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Ground Vehicle Reliability

Concept to Full Rate Initial Production

(A Contractor Perspective)

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System Reliability Life Cycle

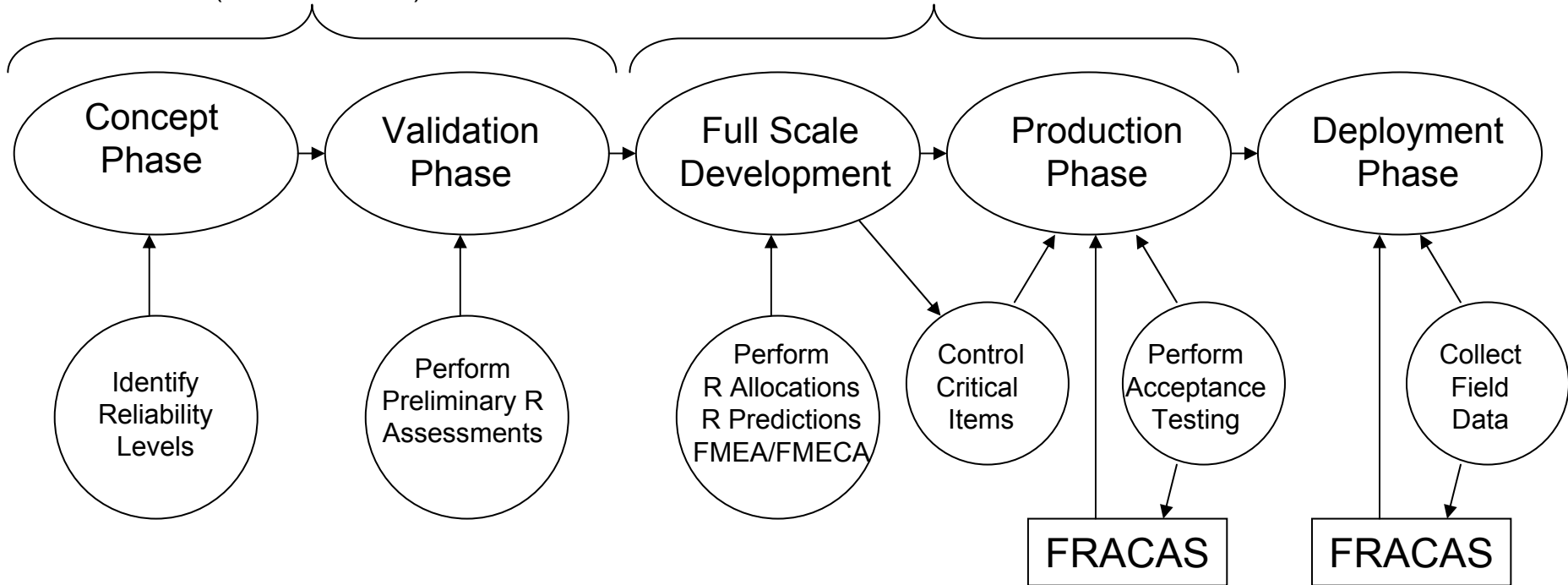
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USER/PMO
(CONTRACTOR)

CONTRACTOR
(USER/PMO)



FRACAS is:

- 1) Understand Root Cause
- 2) Develop Corrective Action
- 3) Modify and Retrofit

Concept Phase (What Must It Do?)

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- Maneuverability
 - Speed
 - Terrain
 - Land
 - Able to Ford Streams
- Transport Crew
 - How Many
 - Rations
 - Personal Gear
 - NBC Gear
- Employ Specialized Mission Equipment
 - Global Positioning System (GPS)
 - Day Sighting
 - Night Sighting
 - Target Acquisition
 - Communications Security

Concept Phase

(What Is The Environment?)

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- Terrain
 - Improved Roadway
 - Unimproved (gravel) Roads
 - Cross Country
 - Streams or Rivers
- Temperature Extremes
 - Heat (Sun Loading)
 - Cold (Snow – Ice - Frozen Tundra)
 - Crew Survivorability
- Sand and Dust
 - Particulate Size
 - Particulate Hardness
 - Particulate Acidity/Alkalinity
- Moisture
 - Constant High Humidity (Rain Forest)
 - Precipitation (Rain - Snow – Sleet – Hail)
 - Stream Crossing

Concept Phase

(What Is The Mission?)

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- Transport
 - Personnel
 - Cargo
 - Munitions
- Surveillance/Target Acquisition
 - Daytime
 - Nighttime
 - Battlefield Smoke
- Survivability
 - Improvised Explosive Devices (IEDs)
 - Rocket Grenades
 - Armor Piercing Gun Fire
 - Nuclear – Biological – Chemical (NBC)
 -

Concept Phase

(What Is The Maintenance Philosophy?)

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- Operator
 - Walk Around Inspections
 - On Board Tools Required
 - Tire/Track Replacement
 - On Board Spares Required (Lamps/Fuses)
- Forward/Contact Support
 - Diagnostic Ports
 - Pneumatic Accessibility
 - Power System Accessibility
- Shop
 - Scheduled Maintenance Frequency
 - Preventative Maintenance Frequency
 - Corrective Maintenance (Skill Level/Personnel Qty/Accessibility)
- Depot/Overhaul
 - How Often
 - Identify Wear Components
 - Technical Insertion

Concept Phase (Reliability Levels)

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- Today's Systems are Complex
 - Structural Considerations
 - Life Limited Items
 - Electronics
 - Hydraulics
 - Pneumatics
 - Software (Loadable) and Firmware (Imbedded)
- Reliability Definitions
 - Mean Time Between Failure (MTBF)
 - Useful for Long Life Systems – Mission Length is Always Short Relative to Mean Life
 - Probability of Survival ($R_{(tm)}$)
 - High Reliability Required During Mission Period – MTBF Beyond Period not Critical Except for its Influence on Availability
 - Probability of Success ($P_{(s)}$)
 - Independent Of Time – Useful for One Shot Devices
 - Failure Rate (λ)
 - Useful for Specifying Reliability Where the Mean Life is too Long to be Useful

Concept Phase

(Specifying Reliability Levels)

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LEVEL OF COMPLEXITY	CONDITIONS OF USE	CONTINUOUS DUTY LONG LIFE (REPAIRABLE)	INTERMITTENT DUTY SHORT MISSIONS (REPAIRABLE)	CONTINUOUS OR INTERMITTENT (NON-REPAIRABLE)	ONE - SHOT (TIME - INDEPENDENT)
	COMPLEX SYSTEMS		R(t) OR MTBF	R(t) OR MTBF	R(t) OR MTBF
SYSTEMS SUBSYSTEMS SETS GROUPS		R(t) OR MTBF	R(t) OR MTBF	R(t) OR λ	P(S) OR P(F)
UNITS ASSEMBLIES SUBASSEMBLIES PARTS		λ	λ	λ	P(F)

CODE:

R(t) = Reliability for specified mission, or period of time, t.
 MTBF = Mean - time- between - failures, or mean life.
 P(S) = Probability of success.
 P(F) = Probability of failure.
 λ = Failure Rate.

Validation Phase (Reliability Assessment)

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- Gather Reliability Data
 - Predictions
 - Electronic Equipment
 - Structural Elements (Factors of Safety)
 - B-10 Bearing Life
 - Vendor Data
 - Power Plant Components
 - Transmission Components
 - Suspension Components
 - Specifications
 - Government Furnished Equipment (GFE)
 - “Similar To” Equipment Requirements
- Understand the Mission Durations
 - What has to operate – For How Long – When
- Generate System Reliability Model
 - What Equipment Must Operate w/o Fail
 - What Redundancies Exist or Need to Exist
 - What Degraded Capabilities Are Acceptable
 - Are Failures Tolerable If Crew Can Repair In Brief Period (Tools and Parts?)

Full Scale Development (Reliability Allocations)

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- Correlate Equipment/Components to Mission Segments/Durations
- Define/Understand Equipment Failure vs Life Characteristics
- Define/Understand Serial and Parallel Reliability Paths
- Define/Understand Subsystems/Components
 - Structure
 - Move
 - Steer
 - Brake
 - Communications
 - Crew Survivability (Heating – Cooling – Relative Humidity)
- Generate Equipment/Component Reliability Requirements
- Assess If Required GFE Reliability Is Compatible With System Requirements
 - Low Inherent/Demonstrated GFE Reliability May Inappropriately drive System Costs
 - Can System Reliability be Defined Excluding GFE?
 - Is There Enough Of The “Pie” Left For The “To Be” Designed Part Of The System?

Full Scale Development (Reliability Predictions)

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- Electronics
 - Bellcore
 - Mil-HDBK – 217
 - GFE Specifications
- Structure
 - Use Finite Element Analysis (FEA) – Assure Required Safety Margins Are Met
 - Material Selection – Corrosion Resistance and Armor Capability
- Procured Items
 - Vendor Supplied Predictions
 - Vendor Supplied Field Data
 - Non-Electronic Parts Reliability Data (NPRD)
 - Contractor Experience With Similar Items/Systems (Field Data)
- Combine Failure Rates
 - Using System Reliability Model
 - Using Mission Profile
 - Some Items Time (Hours or Miles) Dependent
 - Some Items Cycle dependent
 - Some Items Probabilistic (Structure and “One Shot” Devices)

Full Scale Development (FMEA/FMECA)

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- Failure Modes and Effects Analysis (FMEA)
 - Understand How Each Component Failure Affects the Mission
 - Requires understanding Each Components Purpose In The System
 - Determine The Appropriate Level
 - Must Be Sufficiently Detailed To Identify Design Issues That Require Resolution
 - May Only Require Assembly As Opposed To Piece Part If Failure And Effect Can Be Defined
- Criticality Analysis (FMECA)
 - Identify Component Failures Resulting in Mission Loss
 - Identify Component Failures Resulting in Equipment Damage
 - Identify Component Failures Resulting in Personnel Injury
- Identifies Critical Items To Be Controlled
 - Component Testing Requirements
 - Define Need For FRACAS by Vendors
 - Define Need For Serialization (UID) Tracking

Production Phase (Build In The Reliability)

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- Review Manufacturing Instruction Sets (MISs)
 - Are Required Processes In Place to Preclude Failure
 - Are Assembly Personnel Adequately Trained/Certified to Perform the Assembly Tasks
 - Do The Tooling And Facilities Support What Is Required
- Control Critical Items
 - Adequate Internal/Vendor Testing or Certification
 - Monitor Non-Conformance Reports
 - Work With the Quality Organization
- Perform Acceptance Testing
 - Collect Data
 - Operational (Hours/Cycles/Operations)
 - Failure (What – When – How)
 - Repair (What – How Long)
 - Determine Root Cause
 - Require Source of Failure to Develop Corrective Action
 - Fix the Problem
 - Process
 - Instructions
 - Training
 - Accountability

Deployment (Measure The Reliability)

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- Collect the Data
 - Operational (Hours/Cycles/Operations)
 - Failure (What – When – How)
 - Repair (What – How Long)
- Share the Data
 - Allow Contractor Access to the Data Collection System
 - Allow/Require Contractor to Perform Pareto Analysis
 - Using “Cost Of Replacement” Prioritize Items to be Analyzed
 - Allow/Require Contractor to Develop Solutions
 - Engineering Change Proposals (ECPs)
 - Time Compliant Technical Orders (TCTOs)
- Implement Performance Based Logistics
 - Provides Contractor Incentive to Deliver “Best Possible Product”
 - Requires Data Sharing and Agreed to Scoring Rationale
 - War Fighter is Ultimate WINNER!
 - System Performs Mission – With Minimal Failures – At or Below Agreed to Cost