# INSPECTIONS FOR SYSTEMS AND SOFTWARE

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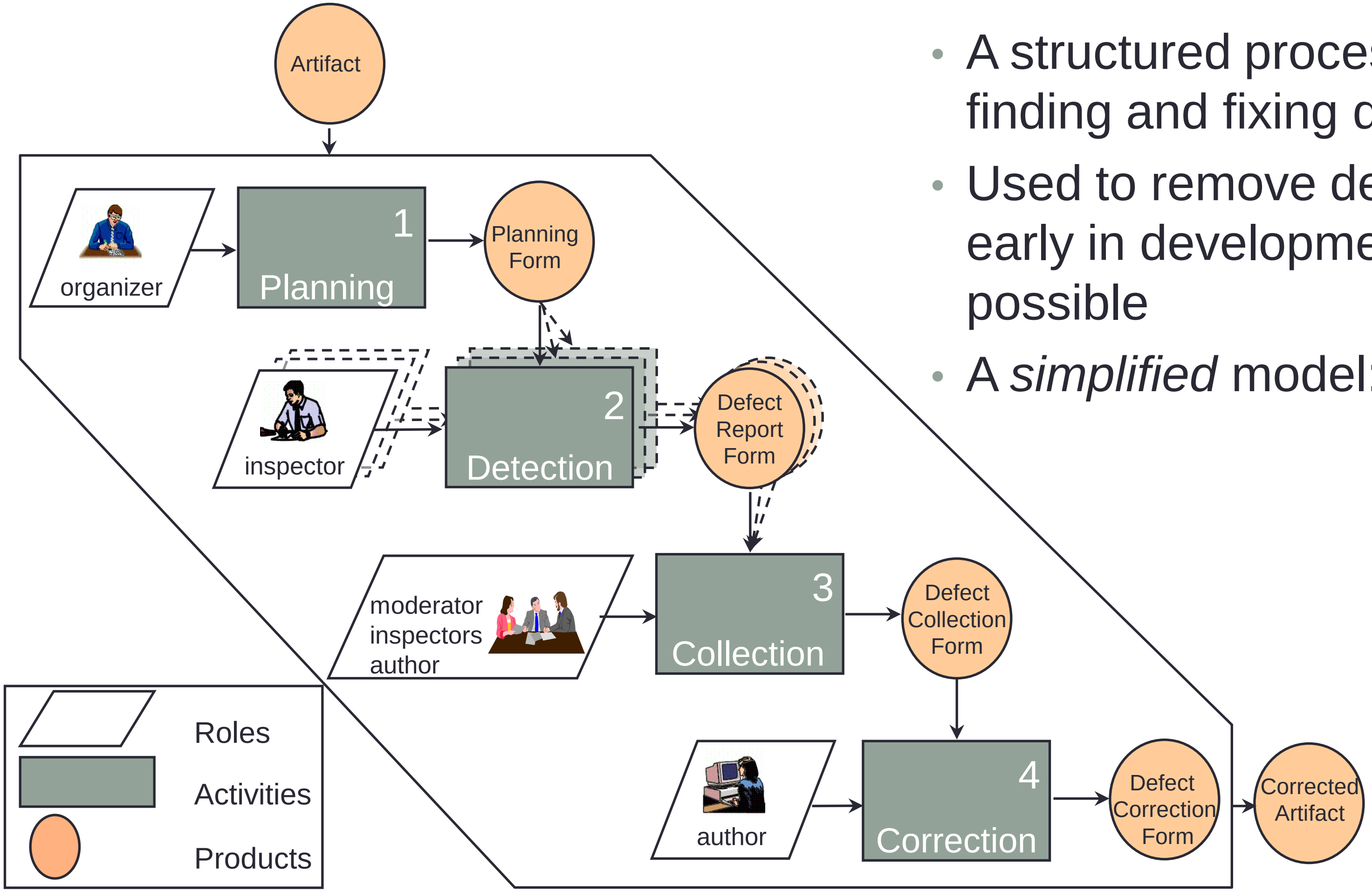
# What is Inspection?

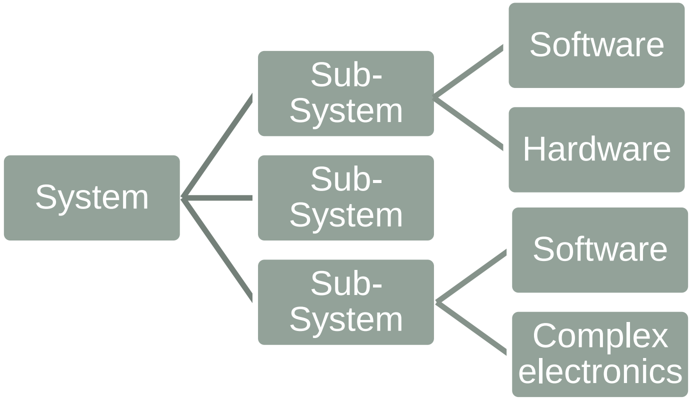


- A structured process for finding and fixing defects
- Used to remove defects as early in development as possible
- A *simplified* model:

# Why Inspection?

- A long history of research & application shows that structured human inspection is one of the most cost-effective practices for achieving quality software:
  - “Cost savings rule”: Cost to find & fix software defects is about 100x more expensive after delivery than in early lifecycle phases, ***for certain types of defects.***
    - IBM: **117:1** between code and use
    - Toshiba: **137:1** between pre- and post-shipment
    - Data Analysis Center for Software: **100:1**
  - “Inspection effectiveness rule”: Reviews and inspections find **over 50%** of the defects in an artifact, regardless of the lifecycle phase applied.
    - **50-70%** across many companies (Laitenberger)
    - **64%** on large projects at Harris GCSD (Elliott)
    - **60%** in PSP design/code reviews (Roy)
    - **50-95%,** rising with increased discipline (O’Neill)
    - … many others

# Problem Statement



- System development is often decomposed to handle complexity.
- Software increasingly plays a larger role in the system…
  - Research on system hazards in NASA's Constellation Program revealed that 51% of the hazards contained at least one software cause [Basili et al., 2010]
- … but it is still just one part of the system
  - Assurance activities are often conducted independently.
  - Domain knowledge may affect quality of activities.
  - Need a more integrated approach → inspection across the system.
    - For each inspection, consider a holistic view of the system.

# Our proposed approach

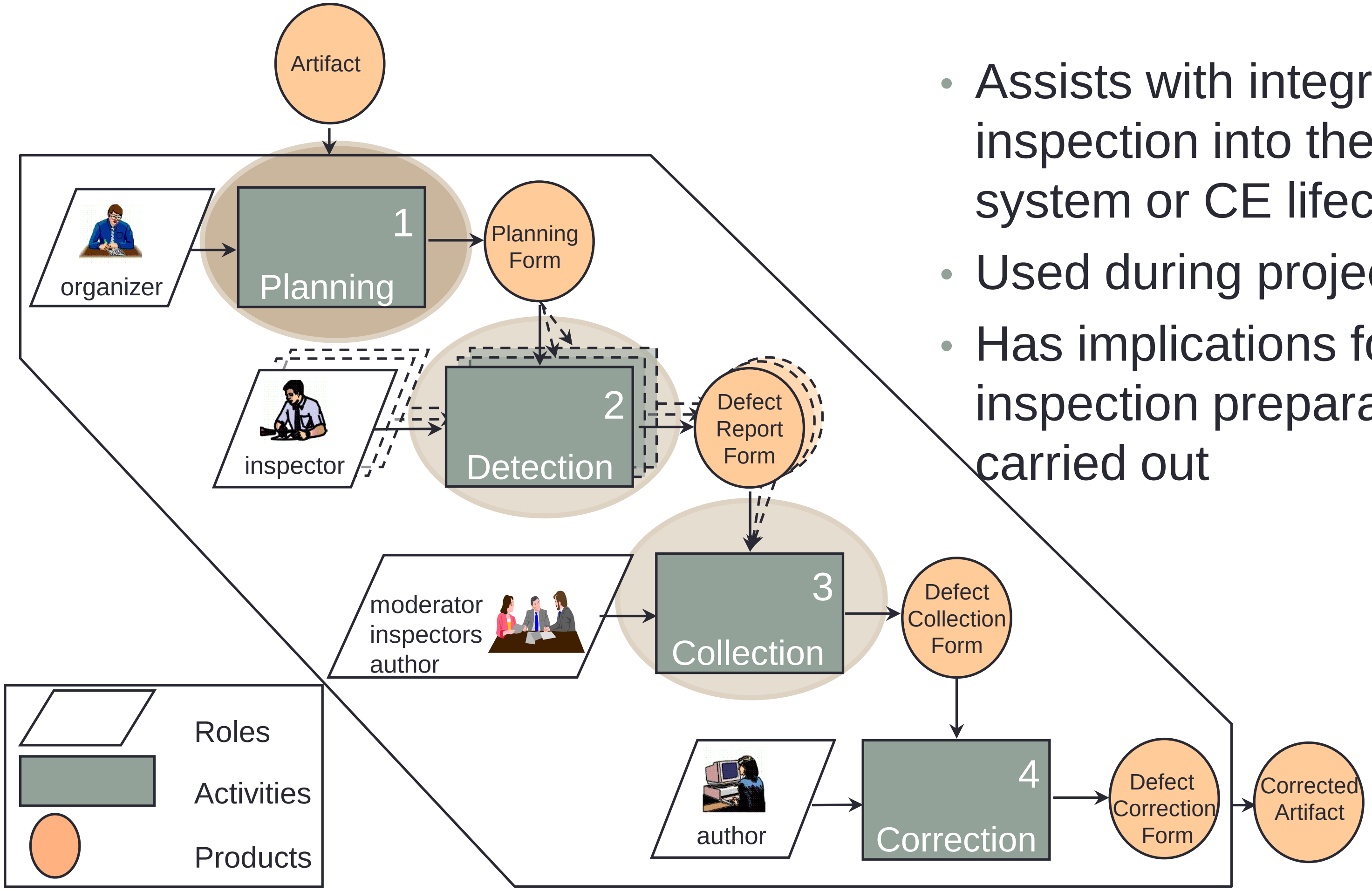
- Research goal: Provide guidance for  teams on planning and conducting inspections across a system.
  - Non-intrusive
  - Cost-effective
  - Adaptable
- Philosophy: Package best practices, including adapting principles from software engineering.
- Our context is inspections of highly critical systems
  - But should be generalizable to other domains.

Health Check – Inspection Process Assessment Methodology

# The “Process Health Check”

- Assess the current inspection process – standards and policies against practice.
- Provide best practices and guidelines for defining an inspection process.
- Identify areas that could benefit from recommendation.

# The “Process Health Check”



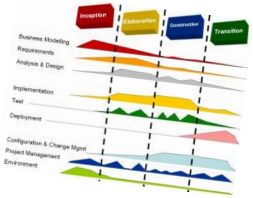
- Assists with integrating an inspection into the larger system or CE lifecycle
- Used during project planning
- Has implications for how inspection preparation is carried out

# Methodology – Overview

- Create baseline of best practices.
- Package best practices in a framework.
- Continuously refine framework:
  - Proof of concept study.
  - Pilot Study
  - Deployment of the approach.

# Building Baseline – Sources

- Understand the practices for system inspections:
  - Sources:
    - NASA, DOD, ESA standards and handbooks
    - System engineering literature.
- Well known software best practices
    - NASA, ESA, DOD, RUP, literature
- Source re-elaboration:
  - Understanding the real issues and needs
    - System is different from software
  - Definition of a common taxonomy
    - Different standards can use different taxonomies
  - Gathering and merging best practices
    - Different standards and practices can propose different solutions

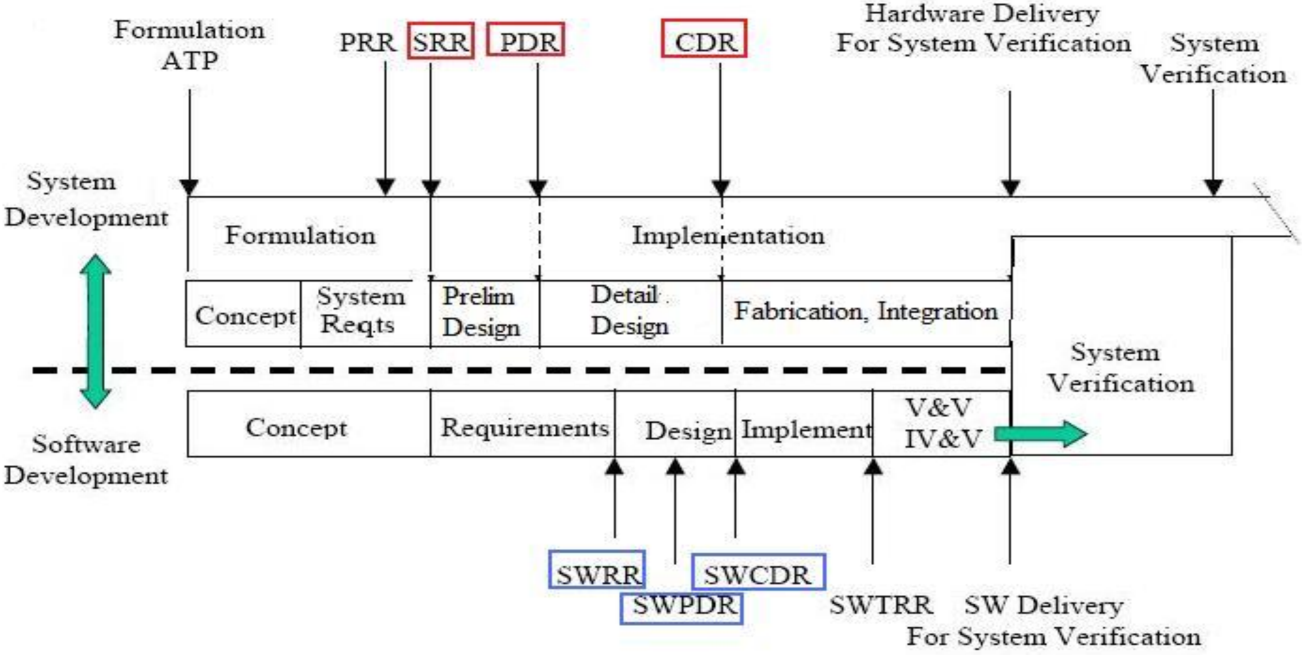


# Building A Baseline – Triggering Questions

- What techniques do people use to review system/software quality issues during development?
  - Which artifacts serve as input to these techniques?
  - Which techniques account for both systems and software?
- How do system engineers and software engineers participate in each other’s activities?
  - Should they participate in each other’s activities? How? When?
- Is there any similarity between software inspections and system reviews?
  - How can our knowledge and experiences in software inspection help to improve the system review process?

# Exploring Interactions between Software and System

- Reviews are "Key Decision Points" in both system and software development.
- Reference models allow us to define system and software reviews that:
  - Reason about *types of information* and how it is encapsulated in documentation at various phases ➔ What's available as input?
  - Understand issues of timing, coordination, and communication across subsystems ➔ How do we assure that future activities can be done correctly?



# Formulating Recommendations

- For each review type, reference models allow us to reason about:
  - Structure of the review
    - Team composition and expertise.
    - Amount of material to inspect.
    - Meeting length.
  - Artifacts to be inspected
    - Type and notation of documents.
  - Quality attributes
    - Mandatory and optional attributes.
    - Which expertise should be checking which qualities.
    - Which artifacts are appropriate for checking various qualities.

# Formulating Recommendations

- For each review type, reference models allow us to reason about:
  - Structure of the review
    - Team composition and expertise.
    - Amount of material to inspect.
    - Meeting length.

These parameters have been shown to affect effectiveness of (software) inspection.

There are heuristics available.

Did they stand the test of time?

# Formulating Recommendations – Inspection Structure

- Our recommendations are tested against a database of inspection results from across NASA centers.
  - 2500+ inspections
  - 5 Centers
- We unified, scrubbed, and verified the data
  - Sparseness: Not all inspections collected our metrics of interest
    - E.g. 721 reported # inspectors
    - E.g. 627 reported page rate
  - Outliers: We retained extreme values that used same definition of the metrics, if not of an inspection
    - E.g. Page rates of hundreds of pages per hour
    - E.g. Meeting length of less than 30 minutes
- Defect data is sensitive – Raw data can be used by us but cannot be shared with other teams

# Formulating Recommendations – Inspection Structure

- Work at NASA in the mid-90s by Dr. John Kelly identified heuristics for key parameters (moderator's control metrics), e.g.:

| | |
|---|---|
| **Team size:**<br>Too small – miss important expertise<br>Too large – drive up costs, dampen discussion<br>=> Rule of thumb = 4 to 6 | **Page rate:**<br>Too small – miss interrelations<br>Too large – thorough review impossible<br>=> Rule of thumb = 10 to 30 pgs for reqts, 20 to 40 pages for test plans, etc. |

- Our database confirms that heuristics are still good predictors of inspections with most defects found.

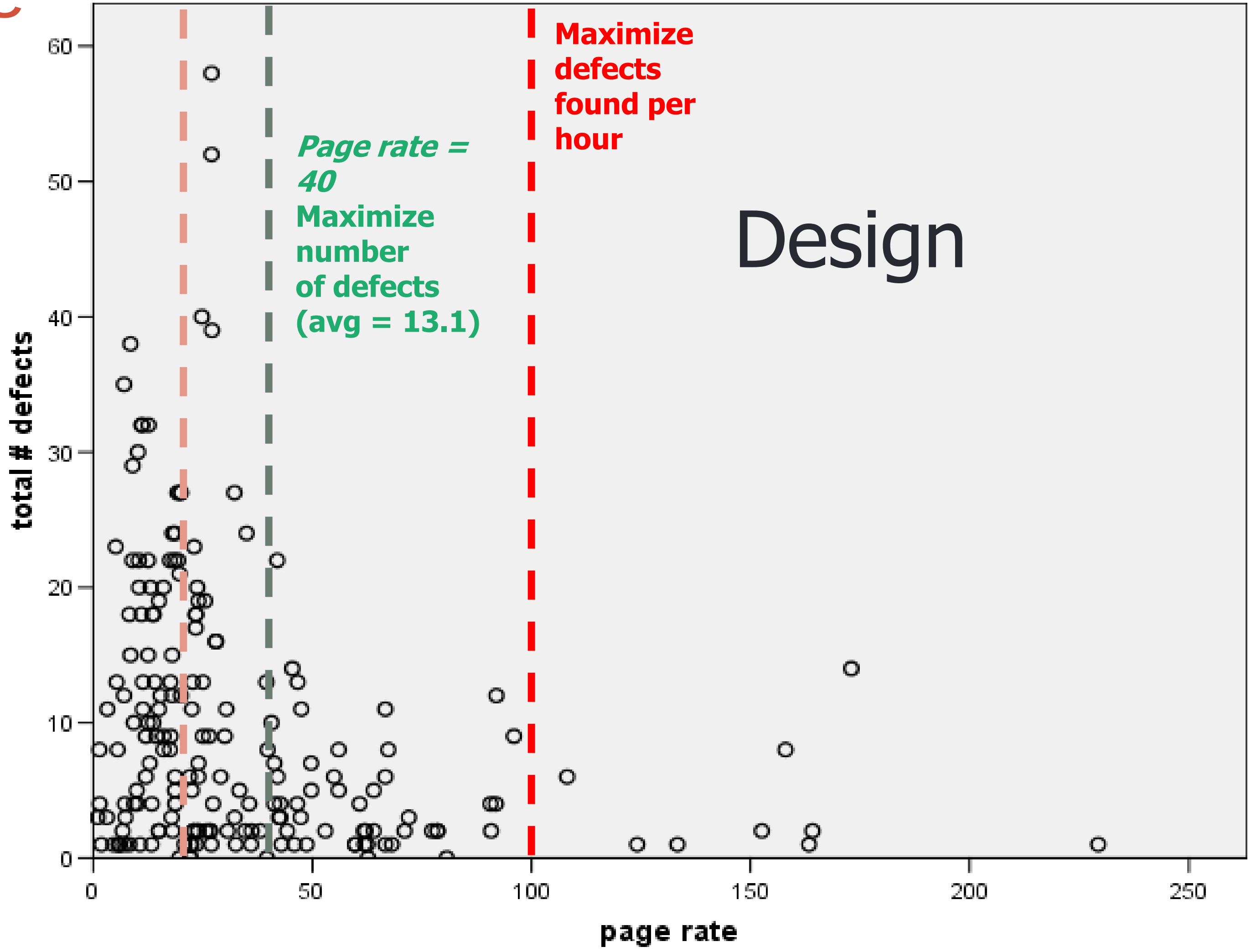
| | |
|---|---|
| **Team size:** Avg results for all projects:<br>If followed: 14 defects detected<br>If not: 7 defects detected<br>*Significant, p<0.0005* | **Page rate:** Avg results for all projects:<br>If followed: 14 defects detected<br>If not: 6.5 defects detected<br>*Significant, p<0.0005* |

- Yet, fewer projects are able to follow them:

| | |
|---|---|
| **Team size:** 10% of contemporary projects followed | **Page rate:** 15% of contemporary projects followed |

# Formulating Recommendations – Inspection Structure

*Page rate = 20*
**Original heuristic**
**(avg = 15.4)**



*Page rate = 40*
**Maximize number of defects**
**(avg = 13.1)**

**Maximize defects found per hour**

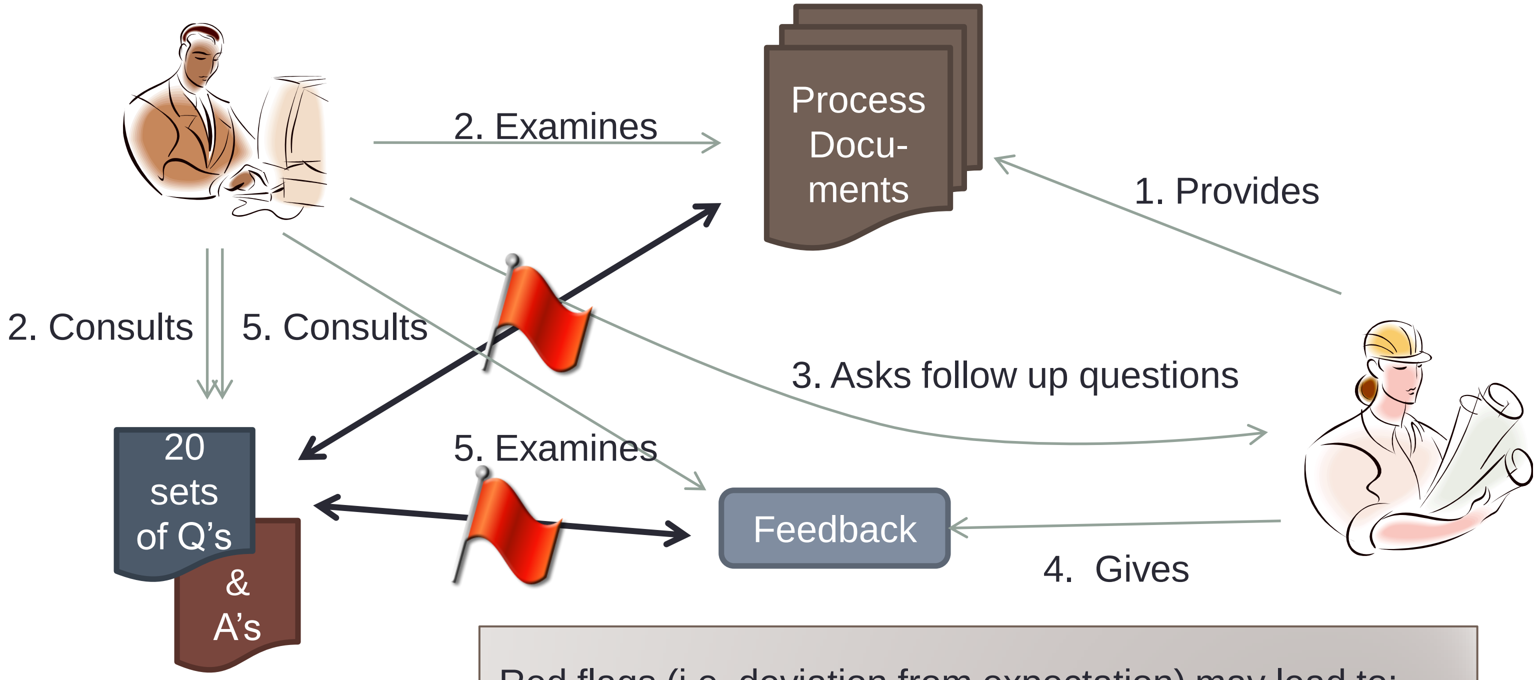
Design

# Packaging Best Practices – as Assessment Process

- Assessment questions and (best practice/recommendation) answers about:
  - Development and review process.
    - Development model, amount of material to inspect, meeting length.
  - Review team
    - Team composition and expertise.
  - Artifacts to be inspected and produced
    - Type and notation of documents.
    - Inspection metrics
  - Quality attributes
    - Mandatory and optional attributes.
    - Which expertise should be checking which qualities.
    - Which artifacts are appropriate for checking various qualities.
- Context questions: understand the need for tailoring of the best practices.

- Assessment questions to tie the recommendations to project context – development process, etc.

# Health Check Process – An Informal Model



2. Examines

Process Docu-ments

1. Provides

2. Consults

5. Consults

3. Asks follow up questions

20 sets of Q's

& A's

5. Examines

Feedback

4. Gives

Structures,
artifacts,
Quality attributes

Red flags (i.e. deviation from expectation) may lead to:
-Recommendations to the inspection process
-Updates to the health check Q-A's

# Health Check Process – Example of Assessment Question

- High-level question:
  - *Who are the team members that are generally required to participate in a review of a particular artifact?*
- Best practice recommendation:
  - *In most types of reviews, an inspection team should represent at least the following perspectives: requirements/user, integration and implementation, quality and process assurance*
- Detailed-level/probing questions (if mismatch occurs):
  - *If a recommended team member is missing from the actual review team, what is the reason for this omission? Who performs his/her tasks in the actual review team?*
  - *If a member of the actual review team is missing from our recommended team composition, why is this particular member needed? Who performs his/her tasks in the recommended review team?*

# Proof of Concept – Application of Health Check

- Applied with NASA team developing safety-critical hardware interlocks.
- Assessment Process:
  - Step 1 :Team sends us process documentation.
    - Development and assurance process.
  - Step 2: Gather answers to the health check questions, and compare them against the expected answers.
  - Step 3:
    - Ask follow-up questions
    - Formulate recommendations.
  - Step 4: Analyze feedback.

# Proof of Concept – Application of Health Check

- Recommendations:
  - **Issue 1**: No inspection is req. in requirements phase
    - **Recommendation**: A review should be performed during requirements phase, perhaps based on our SRR checklists
  - **Issue 2:** V&V Matrix is only constructed during design phase**.**
    - **Recommendation:** V&V matrix is based on requirements. It is a valuable artifact for SRR. Move its development earlier in the lifecycle.
  - **Issue 3:** Development and evolution of test plan is not clear.
    - **Recommendation:** Test plan is valuable artifact for every type of review. Test plan could be created in the early lifecycle phases.
  - **Issue 4:** SRD and SSRD are input to the design and implementation phase, but no change or request document are shown as outputs
    - **Recommendation**: It is beneficial to be open to look for requirement problems even in the later phases of development. Note explicitly constraints that disallow changes to such documents.

Process deficiency → Forwarded

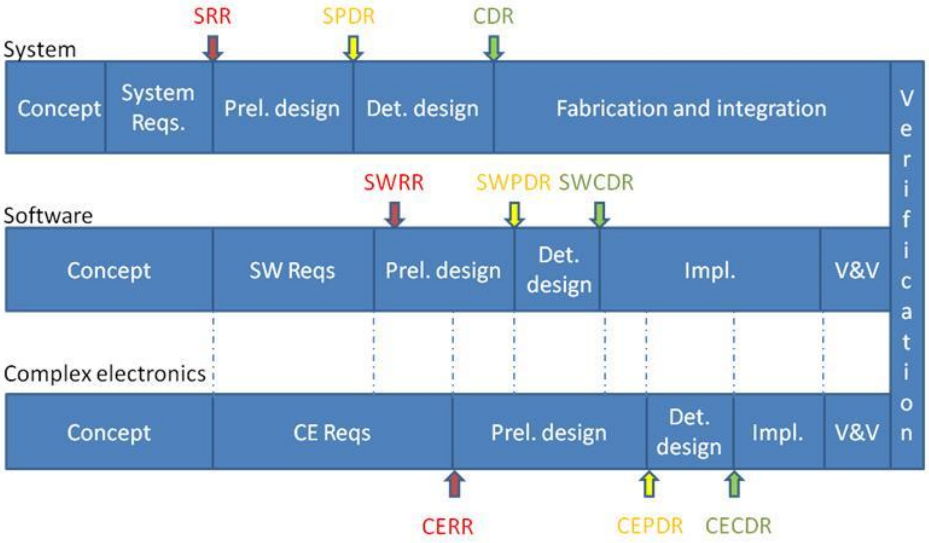
Process error → Forwarded

Documentation error → Fixed

Process deficiency → Fixed

# Future and Ongoing Work (1)

- Further validate and refine our approaches:
  - Reaching out to teams who would be interested in applying health check and providing feedback.
    - Currently work with a NASA team looking at certification review from both software and hardware side.
- Further extend our approaches for inspecting complex electronic applications.
  - Understand the interface between CE and System.
  - Understand which phase of CE is more closely related to software and which phase is more related to hardware.



# Ongoing Work (2)

- Expand best practices recommendations to other V&V technologies
  - Assess trade-offs of each V&V technique and formulate an assurance strategy based on combination and/or sequences of techniques.

# Acknowledgement

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