



**Rational** software

## **Requirements engineering for the aerospace and defense industry.**

*Improving development processes using IBM Rational  
DOORS software*

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**Requirements engineering and its role in the aerospace and defense industry**

For a space shuttle to have a successful journey, each astronaut must perform his or her own unique task. But the team also must work together and follow a strategy to accomplish its mission. Collaboration and coordination are critical to keeping the shuttle on task and safe for all.

Likewise, successful product development depends greatly on collaboration among the many individuals and teams involved—including systems engineers, software engineers, electrical engineers and the engineering director. Because keeping on schedule and meeting regulatory requirements are so critical in the aerospace and defense industry, developers of complex embedded systems for aerospace products must follow a project plan—which in software development is represented by product requirements. They are what connects all project stakeholders and teams together with common objectives. But requirements not only connect teams, they also create a link with customers and business partners. Requirements define the product that satisfies a customer need or marketplace demand, so they must always be in perfect sync with those needs and demands.

Requirements engineering is a vital process that helps companies manage complex requirements, improve team collaboration and ultimately produce high-quality products more cost-effectively. This white paper explores requirements engineering and its important role in product development and engineering in the aerospace and defense segment. It discusses the best practices and benefits of requirements engineering, how they can be achieved through solutions from IBM, and how they can help manufacturers of systems for the aerospace and defense industry overcome today's quality and cost challenges. Case studies illustrate how leading aerospace and defense manufacturers have improved communication and collaboration through the

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**Highlights**

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***To comply with requirements and regulations, engineers in the aerospace and defense industry must ensure complete accountability.***

***Manufacturers and integrators of systems need to focus on new ways to develop complex systems faster, more cost-effectively and at a higher level of quality than ever before.***

requirements engineering process using IBM Rational® DOORS® requirements management software, resulting in increased productivity, time and cost savings, and a higher-quality end product.

**Meeting challenges in the aerospace and defense industry**

Engineers in the aerospace and defense industry must ensure complete accountability in order to comply with customer requirements, government regulations and industry quality standards. Throughout the development process, project leaders are challenged to provide verification of requirements conformance while continuing to meet and document project milestones. If the development organization misses a contractual milestone, the company could face steep fines.

Compliance becomes even more challenging as companies in the aerospace and defense sector expand into international marketplaces and work with globally distributed customers and business partners. To manage new customer expectations and develop model variations for new marketplaces, manufacturers require clear and consistent communication and collaboration throughout the entire development organization.

As a result, manufacturers and integrators of systems for aerospace and defense needs must focus on new ways to develop these complex systems faster, more cost-effectively and at a higher level of quality than ever before. They must be able to reuse software and hardware components across different systems for multiple customers. Most importantly, they must clearly understand what they are building throughout the development lifecycle and ensure that they fulfill all customer requirements and address regulatory mandates. Therefore, aerospace and defense system project teams must take a requirements-driven approach to product development and engineering in order to be successful.

A requirements engineering approach can help manufacturers overcome the following challenges in the aerospace and defense industry.

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***Commercial aerospace companies are looking to expand beyond their traditional marketplaces and broaden their offerings by selling service and support.***

***One of the most challenging issues facing aerospace and defense industry management is learning how to operate efficiently and cost-effectively on a global scale.***

Need to pursue growth through expansion and manufacturing agility

Today, commercial aerospace companies are looking beyond their traditional marketplaces in North America and Europe to secure a foothold in expanded global marketplaces. To fuel this new growth, they are looking to not only expand product sales geographically, but also broaden their offerings by selling service and support.

In addition, the customers of commercial aerospace products and systems are shifting their expectations as they strengthen their own global operations. As a result, commercial aerospace systems providers must be ready to deliver multiple products and models to various business units belonging to a single customer. Understanding and coordinating customer relationships will become more challenging—and more necessary—for an organization to defend and retain long-term relationships that traditionally have been essential to survival in the commercial aerospace sector.

Limited experience in operating and collaborating globally

Doing business as part of a global supply chain magnifies the importance of and strain on responsiveness, communication and development cycle times, which are already stretched to the limit for aerospace and defense systems developers.

Moreover, one of the most challenging issues facing aerospace and defense industry management is the limited number of people with the experience or knowledge of how to operate efficiently and cost-effectively on a global scale. Bringing in partners and external consultants can help bridge the gap and ease the transition, as can leveraging the expertise of current business partners with global expertise.

To do this successfully, however, requires the highest level of communication and collaboration among everyone involved, whether they are across the hall

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or across the ocean. Everyone must have the same understanding of customer and regulatory requirements, product features and capabilities, as well as any changes made to them throughout the development cycle.

**The changing face of warfare**

Defense systems are becoming increasingly interconnected. Today's network-centric warfare requires ground, air, sea and logistics systems to communicate and coordinate seamlessly to form a single, integrated battlefield system. To achieve interoperability, manufacturers must go beyond building high-performance individual systems to networking all of them together in order to create a sophisticated *system of systems*. This interoperability, which is considered the key to successful military operations, helps ensure that communication among all military forces is clear and consistent. Avoiding breakdowns in communications is vital to preventing deadly battlefield errors — such as friendly-fire incidents and poor coordination among units — which can increase the risk for troops who are already in dangerous situations. To avoid cost and security risks, developers and manufacturers must be able to demonstrate that they can build these critical systems to perform reliably.

***Defense and aerospace manufacturing customers are demanding more interoperable and multiuse systems that can perform at higher levels.***

In addition to increasing interconnectedness, customers are demanding more multiuse aircraft. To lower overall costs for their government customers, defense engineers are developing aircraft such as the F-35 Joint Strike Fighter, which meets the requirements of multiple branches of the U.S. military. Organizations that can successfully meet all customer requirements — regardless of the number of customer teams or where they are located — can have a significant advantage over their competitors.

Perhaps most importantly, government defense agencies are demanding more efficient performance from their suppliers. As a result, there is an increasing need for intercompany design partnerships and development organization, since no single company can deliver all of the systems needed for an entire aircraft or integrated battlefield system.

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How can manufacturers and integrators of these complex aerospace and defense systems manage the above challenges? A first step is eliminating poor requirements practices and adopting a requirements engineering process for product development.

**Defining requirements engineering**

Requirements engineering—in terms of systems engineering—defines, manages and systematically tests requirements for a system. Though this definition of requirements engineering is more than a decade old, a standard process has only recently evolved with the availability of integrated suites of automated lifecycle development tools featuring requirements management solutions. In basic terms, requirements engineering helps product development organizations understand what they intend to build in two stages. The first stage is to define requirements up front. The second is to manage them by having clear visibility throughout the product lifecycle.

***Requirements engineering occurs in two stages: requirements definition and requirements management.***

The first stage of requirements engineering—requirements definition—consists of four parts: discovery, analysis, specification and verification. Requirements management, the second stage, simplifies and enhances communication and collaboration among teams and stakeholders, resulting in better requirements management throughout the organization. This stage enables engineers to:

- *Evaluate the effect of proposed changes.*
- *Trace individual requirements to downstream work products.*
- *Track requirements status during development.*

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***Requirements engineering creates a dynamic process that flows from ideas to implementation, testing and maintenance, providing a vital connection between developers and stakeholders.***

***A requirements engineering framework and a supporting tool for requirements management can help engineers tailor their development practices.***

As a result, they can monitor project status by knowing what percentage of the allocated requirements have been either:

- *Implemented and verified.*
- *Just implemented.*
- *Not yet fully implemented.*

The requirements definition and requirements management stages make up a dynamic process that flows from ideas, requirements and feature definitions; to product and system specifications and models; to mechanical, electric/electronic and embedded software implementations; to testing and maintenance. All the while, requirements connect the global engineering teams — systems, software, electrical/electronic and mechanical — and keep them more keenly focused on common objectives. Furthermore, requirements provide a vital connection between the engineering teams and other peripheral stakeholders, including suppliers, customers and internal legal and quality assurance (QA) teams.

Using a requirements engineering framework and a supporting tool for requirements management and traceability, engineers can thoughtfully tailor development practices to suit the project type, constraints and organizational culture.

**Requirements engineering for the aerospace and defense industry**

The sophisticated systems comprising a complete aircraft or a complete integrated battlefield system have many interlinked and interdependent parts, and developers must understand how all of the different parts work together. To do so, they must be able to understand and visualize all of the connections, even those that are invisible. Otherwise, the end result will be a marketplace failure — a product unexpected by the customer and potentially dangerous or noncompliant. Therefore, engineering teams must work as a cohesive unit to

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capture customer requirements, manage changes and reuse components so that they can respond faster to customer demands. IBM Rational DOORS software can help address these and other challenges common to the aerospace and defense sector.

Manage the complexity of extremely large-scope projects

Requirements engineering using Rational DOORS can help manage complexity by helping teams:

- *Deconstruct initial user requirements to detailed requirements.*
- *Link requirements and design to check whether requirements are satisfied by the design.*
- *Trace dependencies between requirements and changes.*
- *Analyze the impact of requirements changes.*

***With Rational DOORS, engineering teams have greater control over managing and analyzing large volumes of requirements.***

As a result, with Rational DOORS, you can enable engineering teams to have greater control over management and analysis of the hundreds of thousands of requirements for aerospace and defense systems. By using this automated requirements management tool as the cornerstone of the requirements engineering environment, you can increase your engineers' productivity through standardized processes, helping to dramatically accelerate your products' time to market.

***Ensuring traceability across all levels of requirements is possibly the only way that engineering teams can effectively and confidently reuse requirements across multiple models.***

Using the traceability functionality of Rational DOORS, engineers can trace a large volume of features back to the requirements and reuse the requirements for common components across multiple models. For example, you can take the requirements from proven commercial aerospace components and apply them to military projects. The traceability functionality helps improve development productivity while the company saves money and confidently delivers customer-driven features.



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***Global aerospace and defense manufacturers can enhance communication among distributed teams by using requirements engineering and Rational DOORS.***

***IBM Rational solutions help improve team productivity and product quality, as well as accelerate marketplace delivery.***

Most importantly, Rational DOORS empowers management to stay in control of the scope and timeframe of these complex projects via impact analysis and change management functionality. To support high levels of transparency and control throughout a multiyear timeframe, project managers can use Rational DOORS to more accurately predict the impact of customer-requested changes, thus reducing the risk of missed milestones and cost overruns.

In addition, because requirements are contained in the Rational DOORS central repository, geographically dispersed teams can share information, collaborate and track changes more easily and efficiently. As a result, they can better ensure that specifications are accurate at the beginning of the project because they are gathering information and working from the same — and the correct — documents.

#### Build high-quality systems

Quality is critical to the performance and safety of aerospace and defense systems. Using Rational DOORS as the foundation of your requirements engineering approach, you can test each requirement to validate its performance. Teams can also integrate requirements and validate them against developed models, enabling systems engineers to provide high-quality, high-performance, innovative products that truly meet customers' needs and that address strict government regulations and safety standards.

#### **Rational DOORS: success stories in the aerospace and defense industry**

Many aerospace and defense companies and their business partners have adopted requirements engineering, supported by IBM Rational solutions, to successfully and cost-effectively improve team productivity and product quality, as well as to generate faster marketplace delivery. Using Rational DOORS, they have the capacity to manage and analyze large volumes of requirements in complex projects designed to satisfy changing customer demands and strict government regulations. Rational DOORS helps them improve the visibility of requirements throughout the engineering lifecycle, and its traceability capabilities help ensure that critical features are not missed.

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***One of the near-immediate benefits of requirements engineering is the user's ability to trace requirements throughout the development lifecycle.***

***Requirements engineering helps users produce high-quality, high-performance products and systems on time and on budget.***

Military systems provider improves productivity and cuts costs using traceability  
One of the near-immediate benefits of requirements engineering is the user's ability to trace requirements throughout the development lifecycle. A leading integrated military systems and support solution provider had been using multiple and diverse requirements management products. The hodgepodge of tools made it nearly impossible for developers to trace requirements or collaborate efficiently. As a result, projects were plagued by duplicated effort, poor efficiency, high development costs and the real possibility that customer requirements would not be reflected in the final product.

Using Rational DOORS for requirements management in conjunction with IBM Rational Synergy change management software, the company created a requirements-driven approach to development. By storing all requirements in a single Rational DOORS repository, the client can test them against customer needs throughout the development lifecycle. Development teams in six locations benefit from improved productivity, less costly rework and greater confidence that all customer-requested changes will be included in the final product.

Satellite imaging company achieves more efficient quality assurance

Requirements engineering also facilitates a competitive advantage by helping users produce high-quality, high-performance products and systems on time, on budget and according to government regulations.

A commercial high-resolution satellite imagery provider adopted Rational DOORS and Rational Synergy to automate parallel development of multiple satellite technology platforms. Rational DOORS helped the company make its software QA process more efficient by facilitating traceability between requirements and test plans. As a result, development teams are more productive, and the efficient QA process supports faster time to market.

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***A requirements engineering approach can help product and systems development organizations work in harmony.***

***Better management of requirements complexity is the foundation of requirements engineering.***

**Conclusion**

Efficient and cost-effective product development is the key to success in today's global development environment. A requirements engineering approach can help product and systems development organizations work in harmony as they communicate and collaborate through standardized processes for requirements management.

Today's best-in-class companies in the aerospace and defense sector know that engineering requirements from the beginning of the product and system lifecycle, through every phase of development and across all disciplines, is essential for the successful deployment of top-quality products. Better management of requirements complexity is the foundation of requirements engineering. Ensuring traceability across all levels of requirements is probably the only way that engineering teams can effectively and confidently reuse requirements across multiple components and clients.

When integrated with testing and validation, requirements traceability also drives cost savings and helps you achieve project milestones on time. Engineering teams can discover discrepancies and missed requirements far earlier in the development lifecycle, thus reducing rework costs and decreasing the risk of losing profits on products that don't meet customer needs.

Moreover, requirements engineering helps organizations achieve enhanced collaboration among globally distributed teams and suppliers. As a result, virtually all stakeholders can be involved in the requirements management process and be confident that everything they do is aimed at fulfilling customer requirements.



By embracing the requirements engineering best practices of managing complexity, requirements traceability and enhanced collaboration, aerospace and defense companies can achieve time and cost savings, build higher-quality products, improve customer satisfaction, address regulatory compliance and ultimately seize a competitive advantage.

**For more information**

To learn more about Rational DOORS software from IBM, contact your IBM representative or IBM Business Partner, or visit:

[ibm.com/software/rational](http://ibm.com/software/rational)

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