Sewing the Digital Transformation Thread: A Deeper Look into Model-Based Six Sigma (MBSS) and the Model-Based Systems Architecture Processes (MBSAP)

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Abstract

Interfaces within a System-of-Systems (SoS) are complex in nature and the necessary steps to define those interfaces are often difficult to capture and communicate across responsible parties. Implementation of a robust communication structure is necessary to support SoS development, production, and sustainment. Communication is one of the key tenets of Systems Engineering (SE) and organizational process improvement attempts are futile without it. The structured improvement focus of Model-Based Six Sigma (MBSS), combined with the knowledge sharing goals of Model-Based Systems Engineering (MBSE) applications, will be analyzed as a collaborative approach to improving communication effectiveness within SoS relationships digitally.

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Purpose – Elimination of Waste

Establish a robust framework for process improvement on both the enterprise and program levels

- Waste associated with over-documentation, inappropriate tool usage, and task duplication
- Combined with innovative techniques for Model-Based Six Sigma (MBSS) development
- Framework will assist in translating customer needs and organizational capabilities into delivered solutions with enhanced efficiency

Why model-based process improvement?

The implementation of continuous improvement principles, tools, and methodologies in a model-based environment help provide reference architecture for digitally traceable threads that can be used to alleviate bottlenecks, defects, and errors that threaten program success (Sliva and Ferreira, 2017).

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Six Sigma, MBSE, SoS

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Six Sigma

- Set of waste elimination tools and methodologies applied within Manufacturing
- Recently emerged as a viable approach to fostering continuous improvement efforts across varying people, products, and process driven systems.
- Lean Six Sigma – defined sequence of steps with quantified goals and financial targets (cost reduction and/or profit increase) and rely on statistical tools to deal with uncertainty (Desai and Shrivastava, 2008).

DMAIC	PROCESS DESCRIPTION
Define	Processes that balance aggregate demand and supply to develop a course of action which best meets sourcing, production and delivery requirements
Measure	Processes that procures goods and services to meet planned or actual demand
Analyze	Processes that analyzes current state to meet planned or actual demand
Improve	Processes that provide finished goods and services to meet planned or actual demand, typically including order management, transportation management, and distribution management
Control	Processes associated with returning or receiving fraudulent products and updating process to prevent future occurrences. These processes extend into post-delivery customer support

This research explores various pathways of enabling effective communication using Six Sigma and MBSE methodologies to capture, assess, and improve System-of-System (SoS) relationships.

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Model-based Implementation

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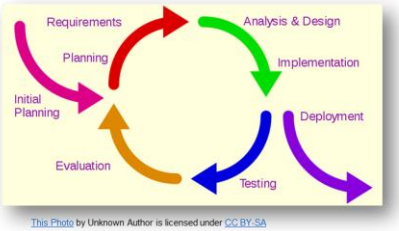

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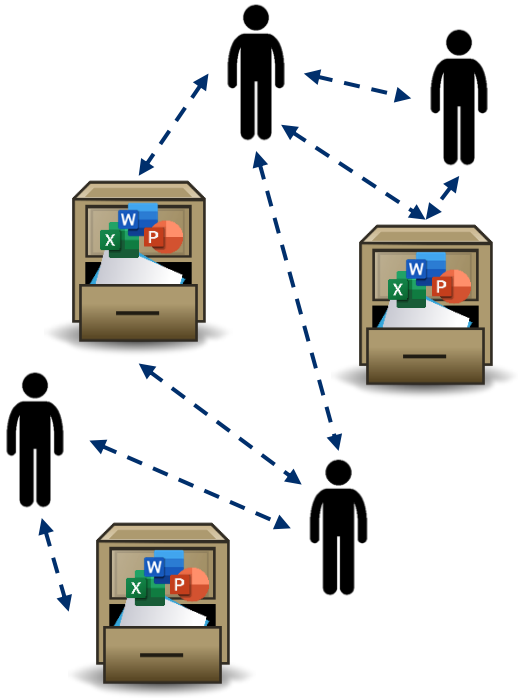
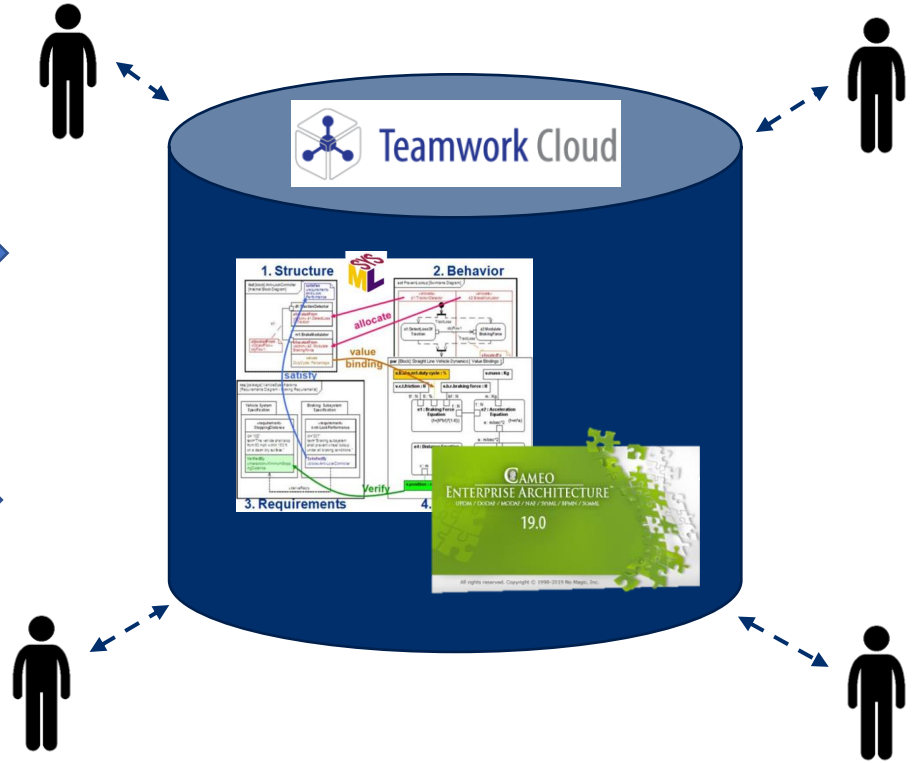
Traditional Process



Model-based Process



To meet the customer's digital transformation expectation, this research will equip organizations with an MBSS toolset and also provide the framework for Lean Six Sigma and MBSE tool integration.

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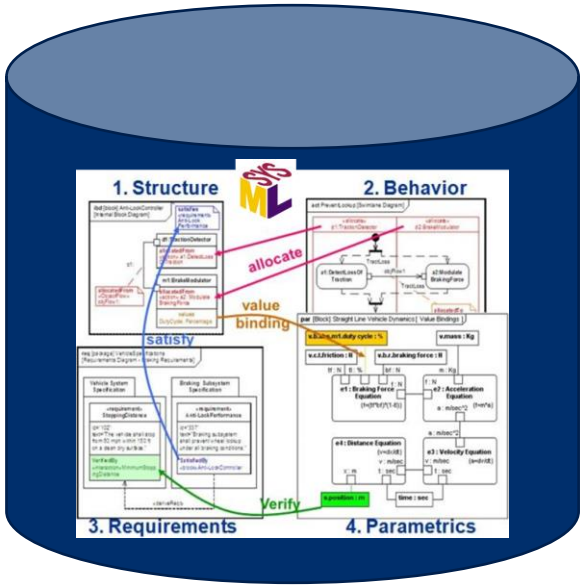
Benefits of MBSE

- MBSE supports a wide range of systems engineering activities,
  - Requirements definition, design, analysis, verification, and validation, beginning with the conceptual design phase continuing throughout development.
- A well-constructed model allows description and analysis to facilitate understanding of the entity and communication among stakeholders, including suppliers.
- The Model-Based Systems Architecture Process (MBSAP) provides a framework and methodology for applying MBSE and enjoying its benefits in dealing with a wide range of technology-intensive systems that extend beyond system design.



Walden DD, Roedler GJ, Forsberg KJ, Hamelin RD, Shortell TM. *Systems Engineering Handbook*. INCOSE-TP-2003-002-04. 4th ed. Hoboken, NJ: John Wiley & Sons, Inc; 2015.

A “Record-of-Authority” is created, leading to the immediate capture of artifacts directly associated with the product.

This includes artifacts created with engineering tools, manufacturing systems, shop floor systems, product planning and procurement, and operational and maintenance systems.

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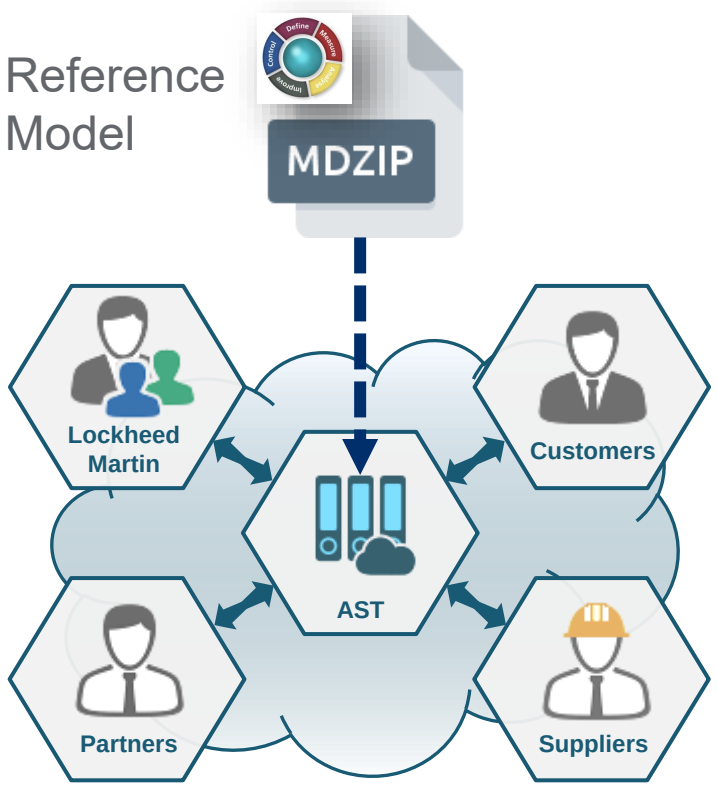
Supplier Communication - Processes

- Clear, unambiguous understanding of process being improved/implemented
- Determine the information needed for evaluation & validation of a vendor response and customer satisfaction
- Processes outside of system development can be captured in a model as well.
- Examples of processes being modeled:
  - Acquisition, Sustainment, ProdOps



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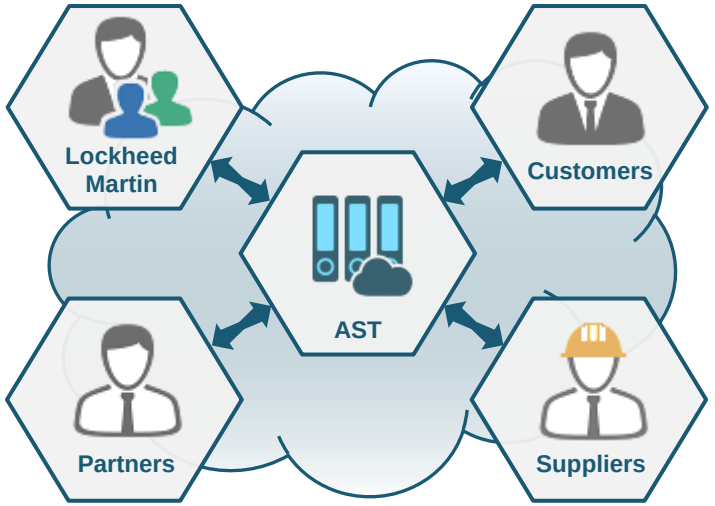
Digital Readiness & Communication

Lean Six Sigma (LSS) methodology will be used to ensure efficiency, effectiveness, and process improvement throughout the capabilities assessments required for Digital Transformation implementation.

- Determine the readiness and capacity of an organization
  - How effectively can they implement steps within the nonconformance management process is vital to the success of counterfeit avoidance initiatives
  - Can they align well with the goals of LSS principles
    - LSS data-driven methodology is used to solve complex business problems and can be thought of as a roadmap for continuous improvement



Tools?
Processes?
Communication methods?
IT resources?

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Lean Six Sigma Toolkit

1. Starts with understanding the existing processes, known as the “as-is” state
2. Together with industry benchmarks and best practices relating to management and software, the “future” state is envisioned.
3. Once the two states have been worked, a gap analysis relative to these processes and metrics are performed to determine the delta between what exists currently and what is desired.

Newly discovered gaps provide roadmaps for additional analysis as well as MBSAP implementation opportunities for interface linkages.

Define	Measure	Analyze	Improve	Control
Benchmark Contract/Charter Kano Model Voice of the Customer Voice of the Business Quality Function Deployment	GQIM and Indicator Templates Data Collection Methods Measurement System Evaluation	Cause & Effect Diagrams/ Matrix Failure Modes & Effects Analysis Statistical Inference Reliability Analysis Root Cause Analysis, including 5 Whys Hypothesis Test	Design of Experiments Modeling ANOVA Tolerancing Robust Design Systems Thinking Decision & Risk Analysis PSM Perform Analysis Model	Statistical Controls: • Control Charts • Time Series methods Non-Statistical Controls: • Procedural adherence • Performance Mgmt • Preventive measures
7 Basic Tools (Histogram, Scatter Plot, Run Chart, Flow Chart, Brainstorming, Pareto Chart), Control charts (for diagnostic purposes), Baseline, Process Flow Map, Project Management, “Management by Fact”, Sampling Techniques, Survey Methods, Defect Metrics				

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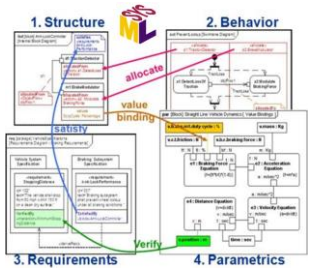
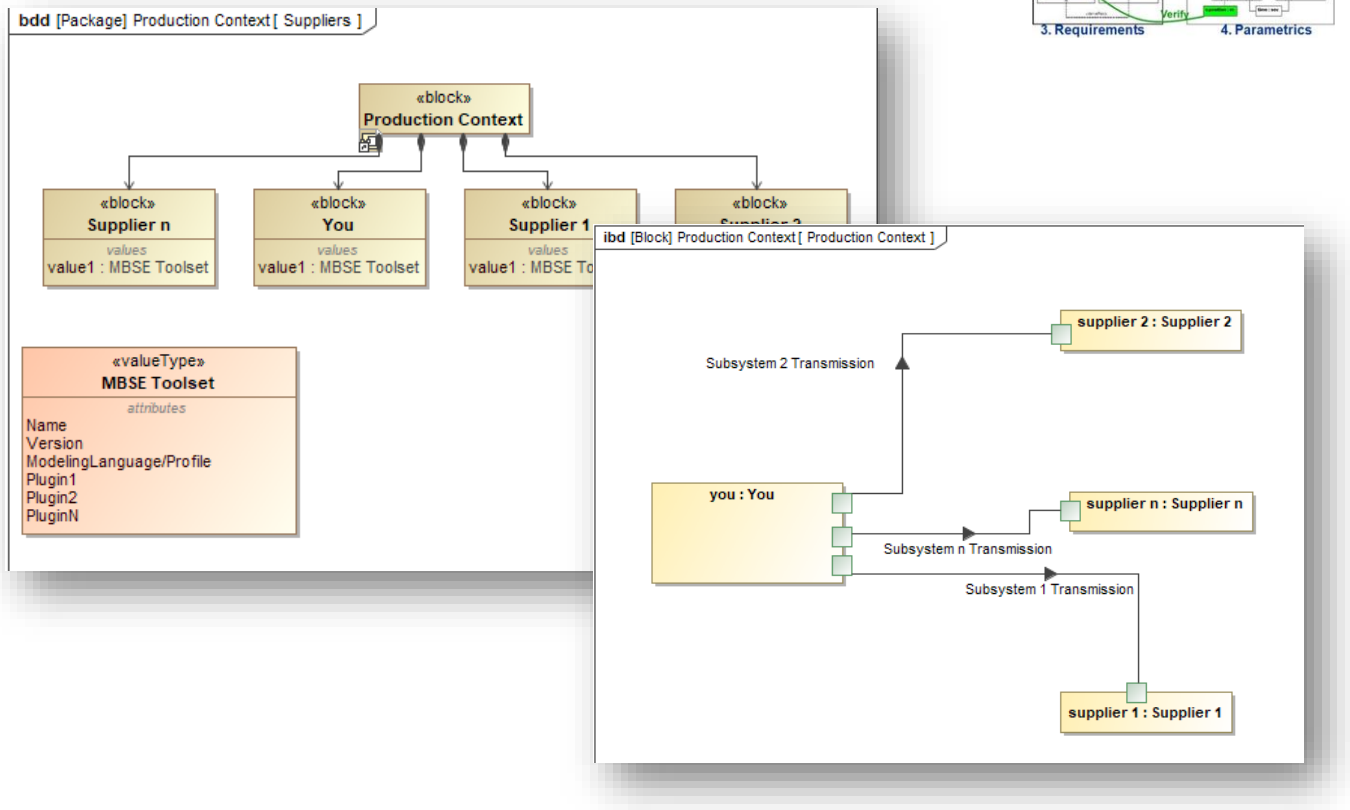
Supplier Communication – Improvement



To successfully implement Lean Six Sigma techniques in support of process improvement goals, teams must:

- Establish infrastructure with specific roles and responsibilities that help mobilize DMAIC process
- Creation of digital threads across systems
  - Digital thread - a linked set of information related to a product that includes all stages of the product lifecycle phases
- Focus on improving communication across integrated product teams, suppliers, and external customers
  - Subsequent diagrams can expand the structure definition of the Project Team to specify team members in another diagram



Rather than being part of a deliverable to a customer, this model can used as a keystone to tie together an entire effort between various stakeholders.

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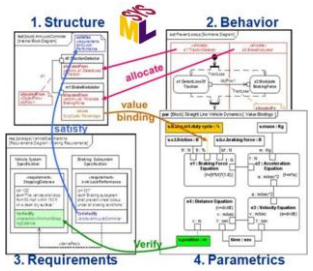
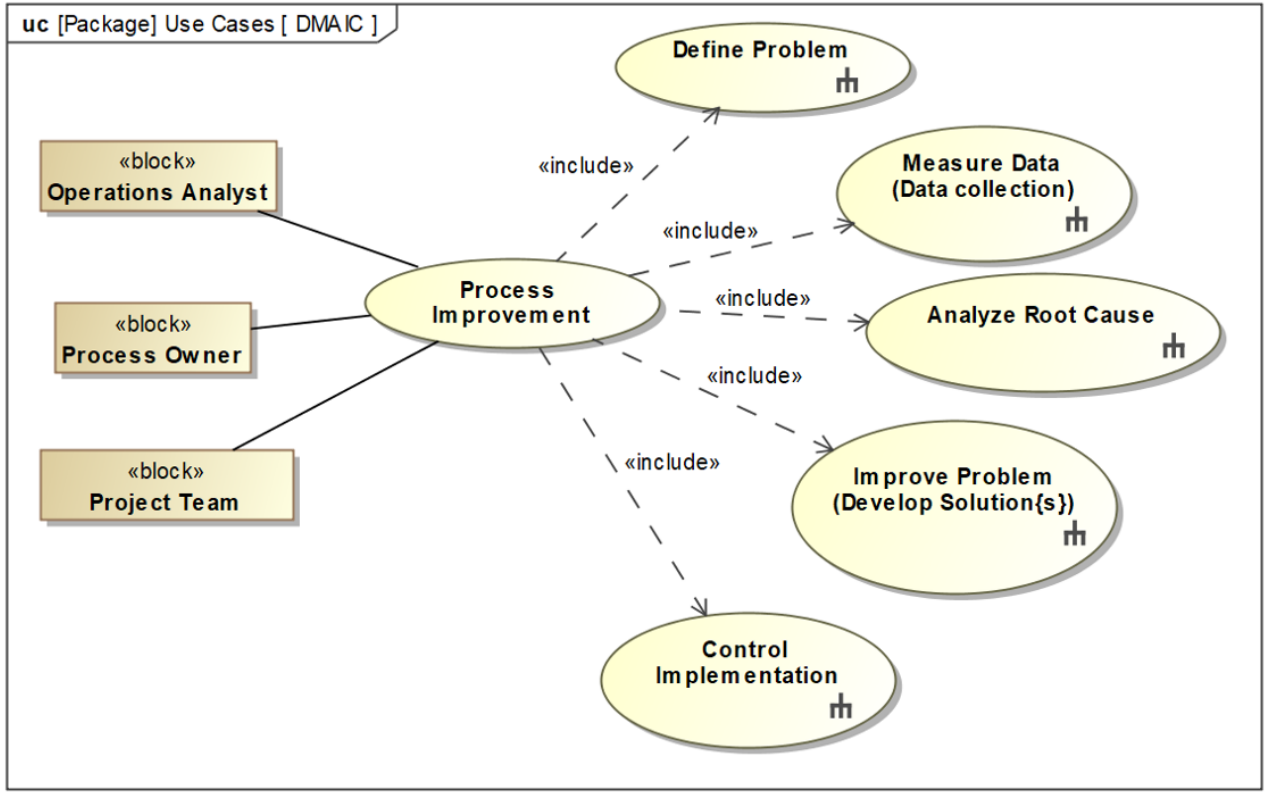
DMAIC Process – Use Case (Behavior)



- A Use Case diagram captures the contextual usage of the system of interest (the DMAIC process, in this case) and the actors involved
- Actors:
  - Operations Analyst
  - Process Owner
  - Project Team
- Included UseCases (DMAIC)
  - *Define* Problem
  - *Measure* Data
  - *Analyze* Root Cause
  - *Improve* Problem
  - *Control* Implementation



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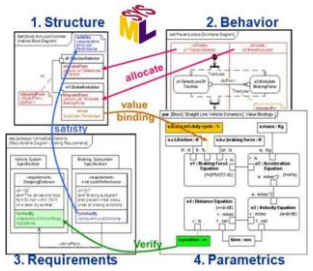
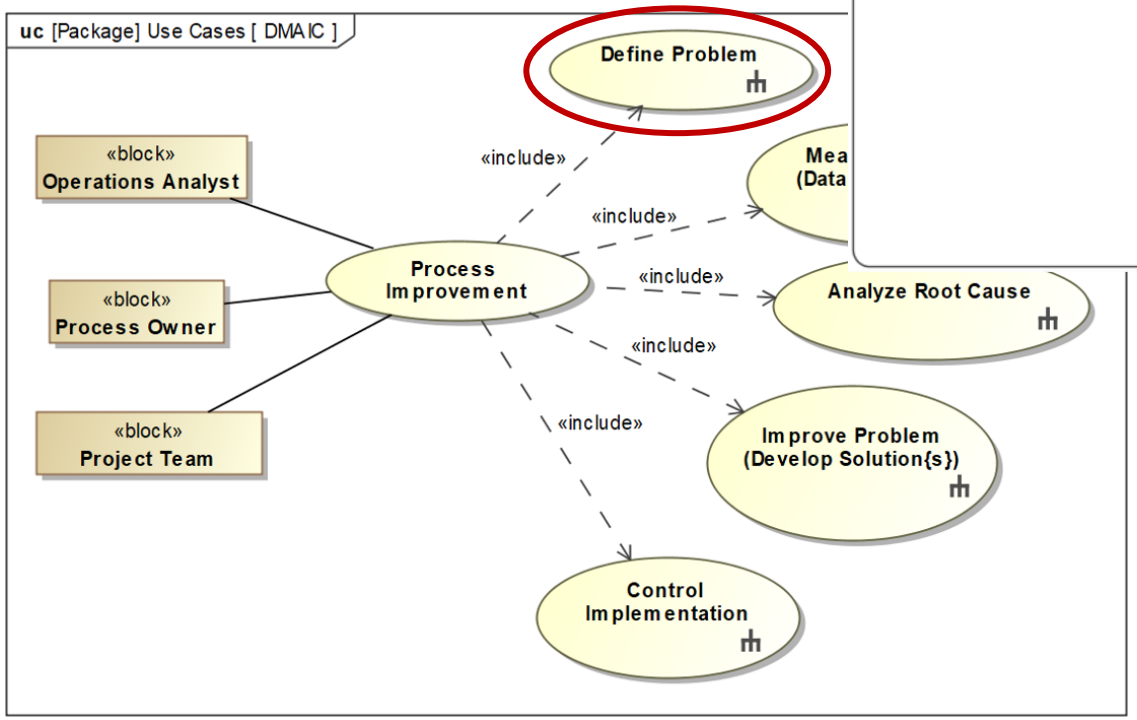
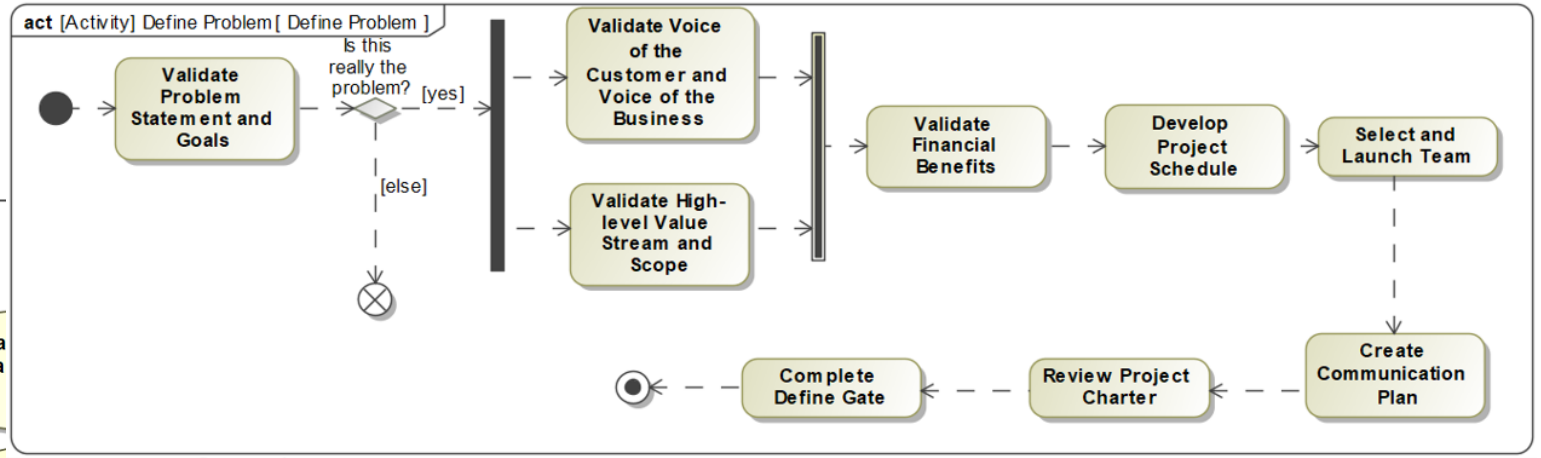
Define Problem – Scenario



- Modeling down one abstraction level, a UseCase's behavior is specified in a step-by-step scenario via a activity diagram





Shown above is the step-by-step scenario for Use Case "Define Problem" depicted in an activity diagram.

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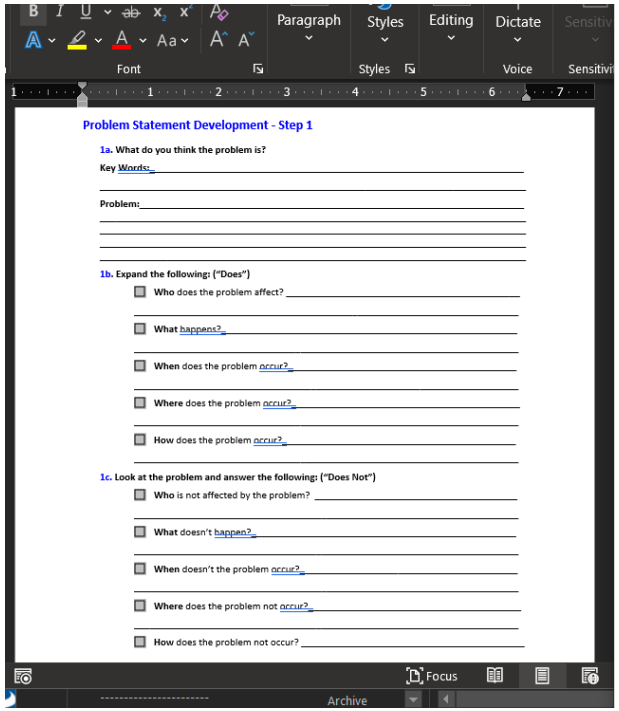
Traditional Problem Definition Artifacts



1. **Start** by writing your problem or the current state using the template provided on the next page. Don't worry too much about quality at this point - simply making a start is significant. Next, expand on your problem by asking: Who, What, When, Where & How. Now, re-write your problem statement based on those answers.

2. **The Second step** is the same as the first, but focuses on the desired Future State.

3. **The Third Step** is to combine your revised Problem or Current State and your desired Future State into a single statement. This might take a couple of attempts but stick with it. Finally, review your new problem statement against the following criteria:

   - Focused on only one problem.
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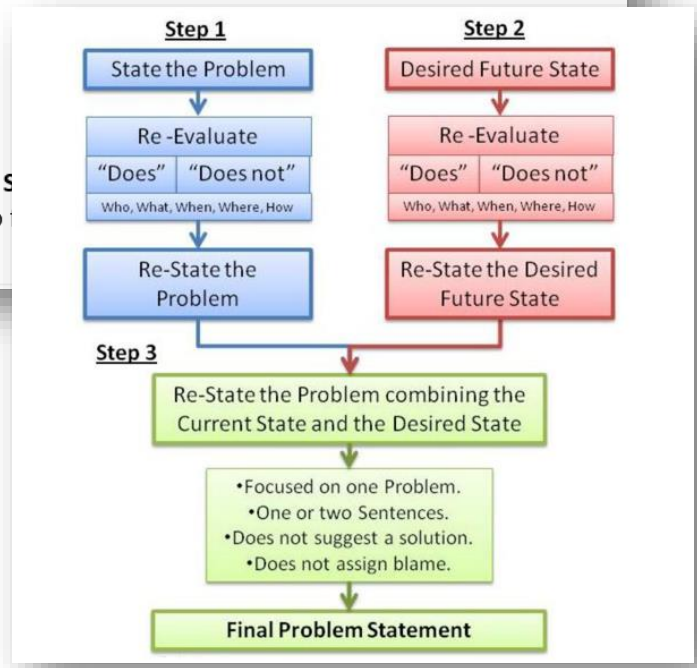

Shown here are the traditional templates that the Process Analyst would access, tailor, distribute to elicit assistance in defining the problem.

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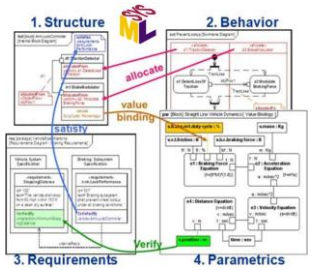
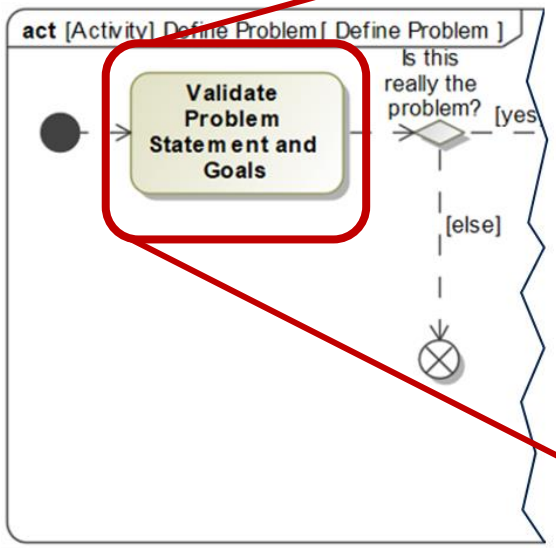
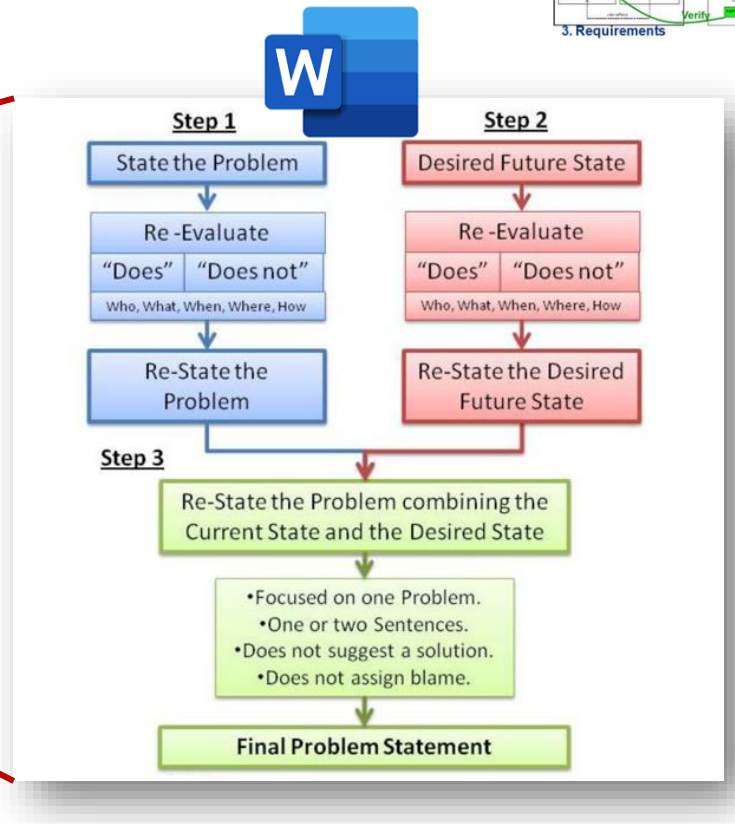
Modeling Traditional Artifacts



Making use of current artifacts to build this model, pedigree to the source material is maintained in the DMAIC process.

This pedigree validates that the model-based method covers all the same content as the document-based approach.





This looks almost like a SysML activity diagram, but the syntax must be corrected.

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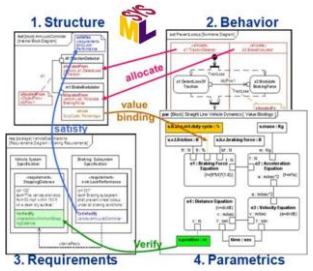
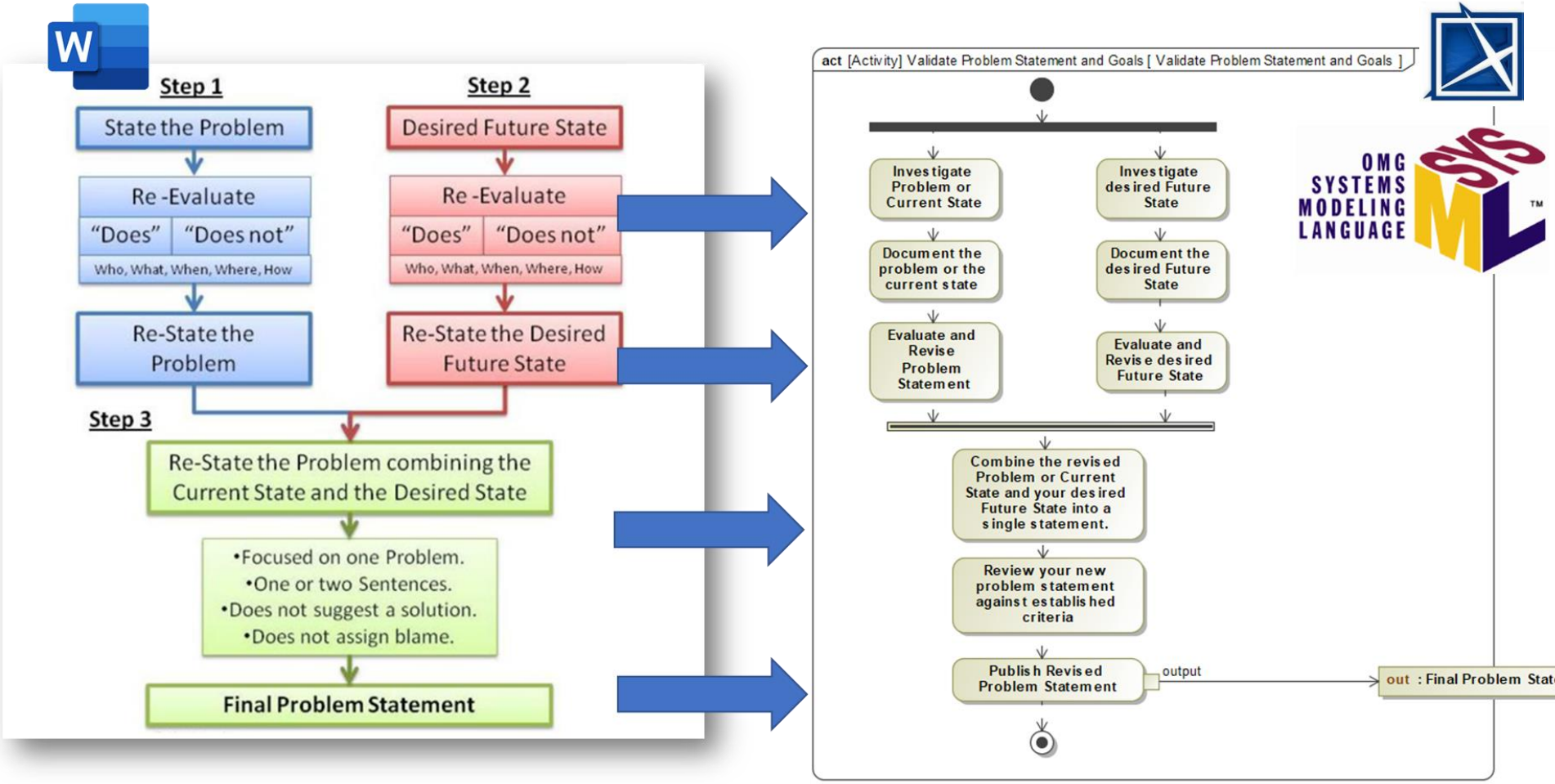
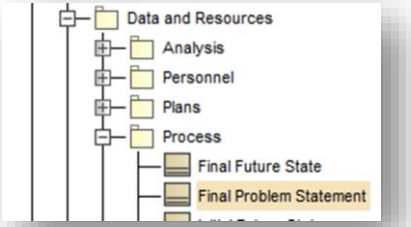
Modeling Traditional Artifacts – 2





Wording is modified to be more consistent with the syntax of an activity diagram "*action*".

Inputs/Outputs to the activity are modeled and data elements are captured.



The static graphic is transformed into a SysML activity diagram.

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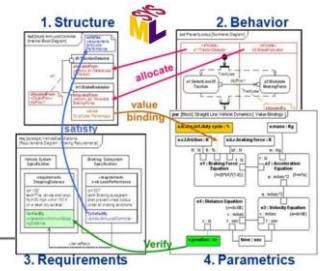
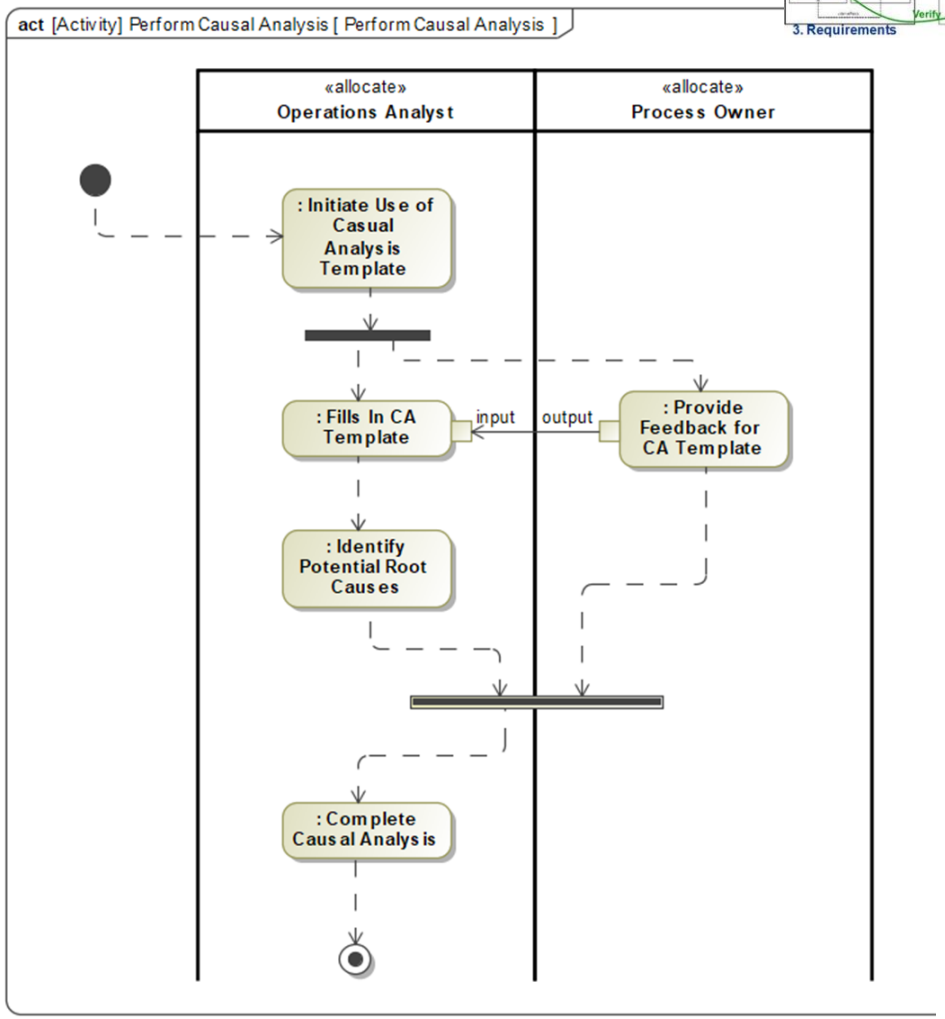
Action Allocation - Tasking



Actions are then allocated to the structure (organization roles) to establish clear responsibilities in tasking.

- Facilitates planning
  - Scheduling can be done in model
  - Tasking is clear and next step is laid out
- Actions can be given further specification at a lower tier diagram
- Necessary data (inputs) and deliverables (outputs) are established
  - Templates/Guidance in the model can be traceable to these data inputs/outputs
- Planning meetings can be run from the model



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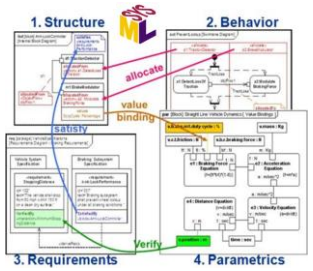
Guidance Encapsulation



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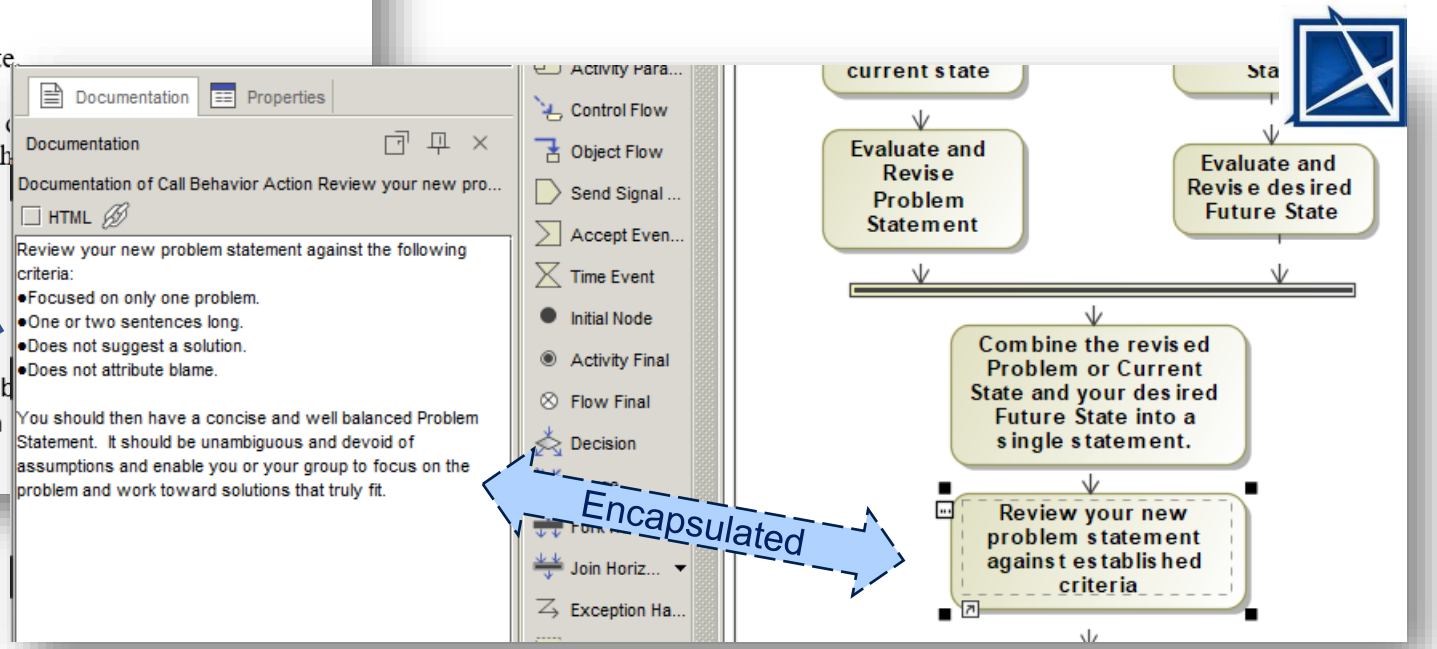

Additional guidance from previous documentation is also captured in the model, encapsulated in the model elements.

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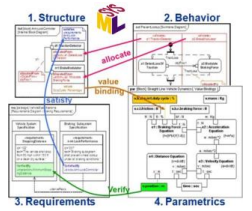
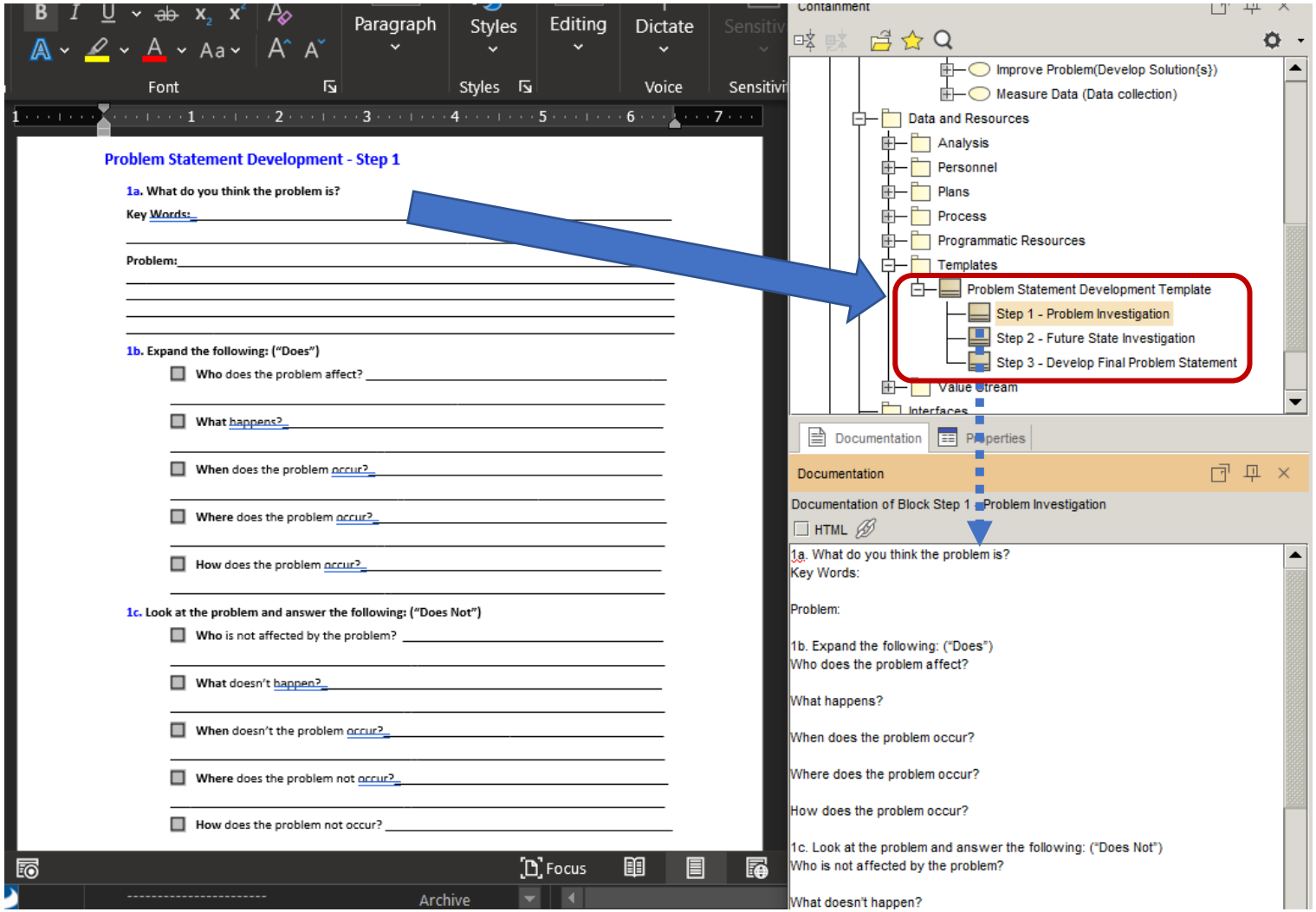
Template Encapsulation



- Templates can be embedded in a model
  - Various methods; shown method uses blocks for document structure
- Document Generation
  - Documents generated from model data
  - Maintains digital thread
  - Ensures pedigree to most current model

All process improvement material can be accessed and managed from one source of truth ***and*** the implementation of the process improvement activities can be documented.



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Model Based Six Sigma (MBSS) Framework

MBSS will allow organizations to:

- Maintain & demonstrate traceable accountability throughout the process improvement activity, resulting in customizable template for program management to implement.
- Facilitate SoS management with *federated models* within the MBSS framework
    - Contains problem/focus area identification and program data, to be used to measure statistical shifts and determine whether or not improvements have been made from a quality assurance perspective.

Data from the model will produce the traceability and relationships required to analyze relevant processes and expose opportunities for waste reduction within those processes.

System capability improvements alongside optimal waste reduction activities will be identified and documented for future front-end assessment.

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Accomplishments

- Supports proposed digital thread initiative by removing silos separating the Six Sigma facilitator, process owner, and team members.
- Establishes traceable thread throughout the structured improvement activity
    - This is a key part of this research that encapsulates the importance of a non-document centric approach.
- As waste scenarios are documented, continuous gathering of metrics can be used to assess improvements as well as empirically verify that waste has been reduced

Because of this effort, organizations can be equipped with the tools necessary to fully identify, document, and mitigate relative waste scenarios that each traditional process can unknowingly generate.

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Future Work

- Projected future improvements include
- creation of a more robust model including process improvement activities outside of Engineering and Technology organizations
    - Examples: Human Resources & Information Technology

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Backup Slides

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Digital Strategy

- Promotes the use of digital representation (e.g. modeling) as technical means of communication with diverse set of stakeholders
- Addresses acquisition, procurement, and innovations in the way we build, test, field and sustain systems.
- Digital Transformation
    - Through Digital Transformation, specifically MBSE platforms (i.e. Cameo, 3DX, etc.), multiple teams can engage and act, using relevant procedures involved in the capture, investigation, determination, and disposition of suspect materials.

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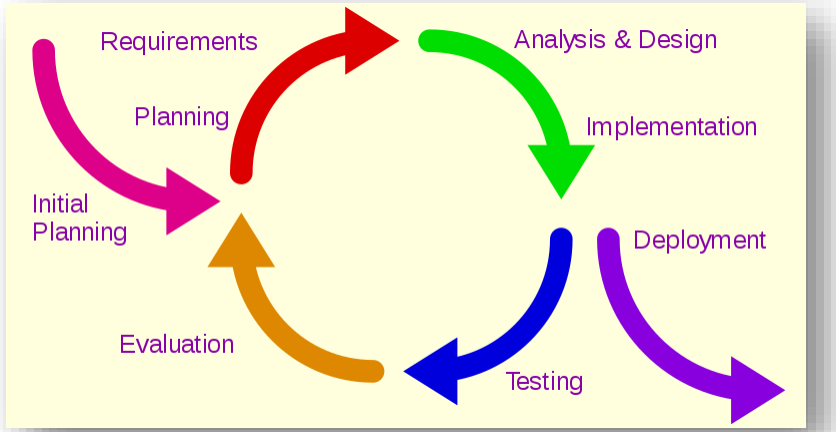

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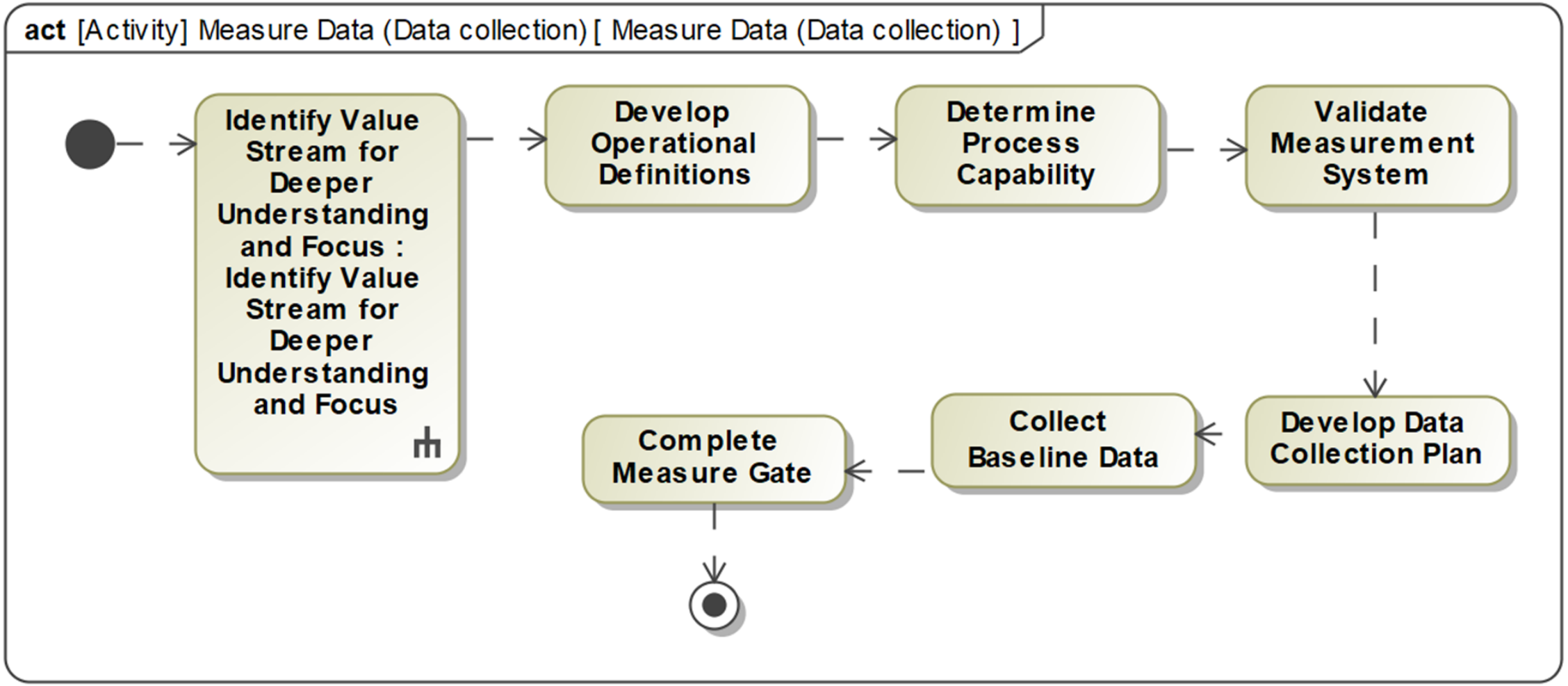

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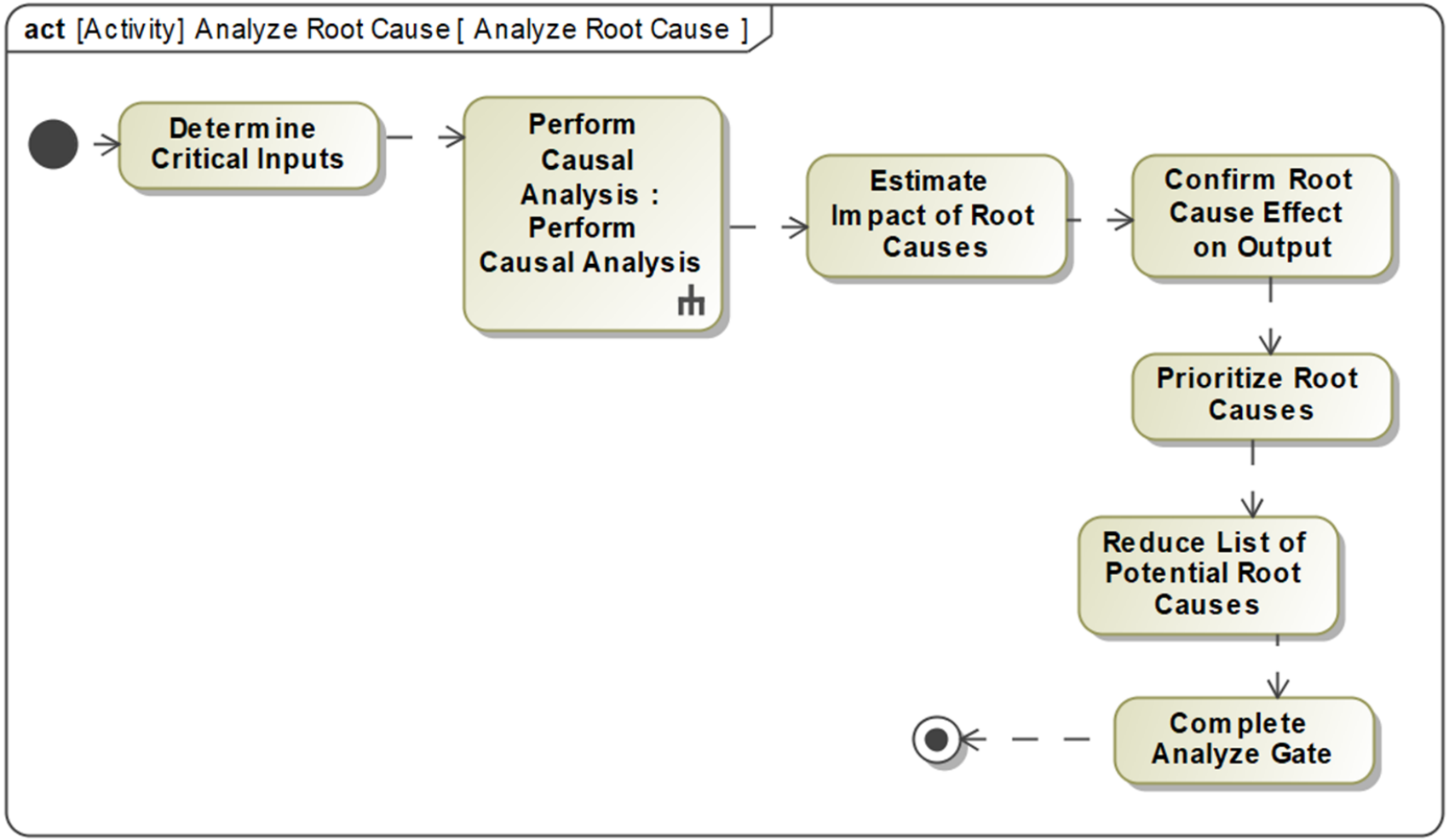

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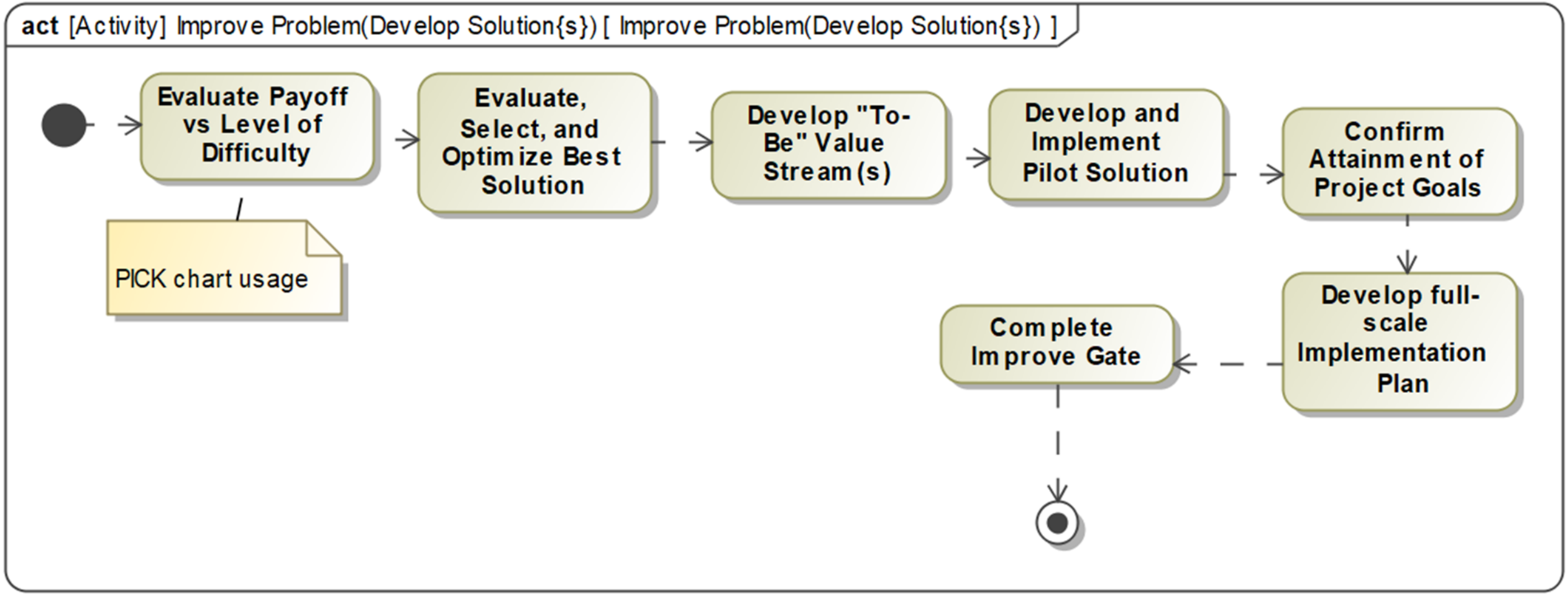

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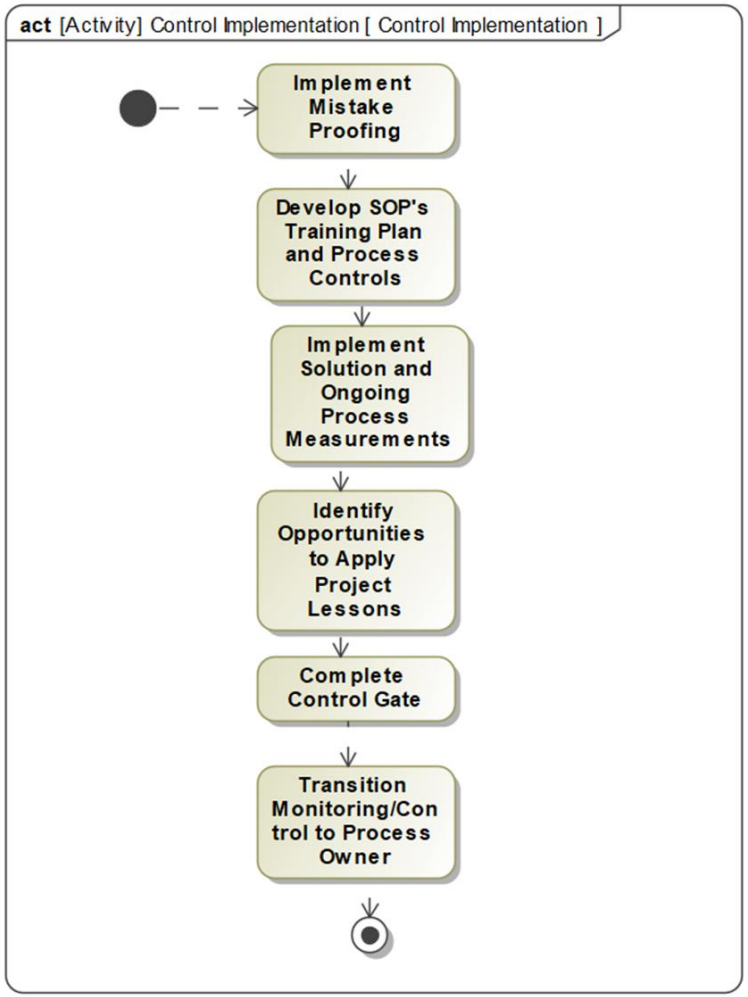

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