LAND. SEA. AIR.

Ground Vehicle Reliability Concept to Full Rate Initial Production

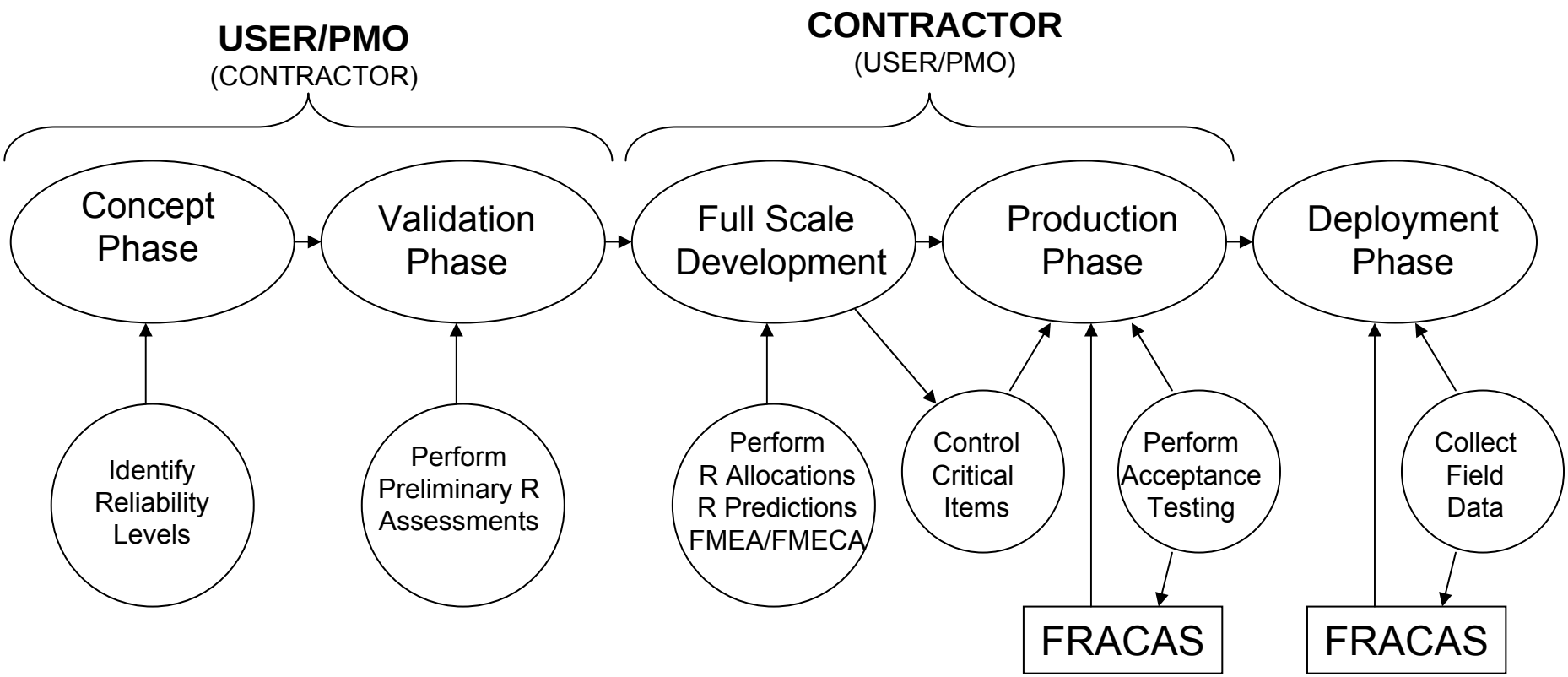
(A Contractor Perspective)

Carl Huck
Sr. Staff Engineer

DRS TECHNOLOGIES

System Reliability Life Cycle

LAND. SEA. AIR.



FRACAS is:
1) Understand Root Cause
2) Develop Corrective Action
3) Modify and Retrofit

DRS TECHNOLOGIES

Concept Phase
(What Must It Do?)

LAND. SEA. AIR.

- 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

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Concept Phase
(What Is The Environment?)

LAND. SEA. AIR.

- 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

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Concept Phase
(What Is The Mission?)

LAND. SEA. AIR.

- 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)
  -

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Concept Phase
(What Is The Maintenance Philosophy?)

LAND. SEA. AIR.

- 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

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Concept Phase
(Reliability Levels)

LAND. SEA. AIR.

- 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

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Concept Phase
(Specifying Reliability Levels)

LAND. SEA. AIR.

LEVEL OF COMPLEXITY / CONDITIONS OF USE	CONTINOUS DUTY LONG LIFE (REPAIRABLE)	INTERMITTENT DUTY SHORT MISSIONS (REAPAIRABLE)	CONTINUOS OR INTERMITTENT (NON-REPAIRABLE)	ONE - SHOT (TIME - INDEPENDENT)
COMPLEX SYSTEMS	R(t) OR MTBF	R(t) OR MTBF	R(t) OR MTBF	P(S) OR P(F)
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) = Proability of failure.
λ = Failure Rate.

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Validation Phase
(Reliability Assessment)

LAND. SEA. AIR.

- 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?)

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Full Scale Development
(Reliability Allocations)

LAND. SEA. AIR.

- 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?

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Full Scale Development
(Reliability Predictions)

LAND. SEA. AIR.

- 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)

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Full Scale Development
(FMEA/FMECA)

LAND. SEA. AIR.

- 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

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Production Phase
(Build In The Reliability)

LAND. SEA. AIR.

- 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

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Deployment
(Measure The Reliability)

LAND. SEA. AIR.

- 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

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