; Priemus et al., 2013). Furthermore, Greiman (2013) points out that “[l]engthy projects create multiple unknowns,

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ambiguity, uncertainty, and risk that do not exist in projects of much shorter duration” (p. 186). This aligns with the description of Floricel and Miller (2001) that megaprojects contain “anticipated risk and unexpected events” (p. 446). Such risks can be design risks related to the planning phase of the megaproject, construction risks with the project schedule and coordination problems as well as financial and/or economic risks (e.g., Irimia-Diéguez et al., 2014; Little, 2011). With the named challenges, risks, unknown events, and the importance of success to the sponsors, megaprojects can easily fail (Morrow, 1988). Thus, in sum, a megaproject is impacted by a variety of factors that are not clear from the beginning. Hence, the teams must understand the project goals, constraints, risks, and the dynamic of the organizational environment and use a production planning and control method to help them navigate through the project.

In IGLC community, many papers have been published supporting the implementation of the LPS as a production planning and control system. The LPS consists of five steps (1) Master Scheduling, (2) Phase Schedule, (3) Lookahead Planning, (4) Weekly Work Plan, and (5) Learning (Ballard & Tommelein, 2021). Regarding megaprojects and LPS, almost no papers have yet been published (Ibrahim et al., 2017 – hospital project in San Francisco; Leth et al., 2019 – redevelopment of an offshore oil and gas field in the North Sea).

When it comes to a megaproject LPS, we see a gap between the master schedule and the phase plan. On the one hand, the master plan consists of the milestones, the phase durations, and overlaps only. On the other hand, the phase plan already consists of specified handoffs and conditions between processes within a phase duration. Thus, the master schedule is too vague, and the phase plan is too detailed. Therefore, an additional level between both levels is missing when it comes to large or mega projects. Implementing the LPS on two megaprojects allowed the authors to integrate another level into the LPS and research the value of the outcome. Consequently, based on the two cases’ findings, we propose to integrate the SMPP as another level into the LPS.

RESEARCH METHOD

The objectives of this research are to introduce the SMPP to the IGLC community and to demonstrate the value of the SMPP as a further level of the LPS based on the two case studies: (1) Stuttgart Main Station Building (Bonatzbau), and (2) Munich Main Station. Therefore, a combination of action research and case study research was used to achieve the research objective as the first author was involved as a consultant/researcher in the second case and the second author was involved as a consultant/researcher in the first case (Dickens & Watkins, 1999; Yin, 2014).

During LPS workshop execution, the authors observed the teams and had small feedback sessions to improve the workshops as well as to define the content/next steps of the following workshops. To better understand the difference between the master schedule and the newly introduced SMPP, worldwide experts were questioned regarding their understanding of the master schedule in January 2023. Furthermore, in January 2023 a survey was carried out to collect data regarding the user experience of the SMPP during the workshops and how the outcome is used. In total, 19 responded to the survey: 42% (response rate 53%, 8 out of 15) from the project team of the first case and 58% from the project team of the second case (response rate 35%, 11 out of 31).

UNDERSTANDING THE MASTER SCHEDULE

To get a better understanding of the master schedule, worldwide experts were asked via mail and call for their definitions of the master schedule (see Table 1). In sum, the master plan can be defined as a general plan based on important milestones and depicts the different phases of

the project by considering previous experiences. This is in alignment with the theory where Ballard and Tommelein (2021) defined the master schedule as “set milestones and phase durations and overlaps” (p. 12).

Table 1: Definitions of the master schedule from worldwide experts

Expert	Definition
Ballard, Glenn (USA)	The master schedule consists of the start and end dates of the project phases. The master schedule is produced within a project execution plan that treats risks and opportunities and is examined to see if the risk that remains after developing mitigations is acceptable. Revision may occur in an indefinite number of cycles until a go/no-go decision is made.
Christensen, Randi (DK & UK)	Includes contractual deadlines/milestones and, depending on the duration of the project, 1–4 milestones per year. Besides contractual milestones, potential additional milestones are either fixed based on delivery time (e.g., precast elements, governance processes by official bodies or the like) or some could be set based on a process plan made by the team.
Etges, Bernado (BR)	A plan that splits the project into general work packages (phases) to help define labor and equipment histograms and the flow through the project.
Hackler, Cory (USA)	General outline with milestones and phases based on previous data.
McConaughy, Tammy (USA)	Aligning Project Phases and Key Milestones that also help outline phase pull plans. This includes: (1) Utilizing any milestone information from the owner or other stakeholders, and (2) any baseline schedules that have been created.
Mossmann, Alan (UK)	A Milestone plan is the first level of decomposition of a project. It defines the overall design or construction and logistics strategy; key dates both for the customer and for the delivery team; the conditions of satisfaction for key milestones; the phases of the project for subsequent phase scheduling; and it details the 'last responsible moments' for ordering long-lead items.
Tsao, Cynthia (USA)	Initially, it was meant for milestones for one project, not for multiple projects.

INTEGRATING A NEW LEVEL TO THE LPS

Tsao et al. (2006) suggested that the IGLC community consider broadening the scope of the LPS so that it scales up to assist with portfolio management. Specifically, they recommended that owners start tracking a project-level Planned Percent Complete that measures how well their projects are meeting initial project goals (e.g., budget, schedule, quality, etc.) and start tracking a project-level variances chart that identifies the root causes of not meeting initial project goals (e.g., labor, long-lead item procurement, etc.). With this trending information, the owner could work on improving portfolio management by addressing those root causes when setting up the initial contractual terms and conditions for new projects. While Tsao et al. (2006) focus on portfolio management that would be integrated into the LPS above the level of the master plan, we suggest integrating an SMPP underneath the master schedule regarding the project itself.

Greiman (2013) reported that on The Central Artery/Tunnel Project in Boston, a Milestone Manager Group was successfully installed “to help manage and overcome project delays that resulted from the unpredictable nature of several aspects of the work” (p. 188). Therefore, the project was divided into four major milestones to track the project’s progress and develop countermeasures based on the outcome. As this task force focused on the milestones, the SMPP focuses on milestones as well as the phases of the project.

Figure 1 shows the integration of the SMPP as a new level into the LPS and considers the level of portfolio management proposed by Tsao et al. (2006). The SMPP covers the entire project from start to finish including major milestones and their fulfillment criteria, all phases of the project/subprojects, specific handoffs as well as conditions of satisfaction between processes, strategic conditions, and defined premises with possible alternatives.

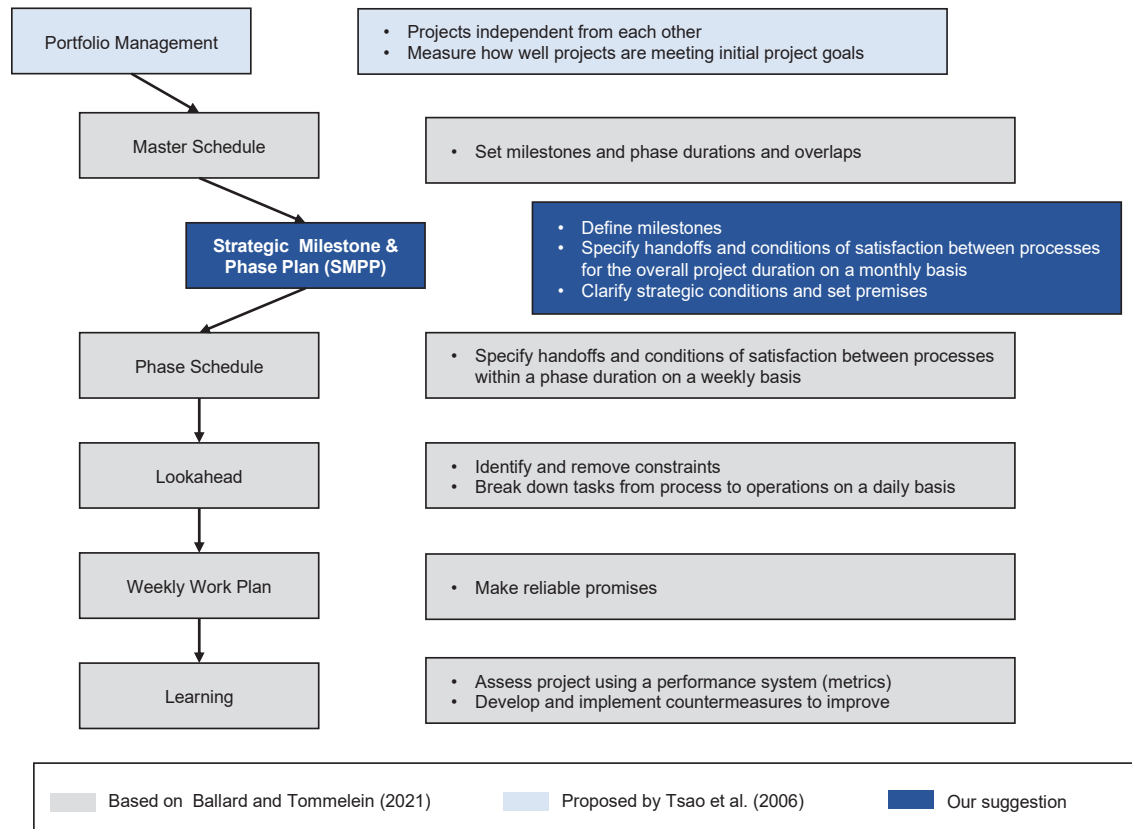


Figure 1: Integration of the SMPP into the LPS

CASE STUDIES

The case studies presented are both main stations in the south of Germany (Stuttgart and Munich) that are part of the infrastructure expansion from the German national railroad company (Deutsche Bahn, DB). Thus, both are capital projects in which the owner initiated the implementation of the LPS. In both projects, the SMPP was integrated as part of the LPS.

CASE 1: STUTTGART MAIN STATION BUILDING (BONATZBAU)

As part of the infrastructure project, Stuttgart 21 (reorganization of the railroad hub), the historic main station building (Bonatzbau) will be completely modernized. The renovated building, in addition to a new stabilizing structure, will contain two floors of a shopping mall as well as a hotel including a lounge and meeting areas. The exterior walls of the almost 100-year-old building are under preservation. The future main entrance allows easy access to the tracks of the new platform hall, which too, is currently under construction. Overall, the investment cost of the whole Stuttgart 21 project is currently indicated at €9.8 billion, of which €200 million is attributed to the historic main station building.

When the new project manager took over in 2020, he found that the team didn't have a common understanding of the project's goals and scope. Searching for an approach that would help the team achieve the milestones brought up the idea of implementing the LPS. Thus, a

workshop series was rolled out to implement the LPS. By that time the project was in the phase of demolition and schematic design. After a project status check, a lean competence workshop, and an Overall Process Analysis (OPA) the SMPP was set up in two workshops for a period of five years (see Figure 2). Based on the SMPP, a weekly MPP was defined in May 2021 to set up a complete LPS for demolition and renovation works. In parallel, the basic design for the new building was further developed which led to an adaptation of the SMPP in four additional sessions from December 2021 to February 2022. To assure a flow from the demolition and renovation works to ground works as well as core and shell works, the schematic and detailed design development was included in the LPS.



Figure 2: SMPP Bonatzbau, 2021

CASE 2: MUNICH MAIN STATION

The core system of the city train (1.SBSS) needs a second core line (2.SBSS) as the first is overloaded. Accordingly, the main station needs to be extended and modernized—this includes overground and underground work. Besides the existing operations, all other buildings will be demolished, and new buildings will be built including services areas, areas for restaurants, shops, and office spaces. The project also incorporates a precautionary tunnel for another subway line as well as the complete renovation of the track hall roof and a new cross-platform roof. Thus, they are building under and overground while the fast trains, city trains, and underground lines are still operating, and services need to be provided for the customers. The anticipated cost for the main station (overground) is estimated at €1.2 billion and the expected cost for the 2.SBSS is approximately €7.2 billion.

In mid-2021 the development of the project organization started with the assignment of a project lead. The project lead was involved in the project team from the first case study. Drawing on his experience of the effect of the workshop series from the first case and understanding of how important it is to tear down silos and enhance communication between participants across different areas of responsibility, a workshop series was rolled out while the project was in different design stages. The project lead intended to reorganize the project organization based on the outcome of the SMPP:

“We intended to develop an SMPP based on lean principles [pull from the last process step of the commissioning process] to achieve a shared and deep understanding of the project program and scope as well as the necessary structure of the subprojects to define the overall project structure and develop a project organization that aligns with the project [...] and we

did. Based on the SMPP outcome we structured, developed, and formed our project organization from scratch. [...] Because our organizational structure reflects this new project structure it is part of the project DNA and therefore will continue to grow naturally. This also ensures that lean and the strategic direction of the project no longer have to be carried into the project [...] [and they] will remain as part of the project from the inside out.” (André Haubrich, DB Netz AG, April 2023)

In total, seven full days of SMPP workshops were necessary to produce an overall picture—the first four workshops were executed in April and May 2022, and the last three workshops were executed in September and October. The break between the workshops became necessary for the team to work off defined actions and to reflect on and adjust the defined premises outlined in the SMPP. It needs to be said that the workshops consist of a core owner team of 10–12 people and additional people that were brought in to work on specific topics. The SMPP was developed for a period of 15 years, aiming for completion at the end of 2035. Figure 3 shows an extract of eight years of the SMPP and Figure 4 the digitalization of the whole SMPP. In between the SMPP workshops, in June 2022, a strategic meeting with the project managers regarding the roles and responsibilities occurred. In addition, in May and June, four workshops were held to analyze the personnel requirements, not only for the main station but also for the whole project. The journey then continued with further workshops regarding the reorganization. Additionally, the team decided to continue learning by developing the MPP on a weekly basis to achieve the first major milestone of the project in January 2026 (duration of MPP 34 months).



Figure 3: Extract of SMPP Munich Main Station, 2022

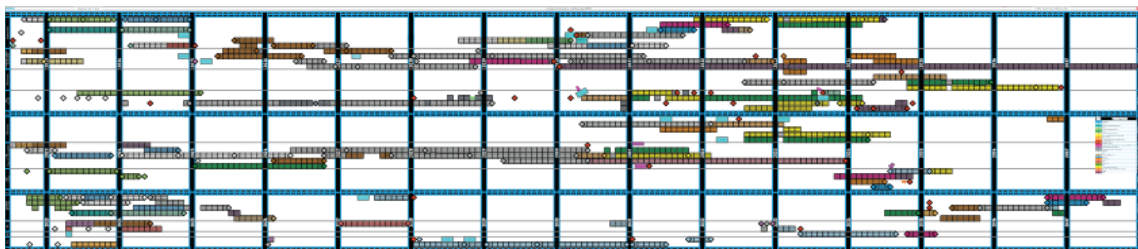


Figure 4: Digitalisation of the SMPP Munich Main Station, 2022

IMPLEMENTATION OVERVIEW

In the Stuttgart main station building project the SMPP was used as the basis to set up a complete LPS followed by an MPP, a six-week lookahead, and weekly work plans to steer and control the overall project delivery. In addition, it was transferred into the overall schedule of the project of the whole reorganization of the railroad junction. In the Munich project, the SMPP was used to better understand the project to restructure its organization. Afterward, the SMPP was transferred into an MS project timetable which is currently supposed to be the control schedule. In March 2023, the team started with workshops to develop an MPP.

Table 2: Overview of the workshop series and execution time for both cases

Workshops	Description	Bonatzbau	Munich Main Station
Project status check	Common collection and assessment of risks, obstacles, opportunities, and drivers of the project.	One workshop, March 2021.	One workshop, February 2022.
LPS competence workshop	Villego simulation to learn about the LPS.	One workshop, March 2021.	Two workshops, February and March 2022.
Condition of Satisfaction	Development of a common goal understanding for the project with a definition of what "success" means for the project team.	Not part of the tendering.	One workshop, February 2022.
Definition of the milestones	Definition of the important project milestones and specification of the compilation criteria of the most important milestones (20% of the project milestones).	Included in the OPA.	One workshop, February 2022.
OPA	Time-independent process analysis to determine and record the project-relevant interfaces.	Two workshops, April 2021.	Three workshops, March 2021.
SMPP	Pull planning from the last project milestone on a monthly basis for the whole project timeline.	Two workshops, April 2021.	Seven workshops: First four workshops, April and May 2022. Last three workshops, September and October 2022.

DISCUSSION OF CROSS CASE FINDINGS

FINDINGS COMPARING IMPLEMENTATION

In both projects, the SMPP was implemented successfully following the different requirements of the project leads. When comparing the implementation of both projects, there are six differences:

1. **Duration of SMPP:** In Case 1 the schedule duration is five years, while in Case 2 the SMPP covers a period of 15 years.
2. **SMPP scope:** Case 1 is a large project that is an integral part of a megaproject, while Case 2 is a megaproject including subprojects.
3. **Project phase when SMPP was developed:** In Case 1 the project was already under deconstruction and in the design phase of construction documents, while in Case 2 the project was mainly in the design development stage.
4. **Intention of the owner regarding SMPP:** In Case 1 the owner's intention was to get a project overview including the main dependencies between design, deconstruction,

construction, and the different building parts. While in Case 2, the intention was to restructure the project organization based on the project's needs.

5. **Action of the owner:** In Case 1 the project was already in progress when the implementation started (reactively), while in Case 2 the implementation was used to set up the project (proactively).
6. **Availability of project participants:** In Case 1 the contractors for demolition and structural works were partly involved in developing the SMPP, while in Case 2 just the owner's team participated in the workshops as the tendering process did not start yet.

The differences show that the SMPP is flexible in its application and focus. Thus, there are no constraints on the time the SMPP should be developed; however, the criteria can be set that the earlier the SMPP is developed, the better.

SURVEY FINDINGS

Before being asked about their SMPP experience, participants were first asked about their pain points regarding the traditional scheduling process of megaprojects to obtain a reference point. Overall, the answers can be clustered into seven major points: (1) political deadlines; (2) missing identification and a lack of understanding of interfaces, dependencies, risks, and responsibilities; (3) lack of communication and information regarding goals and tasks; (4) missing integration of relevant stakeholders and their knowledge; (5) missing focus of the overall project; (6) lack of common understanding among the project team; (7) lack of moderation during development. The pain points result in an unreliable schedule that contains unrealistic durations and impossible sequences.

Participants were then asked how helpful the SMPP workshops were and how helpful the outcome was for furthering the procedure of the project. For most of the participants, 79%, the workshops, as well as the outcome, were extremely or very helpful. Furthermore, 11% answered that the SMPP workshops were somewhat helpful (see Figure 5). Only one person (5%) answered that the SMPP was not helpful, and one person (5%) checked the box of no answers. Overall, it can be stated that the SMPP was very helpful for both project teams. In further questions, the survey participants were asked to give more insights based on open-ended questions. Participants mentioned that simplification and visualization helped to get a better overall view of the relevant processes and dependencies without getting lost in detail. In addition, the information and knowledge exchange and solution-finding collaborations supported by neutral moderation helped to gain a common understanding of the project and critical aspects. It also helped to identify missing dependencies, gaps, prerequisites, and related challenges. They finally stated that the SMPP should be set up as early as possible.

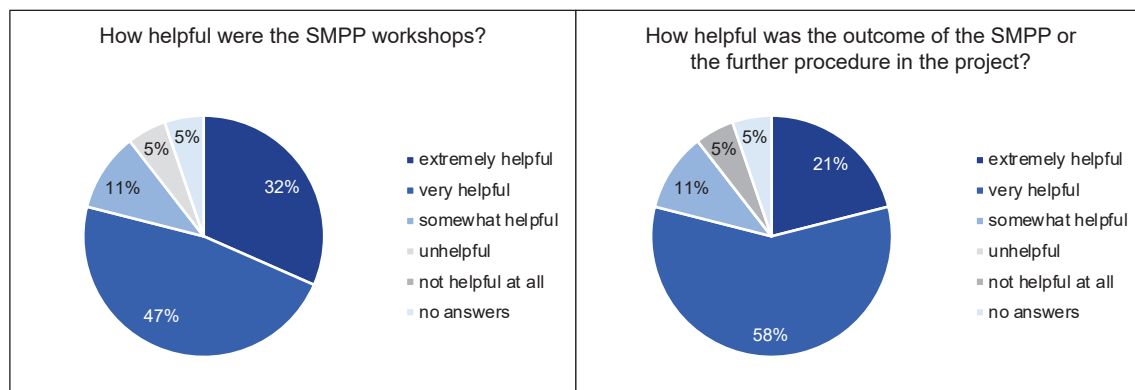


Figure 5: Response of the survey participants regarding the SMPP workshops and outcome
Overall, the survey participants highlighted the following advantages of the SMPP:

- Overview of the entire project on an intermediate and manageable level (measurable).
- Increased focus on relevant steps and long-term scope sequencing/milestones.
- Plausibility check of the total construction time and handoffs.
- Simplification of complicated issues using a common (simple) language.
- Creation of a common understanding of the goals and subsequent steps.
- Exchange of valuable information.
- Involvement of all project participants.
- Joint development process.
- Increased focus on relevant steps and results through pull-planning.
- Transparent and structured presentation of the project.
- It allows the development of a different perspective.
- The holistic approach.
- A better understanding of the current project status.

With the last question of the survey, participants were asked how often the SMPP should be updated (see figure 6). Most participants stated that a smaller time duration (every three or six months) would be better because of the dynamic and resulting changes. A smaller period would also help new project members get a better understanding and check on the intermediate milestones to maintain awareness regarding the overall project milestones.

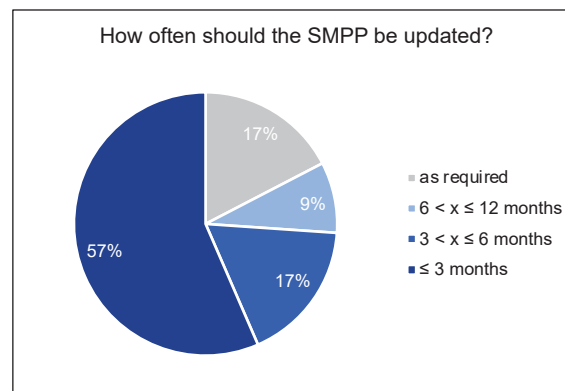


Figure 6: Response on the sequence of updating the SMPP through workshops

CONCLUSION AND RECOMMENDATION

The case studies presented in this paper show the research and findings of the implementation of the SMPP into the LPS of two megaprojects. In the presented cases, the SMPP was developed for a mid (five years in Case 1) and long time period (15 years in Case 2). In both cases, the implementation of the SMPP was a significant benefit for the project teams. It helped to achieve a common understanding of the overall project schedule, related interfaces, and process dependencies. It also helped to close the gap between the master schedule and the MPP. Thus, our recommendation is to implement the SMPP as early as possible in a project. Furthermore, we recommend adding the SMPP to every LPS implementation for projects if it is necessary to generate a full project overview with the project team, the time frame is a minimum of 18 months, and the project is highly complex. If otherwise, the phase plan could be extended.

As both cases are still ongoing projects, the value of the SMPP cannot be evaluated with finality. Also, as in both cases the SMPP was developed for five and 15 years, the value of adding this level to a smaller project with a three-year duration might be beneficial, but this

cannot be verified yet. Furthermore, what would happen if the project duration and thus, the SMPP, were more than 15 years? We assume that the SMPP would then be revised at different, wider intervals for the entire period. For example, instead of monthly, it would be quarterly, with the first years being on a weekly basis. The switch from monthly to quarterly depends on the project stage, the available information, and the independence of the project - the shift from weeks to quarters might be between five to eight years.

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