# Budget & Time-Constrained Failure Analysis in Modern Gun-Launched Weapons Systems Development

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**"21st Century Weapon Systems - Providing the Right Response"**

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# Artillery Application Requires Thorough Testing




## Planning for Failure Analysis

- Constrained Budgets & Schedules in Current Weapons Development Environment
- Test Failures Will Still Happen and Will Have to Be Analyzed & Fixed Quickly
- Still Need to Follow a Very Disciplined Failure Analysis & Corrective Action Approach
- Expect & Plan for Failure Analysis
  - Develop a solid knowledge base on the product design and build processes
  - Conduct early Failure Modes Effects Analysis to characterize potential failures
  - Plan early tests that stress the system
  - Use design-of-experiment techniques
  - Collect as much data as possible during tests
  - Have a well defined failure analysis process
  - Document & share lessons learned

**Expect & Plan for Failures During Development & Production**

# Artillery Application Requires Thorough Testing

## PGK Example - Many Test Scenarios

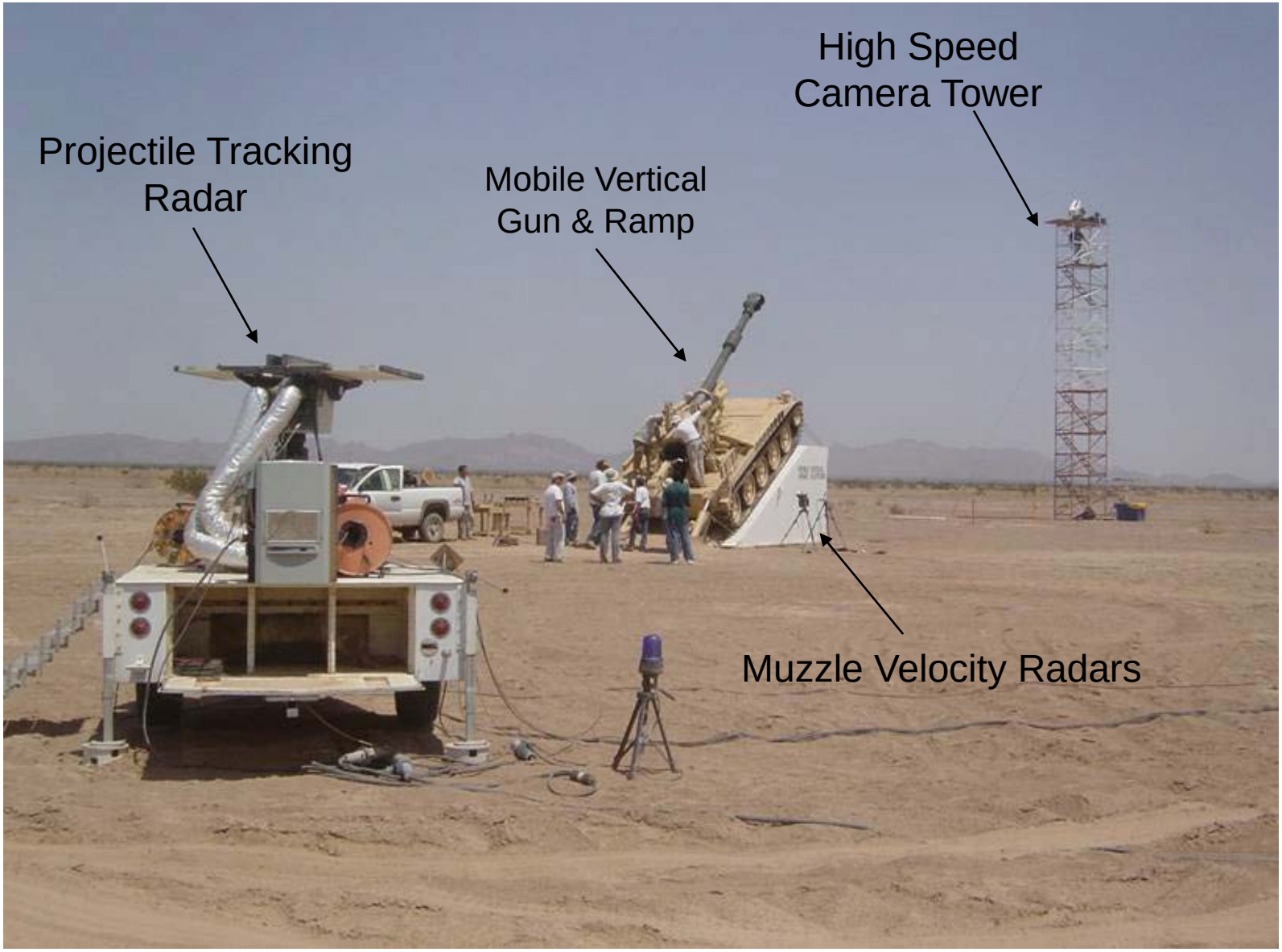
- Two projectile types (M795, M549A1)
- Two gun types (M109A6, M777A2) – new to end-of-life tube
- Five zone charges (MACS1- MACS5)
- Wide range of gun elevation angles (200-1300mils)
- Wide temp range (-25 F to +145 F)
- Harsh environmental conditioning sequence for fuze safety certification

# Data is Key to Rapid Failure Resolution

## Primary Sources of Data for Gun-Launched Weapons

- High Speed Telemetry (TM) System
- On-Board Recorder (OBR) System
- High Speed Muzzle-Exit Cameras (Video and Still)
- Muzzle-Exit Velocity Radar System
- In-Flight Radar Tracking System
- In-Flight Optical Tracking System
- High Speed Target Video Cameras

# High-G Test Setup at Yuma Proving Ground



# High-G Facilities for Launch & Impact Testing

**Unique facilities provide capability for early structural integrity testing and data gathering to support failure investigations**

***Vertical Gun Test Facility at YPG***

***Ballistic Rail Gun Test Facility at ATK***

***Air Gun Test Facility at ATK***


***SCat (Soft Catch) Gun Test Facility at ARDEC***

# Disciplined Process is Key to Rapid Failure Resolution

## 8-D Problem Solving Process

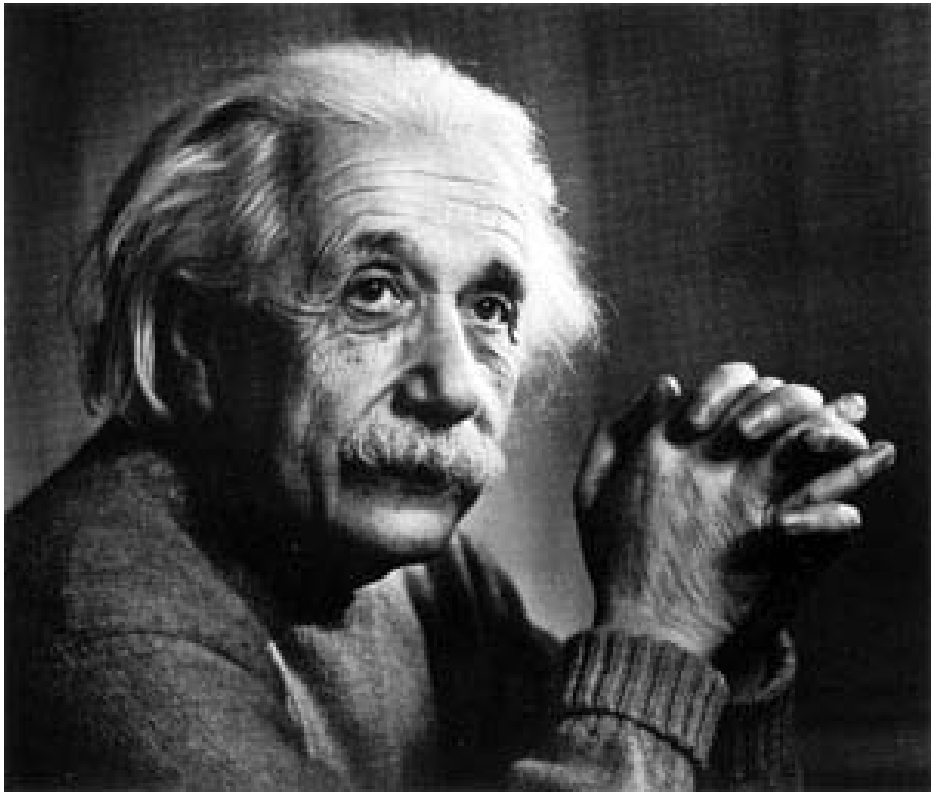
(8 disciplines needed for effective problem solving)

1) ***Form the Right Team to Investigate the Problem …. more later***
2) **Clearly Define the Problem – Who, What, Where, When, Why, How, How Many……. more later**
3) Implement Containment Actions – Temporary Corrective Actions
4) ***Identify & Verify Root Causes & Escape Points…. more later***
5) ***Choose & Verify Permanent Corrective Actions….more later***
   (and Possibly Preventive Actions for Potential Problems)
6) Implement Corrective Actions & Evaluate Results
7) Prevent Recurrence – Document & Share Lessons Learned
8) Celebrate Success – Formally recognize the collective efforts of the team.

# Form the Right Team

- Select an experienced problem-solving facilitator
- Select a cross-functional team with relevant subject matter expertise – systems, design, production, process, quality, test, materials, purchasing
- Include independent team members with “fresh sets of eyes”
- Establish a clear set of ground rules and schedule objectives
- Provide adequate resources

# Clearly Define the Problem

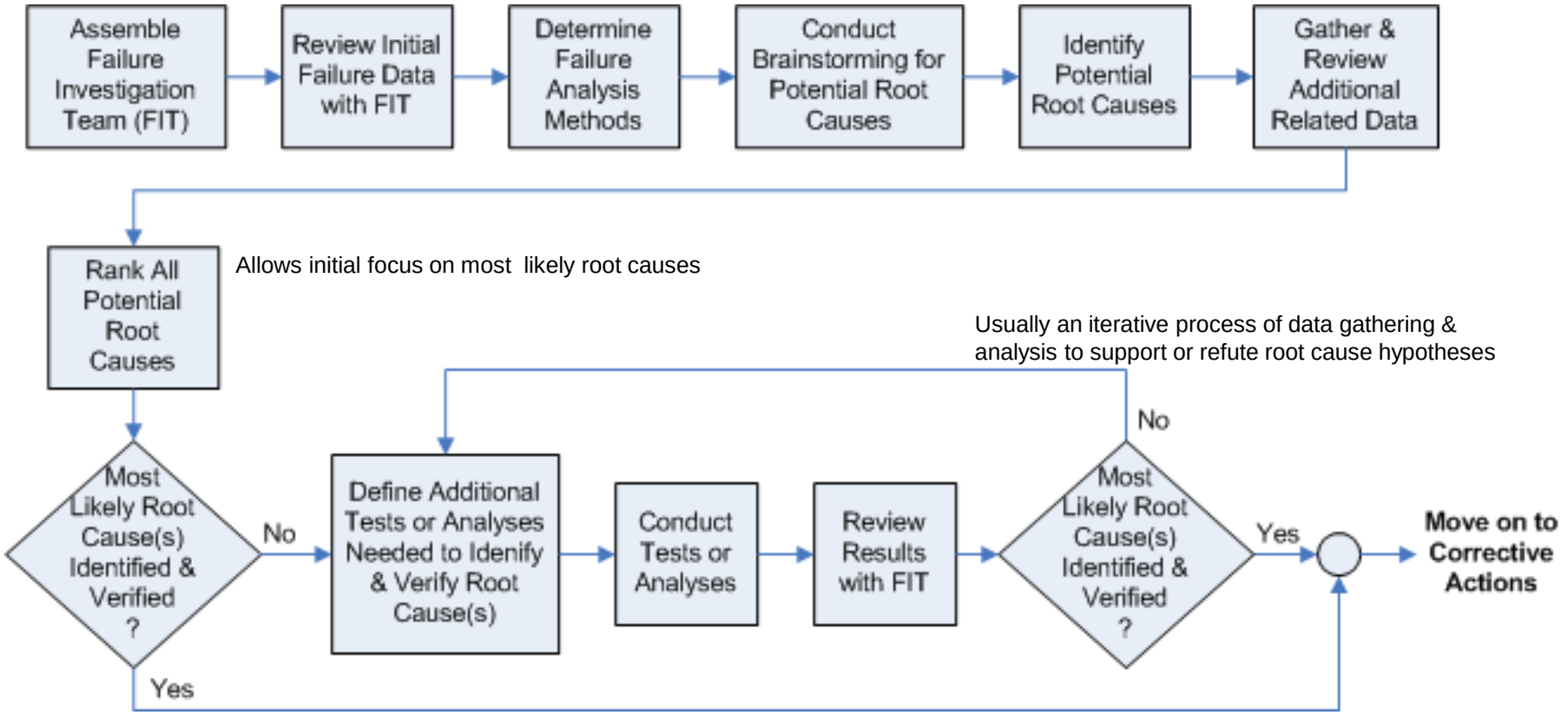


Einstein is quoted as having said that if he had one hour to save the world he would spend *fifty-five minutes defining the problem and only five minutes finding the solution.*

***Need to make sure we're solving the right problem***

# Apply Disciplined Process to Identify & Verify Root Causes

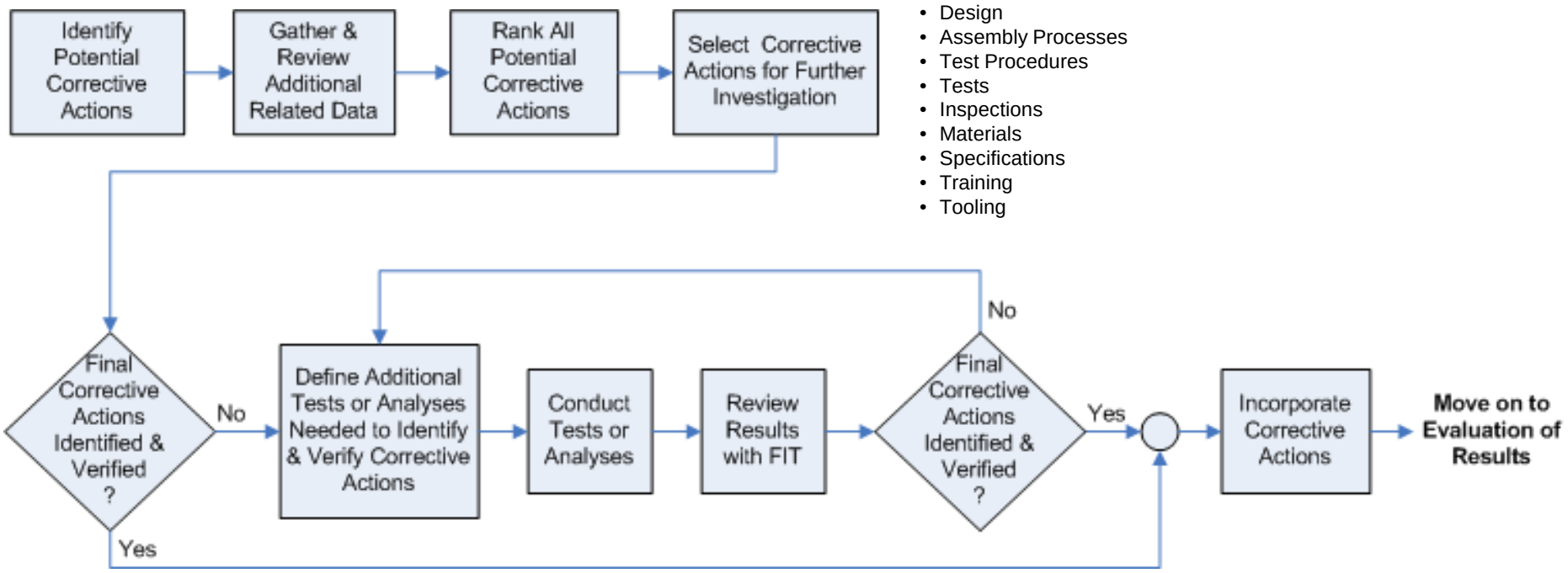
- Fault Tree Analysis
- 5 Whys
- Fishbone
- FMEA
- Difference or Change Analysis
- Pedigree Analysis




Use Design-of-Experiments techniques to effectively & quickly gather & analyze data

# Choose, Implement, & Verify Corrective Actions

## Use the same discipline to define & verify Corrective Actions




Use Design-of-Experiments techniques to effectively & quickly gather & analyze data

# Conclusion

- **Failures will occur during development & production testing**
- **Must have a systematic failure investigation & resolution process to find & fix problems quickly and effectively**
- **The 8-D process at ATK attacks problems to identify the true root causes, implement long-term solutions, and drive continuous improvement**

# Contact Information

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