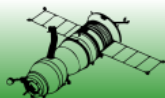


Systems Engineering for Software Intensive Projects Using Agile Methods

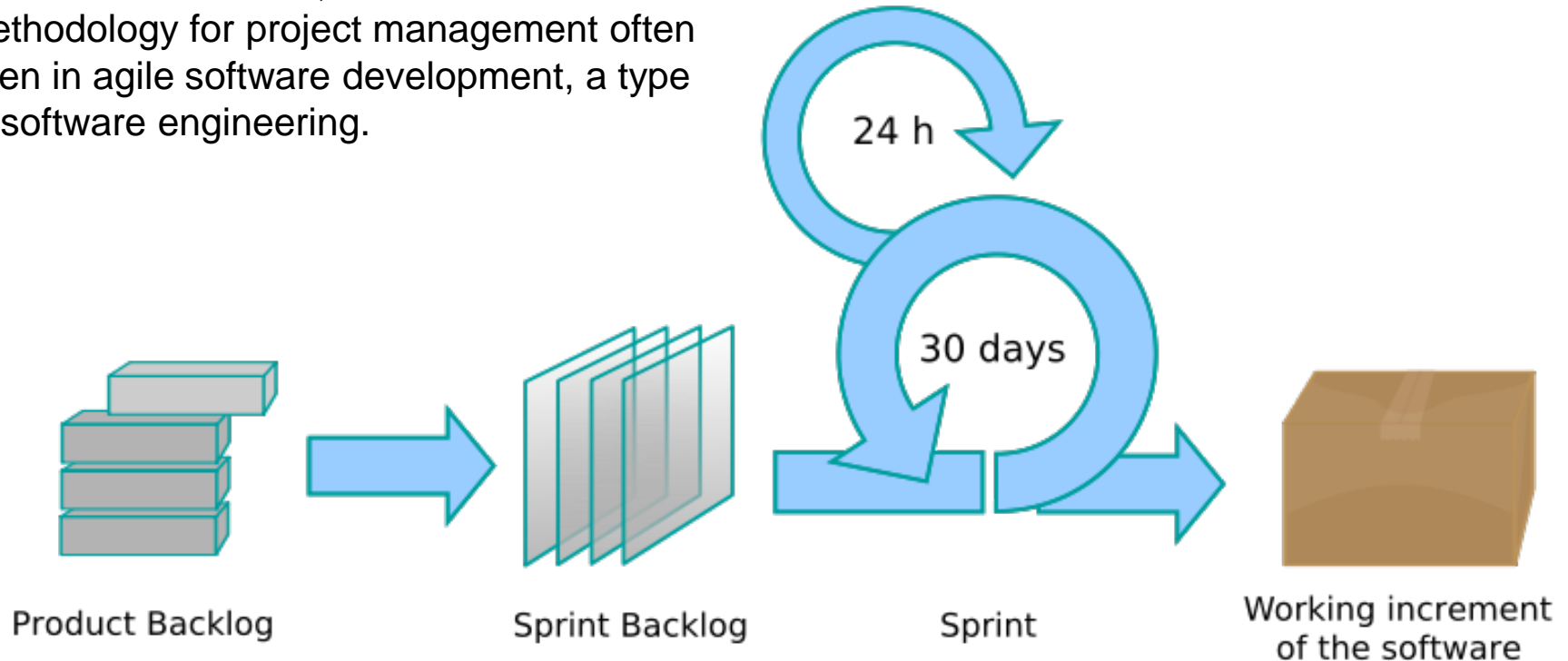
Phyllis Marbach, Boeing
April 30, 2014

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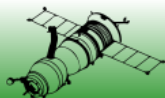


Introduction to Agile (Scrum)

Scrum is an iterative, incremental methodology for project management often seen in agile software development, a type of software engineering.



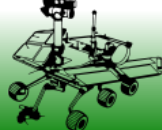
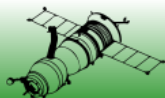
Copyrights specified as freely licensed media http://en.wikipedia.org/wiki/File:Scrum_process.svg



Systems Engineering

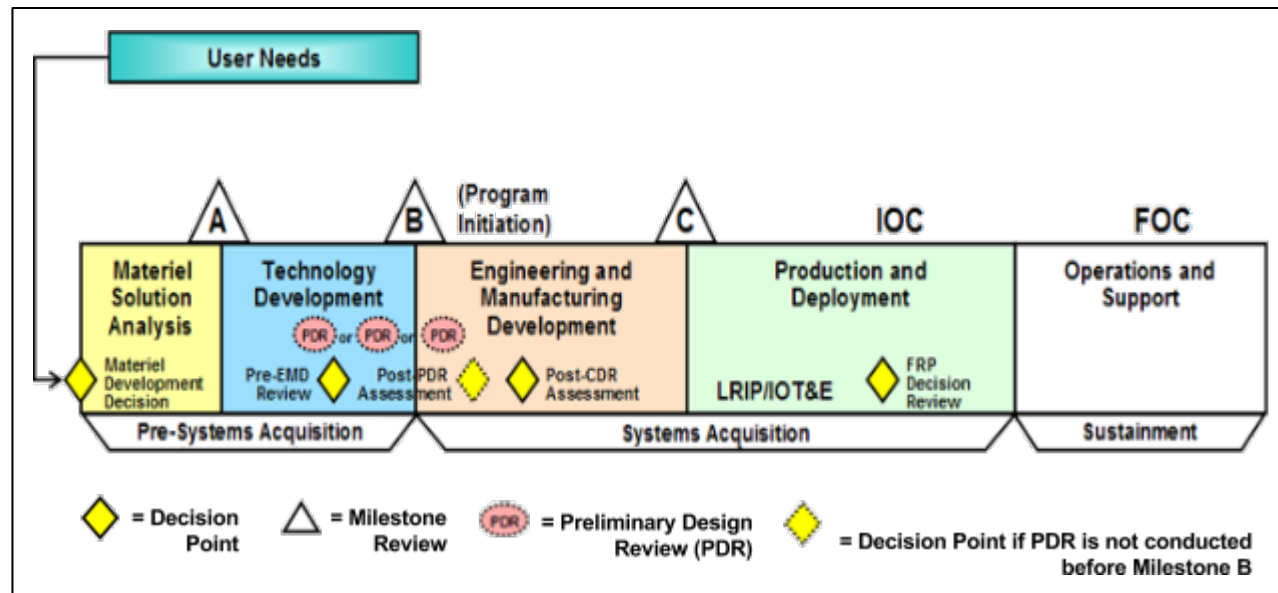
- An interdisciplinary approach and means to enable the realization of successful systems (INCOSE handbook)
- Many SE activities:
 - Technical Management
 - Mission and needs analysis
 - Requirements articulation and management
 - System architecture and design
 - Technical analysis and trades
- SE works with the customers and program office
- This paper's focus is on the role of SE in supporting implementation
- Technical processes addressed:
 - Stakeholder requirements definition
 - Requirements analysis
 - Architectural design
 - Implementation
 - Integration
 - Verification

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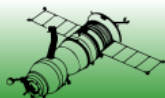
System Acquisition Framework

- Defense Acquisition Guidebook
- Focus on Engineering Manufacturing Development (EMD) Phase
- Requirements are defined at Milestone B
- Traditionally:
 - First engineers define and interpret stakeholder needs
 - Second SE develops the system design or architecture framework
 - Third software engineers develop detailed designs
 - Fourth SWE implements the capabilities



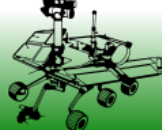
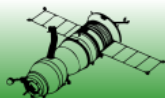
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Agile SE Framework

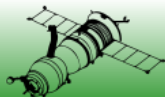
- Changes to the architecture – modular and evolving
- Changes to the process – iterative, incremental
- Changes to the roles
 - SE become members of the implementation teams;
 - SE staffing remains more level throughout the development to support and maintain the architecture, requirements, testing, verification, artifact development, etc.



SE Architect Role

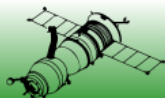
- SE identify and analyze architecture dependencies
- Create and continuously update an architecture description
- Participate with the SE Team (SEIT, Architecture, etc.)
- Participate on one or more Implementation Teams
- Work one iteration ahead of the developers

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SE Architect Role Differences

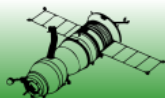
- Flexible, modular architecture framework; rather than having Big Design Up Front (BDUF)
- Detailed design/architecture is implemented in each iteration providing technical and user evaluations often manages technical risk and enables user validation that the solution meets their expectations; rather than waiting until the end of a long development period for this verification of the technical solution and validation from the user
- Quality attributes of the architecture are built in from the beginning and shown to be met each iteration for that part of the development that was just completed; rather than showing traceability between tests and quality attributes at the end of a long development period
- The architecture is adjusted and modified as needed; rather than assuming the architecture and design is fixed and never changing because that phase of development is in the past.



SE Process

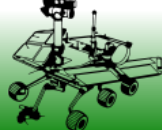
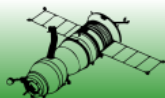
- SE and SWE work together to:
 - Define capabilities
 - Implement capabilities
 - Test capabilities
 - Inspect the results
 - Adapt capabilities as needed
 - Maintain system integrity
- Larger programs with several teams working in parallel need SE engaged
- Each aspect of development (requirements, design, implementation, test, verification) is continually revisited throughout the development lifecycle

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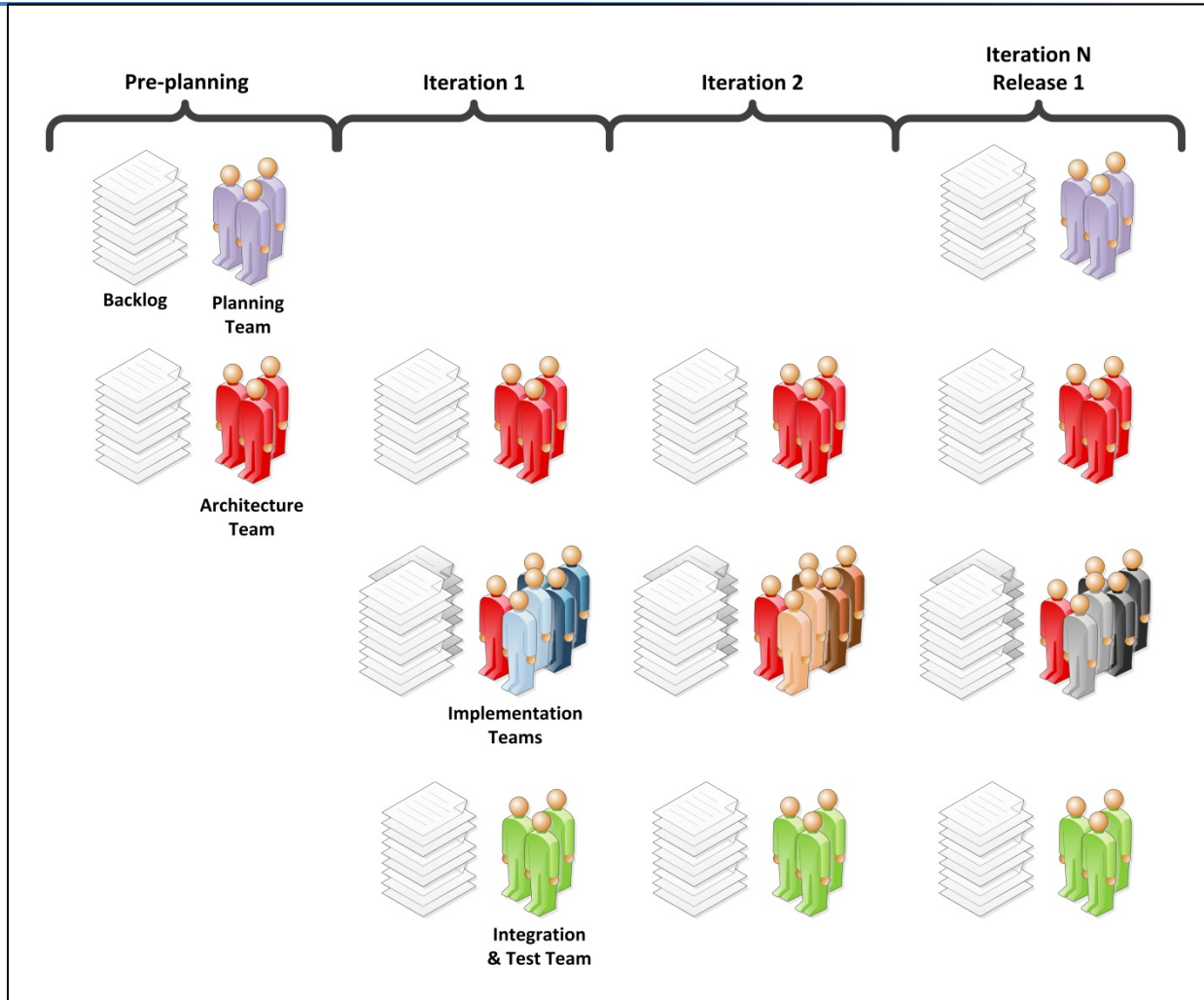


SE Process Differences

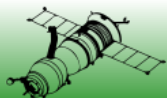
- SE and SWE work together throughout the iterations; rather than having SE define the capabilities and provides the system architecture to SWE and then go away until the software is done. Then SE starts integration and verification.
- Larger programs with several teams working in parallel need SE engaged; rather than having few SE available during implementation to answer questions.
- Each aspect of development is continually revisited throughout the development lifecycle; rather than having the requirements and design formally baselined even for areas of high risk or technical uncertainty



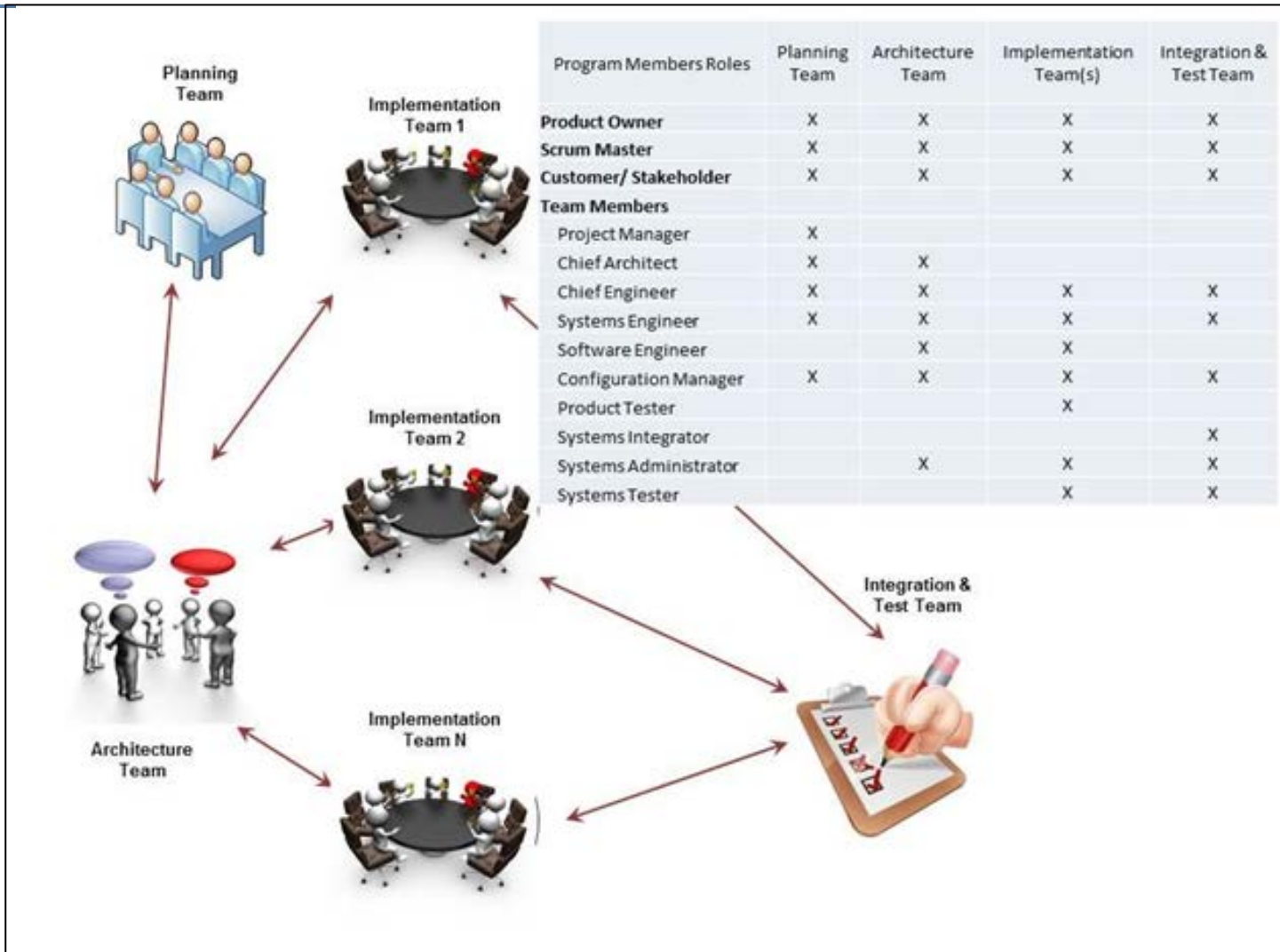
Agile SE Framework



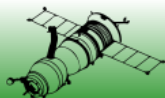
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Agile Teams



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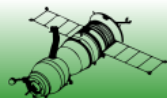


Example Planning Team RACI

| PLANNING TEAM | | | | |
|---|---------------|--------------|-------------|-----------------------|
| ROLES | Product Owner | Scrum Master | Team Member | Customer/ Stakeholder |
| Scope | C | C | R | A |
| Define Deliverables (Product Level) | C | C | R | A |
| Technical Management Mission | A | C | R | C |
| Needs Analysis | A | C | R | C |
| Requirement Articulation (Product Capability Backlog) | R | C | C | A |
| Requirements Management | A | C | R | C |
| Meeting Facilitator/ Impediment Remover | A | R | C | C |

| RACI Matrix Legend | |
|--------------------|---|
| Responsible (one) | Leads the task completion with tangible deliverables |
| Accountable (one) | Delegated the responsibility for task, approves completion |
| Consulted (many) | Multiple contributors provide special knowledge or expertise |
| Informed (many) | Members that will be informed of the task status and deliverables |

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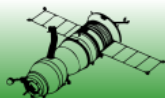


Example Arch Team RACI

| ARCHITECTURE TEAM | | | | |
|---|---------------|--------------|-------------|-----------------------|
| ROLES | Product Owner | Scrum Master | Team Member | Customer/ Stakeholder |
| Vision | A | C | R | C |
| Roadmap | A | C | R | C |
| Architecture Framework/ System Design | C | C | R | A |
| Define and Maintain Interfaces | A | C | R | C |
| Architecture Product Backlog | A | C | R | C |
| Concept of Operations (CONOP) | C | C | R | A |
| Perform Trade Studies | A | C | R | C |
| Meeting Facilitator/ Impediment Remover | A | R | C | C |

| RACI Matrix Legend | |
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| Responsible (one) | Leads the task completion with tangible deliverables |
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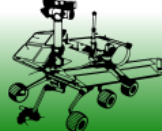
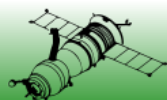


Example Implementation RACI

| IMPLEMENTATION TEAM | | | | |
|---|---------------|--------------|-------------|-----------------------|
| ROLES | Product Owner | Scrum Master | Team Member | Customer/ Stakeholder |
| Develop/ Maintain Software Design (Detailed Design) | A | C | R | C |
| Software Implementation | A | C | R | C |
| Integration - unit test, SW integration as possible | A | C | R | C |
| Verification | A | C | R | C |
| Maintain/ Verify System Capabilities as possible | A | C | R | C |
| Maintain Interface Definitions of SW/ Component | A | C | R | C |
| Perform Trade Studies | A | C | R | C |
| Develop/ Maintain Test Procedures | A | C | R | C |
| Meeting Facilitator/ Impediment Remover | A | R | C | C |

| RACI Matrix Legend | |
|--------------------|---|
| Responsible (one) | Leads the task completion with tangible deliverables |
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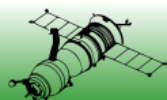


Example I&T Team RACI

| INTEGRATION AND TEST TEAM | | | | |
|--|---------------|--------------|-------------|-----------------------|
| ROLES | Product Owner | Scrum Master | Team Member | Customer/ Stakeholder |
| Software Backup/ SW Baseline Test Baseline | A | C | R | I |
| System Integration | A | C | R | I |
| Validation | A | C | R | C |
| Meeting Facilitator/ Impediment Remover | A | R | C | C |

| RACI Matrix Legend | |
|--------------------|---|
| Responsible (one) | Leads the task completion with tangible deliverables |
| Accountable (one) | Delegated the responsibility for task, approves completion |
| Consulted (many) | Multiple contributors provide special knowledge or expertise |
| Informed (many) | Members that will be informed of the task status and deliverables |

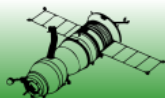
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Challenges from Traditional SE with Agile SWE

- Lack of Rapid Response
- Big Design Up Front
- Architecture Interpretation
- Non-Functional Requirements (NFR)
- Responding to Change at Scale
- Verification, Validation and Test

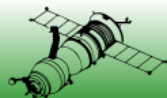
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Lack of Rapid Response

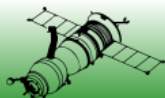
- Challenge:
 - When systems engineering activities are performed in isolation from software development teams,
 - Important systems engineering activities are not informed by or responsive to findings from the software development team:
 - Definition of key performance parameters
 - Definition of testing scenarios
 - Definition of architecture principals
 - Risk analysis
 - Technical trade studies
- Enabler from the Agile SE Framework:
 - Continual Interfacing on cross-functional teams consisting of SE, SWE, and Testers co-develop one story/capability from concept through completed customer acceptance testing during an iteration

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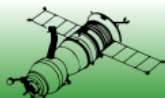
Big Design Up Front

- Challenge:
 - When systems engineering activities are performed on a traditional schedule it is assumed that development will not begin until the Big Design Up Front (BDUF) is released.
 - If the SE is “not finished” implementation is delayed or the software team may start to develop detailed design and code with no input from SE.
- Enabler from the Agile SE Framework:
 - Create a roadmap of capabilities to implement over time.
 - From that roadmap create a prioritized backlog.
 - Break down the capabilities until each high priority backlog item is sized so that it can be implemented in one iteration.
 - Iterative planning allows the Implementation Team to start into development of the detailed design and coding with input from the SE (who is on the Architecture Team).



Architecture Interpretation

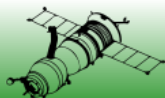
- Challenge:
 - SE, as part of the Architecture Team, develops a detailed and comprehensive architecture and passes it over to the Implementation Team.
 - The risk is that Software implementation opportunities and constraints are not adequately considered in systems engineering thus limiting flexibility.
- Enabler from the Agile SE Framework:
 - Architecture modularity and an iterative process requires architecture design effort throughout the development lifecycle.
 - For large teams the integrity of the architecture needs to be maintained as the development proceeds.
 - A modular framework is sufficient to begin development.
 - Architectural tasks may be planned into releases to be worked over several iterations as needed.



Non-Functional Requirements

- Challenge:
 - The agile paradigm addresses functional requirements as backlog items or user stories.
 - However, common agile practices do not directly address non-functional requirements.
 - When quality attributes (i.e., “ilities” — reliability, speed, usability, flexibility, etc.) are not analyzed and tracked through design and implementation then the system may not perform as desired and confidence in the system’s ability to perform as desired may be limited.
- Enabler from the Agile SE Framework:
 - Quality attributes are planned into each iterative development user story when a team plans and performs work on agile cross-functional Implementation Teams as described in the Agile SE Framework.

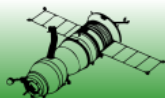
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Responding to Change at Scale

- Challenge:
 - When agile software development methods, used successfully on small projects, are applied to a very large effort, the processes fail to scale and SE activities and products are not effectively used in implementation.
 - Requirements may be interpreted differently by different Implementation Teams, architectural principles may not be universally applied, and interface definitions may develop gaps and overlaps.
- Enablers from the Agile SE Framework:
 - Larger teams need a team to integrate and test the products produced by the Implementation Teams. This is the I&T team shown in the Agile SE Framework and the Agile Teams figures
 - The Planning Team, with SE team members, maintains the requirements and capabilities
 - The Architecture Team, with SE team members, maintains the architecture integrity

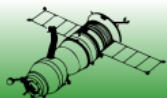
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Verification, Validation and Test

- Challenge:
 - Traditional SE practice for “pull” programs assumes that sell-off is based on Verification of compliance with requirements, not stakeholder (customer) satisfaction with deliverable functions.
 - This requires Validation that capabilities satisfy stakeholder needs.
 - Late Validation can result in customer dissatisfaction that must be dealt with late in the program, when modification is most expensive.
- Enablers from the Agile SE Framework:
 - Leverage the Agile software development practice of continuous integration
 - Create a situation in which stories are demonstrated, tested and even accepted as early as possible in the development cycle.
 - Share the testing artifacts with the customer to ensure a common understanding of the functionality to be developed.
 - Strive to automate testing when each function, feature, and feature set is submitted.

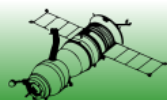
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Agile SE Framework Conclusion

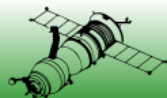
- SE and SWE work together to develop and evolve the work products iteratively
- Define “just enough” architecture and requirements prior to the beginning of implementation
- Release Planning and Iteration Planning are essential to detail the work and coordinate the teams
- Release products frequently
- Absorb changes to mission requirements
- Include requirements, architecture, system design and validation by SE on large scale agile projects

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