A - Decisions in Architecture Development and Implementation - Case from ROCKWOOL

Mikkel Sohrt[1], Willads Blinkenberg[2], Niels Henrik Mortensen[2], Christian Eskildsen[3]

[1]Rockwool A/S.
[2]Technical University of Denmark, Department of Civil & Mechanical Engineering, Section of Engineering Design and Manufacturing Systems.
[3]North European Modularization ApS - N.E.M., Denmark.

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1 Introduction

Architecture implementation has proven to be a key enabler of innovation, operational efficiency, and competitiveness in industries such as automotive and consumer electronics. However, many companies struggle to successfully implement architectural strategies and realize significant business benefits.

One reason is that organizations often attempt to manage and align too many decisions across product development, manufacturing, and service operations. Drawing heavily on experience from the automotive industry, this presentation introduces the concept of A-decisions - the small number of architectural decisions that drive innovation, efficiency, and long-term competitiveness.

The paper demonstrates how A-decisions can be identified and implemented in practice. Rather than attempting to coordinate hundreds of decisions, organizations can focus on a few critical choices that shape the architecture and enable substantial performance improvements. At ROCKWOOL, aligning A-decisions has reduced engineering effort and lead times, creating significant business value. This capability is strategically important in a market where new production facilities must be designed and deployed faster than ever before.

The ability to focus on a limited set of high-impact decisions is also essential for effective implementation. While hundreds of decisions cannot realistically be managed and aligned, a carefully selected set of A-decisions can be governed and deployed across the organization.

2 State of the Art

A variety of methods and tools have been developed to model and manage modular architectures, yet few provide a systematic approach for identifying and prioritizing the architectural decisions that have the greatest impact on project performance.

The Design Structure Matrix (DSM), (Eppinger 2001) is one of the most widely used methods for modelling system architectures by capturing dependencies between components, tasks, or functions,. DSM supports the identification of modules and clusters and has been extended through advanced algorithms that incorporate engineering constraints such as maintenance and thermal considerations. While effective for visualizing complexity, DSM primarily maps relationships and does not distinguish between ordinary design decisions and high-leverage structural decisions. In large projects with hundreds of dependencies, DSM provides limited guidance on which decisions have the greatest impact on lead time, cost, or value-chain coordination.

The Product Family Master Plan (PFMP), (Harlou 2006) provides an object-oriented framework that links customer needs, engineering solutions, and physical components. (Pakkanen 2016) further developed the approach into a structured method for rationalizing product variety and creating modular product families. The method effectively manages partitioning logic, modules, interfaces, architecture, and configuration knowledge. However, PFMP primarily focuses on managing product variety and technical compatibility. It does not explicitly identify which architecture decisions drive project performance in terms of cost, lead time, and cross-functional efficiency.

The Mechanics, Electronics, and Software Architecture (MESA) approach extends PFMP by integrating mechanical, electrical, and software perspectives into a common architectural framework (Askhøj 2021). This creates greater awareness of cross-functional dependencies and the cascading effects of engineering changes. Nevertheless, without a mechanism for prioritizing key structural decisions, architectural development across domains can become fragmented, resulting in conflicting solutions and reduced cost efficiency.

The Integrated PKT Framework provides one of the most comprehensive toolsets for modular product family development (Küchenhof, 2020). Its primary strength lies in validating modular concepts against lifecycle requirements such as procurement, production, assembly, sales, operation, and disposal. The Module Process Chart introduced by (Blees 2011) supports this validation process. However, PKT assumes that potential module concepts have already been identified. Consequently, it offers limited support for identifying which architectural decisions should receive attention first or which decisions have the greatest systemic impact in large projects.

More recent frameworks, including Business-Critical Design Rules (BCDRs) and the Cross-functional Architecture Matrix (CAM), attempt to improve prioritization by focusing on architecture decisions that influence value-chain performance, risk, and time-to-market, (Sohrt 2025). Although these approaches help organizations direct attention toward strategically important decisions, prioritization remains largely dependent on subjective stakeholder assessments. As a result, they lack an objective engineering-based mechanism for identifying which structural decisions will have the greatest downstream consequences.

Many methods have been developed to model, describe, validate, and manage modular architectures. While these approaches provide valuable insights into system structure, dependencies, modularization, and organizational alignment, they do not explicitly identify the key architectural decisions that drive lead time, quality, and costs. As a result, organizations often lack an objective basis for prioritizing the few high-leverage decisions that determine overall project performance. This highlights the need for new approaches that move beyond architecture description and instead focus on identifying and managing the structural decisions with the greatest business impact.

4 A Decisions

From a systems theory perspective (Hubka, 1988), a system has two fundamental attributes: characteristics and properties. Characteristics are the aspects of a system that can be directly designed and specified. For a mechanical component, these include material, dimensions, geometry, and surface quality. At the system level, the most important characteristic is the structure, such as the layout of a vehicle, building, or product architecture for a product line.

Properties, in contrast, emerge once all characteristics have been determined. For a mechanical component, examples of properties include strength, stiffness, weight, and durability. Properties are therefore the result of the interaction between the system's characteristics.

A fundamental principle of systems theory is that changes to the system structure generally have a greater impact on overall system performance than changes to the characteristics of individual elements. Applied to product architecture, this implies that changes to the architecture of a product line typically have a much greater effect than modifications to individual products. Similarly, in building design, altering the floor plan usually has a more significant impact than changing a single door or window.

Consequently, architectural decisions exert a greater influence on system performance, cost, and lifecycle outcomes than any other category of design decision. Within the architecture domain, a particularly important subset is referred to as A-decisions. (Blinkenberg, 2026) and (Short, 2025) define an A-decision as an architectural decision characterized by five key dimensions:

a) It has a significant impact on cost, lead time, operational efficiency, and innovation capability.
b) It is typically cross-disciplinary and cross-functional, affecting multiple engineering domains (e.g., civil, mechanical, electrical, and software engineering) as well as organizational functions such as engineering, manufacturing, and procurement.
c) Customers are generally indifferent to the specific decision itself, making stakeholder alignment and agreement easier to achieve.
d) It affects multiple systems and subsystems, meaning that standardizing and stabilizing such decisions can generate substantial engineering benefits.
e) It influences several lifecycle phases, including manufacturing, installation, operation, maintenance, and service.

5 ROCKWOOL Case

Rockwool is a Danish company and one of the world's leading manufacturers of stone wool insulation solutions. Founded in 1909 and headquartered in Denmark, the company develops products for thermal insulation, fire protection, sound reduction, and sustainable building construction. ROCKWOOL operates approximately 51 manufacturing facilities across 40 countries and employs more than 12,200 people worldwide. Its products are used in residential, commercial, and industrial buildings, as well as in horticultural growing media and acoustic ceiling solutions. In 2025, the company reported revenue of around EUR 3.9 billion.

Critical to Rockwools further growth and profitability is the ability to design and built more plants faster due to further need for more energy efficient buildings. The company has decided to investigate modular architectures based plants as one key enabler to realize this goal. Below is a schematic of a ROCKWOOLplant divided into 8 steps.

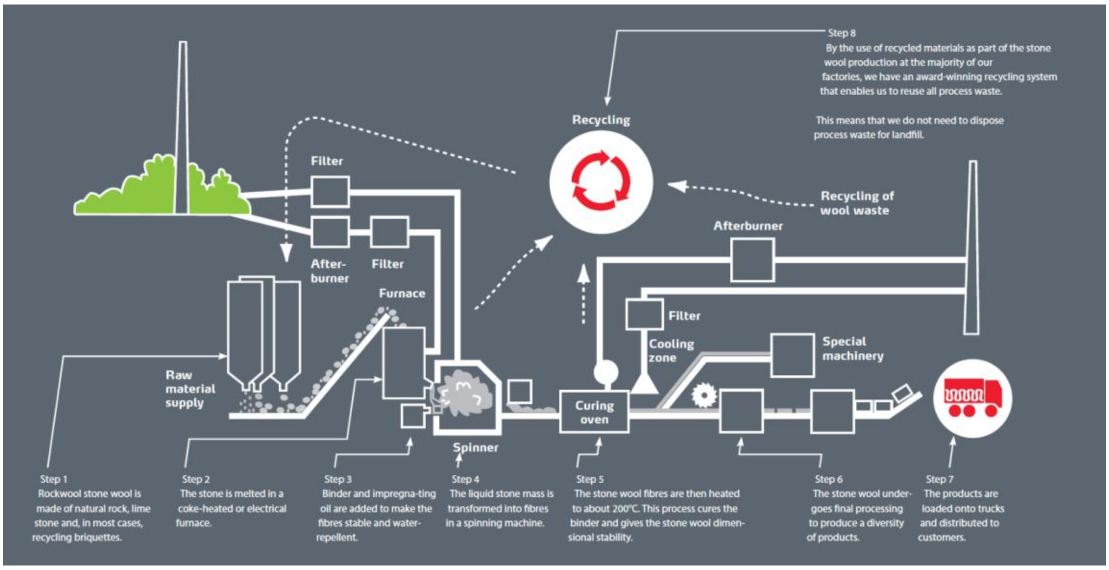

Figure 1. Main process steps in a Rockwool plant

The approach to identify A Decisions were as follows

Activity 1: This activity involved a systematic mapping of the design principles applied across the five most recent projects. Figure 2 illustrates the relationship between these principles. As an example, Design Principle 1.1 is shared across all projects, whereas at Step 3, three alternative solution principles are applied (3.1, 3.2, and 3.3). Due to confidentiality constraints, the data shown does not reflect the actual distribution of solutions across projects. It is important that the mapping was conducted at the design principle level, as this makes it possible to identify major similarities and differences between projects while abstracting from detailed design implementations.

Activity 2: This activity focused on mapping key performance indicators, including production output, quality, availability, and uptime, together with project cost and delivery time. To enable a comprehensive comparison, a lifecycle-oriented data model covering all major life phases was used. This allowed performance and cost implications to be evaluated across the entire value chain rather than within individual project phases.

Activity 3: This activity consisted of an in-depth assessment of the advantages and disadvantages associated with alternative design principles. The evaluation was conducted by a cross-functional team of senior engineers representing all major technical disciplines and interface areas, including civil, mechanical, electrical, and control engineering, as well as procurement, project management, installation, and commissioning. The activity proved challenging because of the large number of stakeholders and viewpoints involved. A design principle that appears optimal from a local perspective is not necessarily the best solution when considering the overall system. For example, a design choice that benefits one discipline may have negative consequences for other areas such as civil engineering, installation, operations, or maintenance.

Activity 4: In this activity, a set of potential A-decisions with significant impact on cost, lead time, efficiency, and innovation capability was identified. One of the first A-decisions recognized concerned the melt direction from the furnace. Two alternative design principles were employed across projects: left-direction melt flow and right-direction melt flow. Changing the melt direction affects more than 20 plant systems and requires substantial engineering modifications throughout the facility. Analysis revealed that more than 10% of total engineering hours were spent adapting designs between left- and right-direction melt configurations. This demonstrated both the extensive impact of the decision and the potential benefits of standardization.

Activity 5: The identified A-decisions were formally documented, including a description of each decision, its rationale, and ownership structure. The resulting agreement was reviewed and approved by all Vice Presidents to ensure alignment and organizational commitment across business units and functional areas.

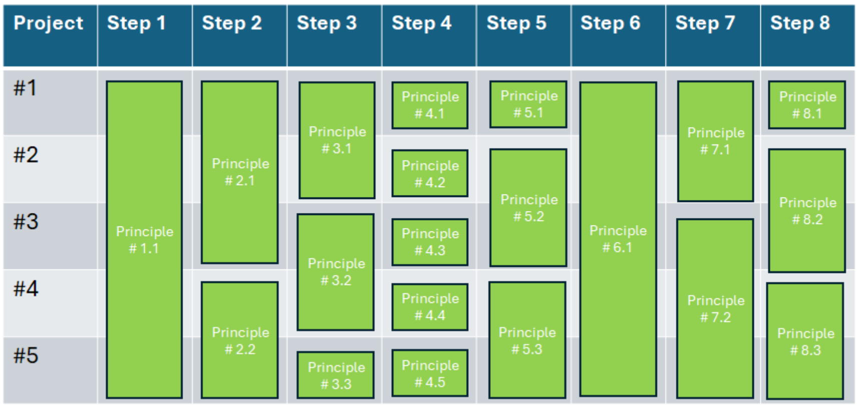

Figure 2. Mapping of main design principles across 5 plant projects

Activity 6: Finally, the A-decisions were incorporated into the company's project execution model as formal evaluation and governance criteria. This ensured that architectural considerations were addressed consistently during project planning, design, and execution, thereby supporting long-term standardization and strategic alignment across the project portfolio.

5 Conclusions

We have had very positive experiences with the introduction of A-decisions at ROCKWOOL. The concept is well understood by both management and the broader organization, including engineering, procurement, project management, installation, and other functions. It is also not open to interpretation; it is clearly defined whether a project complies with a given A-decision or not.

In our experience, A-decisions are a necessary and highly relevant first step in implementing modular architectures. There are three main reasons for this. First, if A-decisions are not stable, none of the underlying sub-architectures can be stable. Second, alignment on A-decisions delivers a significant share of the benefits associated with modular architecture. Third, compliance with A-decisions can be effectively monitored and followed up at the management level.

Reaching agreement on A-decisions is not easy, as it requires aligning multiple perspectives and balancing a range of often conflicting optimization criteria. However, when viewed from an end-to-end business perspective, many A-decisions ultimately have only one correct answer. ROCKWOOL views the A decisions as a critical enabler for reducing lead times and scaling the design, construction, and operation of new plants. However, these decisions alone will not deliver the desired outcomes. They must be implemented in conjunction with organizational changes, capability development, and the establishment of clear digital product and manufacturing standards.

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Contact: N.H. Mortensen, Technical University of Denmark, Department of Civil and Mechanical Engineering, Koppels Allé, Building 404, Kgs. Lyngby, tel: +4545256275, nhmo@dtu.dk