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Agile Dynamics at Scale
A MITRE Innovation Program Research Project

NDIA 20th Annual Systems Engineering Conference

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Outline

- Project Description
- Modeling Agile Dynamics at Scale
- Simulating a Real Project

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Project Description

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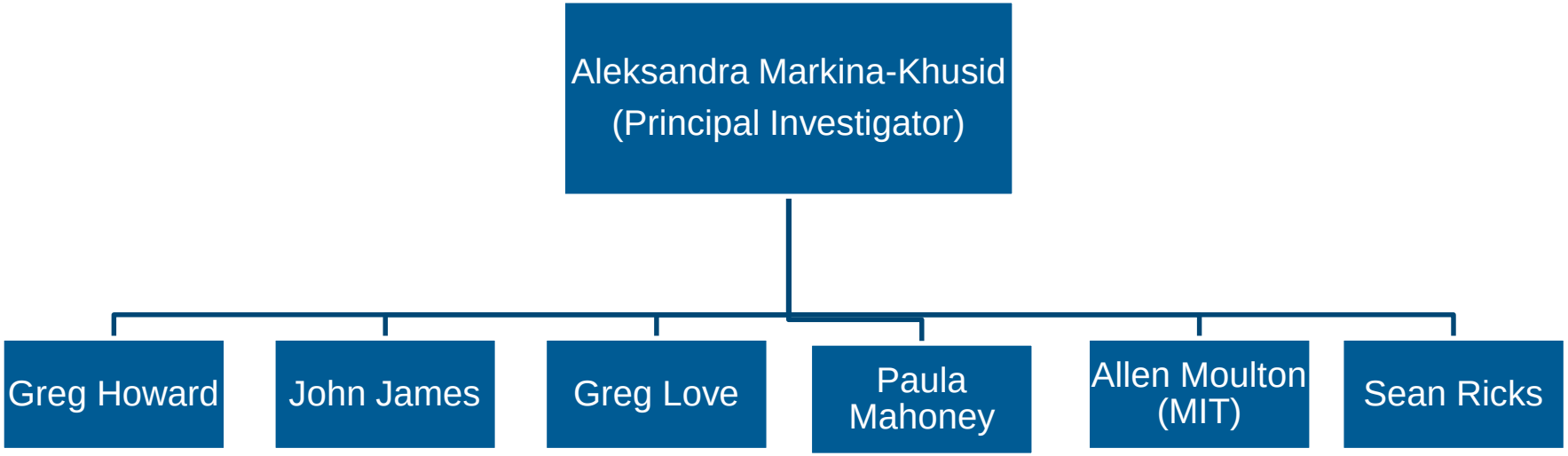
Team Members
A joint MITRE-MIT Research Project



Lean-Agile Methods

Systems Dynamics, Modeling and Simulation

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Goals

1. **Use modeling to study how scaled Lean-Agile methods would enable Agile software development to integrate into a heavily plan-driven and risk averse enterprise such as the Air Force and DOD.**
2. **Perform virtual experimentation with scaled Lean-Agile methods by capturing those methods in a model (or models).**
3. **Provide expanded knowledge about Lean-Agile and a virtual experimentation resource for use by MITRE staff in engagements.**
4. **Develop a baseline for a model that can enable MITRE staff to test alternative management structures on projects they support.**
5. **Build a model that can make relative projections, not precise predictions.**
   - The models built in segments to test hypotheses but with a plan for integration at a later point. Each segment will provide value and contribute to Goal #1.

Perspective User Stories

- **Program Systems Engineer**

  Systems engineers use models to define, understand, communicate, assess, interpret, and accept the project scope; to produce technical documentation and other artifacts; and to maintain "ground truth" about the system(s).

  - DoD Acquisition Modeling And Simulation Working Group

  – As a Program Systems Engineer I need to understand the engineering variables* and trades in order to develop the Program's Systems Engineering Plan (SEP).

  – As a Program Systems Engineer and given a SEP, I need to identify risk and opportunities.

  The Agile Genome
  1. Story/feature driven
  2. Iterative-Incremental
  3. Refactoring
  4. Micro-Optimizing
  5. Customer Involvement
  6. Team Dynamics
  7. Continuous Integration

- **Acquisition and Program Manager**

  – As a Program Manager I need to understand the SE variables impact on cost (development cost curve).

  – As a Program Manager I need to understand the SE variables impact on schedule (backlog burn down and project end).

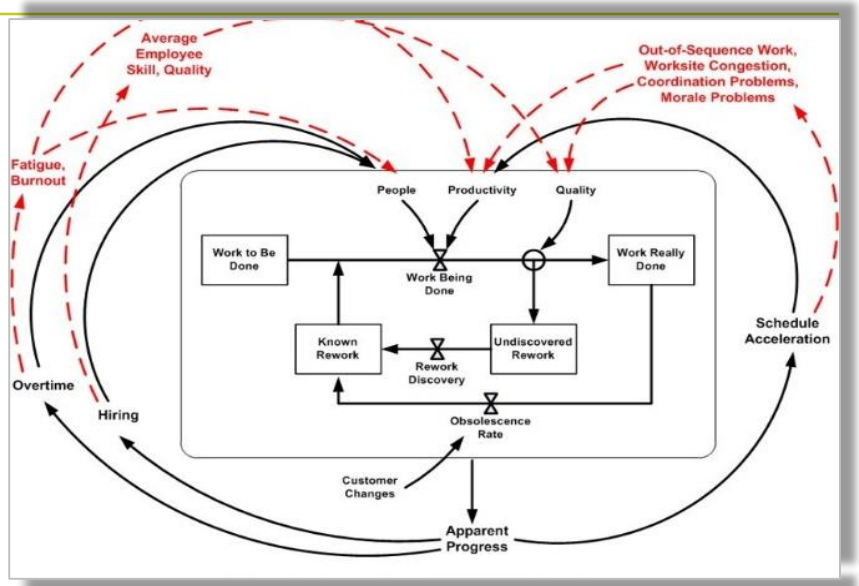
  – As a Program Manager I need to understand the SE variables impact on performance (defect rate).

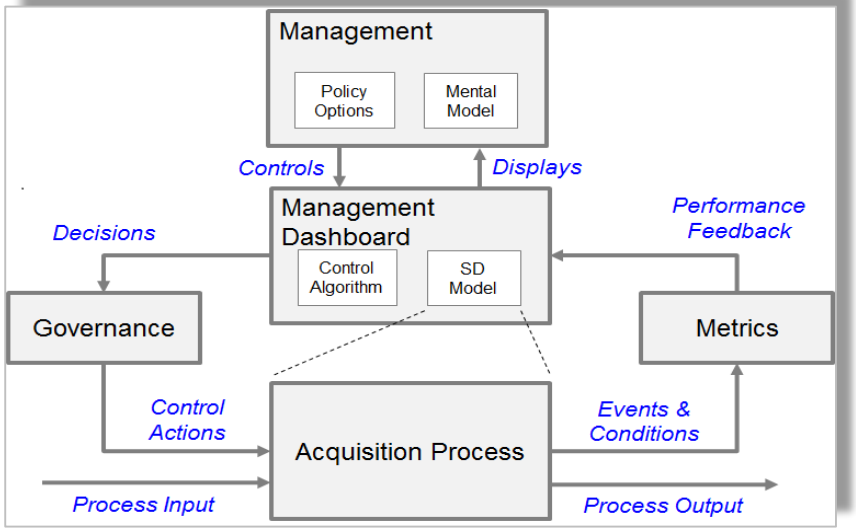
  – As a Program Manager I need to understand the impact on cost, schedule and performance when introducing new technology into the agile development cycle.

Research Idea

Decision Support for Acquisition Professionals and Managers

- **Model the dynamics of Lean-Agile methods for large scale efforts on:**
  - Program acquisition
  - Project management
  - Systems development
- **Incorporate range of structural cause-and-effect feedback loops and factors that drive nonlinear project behaviors that impact:**
  - Cost, Schedule, Performance
  - Risk
  - Value delivery
- **Provide dashboard tools:**
  - Predictive analytics for acquisition outcomes
  - Exploration of policy and governance options





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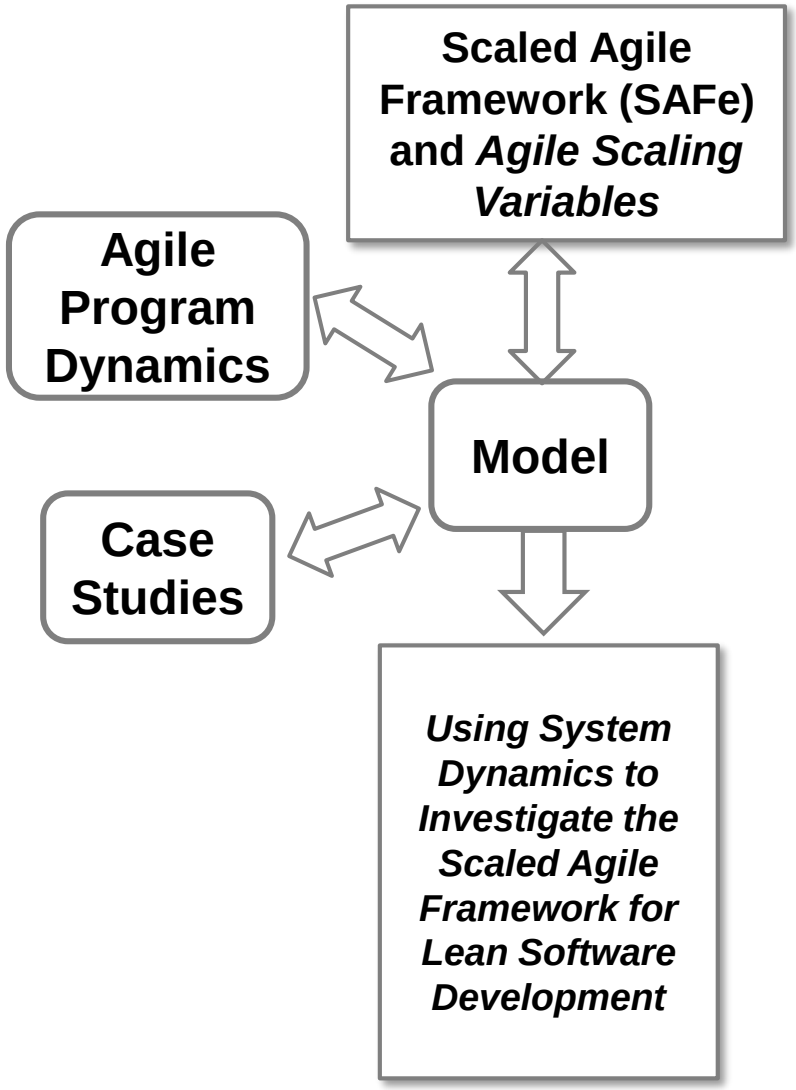
Research Methodology

- **Builds on MIT Agile Program Dynamics model (APD)**
  - Modeled an Agile Team
  - Models **Undiscovered Rework** – a decline in quality not immediately recognized that eventually adds **to Known Work**
- **Adding SAFe and the *Agile Scaling Variables* representing Lean-Agile principles, methods and practices.**
- **Model is validated/updated with case study real world results**
  - Case studies provide and highlight the areas of modeling
- **Show that adjusting variables produce expected effects**
  - Find unexpected behavior
- **Model provides source for conference papers**



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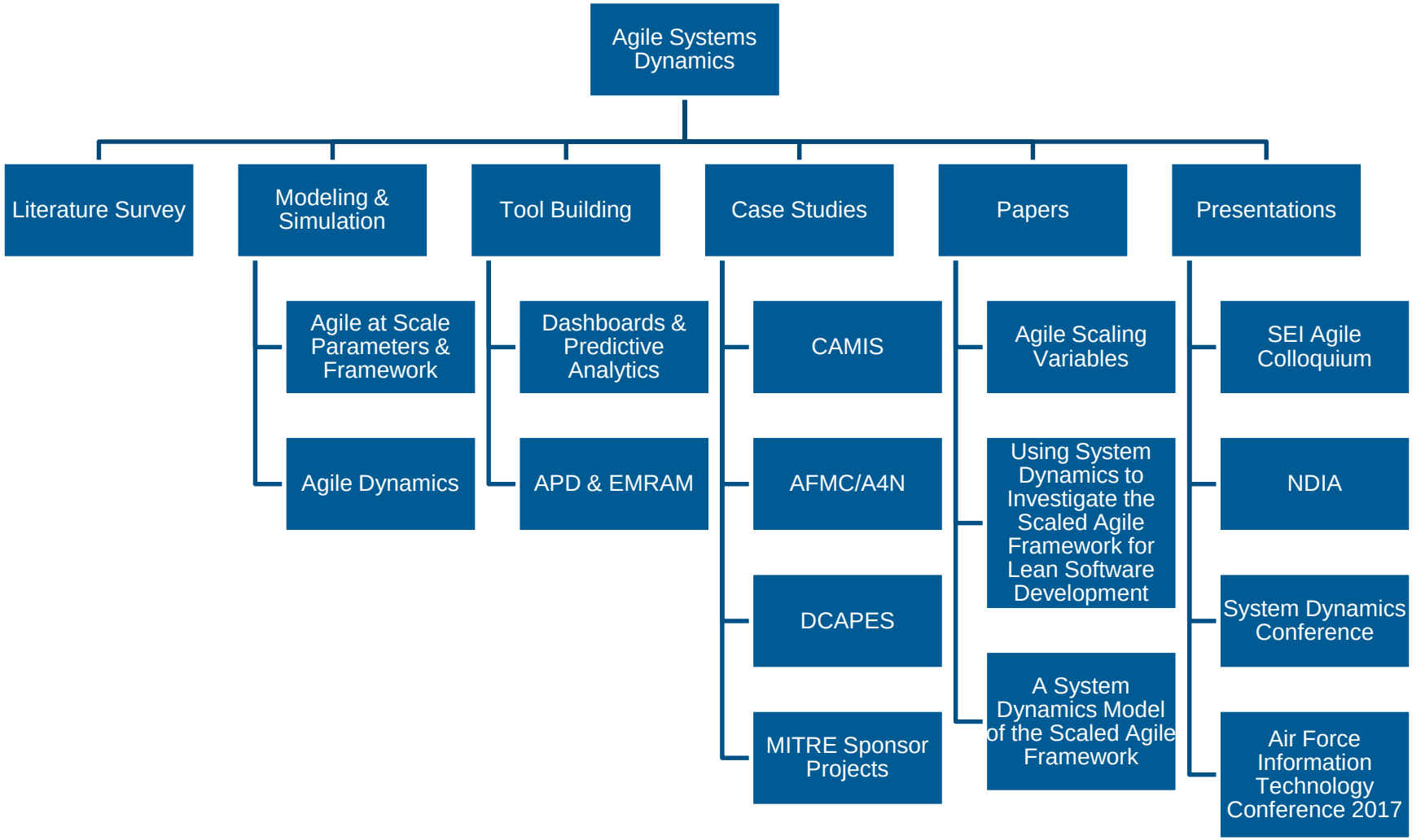
Project Structure



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Modeling Agile Dynamics at Scale

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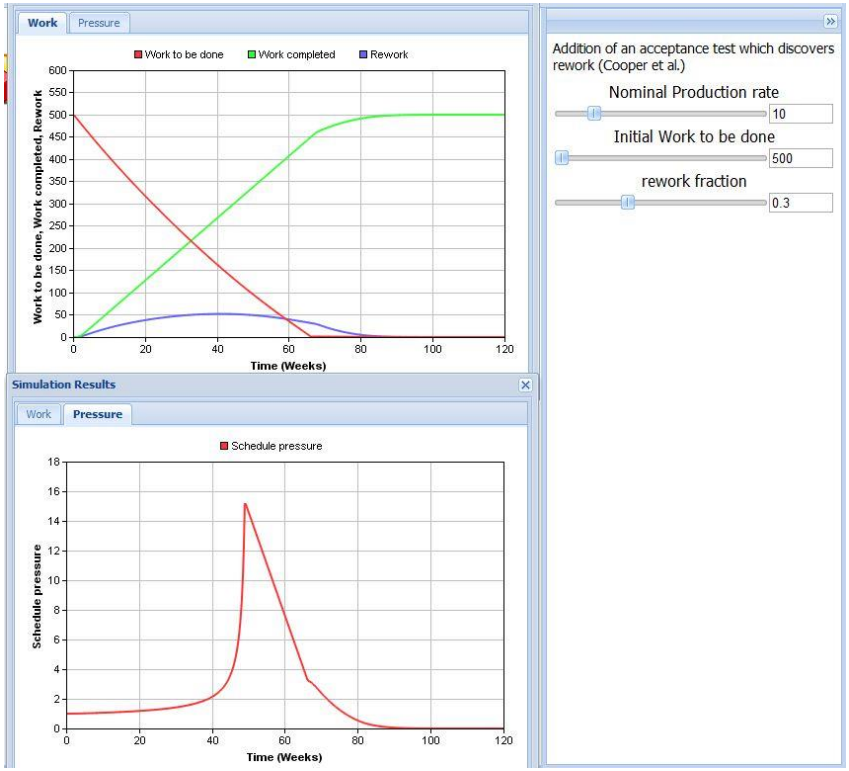
Purpose

- **The rate of work completion depends on…**
  - Team size
  - Number of teams
  - Team experience
  - Sprint duration
  - Number of sprints per Program Increment (PI)
  - Automated testing
  - Frequency of demos
  - Continuous Integration (CI)
  - Etc.



Provide a tool to identify important dynamic relationships and trends and facilitate a conversation on process improvement.

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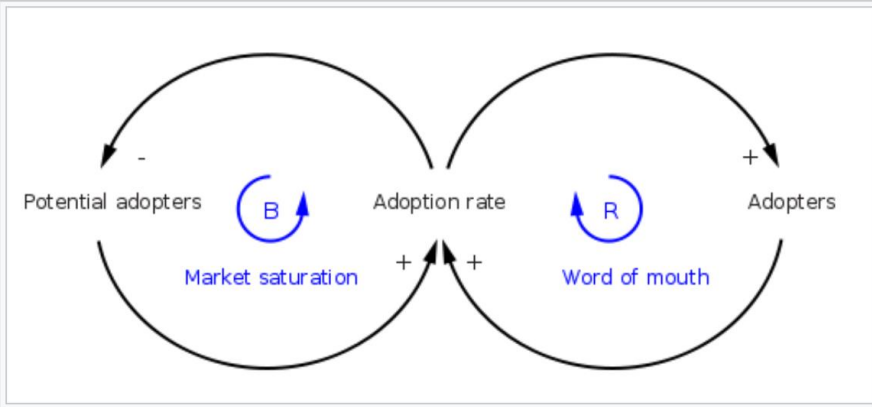
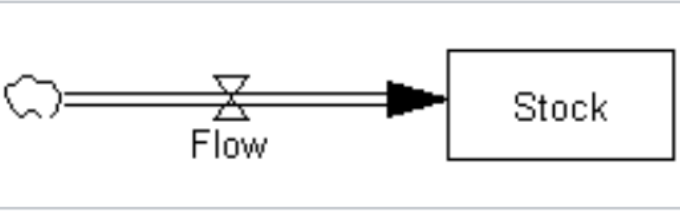
Systems Dynamics

- **A method to understand the dynamic behavior of complex systems**
- **A system's behavior is determined by:**
  - Individual components, and
  - ***The many circular, interlocking, sometimes time-delayed relationships among components***



Causal loop diagram of *Adoption* model, used to demonstrate systems dynamics

The causal loop diagram visualizes how different variables in a system are interrelated



A flow is the rate of accumulation of the stock

Source: Wikipedia

System Dynamics

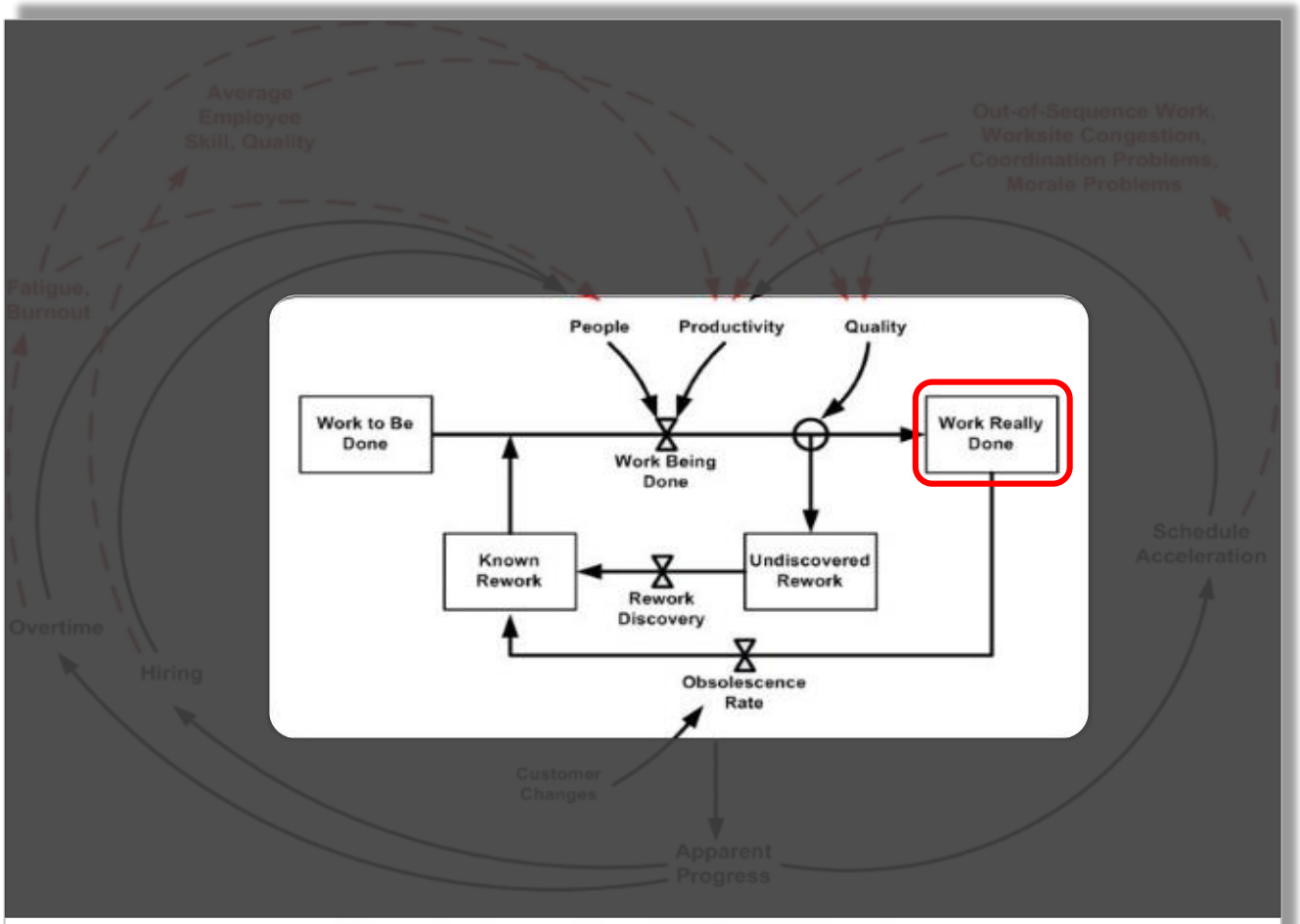
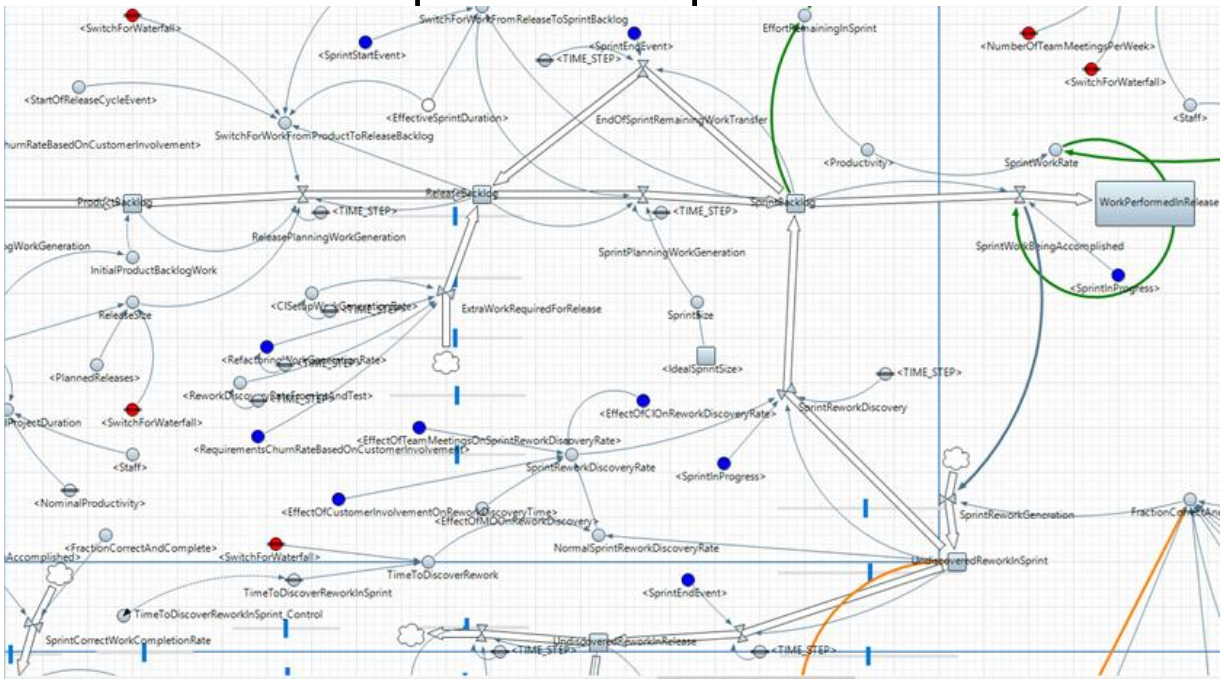


Figure 2 - Some Sample Project Dynamics

Source: Wikipedia

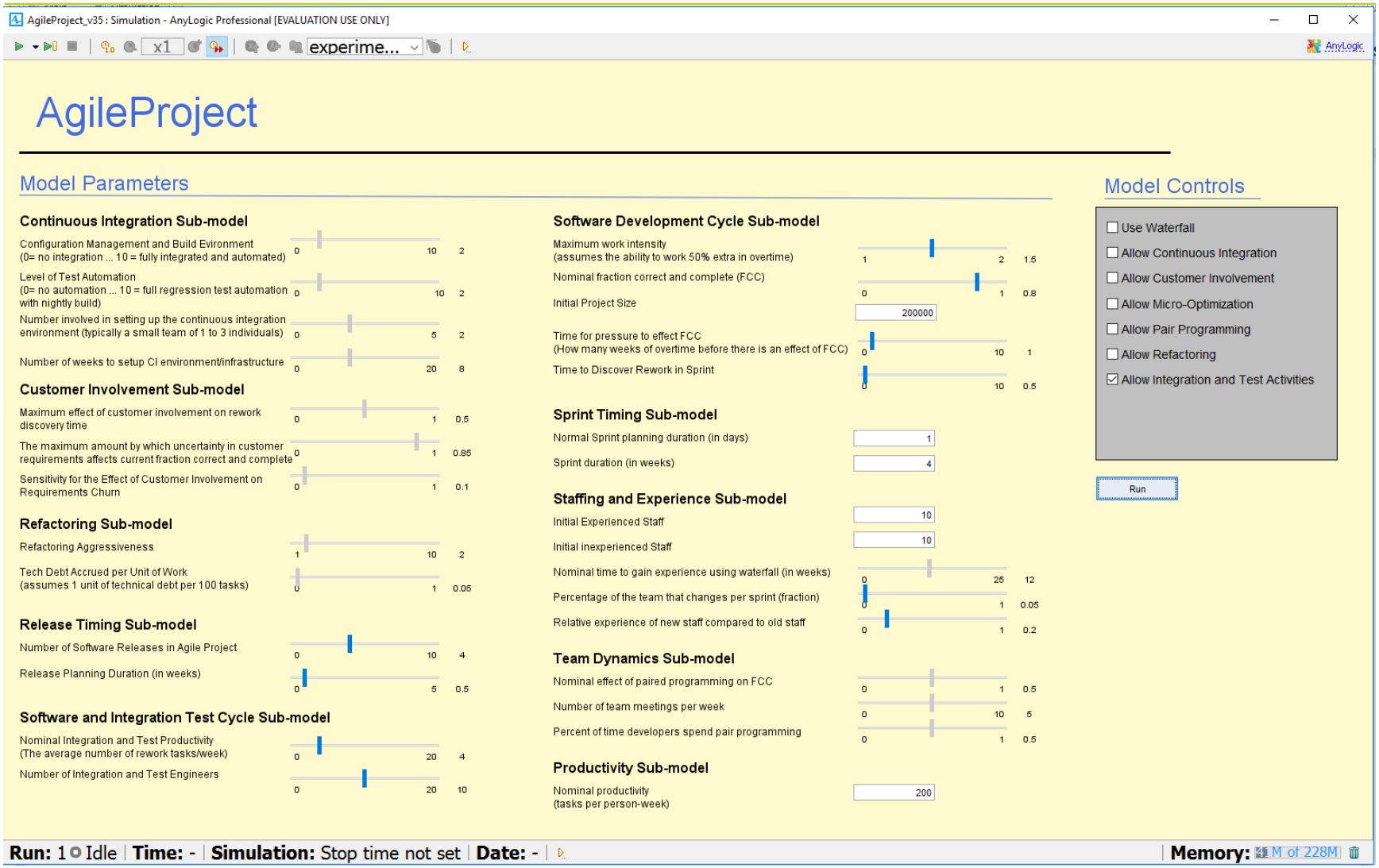
Prior Work

- **Agile Project Dynamics:**
  - MIT effort, Firas Glaiel
  - Model of a single agile development team
  - Product > Release > Sprint > Completed



Glaiel, F. (2012). Agile Project Dynamics: A Strategic Project Management Approach to the Study of Large-Scale Software Development Using System Dynamics. Unpublished MIT SDM Thesis. Working Paper CISL# 2012-05.

Prior Work



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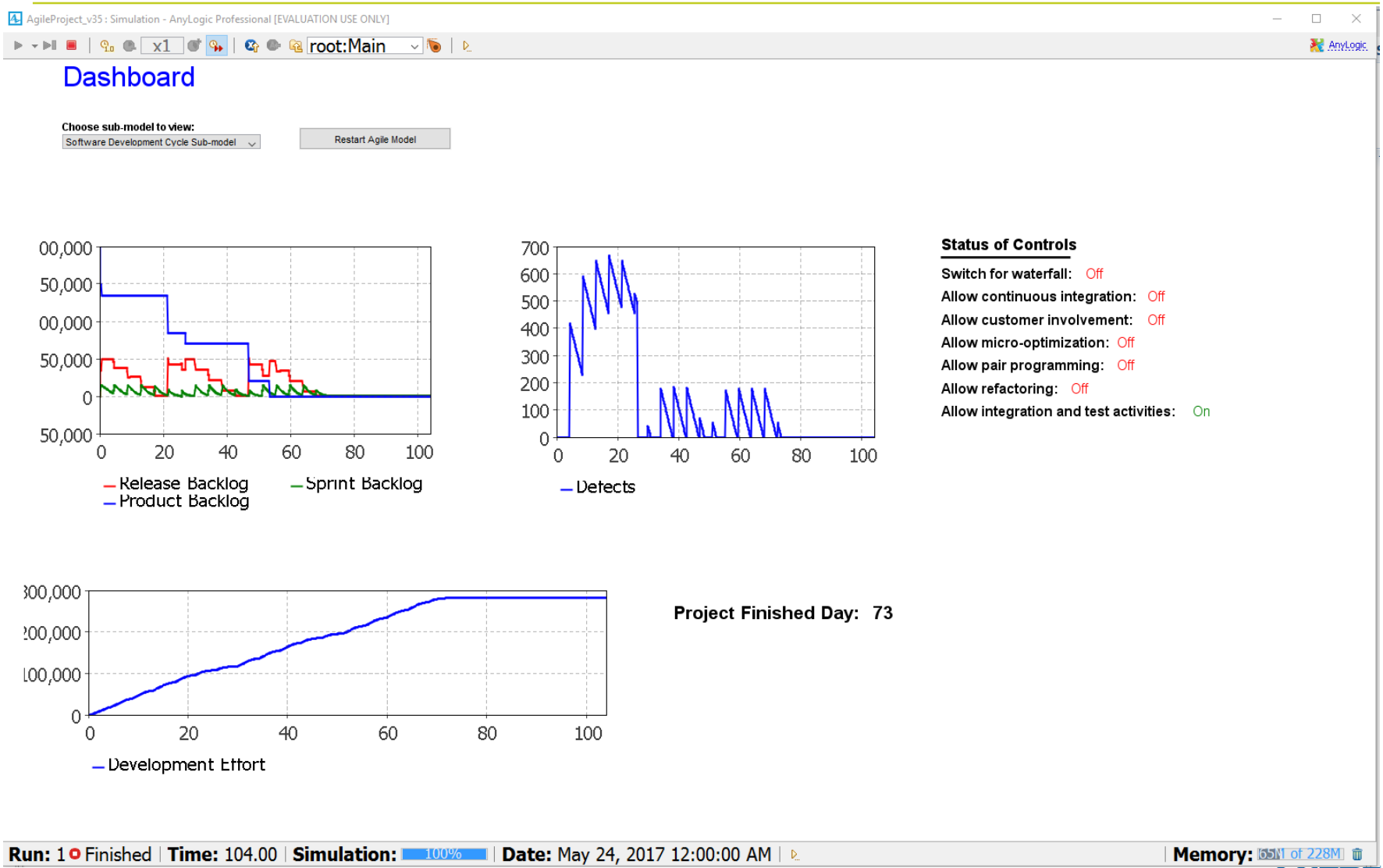
Prior Work



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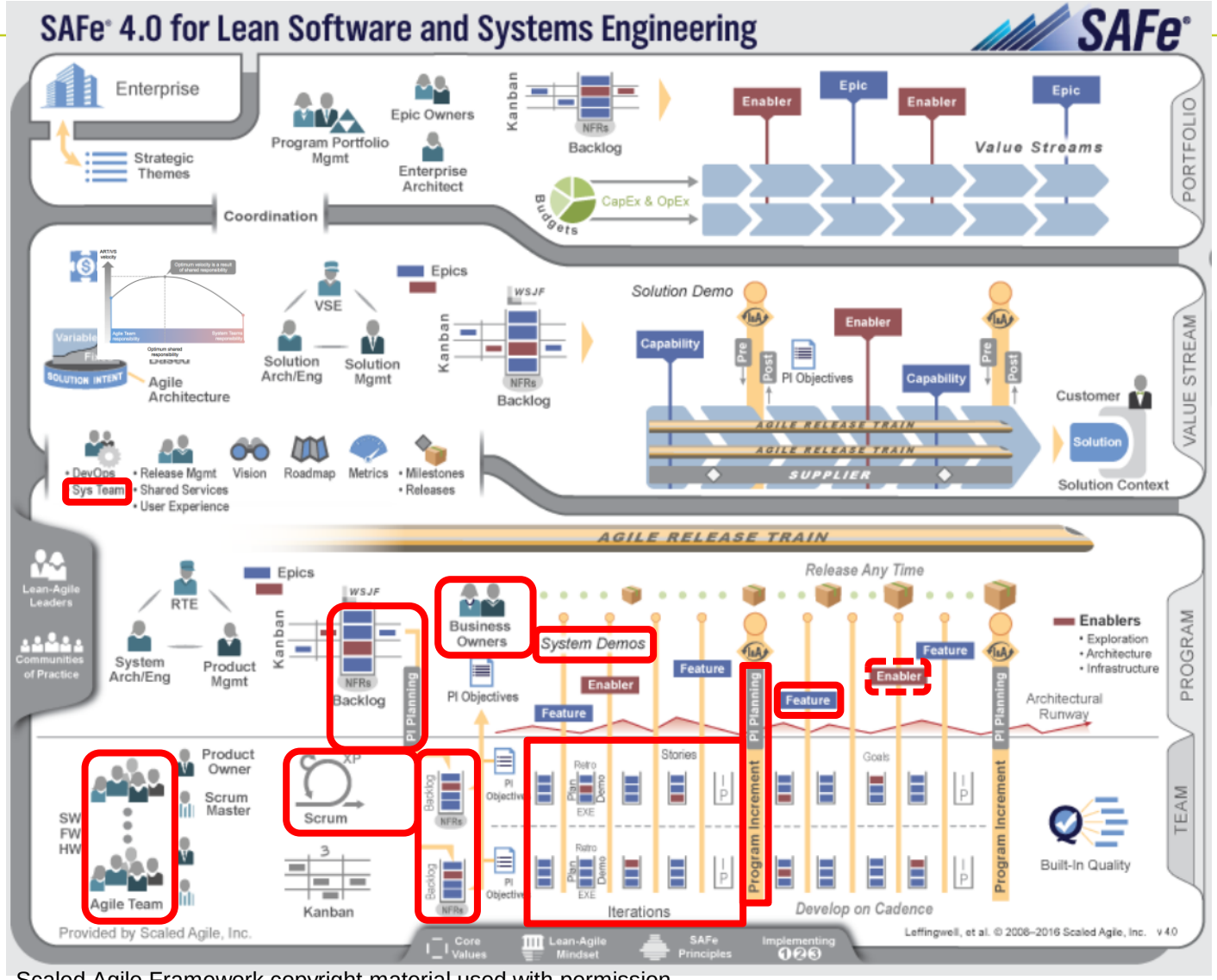
Our Work

- **Applied to Scaled Agile Framework (SAFe)**
- **Higher level dynamics of team interactions**
- **Extended development cycle to include integration and demos**
- **Distinguish between different types of rework**
  - Defects
  - Integration errors
  - Requirements errors

SAFe Elements



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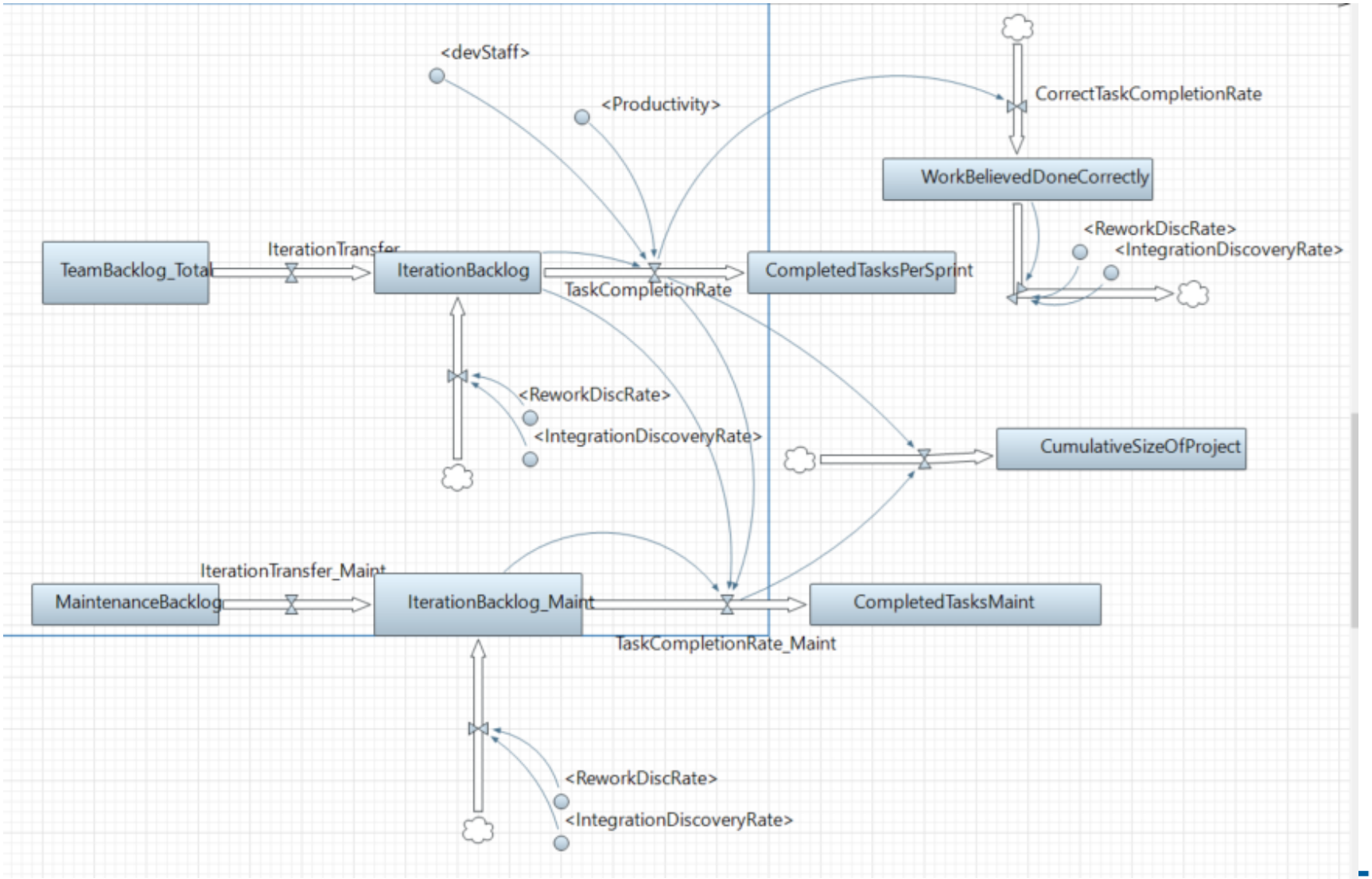
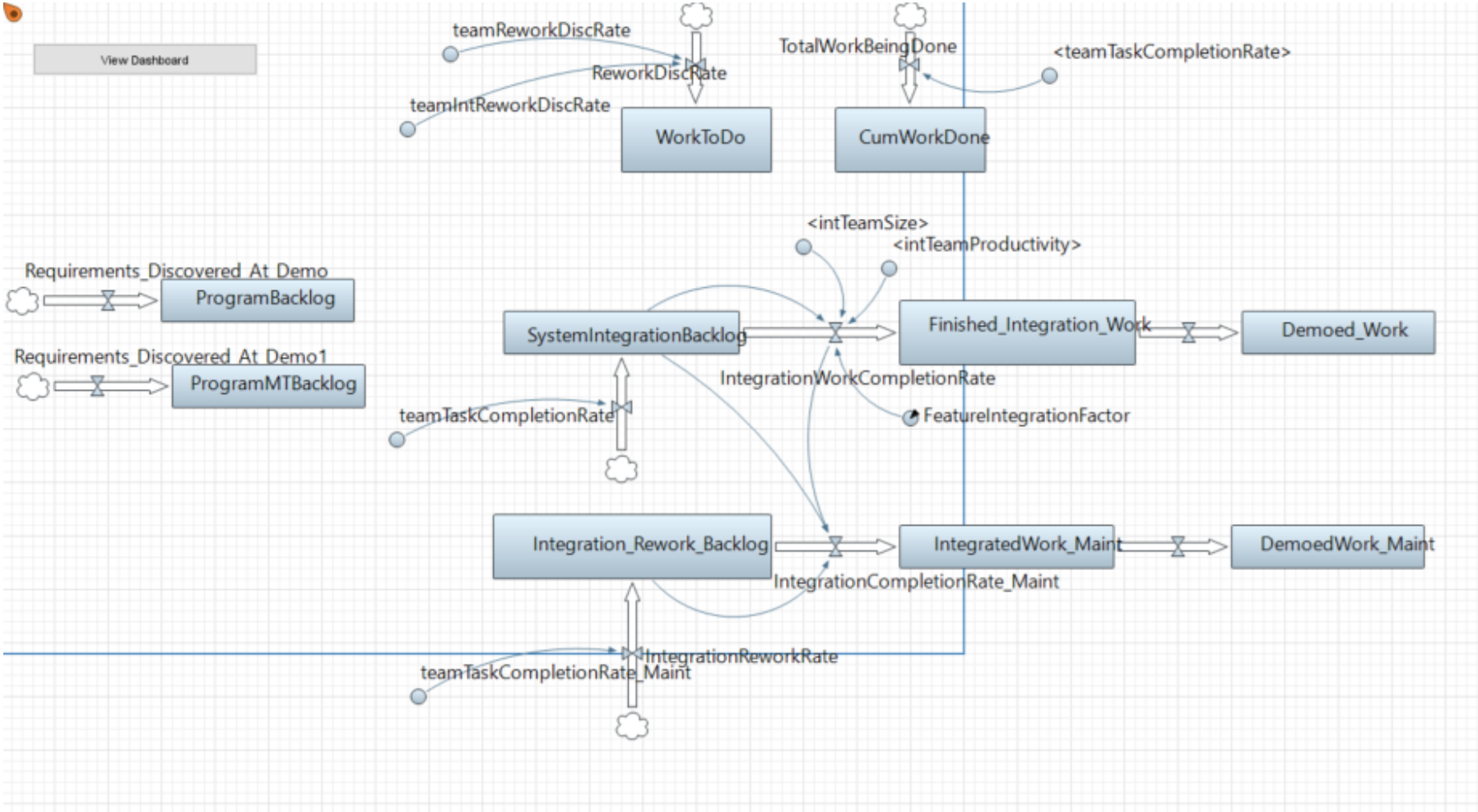
Team Work



Program Work



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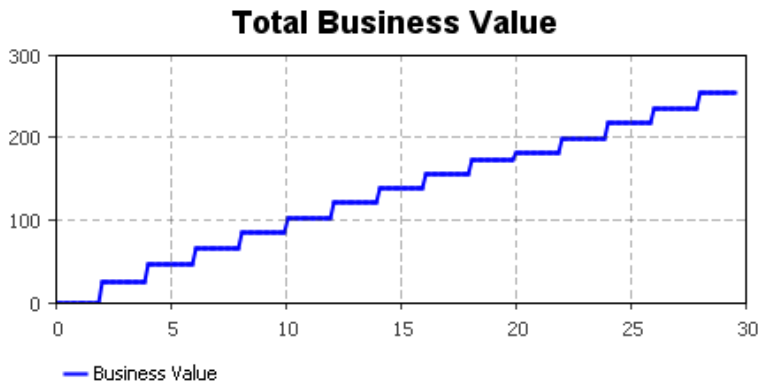
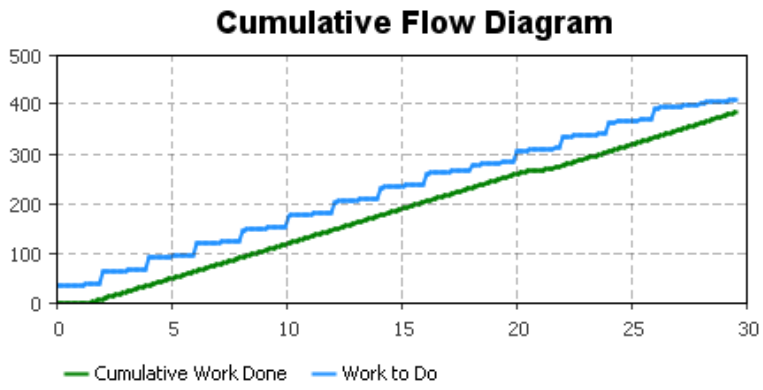
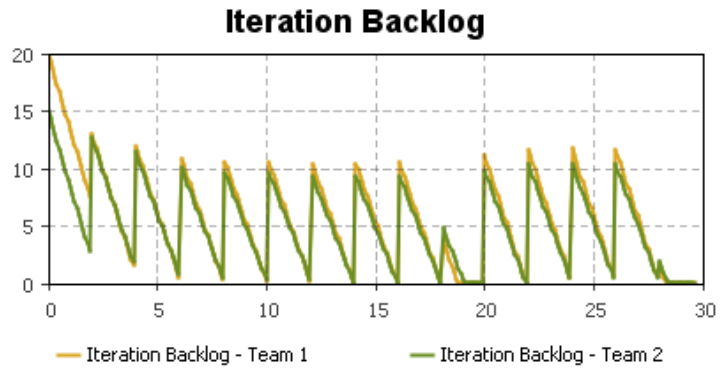
Output

View Model







Team 1

Team 2

Simulating a Real Project

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Case Project Description

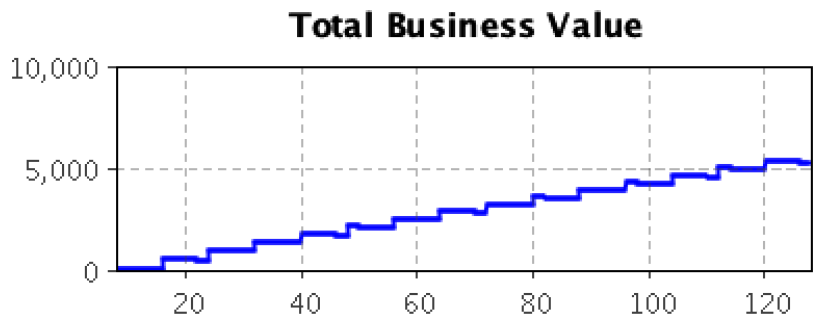
- **Tailored from SAFe 2.0**
  - Most team and program elements
  - 4 development teams
  - 2 weeks per Sprint, 4 Sprints per Program Increment
  - No enablers
  - No dedicated system team, continuous integration
    - The 4th Sprint is used as a development buffer and a time for development teams to do testing and integration work
- **Observations**
  - Large amounts of defects discovered in Sprint 4 leading to delays, cutting into planning sessions, and creating carryover problems for the next Sprint

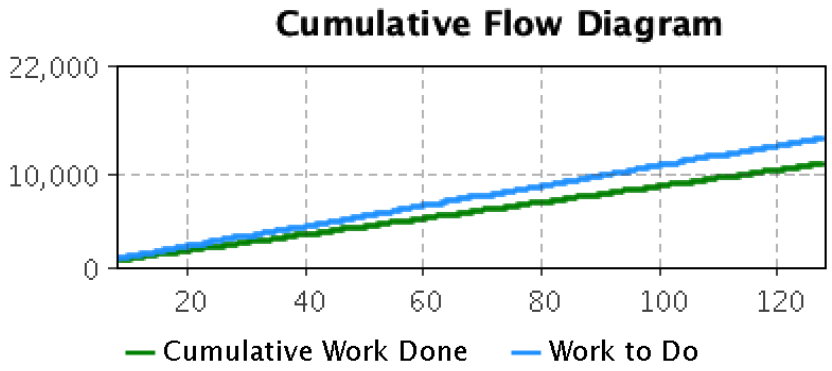
Simulation Description

- **Without CI (baseline)**
  - 4 dev teams of 10 each
  - No dedicated system team
  - 4 * 2-week Sprints per PI
  - Developers do integration during 4th Sprint
  - 16 PIs simulated
- **With CI**
  - 4 dev teams of 9 each
  - Dedicated system team of 4
  - 4 * 2-week Sprints per PI
  - All Sprints used for development
  - 16 PIs simulated

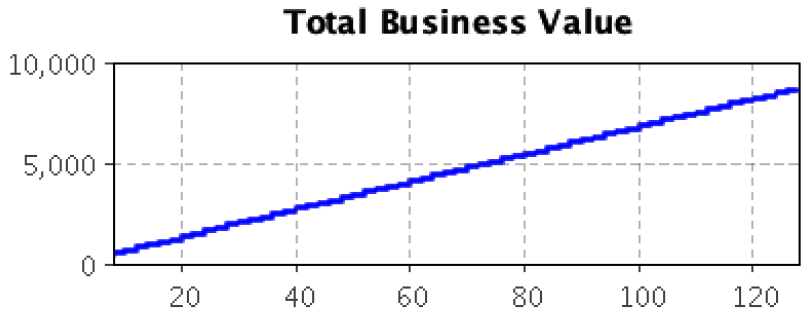
Results

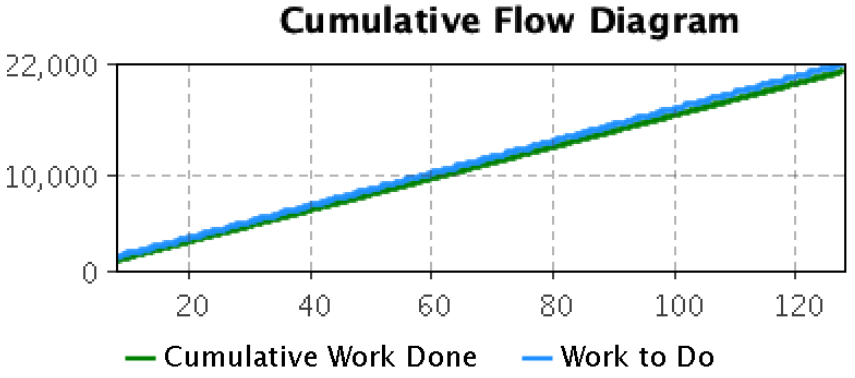
- **Without CI (baseline)**





- **With CI**





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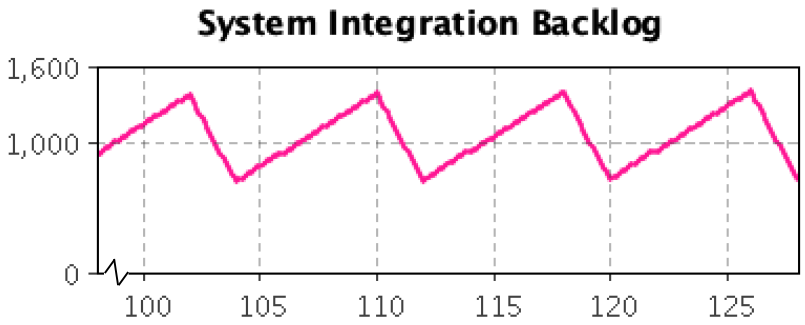
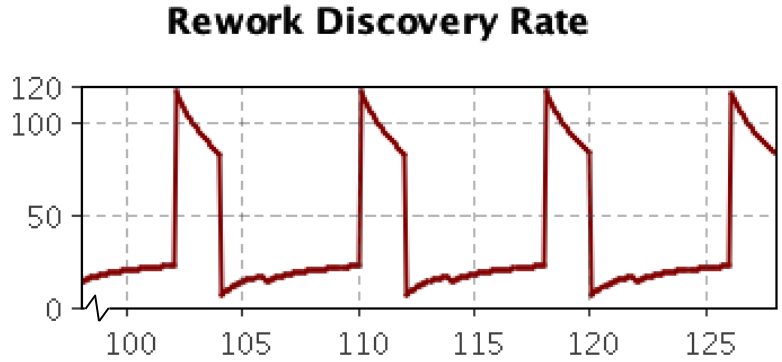
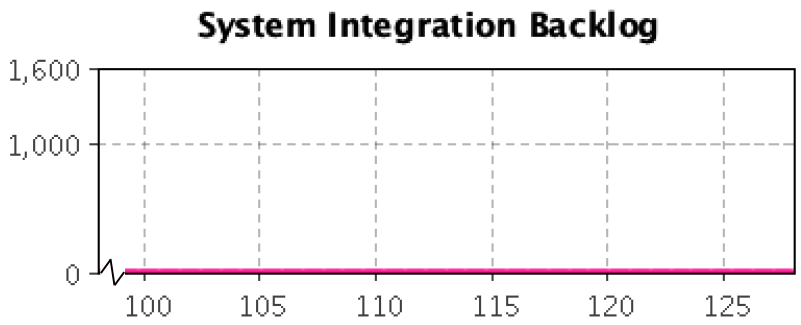
Results

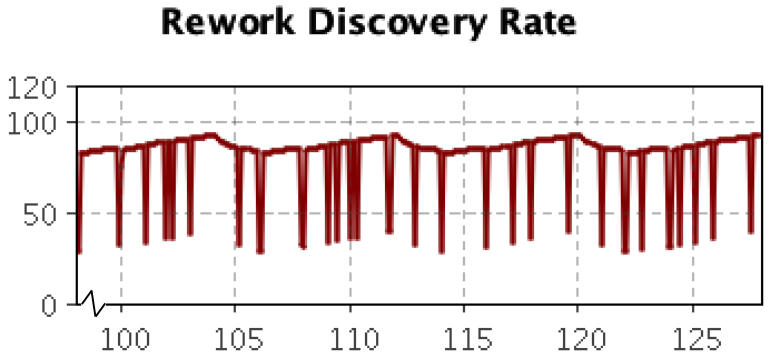
- Without CI (baseline)





- With CI





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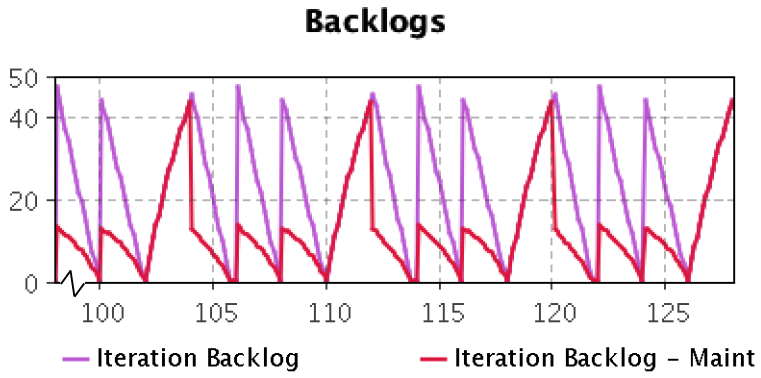
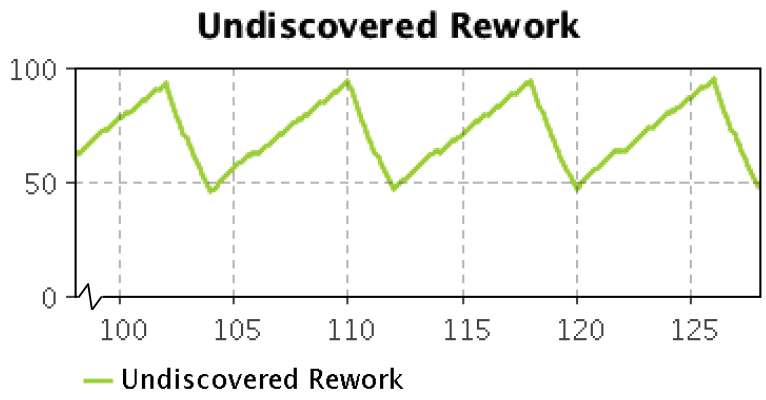
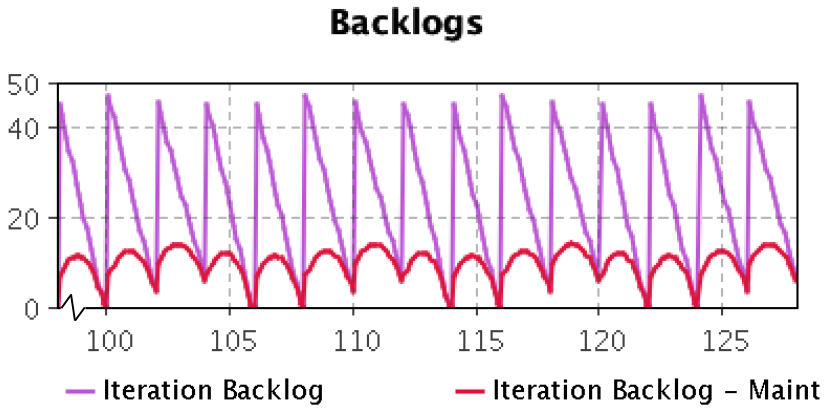
Results (Team 1)

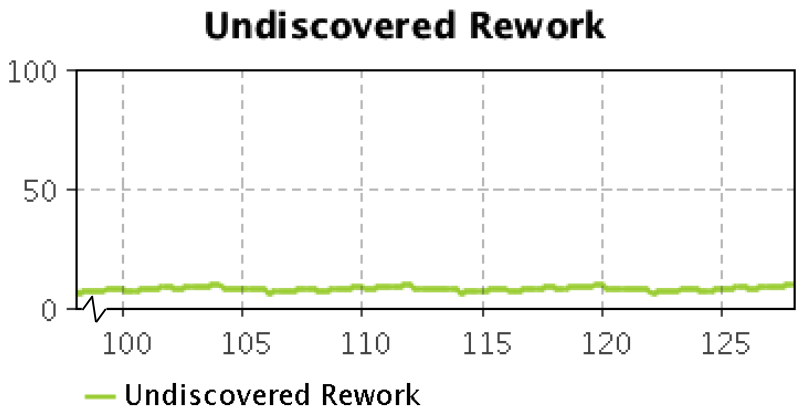
- **Without CI (baseline)**





- **With CI**





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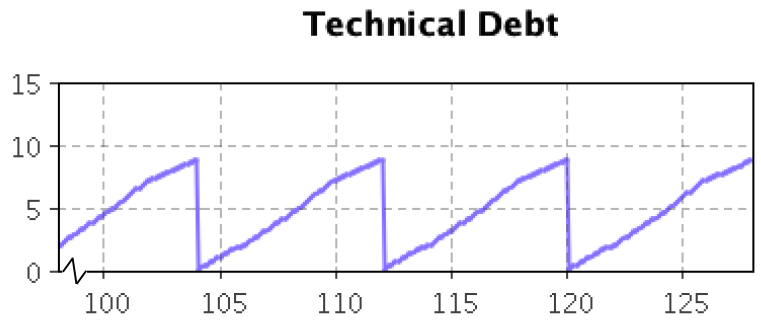
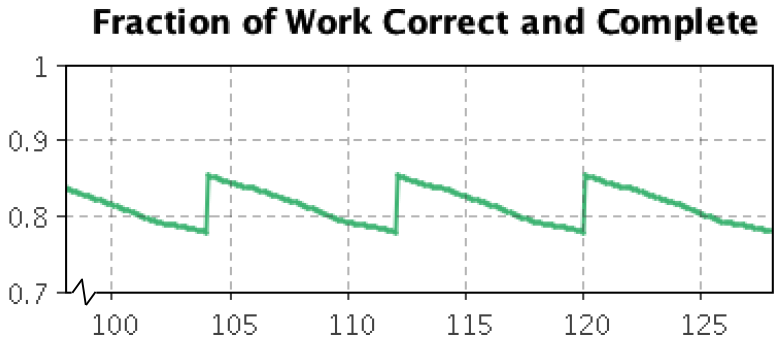
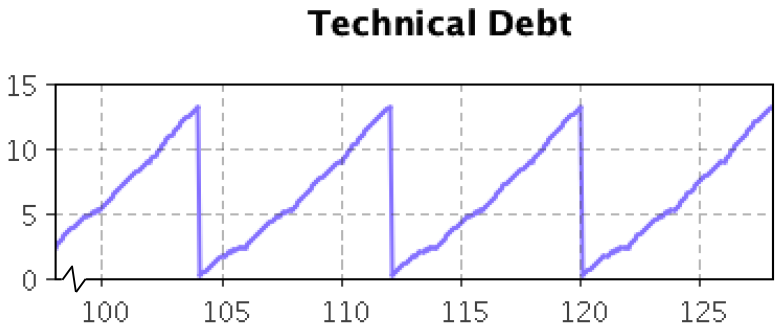
Results (Team 1)

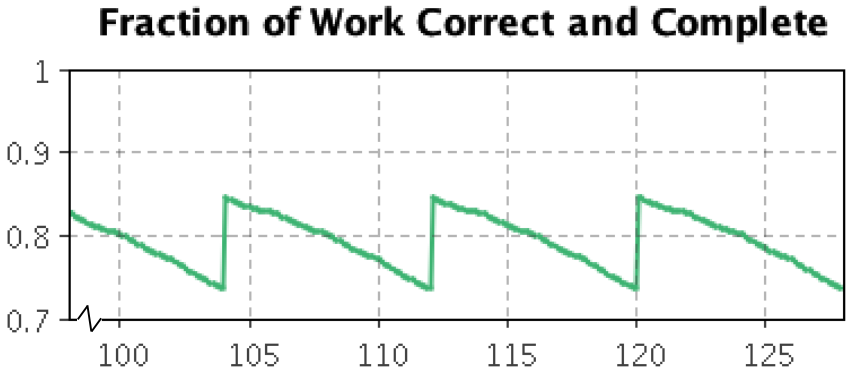
- **Without CI (baseline)**





- **With CI**





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Results

- **Without CI (baseline)**
  - TBV: 5706
  - Average team velocity: 50
  - Average undiscovered rework (bugs): 65
  - Average FCC: .81
- **With CI**
  - TBV: 8787
  - Average team velocity: 49
  - Average undiscovered rework (bugs): 8
  - Average FCC: .78

Doing integration continuously rather than waiting until the 4th sprint resulted in 54% more valuable work accomplished in the same amount of time with 88% fewer bugs in the code.

Limitations

- **SAFe or similar programs**
- **Homogenous stocks**
  - Stories and Features
  - Weighted shortest job first (WSJF)
- **Instantaneous meetings**

Future work

- **Improving the model**
  - Generalization
  - Effects of planning sessions
  - Effects of enablers
  - Communication/coordination overhead
- **Verification/Validation**
  - Case studies
  - Sensitivity analysis
- **Management flight simulator**

Conclusion

- Research builds on work begun at MIT
- Identified Agile scaling variables
- System dynamics techniques used to model the behavior of complex systems over time
- Begun building model for SAFe
- Model will provide a decision support tool

Agile Dynamics at Scale
A MITRE Innovation Program Research Project

Questions

Thank You!

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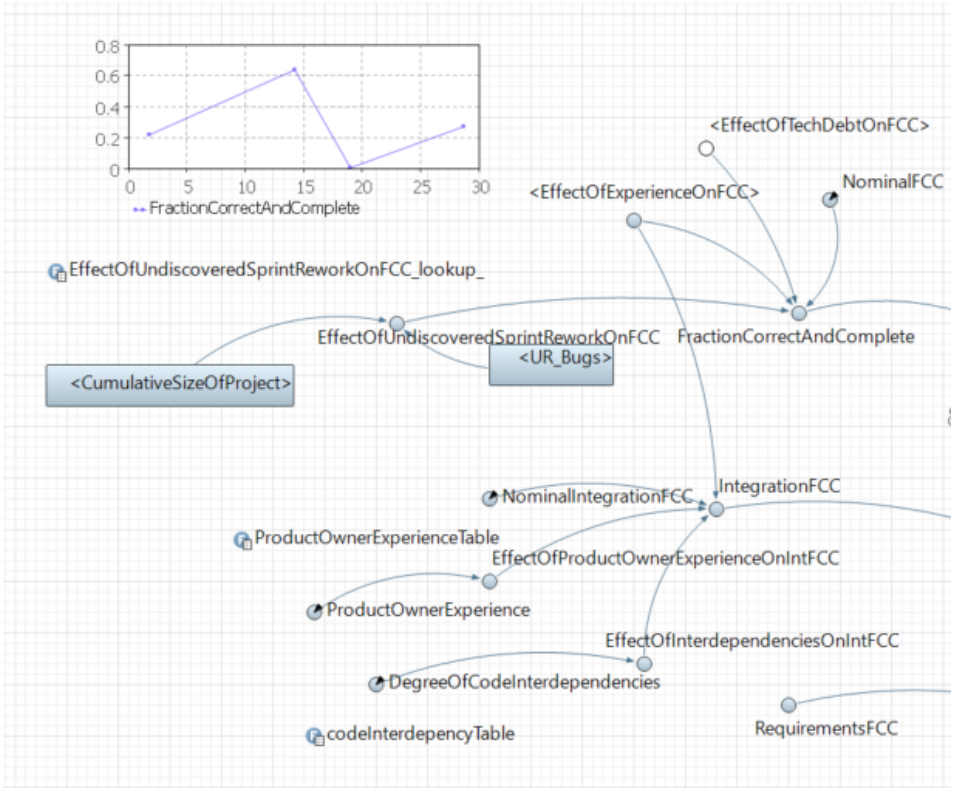
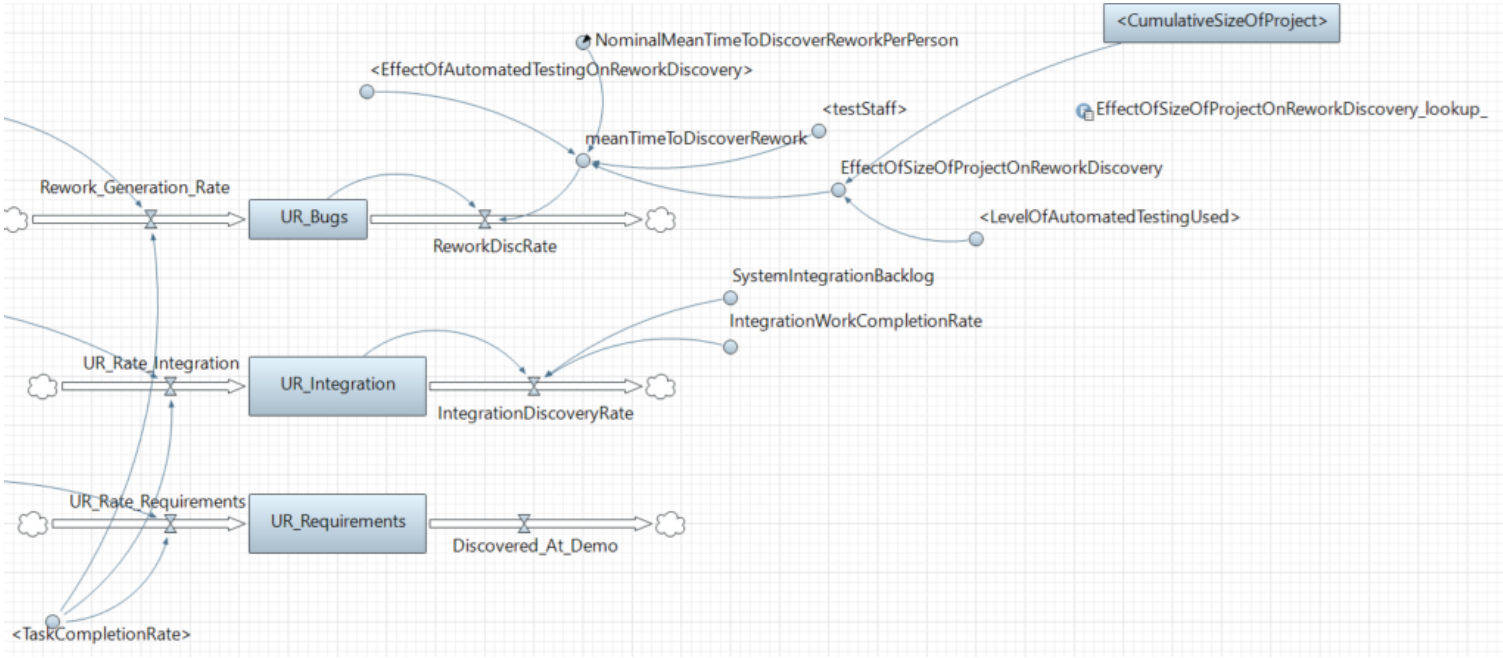
Backup

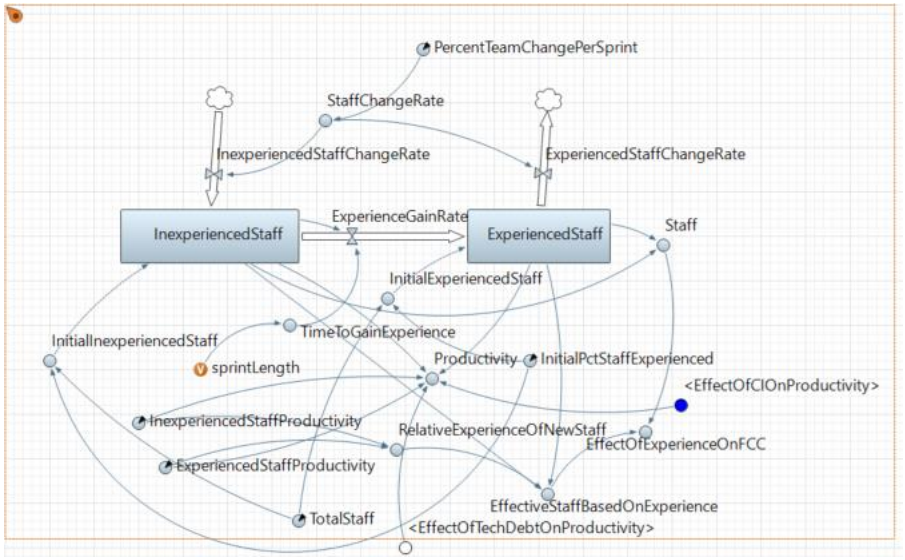
Fraction Correct and Complete

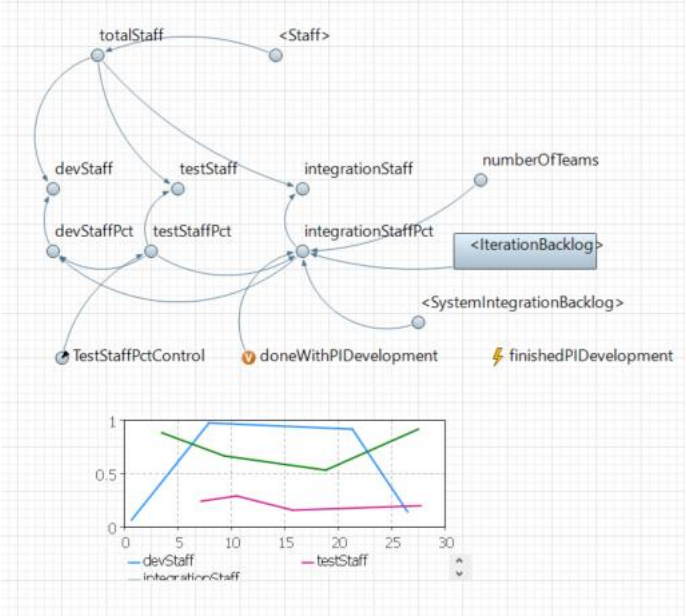


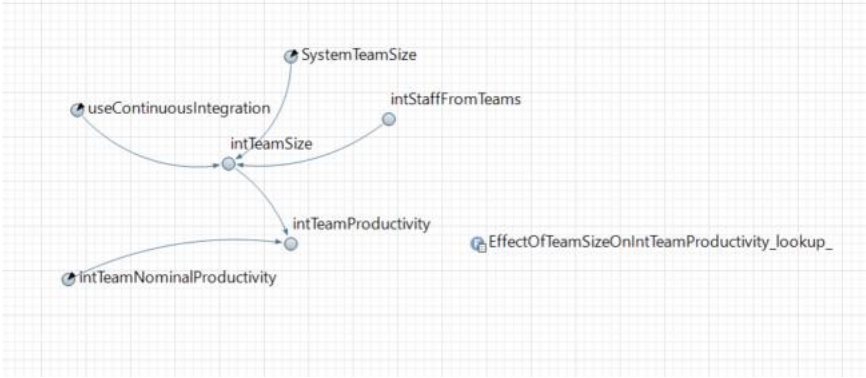
Rework Creation and Discovery



Human Resources and Staff Allocation







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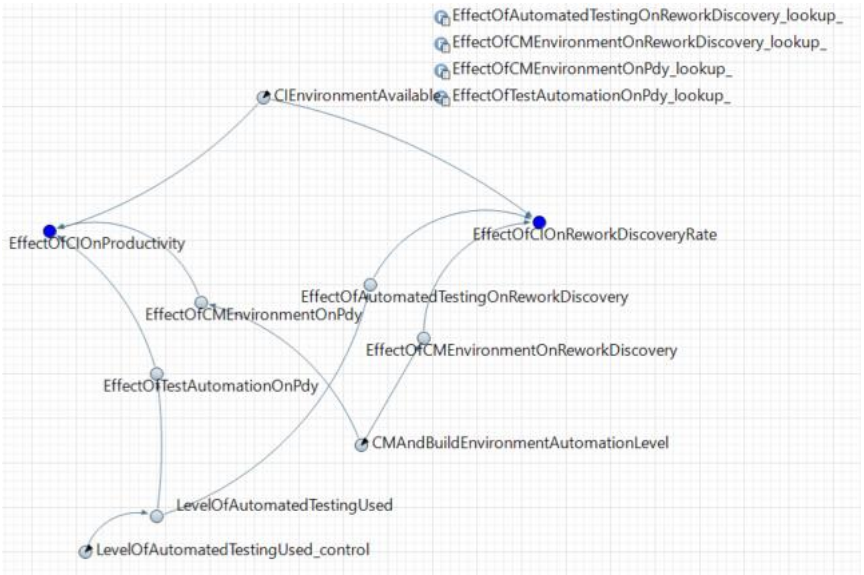
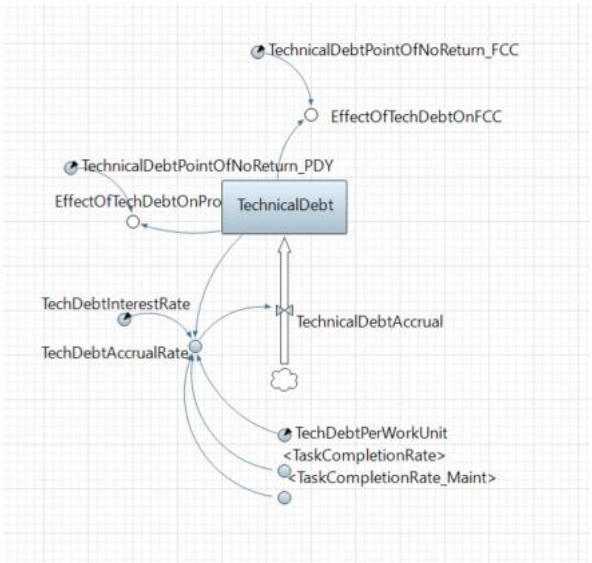
Effects of Automation and Tech Debt





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Acronyms

MIT	Massachusetts Institute of Technology
DOD	Department of Defense
APD	Agile Project Dynamics
SAFe	Scaled Agile Framework
EMRAM	Enterprise Modernization Risk Assessment Model
CAMIS	Cadet Administrative Management Information System
AFMC/A4N	Air Force Materiel Command, System Integration Division
DCAPES	Deliberate and Crisis Action Planning and Execution Segments
SEI	Software Engineering Institute
NDIA	National Defense Industry Association
MDA	Milestone Decision Authority
COR	Contracting Office Representative
PM	Project Manager
FFRDC	Federally Funded Research and Development Center
SME	Subject Matter Expert
SEP	System Engineering Plan
SE	System Engineering
SD	System Dynamics
ALCM	Agile Lifecycle Management
PI	Program Increment
CI	Continuous Integration
TBV	Total Business Value
FCC	Fraction Correct and Complete
WSJF	Weighted Shortest Job First
GOAA	Government Organization Agility Assessment
AiDA	Acquisition in the Digital Age
AF	Air Force