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INTEGRATING DESIGN AND PRODUCTION PLANNING TO ENHANCE COLLABORATION AND SECURE PROJECT OBJECTIVES IN MEGAPROJECTS: A REVERSE APPROACH

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ABSTRACT

The Stuttgart 21 project, a major infrastructure initiative, aims to transform Stuttgart's central station into an underground through-station to enhance railway efficiency. This case study examines the integration of detailed design and production planning to address common challenges in megaprojects, such as unclear responsibilities, design gaps, fragmented communication, and misaligned stakeholder expectations. The study introduces the Integrated Design and Planning Meeting (IDPM), a novel concept that combines Lean principles with engineering and construction expertise to address the unique needs of the design phase. While the Last Planner System addresses similar challenges by focusing on planning coordination, the IDPM uniquely integrates defining and clarifying the technical solution, coordinating design clashes, and making design decisions with planning coordination in a single, structured meeting format. The research applied action research, enabling iterative development and improvement of the dual-focus approach through observations, workshops, and feedback loops. Its effectiveness was evaluated using a structured questionnaire with a 5-point Likert scale. The results show that IDPM improves transparency, coordination, and alignment while highlighting the value of clear communication, owner involvement, and a neutral facilitation entity. Even in late project stages, new practices can strengthen collaboration and design performance.

KEYWORDS

Design phase, Integrated Design and Planning Meeting (IDPM), lean principles, megaprojects.

INTRODUCTION

The Stuttgart 21 project is one of Germany's most ambitious and controversial infrastructure undertakings, aiming to transform Stuttgart's central station into an underground through-station to enhance railway efficiency. This case study investigates the merging of detailed design and production planning as a strategy to secure project objectives and improve collaboration within the design team. Like other megaprojects, Stuttgart 21 also faces numerous challenges, including high staff turnover, unclear roles, hierarchical and long decision-making, conflicting stakeholder expectations, power imbalances, undefined goals, changing project scopes, technological innovations, lack of transparency, and political influences. These factors result in ambiguity, increased risk, and planning inefficiencies (Flyvbjerg, 2017; Greiman, 2013; Floricel & Miller, 2001). To navigate these challenges, teams must understand project goals

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and constraints while employing effective production planning and control methods to mitigate risks (Schöttle & Böker, 2023).

During the design phase, two types of meetings typically guide the process: (1) design meetings, which focus on defining and developing the technical solution — the "what" of the project — including functional and aesthetic requirements, system integration, technical details, and constructability (Eastman et al., 2011), and (2) planning meetings, which focus on coordinating the "how" of the design process by addressing task sequencing, aligning interdisciplinary contributions, setting milestones, and managing dependencies between design packages to ensure timely delivery (Ballard & Howell, 2003). This distinction aligns with Lean thinking, where design defines the product, and planning organizes its production (Liker, 2004).

Typically, project schedules are often developed top-down, where a high-level plan is created first and then progressively broken down into more detailed levels. One method to build reliable production schedules is the Last Planner System, where people doing the work are involved in the development (Ballard & Tommelein, 2021). Stuttgart 21 lacked an overall schedule for the design phase, with only parts being mapped and tracked in newly implemented software. The abstraction levels of the existing processes in the software were defined very differently, ranging from high-level goals to very detailed tasks. Rather than redeveloping the schedule using a method such as pull planning, which risked causing frustration, a reverse approach was applied to develop a production plan for ongoing design activities and their interdependencies, grounded in prioritized design topics that were first discussed in detail and subsequently sequenced. By combining Lean principles with engineering and construction expertise, this study introduces a new concept aimed at streamlining processes, fostering collaboration, and ensuring task completion. As a result, a detailed production plan was created and transferred into the overall schedule. Moreover, this case demonstrates that even in the later stages of a megaproject, adopting a new approach can result in significant improvements.

RESEARCH METHOD

The study follows an action research methodology (Dickens & Watkins, 1999), which is particularly suited to complex, real-world settings such as megaprojects. This approach enabled iterative learning and adjustment in response to dynamic project conditions while ensuring practical relevance. Both authors were directly involved in the project team, developing, implementing, and leading the new format for design and planning to enhance communication, streamline decision-making, and close design gaps. Potential biases from researcher involvement were addressed through systematic reflection, transparent documentation, validation with project participants, and external feedback.

In the initial phase, author one observed meetings and workshops to assess the project's and the team's needs. Based on these observations, a dual-focus concept for design and planning was developed, with continuous improvements through feedback loops during implementation. To assess the impact of the new format, a questionnaire was conducted using 5-point Likert scales. This scale was chosen over a 7-point Likert scale for practical reasons. A 7-point scale would have provided greater differentiation for analysis, but it could have required additional cognitive effort from respondents and extended the time required for completion, which may have reduced the response rate of the target audience. The 5-point scale allowed for a balanced and efficient assessment of participants' perceptions while still providing sufficient differentiation. The questionnaire comprised a total of 39 items (excluding demographic filter, and reasoning questions) and was structured into seven categories: (1) effectiveness, (2) meaningfulness, (3) project progress, (4) documentation, (5) impact on individual work, (6) team communication, and (7) problem-solving. This structure allowed for a comprehensive analysis of both individual and collective project experience. Data collection took place between January 15 and 22 using Google Surveys.

CASE STUDY

The case study focuses on the newly built underground through-station, which is part of the Stuttgart 21 project. Nevertheless, we will first describe Stuttgart 21's overall project and then explain the partial project of the underground station.

PROJECT DESCRIPTION AND CHALLENGES

Stuttgart 21 is one of Germany's most ambitious and controversial infrastructure projects, part of Deutsche Bahn's (DB) rail node Stuttgart modernization. The project aims to improve railway efficiency by transforming Stuttgart's central station into an underground through-station. This includes converting the historic terminus station into an 8-track underground hub, eliminating the need for trains to reverse direction, improving capacity, and reducing travel times. Designed by ingenhoven associates, the new station features a light-eye roof structure that brings natural light to the underground platforms, contributing to its open, futuristic design.

The project also includes significant upgrades to the high-speed rail network. The 9.5-kilometer Filder Tunnel will connect the new underground station to Stuttgart Airport, enhancing regional and international travel. The Wendlingen–Ulm High-Speed Line will reduce travel time to Munich. New underground approach routes will replace old rail yards, optimizing operations. Beyond railway infrastructure, Stuttgart 21 is reshaping the urban landscape by freeing up over 109 hectares in the city center for residential and commercial development. The historic Bonatz building, the original station hall, is being preserved and refurbished while being integrated into the redesigned station.

Stuttgart 21 has faced numerous challenges, particularly massive cost overruns. Initially estimated at around €4.526 billion in 2009 (Deutsche Bahn AG, 2012), the project's costs have now exceeded €11.5 billion. Additionally, delays have plagued the construction timeline—originally planned for completion in 2019, the project is now expected to be finished by the end of 2026. Public protests have also played a major role, with widespread opposition driven by concerns over environmental impact, historical preservation, and transparency in decision-making. The technical complexity is another challenge, with over 60 km of tunneling through geologically difficult terrain while meeting strict architectural requirements.

NEW UNDERGROUND STATION

The hall of the new underground station will be approximately 450 m long and 80 m wide. The project was not conceived holistically for many years but rather developed in separate phases. The focus is initially on shell construction/engineering due to its disproportionate cost share of the overall project, largely driven by the complexity and the exposed concrete design. The market-based awarding of the shell construction was inadequate, leading to an expected high number of additional claims. The timeline of the project is as follows: In 1997, ingenhoven associates won the architectural competition. The design approval process started in 2001, followed by lengthy approval and financing procedures from 2002 to 2009. In 2010 to 2011, massive protests led to a standstill, but an arbitration decision by Heiner Geißler on November 30th, 2010, allowed the project to move forward. In 2011, ingenhoven associates received the full commission, marking the start of the design phase. From 2013 to 2020, the project team focused on special underground engineering until 2014, followed by structural work from 2015. Starting in 2021, the focus shifted to turnkey construction. In 2025, attention moved to connecting the Bonatz building and completing outdoor installations, with start-up and commissioning planned for 2026.

Throughout the project, frequent leadership changes and high employee turnover, especially at Deutsche Bahn, caused shifts in responsibilities and disrupted team continuity.

PROJECT ORGANIZATION

Understanding Deutsche Bahn's system is crucial to project organization, as it shaped subprojects like the Bonatz building (shopping mall, Station & Service) and the Underground Station (infrastructure, DB Netz AG). The original reason for this separation was the financial strength of the infrastructure system, while train stations, the "gateway to the rail transport system," were at risk of deterioration. This led to the establishment of two distinct organizations within Deutsche Bahn, each developing its processes and mindset due to different financing and refinancing models. The founding of Station & Service (S&S) on January 1, 1999, reflected the company's financing strategy, which relied on equity and rental business. A key difference in financial approaches emerged: while S&S focused on real estate and rental income in prime locations, railway infrastructure was funded through public tax money, as it serves a critical role in passenger and freight transport. Twenty-five years later, in 2024, Deutsche Bahn established DB InfraGO and reintegrated S&S as the executive division for "Passenger Stations," returning to the original structure. This organizational separation thus influenced the project, creating contractual and internal corporate interfaces shaped by power dynamics, including building law, financing, asset responsibility, and maintenance duties.

DESIGNING AND APPLYING A CONCEPT FOR THE DESIGN PHASE OF THE NEW UNDERGROUND STATION

UNDERSTANDING THE INITIAL SITUATION

The new underground station, delivered under a traditional design-bid-build model, faces ongoing modifications and adjustments in design, reflecting both its complexity and the evolving nature of its requirements. A significant project challenge is the absence of an integrated master schedule encompassing interior design and building services, resulting in a lack of coordination. In response, the owner's management board mandated the implementation of a "Lean" software tool for project control in mid-2024. However, the software was introduced and applied without the prior definition of key milestones, organizational structures, or vertical scheduling constraints. As a result, the schedule consists of different abstraction levels and numerous assumptions.

To better understand the design phase and how these challenges affected coordination and day-to-day processes, the first author observed the biweekly online design meeting and workshops that aimed to develop the overall design schedule. In addition, the author conducted conversations with a team lead and a project engineer to complement the meeting observations with further context and insights. The design meeting involved five organizations, with an average of 20 participants, although some only attended when topics relevant to their responsibilities were discussed. The meeting agenda allocated three minutes per discussion point; this timeframe was not consistently maintained and didn't provide the option of solution-oriented discussions. Additionally, discussions frequently diverged into historical context rather than focusing on resolving current issues. The meetings lacked structured moderation, leading to uncoordinated problem-solving and no standardized process for defining deadlines or assigning responsibilities for follow-up actions. Furthermore, five parallel schedules coexisted, impeding coordination, and no systematic method was in place to track the progress of tasks. Additionally, technical changes were integrated into the schedule without a defined review cycle, limiting continuity and alignment in the design process. Table 1 provides an overview of the observations and summarizes the new concept's requirements.

DEVELOPING THE NEW CONCEPT

Based on the findings of the initial situation analysis, a concept was developed to overcome the obstacles of the former design meeting. The core intention was to enhance collaboration, ensure

Table 1: Findings from the moment analysis of the existing online design meeting

Observation	Improvements to integrate in new format
Vague status updates, unclear deadlines, overestimated tasks completion	Strengthen follow-up, define tasks and deadlines clearly
Unclear processes and dependencies	Document workflows and outline dependencies
Prerequisites requested/identified too late	Define and document prerequisites
Missing deadlines for task completion	Set deadlines and enforce consequences
Unclear prioritization and flexibility of tasks	Prioritize and document tasks after discussion
Consequences unclear/not addressed, tasks are postponed without discussing the impact	Link tasks to milestones and communicate/document consequences
Substitutes unable to provide information	Ensure proper handovers
Lack of or delayed responses	Ensure early incorporation of topics
late identification of relevant topics	Refer to the execution milestones
Deadlines set based on feasibility rather than need	Define necessity before setting deadlines
Lack of moderator leadership	Strengthen moderator role and separate from taking notes
Redundant discussions across multiple meetings	Distinguish meeting scopes, merge overlaps
Absence of key participants	Increase transparency participant availability
Unclear responsibilities, procurement gaps, and missing procurement approvals	Enhance procurement integration and define deadlines
Lack of overall design coordination	Assign clear coordination responsibilities
Topic closed prematurely without stakeholder confirmation	Assign coordination responsibility to prevent late conflicts
Topics discussed sequentially, not by priority	Prioritize and cluster topics
High number of non-contributing participants	Limit attendance to essential roles

the completion of execution design, and close design gaps through more structured coordination processes. A key priority of the concept was to preserve and promote an emotionally intact environment for all design participants. Creating a constructive and solution-oriented atmosphere was considered essential to foster engagement and encourage proactive problem-solving. The concept is structured around three key principles:

1. **Technical expertise**: Ensure that the relevant specialists are involved in the meeting to provide essential subject-matter knowledge and insights.
2. **Process-oriented thinking**: Promote through a structured meeting format with visual tools, such as Post-its or digital equivalents, to highlight dependencies, workflows, and priorities. This ensures that the meeting discussions remain methodical and productive.
3. **Temporal frameworks**: Established by aggregating individual process steps and presenting them as a graphical thematic landscape. This enhances transparency, helping stakeholders better understand the sequencing of tasks and supporting decision-making.

This concept integrates Lean principles with engineering and construction expertise to enable transparent production planning and holistic, cross-disciplinary coordination. It provides structured decision-making support and fosters collaboration among experts from different organizations. The objectives of the concept include:

- Transformation of the design meeting into an in-person meeting
- Strengthening the development of solutions and interaction within the design team

- Identification of design gaps, including responsibilities
- Consideration of the project control meeting run by the scheduling department as the leading coordination meeting

IMPLEMENTING IDPM FORMAT

To put the concept into practice, the Integrated Design and Planning Meeting (IDPM) format was developed, combining two complementary meeting types: a design meeting (DM) and a planning meeting (PM) (see Figure 1). Due to the high number of topics, the detailed design meeting is held weekly, while the planning meeting takes place biweekly.

The IDPM focuses on multilateral topics to ensure cross-disciplinary coordination, whereas bilateral issues are addressed separately to maintain efficiency. The planning meeting is scheduled for 11:00 AM to 12:30 PM every even week following the project control meeting, and the design meeting runs from 1:30 PM to 5:30 PM on even weeks and from 9:00 AM to 4:00 PM on odd weeks to address specific topics. During the design meeting, participants collaboratively document the current status, discuss technical solutions, define the next steps, and visually map the timeline of the task sequence using sticky notes. This approach creates a shared understanding, forms the basis for a design schedule, and ensures bottom-up integration into the overall project timeline. Additionally, new design topics are raised, prioritized, and added to the agenda for structured discussion. To manage the large volume of topics, the format allows parallel processing in two groups, requiring some parties to attend with two representatives or switch between tables if possible.

As the number of topics grew rapidly and the team faced an overload of tasks, a four-week sprint was conducted from late October to mid-November, during which only existing topics were addressed. After the sprint, the IDPM continued as planned.

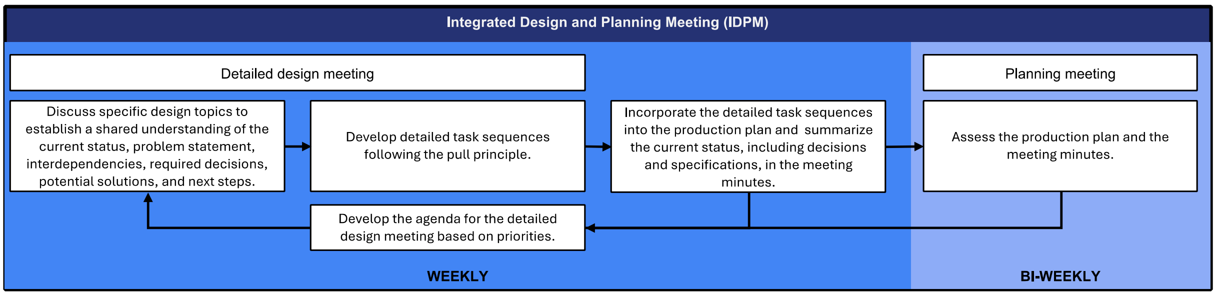

Figure 1: Outline of the IDPM format

EVALUATION OF QUESTIONNAIRE

The questionnaire first collected data regarding the frequency of PM and DM participation using a 7-point Likert scale to filter the sample size. Most participants reported frequent engagement in PM and DM, with five individuals indicating attending “always”. Few participants reported lower levels of involvement. Two respondents were excluded from the final analysis to ensure data consistency, as they attended the PM “rarely” and “never,” and the concept needs to be reflected based on both components. The sample size for this study was N = 22; after excluding two cases, the final analytical sample consisted of N = 20. This reflects the regular core group of participants who consistently attended the IPDM meeting.

SOCIODEMOGRAPHIC CHARACTERISTICS

The distribution of the project participants reveals a varied yet balanced representation across different roles. The majority identified with the owner organization (n = 9), followed by design/ engineering contractors (n = 8), and fewer with the general contractor (n = 3) (see Figure 2).

In terms of age, the participants are primarily concentrated within the 30-55 years range, with the most represented group being those aged $30 < x \leq 40$ years (n = 9). A similar number of participants fall within the $30 < x \leq 40$ years category (n = 8), while individuals over 55 years are less represented (n = 3). This suggests that the project draws primarily from a middle-aged demographic, likely offering a balance of experience. The data on years of involvement in the project shows a diverse range of experience. A portion of participants (n = 3) have been involved for less than a year, while a larger group (n = 5) has contributed for 1 to 3 years. Four individuals each report between $3 \leq x < 6$ years and $6 \leq x < 10$ years of engagement. Interestingly, four participants have been with the project for over 10 years. Regarding the participation period in the IDPM, most participants (n = 16) report being involved for 6 months. This means that they were involved from the beginning. A smaller group participated for 3 (n = 2) and 5 months (n = 1). No participants reported being involved for only 1 or 2 months.

The data reveals a well-balanced composition of the project team, with participants varying in role, age, professional experience, and duration of involvement. This combination suggests a strong foundation of technical expertise alongside a wide range of perspectives shaped by generational diversity.

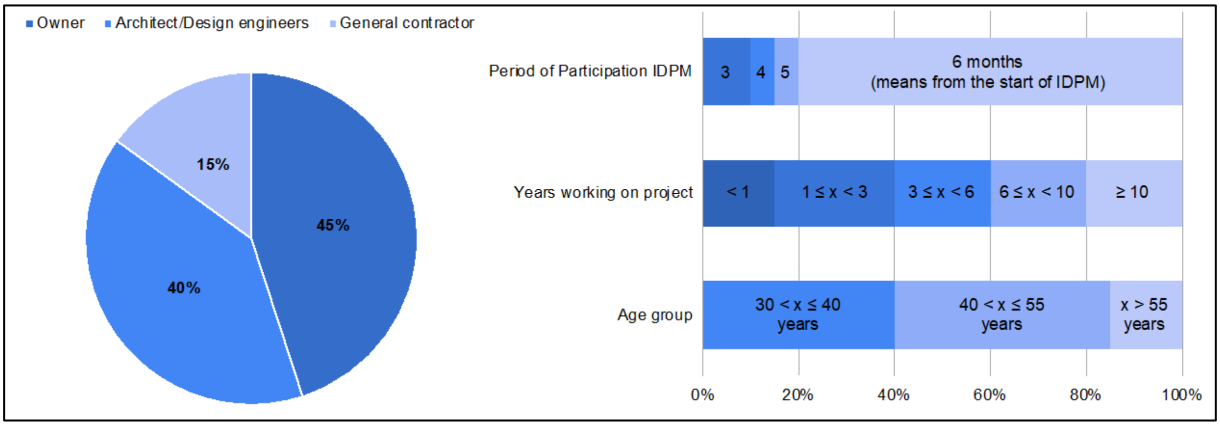

Figure 2: Sociodemographic characteristics of the final analytical sample (N=20)

MEAN (M), STANDARD DEVIATION (SD), AND CRONBACH'S ALPHA

Table 2 presents the mean (M), standard deviation (SD), and Cronbach's alpha (α) for the seven categories assessed in the questionnaire. These measures offer insights into central tendencies, variability, and internal consistency of the respective scales. The highest mean scores were recorded for team communication (M = 4.09) and documentation (M = 4.08), indicating that respondents rated these aspects most positively. Meaningfulness (M = 4.00) and impact on individual work (M = 3.97) also received strong ratings, suggesting that participants view these elements as significant contributors to their work environment. The lowest mean was found for problem-solving (M = 3.81), which may indicate a need for further development in this area. The most significant variability in responses was observed for meaningfulness (SD = 0.74) and impact on individual work (SD = 0.71), indicating diverse perceptions among respondents regarding these constructs. In contrast, team communication (SD = 0.48) and project progress (SD = 0.49) exhibited the least variability, suggesting more uniform evaluations of these aspects. Furthermore, filtering the highest mean (M = 4.55) of all items shows a strong positive perception among participants regarding their opportunity to contribute and the encouragement to express opinions during the IDPM (see Table 3). The standard deviations of both items are relatively low, indicating that most respondents' answers are close to the mean, and since the scale ranges from 1 to 5, most values are in the upper range of the scale. This suggests that these perceptions are consistent among the respondents. The lowest measured mean (M = 3.60) indicates a generally positive perception among respondents regarding the value added by the

IDPM to their work and the involvement of all relevant stakeholders in solution development. Both items have a standard deviation of 1.05, reflecting moderate variability in responses.

Cronbach's alpha (α) was calculated to assess the internal consistency of the scales. The highest reliability was found for impact on individual work (α = 0.89), followed by meaningfulness (α = 0.84) and documentation (α = 0.83), all demonstrating strong internal consistency (see Table 2). The lowest reliability values were observed for project progress (α = 0.70) and problem-solving (α = 0.74), though both fall within an acceptable range, indicating that the scales adequately measure their intended constructs.

However, team communication and documentation received the most favorable ratings, while problem-solving was rated the lowest. The observed standard deviations suggest varied perceptions of meaningfulness and impact on individual work, which may merit further exploration. Reliability analyses show that the questionnaire constructs exhibit acceptable to high internal consistency, supporting the robustness of the measurement instrument.

Pearson's correlation of the seven categories

Category	Mean (M)	Standard Deviation (SD)	Cronbach's alpha (α)
Effectiveness	3.96	0.51	0.78
Meaningfulness	4.00	0.74	0.84
Project Progress	3.88	0.49	0.70
Documentation	4.08	0.65	0.83
Impact on Individual Work	3.97	0.71	0.89
Team Communication	4.09	0.48	0.79
Problem-Solving	3.81	0.47	0.74

Table 3: Items with the highest and lowest achieved mean

Item	M	SD
A.4: Do you have sufficient opportunity to contribute your opinions or ideas during the IDPM?	4.55	0.51
F.2: Were all participants encouraged to openly express their opinions, ideas, or concerns in the IDPM?	4.55	0.60
B.2: To what extend does the IDPM added value to your work?	3.60	1.05
G.4: Were all relevant stakeholders involved in developing solutions in the IDPM?	3.60	1.05

PEARSON'S CORRELATION

Pearson's correlation coefficients were used to evaluate the relationships between the seven questionnaire categories. The results indicate several strong and moderate correlations, highlighting key interdependencies among the factors (see Table 4). The results suggest that effectiveness and meaningfulness are closely related, meaning that meetings perceived as meaningful are also deemed effective. Impact on individual work is strongly influenced by multiple factors, including meaningfulness and project progress. Team communication plays a key role in problem-solving, though it has a weaker relationship with documentation. Overall, documentation appears to be the least correlated with other factors, indicating it might function more independently within the assessed framework. One possible reason why documentation has the least impact on other factors could be its supportive rather than direct role. While documentation is essential for maintaining records, ensuring compliance, and providing reference materials, it may not actively drive immediate outcomes such as problem-solving, team communication, or individual work performance in the same way that effectiveness, meaningfulness, and project progress do. Instead, it primarily serves as a reference to establish alignment, particularly during design iterations. As a result, teams may consult it when needed. Still, its day-to-day influence on problem-solving and communication remains limited—unless a strong culture of integrating documentation dynamically into workflows is established. Regarding the frequency of participation, only a negligible correlation was found. However, as Table 4 shows, there are different interdependent factors impacting the success of a meeting that need to be considered when developing a new concept.

Table 4: Pearson's correlation of the seven Categories

Category	(B)	(C)	(D)	(E)	(F)	(G) Problem-Solving
(A) Effectiveness	0,82	0,74	0,59	0,71	0,56	0,65
(B) Meaningfulness	-	0,69	0,60	0,78	0,48	0,48
(C) Project Progress		-	0,47	0,70	0,57	0,69
(D) Documentation			-	0,59	0,44	0,31
(E) Impact on Individual Work				-	0,62	0,49
(F) Team Communication					-	0,72

FEEDBACK FROM RESPONDENTS

The questionnaire feedback regarding the meeting highlights several positive aspects and areas for improvement. Participants emphasized the meeting's role in fostering open communication and creating a space for direct exchanges. It allowed for sharing ideas and developing solutions, contributing to a collaborative, outcome-oriented culture. The transparency of processes, tasks, deadlines, and project milestones improved, while the direct problem-solving and task assignment led to increased efficiency and time savings. However, some challenges were also noted. Missing participants occasionally hindered the effectiveness of the discussions, and the preparation process was sometimes difficult due to the large number of topics. Despite these challenges, the documentation of the sequences to a detailed production plan was identified as particularly helpful. Additionally, the meetings facilitated the identification of design gaps and critical issues, making it possible to address open interfaces and ensure clear assignment of responsibilities. The presence of key stakeholders in the meetings enhanced problem-solving speed and effectiveness, and raised awareness of important topics and progress tracking.

One notable point is the lack of alignment between the software and the sequences created during the IDPM. Now, as the detailed production plan shows high reliability, the information of the detailed production plan is transferred in a higher degree of abstraction into the project control plan. The high frequency of topics and the identification of design gaps, due to the increased transparency, lead to an overload. Participants also mentioned that some experts were missing during discussions (see also Table 4 item G4) of specific topics. They highlighted the need for two separate spaces to accommodate both groups simultaneously, as the overlap could pose challenges in maintaining focus. In addition, topics should not be limited to the underground station. The respondent requests a stronger consideration of the overall system rather than the division between the subprojects Bonatz building and the underground station.

RESEARCH FINDINGS

The introduction of the IDPM format has stabilized the design process at a detailed level, enhancing the reliability of both technical and scheduling information provided by the design team. This, in turn, has strengthened trust both within the design team and in its collaboration with the owner. The success of this format has led to its expansion to include topics such as tendering and construction workflows. This necessitates stringent prioritization, particularly of highly complex topics involving multiple stakeholders and significant project impacts. A key insight is that, in megaprojects, the design and approval processes, encompassing planning, quality assurance, and internal corporate approvals, are considerably more time- and resource-intensive than construction execution, especially as requirements change over time. As a result, increasing transparency during the design phase has proven essential in shifting attention from construction execution to upstream design activities.

The questionnaire data offers valuable insights into meeting perceptions and internal consistency. Team communication and documentation were rated as the most effective aspects of the IDPM format, while problem-solving scored lowest, often due to missing stakeholders in discussions. The results also indicate a strong link between effectiveness and meaningfulness of meetings, with communication playing a key role in problem-solving. Reliability analyses confirm the robustness of the measurement instrument. Overall, the findings indicate successful improvement of the initial situation through the implemented concept.

Moreover, megaprojects often operate outside established technical standards due to their unique functional requirements or exceptional designs. Their realization requires adherence to the latest scientific advancements, not just conventional technology. From a liability perspective, this unregulated design space leads to major obstacles and causes most delays within this project. Overcoming these challenges requires a strong relationship between the building owner and the design team, with decisive representatives on both sides. This interface coordination doesn’t organize itself; rather, it requires a knowledgeable yet neutral entity to mediate conflicting interests. The findings emphasize that project delays stem less from a lack of technical competence and more from a lack of transparency, undefined processes, and unregulated contractual risk areas. Thus, proactive owner participation and structured coordination mechanisms are essential for successful project delivery.

CONCLUSION

Stuttgart 21 illustrates the complexity of large-scale infrastructure project and emphasizes the need for a structured design phase. This case study demonstrates how the integration of Lean principles with engineering and construction expertise can help overcome typical challenges such as fragmented communication, uncoordinated schedules, intransparency, and misaligned stakeholder expectations. A key step was the introduction of the IDPM format, which, through regular in-person meetings and defined agendas, enhanced coordination and efficiency within the design team. The presence of a neutral coordinating entity further improved stakeholder engagement and collaboration. Overall, the feedback reflects a highly positive response to the concept.

While the study offers valuable initial insights, the small sample limits generalizability. To validate its relevance and assess its long-term impact, the IDPM format should be broader applied across diverse projects. Nevertheless, the lessons learned from Stuttgart 21 offer a practical framework with strong potential to improve coordination and decision-making in megaprojects, even when the design phase has already been in progress for over a decade.

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