IBM Software Group

Model-Based Ada Development for DO-178C Projects and Agile Methods

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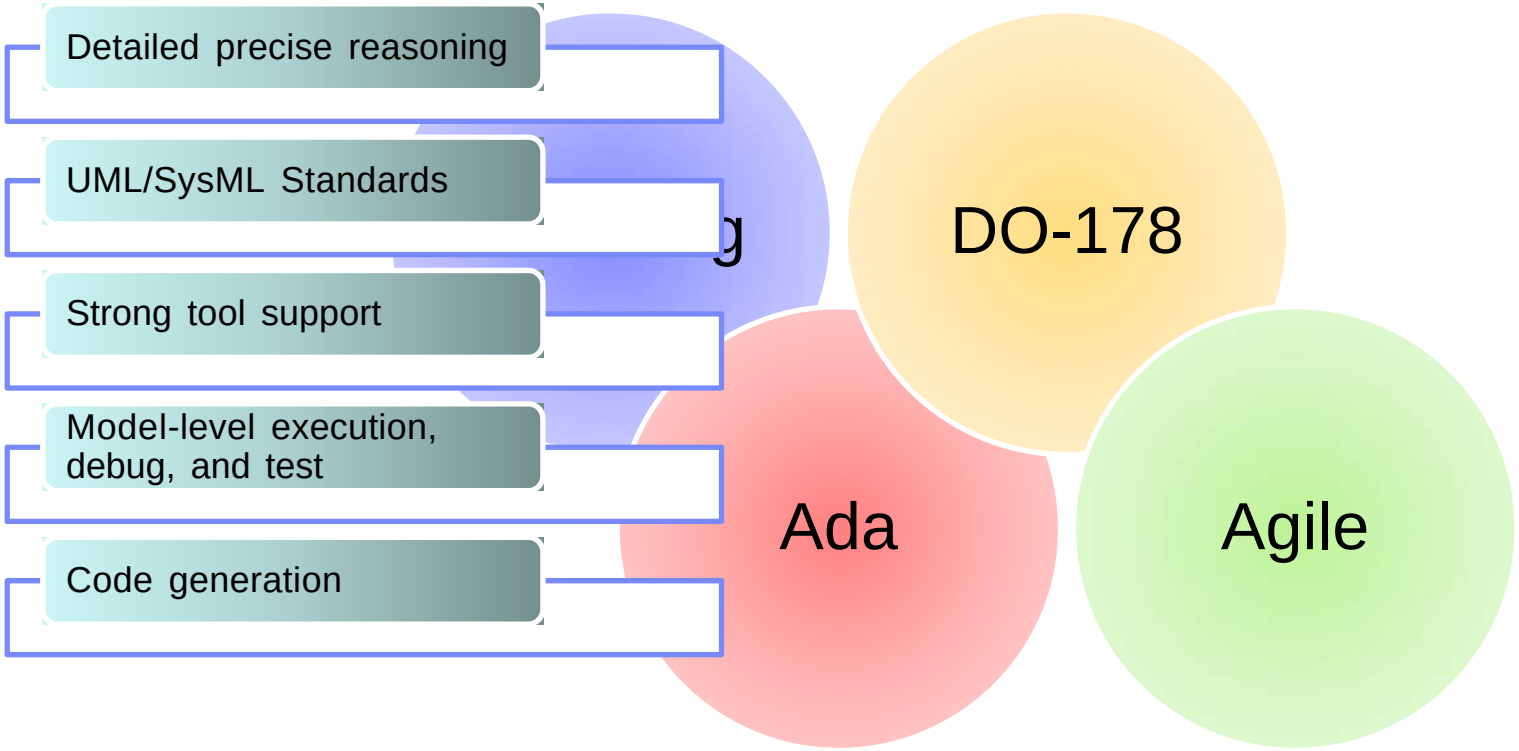
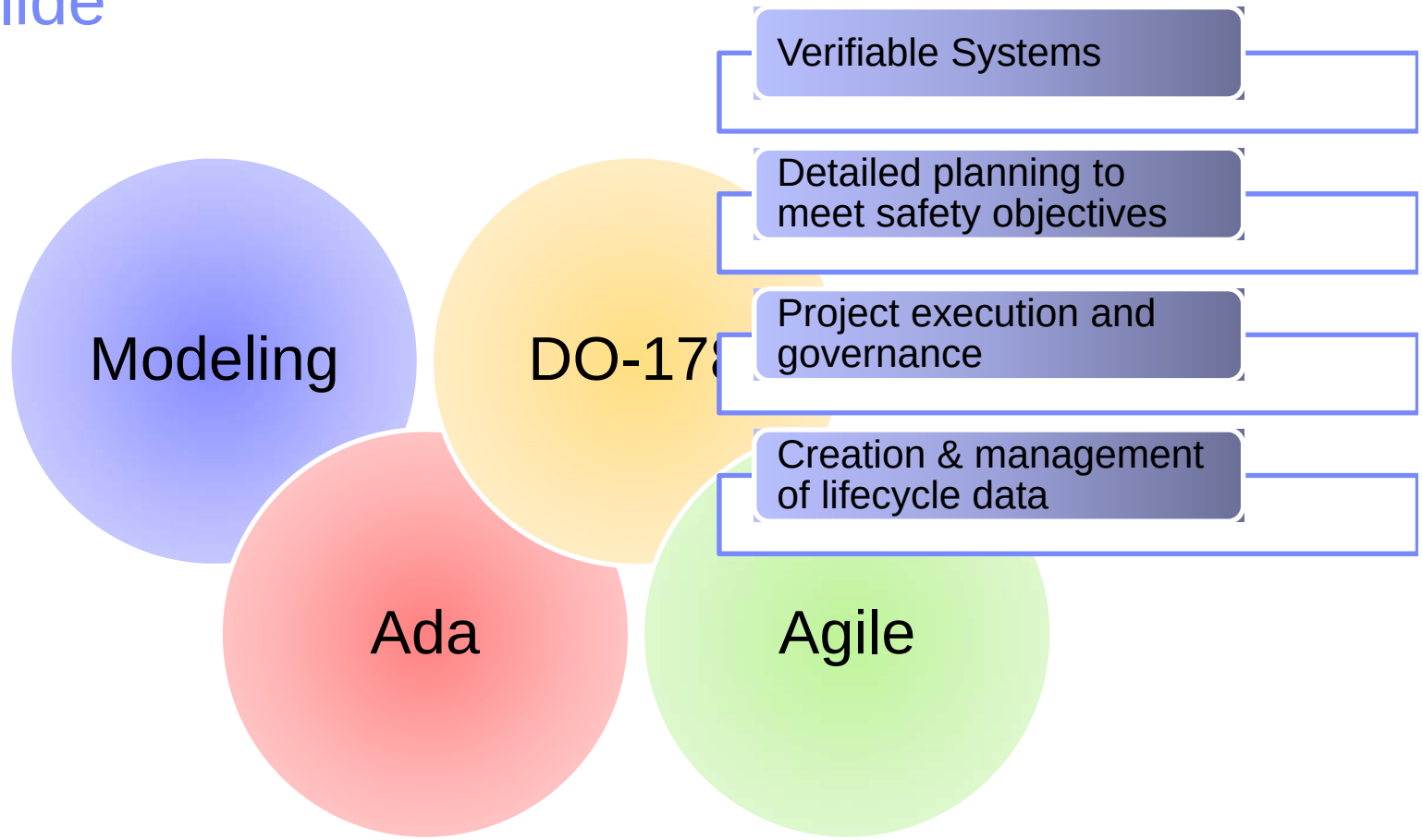
Rational. software

Worlds Collide



Worlds Collide



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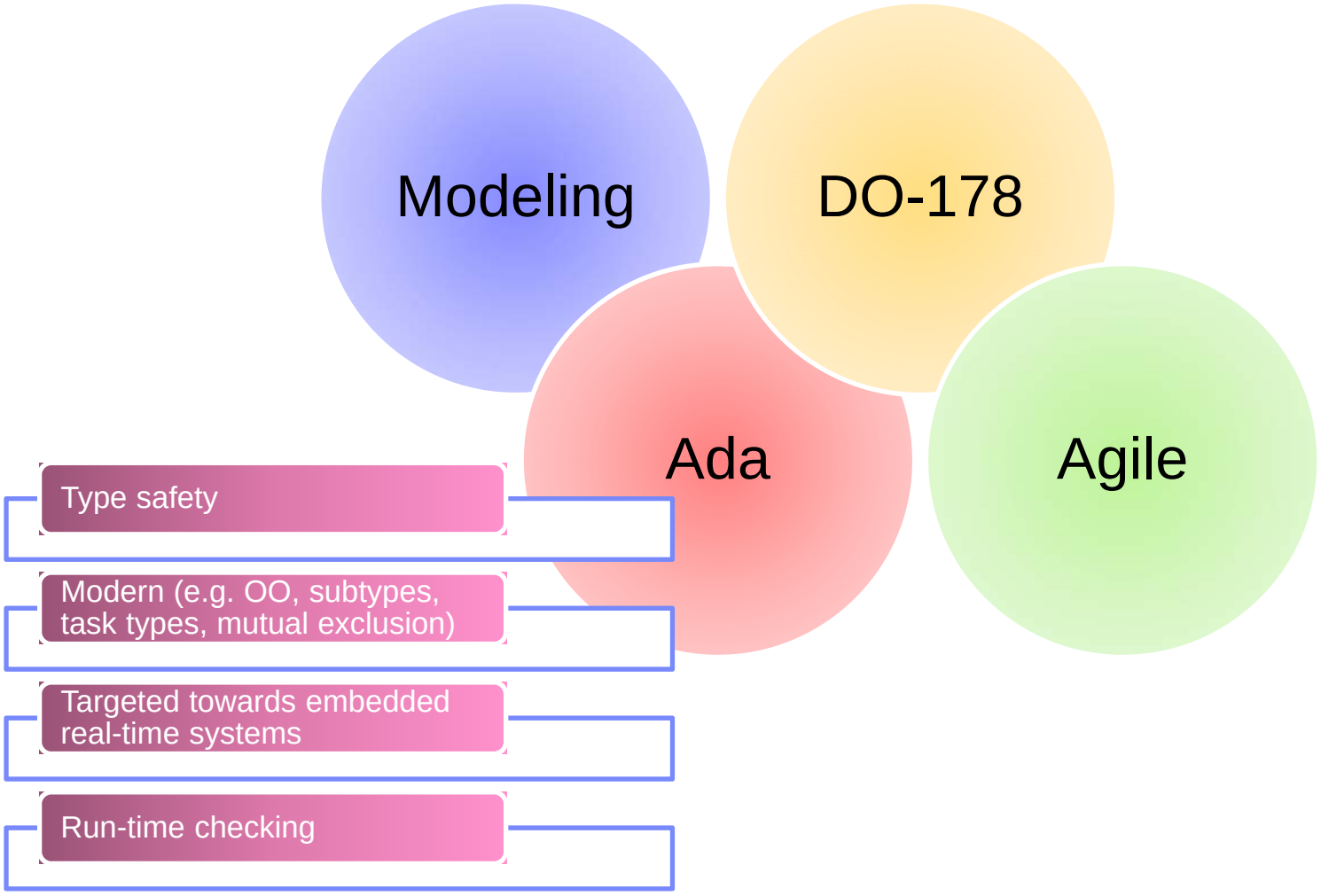
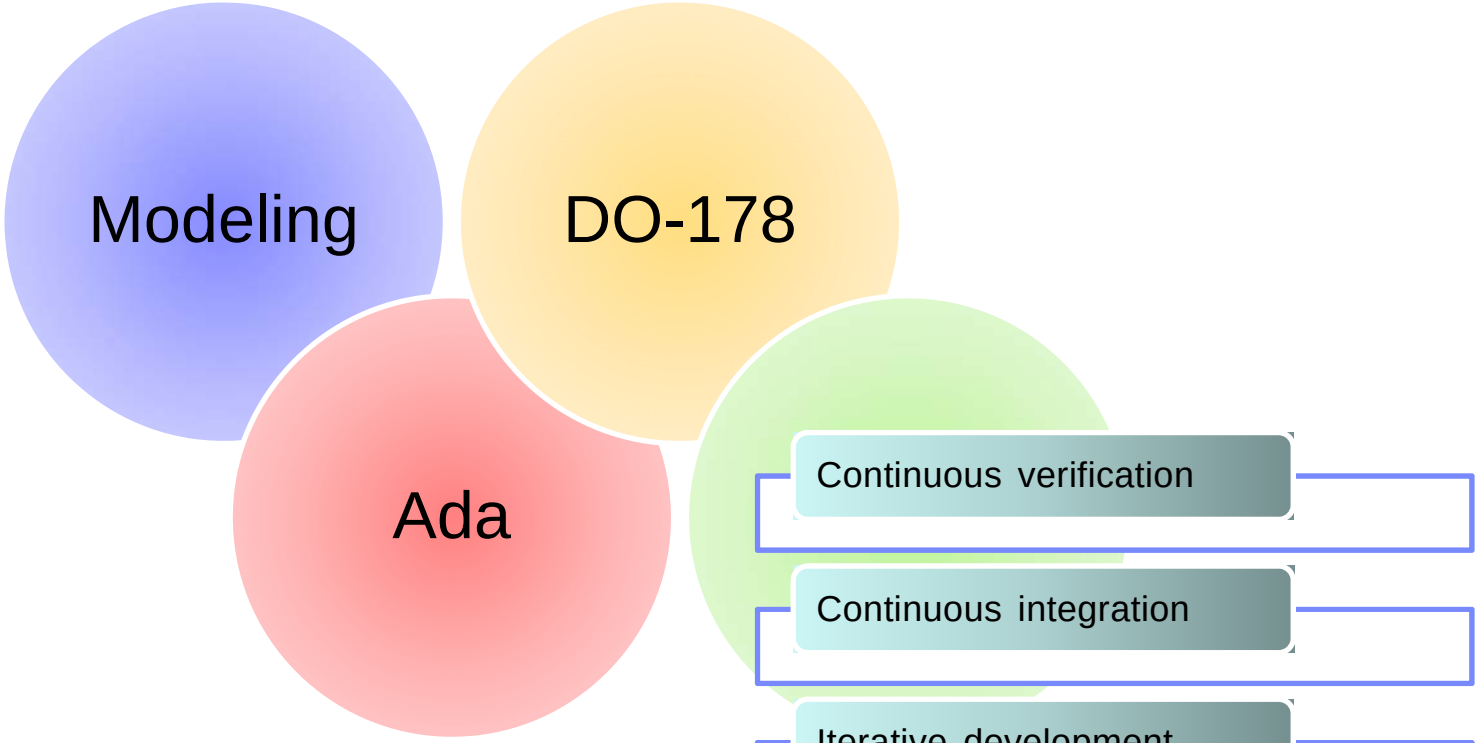
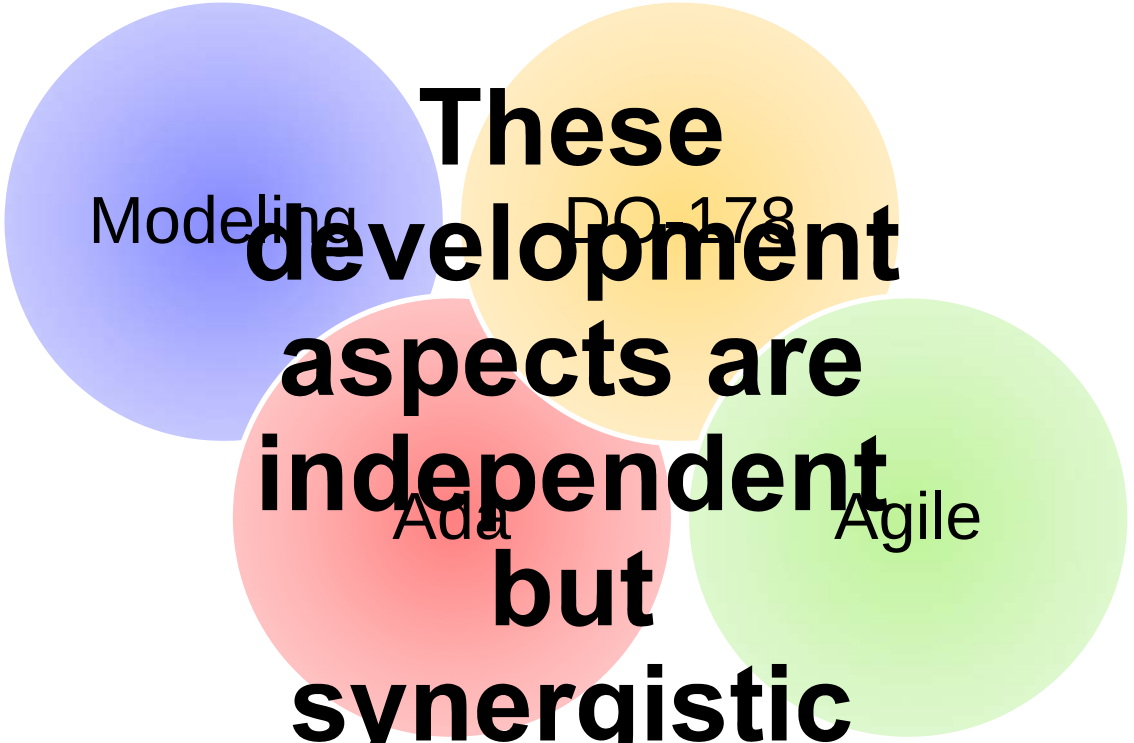


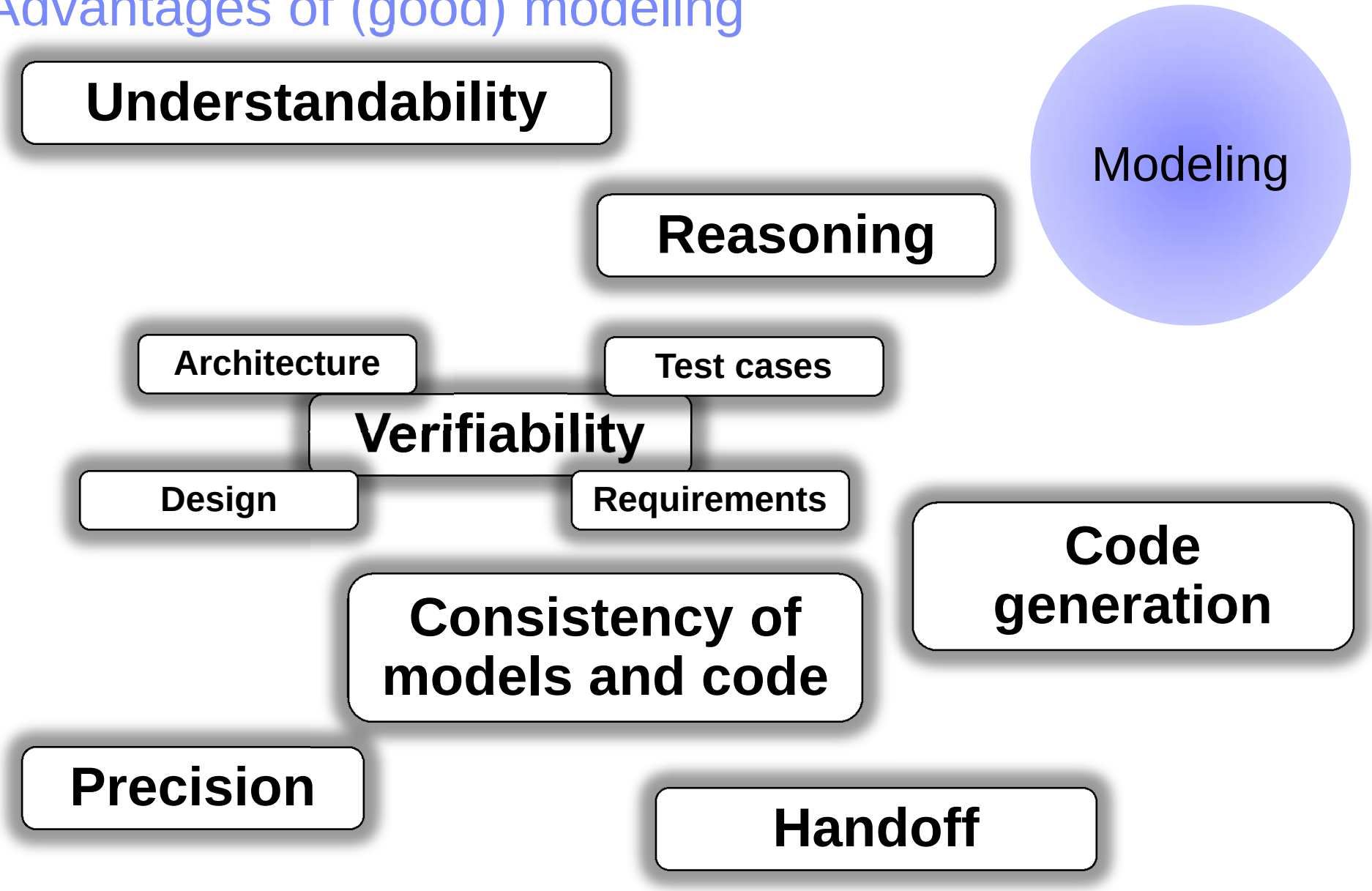
Worlds Collide



Just to be clear …

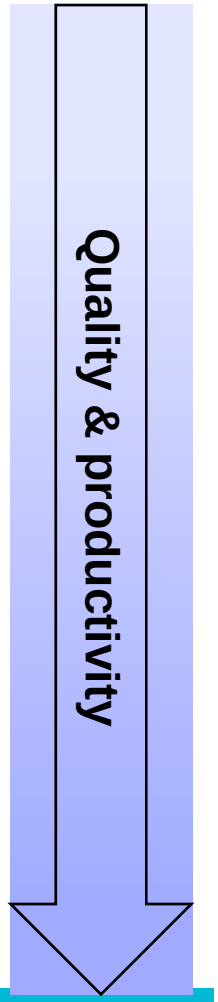


Advantages of (good) modeling

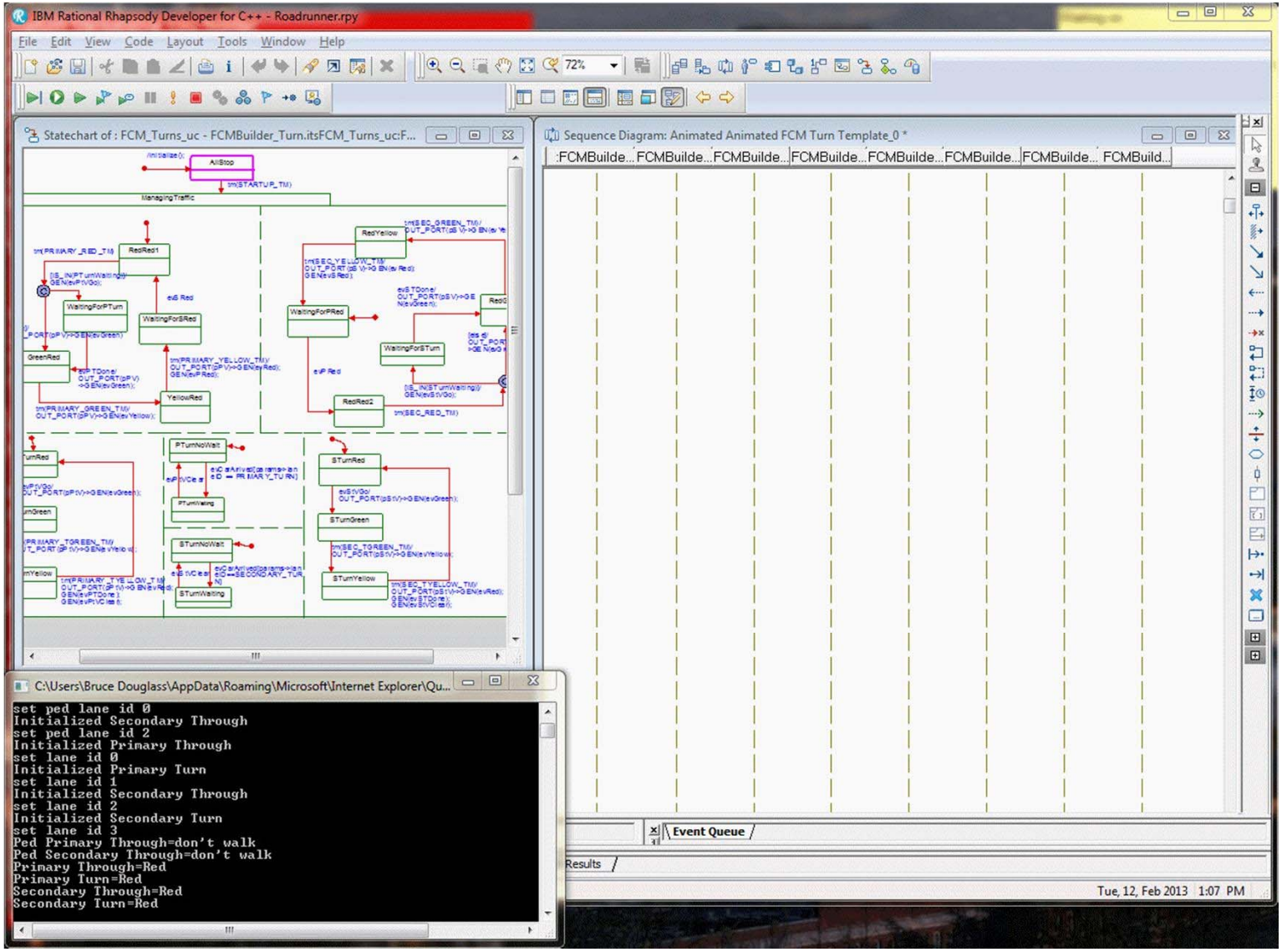


UML Maturity Model Index (UMMI)

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

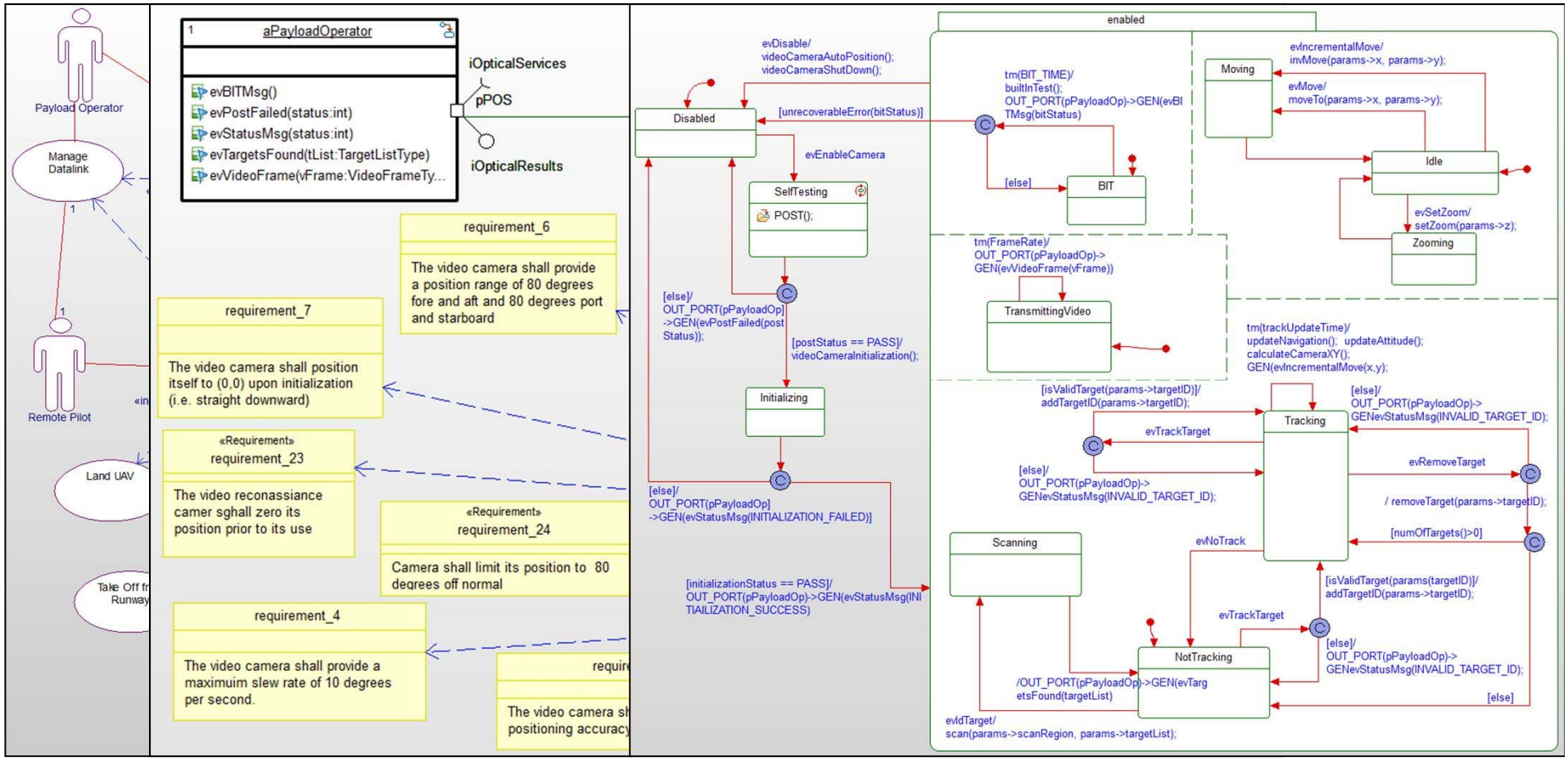


Model Execution



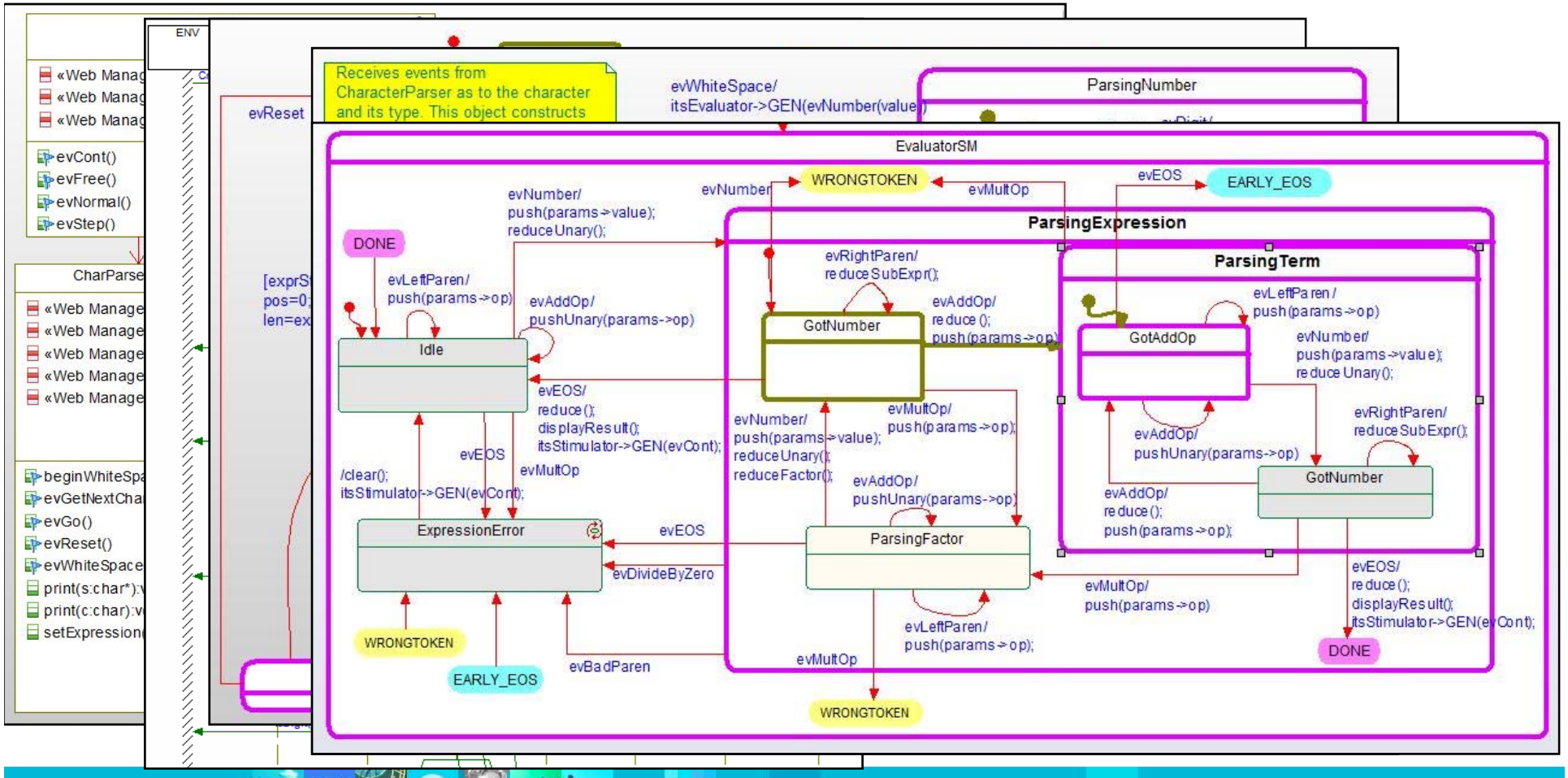
Model Execution supports *Model-Based Verification*

- Requirements Models
  - Requirements specify a systems input-output control and data transformations

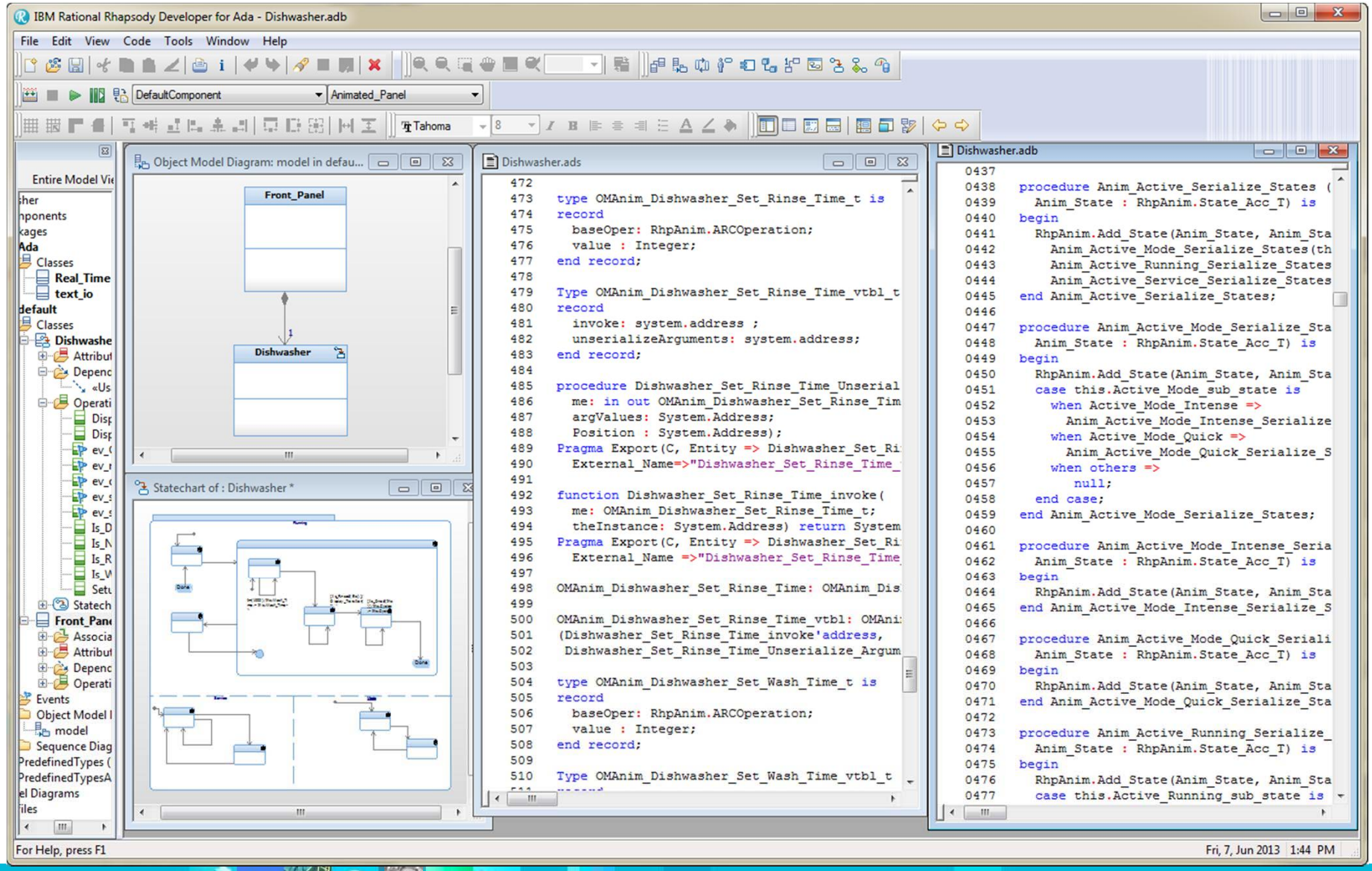


Model Execution supports *Model-Based Verification*

- Design Models
  - Design specifies the (internal) structural elements and their behavior for implementation



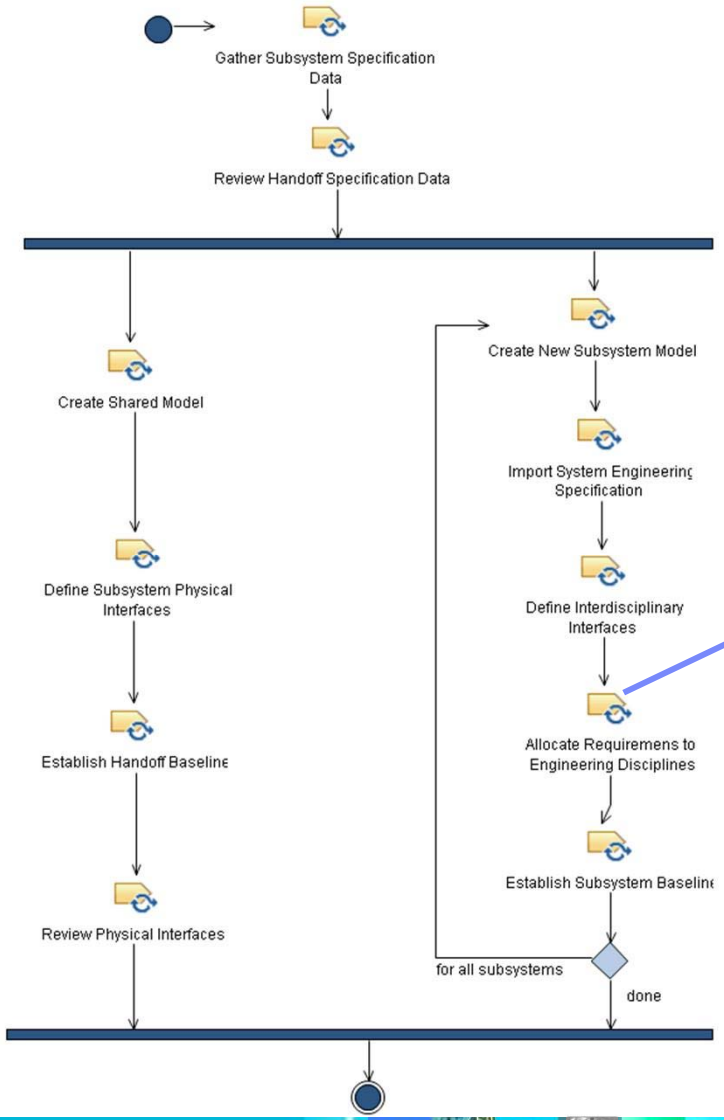
Code Generation from Design Models



Specifications & Models handed off to software from SE

- Any system specification or design model handed off to software should contain
  - Requirements from which model was developed
  - Model configuration items (CIs) (files or data representing the model)
  - Modeling standards describing the modeling techniques
  - Model element libraries
  - Model and system interfaces description
  - Configuration index of model CIs
  - Modeling development environment and user's manuals
  - Any data from V&V activities performed as system level the may be used to satisfy verification objectives

Model-Based Hand-off to Downstream Engineering



Task: Allocate Requiremens to Engineering Disciplines

This task takes the requirements allocated to a subsystem as a whole and allocates them to the different engineering disciplines inolved (e.g. software, electronics, mechanical, optical, hydraulic).

Expand All Sections | Collapse All Sections

Purpose

The purpose is to clearly delinate the required contributions of different engineering disciplines to the engineering development of a subsystem by allocating the requirements allocated to the subsystem by the system engineering team.

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Relationships

Roles	Primary Performer: • Control Engineer • Developer • Electrical Engineer • Mechanical Engineer • Miscellaneous Engineer	Additional Performers: • Architect • Reliability Czar • Safety Czar
Inputs	Mandatory: • Requirements Traceability • Subsystem Model • Systems Requirements Specification	Optional: • Failure Modes and Effect Analysis • Fault-Tree Analysis • Hazard Analysis
Outputs	• Requirements Traceability • Subsystem Requirements Specification	
Process Usage	• handoff_cp > Allocate Requiremens to Engineering Disciplines	

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Main Description

A subsystem team is usually comprised of engineers within different disciplines, such as software, digital electronics, analog electronics, hydraulic, pneumatic, control, and mechanical. Once the subsystem specification is handed off, certain of the requirements will belong to one discipline or the other. Other requirements will require decomposition into derived requirements, allocating portions of a subsystem-level requirement to different discipline. This is particularly true of quality-of service requirements.

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Steps

Expand All Steps | Collapse All Steps

- Review subsystem requirements
- Allocate single-discipline requirements
- Decompose multi-discipline requirements
- Allocate derived requirements
- Update traceability record
- Review allocations

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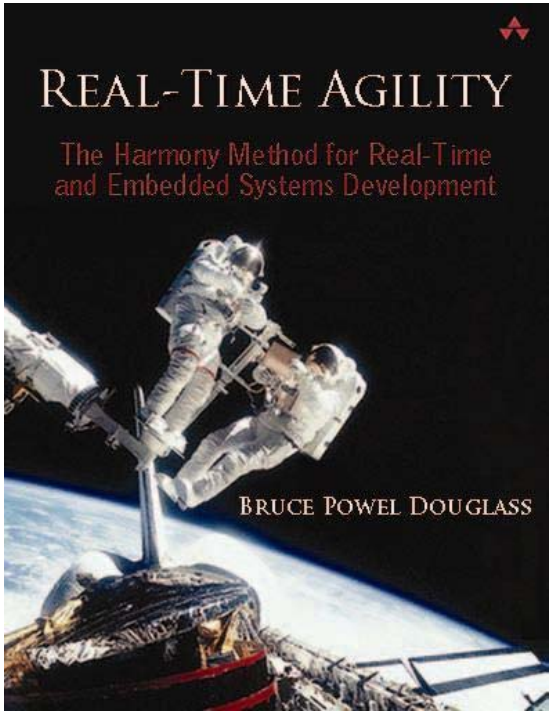
Agile for Embedded Real-Time Systems

- Embedded is *different* than IT
  - More constrained
  - Often safety-critical
  - HW/SW co-design
  - Handed off to manufacturing not end users
  - More difficult to test
  - Far more difficult to update in the field
- Harmony process applied agile methods to embedded
  - Iteration-centric model-based development
  - Includes practices for
    - Test Driven Development
    - High-fidelity modeling
    - Continuous integration
    - Dynamic planning
    - Quality assurance
    - Continuous safety/reliability/security assessment

Agile



Rational. Method Composer

Search this Site:

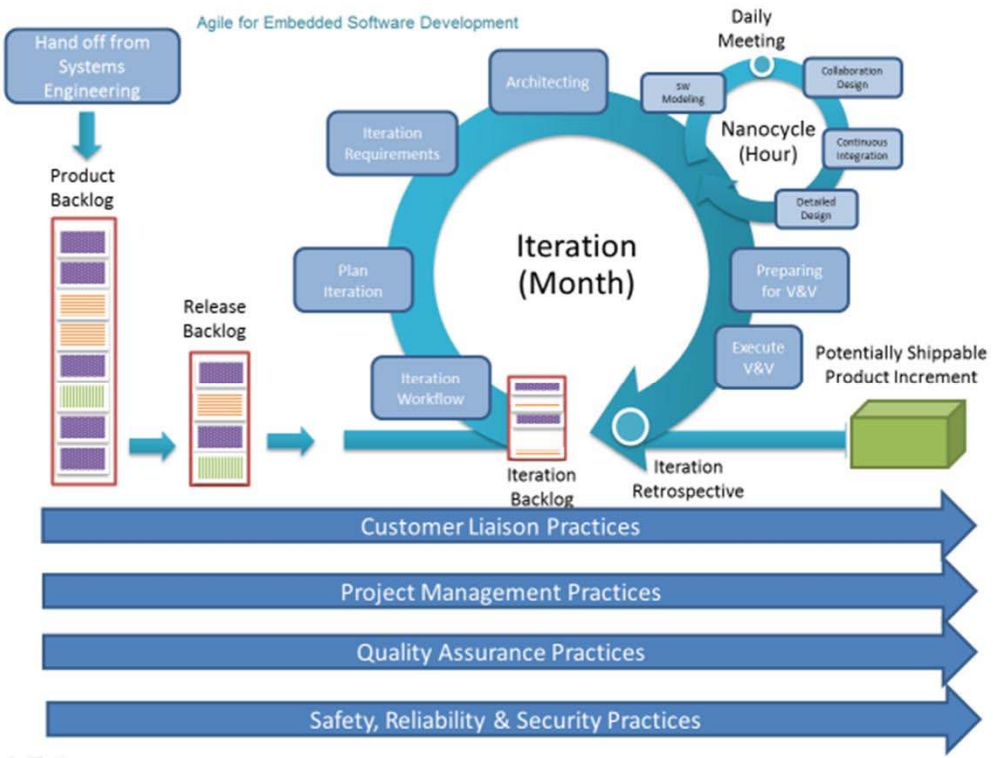
Agile for ESW

- Welcome to Harmony/Agile for Embedded Software Development
- Getting Started
- Delivery Processes
  - Harmony/Agile for Embedded Software Development
    - Handoff for Downstream Engineering
    - Define and Deploy the Development Environment
    - Develop Initial Requirements
    - Development Iteration
    - Configuration Management
    - Control Project
    - Manage Change
    - QA Audit
    - Pre-Iteration Planning
  - Development Iteration
    - Use Case / User Story Analysis
    - Plan Iteration
    - High-Fidelity Modeling
    - Architectural Design - RT
    - Collaboration Design - RT
    - Detailed Design - RT
    - Continuous Integration
    - Prepare for Verification and Validation
    - Verification and Validation
    - Guidance
- Supporting Workflows
- ESW Agile Practices
- Tools

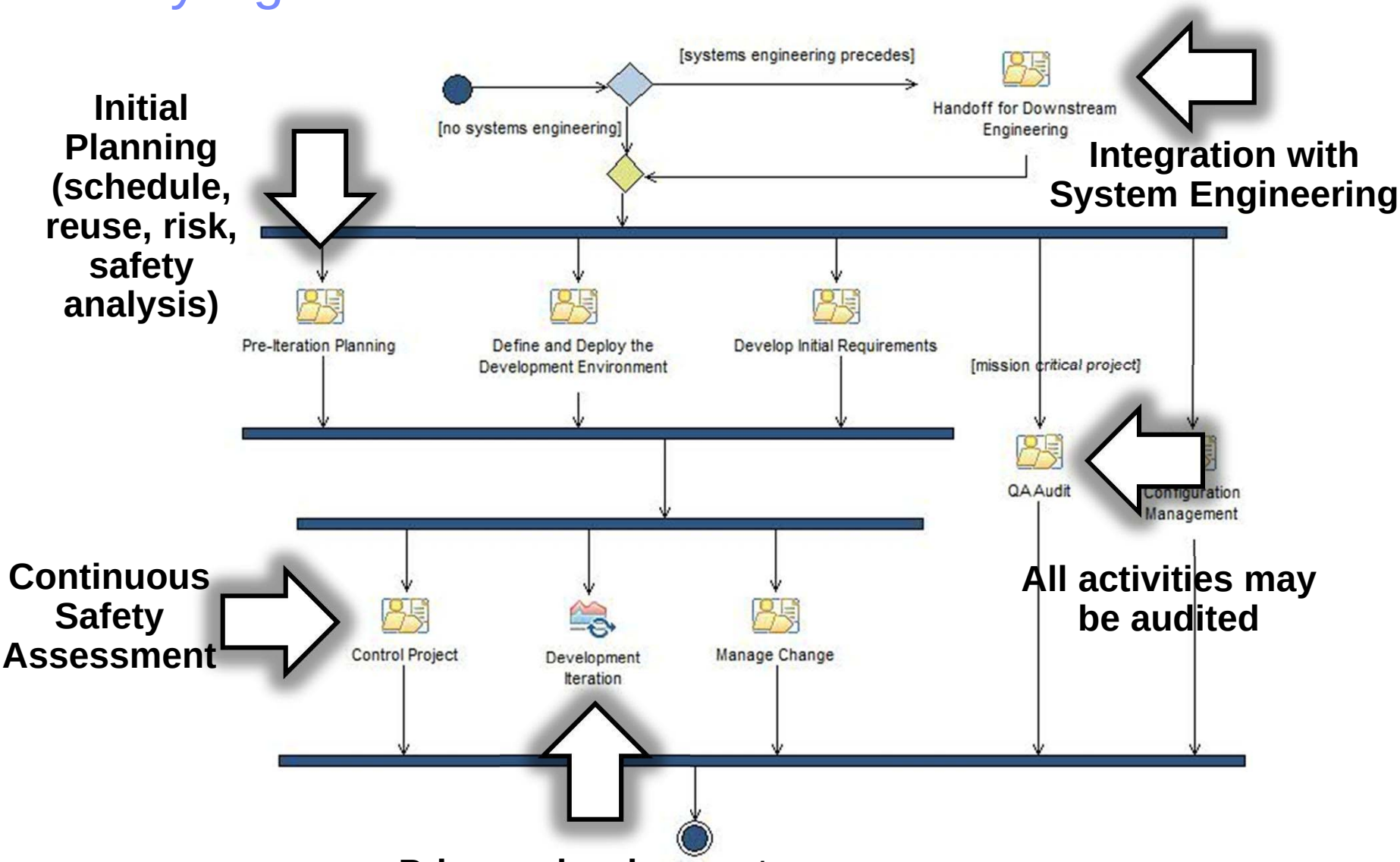
Welcome to Harmony/Agile for Embedded Software Development

Welcome to Harmony/Agile for Embedded Software Development

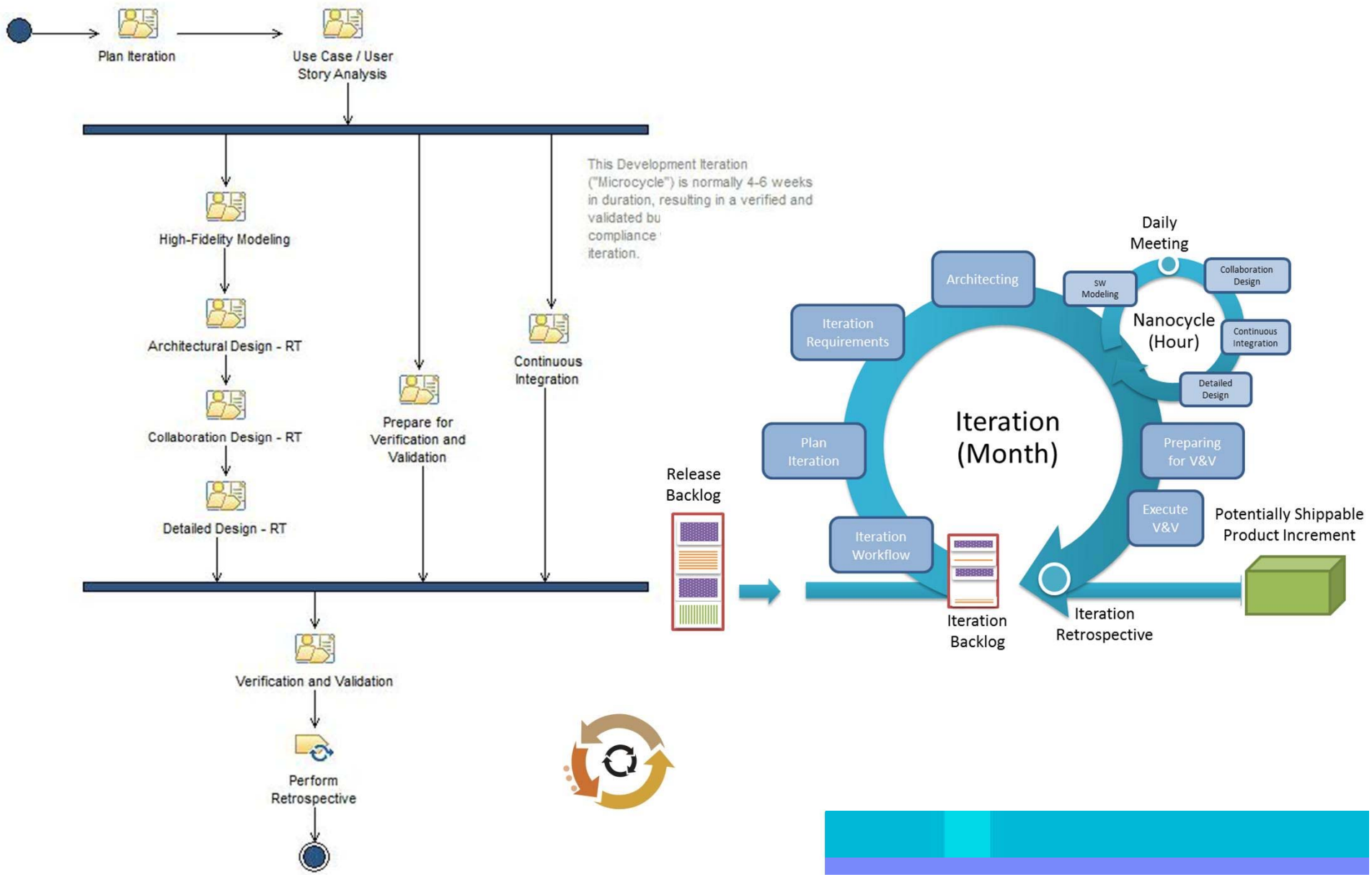
Main Description



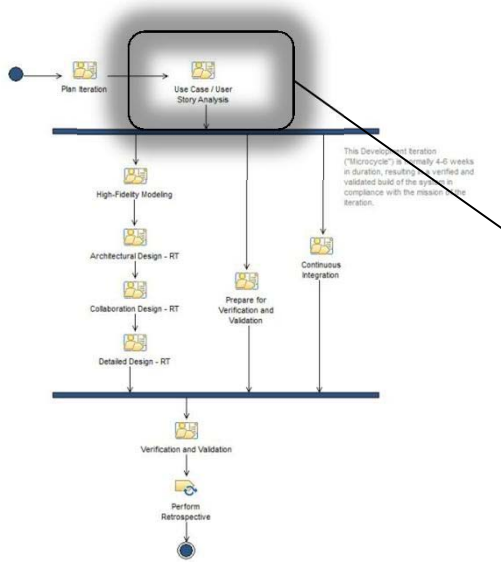
Harmony Agile Overview

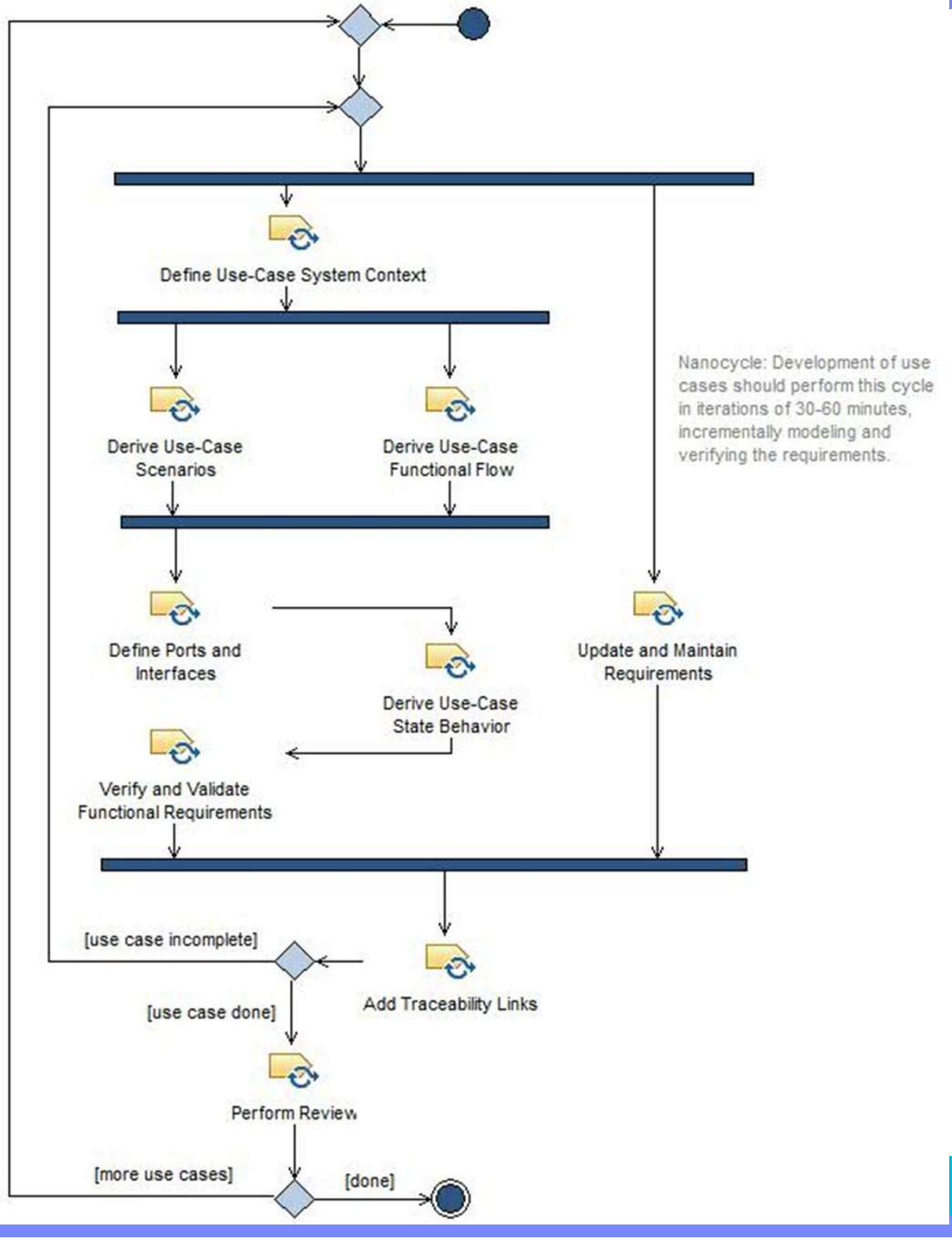


Incremental Development with Harmony

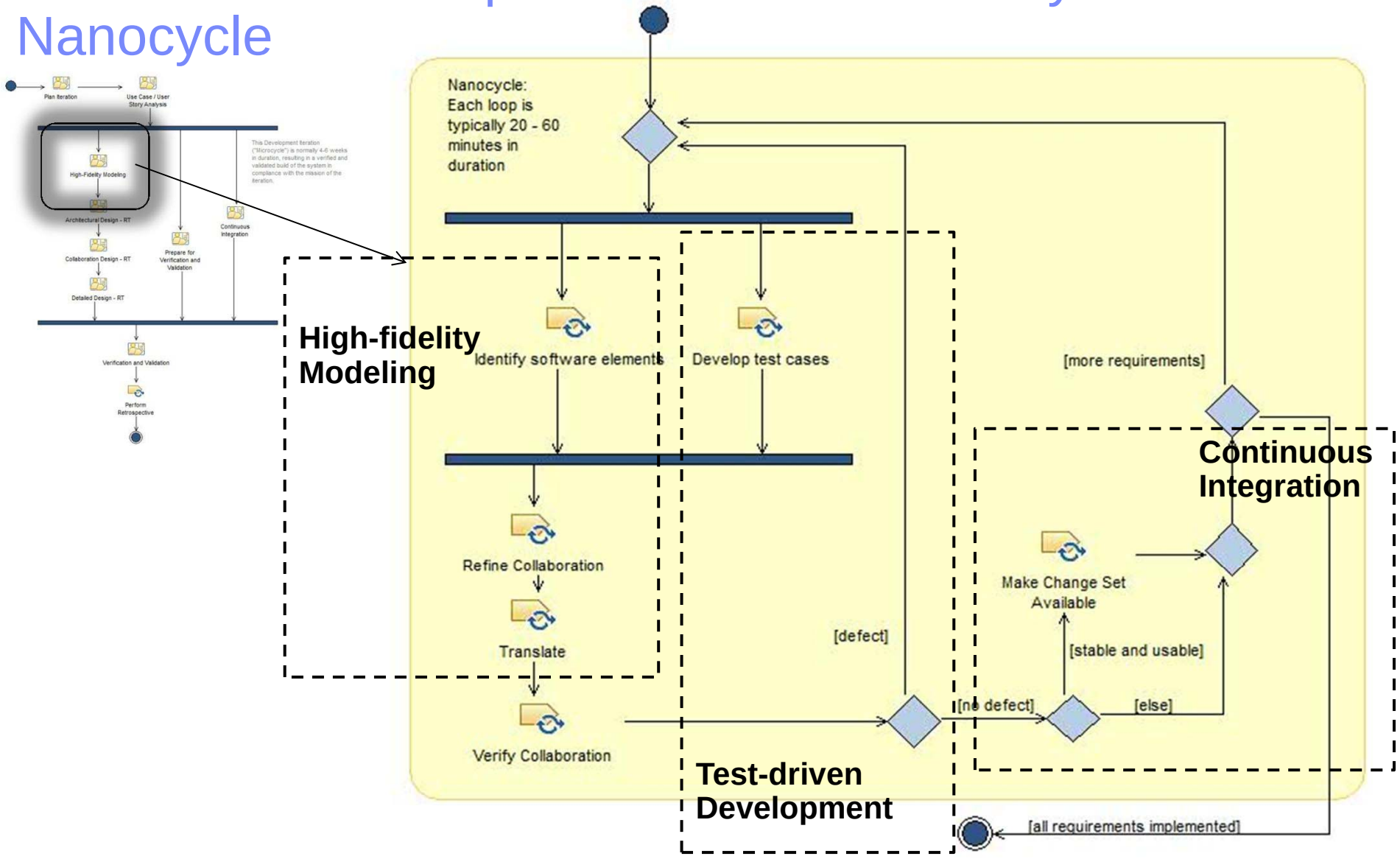


Incremental Use Case Analysis

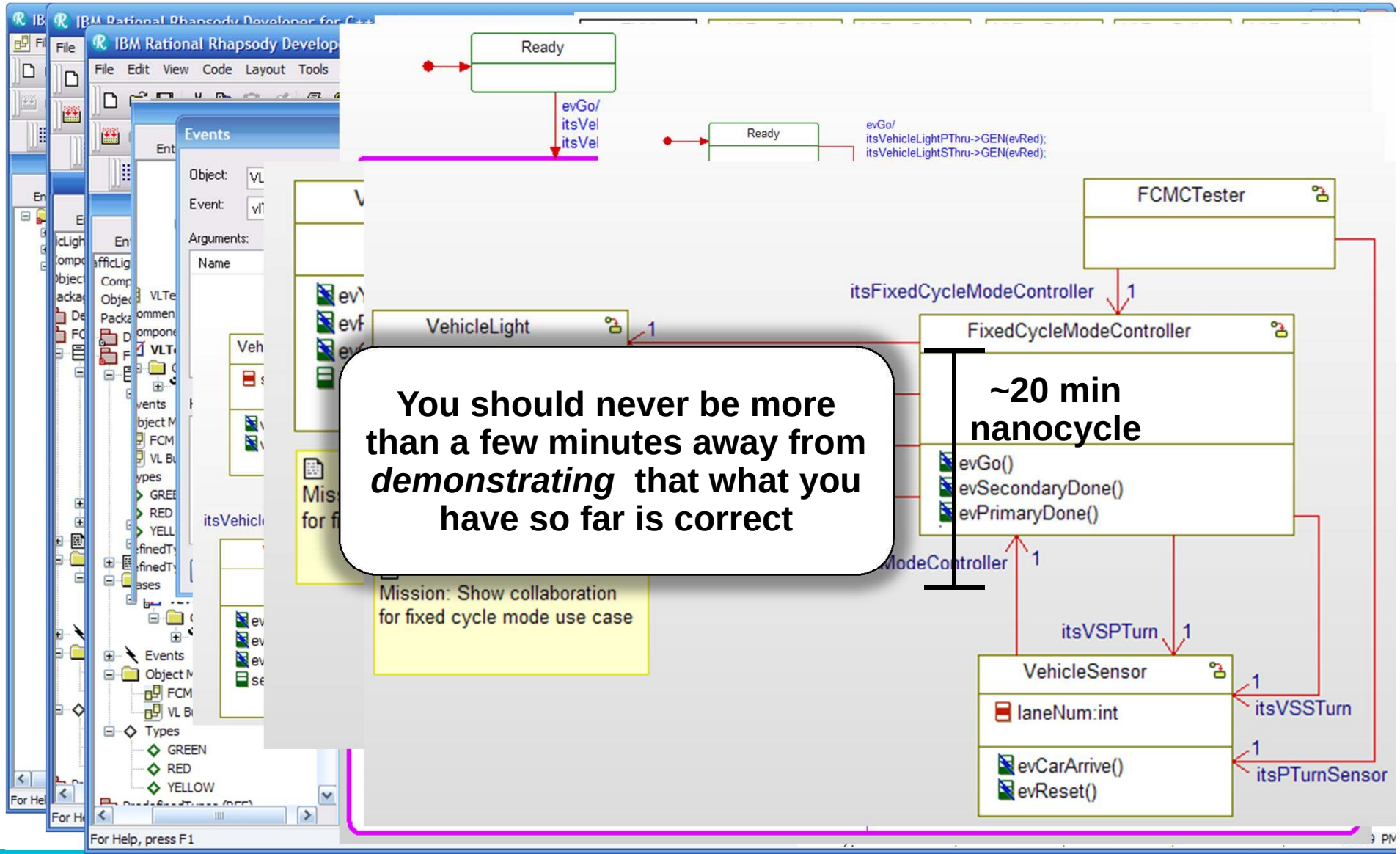




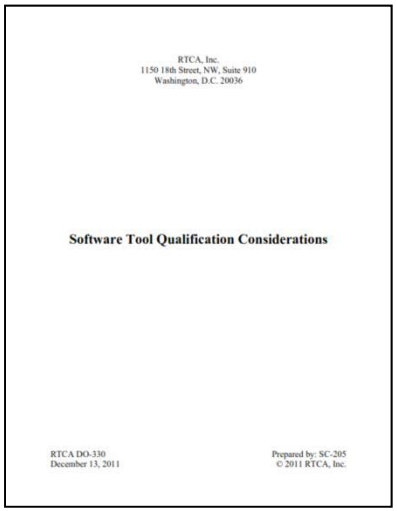
Test Driven Development and the Harmony Nanocycle



Model-Based TDD in Action



DO-331 Model Based Design Supplement to DO-178C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Software Tool Qualification Considerations

RTCA DO-330
December 13, 2011

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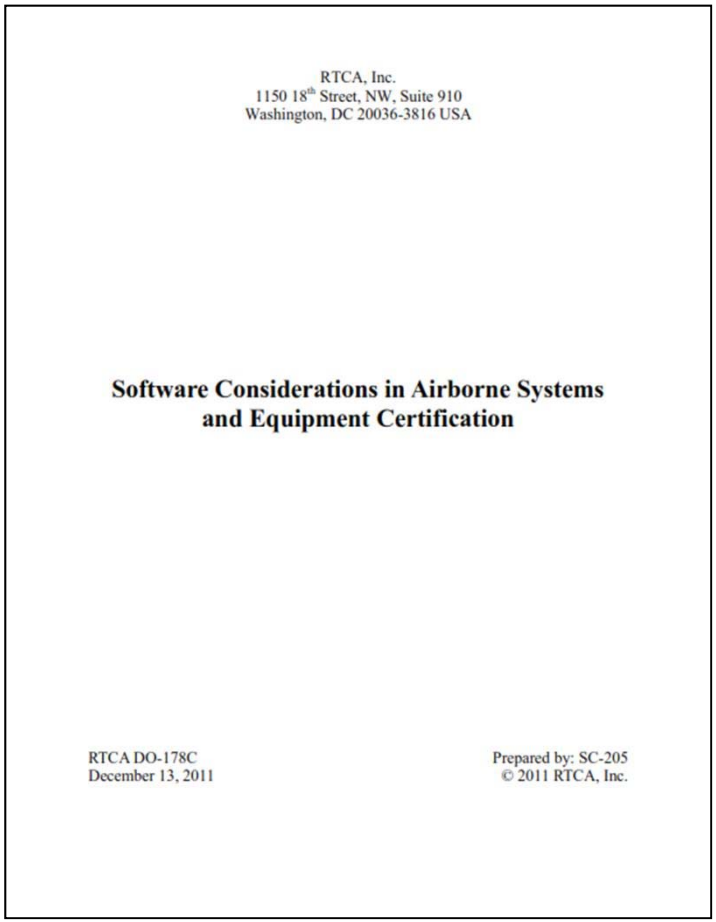
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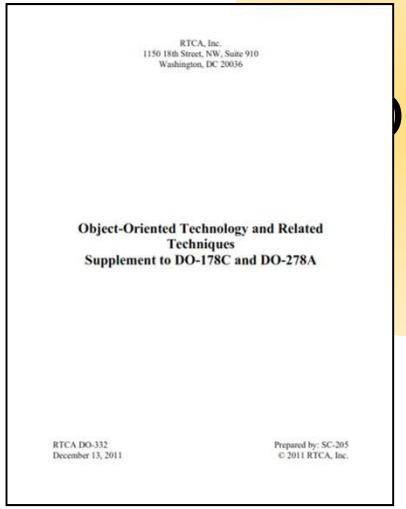
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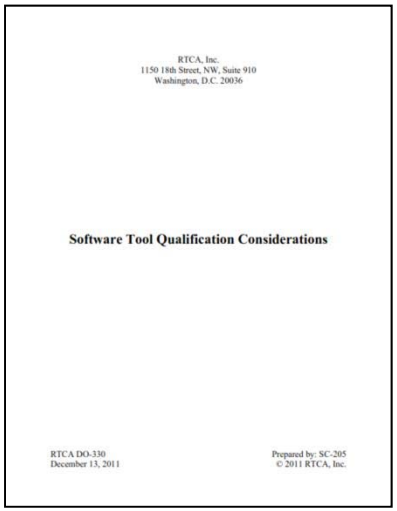
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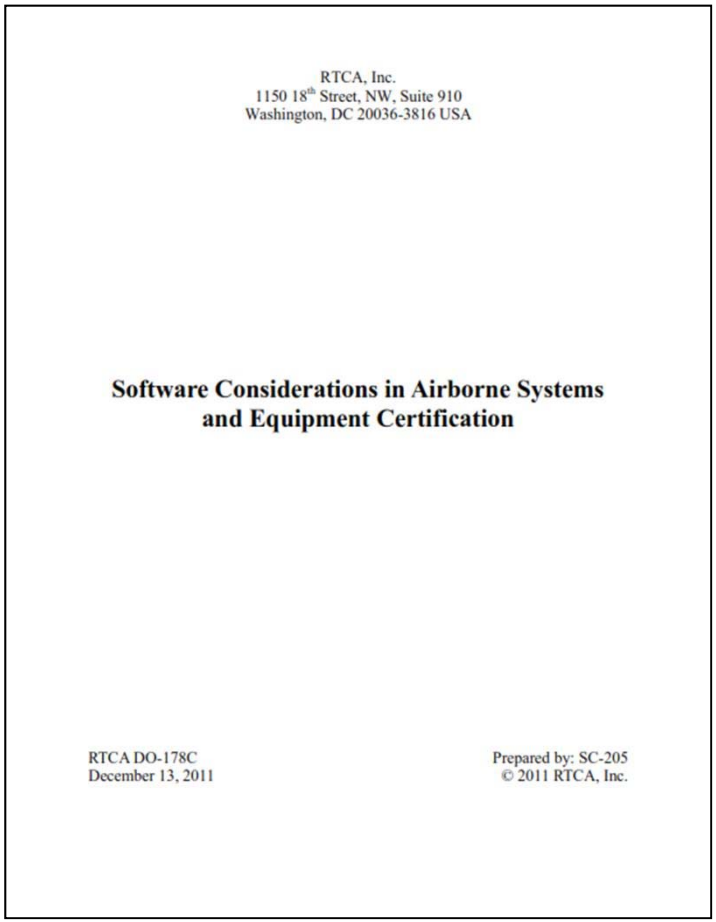
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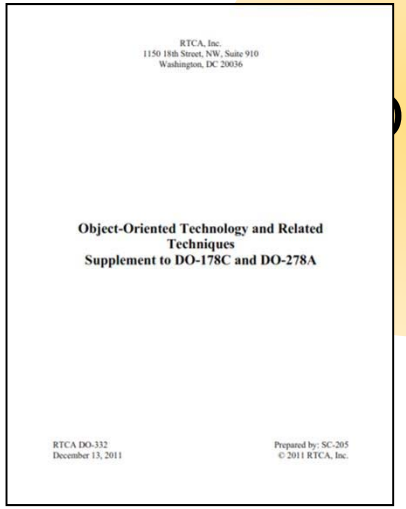
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DO-331

- Clarifies the use of modeling in DO-178 projects
- 83 objectives total
- 12 entirely new objectives
- Identifies
  - Specification Models
  - Design Models
  - Need for identification of normative and non-normative elements
  - Guidance for use of models in DO-1788 projects

Table MB.C-1 Software Planning Process

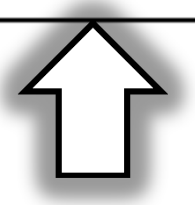
	Objective		Activity	Applicability by Assurance Level					Output		Control Category by Assurance Level				
	Description	Ref	Ref	AL 1	AL 2	AL 3	AL 4	AL 5	Data Item	Ref	AL 1	AL 2	AL 3	AL 4	AL 5
1	*The activities of the software life cycle processes are defined.*	MB.4.1.a	MB.4.2.a MB.4.2.c MB.4.2.d MB.4.2.e MB.4.2.g MB.4.2.i MB.4.2.l MB.4.2.m MB.4.2.n MB.4.2.o MB.4.3.c	❍	❍	❍	❍	❍	*PSAA* *SDP* *SVP* *SCM Plan* *SQA Plan*	MB.11.1 MB.11.2 MB.11.3 MB.11.4 *11.5*	① ① ① ① ① ① ① ② ② ② ① ① ② ② ② ① ① ② ② ② ① ① ② ② ②				
2	*The software life cycle(s), including the inter-relationships between the processes, their sequencing, feedback mechanisms, and transition criteria, is defined.*	MB.4.1.b	MB.4.2.i MB.4.3.b	❍	❍	❍	❍		*PSAA* *SDP* *SVP* *SCM Plan* *SQA Plan*	MB.11.1 MB.11.2 MB.11.3 MB.11.4 *11.5*	① ① ① ① ① ① ② ② ① ① ② ② ① ① ② ② ① ① ② ②				
3	*Software life cycle environment is selected and defined.*	MB.4.1.c	*4.4.1* MB.4.4.2.a MB.4.4.2.b MB.4.4.2.c MB.4.4.3 MB.4.4.4	❍	❍	❍	❍		*PSAA* *SDP* *SVP* *SCM Plan* *SQA Plan*	MB.11.1 MB.11.2 MB.11.3 MB.11.4 *11.5*	① ① ① ① ① ① ② ② ① ① ② ② ① ① ② ② ① ① ② ②				
4	*Additional considerations are addressed.*	MB.4.1.d	MB.4.2.f MB.4.2.h MB.4.2.i MB.4.2.j MB.4.2.	❍	❍	❍	❍	❍	*PSAA* *SDP* *SVP* *SCM Plan* *SQA Plan*	MB.11.1 MB.11.2 MB.11.3 MB.11.4 *11.5*	① ① ① ① ① ① ① ② ② ② ① ① ② ② ② ① ① ② ② ② ① ① ② ② ②				
5	*Software development standards are defined.*	MB.4.1.e	MB.4.2.b MB.4.2.g MB.4.5	❍	❍	❍	❍		*SW Requirements Standards* *SW Design Standards* *SW Code Standards* SW Model Standards	*11.6* *11.7* *11.8* MB.11.23	① ① ② ② ① ① ② ② ① ① ② ② ① ① ② ②				
6	*Software plans comply with this document.*	MB.4.1.f	MB.4.3.a MB.4.6	❍	❍	❍	❍		*Software Verification Results*	MB.11.14	② ② ② ②				
7	*Development and revision of software plans are coordinated.*	MB.4.1.g	MB.4.2.g MB.4.6	❍	❍	❍	❍		*Software Verification Results*	MB.11.14	② ② ② ②				

Model Based Development and Verification

- Examples of some current industry practices using Model Based Development

Table MB.1-1 Model Usage Examples

Process that generates the life-cycle data	MB Example 1	MB Example 2	MB Example 3	MB Example 4 (See Note 1)	MB Example 5 (See Note 1)
System Requirement and System Design Processes	Requirements allocated to software	Requirements from which the Model is developed	Requirements from which the Model is developed	Requirements from which the Model is developed	Requirements from which the Model is developed
					Design Model
Software Requirement and Software Design Processes	Requirements from which the Model is developed	Specification Model (See Note 2)	Specification Model	Design Model	
	Design Model	Design Model	Textual description (See Note 3)		
Software Coding Process	Source Code	Source Code	Source Code	Source Code	Source Code



Source: RTCA D0-331

Bruce's recommendation

Model Based Development and Verification

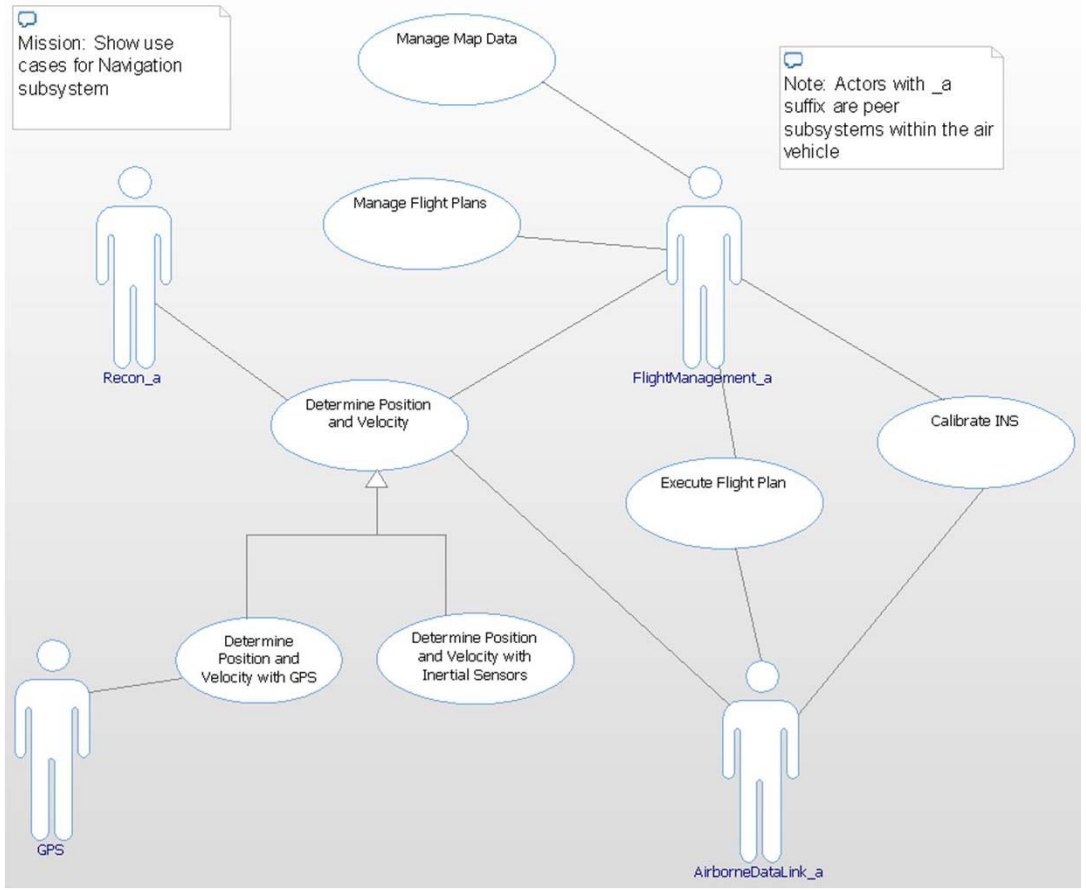
Model Simulation

- For Specification Models or Design Models, simulation may be used in combination with reviews and analysis of requirements and architecture to satisfy some objectives of sections MB.6.3.1, MB.6.3.2, and MB.6.3.3.
- Goal is to provide repeatable evidence that the model complies with its requirements
- Cannot help meet objectives of compatibility with target computer, traceability, conformance to standards, or partitioning integrity.
- Can help satisfy:

Objectives (Compliance to:)	
System Requirements for Specification Models	MB.6.3.1.a
SW HLR for Design Models	MB.6.3.2.a, MB.6.3.2.a
HLR/LLR Accuracy and consistency	MB.6.3.1.b, MB.6.3.2.b
HLR/LLR Verifiability	MB.6.3.1.d and MB.6.3.2.d
Algorithm aspects	MB.6.3.1.g, MB.6.3.2.g
Consistency & Verifiability of SW Architecture	(may provide) MB.6.3.3.b, MB.6.3.3.d

DO-331 Specification Models

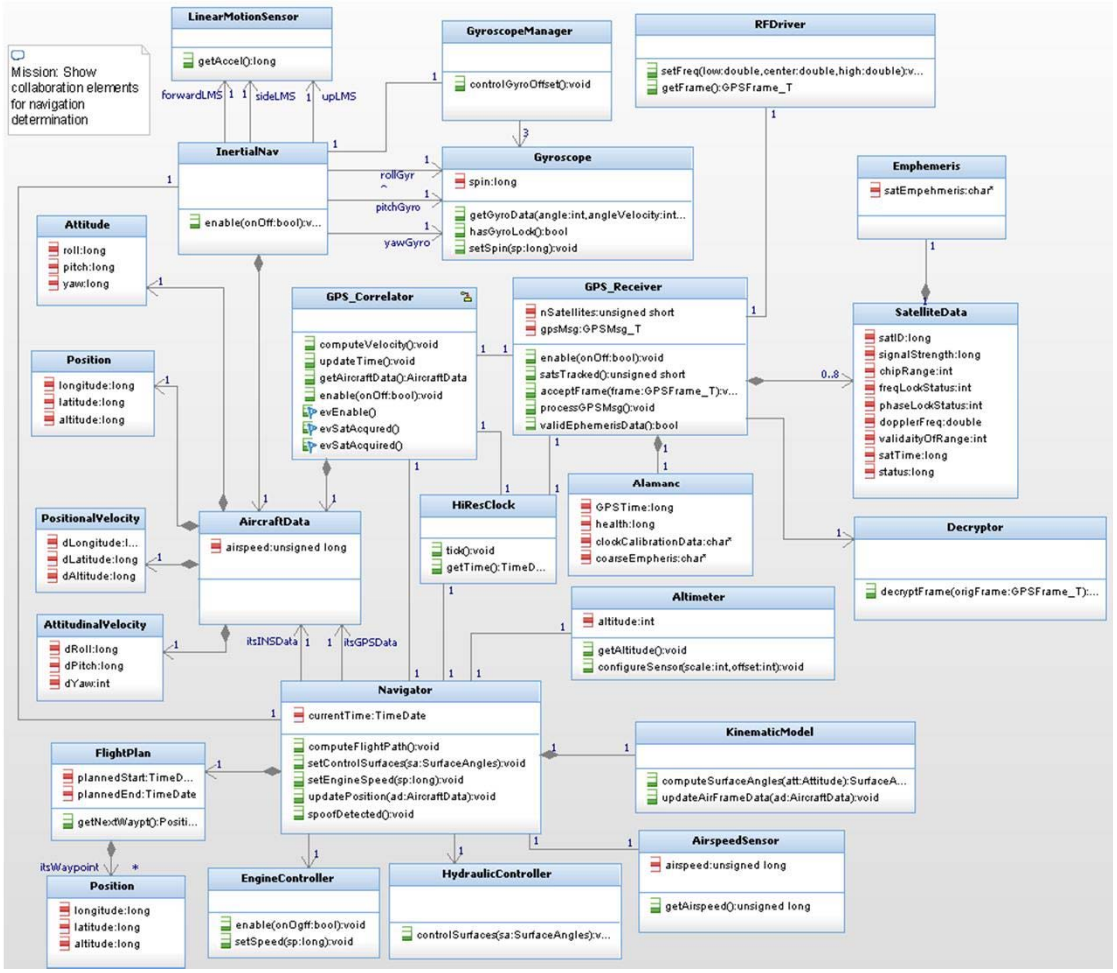
- Contain high-level requirements (HLR)
- Contains no*
  - Design
  - Low-level requirements
  - Detailed data flow
- Typically supported by multiple viewpoints
  - Use case diagram
  - Sequence diagram
  - Activity diagram
  - State machine
  - Links to text-based requirements
  - Simulation / execution data
- May *not* be used to generate code



*(except to justify design constraints in HLR)

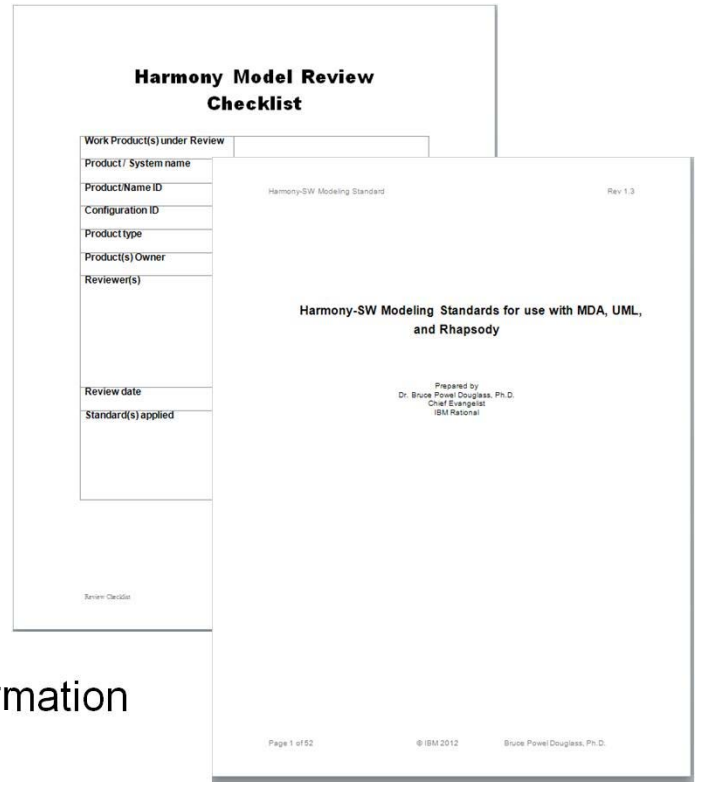
DO-331 Design Models

- May contain
  - Design
  - Low-Level Requirements (LLRs)
  - Architecture
  - Data structures
  - Detailed data flow
  - Detailed control flow
- Typically supported with multiple viewpoints
  - Class / Object / structure diagrams
  - Sequence diagrams
  - Activity diagrams
  - State diagrams
  - Source code
  - Verification data
- *May* be used to generate code



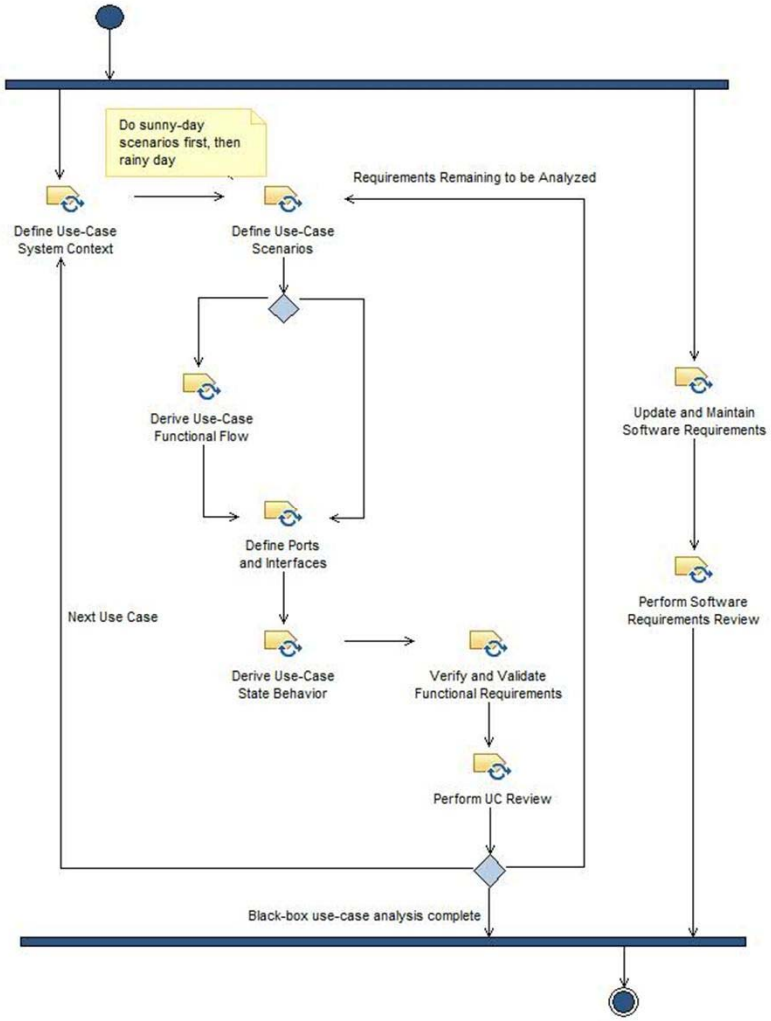
SW Modeling Standards

- DO-178 generally requires project standards and checklists for crucial work products
  - *Standards* lay out the (meta)requirements and organizational principles for work products
  - *Checklists* are used by SQA personnel to review the syntax, format, scope and completeness of the work product (semantics are dealt with by other reviewer roles and by verification)
- SW Modeling standards specify
  - Modeling techniques
  - Methods for modeling
  - Modeling languages (e.g. UML) incl.
    - reference to language standard,
    - style and complexity guidelines,
    - constraints,
    - means to trace to requirements,
    - means to identify any non-normative elements,
    - rational for the suitability of the technique for the information to be expressed



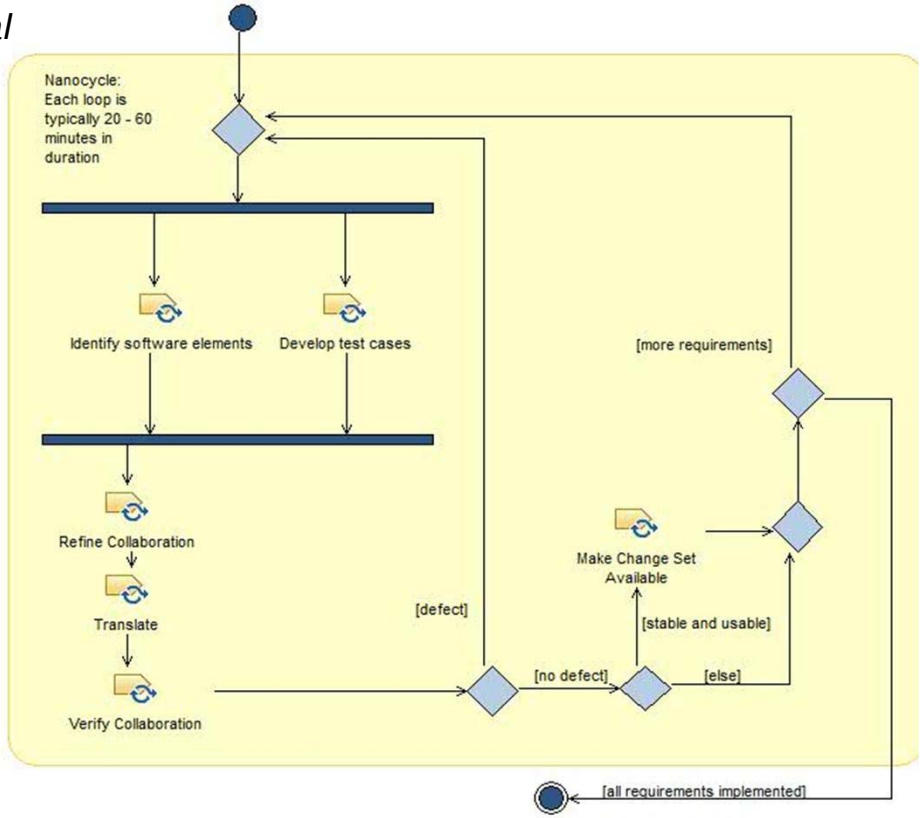
Harmony: Specification Models

- Identify use cases
  - Traceability links to requirements
  - Typically 8-20 pages of requirements
- Incrementally refine use case definition
  - Define the operational scenarios and operational contracts with sequence diagrams
  - Identify flow with activity diagrams
  - Specify normative semantics with state diagram
  - Verify with simulation / execution
  - Validate with customer at stable points
  - Repeat until all requirements represented



Harmony: Design Models

- Development proceeds incrementally with the basic premise of “make small incremental additions, verify, repeat”
- High Fidelity Modeling
  - Identify the software elements required for *functional correctness*
  - Produce a *functionally correct code base* that is verified at unit- and integration - levels
- Design optimizes at three levels of abstraction
  - Architectural – optimize the overall system with 5 key views
    - *Subsystem and Component View*
    - *Safety and Reliability View*
    - *Distribution View*
    - *Concurrency and Resource View*
    - *Deployment View*
  - Collaboration – use-case level scope
  - Detailed – individual software element scope



Wrapping up: State of the Art