Nick’s Bio

- Nick has been a Systems Engineer at Raytheon for 3 years, working in the Patriot BMC4I Requirements Team. Nick joined Raytheon after graduating from the University of Massachusetts Amherst with a Bachelor of Science in Electrical Engineering. He is currently pursuing a Master of Science in Industrial Engineering, with a certificate from the Gordon Institute of Engineering Leadership. As a part his capstone project, Nick has developed a series of MBSE work instructions and a proof of concept model of a notional Urban Traffic Control System.

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Key MBSE Enablers with Examples

Nick Driscoll (Presenter)
Phil Levesque

Abstract: 19920

11/28/2017

Agenda

- Model Based Systems Engineering (MBSE) Description
- MBSE Environment and Enablers
- Example Model Using Enablers

Systems Engineering

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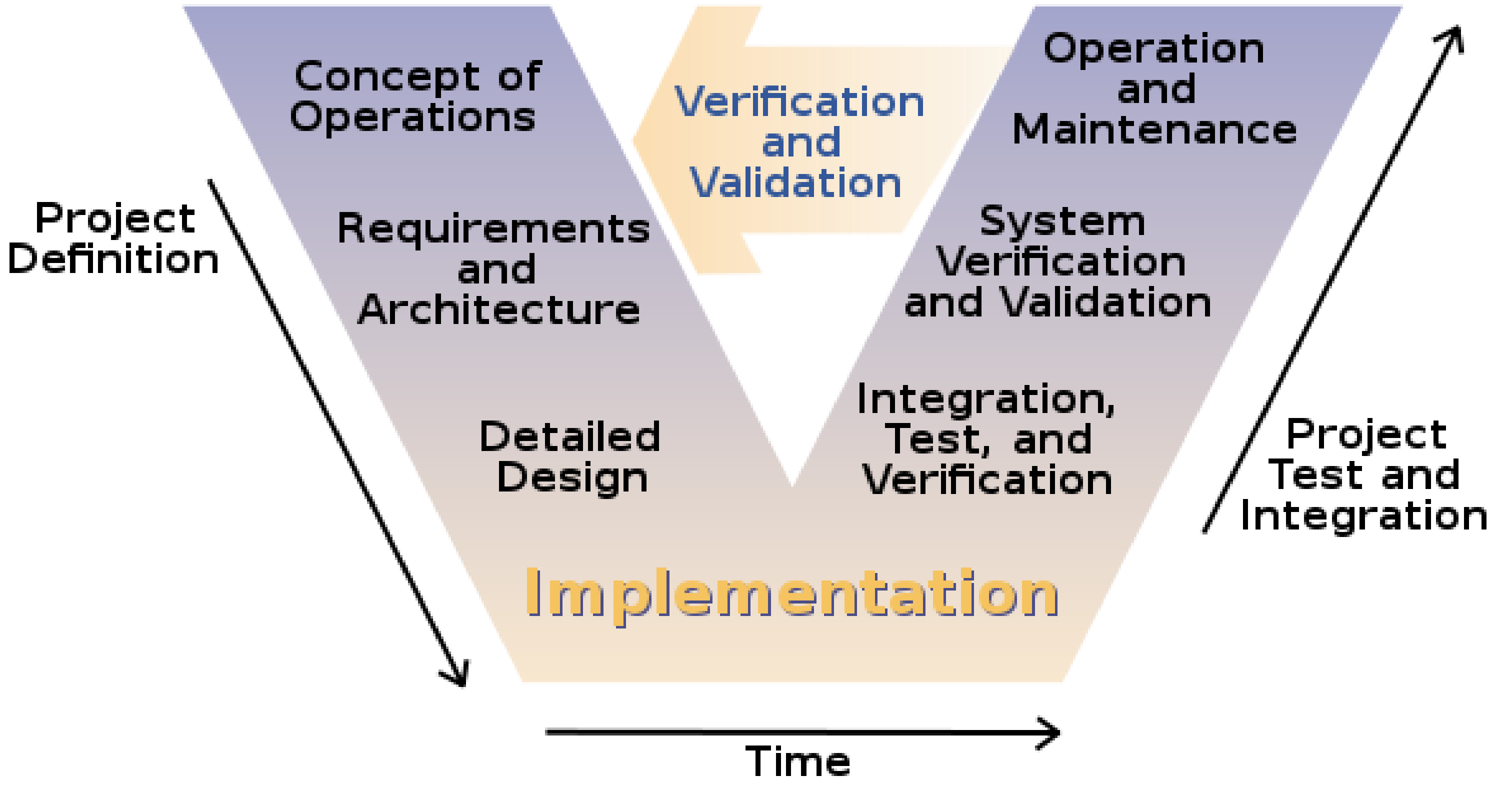
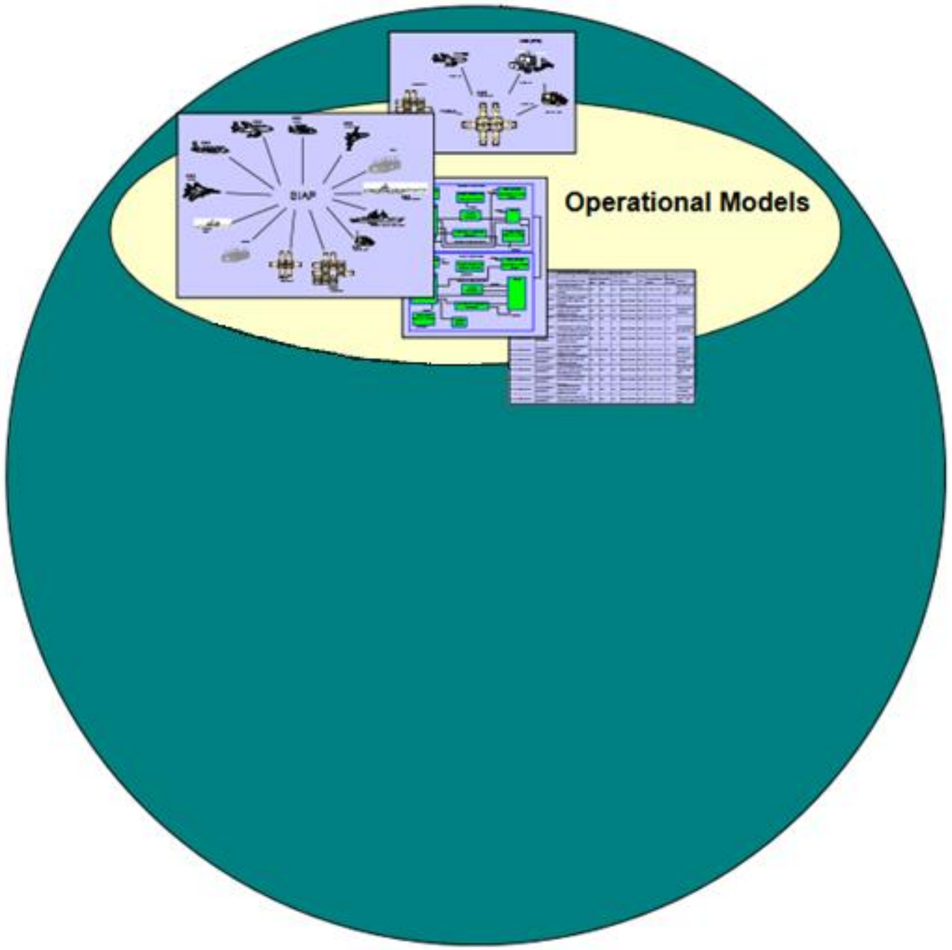
- Traditional requirements-based designs have Undesirable Effects over the product lifecycle:
  - Incorrect
  - Incomplete
  - Uninformed
  - Ambiguous
  - Infeasible
  - Unverifiable



Model Based Systems Engineering

- Visual representations
  - System Composition
  - Interfaces
  - Behaviors
- Multiple levels of Decomposition
  - Operational – Concept of Operations, Operation and Maintenance
  - System – Requirements and Architecture, System Verification and Validation
  - Component – Detailed Design, Integration and Test
- MBSE can provide:
  - Integrated Environment
  - Design Validation
  - Document Generation
  - Generation of code



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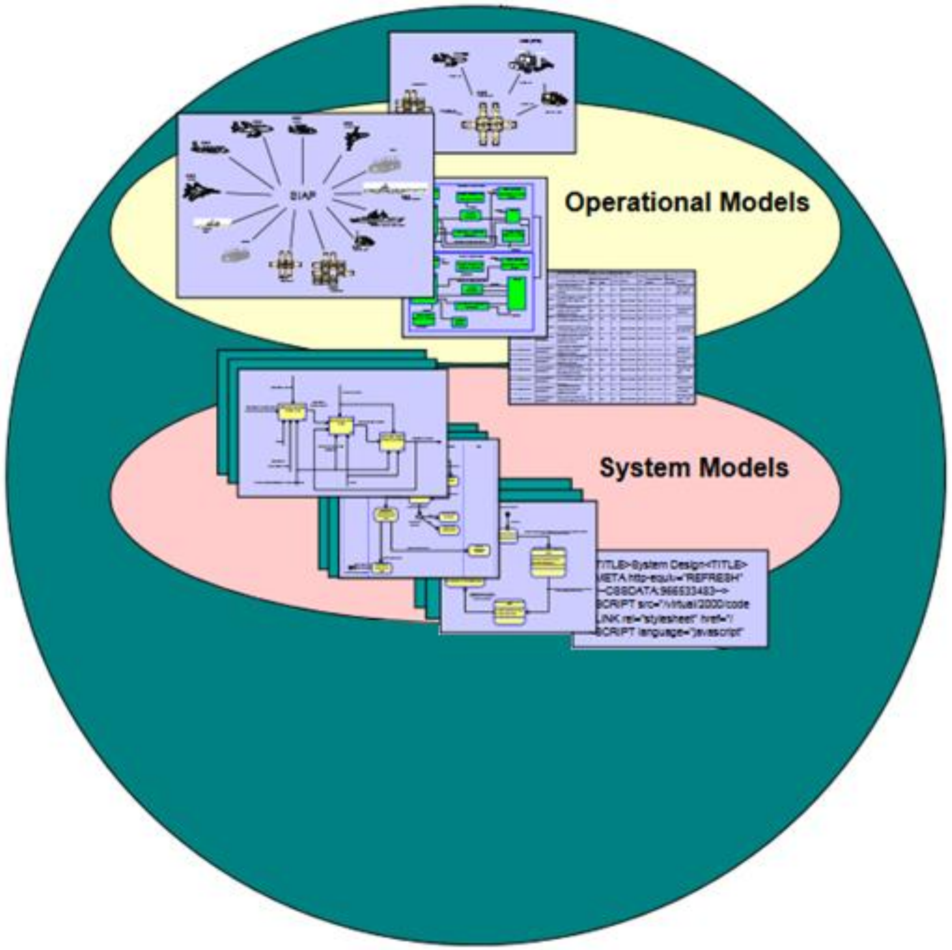

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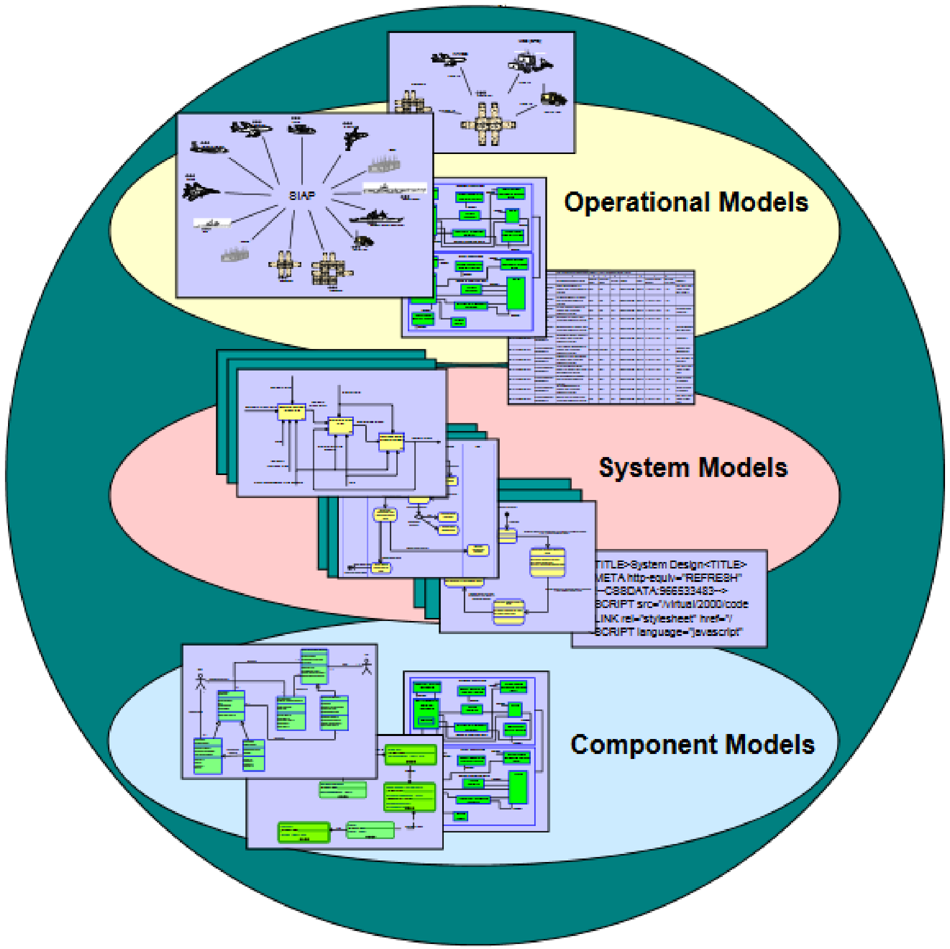
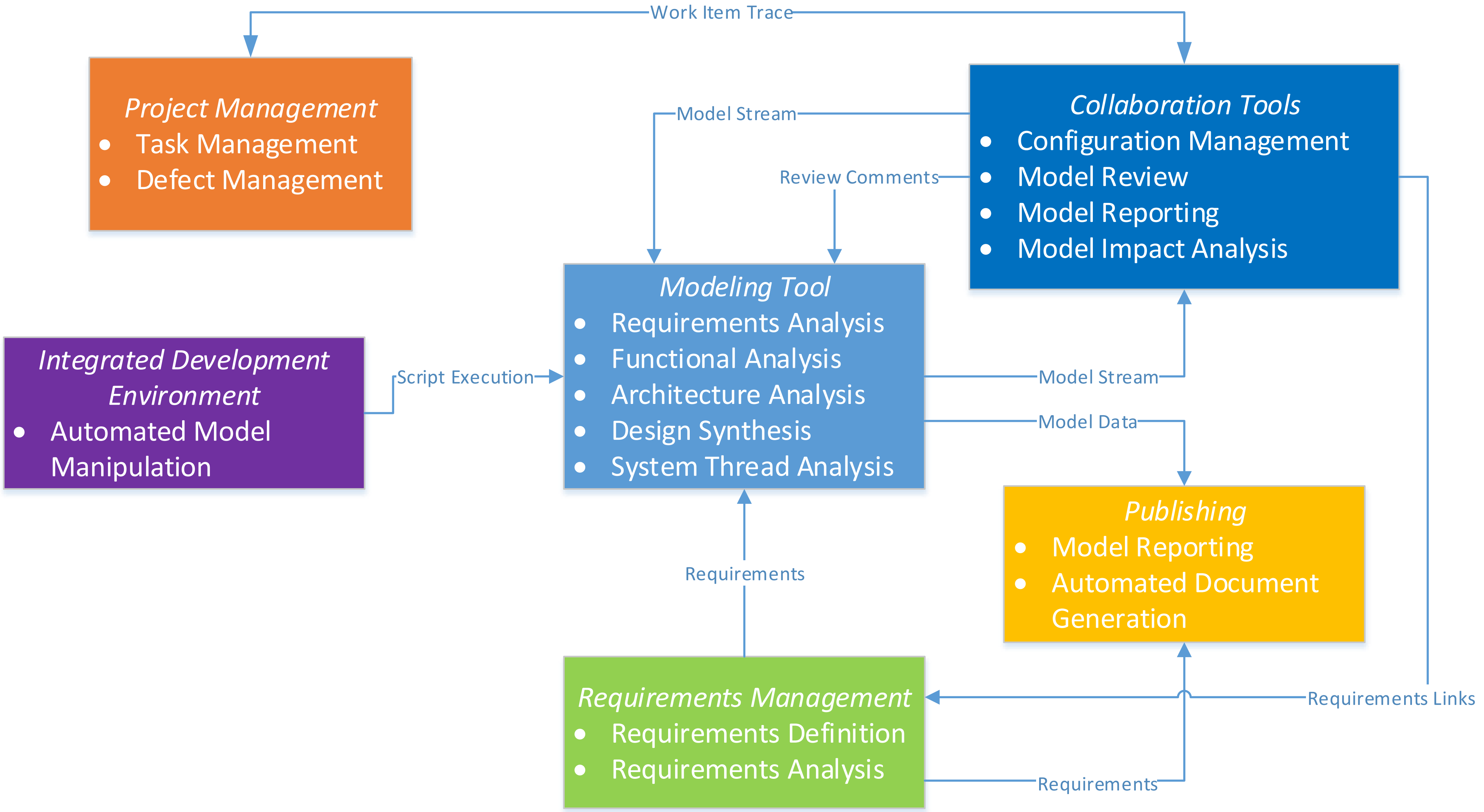


MBSE Environment

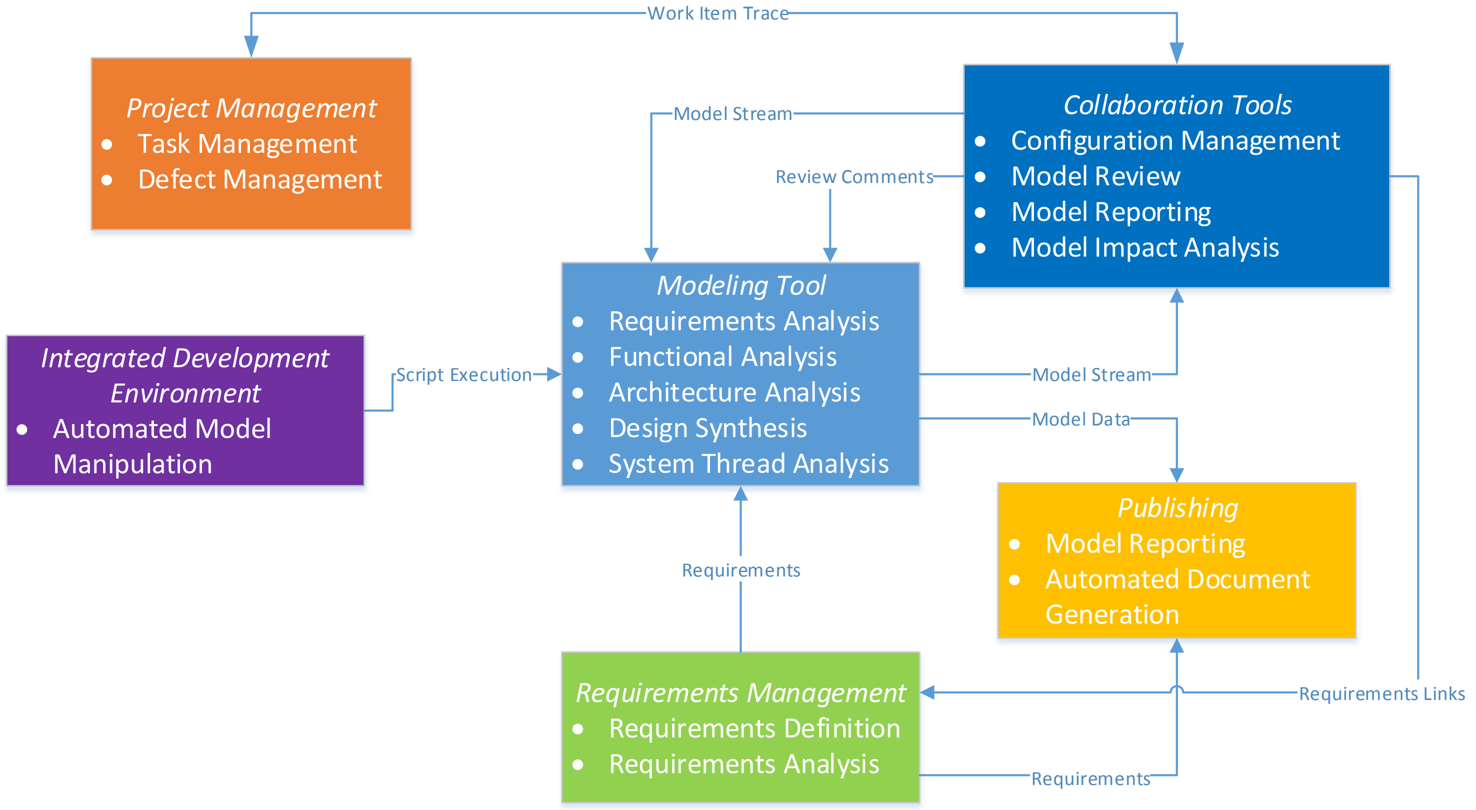


MBSE Impact on Design Methodology

- Design Efficiency
  - Consistent approach to MBSE
  - Stricter Analysis
- Enhanced Communication and Knowledge Transfer
  - Ease complexity management and understanding
  - Graphics and flowcharts are less convoluted than requirements specifications
- Improved Design Quality
  - In-phase defect detection
  - Defect reduction
  - Configuration Management

Enablers Supported by MBSE Environment

- **Modeling Enabler/Methodology**
- Integrated Design Reviews
  - Improved Quality
  - In-phase Correction
  - Knowledge Dissemination
  - Save Costs
  - Reduce Schedule
- Configuration Management
  - Consistency
  - Collaboration
- Team/Metric Tracking
  - Defect Tracking
  - Project Progress Reports



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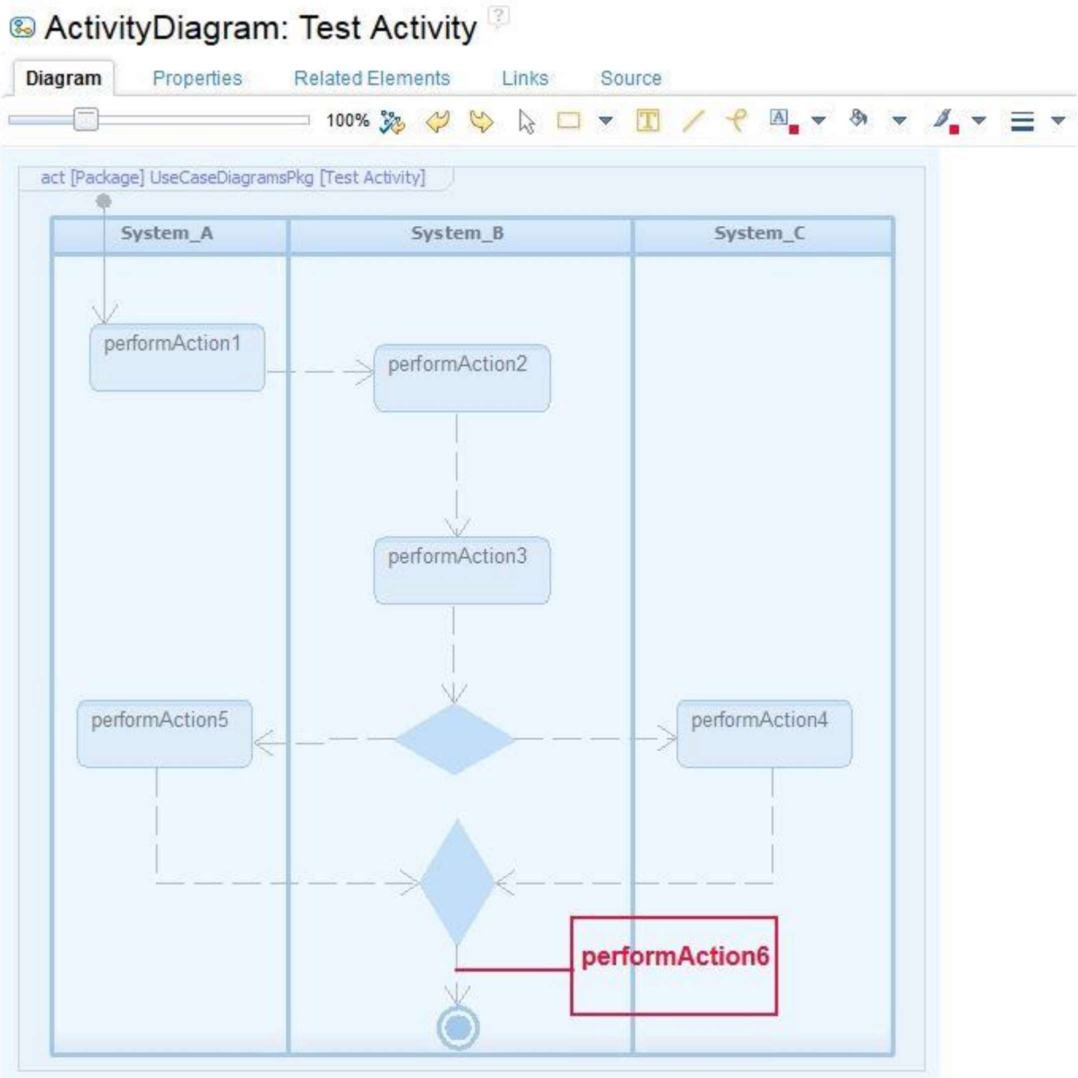

Image Extracted from Rational Design Manager

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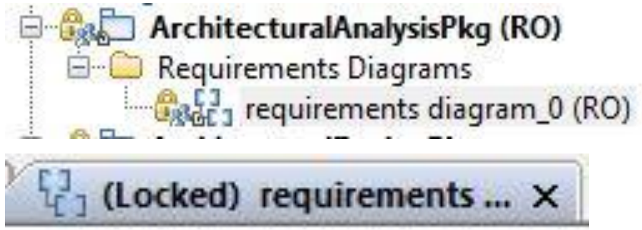
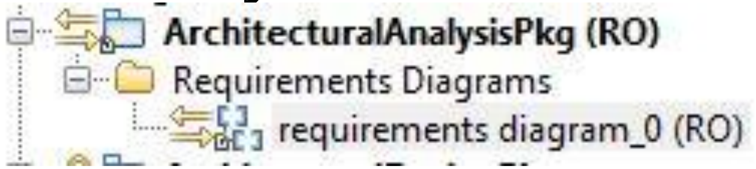
- Element-wise lockout:

- Collaborative Lockout Notifications:



- Out-of-Sync Notifications:



Images Extracted from Rhapsody using Rational Design Manger

Enablers Supported by MBSE Environment

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- Modeling Enabler/Methodology
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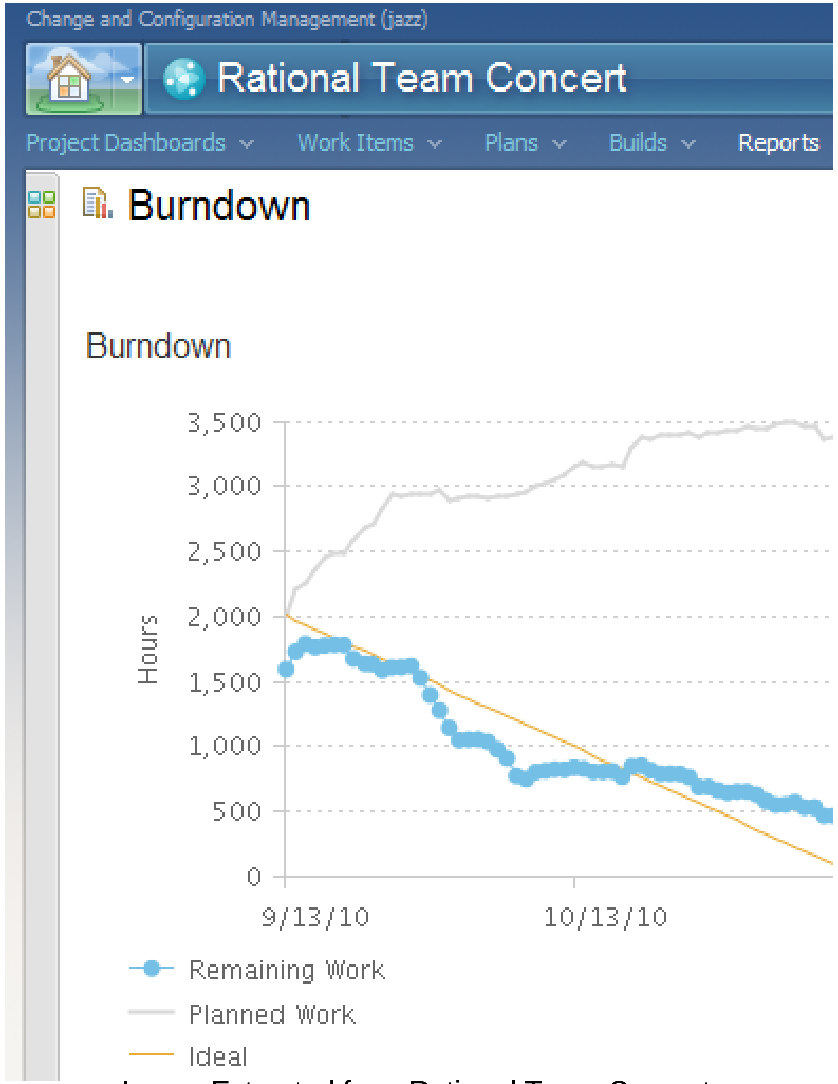


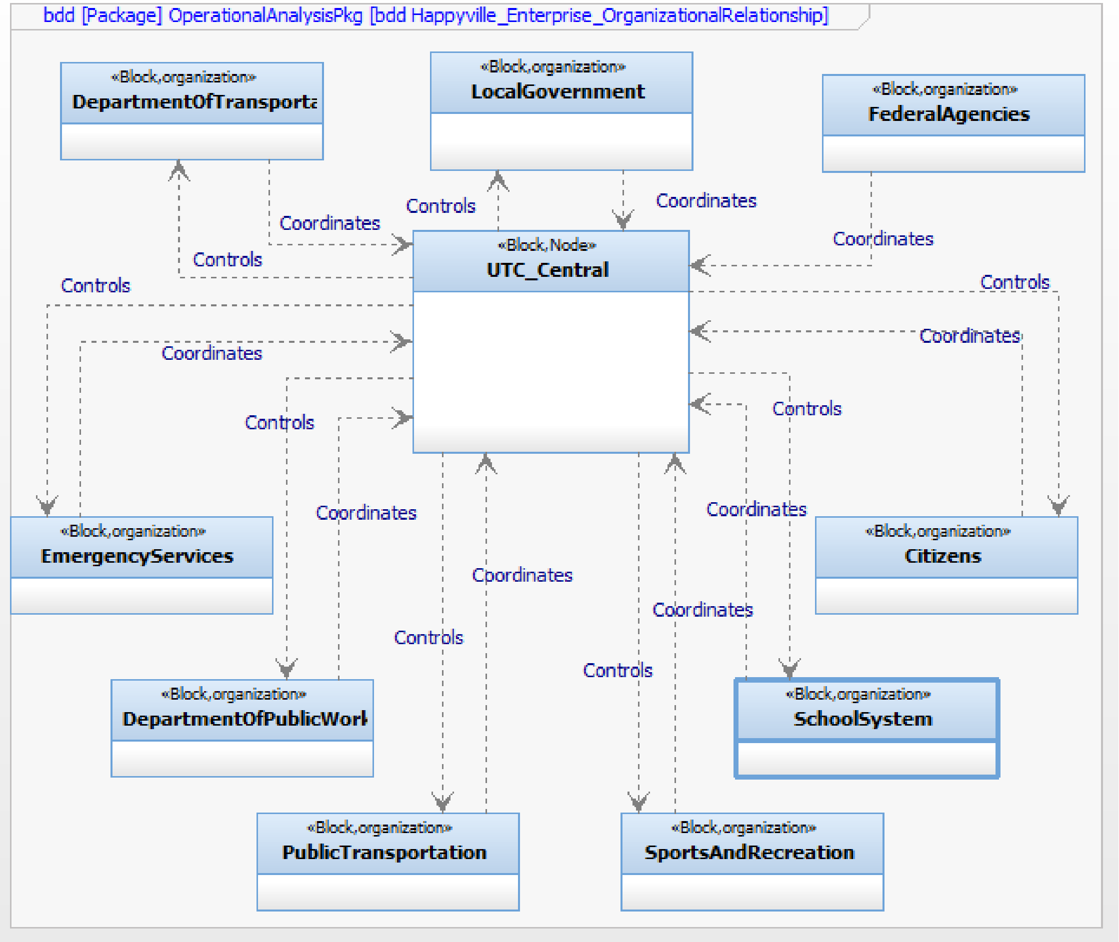
Image Extracted from Rational Team Concert

Example Model Using Enablers

- Rationale for Urban Traffic Control (UTC) System as an Example:
  - Notional example of a highly-variable complex system
  - Multiple levels of decomposition
  - Sharable across-company and externally without divulging customer or company information
- UTC System Customer Needs:
  - Maintain Traffic Flow
  - Public Transportation Priority
  - Timely Response to Incidents
  - Maintain Pedestrian Well-Being
  - Control Center Design Constraints
  - System Maintenance and Fault Detection
  - Interface Requirements

UTC System Operational Block Diagram

- Operational Block Definition Diagram: high level graphical overview of the operational concept
- Identifies the other organizations and systems in the system under design's operational environment
- Describes the relationships between the system under design and the identified organizations and systems



UTC System Block Definition Diagram

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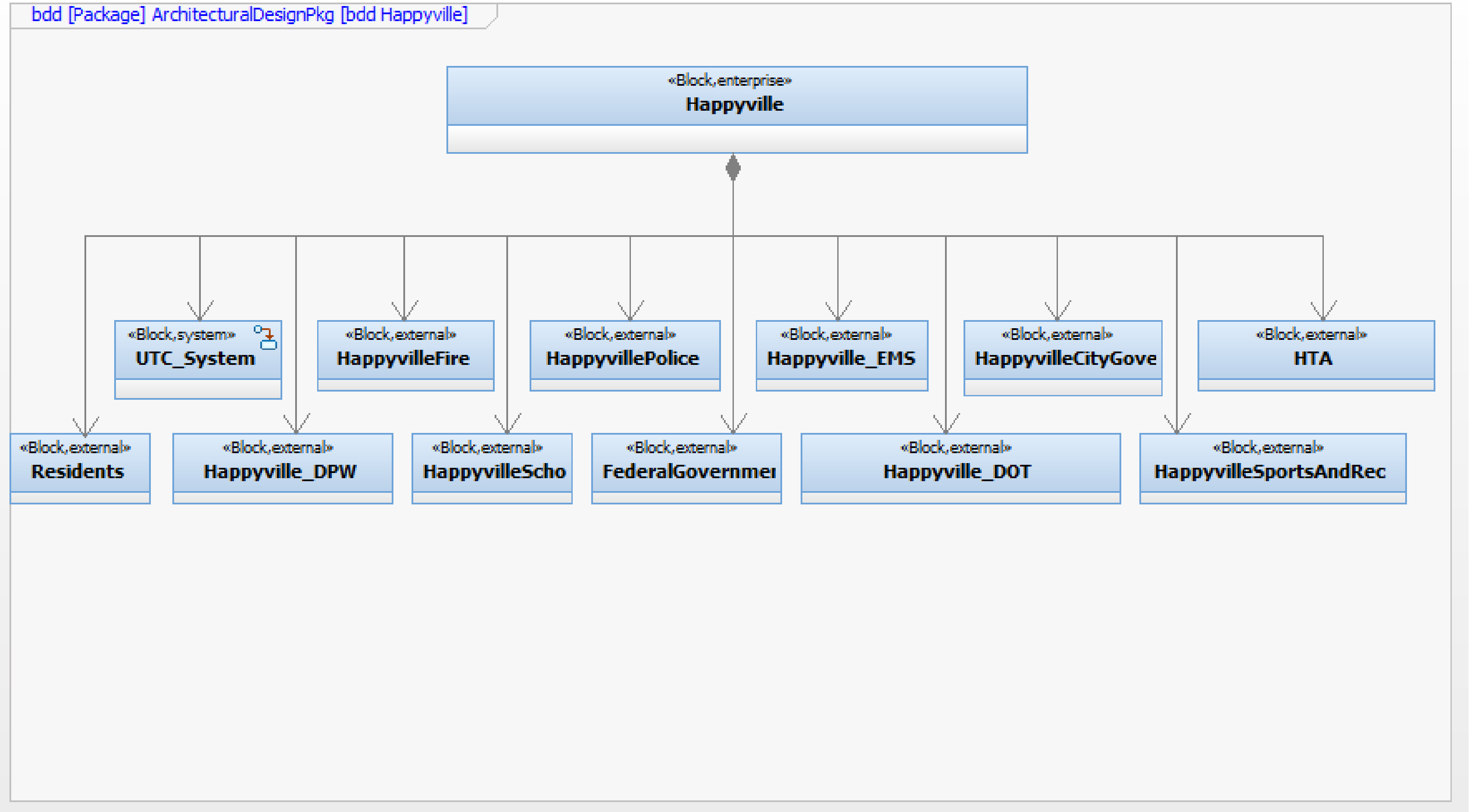
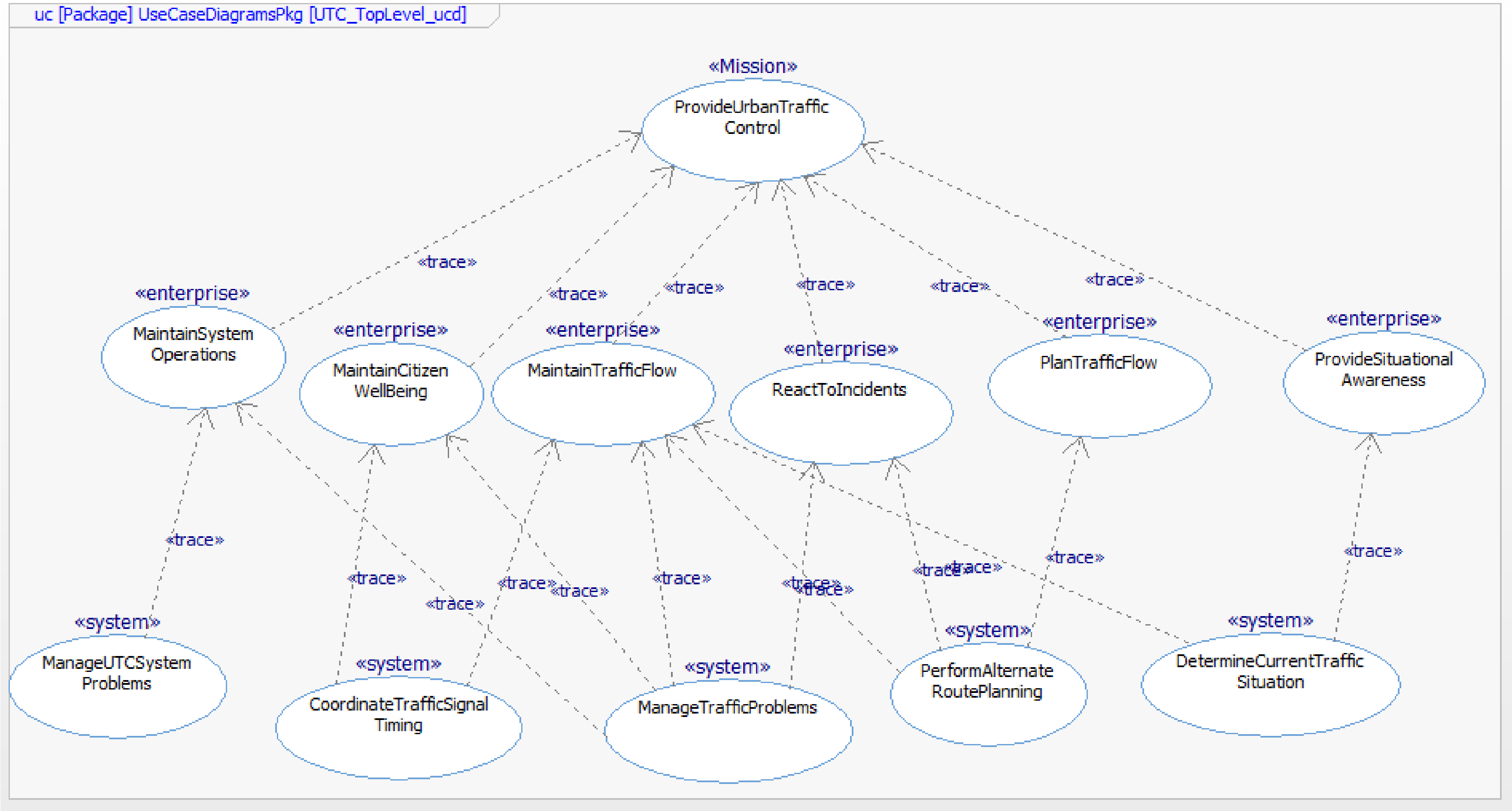
- Block Definition Diagram: A representation of the structure elements and their relationships.



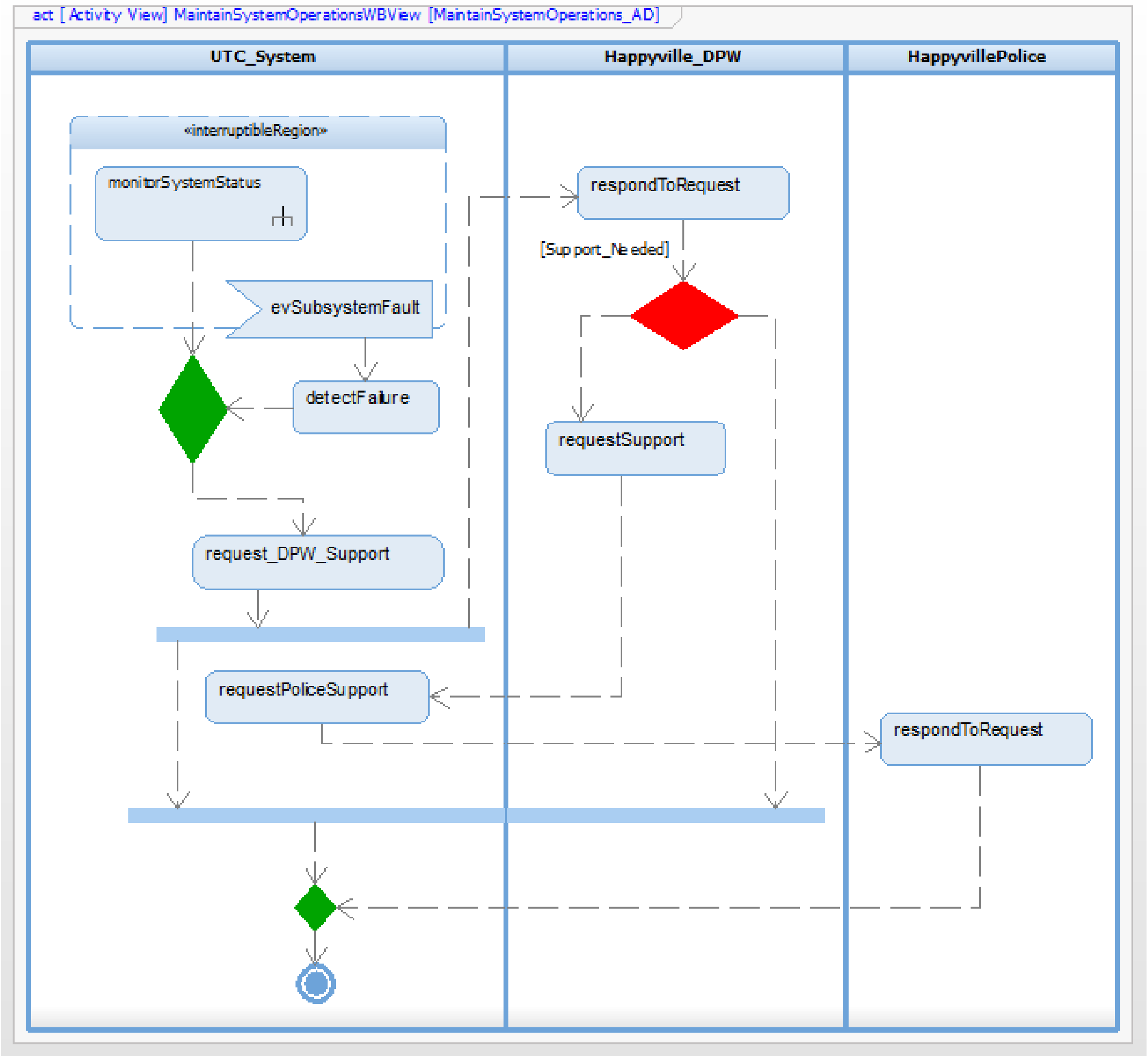
UTC System Use Case Diagram

- Use Case Diagram: Define the main functions that the system must perform. Used to develop the operational threads.



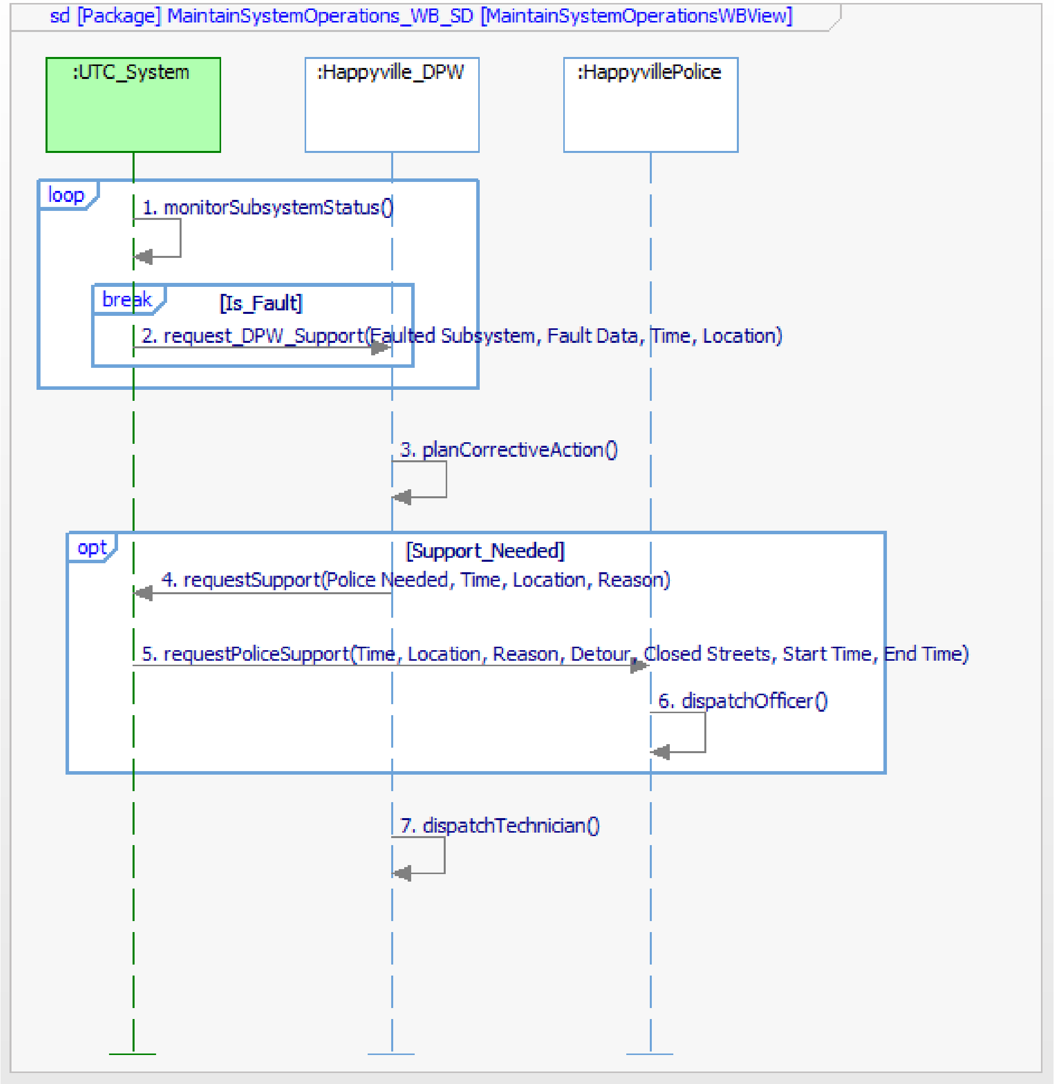
UTC System Activity Diagram

- Activity Diagram: Represents a specific system behavior or set of system behaviors. Similar to a flow chart, can depict the interactions between various external actors, or elements within the system
- Describes flow-based behavior



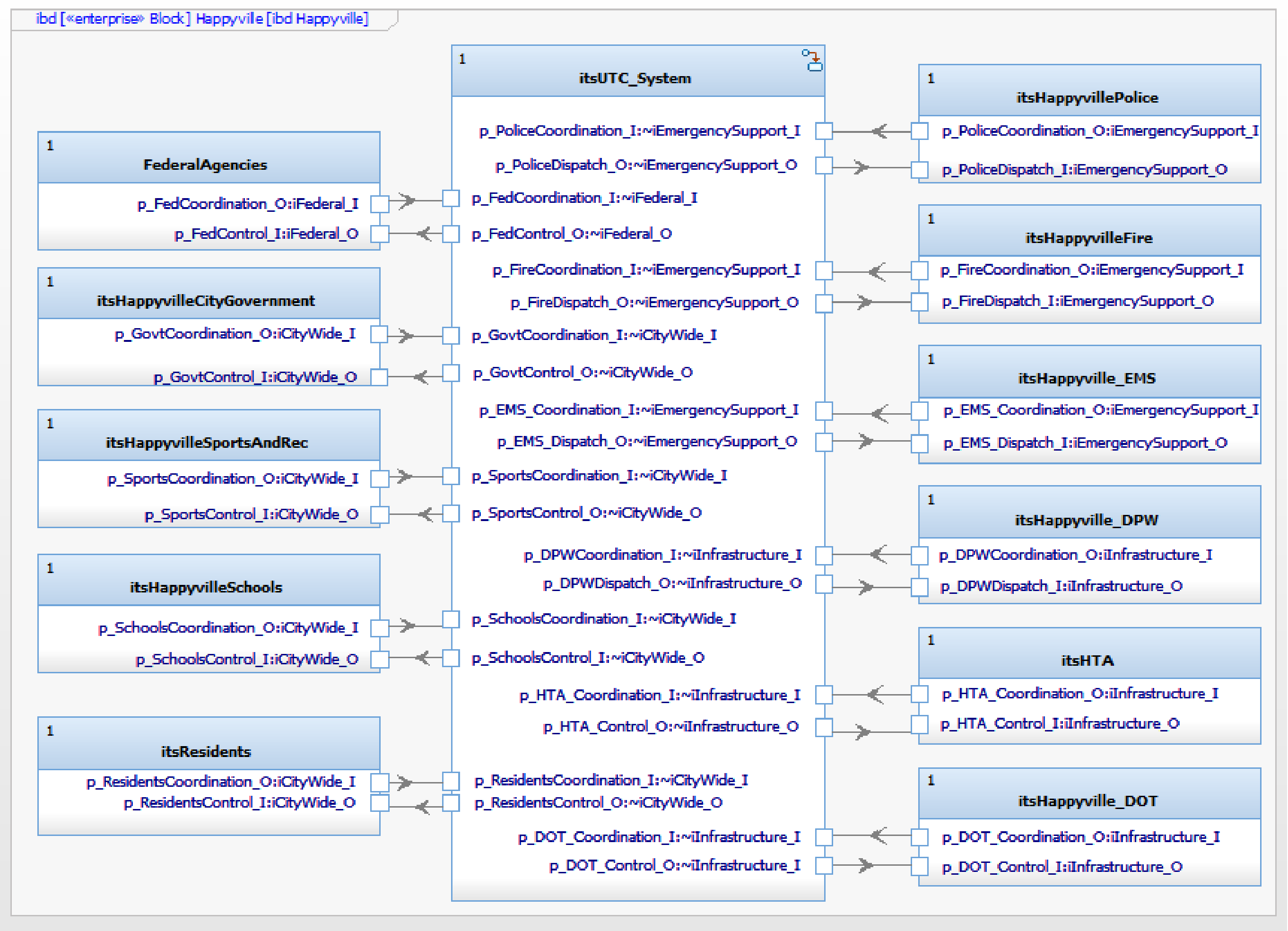
UTC System Sequence Diagram

- Sequence Diagram: Represents message exchanges between systems, subsystems, or components.
- Describes message-based behavior



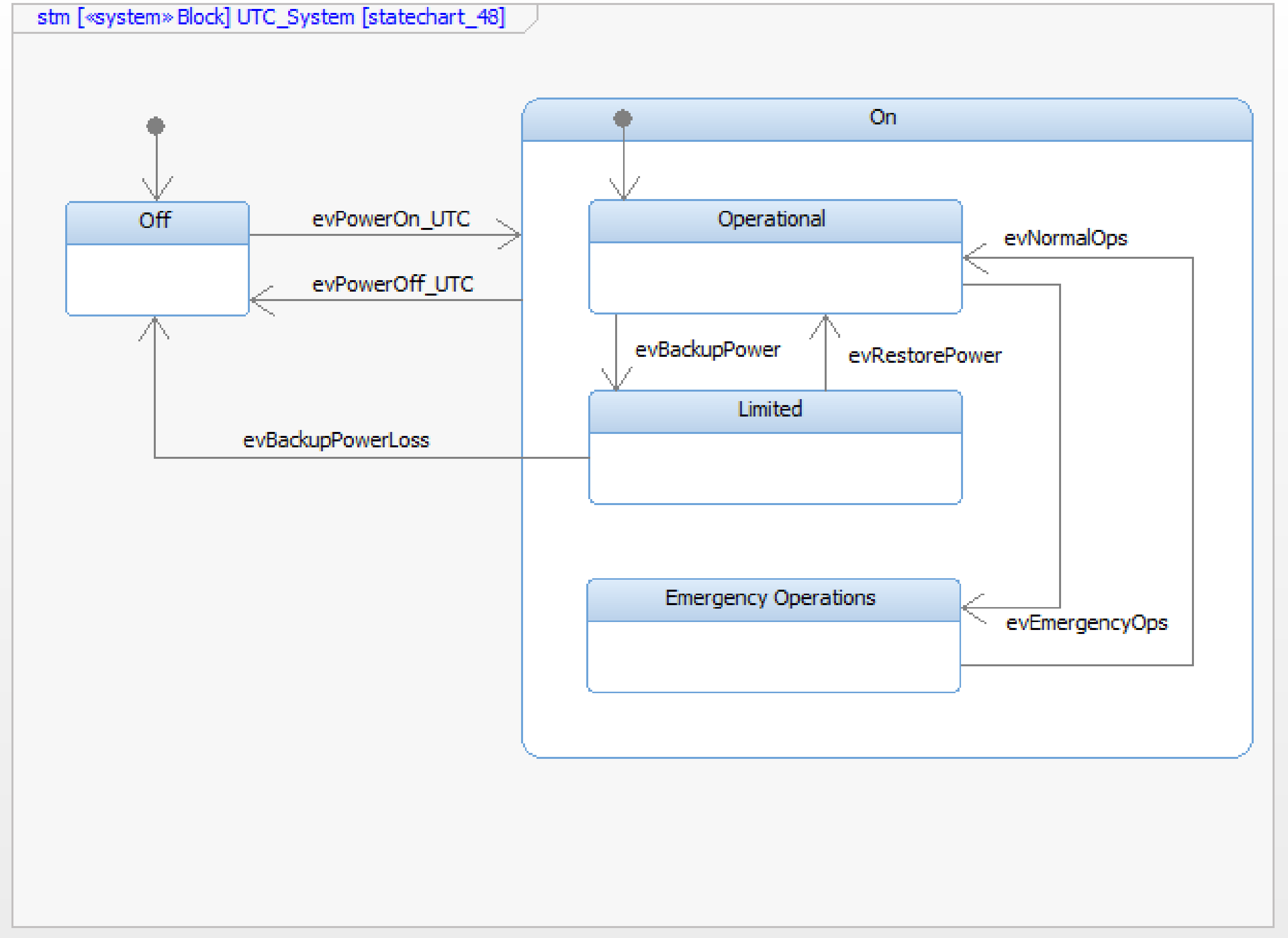
UTC System Internal Block Diagram

- Internal Block Diagram: Represents the interconnection and interfaces between the internal parts of a block (enterprise, system, or subsystem)



UTC System State Machine Diagram

- State Machine Diagram: Defines the states and modes of the system, and depicts the transitions from one state to another.
- Describes event-based behavior



UTC System Metrics

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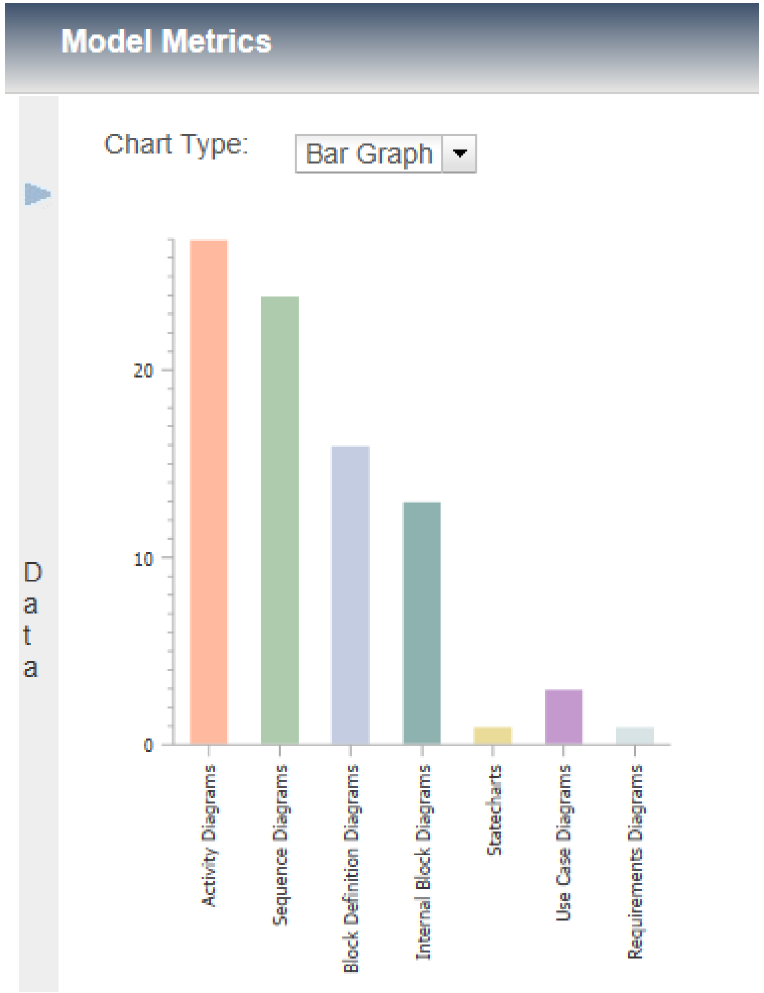
Metric Type	Count	Description
Diagrams/Views (Total)	85	Total number of diagrams in model
Activity Diagrams	27	Total number of activity diagrams
Sequence Diagrams	24	Total number of sequence diagrams
Block Definition Diagrams	16	Total number of block definition diagrams
Internal Block Diagrams	13	Total number of internal block diagrams
State Charts	1	Total number of state charts
Use Case Diagrams	3	Total number of use case diagrams
Requirements Diagrams	1	Total number of requirements diagrams
Structural Elements	51	Includes blocks for Enterprise, Systems, Subsystems, Nodes, Organizations
Interface Items	142	Includes send event actions, exchanged messages, interfaces, interface blocks
Functional Elements	46	Includes use cases (threads), activities and call behaviors
People Elements	20	Enterprise Actors
Time-Related Events	485	Includes transitions, events, flows, interaction occurrences, sequences, and states
Satisfied Requirements	29	Number of requirements traced to an element
Unsatisfied Requirements	27	Number of requirements not traced to an element
Percent of Requirements Linked	52%	Percentage of total requirements traced to a model element
Percent Under Configuration Control	100%	Model is configure controlled in RDM with the candidate as the only approver



UTC System Requirements Compliance

- Model Elements are linked to requirements within Rhapsody, and satisfaction tables can be output to help determine model completeness:

Requirement ID	Specification	Satisfying Element
UTC_46	The UTC System shall have an Operational State.	Operational
UTC_51	The UTC System shall avoid large fluctuations in traffic control behavior due to temporary traffic pattern changes.	changeSignal, detectCongestion, evDetectCongestion, commandSignalChange, detectCongestion, executeSignalChange
UTC_53	The UTC System shall provide a limited sub-set of capabilities when faced with a disaster scenario.	Limited, Emergency Operations
UTC_54	The UTC System shall be able to transition to Emergency Operations within 1 hour of a State of Emergency Declaration.	evEmergencyOps, Emergency Operations
UTC_56	The UTC system shall provide priority to public transportation without increasing traffic congestion.	commandSignalChange, executeSignalChange, changeSignal, detectBus, evDetectBus
UTC_58	The UTC system shall detect all traffic incidents within 1 minute of occurrence to include: • Multiple Vehicle Collisions • Single Vehicle Collisions with stationary objects (light posts, buildings, etc.) • Single Vehicle Collisions with pedestrians, bicyclists and/or animals • Debris in the roadway.	assessSensorData, senseEnvironment, detectIncident, determineIncidentType, evDetectIncident

Summary

- Facilitating transition to Model Based Systems Engineering
- Enhanced communication and knowledge transfer
- Reduced lifecycle cost through improved design quality
- MBSE and SysML to model complex systems
- Potential re-use

Questions?

Contact Information

Nicholas Driscoll

IDS HQ, Tewksbury, MA

Nicholas.J.Driscoll@Raytheon.com

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Philip Levesque

IDS HQ, Tewksbury, MA

Philip_R_Levesque@Raytheon.com

Phil Levesque is a Senior Principal Systems Engineer with Raytheon. Phil is a Raytheon Certified Architect and has worked in Systems Engineering for the past 14 years. Phil holds a MS in Computer Engineering degree from the University of Massachusetts at Lowell and BS in Electrical Engineering degree with a double major in Electrical Engineering & Computer Science from the University of Massachusetts at Lowell.

Backup

MBSE Environment Tooling

Raytheon