How Do You Use Agile Methods on Highly-Critical Systems that Require Earned Value Management?
Phyllis Marbach, INCOSE LA Chapter President; Senior Software Engineer at Boeing – Retired
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How Do You Use Agile Methods on Highly-Critical Systems that Require Earned Value Management?

Phyllis Marbach
Engineering Consultant
6 June 2018
Contents

• Introduction to Agile (Scrum)
• Agile Systems Engineering (SE) Framework
• Differences in Agile and Traditional SE
• Agile Earned Value Management (EVM)
  • Planning
  • Implementing
  • Measuring
• Highly-critical systems and Agile
• The Government Accounting Office (GAO) and Agile
• References: see the NDIA white paper
Scrum is an iterative, incremental methodology for project management often seen in agile software development, a type of software engineering.
Agile Includes:

• Scrum: Iterative, incremental methodology for project management

• Lean: reduce waste, reduce Work in Process (WIP); have what you need to start; once an item is started finish it before starting the next item;

• eXtreme Programming: pair programming, continuous integration, automated testing, test first development,

• Crystal Methods: frequent delivery, reflective improvement, daily stand-up meetings, side-by-side programming, burn charts, automated tests, configuration management, frequent integration

Agile is often called Lean-Agile
Agile Systems Engineering (SE) Framework

Release Planning

Iteration Planning

Pre-planning

Iteration 1

Iteration 2

Iteration N
Release 1

Backlog

Planning Team

Architecture Team

Implementation Teams

Integration & Test Team

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Agile SE Framework

Differences from Traditional SE

• Changes to the architecture – Flexible, modular architecture framework; rather than having Big Design Up Front (BDUF)

• Changes to the process – iterative, incremental rather than traditional or sequential

• Changes to the roles
  • SE become members of the implementation teams;
  • SE staffing remains more level throughout the development to support and maintain the architecture, requirements, testing, verification, artifact development, etc.

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Agile SE Framework Summary

• SE and SWE work together to develop and evolve the work products iteratively
• Define “just enough” architecture and requirements prior to the beginning of implementation
• Release Planning and Iteration Planning are essential to detail the work and coordinate the teams
• Demonstrate working products frequently
• Absorb changes to mission requirements
• Artifacts such as requirements, architecture, system design and verification traceability are produced incrementally

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Once the plans are in place, the product backlog iterations begin.

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Projects using agile practices should have an identified period of performance. During that period of performance releases are defined that have specific features or capabilities. This is called a Roadmap.
Estimate the Project for the Period of Performance

- Initial planning estimates Features in story points
- You may not know the specific stories to create each Feature in the beginning
- Story points are relative to each other
- Find the Feature that is the easiest or fastest to do
- Give it 1
- Estimate rest of Features relative to that 1 using
  - Powers of 2: 1, 2, 4, 8, 16, 32, 64, 128, 256, . . . or
  - Fibonacci Series: 1, 2, 3, 5, 8, 13, 20, 40, 100, . . .
Estimate Features and Prioritize

<table>
<thead>
<tr>
<th>Feature</th>
<th>Story Points</th>
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<tbody>
<tr>
<td>Feature 1</td>
<td>1</td>
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<tr>
<td>Feature 2</td>
<td>40</td>
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<tr>
<td>Feature 3</td>
<td>100</td>
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<tr>
<td>Feature 4</td>
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<tr>
<td>Feature 5</td>
<td>256</td>
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<td>Feature 6</td>
<td>13</td>
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<td>Feature 7</td>
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<td>Feature 8</td>
<td>5</td>
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<td>...</td>
<td>...</td>
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<tr>
<td>Feature xx</td>
<td>256</td>
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</tbody>
</table>

Features are ordered into the roadmap based on milestones/releases to meet customer expectations. Use Rolling Wave Planning for later releases.

Release 1

<table>
<thead>
<tr>
<th>Feature</th>
<th>Story Points</th>
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<tbody>
<tr>
<td>Feature 1</td>
<td>1</td>
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<tr>
<td>Feature 8</td>
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<td>Feature 4</td>
<td>20</td>
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<tr>
<td>Feature 7</td>
<td>8</td>
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<td>Feature 6</td>
<td>13</td>
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<td>Feature 2</td>
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<tr>
<td>Feature 3</td>
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<td>Feature 5</td>
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<td>...</td>
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</tr>
<tr>
<td>Feature xx</td>
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Agile and Earned Value Management (EVM)

- Each software release is a milestone deliverable.
- Progress reported weekly on the % complete story points for each feature’s planned total story points.
- An EVM work package (WP) is one or more Features.
- Story points are the estimated effort to complete a backlog item, or user story.
  - Example, some features might have a total of 120 story points and 10 user stories.
  - Others might have 20 story points and 2 user stories.
- Business value is in the completion of the Features (WP).
- A release might have a partial feature delivered that will be finished in the next release (Feature 4a and 4b).

Features are measured in story points, a measure of effort or complexity.

Roadmap provides the big picture - Details come during Release and Iteration Planning

Release 1: xx weeks

x iterations

- Release 1 priority features
- Features are sets of stories

Release Planning:
dependencies, critical path and float are defined

Integration & Test
Earned Value Management (EVM)

• Earned Value Management (EVM) is a management system that integrates scope, schedule, cost and performance policies, procedures and processes by which programs manage work.

• Helps project managers measure project performance and progress in an objective manner.

• Project Plan – identifies work to be accomplished

• Planned Value (PV) – Valuation of planned work, budgeted cost for work scheduled (BCWS)

• Earned Value (EV) – Metrics that quantify work accomplished, budgeted cost for work performed (BCWP)

• Actual Cost of Work Performed (ACWP) is cumulative hours and/or cost to time now for work.
Budgeted Cost of Work Performed (BCWP)

The value of work completed at a given point in time, synonymous with “Earned Value”. Expressed in dollars representing the portion of the budgeted value of the baseline Work Package that is complete.

Example Formula: BCWP = % Complete * BAC, where % Complete = completed Work Package Story Points / current total Work Package Story Points.

Note: the Work Package baseline budget (BAC) of the calculation does not fluctuate if the team adds or removes Stories / Story Points provided that the baseline Work Package scope does not change. Changing the total Story Points in a Work Package would impact the % Complete recognition but does not require a baseline change.

Example: BAC WP for WP xyz has a baselined estimated cost of $100,000. The team targeted to deliver 33 of 100 Story Points by the end of Sprint n for WP xyz. At time now the team delivered 28 Story Points. The BCWP is: 100,000 * (28/100) = $28,000

The % complete is: (28/100) * 100 = 28%

Cost Variance

A metric for cost performance on a program. It is the difference between budgeted cost of work performed and actual cost (CV = BCWP – ACWP.) A positive value indicates a favorable position and a negative value indicates an unfavorable condition, and is expressed in dollars or as a percentage. The calculation for CV dollars is the difference of BCWP – ACWP. The calculation for CV percentage is the ((CV divided by BCWP) * 100).

Example: The team targeted to deliver 33 of 100 Story Points weighted Story Value by the end of Sprint n for WP xyz. At time now the team delivered 28 Story Points of weighted Story Value. ACWP cum to date for WP xyz is $25,000 at end of Sprint n.

The Cost Variance, CV: $(100,000 \times (28/100)) – \$25,000 = \$3000$

CV % = $(\$3,000 /\$28,000) \times 100 = 11\%$

Metrics used to track progress

Customer attends the demonstrations every 3 weeks and has visibility of the detailed progress

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Reporting story points complete each iteration versus planned

Percent complete reporting of that feature, the high value work product in development, can be used for the EVM measures.
Highly-Critical Systems

• A system that must be highly reliable, that retains this reliability as it evolves without incurring prohibitive costs

• Types of critical systems
  • Safety critical: avoid loss of life, serious injury, or damage to environment
  • Mission critical: avoid loss of ability to complete the mission objectives
  • Business critical: avoid economic costs
  • Security critical: avoid loss of sensitive data

• Examples of highly critical systems:
  • Vehicles: air, ground, sea, space, unmanned and manned
  • Defense systems: communications, missiles,
  • Manufacturing systems: chemical, industrial,
  • Infrastructure, Transportation, Health Care

Using Agile practices as highly-critical systems are developed will enable the system to evolve
Government Accounting Office (GAO)

• GAO is the watchdog for congress to make sure projects are using best practices when spending government funding

• The customer for these projects is really the American taxpayer

• GAO Schedule Assessment Guide: Best Practices for Project Schedules, GAO-16-89G, Feb 16, 2018


https://www.gao.gov
Government Accounting Office (GAO)

- Armed forces: Army, Air Force, Navy, Marines, US Coast Guard; Veterans
- Bureau of Land Management
- Congress Legislative
- Dept of Agriculture
- Dept of Education
- Dept of Energy
- Dept of Health and Human Services
- Dept of Homeland Security
- Dept of Housing and Urban Dev.
- Dept of Interior
- Dept of Justice
- Dept of Labor
- Dept of Treasury
- Dept of Transportation
- Environmental Protection
- FBI, FAA, FEMA,
- NASA
- National Science Foundation
- US Customs and Border Protection
- US Postal Service

https://www.gao.gov
<table>
<thead>
<tr>
<th>Best Practice</th>
<th>Agile Artifacts &amp; Documentation</th>
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<tbody>
<tr>
<td>1. Capture All Activities</td>
<td>• Roadmap with Prioritized Must Have Features developed with input from stakeholders and SMEs</td>
</tr>
<tr>
<td></td>
<td>• Roadmap linkage to SOW</td>
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<tr>
<td></td>
<td>• Prioritized product backlog consisting of epics, features, and stories</td>
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<tr>
<td></td>
<td>• Product Backlog</td>
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<tr>
<td>2. Sequence Activities</td>
<td>• Kanban Board (or similar)</td>
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<td></td>
<td>• Dependencies for sprints can be captured in the schedule</td>
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<tr>
<td>3. Assign Resources</td>
<td>• Kanban Board (or similar)</td>
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<td></td>
<td>• Small teams of 5-9 people</td>
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<td></td>
<td>• Scrum master coaching</td>
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<td></td>
<td>• Training in Agile method</td>
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<tr>
<td>4. Establish Durations</td>
<td>• Sprint durations consistent and between 1-3 weeks</td>
</tr>
<tr>
<td>5. Ensure Horizontal and Vertical Traceability</td>
<td>• Vertical</td>
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<tr>
<td></td>
<td>o Roadmap</td>
</tr>
<tr>
<td></td>
<td>o Product Backlog (Themes, epics, features, stories)</td>
</tr>
<tr>
<td></td>
<td>o Burn down / burn up charts</td>
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<tr>
<td></td>
<td>• Horizontal</td>
</tr>
<tr>
<td></td>
<td>o Kanban Board (or similar)</td>
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<td></td>
<td>o Releases included in Program Schedule</td>
</tr>
<tr>
<td>Best Practice</td>
<td>Agile Artifacts &amp; Documentation</td>
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<tr>
<td>---------------------------------------------------</td>
<td>------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>6. Ensure the Critical Path is Valid</td>
<td>• Releases included in Program Schedule</td>
</tr>
<tr>
<td>7. Ensure that Total Float is Valid</td>
<td>• May also have Hardening sprints or catch up sprints for Unfinished work</td>
</tr>
<tr>
<td>8. Conducting a Schedule Risk Analysis</td>
<td>• Iteration 0 planning</td>
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<td>• Sprint Planning Sessions</td>
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<td>• Uncertainty regarding number of sprints, releases and velocity</td>
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<td>• Retrospectives</td>
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<tr>
<td>9. Updating the Schedule Using Actual Progress and Logic</td>
<td>• Releases included in Program Schedule</td>
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<td>• Daily stand up meetings</td>
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<td>• Velocity metrics</td>
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<td>• Burn up/Burn down charts quantifiable back up data for schedule progress</td>
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<td></td>
<td>• Kanban board</td>
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<tr>
<td>10. Maintaining a Baseline Schedule</td>
<td>• Roadmap becomes baseline from which to measure variances</td>
</tr>
<tr>
<td></td>
<td>• Demonstration to stakeholders</td>
</tr>
<tr>
<td></td>
<td>• Retrospective</td>
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</tbody>
</table>
References

- Measuring Integrated Progress on Agile Software Development Projects by Tamara Sulaiman, PMP, CST, SolutionsIQ and Hubert Smits, CST, Rally Software

- AgileEVM – Earned Value Management in Scrum Projects by Tamara Sulaiman, PMP, CSM and Brent Barton, CSM, CST and Thomas Blackburn, PMP, CSM SolutionsIQ SolutionsIQ InfoTech, Inc.


- www.gao.org

- An Industry Practice Guide for Agile on Earned Value Management Programs, National Defense Industrial Association (NDIA), Integrated Program Management Division (IPDM), March 31, 2017
Upcoming Events
UPCOMING TALKS:
“Systems and Software Qualities Tradespace Analysis” Series

Barry Boehm, Chief Scientist, SERC; TRW Professor of Software Engineering and Director, Center for Software Engineering, University of Southern California
August 1 | 1:00 PM ET

Bill Curtis, Senior VP & Chief Scientist, CAST Software; Head of CAST Research Labs, Executive Director, Consortium for IT Software Quality (CISQ)
October 3 | 1:00 PM ET

Xavier Franch, Full Professor, Polytechnic University of Catalonia (BarcelonaTech)
December 11 | 1:00 PM ET

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Thank you for joining us!
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