Innovate201
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Turning Product Development Into Competitive Advantage:

Increase Product Success through Effective Requirements Engineering

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Let's build a smarter planet.
August 31, 2010 台北喜來登

Agenda

- Trends in Product Development & Delivery
- Challenges Resulting from Insufficient Requirements Engineering Processes
- Best Practices for Successful Requirements Engineering
- Case Studies

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Competition and Customer Demand are Driving Changes In Product Development

Aerospace and Defense

- Need for cost reduction/ increased innovation is resulting in extensive design partnerships across legal, technology & security boundaries

Transportation

- 35% increased value of in-vehicle electronics & software by 2010
- 90% of innovation is based on electronics & embedded software

Electronics

- Need for product differentiation is driving increasing amount of software into products

Changes are being driven across the entire supply chain - even to commodity parts that now require sophisticated software & electronics

The Product Development Landscape is Evolving

From Focusing on Cost - to Focusing on Innovation

	1970 - 1980	1980 - Present	Present & Beyond
Business Drivers	Productivity improvement through automation	New technology for reduced cost & time, increased flexibility	Globalization of suppliers, workforce & markets
Product Development	▪ **2D CAD** ▪ **Ad-hoc data management** ▪ **No organization / process change**	▪ **3D CAD** ▪ **PDM focus on mechanical BOM** ▪ **Organization & process improvement**	▪ **Increased focus on software engineering** ▪ **Full traceability of requirements throughout product lifecycle** ▪ **Holistic system design and interaction**
Business Value	Improved production with higher quality	Time and cost reduction	Rapid innovation with software as major differentiator

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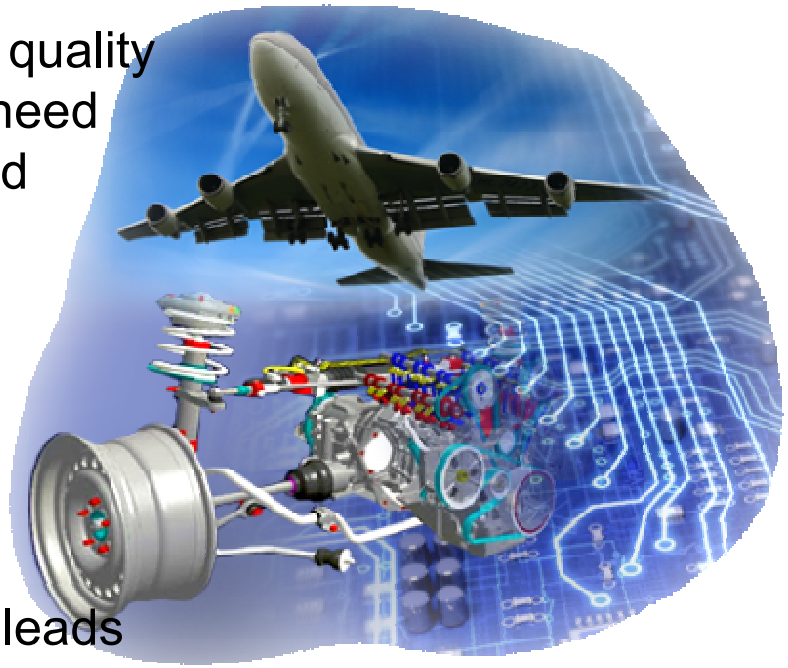
Product Development Failures Are Impacting the Bottom Line

Aerospace and Defense

- Serious financial & quality issues result from need to better understand & manage change across teams



Transportation

- Complexity of electronic systems leads to quality issues, project delays & warranty costs
  - *Warranty costs in US and Europe are 2-3% of revenue*
  - *~50% of warranty costs are related to electronics & embedded software*

Electronics

- Delays & cost overruns caused by errors found during electronics & software integration testing
- Warranty costs skyrocket when errors are found after product release

Software & Integrated Product Failures Still Plague Companies

Despite the Ongoing Focus on PLM

- **Aerospace Agency**

  $1 billion prototype rocket self-destructed 40 seconds after takeoff. due to a bug in on-board guidance software

- **Automobile OEM**

  Software bug forced recall of 75k cars that stalled at high speeds

- **Medical Equipment Manufacturer**

  Recalled 42K defibrillator device due to poor software

Rain Sensing Wiper: Example of a System Design Failure

Individual Systems Worked, But Failed When Integrated

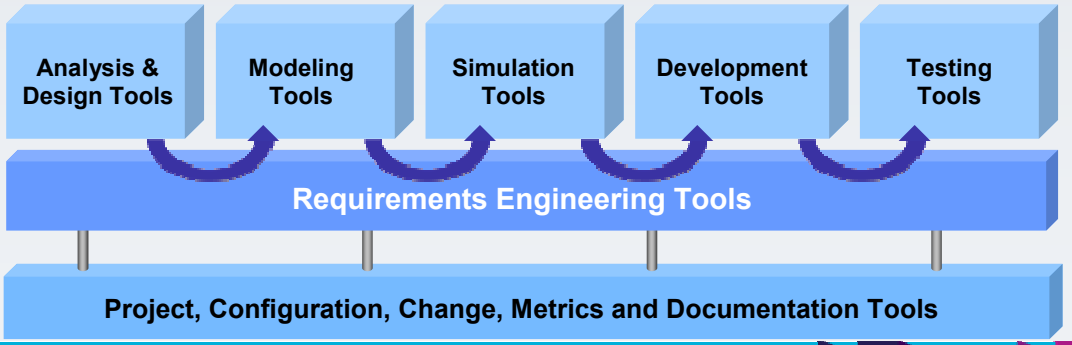
- Windshield provided by local supplier
  - Incompatible with the operation range of the sensor
  - No captured requirement for proper system calibration (i.e., verifying sensor and windshield compatibility)
  - *Cars were sent to customers with non-functioning wiper system*

- Initial diagnostics designated software as culprit for malfunction
  - Mechanics couldn't test software behavior
  - Other components (electronic control unit, sensor, and windshield) functioned normally when tested independently
  - *Failure was not of individual components, but in the interaction at a system level*

Requirements Engineering Poses Significant Challenges

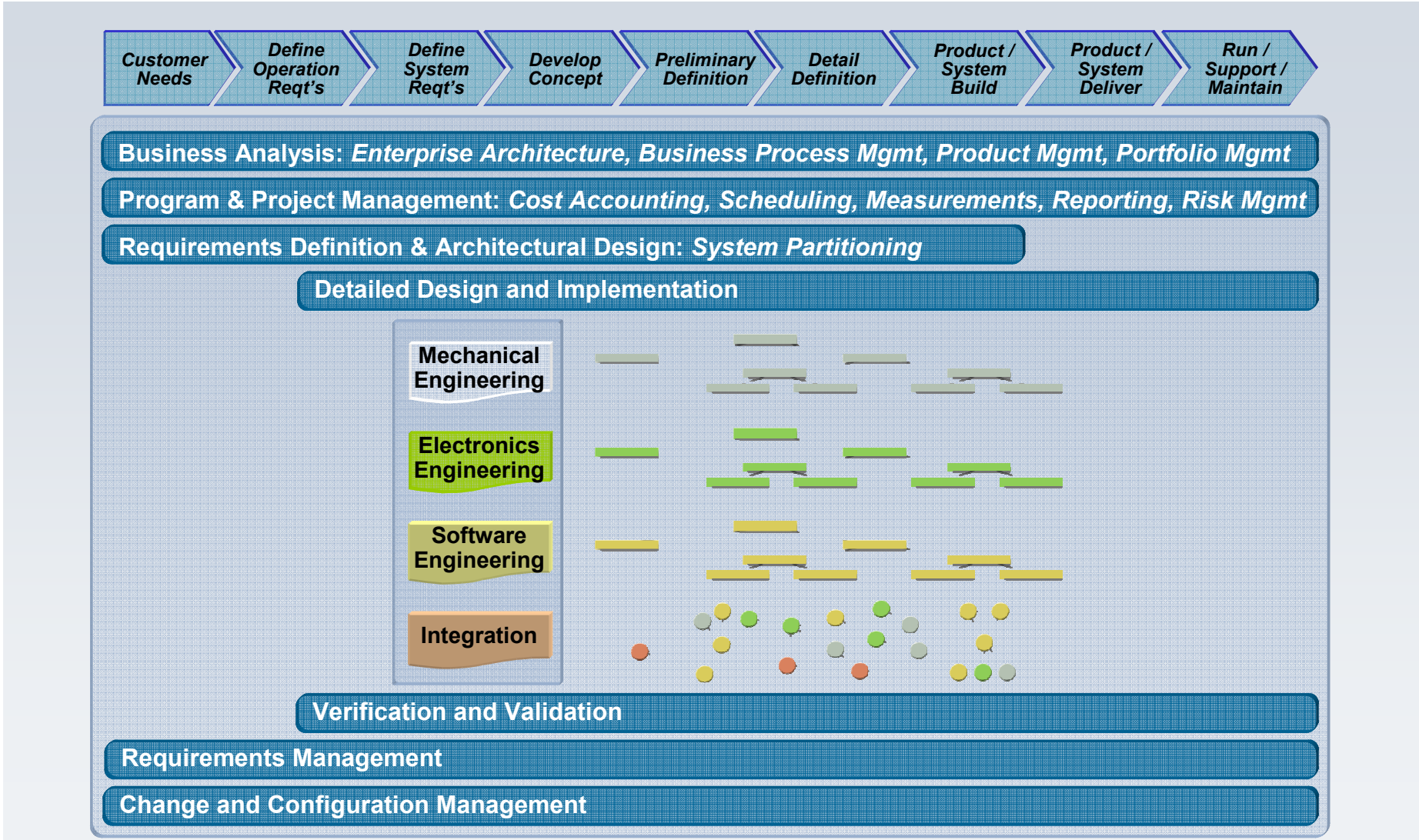
Across the Product Lifecycle and Across Engineering Domains

- Poor quality of requirements definition
  - Requirements are often expressed poorly
  - Misunderstandings and misinterpretations occur frequently
- Requirements Definition is typically inefficient
  - Requirements are ubiquitous and labor-intensive
  - Requirements gathering is complex and involves numerous stakeholders
- Requirements Management requires significant commitment
  - Many activities are manual (e.g. coverage and dependency analysis)
  - Establishing and maintaining traceability can be time consuming and error-prone
  - Change management in the context of requirements engineering can be difficult
  - Requirements are often validated late in the process, with linkage to quality assurance at the very end



Requirements Engineering

Must Be Better Integrated into the Product Lifecycle



Requirements Engineering

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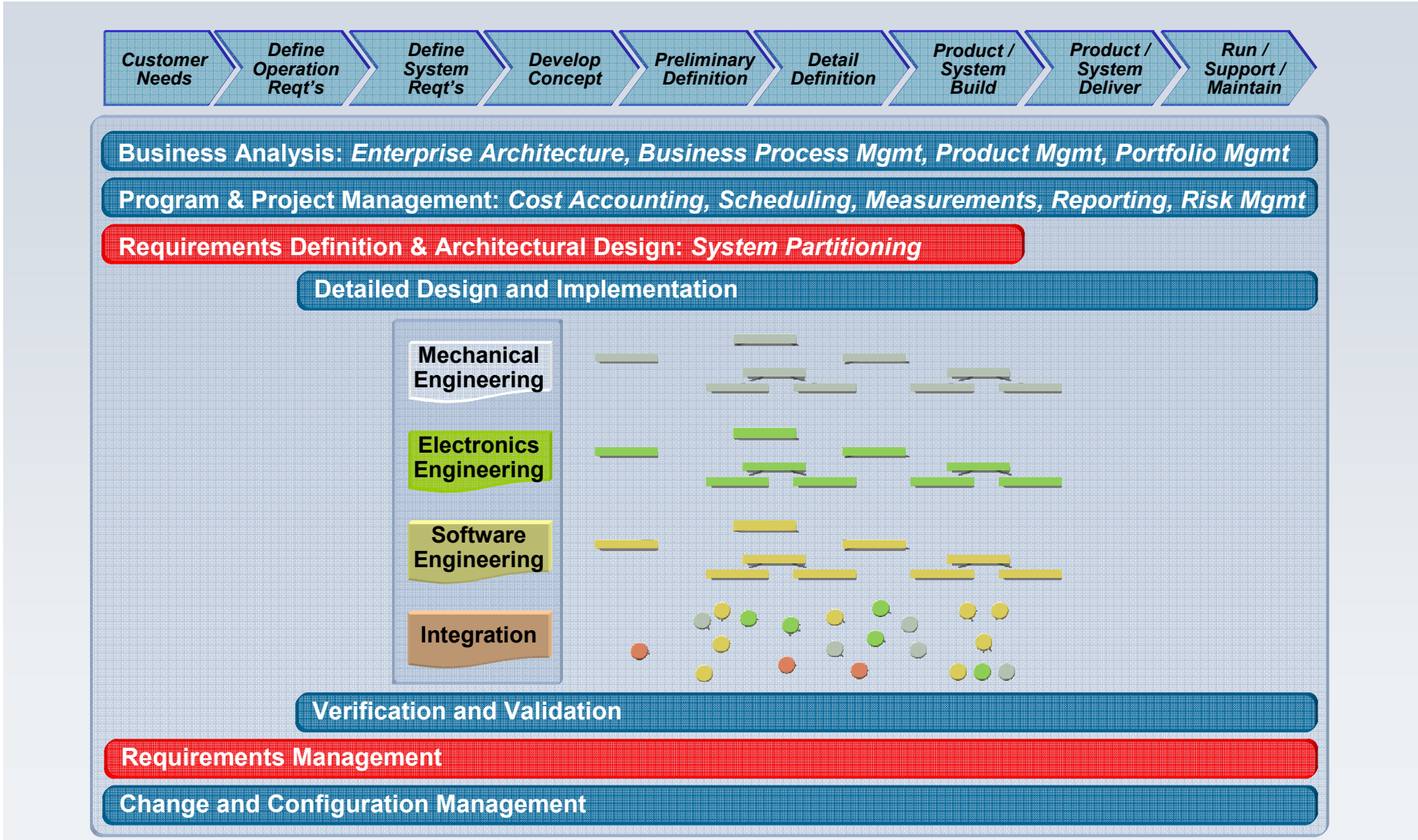

Why Do Requirements Processes Often Fail

To Deliver the Expected Business Results

- Requirements Engineering process is not fully defined and enforced
- Multiple authoring tools are used in the requirements process
  - Inconsistent requirements data
  - Lack of a unified view of requirements as they change and mature across the lifecycle
- Lack of communication across business and functional silos
  - Individual groups interact with requirements that are relevant to their functional process

Requirements should be the common thread that keeps all teams focused on delivering value to customers

- *Throughout the product development lifecycle*
- *Across all engineering disciplines – mechanical, electronic and software*

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Requirements Engineering Best Practices

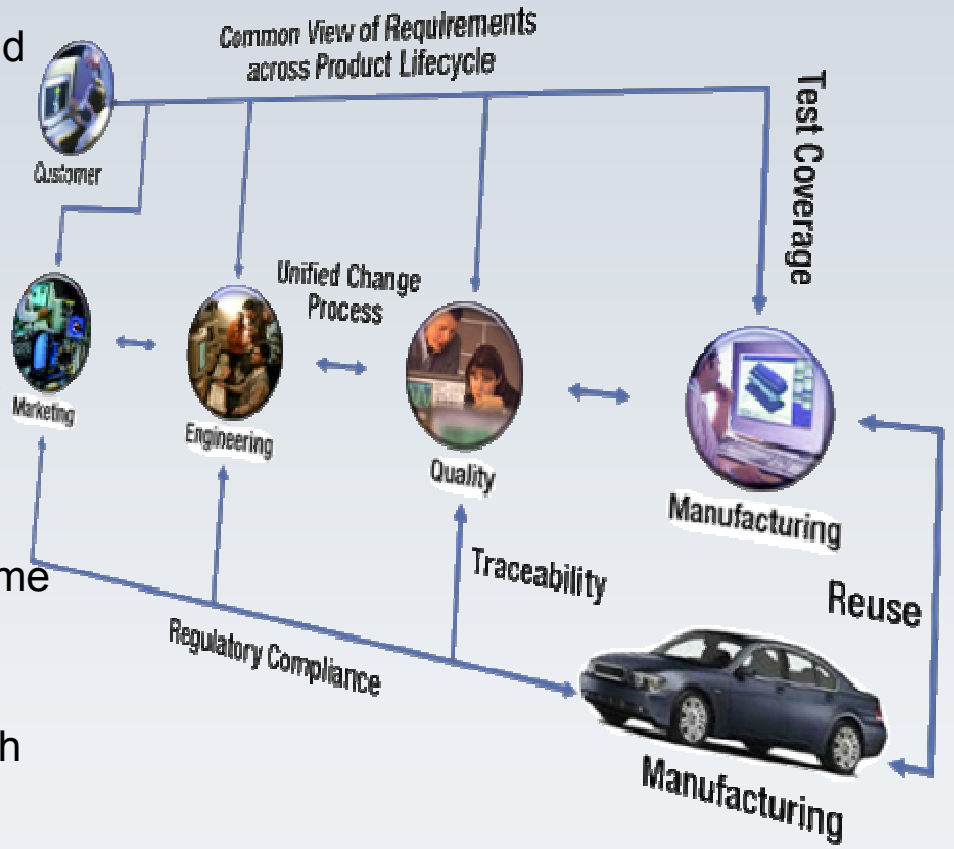
Best in class companies…

- Engineer requirements:
  - From the beginning of the product and system lifecycle
  - Through every phase of development
  - Across all disciplines of mechanical, electronic and software
- Ensure traceability across all levels of requirements
- Mature from an isolated to a collaborative environment
- Invest the same focus and rigor on engineering requirements as in managing mechanical Bill of Materials
- Integrate Requirements Engineering closely with Change, Product and Portfolio Management, and Quality Assurance

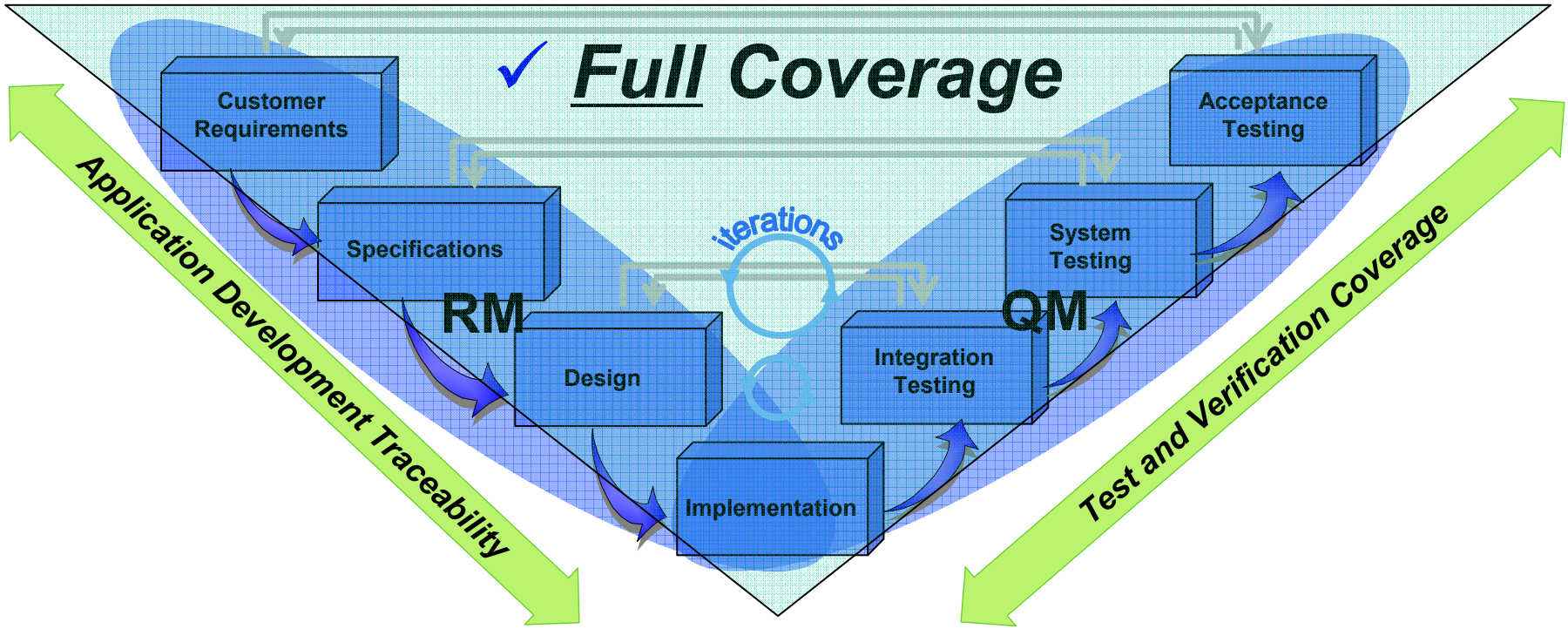
The Benefits of Effective Requirements Engineering

Yield Products that Better Address Customer Needs

- Close gaps and link the product development lifecycle
  - Closes gaps in the communication and data sharing between product marketing, engineering, and manufacturing
  - Prevents customer required features from 'falling through the cracks'
- Reduce rework, delays and warranty costs; improve customer satisfaction
  - Brings the mechanical, electrical, and electronic engineers onto 'the same page' with the systems and software engineers
  - Enables issues to be discovered much earlier in the development lifecycle, resulting in fewer recalls



IBM Rational Requirement Driven Quality Management



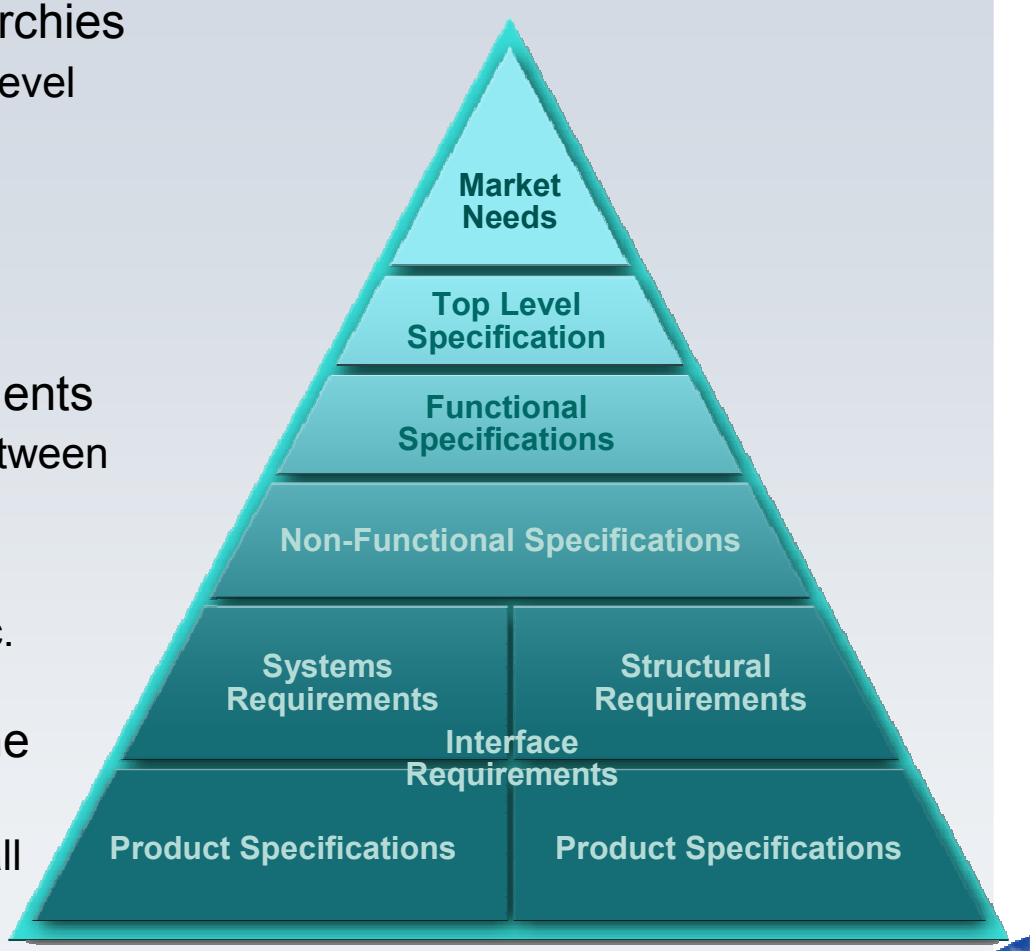
IBM's full life cycle coverage and traceability solution

- ✓ Common set of clear requirements shared by team
- ✓ Don't miss out critical requirements
- ✓ Assess requirements change impact
- ✓ Identify most critical requirements to test
- ✓ Prove compliance (audit-ability)

Good Requirements Engineering

Is Based on a Structured Approach

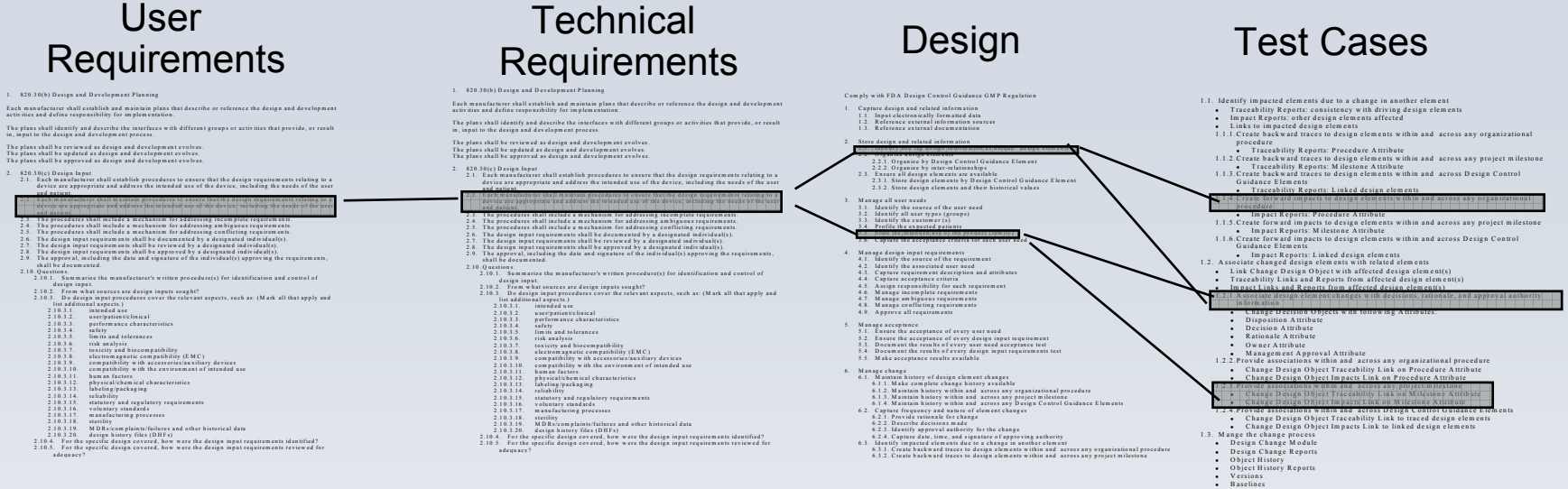
- Break-down requirements into hierarchies
  - From high-level architecture to low-level design
  - From the entire system down to the mechanical, hardware and software disciplines
- Manage relations between requirements
  - From one level to another and in between
- Add attributes to requirements
  - Author, History, Priorities, Risks, etc.
- Make requirements visible across the entire lifecycle
  - Provide access to requirements to all participants in the process



Maintain visibility and traceability of requirements throughout the process

Requirements Engineering Must Provide Lifecycle Traceability

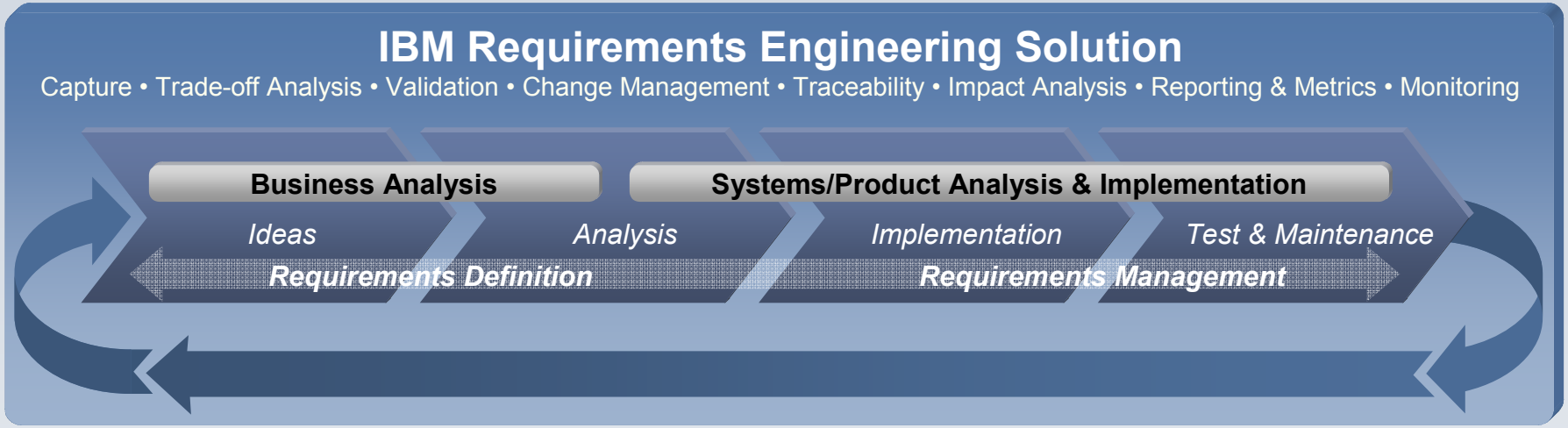
From Idea through End of Life



- Traceability is the key to compliance
  - Initial requirements will be decomposed, which creates traceability relationships
  - Other relationships can also be traced such as “consists of”, “verifies”, etc.
  - Traceability must be enforced in order to ensure consistency and completeness
- Traceability from customer requirements through product development to test and delivery enables organizations to:
  - Know which requirements are implemented and tested vs. those which are not
  - Manage and defend against scope creep

IBM Requirements Engineering Solution

For Programs, Projects, Products, Systems and Systems-of-Systems

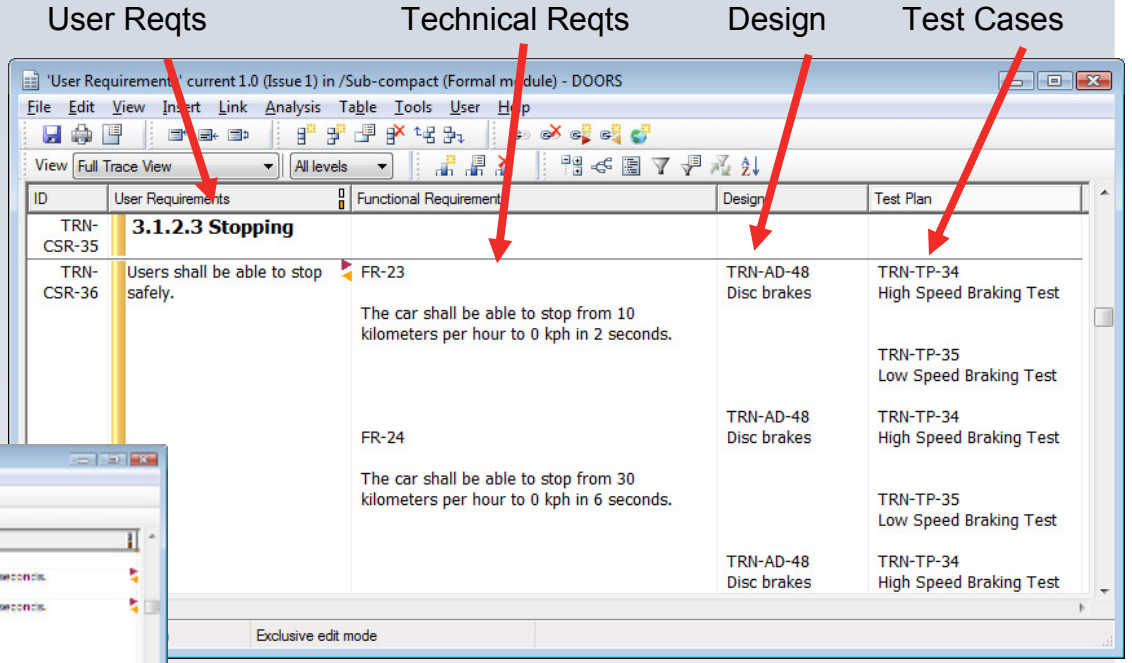


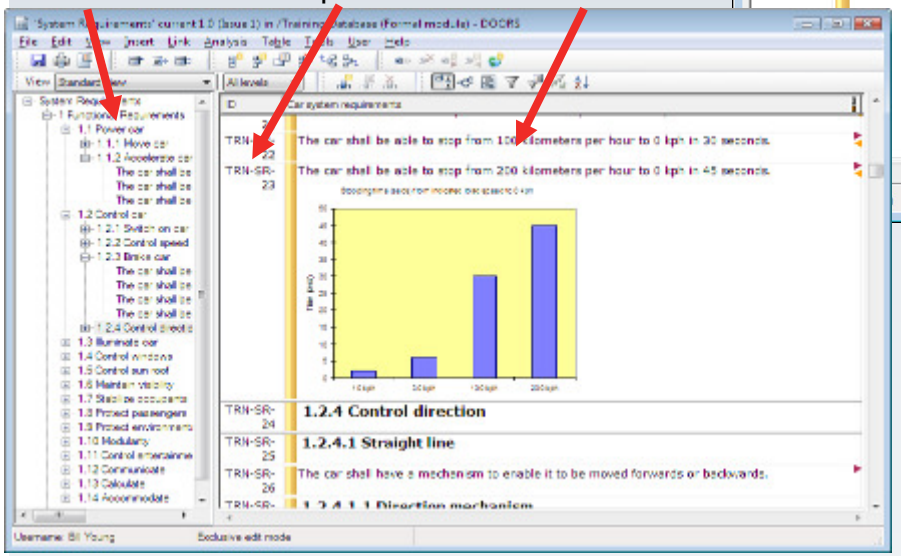
- Getting everyone on the same page
  - Includes suppliers and subcontractors
- Managing scope, plus assessing and controlling the impact of change
- Ensuring end-to-end traceability
  - From ideas, feature definitions, product specifications and models…
  - To mechanical, electric/electronic and embedded software implementation, test and maintenance
- Ensuring conformance to contractual agreements
- Demonstrating compliance to regulations

IBM Rational DOORS

Manage All Requirements Across the Lifecycle and Across Disciplines

- Combined document and spreadsheet views
- Simple, intuitive interfaces for easy adoption
- History and baselines





Writing Requirements within Context

End-to-end visual validation in a single view

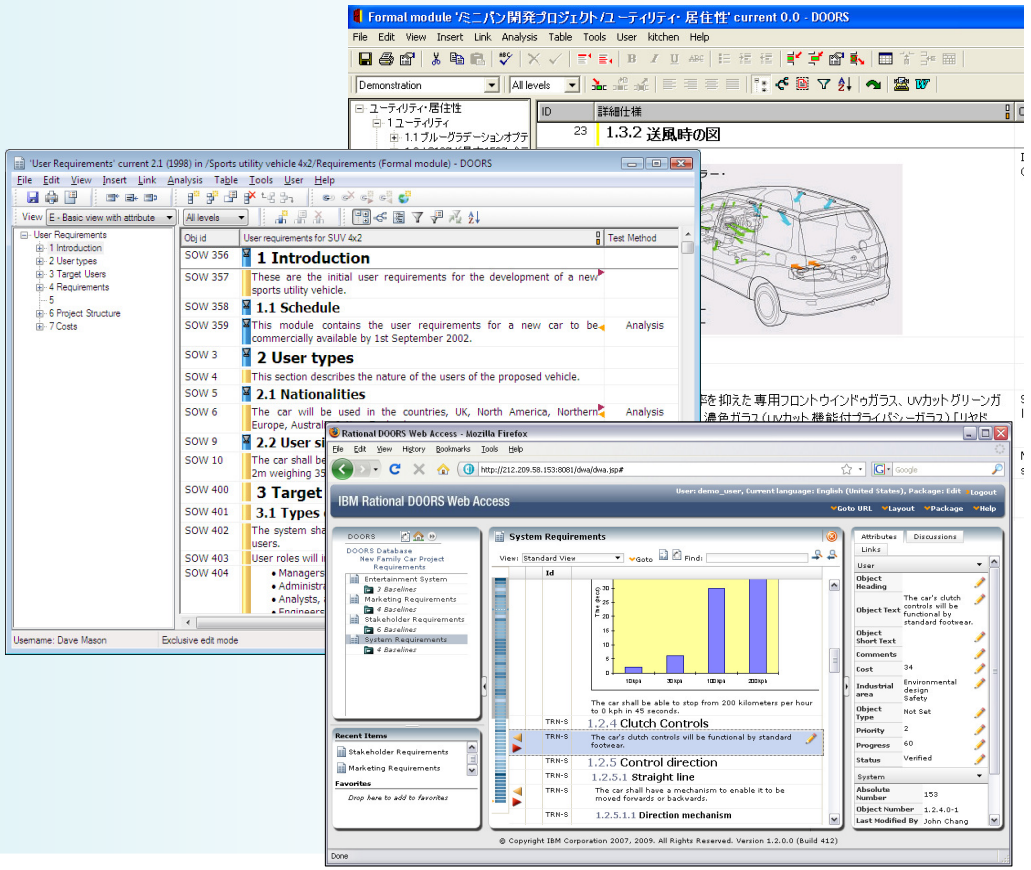
- Input and output from/to various common formats

Solve the right problem because the requirements are visible at all times

Role Based Document Style Interface

Underpinned with the power of an object oriented database

- Highly flexible display gives the right people the right information at the right time
- Intuitive interface means you'll be up and running quickly
- Document based for efficient organization and reporting
- Classic or Web Access client both on the same database



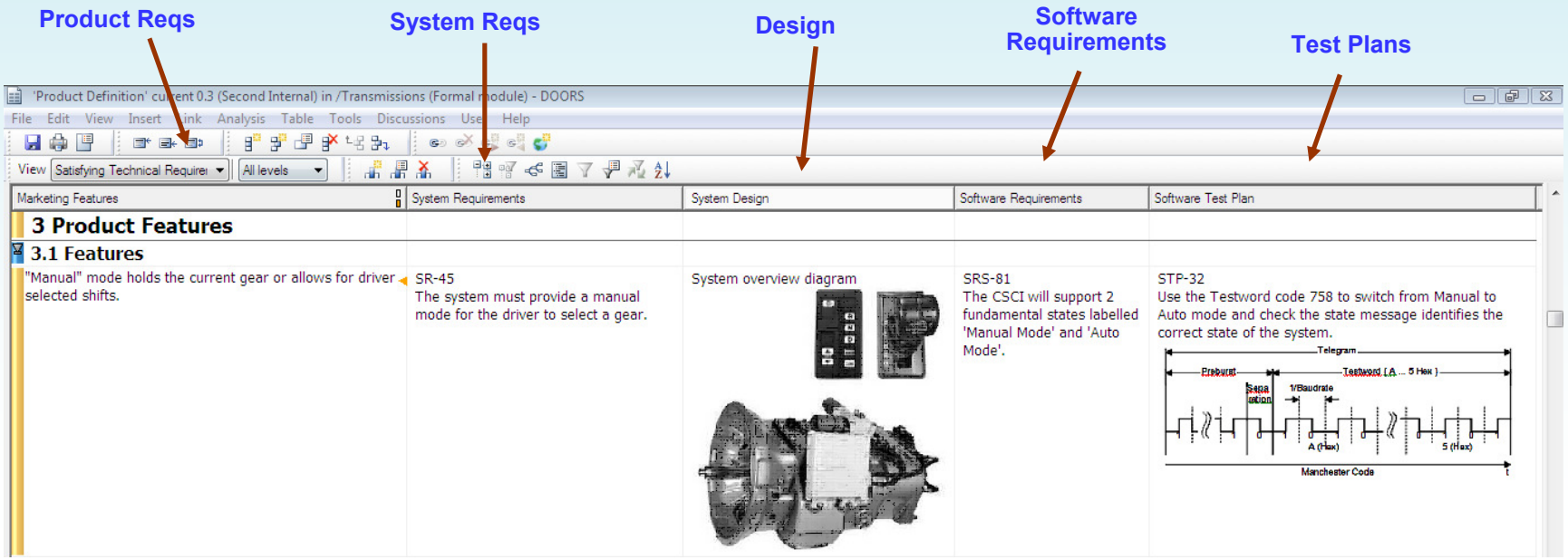
Gives you access to complex interconnected data presented in a single display

Multi-Level Traceability

Information transparency allows you to take control

Complex traceability made as simple as drag and drop

Trace through multiple levels of documentation in a single display



Make maintaining traceability an asset rather than an overhead

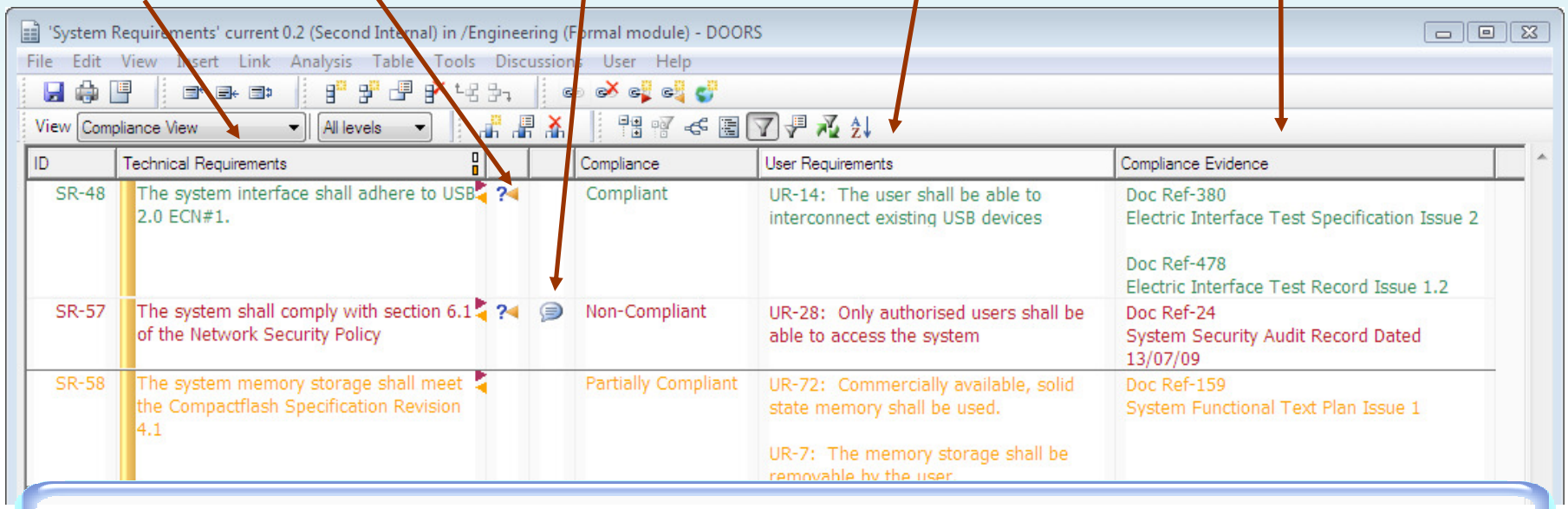
Multi-Level Traceability

Information transparency allows you to take control

Trace to & from information both inside and outside DOORS

View traceability from multiple perspectives allowing you to perform impact analysis across the whole lifecycle

Technical Reqs **Suspect Links** **Discussions** **Higher Level Reqs** **Evidence Detail**



Make maintaining traceability an asset rather than an overhead

DOORS Gives You Control

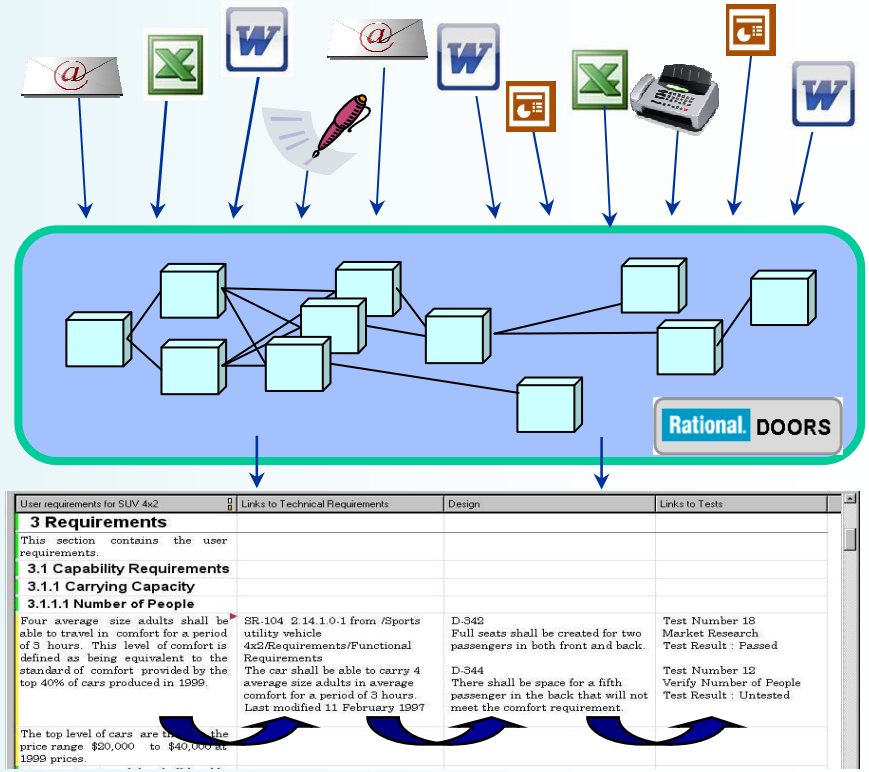
Always understand the scope and status of your projects

Manage scope creep by better understanding customer needs

Manage complexity by tracing every requirement from capture and design through to integration and acceptance

Manage change by seeing the full impact as early as possible in the lifecycle

Take control with full auditing capabilities and electronic signoff of requirement baselines

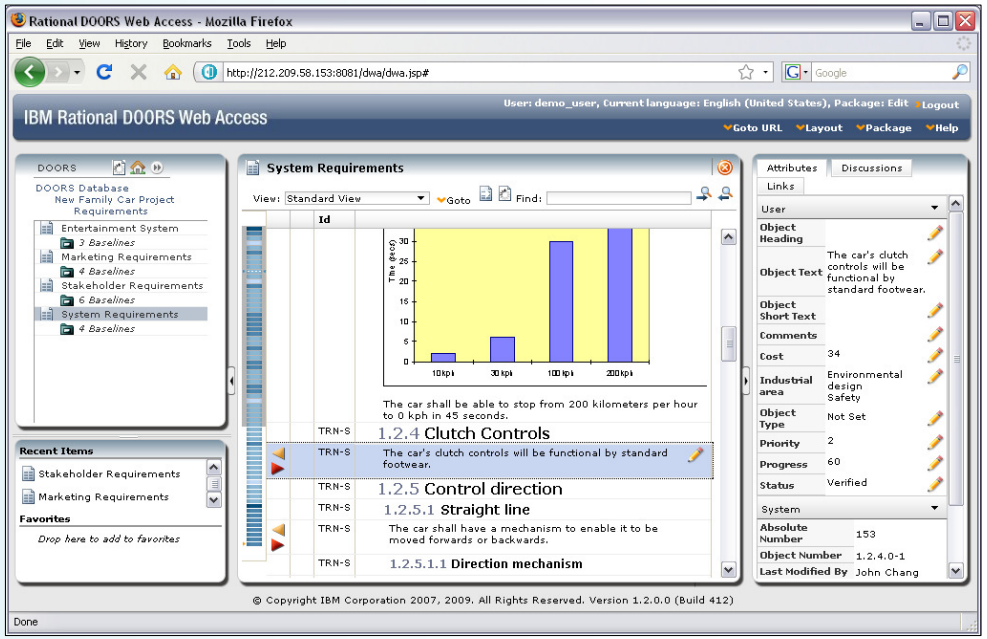


Deliver best practices to every project across your enterprise

Collaborate with DOORS Web Access

Share your requirements across your global team

- Review and edit requirements through a rich web based environment
- View and browse traceability using configured document views
- Distribute requirements to other team members using HTTP URLs
- Communicate with other DOORS and DWA users with threaded discussions



All Stakeholders working from a common requirements baseline

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Consumer Electronics: Large organization

Client situation

A leader in the consumer electronics industry, known for its ability to integrate R&D, manufacturing and sales operations. The company operates multiple product design and development sites in the United States, United Kingdom and Japan (as well as a subsidiary in China) to serve these regional markets.

Challenges:

- Develop new products faster that meet the differing requirements of telecommunications carriers, service providers and end users around the world
- Unite the design centers and streamline collaboration
- Manage requirements of wireless communications software across the enterprise

Solution

- **Rational DOORS**

The company started using Rational DOORS in 2002 to merge the individual requirements of customers with the engineering requirements of product development. They decided to link all global design centers with a centralized DOORS database in Atlanta, Georgia. After a four-month deployment process, using Citrix servers they deployed DOORS at design centers in Thatcham, England; Yokohama, Japan; and Beijing, China. This architecture provided each design center with seamless access to the central DOORS requirements management database in Atlanta, which run on a separate, well-protected server with backup.

Results

- ***"Rational DOORS helps us produce mobile phone handsets on a global scale by effectively managing customer requirements from telecommunications carriers in each geographic region. It lets us cost-effectively create a developmental architecture that is customizable for different markets, including managing requirements tailored for products from high to low end in each market."***
  – Senior Staff Engineer, Systems Engineering Group

Automotive: Leading European OEM -

Client situation

For the past 5 years, the company suffered from a bad reputation due to quality issues with a specific car series. This car series was subject to a number of recalls and they saw a relationship between requirements and quality and the management of requirements and suppliers

Challenges:

- Managing the complexity of a vehicle with hundreds of systems, thousands of components
- Collaborating with a large ecosystem of suppliers who provide these components - everything but the body, chassis and engine is built by suppliers
- Managing the variation of these components
- Mandate to reduce costs and development time
- Difficulty reusing component specifications across several different brands, markets and models

Solution

- **Rational DOORS**
- Originally used DOORS to manage the supply chain with their customers. The use of DOORS is also being expanded beyond components to the systems/subsystems and the entire car. Following the success of the deployment in electronics development, DOORS has been extended to the mechanical domain along side their CAD/CAM tools.
- **$>1M Deal over three years–** 200 licenses, best practice workshops and consulting
- **Deployment continues to grow -** 500 licenses in Car Division, 75 in Trucks Division, 5 in TSS (Technology Systems and Services).

Results

- **Reduce costs and increase efficiency by building common components for different brands**
- **Solution for collaboration and communication with suppliers improved their supplier relationships**
- **Increased productivity through centralized, real-time access to latest version of a specification**

"Delphi uses IBM Rational solutions to meet customer requirements faster, more accurately and with less cost"

Need: Delphi wanted to automate requirements management to promote cost savings through component reuse among global development teams.

Solution: After running a parallel project of Rational DOORS and another requirements management tool for approximately one year, Delphi selected Rational DOORS. Rational (acquired by IBM) provided on-site consulting services after Delphi completed training and implementation.

Benefits: Rational DOORS helped Delphi's managers to improve team communication and catch "orphan requirements" and other problems earlier in the development lifecycle, thus reducing costly rework. As a result, the quality of meeting customer requirements has improved, time-to-market has accelerated and costs can be managed more accurately.

"Rational DOORS improves development team communication, which helps us meet customer requirements faster and more accurately."

Lillian Kelly,
Senior Systems Engineer,
Delphi

Leading Financial Institution in APAC

The customer: A leading provider of integrated financial services including retail banking, premium banking, business banking, institutional banking, funds management, insurance, and investment and share broking products and services.

DOORS Requirements Management Solution

The company invested **over $800 million** to replace their entire back office and modernize their enterprise architecture (4 year program). They chose DOORS and other Rational products (Change, Rational Dashboard and Publishing Engine, DOORS -HP QC integration) to create a requirements-driven approach to development and testing.

Leading airport company: savings of over £40M

- **Successful Requirements Management on major infrastructure development, proving DOORS flexibility to be used across the operational disciplines**
  - Requirements Engineering from 2001
  - Assumptions Management from 2002
  - Systems Assurance Support from 2003
  - Interface Test Management from 2005
  - Project Dashboards from 2006

- **Lessons Learned:**
  - Incremental introduction → realise early benefits.
  - Ownership to Project Teams → users suggest new applications
  - Maturity of the project evolves with positive and negative experience
  - Toolbox approach → DOORS, Excel and Documentum

Operator Requirements

Design, Build & Maintain Infrastructure

Baggage Handling

Transit System

Metro Rail Extention

Emerging Health I.T. helps clinicians improve patient care while reducing development costs and improving productivity with help from IBM Rational software

Situation

Healthcare professional services and consulting firm developing the Clinical Looking Glass (CLG) product, a web-based tool that accesses the electronic medical record to place powerful patient data analytics in the hands of clinicians. Increased focus on Electronic Medical Record puts spotlight on CLG, and regulatory compliance is also an issue with the Health Information Portability and Accountability Act (HIPAA) requirements having to be articulated at data and application levels.

Challenges:

- Requirements delivered via email, documents, and discussion; converted by management and engineering to one all-encompassing use case
- No documented requirements for much of existing CLG functionality
- No requirements process (e.g., formal peer review, baseline)
- Highly reliant on engineering and database team member knowledge of the code and data structure
- Frequent disconnects between delivered product and stakeholder expectations
- Poor estimation and extremely loose release scheduling.

Solution - Benefits

Rational DOORS

- Emerging Health I.T. took steps to improve their requirements process including training business analysts; they examined a number of requirements managements products and chose IBM Rational DOORS as the best fit for their needs.
- Deployed to a team of 18 application and database engineers, testers, analysts, and managers; each wears various “hats”; follows Rational Unified Process.

Benefits

- 6 months after implementation of the solution, business analysts delivered specific requirements in a coherent form and the development team delivered a similar amount of functionality in less than 25% of the calendar time that it took before the implementation. They’ve seen a 69% net reduction in cost of test preparation, testing, and rework.
- Stakeholder expectations are now more clearly defined and therefore they are able to meet more of those expectations than in the past. The development team has improved estimation and gained a deeper understanding of how much functionality they can deliver within a specific timeframe.

“In 6 months since deployment we’ve seen a 69% net reduction in the cost of test preparation, testing, and rework by using IBM Rational DOORS and an improved requirements management process.

Our team is testing and reworking comparable functionality in one sixth the calendar time and one third the person hours. And we are able to better meet the needs of our stakeholders."

Mia McCroskey, Senior Project Manager for Product Development at Emerging Health Information Technology

Return on Investment achieved by Emerging Health I.T.

- Investment in defining needs, tool evaluation, tool deployment and configuration, software licenses, tool training, and requirements uploading of $115,830

	Testing Effort (hours)	Rework Effort (hours)	Test Hours/ Defect	Rework hours/ Defect	Test Prep (hours)	Cost of Testing	Cost of Rework	Cost of Quality (Testing plus Rework)**
Pre DOORS Implementation Release*	498.80	1810.00	0.47	1.72	190.00	$97,266.00	$352,950.00	$450,406.00
Post DOORS Implementation Release*	389.00	336.00	1.50	1.29	288.00	$75,855.00	$65,520.00	$141,663.00
Saving (hours/cost)	109.80	**1474.00**	-1.02	**0.43**	-98.00	**$21,411.00**	**$287,430.00**	**$308,743.00**
% Saving	**22%**	**81%**	-216%	**25%**	-52%	**22%**	**81%**	**69%**

*Comparison releases of similar scope.

**Effort for requirements unavailable for both releases

- Cost of quality saving of $308,734
- **Return on Investment within six months of $192,913**
- **...and a productivity improvement of more than 75%**

IBM Rational DOORS

Worldwide market and technology leader

- ✓ Yphise award for best RM Product
- ✓ ISO 9001 Compliant development

Success from comprehensive requirements management process

- ✓ Easy-to-use document oriented views
- ✓ Lifecycle traceability to *any* information
- ✓ Web-based access and review

"DOORS enables us to plan, execute, and track the progress of the practices that we're improving for our members … DOORS helps us provide a good example of best practices in systems engineering."

Pat Hale, President-elect, International Council on Systems Engineering (INCOSE)

Business Wire, May 15, 2007

Highest compliance and audit capabilities

- ✓ Simple but powerful versioning
- ✓ FDA Compliant Electronic Signature
- ✓ Comprehensive traceability reporting

INCOSE
International Council on Systems Engineering

www.ibm.com/software/rational