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# ROOT CAUSE ANALYSIS (RCA) COURSE CURRICULUM (VIRTUAL OR ONSITE – 18 HOURS)

(*) Unlock the power of Fault Tree Analysis (FTA) to enhance system reliability, improve risk assessment, conduct Root Cause Analysis (RCA), and drive smarter engineering decisions.

## Course Overview


This Root Cause Analysis (RCA) course is designed to provide participants with comprehensive skills and techniques to identify, analyze, and resolve problems and issues effectively. As most products and processes have the potential for problems to emanate from hardware, software, and manufacturing, this course will teach students the fundamentals of each domain to make them confident in preventing recurring problems, enhancing reliability, and improving manufacturing quality.

## Course Objectives

Students who complete this course will be able to:

- properly define and recognize 'root causes' to ensure meaningful solutions are developed for things they and their organization can control;
- fluently identify different issues and elements of hardware, software, and manufacturing that can contribute to failure;
- confidently conduct RCA on products, processes, and systems that combine hardware, software, and manufacturing;
- identify a range of potential 'corrective actions (CAs)' for problems that allow the cheapest, most effective, and fastest solutions to be implemented (and not the 'favorite' or 'expensive/obvious' solution);

- understand how and when to use ‘5 whys,’ ‘Ishikawa/fishbone/cause and effect diagrams,’ and ‘fault trees’ to facilitate RCA;
- facilitate RCA workshops being cognisant of how to deal with human factors and group psychology;
- implement the ‘8D’ RCA strategy; and
- apply the skills above to real-world scenarios.

## Course Structure

The course comprises 18 1-hour lessons that can be delivered virtually or onsite.

## Course Materials

- For students attending the virtual course, 12 months of access to recorded lessons.
- Accompanying RCA guidebook that contains all the content of the course
- An ‘8D RCA’ Microsoft ® Word ® template for students to use as the basis for their organization's template.
- Ongoing support in the form of questions and answers.

## Assessment Methods

- Ongoing worked examples and quizzes throughout the course.
- A certificate will be issued to each student who completes the course.

## Course Duration

This is an 18-hour course that can be delivered onsite or virtually over 2 days (9 hours of lessons per day) or 3 days (6 hours of lessons per day).

## Enrollment Requirements

This course is designed for professionals in any engineering discipline, safety analysis, manufacturing, software development, or related fields. No prior knowledge of hardware, software, or manufacturing failures is required.

# Course Outline (1-hour lesson descriptions)

LESSON 1. INTRODUCTION

This lesson covers the course structure and a 'root cause.' The definition of a 'root cause' is unnecessarily complicated in textbooks and standards. A 'root cause' is limited to things you can control. This is both limiting and empowering, as problems are fixed only when you believe the things you can try are achievable. Students are introduced to how 'root cause analysis (RCA)' for hardware, software, and manufacturing engineers needs to cover each other's disciplines as each is intertwined with the others.

LESSON 2. 10 REASONS TO DO RCA

Students will be motivated by this lesson as the benefits of RCA are discussed at the organizational and individual levels. Thorough RCA not only finds solutions to problems but also a range of cost-effective, fast, and 'easy' solutions from which you can choose to implement in ways that suit you and your business plan.

LESSON 3. CAUSAL CHAINS

'Causal chains' refer to the many different chains of events triggered by potential root causes, each resulting in a plausible scenario for the 'undesirable event' your RCA focuses on. Ensuring that as many 'causal chains' are identified in RCA allows a much larger range of potential 'corrective actions (CAs)' to be introduced, meaning the cheapest, fastest, and easiest ones can be selected.

LESSON 4. '5 WHYS' AND 'ISHIKAWA (FISHBONE) DIAGRAMS'

The '5 whys' and 'Ishikawa diagrams' are both RCA tools that help structure the brainstorming process and allow potential root causes to be identified. Students will learn the fundamental differences between the two well-known approaches. '5 whys' is based on 'observational reasoning' where the answers to questions of inquiry can be confirmed through inspection. The 'Ishikawa diagram' is based on 'deductive reasoning' as it allows brainstorming to capture the range of possible ways an undesirable event occurred if we can't confirm what happened through observation.

LESSON 5. FAULT TREES AND IDENTIFYING THE PROBLEM

'Fault trees' are another visualization methodology based on 'deductive reasoning.' Students will learn in this lesson how to embark on constrained brainstorming, focusing on identifying the problem that needs to be solved.

LESSON 6. IMMEDIATE ACTIONS AND SPACE SHUTTLE EXAMPLE

‘Immediate actions’ are implemented to minimize the harm of an ‘undesirable event’ but not correct the issue that caused it. They are essential and are usually based on some form of understanding of what went wrong. Students will learn about immediate actions and work through a Space Shuttle RCA example.

LESSON 7. PARETO ANALYSIS AND HOW HARDWARE FAILS

‘Pareto analysis’ is a key tool to help us focus on the ‘vital few’ reasons things fail. There are typically only a small number of issues that cause the majority of problems, and they need to be addressed to the exclusion of all else. Students will learn to look for dominant ‘reasons’ for ‘undesirable events,’ focusing on how hardware fails.

LESSON 8. FUNCTIONAL AND PHYSICAL FAILURE MODES

‘Failure modes’ are the consequences of hardware ‘failure mechanisms.’ A ‘functional failure mode’ describes what a product or system is not (or is) doing due to failure (such as leaking, not calibrating, and not reaching top speed). A ‘physical failure mode’ describes the state of the product or system (such as bent contact, fractured strut, or discolored pad). Students are taught what these different failure modes mean and how they can be used to find potential root causes of failure.

LESSON 9. FAILURE MECHANISMS, FAULTS, AND FAILURE ANALYSIS

RCA needs to identify ‘why’ some undesirable event happened. If that undesirable event involved the failure of a hardware component, system, or product, we need to determine ‘how’ the failure occurred. This means identifying the failure mechanism (the physical, chemical, electrical, or other phenomenon) triggered by a fault (the circumstance that starts a physical failure process like a defect or wrong material being used). Students learn how ‘failure analysis’ can identify ‘how’ something failed as part of RCA.

LESSON 10. SMART LOCK KEYPAD AND THE STATISTICS OF FAILURE

Hardware failure processes are random. But just because something is random doesn’t mean it is unpredictable or has no ‘signature.’ This lesson starts with a worked example of an investigation into the failure of specific keys on a smart lock keypad. It then teaches students how to look for ‘statistical signatures’ in the failure data of components to see if it is wearing out too quickly, wearing in (likely caused by manufacturing defects), or something else.

LESSON 11. SOFTWARE FAILURE AND FAILURE MODES

Software fails differently from hardware and has its own type of failure mode. Virtually every product or manufacturing process relies heavily on software, so software needs to be included in most RCA. Students (especially those without a background in software) will be taught how to conduct RCA of software either by itself or as part of a more extensive system.

LESSON 12. SOFTWARE DEFECTS AND ENTRY POINTS

Less than 30 % of software defects are simple coding errors. These simple coding errors are typically easy to identify and fix. The remaining 70 % come from what are called 'entry points,' which can be incomplete 'software specifications' or steps skipped in the overall software design. This lesson will focus on software defects and how they got there to help RCA.

LESSON 13. SOFTWARE ROOT (PROCESS) CAUSES OF FAILURE AND WORKED EXAMPLE

There will always be a need for 'simple software debugging' where defects are resolved ad hoc based on customer or user feedback. However, the root causes of 'big' software failures, or repeated software failures, are key procedural (or cultural) issues in the organization responsible for the software. This lesson will focus on the root causes of these software problems and how to address them.

LESSON 14. MANUFACTURING, QUALITY, AND STATISTICAL PROCESS CONTROL (SPC)

'Quality' is a term that can be used to describe manufacturing processes and how well they can produce defect-free parts and components. Manufacturing processes are constantly 'changing' as cutting tools blunt, manufacturing machines age, and raw materials change. Students will learn how 'statistical process control (SPC)' can look for telltale 'statistical signatures.' SPC can be used as a 'corrective action (CA)' to address manufacturing issues and trigger RCA to pre-empt manufacturing process failure before defective parts are created.

LESSON 15. SMART LOCK KEYPAD STROKE DEFECTS AND CORRELATION

'Correlation' is a statistical relationship between two variables. This can be useful for finding links between temperature and manufacturing settings on part characteristics. This helps find the root causes of manufacturing problems. Students will learn about correlation and its application to the RCA of smart lock keypad stroke defects.

LESSON 16. DESIGN OF EXPERIMENTS (DOE) AND NOT ADMIRING PROBLEMS

Some manufacturing behaviors are challenging to understand, especially when they are based on things like atmospheric humidity, abrasive material, and lots of factors we don't initially anticipate influencing our process. 'Design of experiments (DOE)' is a useful way of efficiently comparing different scenarios with different characteristics to understand what influences process performance. Students will learn how to use DOE and previously taught tools to inform meaningful, impactful 'corrective actions (CAs)'

LESSON 17. THE 8 (OR 9) DISCIPLINES

The '8D process' is a robust baseline strategy for RCA. Students will go through a template 8D worksheet that can be tailored and adapted for most RCA scenarios. Students will then use the 8D process as part of a worked exercise where all the skills and approaches taught in the course will be practiced.

LESSON 18. PREVENTING PROBLEMS AND REVIEW

Students will review the course where the importance and value of doing RCA well is reinforced. Other activities that focus on preventing problems are also discussed at a high level and how that related to RCA.

# Instructor Information (Dr Chris Jackson)

Dr Jackson co-founded Acuitas in 2010 with a focus on quality and reliability engineering training.

Dr Jackson holds a Ph.D. and MSc in Reliability Engineering from the University of Maryland's Center of Risk and Reliability. He also holds a BE in Mechanical Engineering, a Masters of Military Science from the Australian National University (ANU) and has substantial experience in the field of leadership, management, risk, reliability and maintainability. He is a Certified Reliability Engineer (CRE) through the American Society of Quality (ASQ) and a Chartered Professional Engineer (CPEng) through Engineers Australia.


Dr Jackson was the inaugural director of the University of California, Los Angeles (UCLA's) Center of Reliability and Resilience Engineering and the founder of its Center for the Safety and Reliability of Autonomous Systems (SARAS). He has had an extensive career as a Senior Reliability Engineer in the Australian Defence Force, and is the Director of Acuitas Reliability Pty Ltd.

He has supported many complex and material systems develop their reliability performance and assisted in providing reliability management frameworks that support business outcomes (that is, make more money). He has been a reliability management consultant to many companies across industries ranging from medical devices to small satellites. He has also led initiatives in complementary fields such as systems engineering and performance-based management frameworks (PBMFs). He is the author of two reliability engineering books, co-author of another, and has authored several journal articles and conference papers.