

INSPECTIONS FOR SYSTEMS AND SOFTWARE

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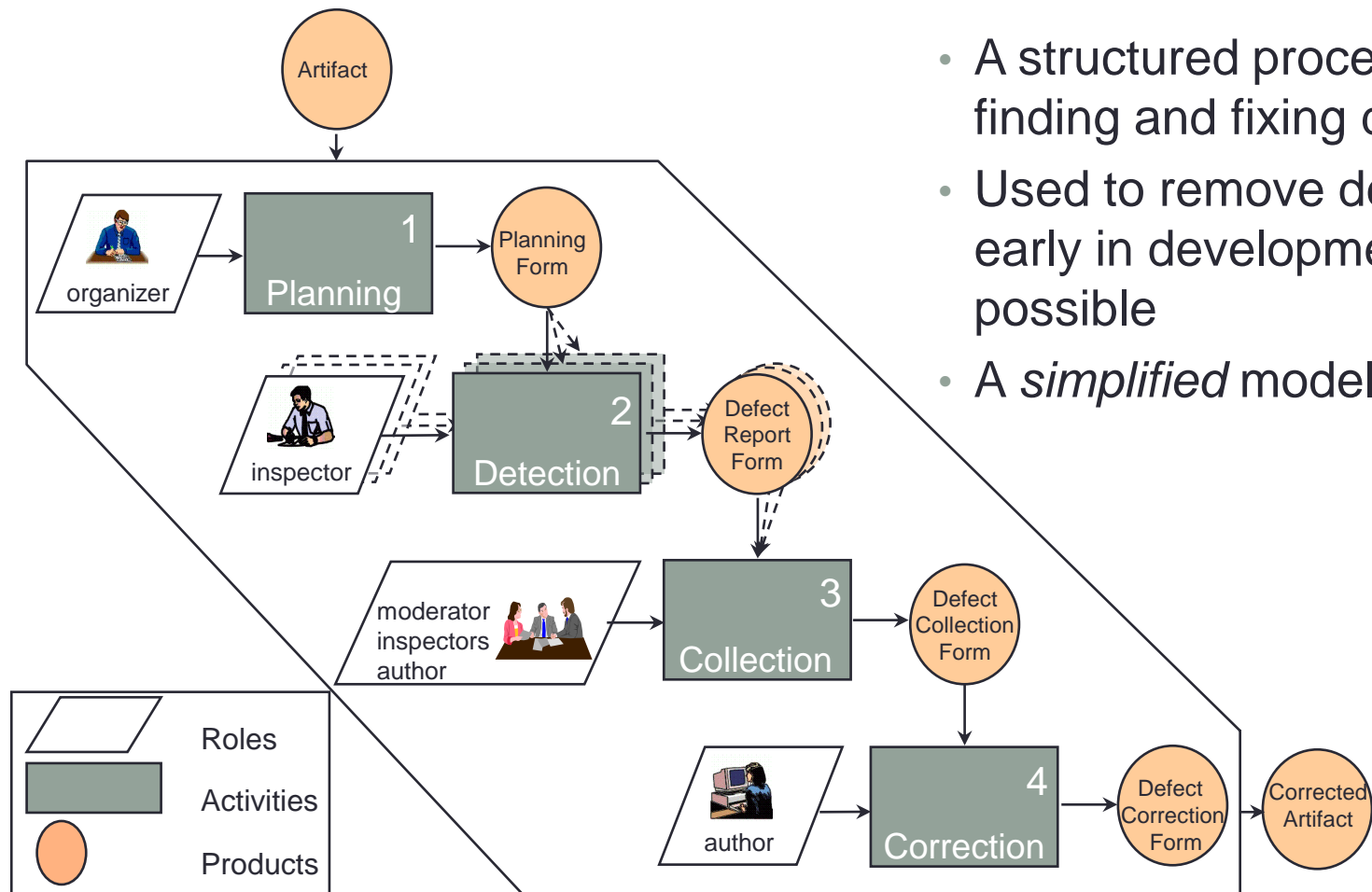
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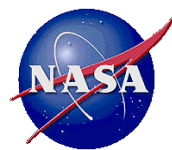
**NASA Goddard Space Flight Center

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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:

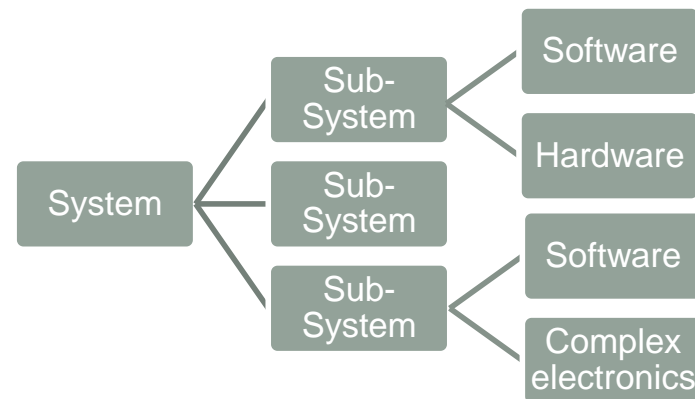


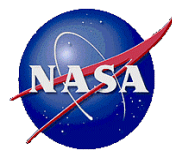
Why Inspection?

- 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.

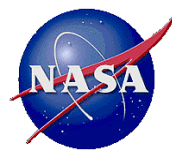




Our proposed approach

- 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

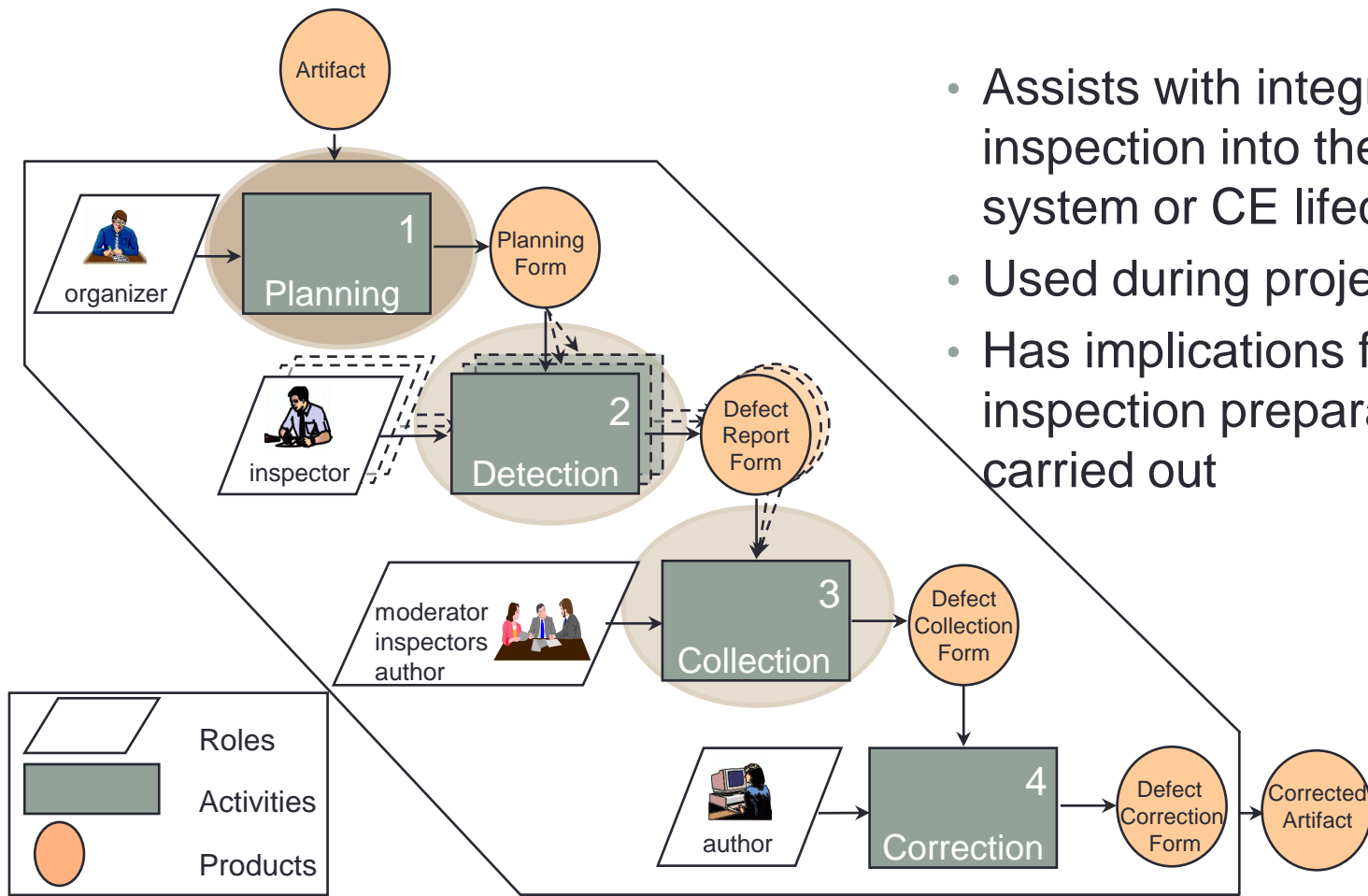


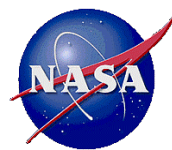
The “Process Health Check”

- 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”

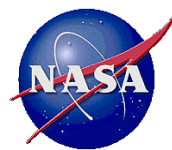
- Assists with integrating an inspection into the larger system or CE lifecycle
- Used during project planning
- Has implications for how inspection preparation is carried out





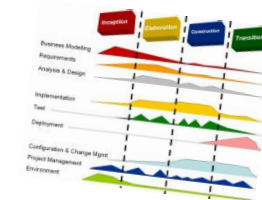
Methodology – Overview

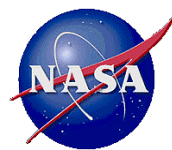
- Create baseline of best practices.
- Package best practices in a framework.
- Continuously refine framework:
 - Proof of concept study.
 - Pilot Study
 - Deployment of the approach.



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



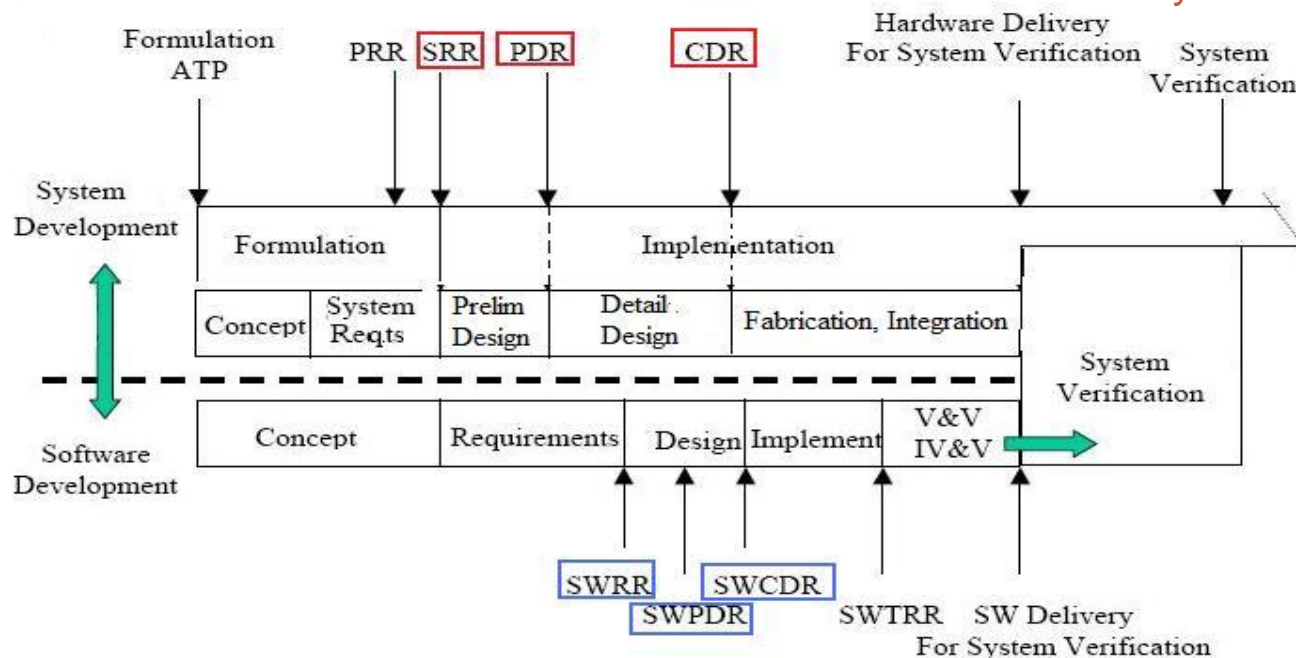


Building A Baseline – Triggering Questions

- 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

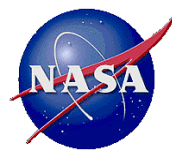
- For each review type, reference models allow us to reason about:
 - Structure of the review
 - Team composition and expertise.
 - Amount of material to inspect.
 - Meeting length.

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

There are heuristics available.

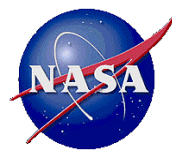
Did they stand the test of time?





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:

Too small – miss important expertise
Too large – drive up costs, dampen discussion
=> Rule of thumb = 4 to 6

Page rate:

Too small – miss interrelations
Too large – thorough review impossible
=> 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:

If followed: **14** defects detected

If not: **7** defects detected

Significant, $p < 0.0005$

Page rate: Avg results for all projects:

If followed: **14** defects detected

If not: **6.5** defects detected

Significant, $p < 0.0005$

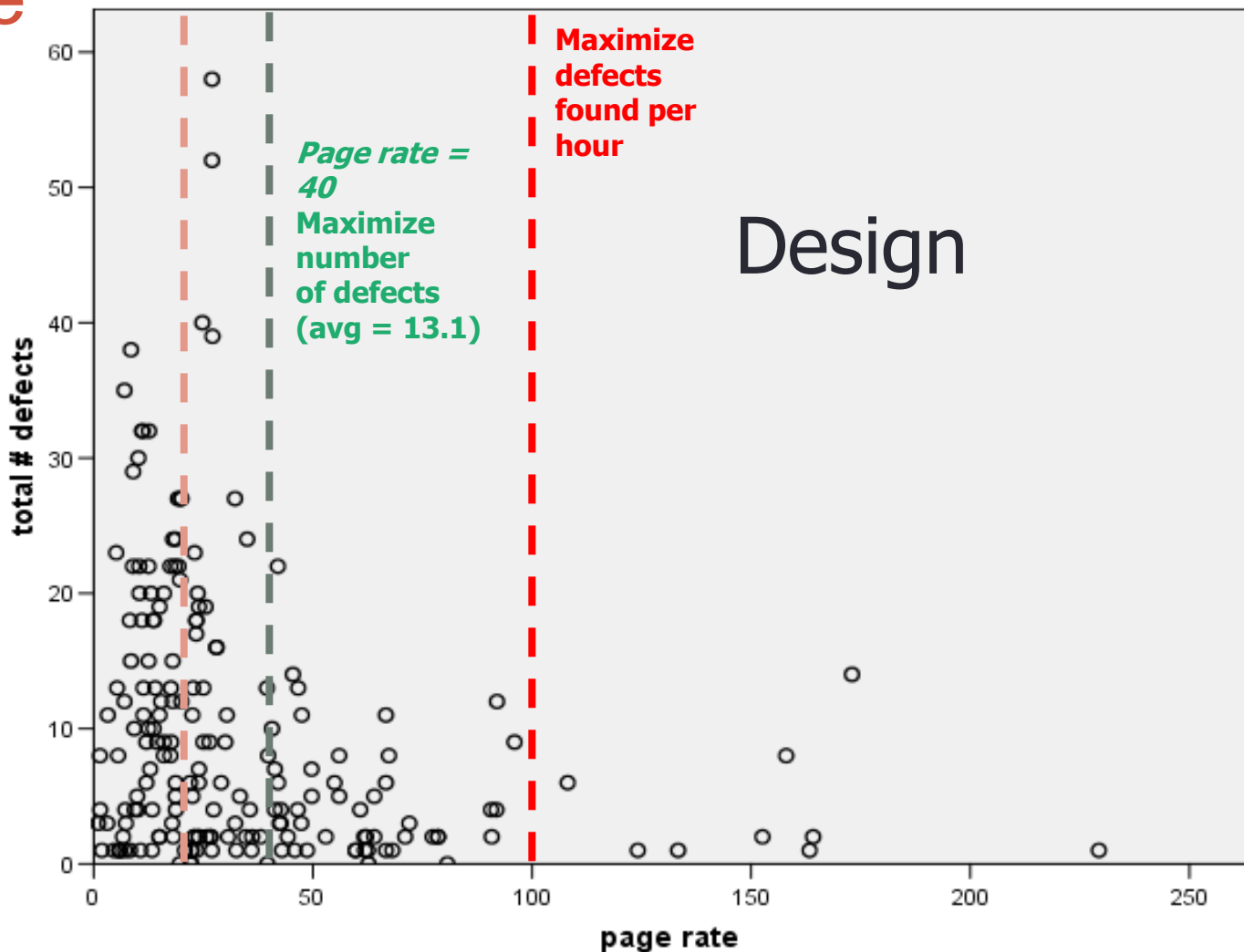
- Yet, fewer projects are able to follow them:

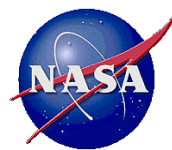
Team size: **10%** of contemporary projects followed

Page rate: **15%** of contemporary projects followed

Formulating Recommendations – Inspection Structure

Page rate = 20
Original heuristic
(avg = 15.4)

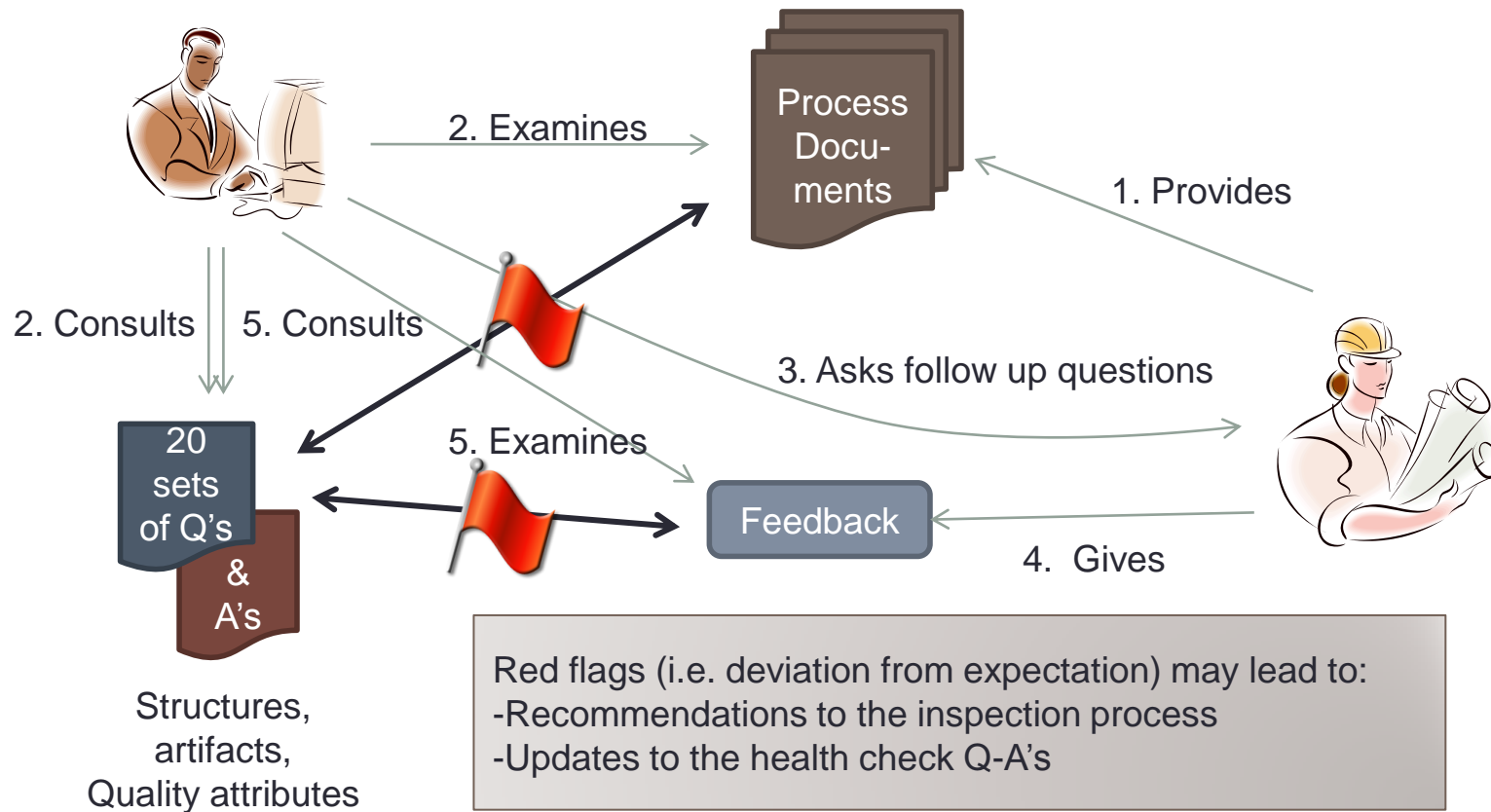




Packaging Best Practices – as Assessment Process

- 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





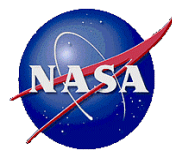
Health Check Process – Example of Assessment Question

- 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

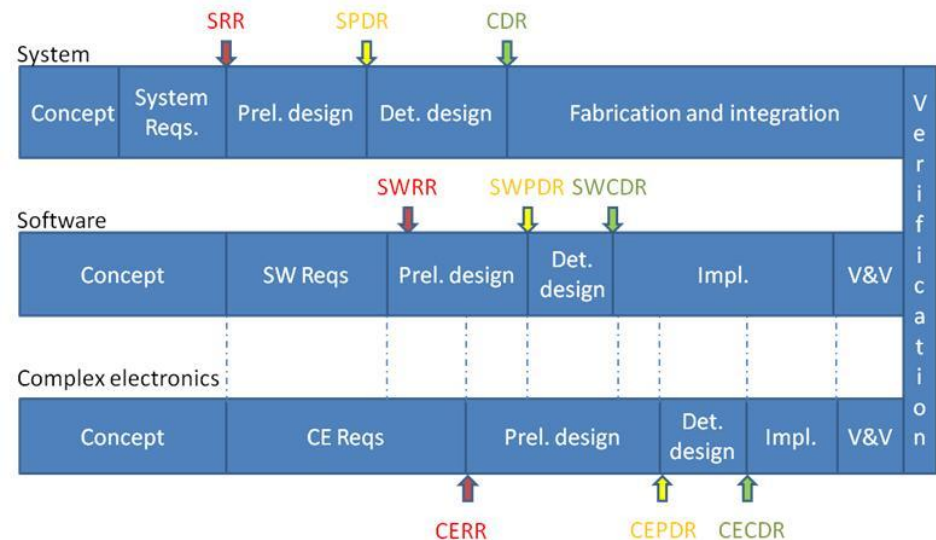
Process error →
Forwarded

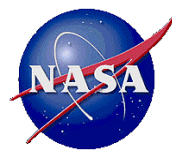
Documentation error →
Fixed

Process deficiency →
Fixed

Future and Ongoing Work (1)

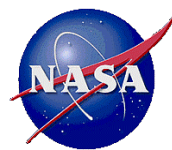
- Further validate and refine our approaches:
 - Reaching out to teams who would be interested in applying health check and providing feedback.
 - Currently work with a NASA team looking at certification review from both software and hardware side.
- Further extend our approaches for inspecting complex 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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