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ALM & MBSE

FOR REQUIREMENTS MANAGEMENT

WHITEPAPER 2025



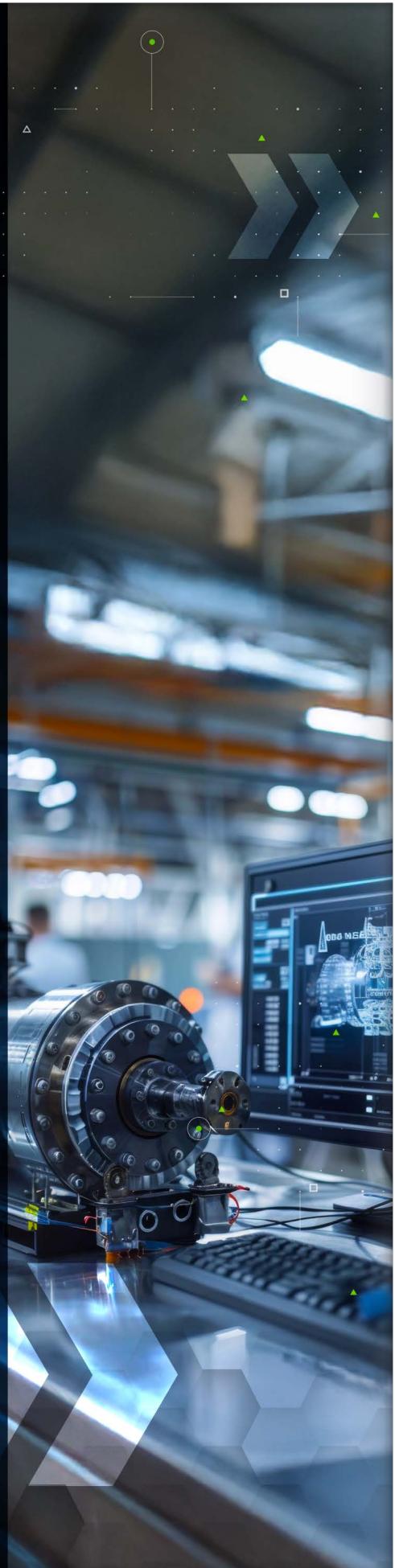


INTRO

Complex systems demand sophisticated approaches to requirements management. While Application Lifecycle Management (ALM) and Model-Based Systems Engineering (MBSE) each offer powerful capabilities, understanding when and how to use them together creates the foundation for successful project delivery.

CONSIDER THIS SCENARIO: A car manufacturer manages 30,000 to 50,000 requirements for a single vehicle. Some requirements are straightforward, such as color preferences, while others involve complex interactions between safety systems, engine performance, and user interfaces. This mix of simple and complex requirements highlights why organizations need both ALM and MBSE tools.

This whitepaper explores how ALM and MBSE complement each other, when to use each approach, and how their integration strengthens requirements management across complex projects.





OVERVIEW OF APPLICATION LIFECYCLE MANAGEMENT (V-MODEL)

Application Lifecycle Management (ALM) is a framework that governs the complete lifecycle of a system or product, from initial conception and requirements through design, development, testing, deployment, maintenance, and eventual decommissioning. ALM provides an integrated, end-to-end approach to managing the tools, processes, and people involved in system development.

THE V-MODEL

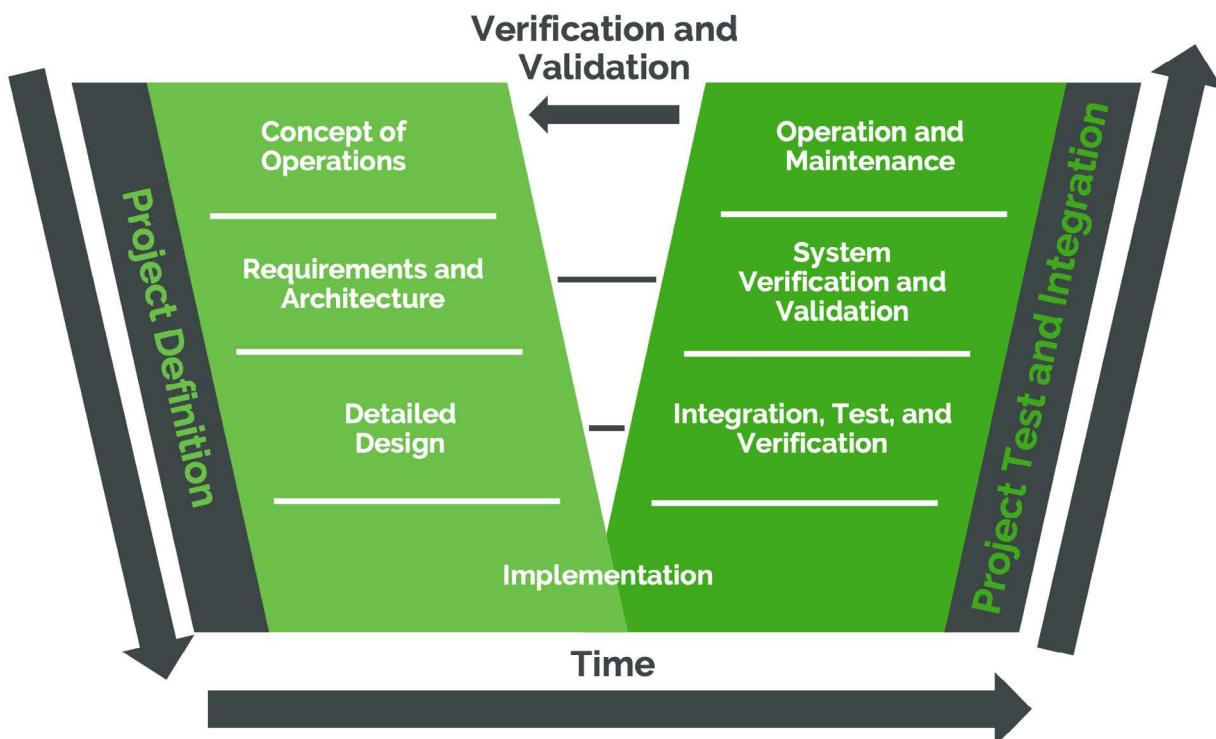
One of the most recognized ALM frameworks is the V-Model, a systems engineering model that emphasizes verification and validation. The V-Model—also known as the Engineering V-Model—encompasses a broad range of variants, all of which use a V shape to describe complex engineering projects.

The V-Model provides a straightforward and practical approach to breaking up complex projects

into discrete and actionable modules, producing those modules, and then integrating or assembling them to deliver a final product. The process spans two axes: vertical and horizontal.

On the vertical axis, the framework increases in granularity as we go from top to bottom. Systems of systems are decomposed into systems, sub-systems, and components. For example, a space rocket program may be defined by a high-level program vision (system of systems) which is decomposed into a specific rocket project (system), and sub-systems (propulsion, payload, and guidance systems). Each sub-system may be further decomposed into mechanical, electrical, and software engineering components that make up the sub-system.

The base of the V-Model represents the implementation of the project, where specifications are transformed into physical and software-based deliverables.





VALUE OF ALM

Effective requirements management is the backbone of successful system delivery. ALM provides a structured environment to manage this complexity and ensures alignment across teams, domains, and lifecycle stages.

KEY BENEFITS OF ALM FOR REQUIREMENTS MANAGEMENT

- **END-TO-END TRACEABILITY**

ALM establishes traceability between high-level requirements, design elements, test cases, and defects. This allows for complete impact analysis when changes occur.

- **CHANGE AND CONFIGURATION MANAGEMENT**

Built-in versioning and change control ensure that all stakeholders are working with the correct and current versions of requirements and associated artifacts.

- **COLLABORATION ACROSS DISCIPLINES**

ALM platforms break down silos between business analysts, systems engineers, developers, and testers by providing a single source of truth and shared workflows.

- **REGULATORY COMPLIANCE**

Traceability metrics, audit trails, and automated reporting help organizations meet stringent industry regulatory requirements (e.g., DO-178C, ISO 26262, FDA 21 CFR Part 11, EN50168).

- **PROCESS GOVERNANCE**

ALM enforces standardized development processes and ensures accountability through workflow automation, role-based access, and approval gates.

In essence, ALM transforms requirements management from a disconnected, document-driven process into a transparent, integrated part of the development ecosystem with comprehensive audit trails and enforced process controls.





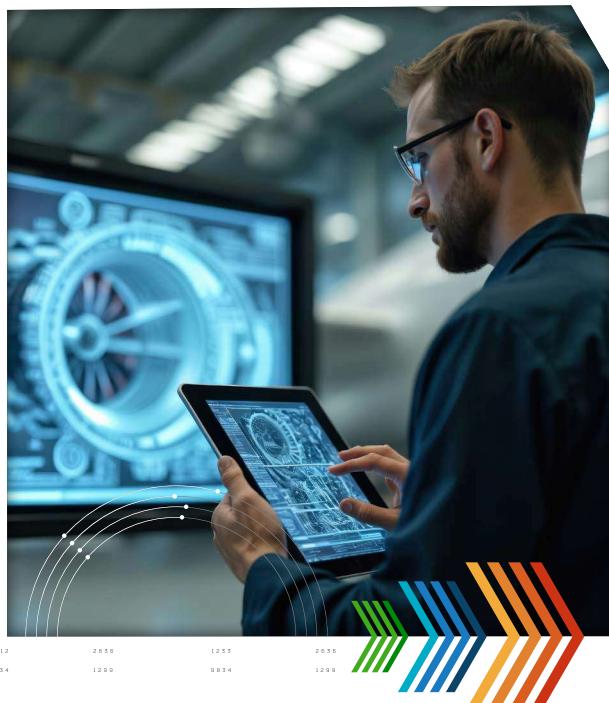
OVERVIEW OF MODEL-BASED SYSTEMS ENGINEERING

Model-Based Systems Engineering (MBSE) is a formalized methodology that uses models, not documents as the primary means of capturing, analyzing, and communicating system requirements, design, behavior, and validation data throughout the lifecycle.

Unlike traditional systems engineering, which relies heavily on static documents, MBSE creates dynamic, interrelated system models that support early analysis, design consistency, and simulation-based verification.

MBSE commonly uses standardized languages, such as SysML (Systems Modeling Language), UML, or domain-specific modeling languages to describe system structure, behavior, and requirements.

By transitioning to MBSE, organizations move from passive documentation to active system representation, enabling deeper insight into how requirements translate into system behavior and performance.



VALUE OF MBSE

MBSE brings significant value to requirements management by enabling early validation, reducing ambiguity, and improving consistency across system elements

CORE BENEFITS OF MBSE FOR REQUIREMENTS MANAGEMENT

- **IMPROVED CLARITY AND PRECISION**

Graphical models make requirements easier to interpret, helping identify gaps, conflicts, or misunderstandings early in the lifecycle.

- **EARLY VALIDATION AND SIMULATION**

Behavior and performance models allow teams to simulate system response and validate that requirements are feasible before implementation begins.

- **REQUIREMENT DECOMPOSITION AND ALLOCATION**

MBSE enables hierarchical modeling, where systems-level requirements are decomposed and allocated to subsystems, components, and software modules in a traceable manner.

- **CONSISTENCY AND CHANGE MANAGEMENT**

Changes to one model element automatically propagate across related diagrams and artifacts, reducing the risk of inconsistencies or missed updates.

- **ENABLING DIGITAL ENGINEERING**

MBSE is foundational for digital threads and digital twins, supporting lifecycle traceability from concept to operations.

By shifting to a model-centric approach, MBSE enhances the quality of requirements and ensures they remain connected, testable, and relevant throughout the system's lifecycle.

COMPLIMENTARY BENEFITS OF ALM & MBSE

ALM and MBSE are often seen as distinct disciplines, but when used in tandem, they form a powerful, integrated framework for systems development. ALM provides the structure for managing the development process and its artifacts, while MBSE provides the technical depth to rigorously define, analyze, and validate systems behavior and architecture through models.

When integrated, ALM and MBSE offer organizations a holistic approach to requirements, test, and risk management, enhancing consistency, reducing development risk, and improving time-to-market for complex systems.

APPROACH TO INTEGRATED REQUIREMENTS, TEST, AND RISK MANAGEMENT AND MODELING

MBSE models help define and visualize system behavior and constraints, while ALM tools manage the broader lifecycle context, linking models to tests, risks, and verification plans. This integration enables:

- **Direct association of model-derived requirements with verification activities and test cases**
- **Risk-aware design decisions using real-time impact analysis in both ALM and MBSE domains**
- **Early simulation of requirements and architecture to reduce downstream verification failures**
- **Consolidated dashboards and reports showing requirements coverage, test status, and open risks**

This approach enables proactive risk management and ensures that each requirement—whether textual or modeled—has a validation path throughout the lifecycle.

END-TO-END TRACEABILITY AND CHANGE MANAGEMENT

ALM platforms provide traceability across requirements, test cases, defects, documentation, and electronic signatures. MBSE enhances this traceability by introducing formal model elements, enabling semantic relationships that go beyond document links. By integrating MBSE with ALM:

- **Traceability extends from stakeholder needs to system models, to test cases, to results**
- **Changes in one domain trigger trace propagation and change impact analysis across the ALM chain**
- **Teams can manage baselines across both textual and model-based artifacts**
- **Digital threads connect every lifecycle artifact, enhancing visibility and governance**

This unified traceability model supports agile iteration while maintaining compliance with formal engineering standards.

COLLABORATION AND STAKEHOLDER ENGAGEMENT

MBSE and ALM together create a shared ecosystem where technical and non-technical stakeholders can engage effectively:

- **MBSE models offer visual clarity that improves stakeholder understanding of complex requirements**
- **ALM workflows manage roles, approvals, and task assignments across engineering functions**
- **Bidirectional links between models and ALM artifacts reduce silos and enable concurrent engineering**
- **Cloud-based dashboards and traceability views promote transparency for all stakeholders, from project managers to regulators**

This synergy helps align cross-functional teams and ensures that stakeholder feedback is reflected in both the system models and the execution plan.

COMPLIANCE AND AUDITING

Industries like FA&D, automotive, and MedTech demand strict compliance with standards such as DO-178C, ISO 26262, IEC 62304, and EN50168. ALM and MBSE integration supports these needs by:

- **Automatically generating traceability matrices and verification reports**
- **Capturing digital signatures, approval, and change history in audit-ready form**
- **Supporting model validation and verification as part of formal review cycles**
- **Ensuring that every requirement, whether graphical or textual, is covered by design and test evidence**

Together, ALM and MBSE create a transparent, auditable lifecycle that reduces the burden of manual documentation and simplifies regulatory submission.

SCALABILITY AND INTEGRATION

Modern systems are rarely developed in isolation; they require scalable, interoperable toolchains. When properly architected, ALM and MBSE can scale across large programs and integrate with other tools in the ecosystem:

- **Support for OSLC, ReqIF, and REST APIs enables integration between ALM and MBSE tools**
- **Scalable configuration and variant management supports product lines and system families**
- **Cloud-based ALM platforms enable globally distributed teams to collaborate in real time**
- **Enterprise integration with PLM, DevOps, and simulation environments closes the loop between design intent and delivered system performance**

This integrated environment ensures that models and lifecycle data can scale with program complexity, while maintaining consistency and control across domains.



HOW TO DETERMINE THE RIGHT FIT: ALM, MBSE, OR A COMBINED APPROACH

Modern engineering teams face increasing amounts of pressure to deliver complex products faster while maintaining high-quality and compliance standards. Traditional documentation-heavy approaches often fall short when managing thousands of requirements, intricate system interactions, and evolving customer needs. This challenge has led many organizations to adopt ALM, MBSE, or hybrid approaches.

WHEN TO CHOOSE ALM

ALM approaches work best for projects with extensive requirement portfolios and established development processes. Several indicators suggest ALM as the primary methodology:

- **LARGE-SCALE REQUIREMENT MANAGEMENT**

Projects managing thousands of requirements benefit from ALM's filtering and organization capabilities. Traditional automotive development projects, for instance, handle 30,000 to 50,000 requirements spanning everything from basic functionality to regulatory compliance.

ALM systems excel at categorizing these requirements by type, priority, and stakeholder. Teams can quickly filter requirements based on specific criteria, making large portfolios more manageable. This organizational capability becomes essential when requirements span multiple disciplines and stakeholder groups.

- **COMPLIANCE-HEAVY INDUSTRIES**

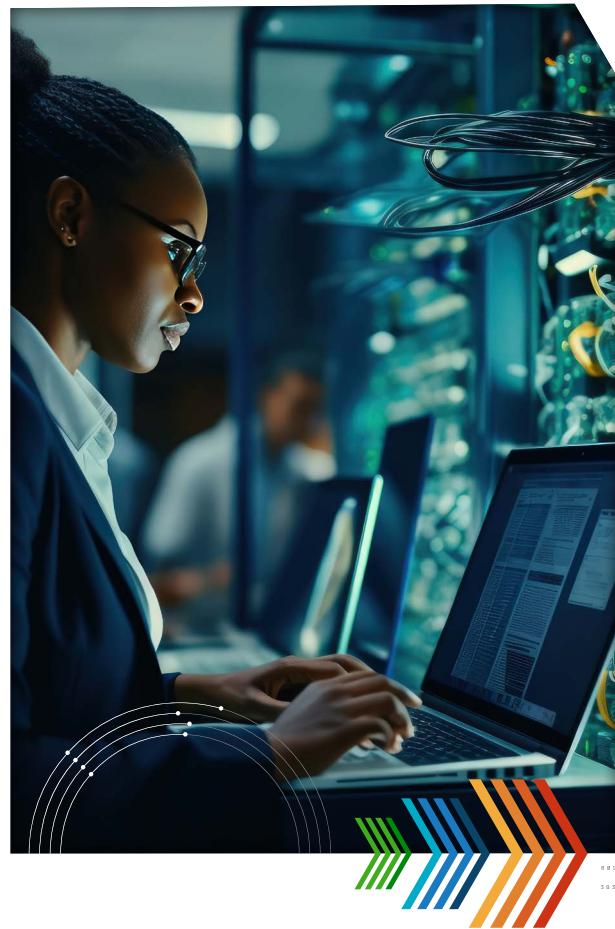
Regulated industries require comprehensive documentation and traceability. ALM systems provide the structured approach necessary for demonstrating compliance with safety standards, quality requirements, and regulatory frameworks.

The pharmaceutical industry exemplifies this need. Drug development projects must trace requirements through multiple validation stages, maintaining detailed records for regulatory approval. ALM tools provide the documentation structure and audit trails necessary for these complex approval processes.

- **DISTRIBUTED DEVELOPMENT TEAMS**

Projects involving multiple locations, languages, or organizational boundaries benefit from ALM's structured communication approach. When requirements must be translated or interpreted across cultural boundaries, ALM's documentation-centric approach reduces ambiguity.

Large aerospace projects often involve suppliers across multiple countries and regulatory environments. ALM systems provide the common framework necessary for coordinating these complex, distributed development efforts.



WHEN TO CHOOSE MBSE

MBSE approaches excel for projects where system complexity exceeds the ability of traditional documentation to convey understanding. Several factors indicate MBSE as the preferred approach:

- **COMPLEX SYSTEM ARCHITECTURE**

Systems with intricate component interactions benefit from MBSE's visual modeling capabilities. When no single individual understands all system relationships, models provide the shared understanding necessary for effective development.

Modern aircraft systems exemplify this complexity. Flight control systems integrate sensors, actuators, computational units, and communication networks in ways that are difficult to describe textually. MBSE models make these relationships visible and understandable.

- **BEHAVIORAL SIMULATION REQUIREMENTS**

Projects requiring behavioral analysis before physical implementation favor MBSE approaches. When system behavior is critical to success but difficult to predict, simulation capabilities provide essential validation.

Autonomous vehicle development represents a prime example. Control algorithms must respond correctly to countless scenarios, many of which are dangerous or expensive to test physically. MBSE behavioral models enable safe, cost-effective validation of these critical behaviors.

- **INNOVATION-DRIVEN PROJECTS**

Emerging technology projects often lack established requirement frameworks. MBSE's exploratory modeling capabilities help teams understand problem spaces and solution approaches before committing to specific implementations.

Electric vehicle charging infrastructure projects illustrate this scenario. The technology involves complex interactions between power electronics, communication protocols, and grid management systems. MBSE models help teams explore these interactions and identify optimal solutions.



WHEN TO CHOOSE A COMBINED APPROACH

Many complex projects benefit from combining ALM and MBSE approaches. The integrated methodology leverages each approach's strengths while mitigating individual limitations.

• COMPLEMENTARY STRENGTHS

ALM and MBSE address different aspects of complex product development. ALM excels at managing large requirement portfolios, while MBSE clarifies complex system behaviors. Together, they provide comprehensive coverage of modern engineering challenges.

Consider a typical automotive project with 40,000 requirements. Perhaps 1,000 of these requirements involve complex behaviors that benefit from modeling. ALM manages the full requirement set, while MBSE clarifies the complex subset through visual models.

• TRACEABILITY INTEGRATION

Modern tool integrations enable seamless traceability between ALM requirements and MBSE models. Requirements maintained in ALM systems can link directly to behavioral models, ensuring comprehensive validation coverage.

This integration proves particularly valuable during change management. When requirements evolve, teams can quickly identify affected models and update behavioral simulations accordingly.

This integrated approach maintains consistency across both documentation and models.

• STAKEHOLDER COMMUNICATION

Different stakeholders prefer different communication approaches. Business stakeholders often prefer ALM's structured documentation, while technical teams favor MBSE's visual models. Combined approaches serve both constituencies effectively.

Project reviews benefit from this dual perspective. Business stakeholders can review requirement coverage and traceability through ALM systems, while technical teams can examine system behavior through MBSE models. Both perspectives contribute to comprehensive project understanding.

• SCALABILITY CONSIDERATIONS

Large organizations often require both approaches to serve different project types and development phases. ALM provides the structured foundation necessary for enterprise-scale development, while MBSE addresses specific complexity challenges as they arise.

This scalable approach allows organizations to apply appropriate methodologies based on project characteristics rather than forcing all projects into a single framework. Simple projects can rely primarily on ALM, while complex projects can leverage MBSE where beneficial.





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