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Root Cause Investigation (RCI) Best Practices Guide Product Overview

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Acknowledgments

This presentation provides a summary overview of TOR-2014-02202, “Root Cause Investigation Best Practices Guide”, which was produced as part of the 2014 Mission Assurance Improvement Workshop.

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Root Cause Investigation (RCI) Best Practices Guide Overview

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May 21, 2014

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RCI Overview Agenda

- Motivation for RCI Guide
- Example
- Product Overview
- Topic Details
- Product Implementation Recommendations
- Topic Follow-on Recommendations
- Team Membership and Recognition

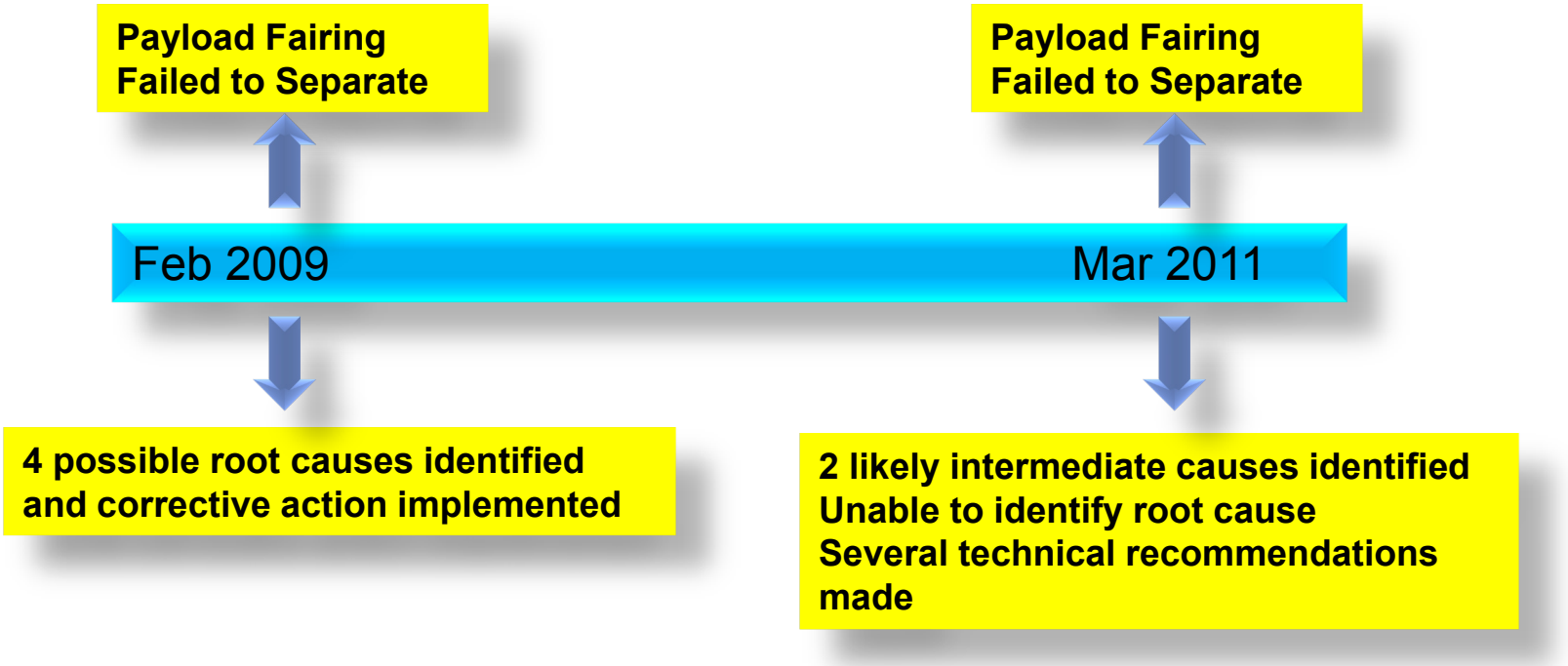
Motivation for RCI Guide

- Some root cause failure investigations failed to identify true root cause
  - *Unfortunately, failure recurred after corrective actions were implemented for what was believed to be the root cause*
- Projects and teams may lack leadership and guidance documents on performance of root cause analysis (RCA)
- Variability in RCA techniques used can result in ineffective or inefficient root cause investigations
- For the National Security Space community, no recognized RCI best practice exists

Summary

- This guide has been prepared to help determine what methods and software tools are available when significant detailed root cause investigations are needed and what level of rigor is appropriate to reduce the likelihood of missing true root causes identification. For this report a root cause is the ultimate cause or causes that if eliminated would have prevented the occurrence of the failure. In reality, many failures require only one or two investigators to identify root causes and do not demand an investigation plan that includes many of the practices defined in this document.
- During ground testing and on-orbit operations of space systems, programs have experienced anomalies and failures where investigations did not truly establish definitive root causes. This has resulted in unidentified residual risk for future missions

Notional Failure Recurrence Example



Failure to Identify True Root Cause Increases Mission Risk

Goal of RCI Best Practices Guide is to Improve Identification of True Root Causes and Minimize Mission Risk

RCI Topic Team Charter

- Establish a cross industry and government team to formulate foundational information and recommended best practices for Root Cause Investigations (RCI) focused on the space industry

Root Cause Investigation Purpose and Scope

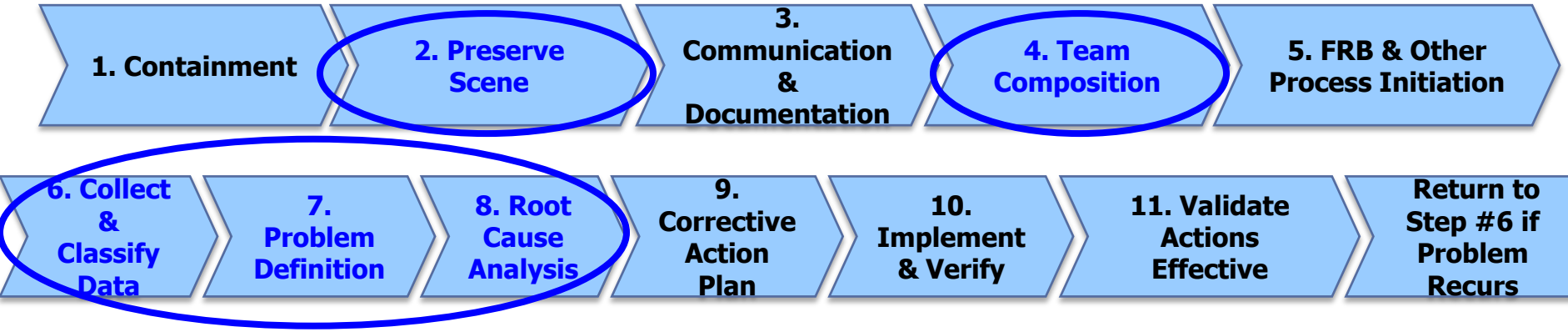
- During ground testing and on-orbit operations of space systems, programs have experienced anomalies and failures where investigations did not truly establish definitive root causes. This has resulted in unidentified residual risk for future missions
- Guide focuses on RCA elements of the broader Root Cause Corrective Action (RCCA) process per request of the Steering Committee. Corrective action process is not discussed in this guide.

Root Cause Investigation Guide Traceability to Steering Committee

Deliverable Requested	Location in RCI Guide
Overview of basis for RCAs, definitions and terminology, commonly used techniques, needed skills/experience	Sec 2, Sec 3, Sec 8, Sec 5.3
Key early actions to take following anomaly/failure	Sec 5.0
Data/information collection approaches	Sec 6.0
Structured RCA approaches – pros/cons	Sec 8, Table 11
Survey/review of available RCA tools	Sec 9.0
Guidance on criteria for determining when a RCA is sufficient (when do you stop)	Sec 10.0
RCA of on orbit vs. on ground anomalies	Sec 11.0
Handling of root cause unknown and unverified failures	Sec 12.0

Root Cause Investigation Best Practices Guide

Key Early Actions following the failure/anomaly are included in the top chevron bar, and the balance of the RCCA process is included in the bottom chevron bar. Note that this document only addresses those actions that significantly affect the **Root Cause Analysis** step (noted in **bold blue**):



- Focus is on Root Cause Analysis Methods and Tools utilized by the RCI Space Systems Team and companies
  - *No magic methods or tools; identified common issues and facilitation techniques*
  - *Many ground failure RCI's validate true root cause quickly (hardware available)*
  - *A few complex anomalies benefit from a combination of items in the RCI guide*

RCI Guide Details

- This Guidance Document summarizes root cause investigation best practice recommendations and key takeaways for use with simple or complex on-ground or in-orbit failures and anomalies.
- The industry Core Team focused on combining most effective root cause investigation approaches from each company in a usable format.
- Provide Pro and Cons for RCA Methods and RCA Pitfalls.

RCI Guide Details- Cont

- **Preservation of the "scene" of the failure:** Don't contaminate evidence (by immediately reworking affected unit to restore operation if it would affect failure investigation)
- **Immediate Data Collection:** Interviews, observations, measurements, audio/video, chart recordings, all relevant data, etc.
- **Determine Team Composition (as appropriate):** Ideally include 6-8 people including Process Performers (operators, technicians, etc.), Subject Matter Experts (engineers, scientists, etc.), Customer or Rep (Quality, Mission Assurance, etc.), RCCA Facilitator, Team Leader/Chair; define roles (RACI – Responsible, Accountable, Consulted, Informed and/or RAA – Responsibility, Accountability, Authority)

RCI Guide Details - Cont

- **Problem Definition ("Problem Definition Worksheet"):** Define, understand and agree upon the facts surrounding the anomaly: Title, Customer, What happened (be specific)?, When did it happen (start date/time – stop date/time)?, Where did it happen (be specific)?, How often did it happen?, Was it repeatable under specific conditions?, Importance/Significance?, Avoid "Who" (may inhibit cooperation if people think they are being blamed), Avoid "Why" and "How" (RCCA process will determine this)
- **Brainstorm potential causes/contributing factors including use of Data Collection above:** Classify data utilizing KNOT Chart, may also use Affinity Diagram, Pareto or Scatter Chart, Histogram, or other tools; assign actions, ECD's, etc

RCI Guide Details - Cont

- **Root Cause Analysis (RCA):** Almost always more than one root cause, and the level of rigor is determined by complexity of problem. Consider "Severity/Recurrence Risk Cube" analysis for RCA approach
  - ***RCA Techniques (may use one or more):*** *Timeline, 5-Whys, Apollo, Fishbone (Ishikawa) Cause and Effect Diagram, Process Analysis or Process Classification Method including Process Mapping or Logic Flow Pert Chart , Advanced Cause and Effect Analysis (complex Cause/Effect relationships in Fault/Failure Tree format), RCA "Stacking" (apply multiple techniques) or Interaction of methods (i.e., Fishbone diagram followed by 5-Why's on the identified RC from the Fishbone)*
  - ***Special Considerations for Space RCA:*** *Low volume, high value assets vs. serial production situations, Pre-launch vs. on-orbit investigations, Managing schedule pressures and team technical independence*
  - ***Unverified Failures (UVF):*** *What to do when root causes cannot be determined (in this context the UVF discussion is often about "how far do you go in looking for root cause?")*

RCI Outline – 1 of 3

RCI Outline – 2 of 3

RCI Outline – 3 of 3

Reasons For Missing True Root Cause

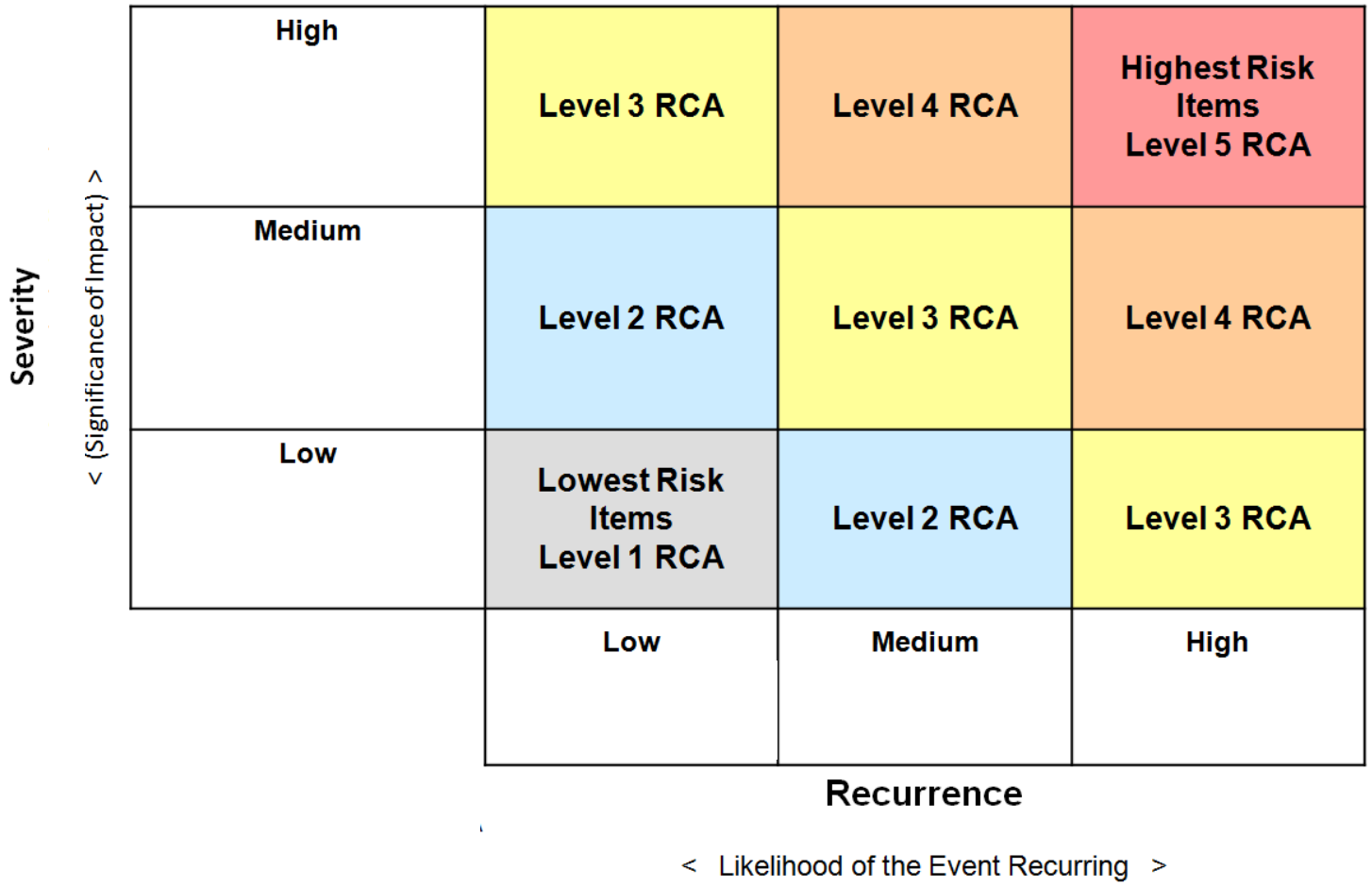
- Incorrect team composition
- Incorrect data classification
- Lack of objectivity/incorrect problem definition
- Cost and schedule constraints
- Rush to judgment
- Lack of management commitment

Details on RCA Pitfalls Covered in Exec Overview and Section 13

Team Facilitation Techniques

- Knowledge of group dynamics
  - *Ability to "read" the team (confusion, progress, intimidation)*
  - *Ability to create a safe environment*
  - *Ability to deal with disruptions and intimidation*
- Ability to determine if team is diverse enough
- Approach the problem from both right brain creative and left brain logical perspectives
- Classify data accurately (KNOT)
- Use RCA tool with which the team is most comfortable
- FOLLOW THE PROCESS (deviation introduces risk)

RCA Level Based on Risk Matrix



Failure Risk Matrix used to Determine RCA Rigor Needed

RCA Level by Impact Matrix

RCA Level	Impact	Commonly used Data Collection & RCA Methods	Typical Analysis Span	Output Artifacts (as required)
5	High-High	• KNOT Chart • Event Timeline • Process Mapping • Cause Mapping • Fishbone Diagram • Advanced Cause & Effect Analysis • Fault Tree Analysis	2 – 6 Weeks (or longer)	• RCA Findings and Conclusions • Validation and Measurement Strategy • Illustration of Root Cause Analysis • Company wide communications
4	High-Medium Medium-High	• KNOT Chart • Event Timeline • Process Mapping • Cause Mapping • Fishbone Diagram • Advanced Cause & Effect Analysis	4 days – 2 Weeks	• RCA Findings and Conclusions • Validation and Measurement Strategy • Illustration of Root Cause Analysis • User Community communications
3	High-Low Medium-Medium Low-High	• Brainstorming • Event Timeline • Cause Mapping • Fishbone Diagram	1 – 3 days	• RCA Findings and Conclusions • Validation and Measurement Strategy • Illustration of Root Cause Analysis • Affected people communications
2	Low-Medium Medium-Low	• 5 -Whys • Brainstorming • Fishbone Diagram	.5 – 1 day	• RCA Findings and Conclusions • Affected people communications
1	Low-Low	• 5 -Whys • Brainstorming	1 – 4 hours	• RCA Findings and Conclusions • Affected people communications

Impact Matrix Provides Guidance on Applicable RCA Methods

Intended RCI Guide Use

- **Primary use**
  - *Guide for RCI teams and sponsors on space related investigations*
  - *Help develop effective RCI plan and depth of rigor*
- **Publicize RCI guide at conferences**
  - *International Society of Testing and Failure Analysis (ASM)*
  - *International Reliability Physics Symposium (IEEE)*
  - *Reliability Availability and Maintainability Symposium (RAMS)*
  - *And others*
- **Specific recommendations for industry:**
  - *Incorporate best practices in corporate command media*
  - *Use as a reference to subcontractors to set expectations and improve communications*
- **Specific recommendations for government:**
  - *Use as a reference to contractors to set expectations and improve communications*
  - *Consider using as reference in program offices and RFP's*

RCI Team Introductions

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