



Model-Driven Development for Safety Critical Code

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Agenda

- 1 Safety Critical Application Standards
- 2 Integrated Software Development Process
- 3 Model-Driven Development for Safety Critical
- 4 Rational Rhapsody Enhancements for Safety Critical
- 5 Rhapsody TestConductor AddOd Qualification Kit
- 6 Summary

Standards for Safety Critical Applications

A **Safety Critical System** is a system whose failure or malfunction may result in serious injury or even death to people.

Some Safety Critical Standards:

- **IEC 61508**, Functional Safety Standard
- **DO-178B/C**, Aerospace and Defense
- **ISO 26262**, Automotive
- **EN 50128**, Rail
- **IEC 60601 & 62304**, Medical



Increase of Software in Aerospace & Defence

- Complexity in modern systems requires **more software**
- Technology enhancements and project constraints make aerospace Industries to adopt **new processes** and **programming languages** (F-35 uses C++)

F-35 Lightning



F-22 Raptor



F-16 Falcon



F-4 Phantom



First adopting
"relaxed
static
stability"

1960'

Only 8% of requirements required software (assembly) in the F-4

1970'

45% of requirements required software (JOVIAL) in the F-16

1980'

80% of specification requirements required software (Ada83) in the F-22

2000'

F-35 has 24 million lines of code (C/C++), vs 1.7 million lines of code for F-22

Example: RTCA DO-178B

- RTCA DO-178B is an **objective-based** standard applied by FAA (Federal Aviation Administration) for the certification of software in avionics systems.
- Published in 1992, it covers the **5 main processes** concerning Planning, Development, Verification, Configuration Management and Quality Assurance.
- DO-178B outlines the **objectives** to be met, the work **activities** to be performed for each objective, and the **evidence** (output documents) to be supplied for each objective (based on criticality level A-E)

Software Criticality Level	Failure Condition Category	Failure Condition Description	Objectives
Level A	Catastrophic	Conditions which would prevent continued safe flight and landing.	66
Level B	Haazardous/ Sever-Major	Conditions which would reduce aircraft safety margin/functional capabilities, produce a higher workload to the flight crew or have serious adverse effencts on occupants	65
Level C	Major	Conditions which would not significantly reduce aircraft safety, crew ability to work under adveser operation or produce discomfort to occupants.	57
Level D	Minor	Conditions which would not significantly reduce aircraft safety, slight increas in crew workload or produce some inconvenience to occupants	28
Level E	No Effect	Conditions which do not affect the aircraft operations or crew workload.	0

Integrated Software Process for DO-178B

- The **Integrated Software Development Process for DO-178B (ISDP-178)** is a set of practices to help organizations developing products for certification under DO-178B
 - ▶ Specifies a large number of modern sw engineering best practices, including MDD and MBT
- The process may be applied to any appropriate development tooling but is specifically optimized for the Rational System Accelerator consisting of tools
 - ▶ **Rational Team Concert** for project planning, enactment, and tracking, incl. CM
 - ▶ **Rational DOORS** for requirements management
 - ▶ **Rational Rhapsody** for system engineering, safety analysis, software design & development
 - ▶ **Rational Quality Manager** for test specification, execution, and analysis
 - ▶ **Rational Method Composer** for process customization
- The ISDP-178 address three primary needs
 - ▶ Process specification
 - ▶ Process enactment
 - ▶ Specific links from the DO-178B standard to process content to aid in ensuring compliance
 - By Objective
 - By Certification Level
 - By Work Product

ISDP-178 Process Description



Rational. Method Composer

Search this Site:

DO-178B

- Welcome to the DO178 Accelerator
- Getting Started
- Delivery Processes
- DO-178B Objectives
- DO-178B SW Certification Levels
- Guidance
- Practices
- Roles Sets
- Tasks
- Work Products
- Release Info

Welcome to the DO178 Accelerator

Welcome to the DO178 Accelerator

The DO-178B mapping is a set of pages providing links between the objectives, plans, tasks, and work products specified in the RTCA DO-178B standard (particularly Appendix A) and the work tasks, work products, process roles and guidance provided by the Rational Practices. This mapping is meant to aid the development of software intended to be certified under this standard by providing links between the standard and the process assets represented within the Rational Practice library and processes.

This process content represents Best Practices for Embedded Software development in a variety of safety critical industries. It is our expectation that every deployment of this process will require customization in some form. Practices and work products may be inserted, deleted, or replaced as appropriate for your organization and your project.

Main Description

About this configuration

Welcome to the DO178 Website!

This configuration includes the practices, delivery process and the mapping to the DO-178 standard.

It also includes tool configuration assets and instructions. See [Tools Setup and Configuration](#) for more information.

Learning

- Getting Started

Resources

- IBM Rational Method Composer
- Practice-based enablement
- Additional Practice Plug-ins
- General IBM resources
 - IBM Rational training
 - Jazz.net

Navigation Links

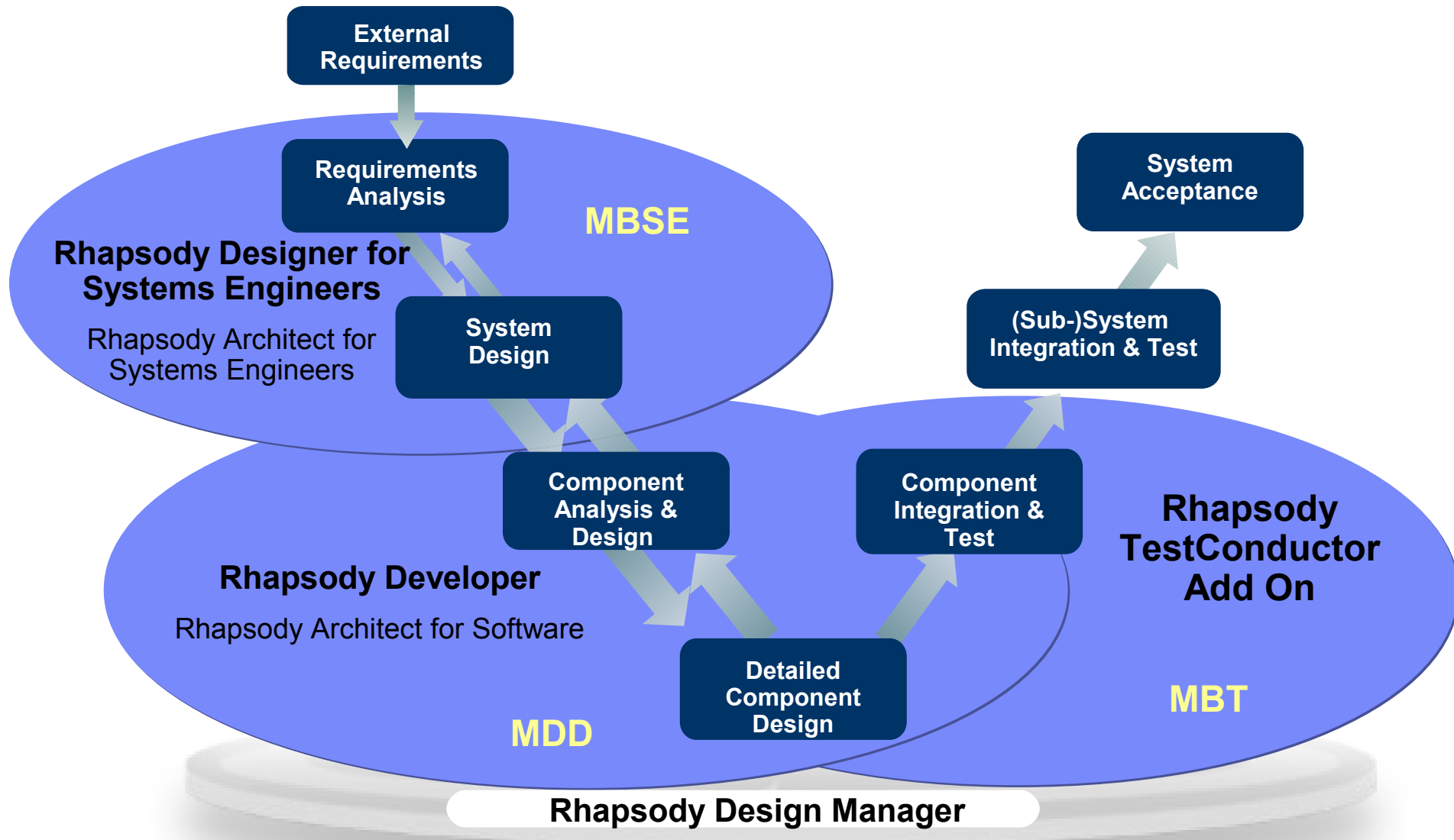
Roles
 Work Products
 Tasks
 Processes
 Practices

Note that the DO-178B standard calls for a number of project plans as deliverables. It is anticipated that the process content in this configuration forms the base content for most of those plans (see the Artifact section). This entails customizing this content for each new project with project-specific information. This refers specifically to the Software Configuration Management Plan, Software Quality Assurance Plan, Software Development Plan, and Software Verification Plan, supplemented with additional project data in external documents. The Plan for Software Aspects of Certification is created within the DO-178B Certification Practice but results in an external document.

Process assets provided within the library include:

More Processes Available:
 Harmony/SE
 Harmony/ESW
 ISO 26262

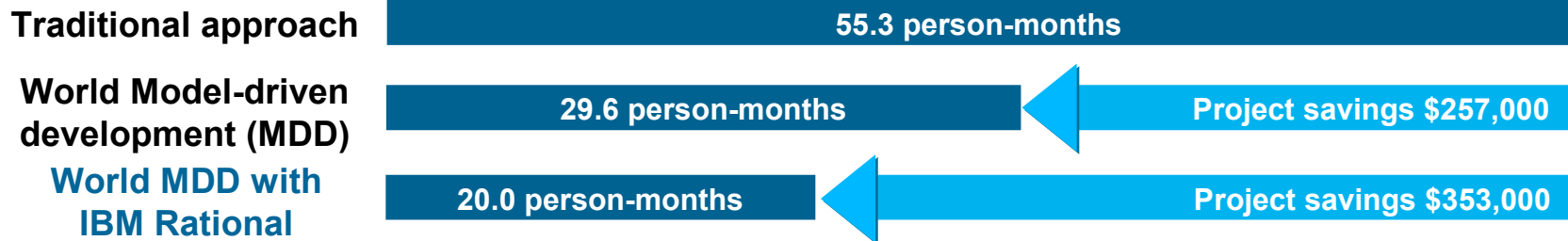
Model-Driven Development positioning in the V-Process



Model-Driven Development in Safety Critical Development

- Adopting MDD you can increase productivity and code quality
- Rhapsody provides many MDD technologies:
 - ▶ Production Code Generation (80%-90%)
 - ▶ Model/Code Associativity (aka Roundtripping)
 - ▶ Model Checking
 - ▶ Model Helpers and Transformations via Rhapsody API and Rhapsody RulesComposer

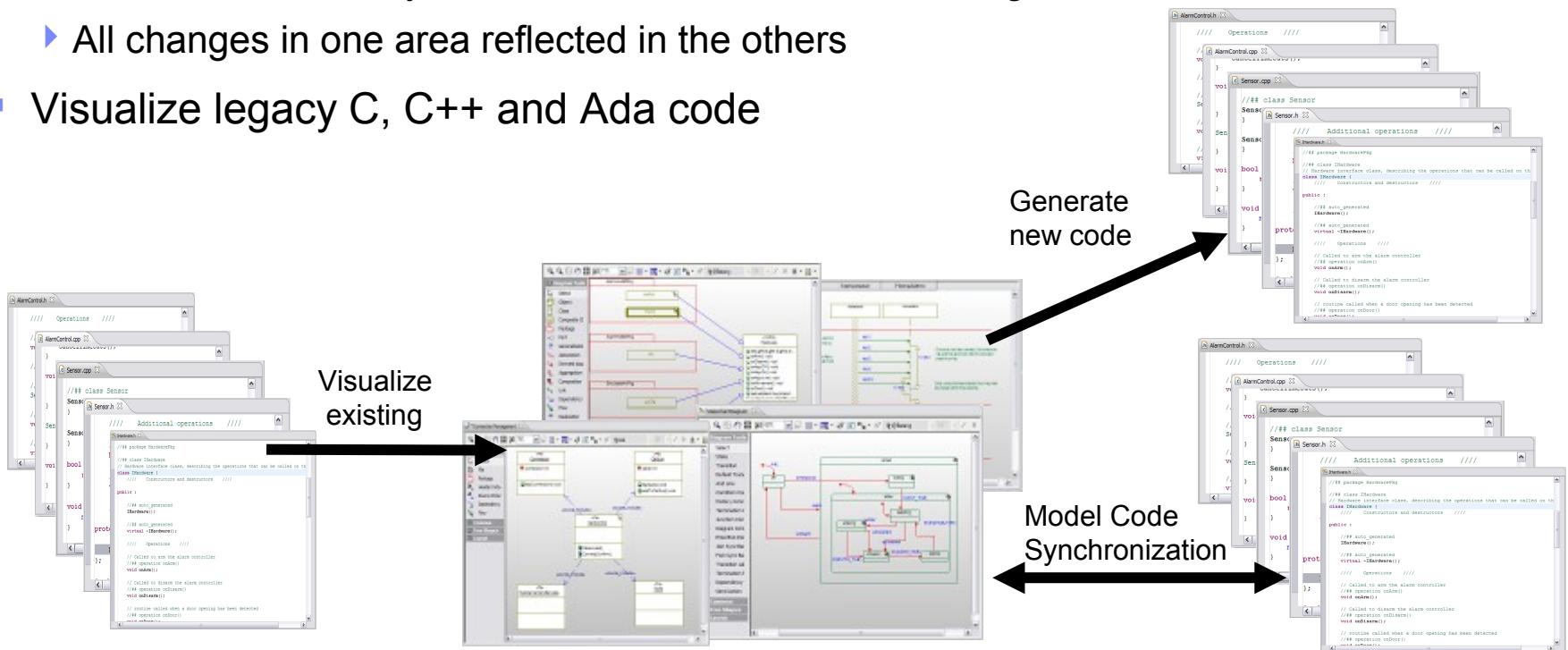
Average Developer time lost to **delays in design completion**



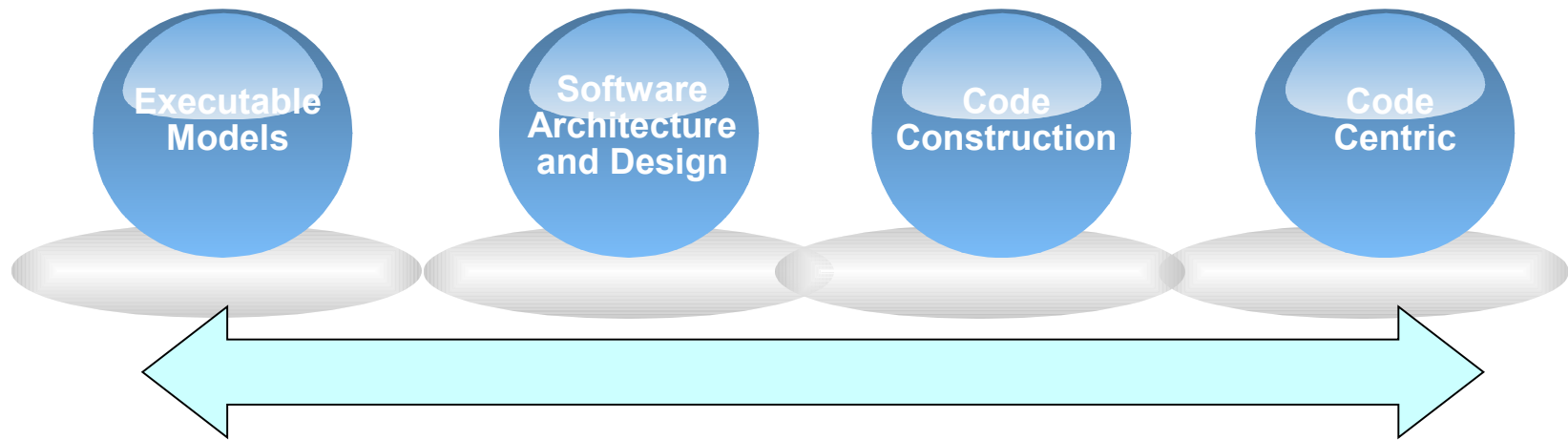
Source: 2011 EMF (Embedded Market Forecasters) Study

Model-Driven Development Approaches

- Generate new code from the model
 - ▶ Develop MISRA-C, MISRA-C++ and Ada applications
- Maintain automated synchronization between model and code
 - ▶ Work simultaneously with architecture, software and target
 - ▶ All changes in one area reflected in the others
- Visualize legacy C, C++ and Ada code



Different Modeling Paradigms: Code-Centric or Model-Centric



Model-is-code

From the model
Code is “black box”
One-way development flow

Using implementation language

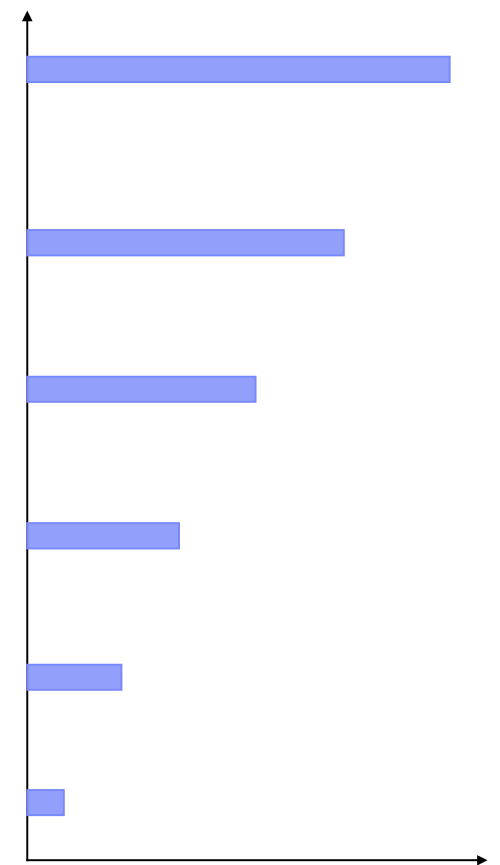
- Generating readable code
- Open framework
- Model-Code Associativity
- Model-Code co-Debugging

Code is the master

Everything is done in the code and should stay exactly as-is

UMMI – UML Modeling Maturity Index (By Bruce Douglass)

Level	Benefit	Focus	Technologies	Result
5 Optimizing	100%	Agile and Engineering Best Practices	Model-based testing, nanocycle execution, test driven development, continuous integration	Productivity and Quality
4 Executing	70%	Model-based verification	Model execution, code generation, model-based debugging	
3 Behavioral Modeling	30%	State and algorithmic modeling	State, sequence and activity diagrams	
2 Structural Modeling	15%	Class and block modeling of structure	Class and block diagrams	
1 Visualization	5%	Visualizing code structures	Reverse engineering	
0 Code Based Development	0%	Manual, time intensive heroic development		



Model-Driven Development with IBM Rational Rhapsody



Find errors early in the process with advanced model execution

Requirements test through execution

Model execution enables iterative development

Correct specification hand-off to software

Main Enhancements for MDD in Rhapsody 8

- “High-Level” and “Low-Level” Requirements stereotypes
- Better Traceability from Statechart to Code
 - ▶ Distinguish between HLR and LLR with new stereotypes
 - ▶ Improved location in code for Transitions and States’ Requirements
 - ▶ Improved mapping-back of Statechart code to the specific model element
 - ▶ Generate Requirements associated with Entry/Exit Action and Internal Transition
 - ▶ Associate Statechart’s auto-generated code with its justification
 - ▶ Ability to generate Requirement on Operation to implementation file as well
- Safety-Critical Frameworks for Rational Rhapsody
 - ▶ C: SMXF (Simplified MicroC eXecution Framework)
 - ▶ C++: SXF (Simplified C++ eXecution Framework)
- Rhapsody TestConductor Qualification Kit for ISO 26262 and ICE 61508

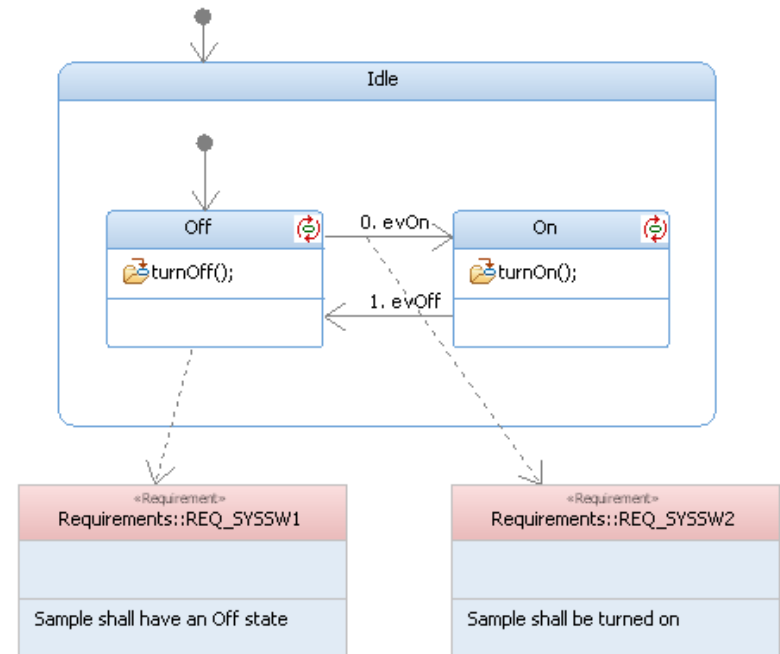
Improved location of Requirements for Transitions/States in a Statechart

- If you have Requirements that are met by specific States or Transitions in a Statechart, they can be included as comments in the generated code.

```

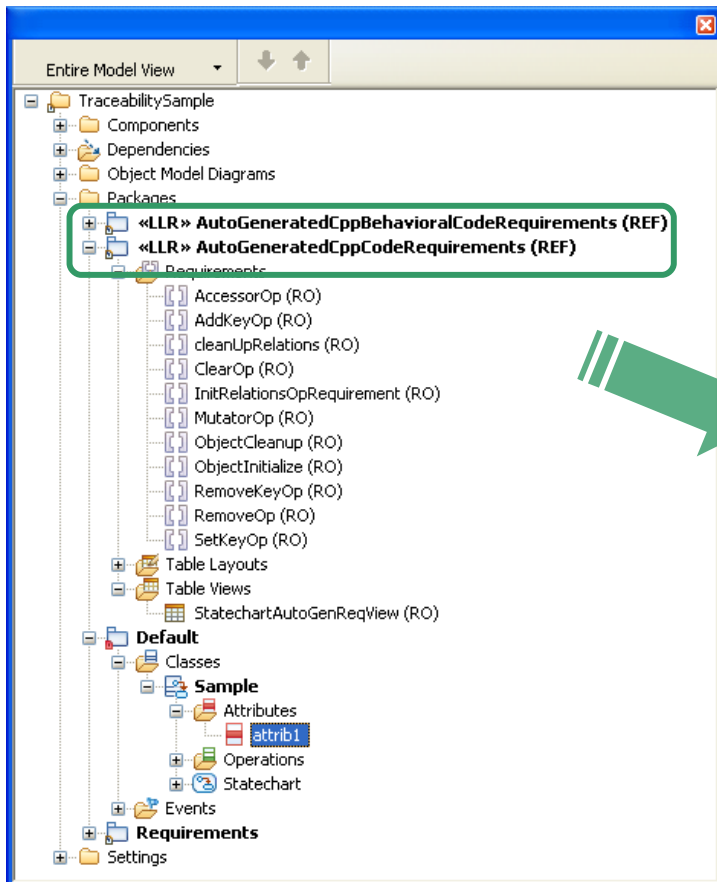
switch (rootState_active) {
  // State Off
  // Realizes requirement REQ_SYSSW1:
  // Sample shall have an Off state
  case Off:
  {
    // Realizes requirement REQ_SYSSW2:
    // Sample shall be turned on
    if (IS_EVENT_TYPE_OF(evOn_Default_id))
    {
      ...
    }
  }
  break;
  // State On
  case On:
  {
    ...
  }
  break;
  default:
  // Realizes requirement SwitchStatementDefaultClause #SCR1.36:
  // The default clause shall be generated for a switch statement;
  break;
}
return res;

```



Requirements Justification for Autogenerated Code

- Rhapsody can include Requirements to **justify autogenerated code**, such as accessor and mutator operations of an attribute.



```
// Realizes requirement ObjectInitialize #LR1.05
///  
auto_generated
Sample(IOxfActive* theActiveContext = 0);

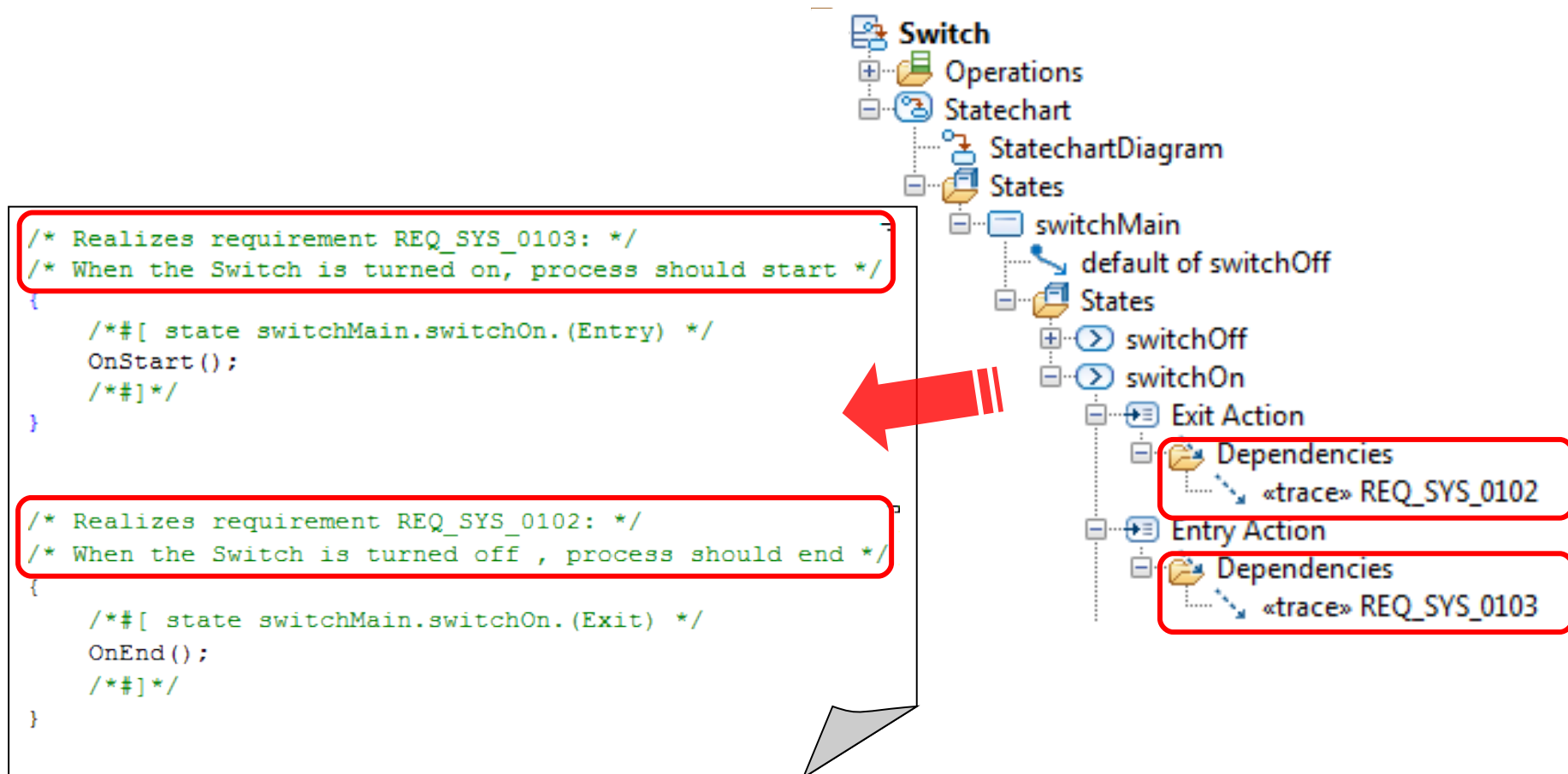
// Realizes requirement ObjectCleanup #LR1.04
///  
auto_generated
~Sample();

// Realizes requirement AccessorOp #LR1.06
///  
auto_generated
int getAttrib1() const;

// Realizes requirement ReactiveStartBehavior #SCR1.23
///  
auto_generated
virtual bool startBehavior();
```

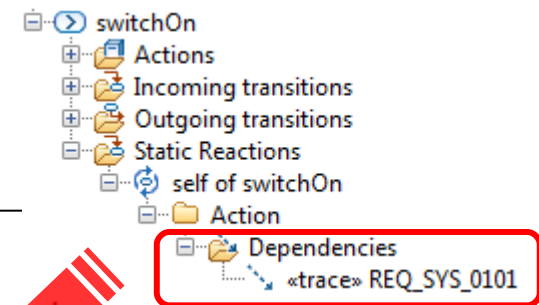
Requirements for Entry/Exit Actions

- Rhapsody supports Requirements on Entry Action / Exit Action
 - ▶ You can associate Requirements in the Browser
 - ▶ Rhapsody generates the Requirements in the Generated Code



Generate code for Requirements of Internal Transition

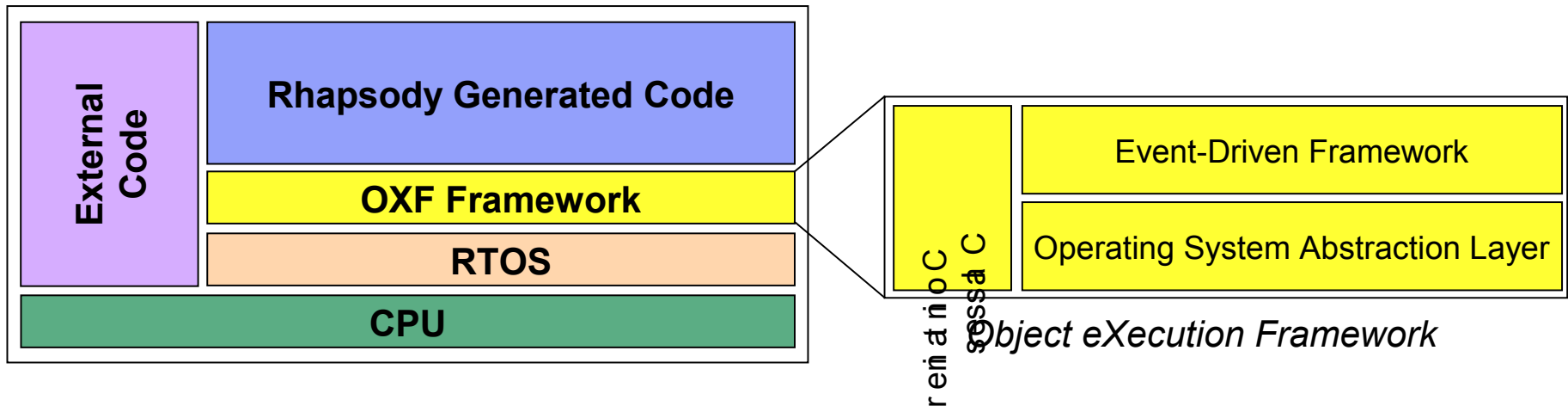
- Rhapsody supports Requirements on Internal Transition and on its Action (if any)
 - Generate Requirements into code, using the transition trigger for mapping back to model
 - You can associate Requirements in the Browser



```
/* State switchOn */
/* Description: myDescription */
case Switch_switchOn:
{
    switch (id) {
        case Timeout_id:
        {
            if(RiCTimeout_getTimeoutId(me->ric_reactive.current_event) == Switch_Timeout_switchOn_id)
            {
                /* Realizes requirement REQ_SYS_0101: */
                /* Indication of switch on should be green light blinking */
                {
                    /*#[ transition 0 */
                    GreenBlink();
                    /*#]*/
                }
                res = eventConsumed;
            }
        }
    }
    break;
}
```


How Rhapsody implements Behavioral Diagrams

- Rhapsody implements behavioral diagrams by leveraging a framework of base classes and interfaces.
- There are two main parts to this framework:
 - ▶ The **Object eXecution Framework (OXF)**, which is the part of the framework that is always linked into the final generated code.
 - ▶ The **Animation and Tracing Framework**, which is only used when animating or tracing.
 - ▶ The OXF is provided for each supported language (**C, C++, Java, Ada, C#**), with different flavors (interrupted-driven, static memory only, etc..)



Simplified MicroC Framework (SMXF) Overview

- SMXF is an execution framework optimized for MISRA compliant real-time C applications generated from Rhapsody Models
- Full static/compile-time architecture
 - ▶ Support only compile-time initialization, Support segmented memory (allocation to memory banks)
- MISRA-C 1996/2004 compliance
- Supporting the Extended Execution Model
 - ▶ Periodic Execution
 - ▶ Execution Manager, Runnable Manager
 - ▶ Events (Asynchronous events, Synchronous events, Timeouts)
- Adapters
 - ▶ ARINC 653 (APEX API based)
 - ▶ “Mainloop” - self scheduling executive

Comparison of C eXecution Frameworks

Purpose	Standard C Object Execution Framework (OXF)	MicroC eXecution Framework (MXF)	Simplified MicroC eXecution Framework (SMXF)	Interrupt- Driven Framework (IDF)
Supports statecharts	Y	Y	Y	Y
Supports asynchronous messaging	Y	Y	Y	Y
Supports synchronous messaging	Y	Y	Y	Y
Timers (time events)	Y	Y	Y	Y
UML ports	Y	Flow ports	N	N
Deterministic	N	Y	Y	Y
Periodic scheduling	N	Y	Y	N
Multi-thread support	Y	Y	Y	N
Supports multiple event queues	Y	Y	Y	Y
Resource protection	Y	Y	Y	N
Requires an OS?	Y	N	N	N
Can be used with an OS?	Y	Y	Y	Y
Defines own Container Classes	Y	Configurable	N	Y
Defines a Memory Manager	Y	Configurable	N	N
Error manager / notifier	N	N	N	Y
Static memory allocation	N (property settings or user-defined)	Y	Y	Y
Animation	Y	Y	N	N
Tracing	Y	Y	N	N
Simulated time model	Y	N	N	N
Size	~15000 LOC	~10000 LOC	~5000 LOC	~2500 LOC
MISRA C compliance	N	Med-high compliance	High compliance	High compliance

Simplified C++ eXecution Framework (SXF)

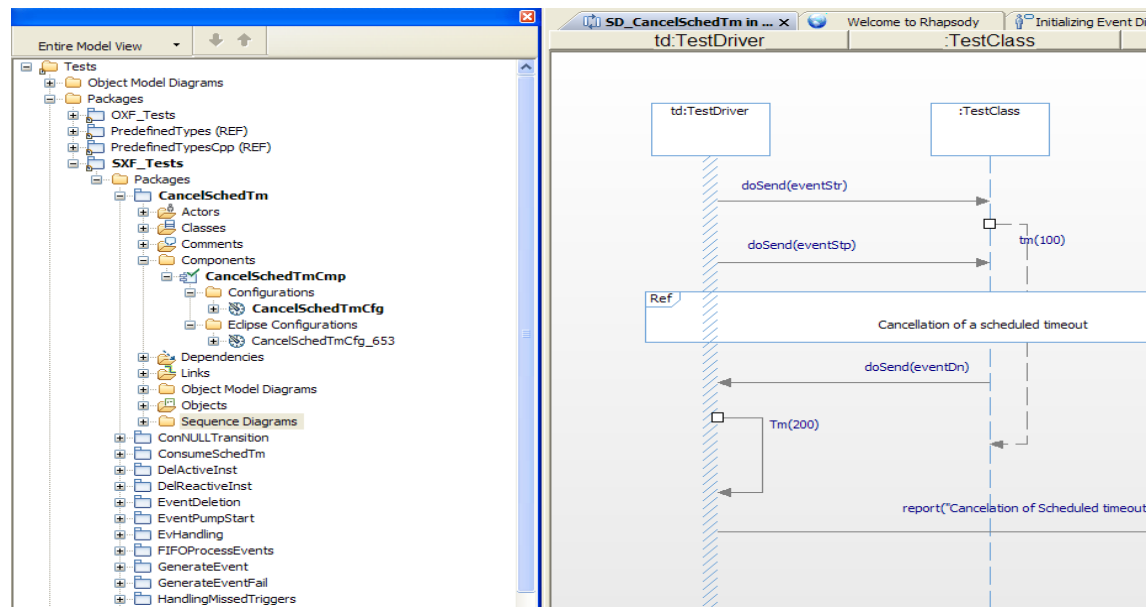
- Based on IDF with support for Active classes (multi threading)
- Static architecture
 - ▶ Static memory manager for events allocation
- MISRA C++ 2008 compliance
 - ▶ Safety critical C++ settings
 - ▶ Checks to support MISRA compliant modelling style
- Events
 - ▶ Asynchronous events, Synchronous events (triggered operations), Timeouts
- Adapters
 - ▶ Workbench Managed 653 (APEX API based)
 - ▶ Microsoft (VS 2008/2010)
- Constraints
 - ▶ Flat state charts
 - ▶ No Ports
 - ▶ No Animation/Tracing

Comparison of SXF and OXF for C++

SXF C++	OXF C++
Static architecture	Dynamic allocation
No animation/tracing	Animation/Tracing
Only Real Time	Real Time/Simulated Time
No containers (can be added)	Containers
Static memory manager (only BasedNumberOfInstances)	Static memory manager
Flat state charts	Flat/Reusable state charts
No Multi core in 7.6	Multi core
No Interfaces	Interface based
No Ports	Ports

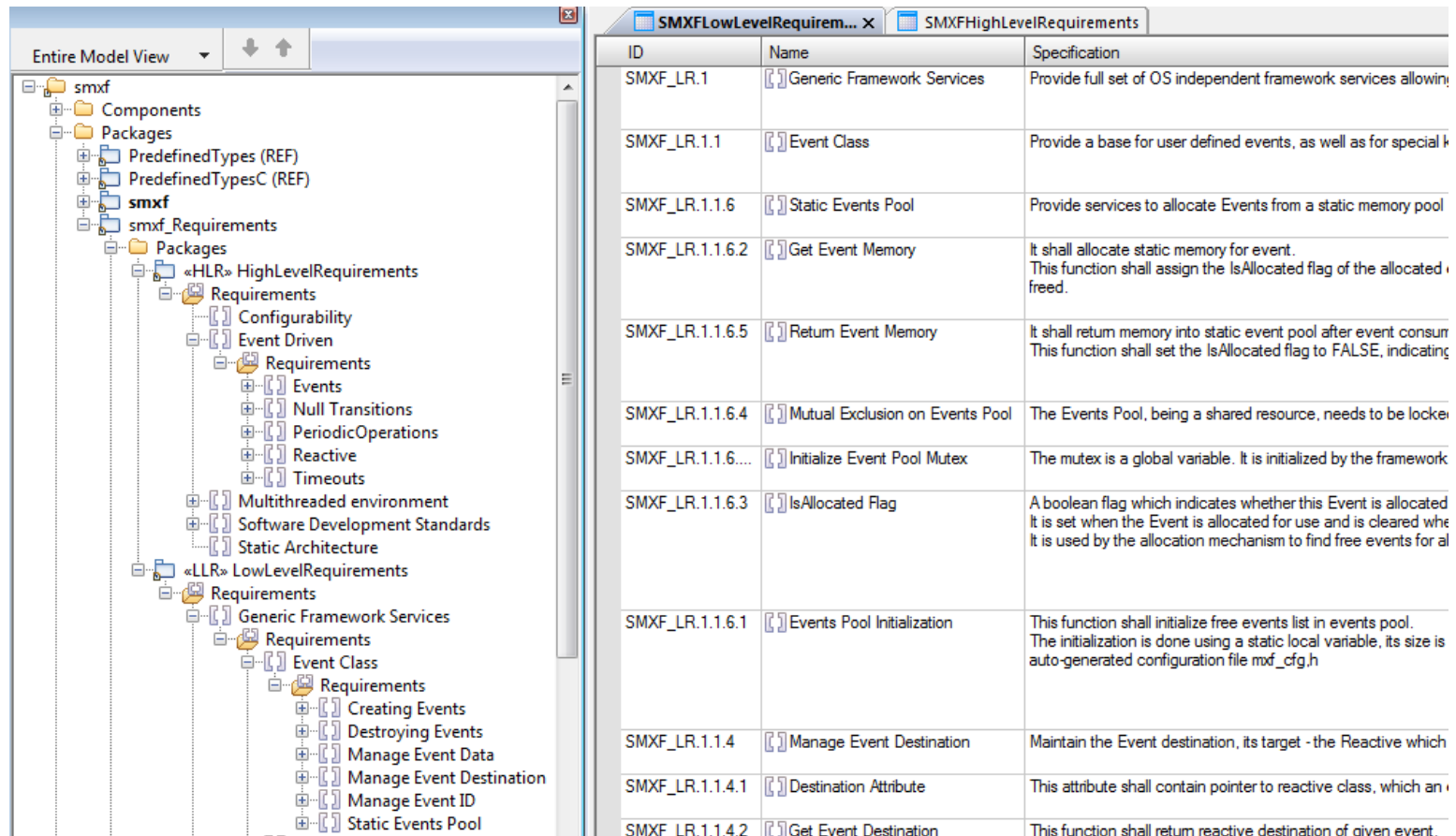
Certification Supporting Materials for SMXF and SXF

- Associated High Level (HLR) and Low Level (LLR) Requirements provided
- Trace back from code to requirements
 - ▶ Fully justified code
- Test Cases provided using Rational Rhapsody TestConductor Add On
 - ▶ Test Cases trace back to requirements
 - ▶ Statement coverage
 - ▶ Branch coverage



SMXF High Level (HLR) and Low Level (LLR) Requirements

- Both SXF and SMXF Models include coverage to High and Low Level Requirements



The screenshot displays the Rational Software Architect interface. On the left, the 'Entire Model View' shows a hierarchical tree of the SMXF model. The tree is organized into packages: 'smxf', 'Components', 'Packages', 'PredefinedTypes (REF)', 'PredefinedTypesC (REF)', 'smxf', and 'smxf_Requirements'. Under 'smxf_Requirements', there are two main sections: '«HLR» HighLevelRequirements' and '«LLR» LowLevelRequirements'. The '«HLR» HighLevelRequirements' section includes 'Configurability', 'Event Driven', 'Requirements', 'Events', 'Null Transitions', 'PeriodicOperations', 'Reactive', and 'Timeouts'. The '«LLR» LowLevelRequirements' section includes 'Multithreaded environment', 'Software Development Standards', 'Static Architecture', 'Requirements', 'Generic Framework Services', 'Requirements', 'Event Class', 'Requirements', 'Creating Events', 'Destroying Events', 'Manage Event Data', 'Manage Event Destination', 'Manage Event ID', and 'Static Events Pool'.

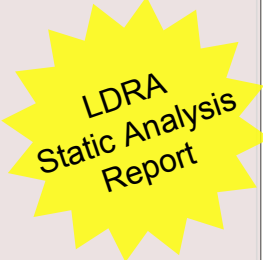
On the right, a table titled 'SMXFHighLevelRequirements' lists specific requirements. The table has three columns: ID, Name, and Specification.

ID	Name	Specification
SMXF_LR.1	Generic Framework Services	Provide full set of OS independent framework services allowing
SMXF_LR.1.1	Event Class	Provide a base for user defined events, as well as for special k
SMXF_LR.1.1.6	Static Events Pool	Provide services to allocate Events from a static memory pool
SMXF_LR.1.1.6.2	Get Event Memory	It shall allocate static memory for event. This function shall assign the IsAllocated flag of the allocated freed.
SMXF_LR.1.1.6.5	Return Event Memory	It shall return memory into static event pool after event consum This function shall set the IsAllocated flag to FALSE, indicating
SMXF_LR.1.1.6.4	Mutual Exclusion on Events Pool	The Events Pool, being a shared resource, needs to be locke
SMXF_LR.1.1.6...	Initialize Event Pool Mutex	The mutex is a global variable. It is initialized by the framework
SMXF_LR.1.1.6.3	IsAllocated Flag	A boolean flag which indicates whether this Event is allocated It is set when the Event is allocated for use and is cleared whe It is used by the allocation mechanism to find free events for al
SMXF_LR.1.1.6.1	Events Pool Initialization	This function shall initialize free events list in events pool. The initialization is done using a static local variable, its size is auto-generated configuration file mx_f_cfg.h
SMXF_LR.1.1.4	Manage Event Destination	Maintain the Event destination, its target - the Reactive which
SMXF_LR.1.1.4.1	Destination Attribute	This attribute shall contain pointer to reactive class, which an
SMXF_LR.1.1.4.2	Get Event Destination	This function shall return reactive destination of given event.

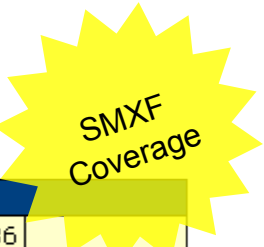
SMXF and SXF Test Reports

- Also the Test Reports generated from the SMXF and SXF frameworks are provided or can be re-generated:
 - ▶ Code Coverage Report
 - ▶ Requirements Coverage Report
 - ▶ MISRA/MISRA-C++ Compliancy Statement
 - ▶ MISRA/MISRA-C++ LDRA Testbed Report

	Quality Result	Uniq Violations % in Function	No in Function	Breakdown of Violations
<u>SXF (Set)</u>	Pass	12 Files 145 Functions		
OMOSSpecific.cpp	Pass	0		
OXF.cpp	Pass	0		
OMTimeoutPool.cpp	Pass	0		
OMTimeout.cpp	Pass	0		
OMThread.cpp	Pass	0		
OMStartBehaviorEvent.cpp	Pass	0		
OMReactive.cpp	Pass	0		
OMProtected.cpp	Pass	0		
OMMainThread.cpp	Pass	0		
OMGuard.cpp	Pass	0		
OMEventQueue.cpp	Pass	0		
OMEvent.cpp	Pass	0		



Function Coverage



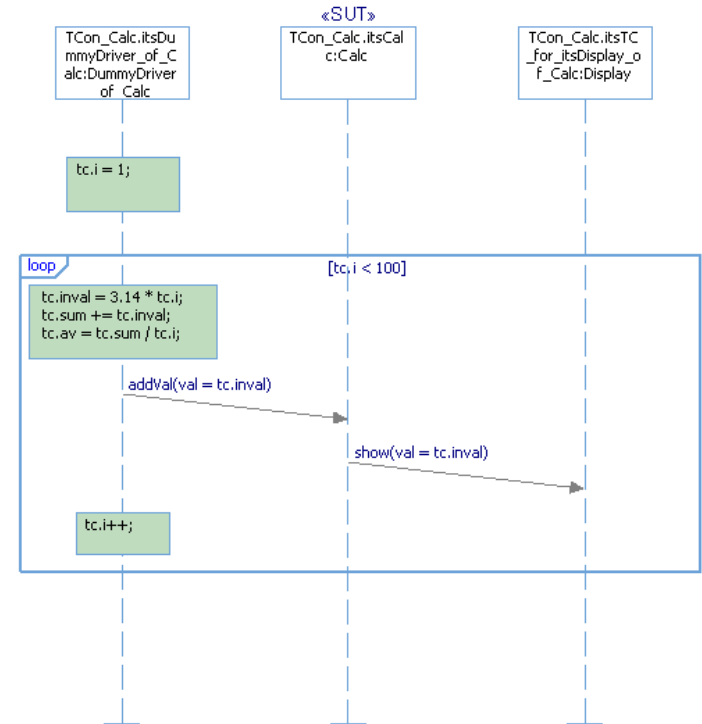
Coverage Goals		
total	136	
covered	136	100%
unknown	0	0%

Coverage Items (1 Goal)		
total	136	
covered (completely)	136	100%
covered (partially)	0	0%
uncovered	0	0%

Detailed Coverage Results

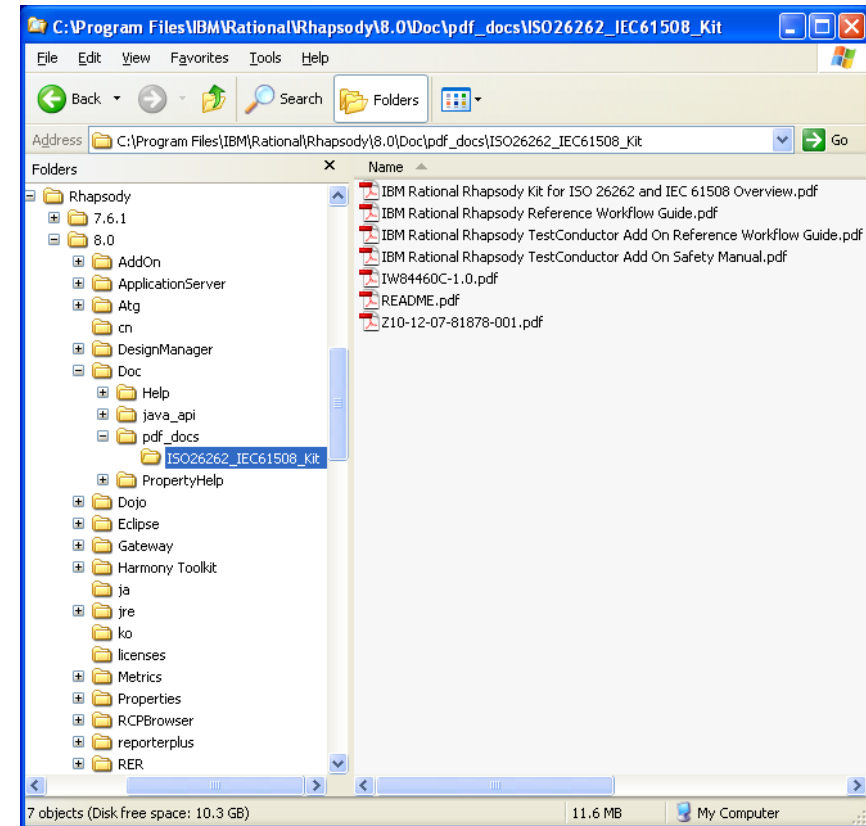
Rhapsody TestConductor Add-on for Model-Based Testing

- ▶ Define test cases with sequence diagrams, statecharts, flowcharts or even code
 - OMG UML Testing Profile
- ▶ Automate testing tasks
 - Create Test Architecture
 - Execute and monitor tests
 - Interactive for debugging,
 - Batch test suites for nightly regression
 - Include CUnit/CppUnit tests
- ▶ Traceability across lifecycle – from requirements to integration
- ▶ Host level and target based execution
 - White-Box, Black-Box for design validation
 - “Offline testing” mode:–for testing on target
 - C++, C, Java, Ada Supported
- ▶ Definition and management of regression tests
- ▶ Reporting of results, coverage and traceability



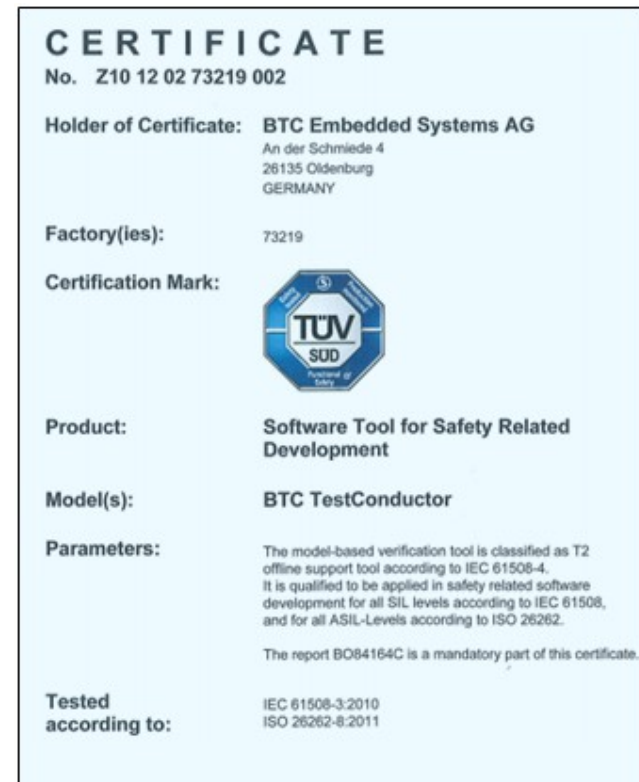
Rhapsody Kit for ISO 26262 and IEC 61508

- **Overview Doc:** describes the contents of the Rhapsody kit
- **Rhapsody Reference workflow:** provides an exemplary workflow for modelling, code generation and verification in safety critical
- **Rhapsody TestConductor Add On Workflow:** describes testing activities and objectives
- **Rhapsody TestConductor Safety Manual:** provides additional information for using TestConductor in safety related applications
- **TÜV SÜD Certificate for Rhapsody TestConductor Add On**
- **TÜV SÜD Report on Certificate for ISO 26262 and IEC 61508**
- **Rhapsody TestConductor Add On Validation Suite:** separately available test suite for Rhapsody TestConductor to help in qualification efforts
- **Certification kits** for the SXF and SMXF frameworks



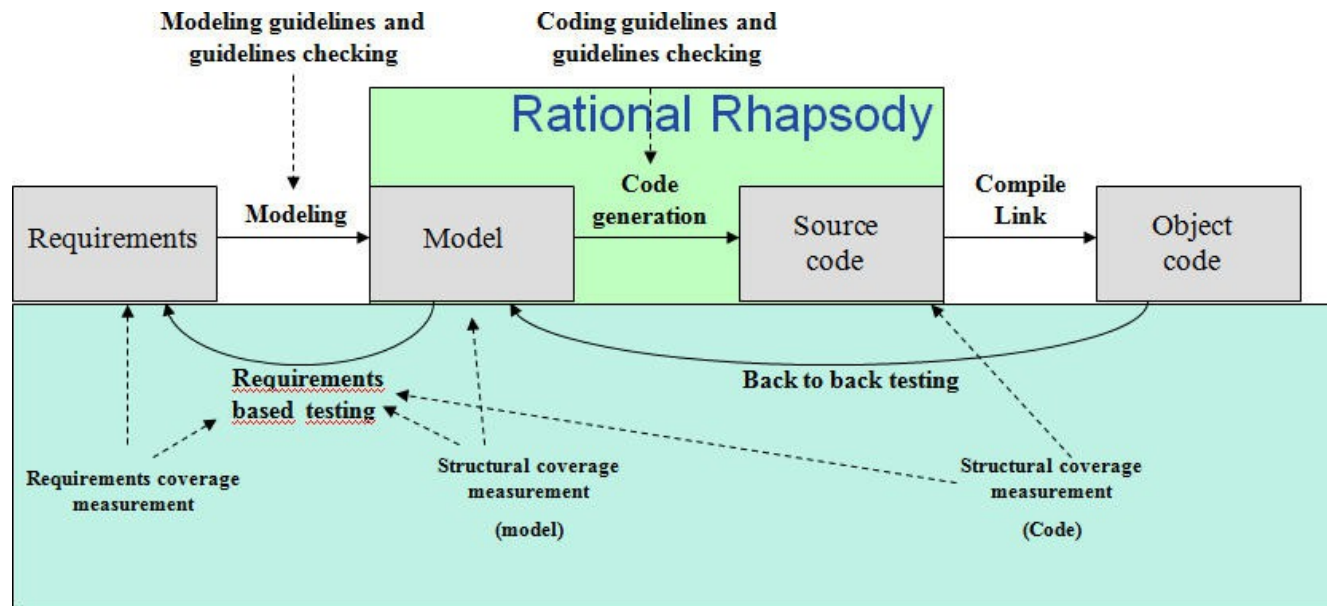
IBM Rational Rhapsody TestConductor Add-On Certification

- The **Validation Suite** is an integral part of the IBM Rational Rhapsody TestConductor Add-On certification (ISO 26262 and IEC 61508)
 - ▶ IBM Rational Rhapsody TestConductor Add-On is a **qualified testing tool** for IBM Rational Rhapsody
 - ▶ Successful qualification has been acknowledged by **TÜV Süd** (independent German certification body)
 - ▶ TÜV Süd issued a certificate about **successful qualification**
 - ▶ Customers can immediately leverage from the certificate
 - ▶ Certificate will be also issued for IBM Rational Rhapsody TestConductor Add-On integrated into IBM Rational Rhapsody



IBM Rational Rhapsody Reference Workflow

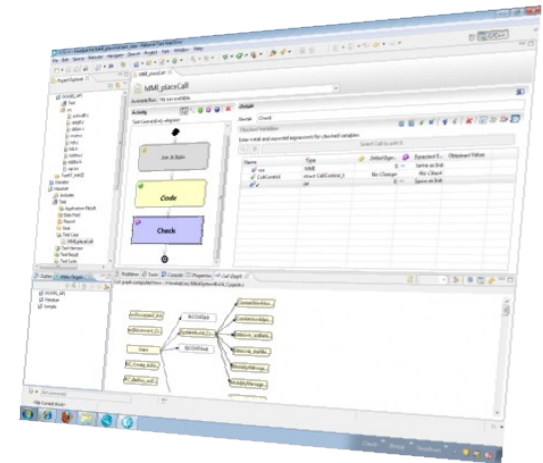
- Rhapsody Reference Workflow for the development of safety-related software
 - provides **guidance** on how to fulfill functional safety requirements with model-based development methods and tools;
 - is based on **best practices** for safety-related projects;
 - addresses various workflow **activities** relevant for the development of safety-related software with a special focus on verification and validation to develop safe software;
 - conforms to **IEC 61508** and **ISO 26262**.



IBM Rational Test RealTime



- **Rational Test RealTime** is a cross-platform solution for component testing and runtime analysis of embedded software for C,C++, Ada and Java.
 - ▶ Software Unit & Integration Testing
 - ▶ Electronic Control Unit (ECU) / Hardware in the Loop (HIL) Validation
 - ▶ Modified Condition/Decision Coverage (MC/DC)
 - ▶ Memory Profiling
 - ▶ Performance Profiling
 - ▶ Runtime Tracing
 - ▶ Static Code Analysis (MISRA-C)
 - ▶ Integrated with Rhapsody TestConductor
- Rational Test RealTime DO-178B Qualification Kit

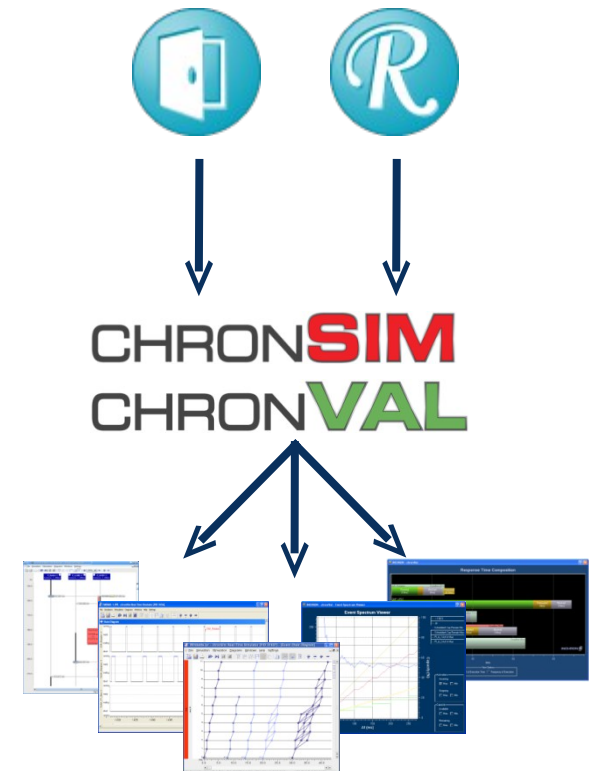
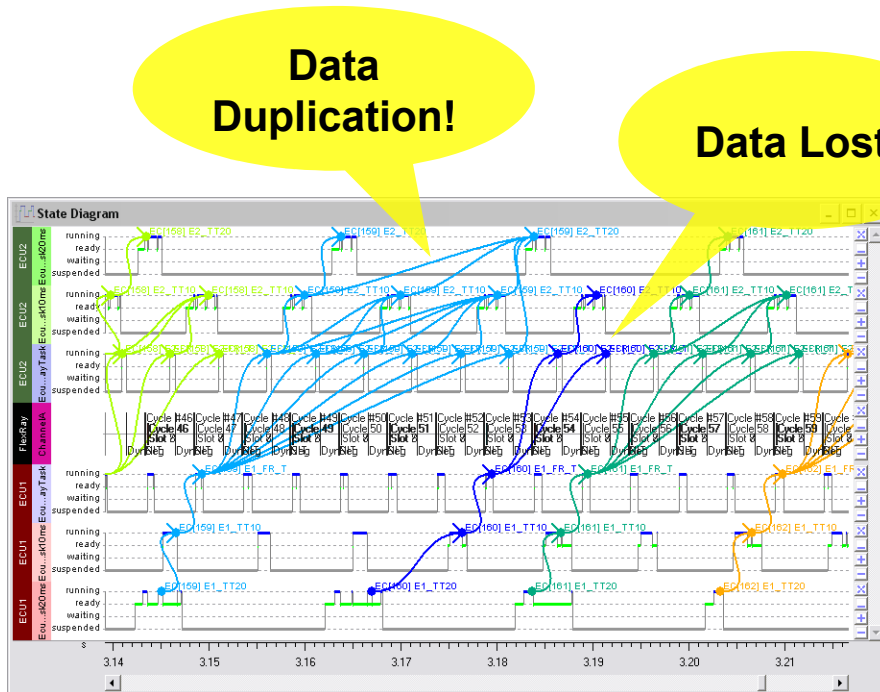


Testing Ecosystems: Timing-Modeling



INCHRON, an IBM Business Partner, offers test tools for model based **real-time** simulation, **chronSIM**, and analysis/validation, **chronVAL**.

The INCHRON Tool Suite is integrated with IBM Rational products, such as **Rhapsody**, **DOORS**, **Rational Team Concert**, **Rational Quality Manager**.



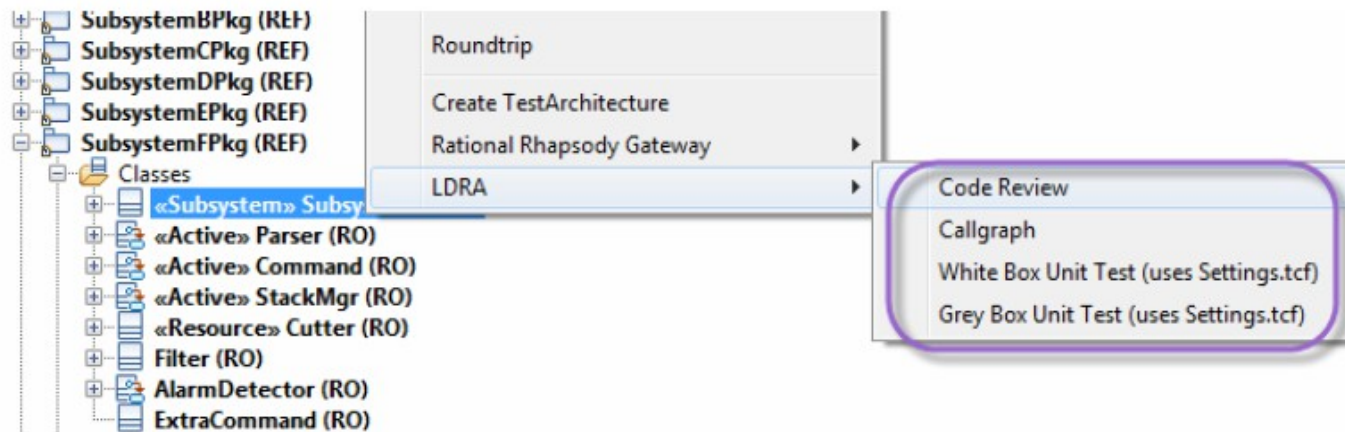
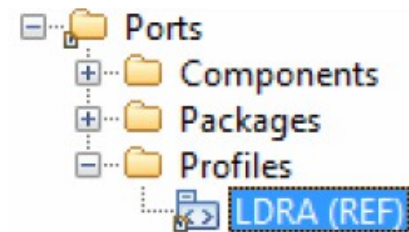
Testing Ecosystems: LDRA



LDRA offers automated analysis and testing tools for safety-critical software to ensure adherence to compliance to standards (i.e. MISRA-C, MISRA-C++, JSF++).

The LDRA Tools Suite for C/C++ provides a **Rhapsody plugin**:

- To instrument all the files generated by a Rhapsody configuration for Static and Dynamic Analysis
- To Analyze a single file and perform Unit Testing on it



An Example: Invensys Rail Dimetric

Speeds innovation with a unified platform for multi-stage development processes



The need:

- Modernize development processes
- Ensure systems integration with other railways while meeting railway standards

The solution:

- Incorporated system intelligence into its development process
- Deployed an application development platform to:
 - Model system reliability
 - Highlight areas requiring improvement

The benefits:

- ✓ Reduced time-to-market for signaling systems products by 40%
- ✓ Facilitated 100% compliance rate with ERTMS standards for code traceability and safety
- ✓ Reduced cost and risks of development and documentation

“Innovation and process flexibility are important in allowing us to differentiate our offerings. We’re now able to ensure that our design can be rapidly adapted, not only to customer needs, but to changing ERTMS requirements, at a reasonable cost.”

Francisco Lozano
ERTMS Program Manager



Solution components:

- IBM® Rational® Rhapsody
- IBM Rational DOORS
- IBM Rational Synergy
- IBM Rational Change
- IBM Rational Publishing Engine
- IBM Software Services

An Example: Tata Consultancy Services Limited

Improving time-to-market with IBM Rational Rhapsody



The need:

- Achieve high-quality design/code
- Speed-up development and variants

The solution:

- Improved software development process by incorporating both MBDA (SysML) and MDD (UML) for embedded real-time:
 - Systems Engineering
 - Software Development
 - Software Testing

The benefits:

- ✓ Extracted 60% of a new design from reverse engineering of existing software
- ✓ Reduced 50% learning curve for new staff members
- ✓ Eliminated 90% of design errors with model simulation

“We used IBM Rational Rhapsody to aid and succeed in the model-driven development (MDD) methodology for the key product development of our customers. Behavioral modeling in Rhapsody is very powerful and we used it extensively to test our design and generate high-quality code.”

Rampura Venkatachar Raman

Head – EIS Semiconductor & Consumer Electronics Vertical, Tata Consultancy Services



Solution components:

- IBM® Rational® Rhapsody

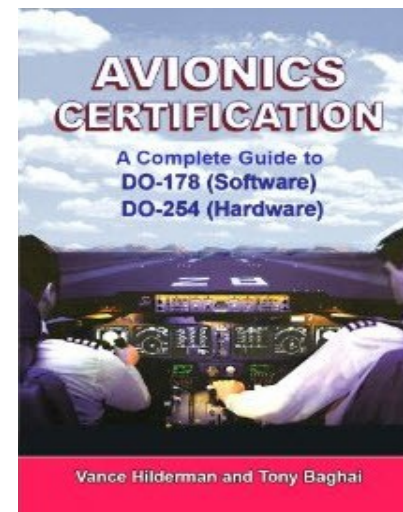
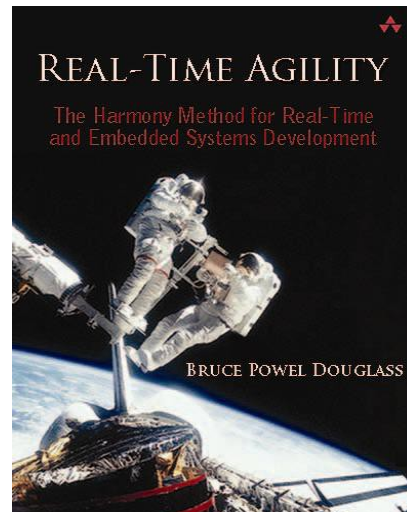
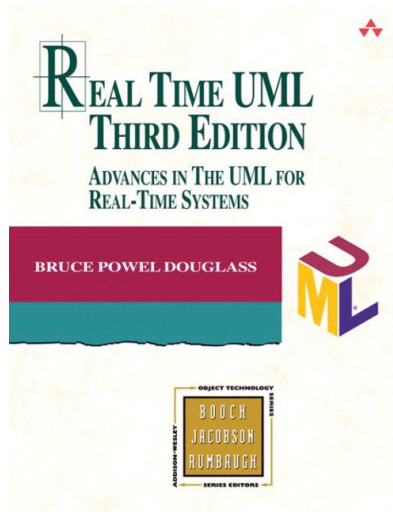
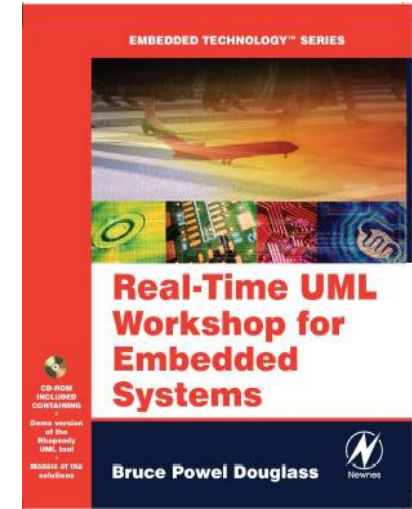
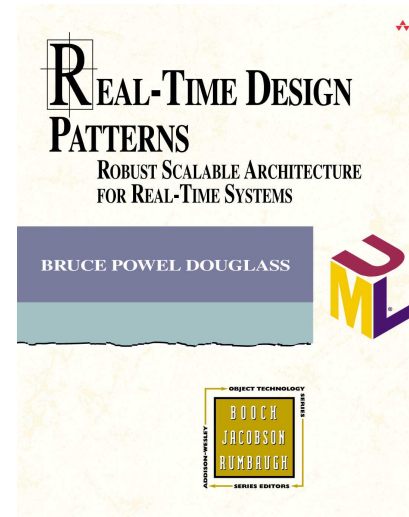
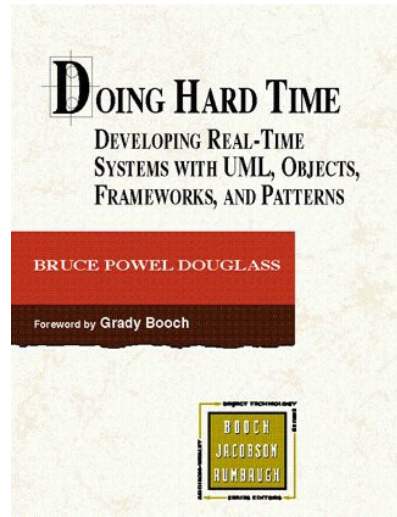
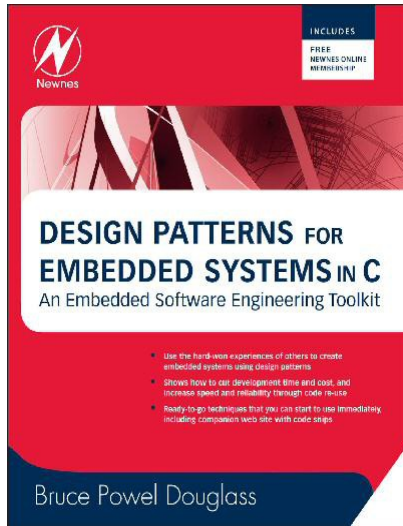
Summary

- **Safety Critical** software development is hard and expensive
- **Model-Driven Development** brings better quality and
- The **IBM Rational Solutions for Systems and Software Engineering** enables you focusing on what really matters and reduce the certification effort.



<http://www-01.ibm.com/software/rational/workbench/systems/>

Some References





www.ibm.com/software/rational

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C++ for Safety Critical Systems: JSF++

- Lockheed Martin decided to adopt C++ for the Joint Strike Fighter (F-35) Project
- **Bjarne Stroustrup** has been asked to define a C++ Safe Coding Standard
 - ▶ “C++ can provide a **safer** subset of a C superset”
- JSF++ AV (Air Vehicle) Coding Standard has formally released on 2005
- MISRA-C++ has been released on 2008

