

Principles of Managing in the Presence of Uncertainties That Create Cost, Schedule, and Technical Risk



Glen B. Alleman, Niwotridge Consulting, LLC, Niwot, Colorado, USA

We Have Under an Hour
To Address the Principles Needed to Increase the
Probability of Project Success with Risk Management
So, It's Going to Be...



What is Risk?

- Risk as a science was born in the sixteenth century Renaissance, a time of discovery
- The word risk is derived from the early Italian risicare which means “to dare”
- Today, risk is defined as the possibility of loss
- Loss – Unless there is potential for loss, there is no risk
- The loss can be either a bad outcome or a lost opportunity
- Choice – Unless there is a choice, there is no risk management



Risk-Based Decision Making

- Risk-based decision making and risk-based approaches in decision making is a systematic process to deal with uncertainties
- Engineering systems are almost always designed, constructed, and operated under unavoidable conditions of risk and uncertainty
- Multiple and conflicting objectives are expected to be achieved
- The identification, quantification, evaluation, and trading off of risks, benefits, and costs must become an integral and explicit component of the overall managerial decision-making process
- Risk-Based Decision Making Cannot be a cosmetic afterthought to our project processes!



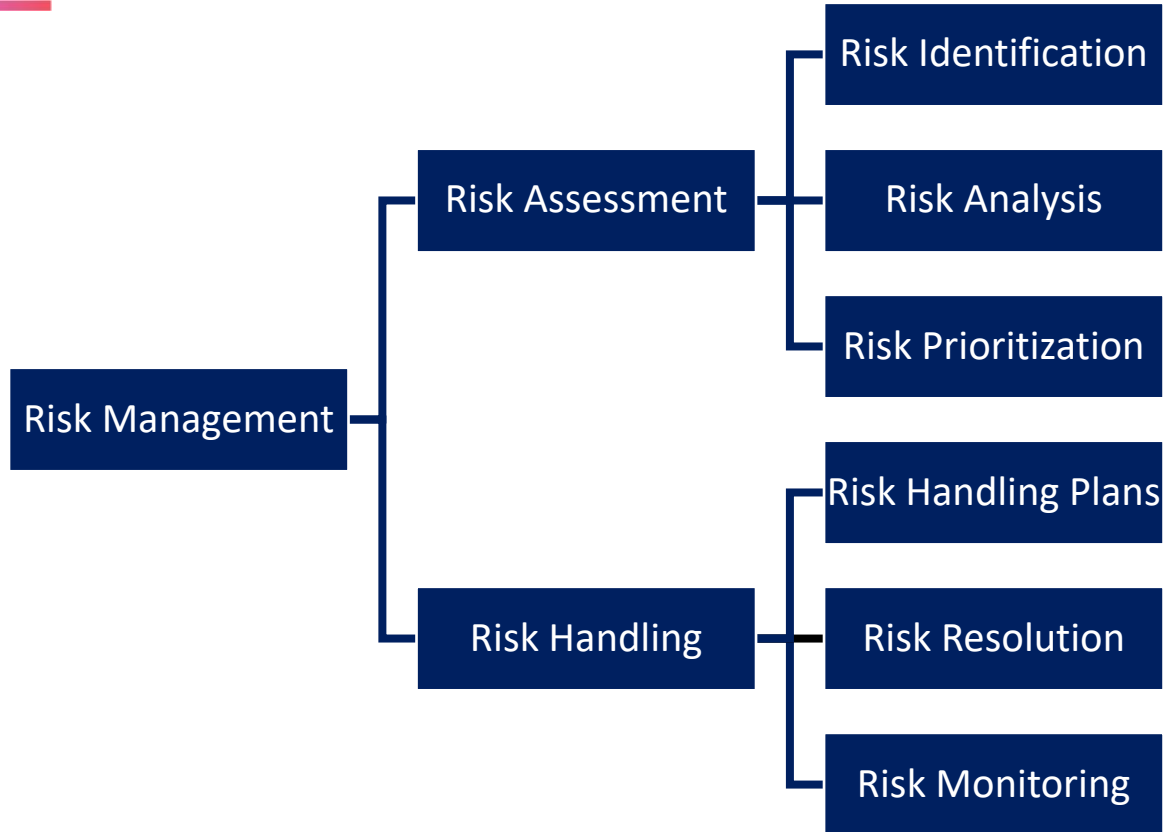
What is Risk Management?

Risk management is the systematic process of planning for, identifying, analyzing, responding to, and monitoring project risks. This activity is the means by which uncertainty is systematically identified and managed in order to increase the likelihood of meeting project objectives.

These uncertainties can be related to functionality, schedule, cost, or quality variability of the end deliverable. †



Elements of Risk Management



Risk Management as a Systems Engineering Process, Starts With ...

- Risk Identification
- Review and analysis of the requirements specification
- Review business, economic, environmental elements impacting the project
- Review the elements of the Work Breakdown Structure
- Review of the elements of the project plan
- Document the context of the risks



Thinking About Engineering and Its Associated Principles Including Risk Management

- In the world where we're presented with a need that gives rise to an idea...
- We design something and we make that *Thing* cater to the need.
- If we don't extract Principles from the *thing* we're not doing engineering, we're just tinkering.
- We need to extract Principles from process, and those Principles must link back to how we design things, and even link back into how we have those ideas
– Alan Kay



Starting with End In Mind

The Principles of Project Success ...

- **Continuously Managing Risks** produced by uncertainty has shown positive correlations between risk management and increasing the probability of project success.
- **Determining Which Risks Are Important To Deal With** in a prioritized model, their interactions, statistical interdependencies, propagation, and evolution.
- **Implementing Risk Handling Strategies For Correction, Prevention, And Avoidance**, of issues, derived from Root Cause Analysis, that identifies the steps needed to remove and prevent the conditions and actions creating the risks.

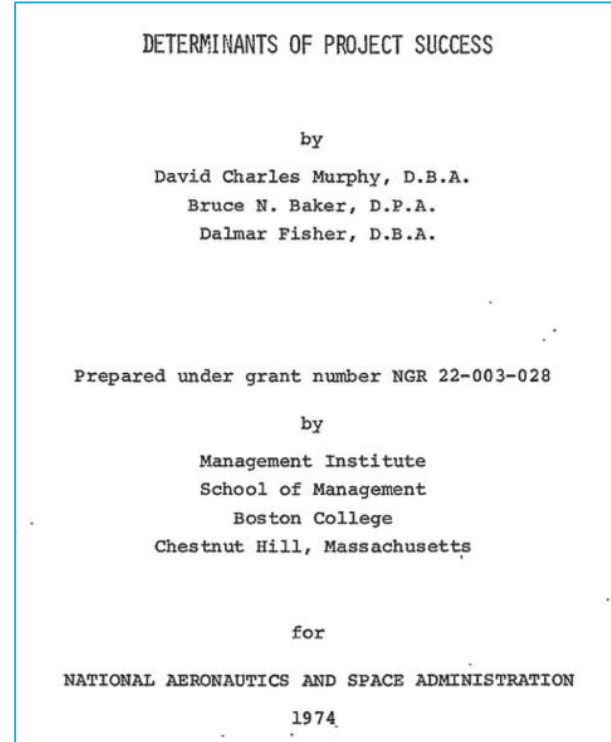


In these Two Workshops (Principles and Practices), We'll Separate Principles from Practices



- In Principle there is no difference between Principle and Practice.
- In Practice there is.

But always remember – *Project Management is a complex mechanism containing numerous variables of significance to project success. There is NO simple approach to insure project effectiveness. Many factors contribute to project success, in* “Determinants of Project Success,” David Charles Murphy, Bruce N. Baker, and Dalmar Fisher, Manager Institute Boston College, for NASA, 1974



Continuous Risk Management Increases the Probability of Success by ...

- **Preventing problems before they occur** with a *pre-mortem* to identify cause, take corrective and preventive actions to remove the conditions and actions of the root cause before the risk becomes an issue.
- **Improving product or service quality by focusing on project objectives** and consciously looking for risks that affect Cost, Schedule, and Performance throughout the project's lifecycle.
- **Enabling better use of resources** through early identification of problems and providing input to management decisions regarding resource allocation.
- **Promoting teamwork** by involving personnel at all levels of the project in risk management and focusing their attention on a shared vision of the mission to provide a mechanism for achieving the MOEs and MOPs as planned.



“Why do so many projects overspend and overrun?

Because they’re managed as if they were merely Complicated when in fact, they are Complex.

They’re planned as if everything is known at the start when in fact, they involve high levels of uncertainty that create cost, schedule, and technical risk.”

In, Architecting Systems: Concepts, Principles and Practice,
Hillary Sillitto, College Publications, 2014.



The Scope of Risk Management On Projects

Risk Management is essential for development and production programs. Information about key project cost, (technical) performance and schedule attributes is often uncertain or unknown until late in the program. Risk issues that can be identified early in the program, which will potentially impact the program later, termed Known Unknowns and can be alleviated with good risk management.

– *Effective Risk Management 2nd Edition*, Edmund Conrow, AIAA, 2003

The purpose of project management is to ensure effective management of these activities to bring the expected results and benefits in the shortest time. Project management is thus the application of knowledge, skills, activities, tools, and techniques to the project so that the project will satisfy the requirements imposed on it and achieve its goals. Risk management is also an integral part of project management, which should be incorporated into.



The 1st Step to Increasing the Probability of Project Success



Stephen
Covey

*Start with the
End In Mind –*

*Risk
Management is
Project
Management
for Adults*



Tim Lister





The Five Principles



Five Immutable Principles of Project Success



Credible Answers to the Questions Needed for Project Success ...

- | | | |
|---|-------------------------------------|-------------------------------|
| 1 | ▶ What does Done look like? | Capabilities and Requirements |
| 2 | ▶ How do we get there? | Master Plan and Schedule |
| 3 | ▶ Are there enough resources? | Resource Loaded Schedule |
| 4 | ▶ What are impediments to progress? | Risk Management Plan |
| 5 | ▶ How do we measure progress? | Earned Value Management |



All Risk Comes from Uncertainty



Uncertainties are things we can not be certain about.

Uncertainty is created by our incomplete knowledge – not by our ignorance.

Making decisions in the presence of Uncertainty requires making estimates of the impact of our decisions.



Five Immutable Principles of Project Success – Focused on Risk



Credible Answers to the Questions Needed for Project Success ...

- | | | |
|---|--|-------------------------------|
| 1 | ▶ What does Done look like? | Capabilities and Requirements |
| 2 | ▶ How do we get there? | Master Plan and Schedule |
| 3 | ▶ Are there enough resources? | Resource Loaded Schedule |
| 4 | ▶ What are impediments to progress? | Risk Management Plan |
| 5 | ▶ How do we measure progress? | Earned Value Management |



But What is Risk?

Risk is the effect of uncertainty of objectives. Uncertainty is a state or condition that involves a deficiency of information and leads to inadequate or incomplete knowledge of understanding. In the context of risk management, uncertainty exists whenever the knowledge or understanding of an event, consequence, or likelihood is inadequate or incomplete

– ISO 31000:2009, ISO 17666:2016 and ISO 11231:2010

Risk is Uncertainty that Matters



Some Words About Risk Resulting From Uncertainty

- Risk has two dimensions
 - The degree of possibility that a risk will take place or occur sometime in the future, or that a natural occurring process will create Risk
 - The consequences of that event or natural occurrence , once it is present (an issue) will unfavorably impact the project
- The degree of possibility is qualified as the Probability of Occurrence (event based) or a Probability Distribution Function (a distribution of the variance of the naturally occurring process)
- The consequences are usually taken to be undesirable and qualified as the magnitude of harm and the remaining probability of a recurrence of the same risk and can also be modeled with a Probability Distribution Function.



Relationship Between Uncertainty and Risk

- **Uncertainty** is present when probabilities or statistical processes cannot be quantified in a rigorous or valid manner, but can only be described as intervals within a probability distribution function (PDF) or a Statistical process.
- **Risk** is present when the uncertainty of the outcome can be quantified in terms of probabilities or a range of possible values.
- This distinction is important for modeling the future performance of cost, schedule, and technical outcomes of a project.

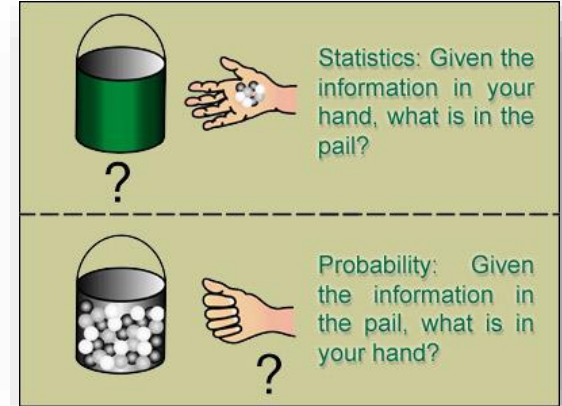


All Project Activities have Naturally Occurring *Uncertainties*

- *Naturally occurring* uncertainty and its resulting risk, impacts the probability of a successful outcome.

What is the probability of making a desired completion date or cost target?

- The irreducible statistical behavior of these activities, their arrangement in a network of activities, and correlation between their behaviors creates additional risk.
- Only *margin* can protect the outcome from the impact of this naturally occurring uncertainty



Risk Management is about Making Decisions in Presence of Uncertainty

- All project work operates in the presence of uncertain.
- Most project or product development can inform Risk Management, but it itself is not Risk Management.
- Rapid feedback, small increments of produced software, close knit teams of developers with customers, all help reduce risk – but risk produced by uncertainty.
- Those risks still must be managed outside the development processes, since they impact other aspects of the project beyond the production of software.

Tyche, Goddess of Chance



The Foundation of Risk Management

- **The Setting** – Many projects have not successfully delivered the effectiveness and performance needed to achieve the capabilities paid for by the user.
- **The Protagonist** –Project Managers and their supporting Engineering, Project Controls, and Finance and Business Operations staff.
- **The Imbalance** – many times Project management is incentivized to downplay the technical difficulties of development projects. This leads to overlooking the principles, processes, and practices that would have revealed the risk to cost, schedule, and technical performance and identified the corrective and preventive actions needed to Keep the Project Green.
- **The Balance** – prior to committing to a project, management needs to have a clear understanding of what Done looks like in units of measure meaningful to the decision makers, informed with analysis of the technical, schedule, and cost risks affecting the probability of project success.
- **The Solution** – Project Management creates a Master Plan, containing Measures of Effectiveness (MOE), Measures of Performance (MOP), Technical Performance Measures (TPM), and Key Performance Parameters (KPP) for each delivered Capability needed to accomplish the Mission or fulfil the Business Strategy.



The Purpose of Risk Management †

- The purpose of risk management is to reduce potential risks to an acceptable level before they occur, throughout the life of the product or project.
- Risk management is a continuous, forward-looking process that is applied to anticipate and avert risks that may adversely impact the project and can be considered both a project management and a systems engineering process.
- A balance must be achieved on each project in terms of overall risk management ownership, implementation, and day-to-day responsibility between these two top-level processes.



† “Systems Engineering Body of Knowledge (SEBOK), Risk Management,” V2.4, 2021

Measures of Progress to Plan

- **Measures of Effectiveness (MoE)** – are operational measures of a desired capability whose success is related to the achievement of the mission or operational objectives, evaluated in the operational environment, under a specific set of conditions.
- **Measures of Performance (MoP)** – are measures that characterize physical or functional attributes relating to the system operation, measured, or estimated under specific conditions.
- **Technical Performance Measures (TPM)** – are attributes that determine how well a system or system element is satisfying or expected to satisfy a technical requirement or goal.
- **Key Performance Parameters (KPP)** – represent the capabilities and characteristics so significant that failure to meet them can be cause for reevaluation, reassessing, or termination of the program.



A Few Risk Management Quotes

If you don't actively attack the risk, they will actively attack you – Tom Glib, in Principles of Software Engineering Management

Bad news isn't wine. It doesn't improve with age – General Colin Powell

Risk and Risk Handling—Don't' Be a Spectator – Frank Kendall, Under Secretary of Defense for Acquisition, Technology, and Logistics



Before We Proceed, Let's See How *Risk Management is About Finding Out What Can Go Wrong*



I cannot imagine any conditions which would cause a ship to founder. I cannot conceive of any vital disaster happening to this vessel. Modern shipbuilding has gone beyond that..."

Captain E.J. Smith, 1906, about the Adriatic (Captain of *Titanic* on the evening on 14 April 1912)



...there is a degree of doubt, caution, and modesty, which, in all kinds of scrutiny and decision, ought for ever to accompany a just reasoner

– David Hume (1711–76)

Three Sources of Uncertainty Create Risk to the Probability of Project Success



An Epistemic Uncertainty Statement

- **If–Then** – if we miss our next milestone then the project will fail to achieve its business value during the next quarter.
- **Condition–Concern** – our subcontractor has not provided enough information for us to status the schedule, and our concern is the schedule is slipping and we do not know it.
- **Condition–Event–Consequence** – our status shows there are some tasks behind schedule, so we could miss our milestone, and the project will fail to achieve its business value in the next quarter.

For risk created by *Epistemic Uncertainty*, explicit or implicit risk handling strategy is needed.



Reducible (Epistemic) Cost, Schedule, Technical, and Estimating Project Risks

- Reducible cost risk is often associated with unidentified reducible Technical risks, changes in technical requirements and their propagation that impacts cost.
- Technical risk is the impact on a project, system, or entire infrastructure when the outcomes from engineering development do not work as expected, do not provide the needed technical performance, or create higher than planned risk to the performance of the system.
- Most reducible schedule risk is directly linked to reducible technical risk.
- Reducible cost estimating risk is dependent on technical, schedule, and programmatic risks, which must be assessed to provide an accurate picture of project cost.



Aleatory Uncertainty Creates Irreducible Risk

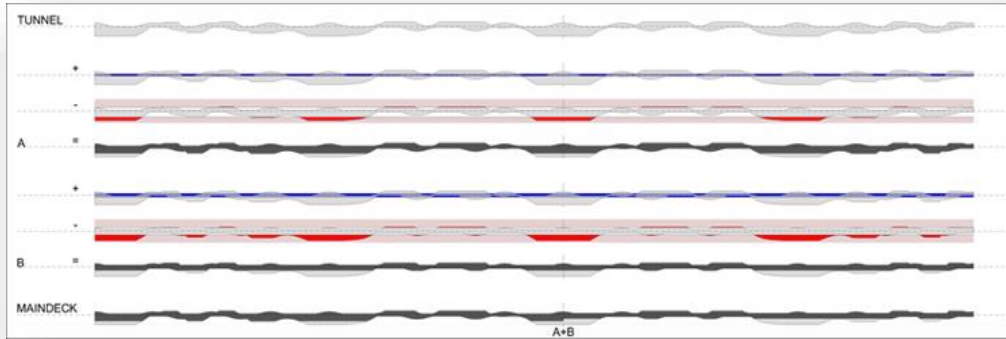
- For aleatory uncertainty, more information cannot be bought nor specific risk reduction actions taken to reduce the uncertainty and resulting risk.
- Only ***Margin*** can be the handling strategy for Aleatory uncertainty
- Cost margin in the form of ***Management Reserve***
- ***Schedule Margin*** is used to protect delivery dates. This margin has no budget assigned
- ***Technical Margin*** through redundancy, extra strength, extra capacity, bandwidth, or other performance factors

For risk created by *Aleatory Uncertainty*, explicit or implicit risk handling strategy is needed.



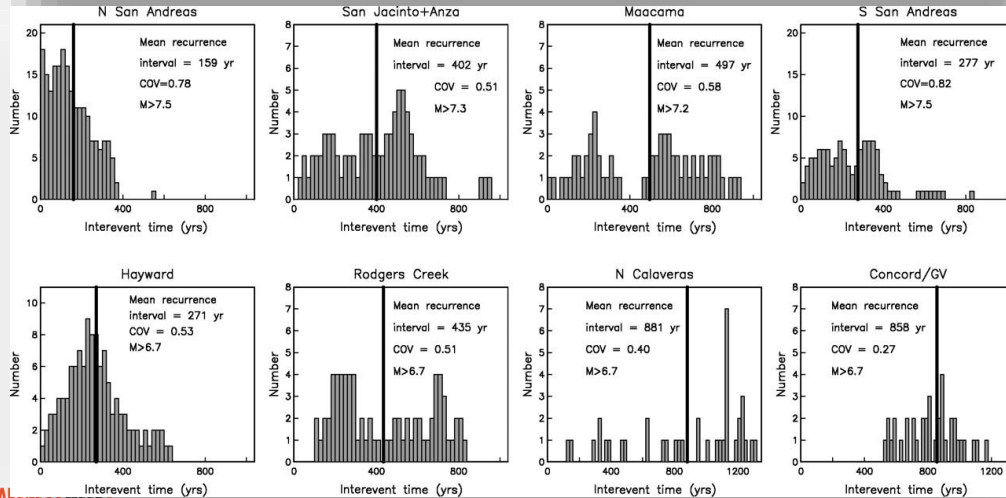
Aleatory and Epistemic Uncertainty Create Risk to Project Success

Aleatory



Natural Variance
in Underlying
System

Epistemic



Probability of an
Event impacting
Cost, Schedule, or
Technical
Performance



Epistemic Uncertainty and Aleatory Variability are Both Risk Drivers †

Epistemic Uncertainty

Randomness With Knowable Probabilities

- Epistemic uncertainty is the scientific uncertainty due to limited data and knowledge in the model of the process
- Epistemic uncertainty can, in principle, be eliminated with sufficient study
- Epistemic (or internal) uncertainty reflects the possibility of errors in our general knowledge.

The probability of occurrence can be defined through a variety of methods. The outcome is a probability of occurrence of the event

Aleatory Variability

Randomness With Unknowable Probabilities

- Aleatory uncertainties arise from the inherent randomness of a variable and are characterized by a Probability Density Function
- The knowledge of experts cannot be expected to reduce aleatory uncertainty although their knowledge may be useful in quantifying the uncertainty

A Probability Density Function (PDF) generates a collection of random variables used to model durations and costs



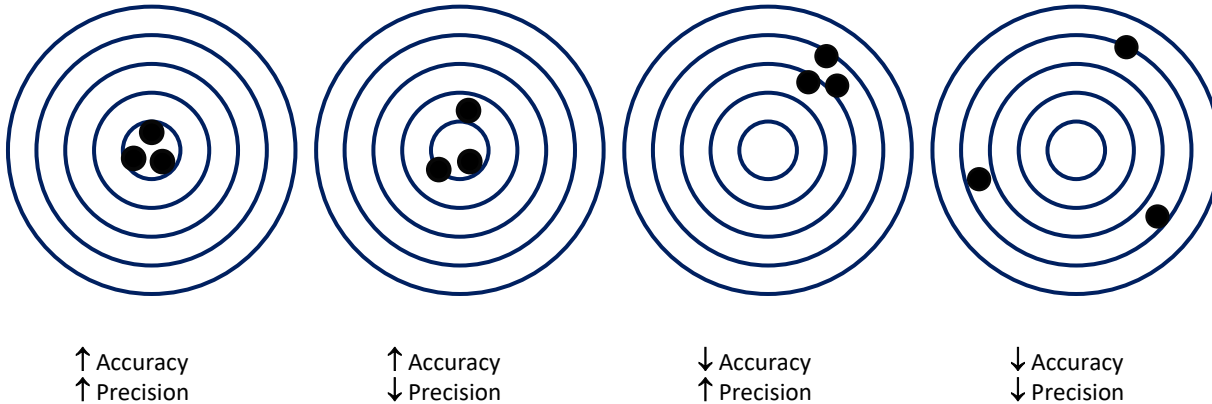
Uncertainty about Uncertainty

- Lack of precision about the underlying uncertainty.
- Lack of accuracy about the possible values in the uncertainty probability distributions.
- Undiscovered or unidentified Biases used in defining the range of possible outcomes of project processes.
- Natural variability from uncontrolled processes.
- Undefined probability distributions for project processes and technology.
- Unknowability of the range of the probability distributions.
- Absence of information about the probability distributions.



Measurement Uncertainty

- **Precision** – how small is the variance of the estimates
- **Accuracy** – how close is the estimate to the actual values
- **Bias** – what impacts on precision and accuracy come from the human judgments (or misjudgments)

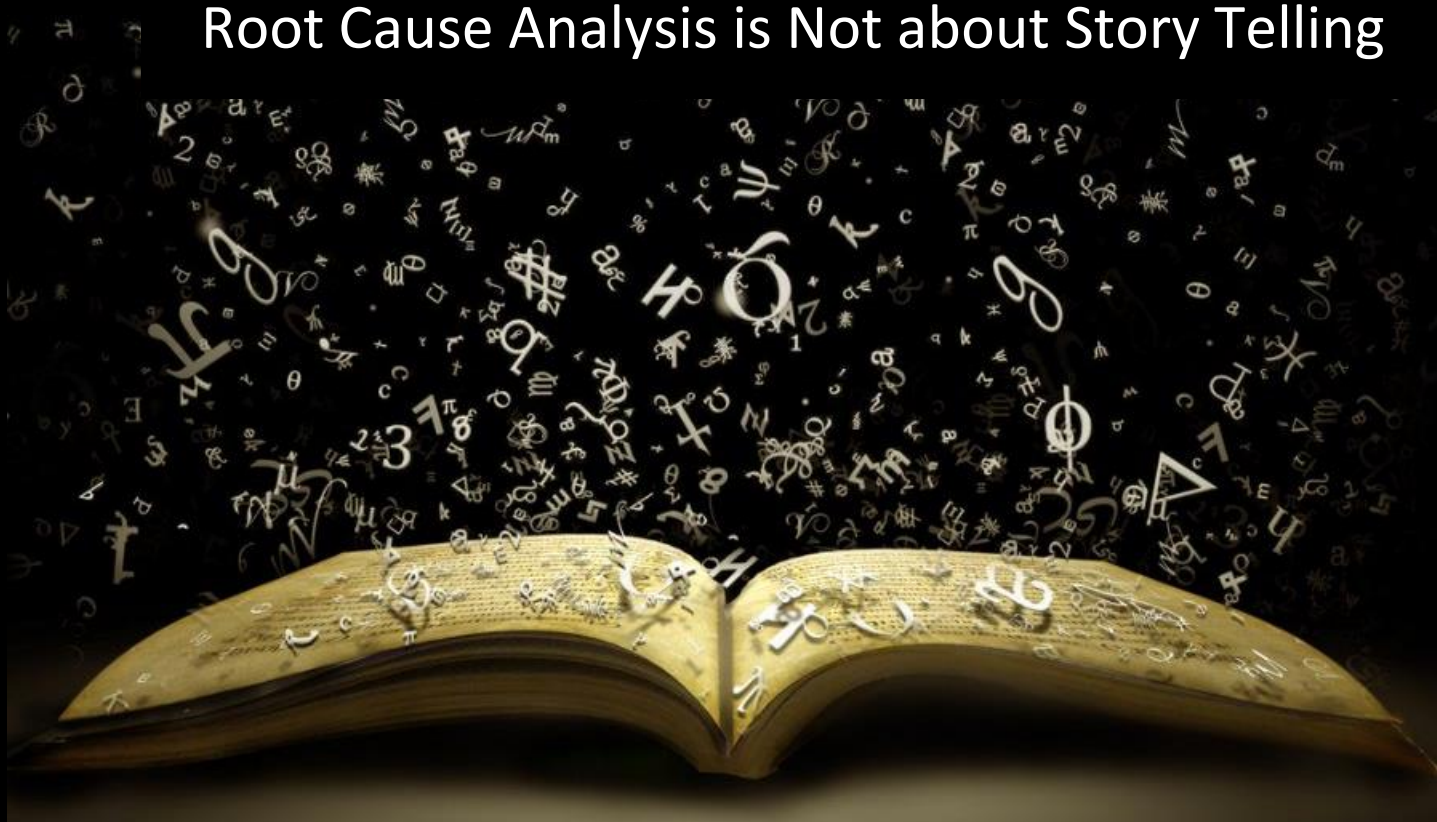


Root Cause Analysis is the Foundation of Risk Management

It's not the Root Cause We Seek
It's the Effective corrective and preventive actions to handle the the Root Cause of the Uncertainties that create the Risk



Root Cause Analysis is Not about Story Telling



Stories seldom identify causes because they are busy setting the stage for who was where and when some action occurred.

A story is a sequence of events starting in the past, leading to the consequences disguised as a root cause



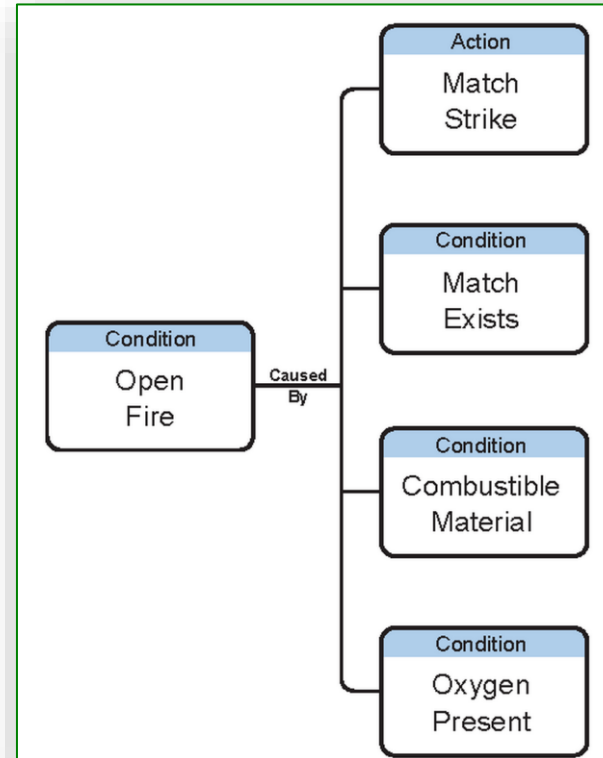
The Principles of the Apollo Method

- **Cause and Effect** are the same thing
 - If we look closely at cause and effect, we see that a “cause” and an “effect” are the same thing.
 - A single thing may be both a cause and an effect.
 - They differ only by how we perceive them in time.
- Each Effect has at least two Causes in the form of Actions and Conditions.
 - This is the most important and overlooked principle of causation.
 - Unlike storytelling used to capture the Fishbone style charts, which focuses on linear action causes, reality demands that each effect have at least one action cause and one or more conditional causes.



Each Effect Has At Least Two Causes in the Form of Actions and Conditions

- **Primary Effect** – is any effect we want to prevent
- **Action** – momentary causes that bring condition together to create an effect
- **Conditions** – the fundamental causal element of all that happens, made up of an effect and its immediate causes of a single causal relationship.
 - As a minimum, the causes in this set consist of an action and one or more conditions.
 - Causal sets, like causes, cannot exist alone.
 - They are part of a continuum of causes with no beginning or end, which leads us to the next principle:



Define the Problem

- Understanding the true problem
- Determines what your corrective actions
- Creating a common reality
- Outline the what, when, where, and significance (safety, environmental, cost, revenue, frequency, etc) with as much detail as possible.



Determine Causal Relationships

- Understanding the true problem
- Determines what your corrective actions
- Creating a common reality
- Outline the what, when, where, and significance (safety, environmental, cost, revenue, frequency, etc) with as much detail as possible.

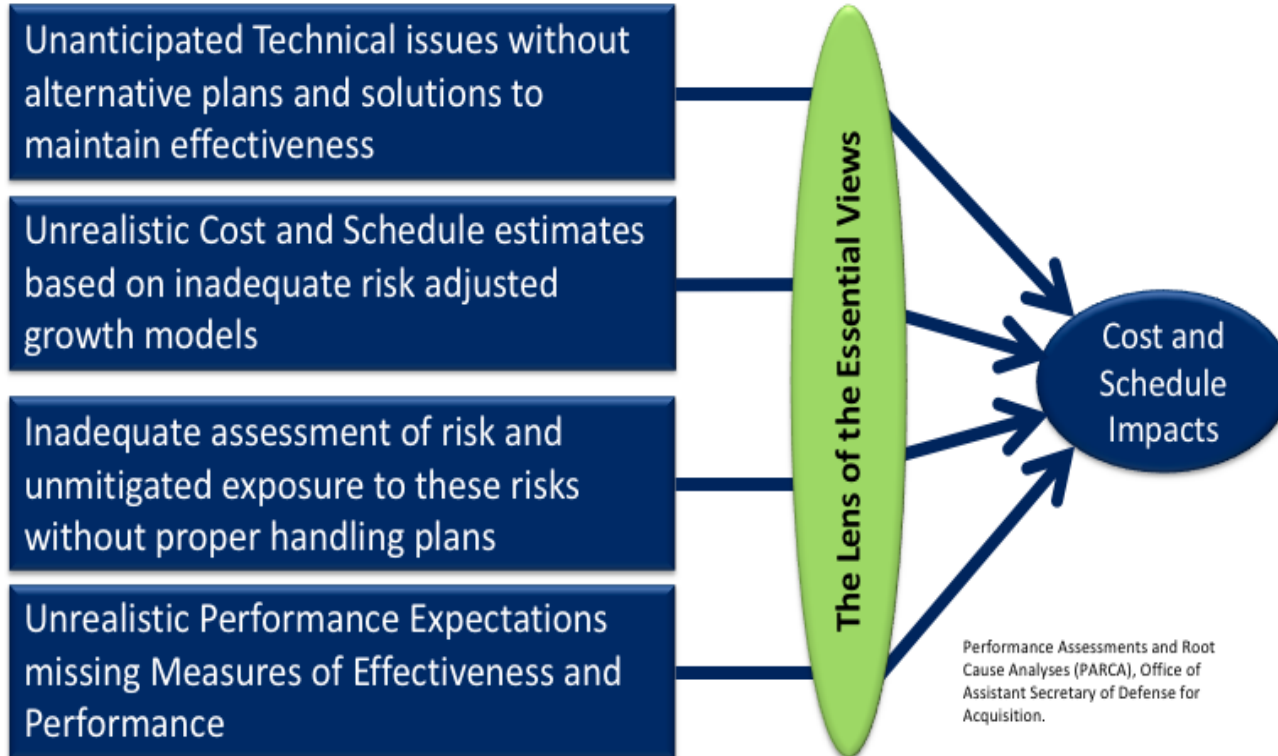


Identify Effective Solutions That Are ...

- Within your control
- Prevents recurrence
- Meets your goals and objectives
- Does not cause other problems



4 Summary Sources of Project Cost and Schedule Overruns and Technical Shortfalls



Performance Assessments and Root Cause Analyses (PARCA), Office of Assistant Secretary of Defense for Acquisition.



Risk Management is Part of Systems Engineering

Risk Management develops a strategy for identifying and assessing risks, dealing with hazards and tracking progress toward risk reduction in Systems.



Risk is the Possibility of Failing to Meet Overall Project Objectives within Budget, Time, and Technical Constraints



Different Approaches to Risk Management From the Systems Engineering Framework

- Inactive Risk Management – does not consider risk factors
- Reactive Risk Management – trying to handle risks
- Interactive Risk Management – risks managed throughout project lifecycle
- Proactive Risk Management – anticipate risks and implement preventive and corrective actions to

The last action is the most effective for any project, in any domain



Beware the Black Swan



Risk Bibliography

- Compendium of Papers, Books, and Resources
 - https://herdingcats.typepad.com/my_weblog/2021/08/a-compendium-of-risk-management-resources-1.html
 - Compendium of Blog Posts for Managing in Presence of Risk
 - https://herdingcats.typepad.com/my_weblog/2021/07/compendium-of-blog-topics.html
 - Presentations, Conference Briefings, Client Briefings on Risk
 - https://herdingcats.typepad.com/my_weblog/2019/04/the-collected-works-to-increase-the-probabilty-of-project-success.html#RM
- Give the Blog server a 15 to 20 seconds to take you to the right spot

