Project management in construction and dealing with complexity[1]

Michael Frahm

Introduction

In today's construction industry, projects are under increasing pressure to respond flexibly, sustainably and efficiently to complexity. In addition to traditional goals such as adherence to deadlines, cost certainty and compliance with quality standards, other requirements are now coming to the fore. These include short innovation cycles, changing regulatory frameworks, volatile markets, multidimensional target systems and staff shortages. Against this backdrop, project management is increasingly important as a formative element. It creates structures that enable not only stability but also adaptability. The established tools and procedures as described, for example, in the AHO (2020) service profile, form an important basis for this. At the same time, it is becoming apparent that traditional methods alone are often not enough to cope with the growing complexity and dynamism. It therefore makes sense to consider complementary approaches from other areas. These include principles of lean construction, integrated project delivery and approaches from systems thinking, which can provide valuable impetus for the further development of project management (Frahm & Rahebi 2021).

Complexity as a fundamental condition of project management

Construction projects are characterised by a multitude of participating institutions, interests and interfaces. Decisions made in one area often have unexpected impact on other parts of the system. Complexity requires an understanding of interactions, uncertainty and the dynamics of change. Complex project contexts involve characteristics such as:

- Rapid phase transitions,
- Unclear or changing goal definitions,
- Mutual dependencies with non-linear influence,
- High sensitivity to disruptions,
- Time-delayed or feedback-based cause-and-effect relationships,
- High risks (Frahm & Pfiffner 2023).

Today, project management must do more than just classic control and planning. It must grasp contexts, anticipate changes and keep decision-making options open. This is

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resource-intensive and requires not only methodological competence but also a high degree of flexibility. It is important to actively manage interfaces and changes, to react quickly to short-term shifts and, at the same time, to identify long-term trends early on and take them into account strategically.

W. Ross Ashby's Law of Requisite Variety provides a central theoretical foundation for managing complexity (Ashby 1956). Put simply, it states that only variety can regulate variety. This means that a control system must have at least as many options for action (variety) as the disturbances it seeks to regulate (Frahm 2025 a). Applied to project management, this means that the more complex and dynamic a project context is, the greater the flexibility, variety of action and responsiveness of the project management must be.

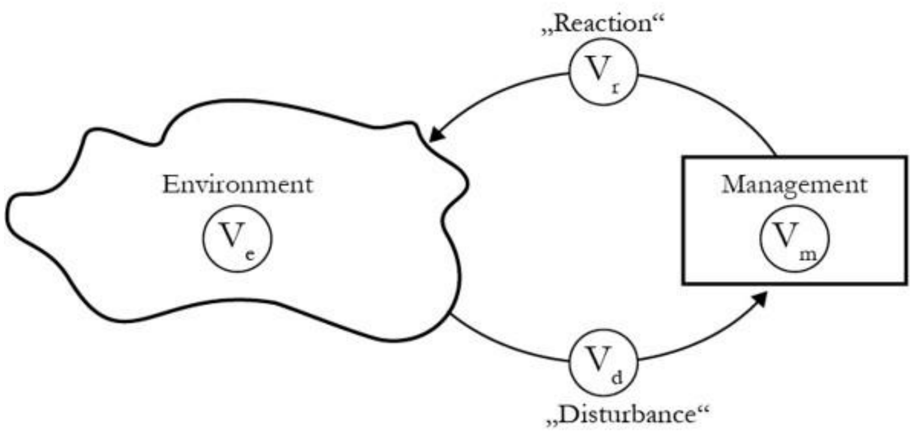

Figure 1 Ashbys Law

Conventional control models are based on fixed fields of action, such as project organisation, schedule and cost management, or contract coordination (AHO 2020). These provide stability and the foundation for the complexity-appropriate management of any project. However, limitations become apparent in dynamic projects. Project structures and processes are needed that are capable of responding to disruptions in a self-regulating manner via control loops and transparent information flows. Adaptive, complexity-appropriate, feedback-based management that takes both formal and informal processes into account is necessary (Frahm 2015).

Lean Construction: Control orientation through production systems

Lean construction stands for a methodical approach to increasing efficiency that is consistently oriented towards value creation, transparency and learning-based control. In contrast to traditional models, control here is continuous and adaptive. Essential principles are:

- Customer orientation: Not every activity adds value, what matters is what benefits the user.

- Flow orientation: Processes should run as smoothly, evenly and predictably as possible.
- Cooperative control: Decisions are made decentrally and on the basis of current information.
- Visual management: Transparency is not created through documentation, but interactively and directly at the place of action.

Proven methods for implementation include:

- Bigroom as collaborative workplace on site
- 5S for workplace organization
- A3 method for structured problem-solving
- Value Stream Mapping (VSM) for analyzing and optimizing material and information flows
- Kaizen for continuous improvement
- Kanban for controlling processes using the pull principle
- Poka Yoke for error prevention
- SMED (Single-Minute Exchange of Die) for reducing setup times
- TPM (Total Productive Maintenance) for optimizing maintenance activities
- Heijunka for production leveling
- Andon systems for visual fault management
- Hoshin Kanri for strategic lean management
- 5-Why method and Ishikawa diagram for root cause analysis

As production systems, the Last Planner Method and Takt Planning and Building are commonly used (Frahm & Roll, 2022; VDI Guideline 2553, 2019). This way of thinking promotes an understanding of control that strengthens responsiveness, shorter communication channels and trust, thereby reducing waste (Ritzinger-Roll et al. 2024).

At the same time, lean construction refers to the systemic understanding that Taiichi Ohno already established with the Toyota Production System (TPS). Value creation does not result from optimising individual work steps, but from the holistic design of the overall system. Every intervention has influence on other parts of the process and the system. Management therefore does not mean control in the traditional sense, but rather continuous learning about interactions. Lean thus requires not only methodological competence, but also thinking in terms of contexts, relationships and feedback, a systemic mindset as the basis for complexity-appropriate process management (Frahm & Roll 2022).

Integrated Project Delivery (IPD): Control orientation through trust

Integrated Project Delivery (IPD) is not a tool in itself, but an alternative organizational approach. The central idea is to involve project participants, especially construction contractors, at an early stage, align them through shared financial incentives, and bind them contractually to collective project goals.

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This changes the traditional control paradigm in several ways:

- Conflicts of interest between design and execution are addressed collaboratively from the outset.
- Decisions are made through consensus rather than hierarchical command structures.
- A culture of error acceptance and continuous learning becomes part of the management logic

Unlike conventional project delivery models such as Design-Bid-Build or Design-Build, which often reinforce siloed responsibilities, IPD seeks to dissolve these divisions. It fosters a joint project identity by aligning objectives, risks, and rewards across disciplines. Early involvement is not merely procedural but shifts the logic of coordination from control to cooperation. A key element of this logic is the shared risk/reward model. Participants agree to link parts of their compensation to the overall project performance. This mechanism reduces opportunistic behavior and encourages problem-solving beyond individual scopes of work. In practice, it establishes a collective interest in cost control, schedule adherence, and quality. Digital tools such as Building Information Modeling (BIM) further support this by enabling transparent planning processes and shared access to real-time information (CIDCI et al., 2020).

From a systemic perspective, this approach aligns with Anatol Rapoport's conception of participation as more than formal inclusion, it requires influence over goals and norms of cooperation. His "tit for tat" principle, rooted in reciprocity and tested across game-theoretical models, is particularly applicable in this context. It begins with cooperation, mirrors the behavior of others, and allows for flexible responses to uncooperative actions. In IPD projects, this encourages a relational dynamic in which reliability is reinforced and opportunistic behavior becomes visible and socially regulated, without relying on punitive measures (Frahm & Rahebi, 2019).

Similarly, Lynn Margulis notion of symbiosis as an evolutionary driver resonates with the IPD philosophy. Development, in this view, does not emerge through competition alone but through co-adaptive collaboration. The IPD framework creates conditions under which diverse actors, planners, builders, and clients, develop mutual dependencies that strengthen resilience and innovation capacity (Frahm 2025b). From a sociological standpoint, Niklas Luhmann's theory of social systems suggests that trust serves as a means of reducing complexity. In IPD environments, trust is not an abstract value but a structural component. It is institutionalized through multiparty agreements and reinforced by the everyday culture of the project team. Rather than relying on formal control mechanisms alone, IPD builds expectations of consistency and accountability. Trust becomes a functional equivalent of control in a high-uncertainty environment (Luhmann 2014).

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IPD thus represents not only a reconfiguration of delivery processes but a broader cultural shift. Control is no longer externally imposed but emerges from within the social system of the project. Learning replaces blame, and governance becomes a dynamic process of negotiation and mutual commitment.

Systems thinking: Mindset and concepts

Systems thinking fundamentally changes the understanding of project management. Projects are no longer seen alone as linear, plannable processes, but as dynamic, interacting networks. According to Hoverstadt (Hoverstadt 2022), system thinking, in contrast to conventional thinking, is the application of system approaches as described below with the SOSM - System of Systems Methodology and the way in which one perceives the world. Below are nine key mindsets that characterise systems thinking are given:

1. Emergence instead of reductionism

While reductionism assumes that a system can be understood by understanding its parts, systems thinking emphasises that systems have properties that only arise at the level of the whole. These so-called emergent properties are lost in purely analytical decomposition.

2. Holism instead of analysis

Analysis breaks things down into individual parts in order to understand them. The holistic approach first asks: "What is this element part of?" Understanding comes from context, not decomposition.

3. Relationships instead of things

Conventional approaches focus on objects and types (e.g. personality tests such as Myers-Briggs). Systems thinking, on the other hand, emphasises relationships and interactions between elements as the primary unit of analysis.

4. Non-linearity instead of linearity

Classical approaches think in terms of cause-and-effect chains. Systems thinking works with feedback loops (positive and negative) through which systems experience stability or change, a completely different view of cause and effect.

5. Differences instead of equality

While conventional thinking sorts by equality, systems thinking looks for the differences that make a difference. Differences define boundaries, and these structure a system.

6. Dynamics instead of statics

Classical thinking looks at states. Systems thinking looks at systems in motion, i.e. in change, and asks: "What is it becoming?"

7. Complexity instead of superficial effects

Classical methods respond to visible behaviour. Systems thinking asks about the hidden complexity that produces these behaviours, i.e. about the causes, not just the symptoms.

8. Working with models instead of just intuition

Everyone uses models to understand the world. Systems thinking makes these models conscious and usable. Changes are first tested in the model, not in reality, in order to minimise risks.

9. Acceptance of uncertainty instead of the illusion of certainty

Classical thinking strives for order and certainty. Systems thinking accepts uncertainty as part of reality and still designs consciously. Or as Voltaire said: "Uncertainty is unpleasant, but certainty is absurd." (Hoverstadt 2022)

Mike C. Jackson's System of Systems Methodologies (SOSM) provides a frame of reference for selecting suitable systemic approaches to thinking and acting depending on the respective problem context (Jackson 2019). At its core is the assumption that different project situations cannot be tackled with a universal methodology, but that the choice of methods must be context-sensitive. The model distinguishes between two central dimensions: the degree of complexity of the system to be controlled and the degree of agreement on goals and values among the actors involved. This results in six fields, each of which suggests different methodological approaches. In the practice of complex projects, all areas are important, as technical and organisational complexity, as well as diverging interests, power relations and normative issues, must be considered in an integrated manner. SOSM thus promotes a differentiated understanding of project management as a context-related, reflexive design practice. Various systemic methods such as VSM - Viable System Model, SD -System Dynamics or SSM - Soft Systems Methodology are located within this matrix and show the contexts in which they are typically used. The graphic thus supports the basic idea of a methodologically pluralistic, situation-appropriate system practice.

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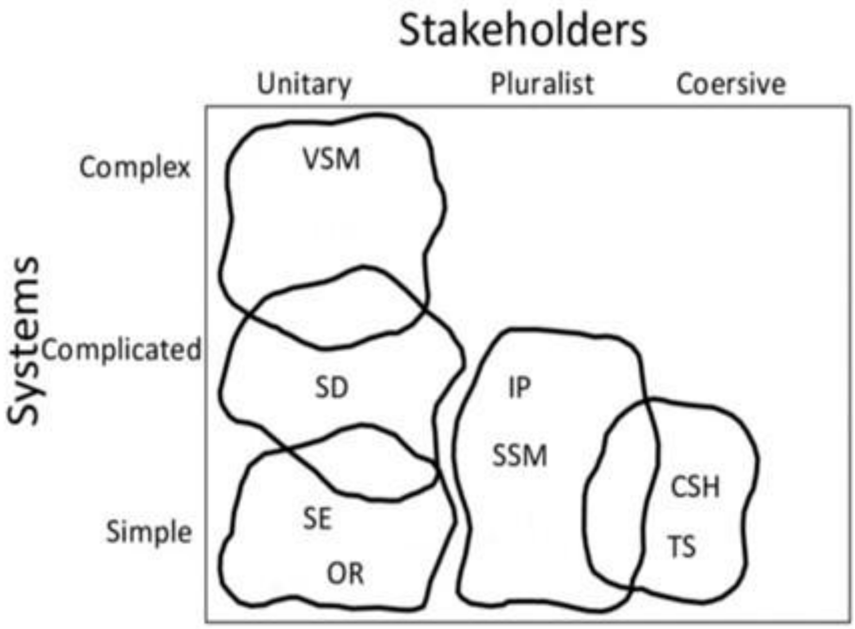

Figure 2 – SOSM Adaption according to Jackson (2019)

The key methods are briefly described below.

Unitary:

OR (Operations Research)
Operations Research uses mathematical models to improve processes and support decision-making. It is commonly applied in areas like logistics, production, and resource allocation.

SE (Systems Engineering)
Systems Engineering is an interdisciplinary approach to designing, managing, and integrating complex technical systems throughout their life cycle.

SD (System Dynamics)
Founded by Jay W. Forrester, System Dynamics models how systems evolve over time, including feedback loops, delays, and non-linear behavior.

VSM (Viable System Model)
Founded by Stafford Beer, the Viable System Model helps analyze and design organizations that are capable of adapting and surviving in complex environments.

Pluralist:

SSM (Soft Systems Methodology)
Founded by Peter Checkland, the SSM is a practical, qualitative method for tackling messy problems where goals are unclear and people have different views.

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IP (Interactive Planning)
Founded by Russel Ackoff, Interactive Planning is a participatory way to plan for the future, focusing on learning, collaboration, and adapting to change.

Coersive:

CSH (Critical Systems Heuristics)
Founded by Werner Ulrich, CSH is a reflective approach for analysing complex situations with a focus on power, values, and assumptions. It questions who is affected by decisions and whether the decision-making framework is legitimate.

TS (Team Syntegrity)
Founded by Stafford Beer, Team Syntegrity is a structured process that supports balanced, inclusive communication in groups. It enables collaborative decision-making without relying on hierarchy.

Conclusions: Project management as complexity practice

With second-order cybernetics, von Foerster emphasises that controllers do not stand outside the system. Control is reflexive. Decisions influence the system and the decision-making logic itself. The ethical imperative "Always act in such a way that the number of options increases" calls for long-term, wise decisions (Frahm 2025 b). The project management of the future is neither purely technocratic nor purely intuitive, it is systemically grounded, iterative, learning and orientation-oriented. The key conclusions are: Complexity is not a disturbance, but a basic condition. Those who try to eliminate it create artificial instability. Resilient project management arises from the ability to recognise patterns, create meaning and be prepared for emergence. This article presented various ways of dealing with complexity. Project management must evolve from a reactive control function to a proactive, systemic design practice. Integrating methods from systems thinking, lean construction, and integrated project delivery enhances the capacity to navigate complexity constructively. Future-oriented project management requires not only methodological pluralism, but also a fundamental shift in mindset towards emergence, adaptability and shared responsibility to become a future complexity practitioner.

Information on the use of AI

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About the Author

Michael Frahm

Baden-Württemberg, Germany

Michael Frahm studied civil engineering and business law in Stuttgart, Kaiserslautern and Saarbrücken. Management courses at HEC Paris, HHL and Northwestern University. Winner of the Young PM Award of the GPM (IPMA) in 2010. Certification as Senior PM of the IAPM and certification as Advanced System Thinking Practitioner of the SCiO. Author of construction project management books with a systems perspective. Numerous articles and lectures on engineering and management. Lecturer on major project management and systems practice. More than 15 years of experience in the construction industry. Director of SCiO in German-speaking countries. Vice President of the EFBK- European Forum for Construction Cybernetics.

He can be contacted at michael.frahm@systemspractice.org or Orcid: https://orcid.org/0000-0001-8470-6147 or Linkedin: https://www.linkedin.com/in/michael-frahm-65220573/

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