

# Applying System of Systems and Systems Engineering to the Military Modernization Challenge

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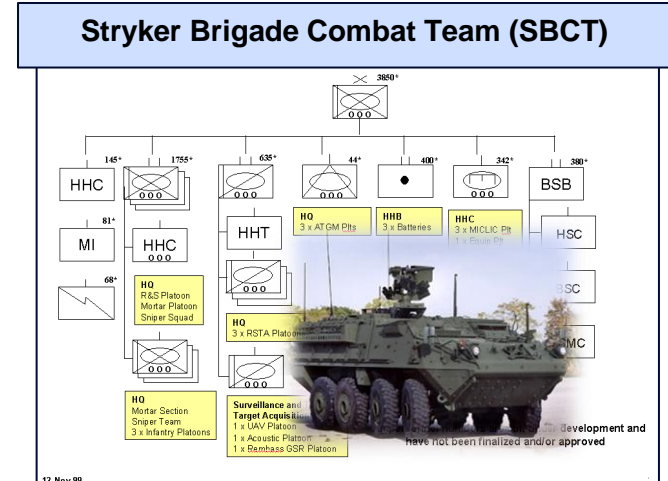
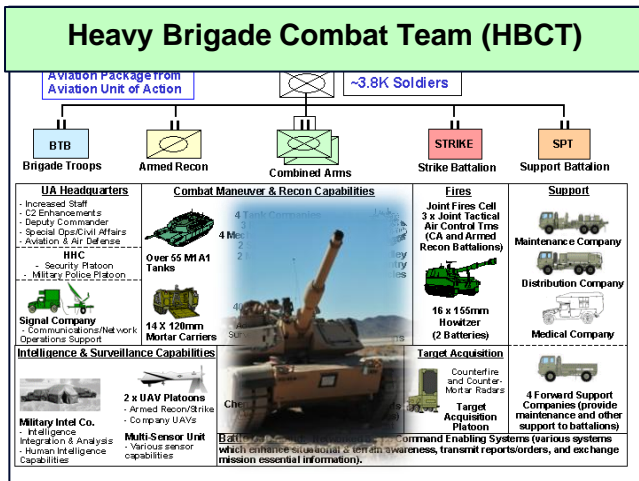
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# The Challenge

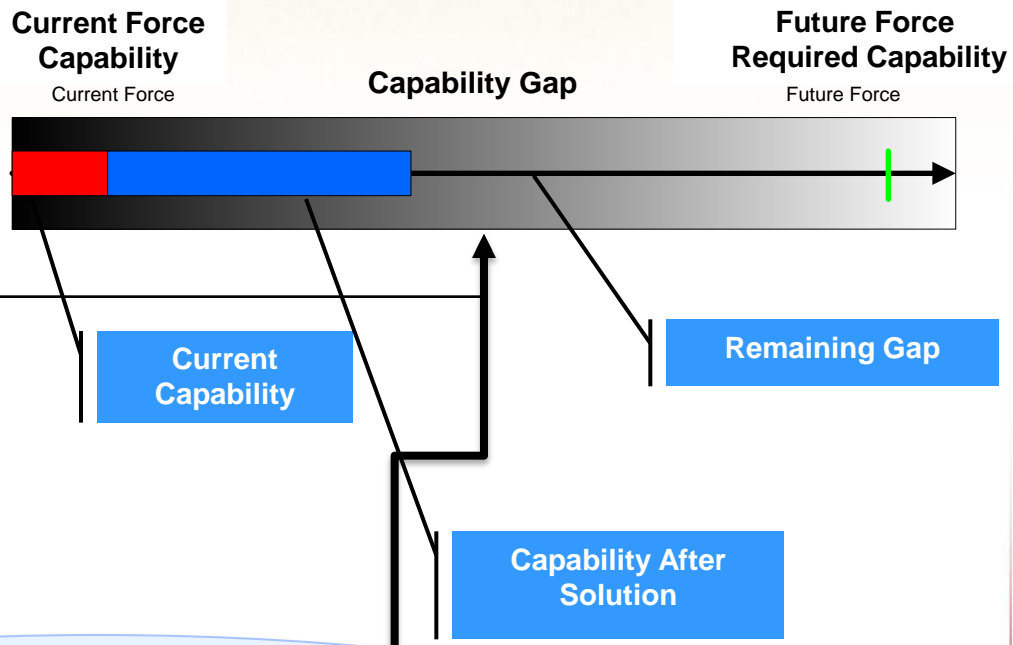
- **Challenge:** The ground combat systems of the current force (some developed in the 1970's) are going to be required to remain in service into the foreseeable future (~2050) and will need to be modernized in order to combat an evolving future threat
- **Overall Goal:** Provide and apply a System of Systems analytical framework and set of capabilities that can support developing the most cost effective brigade level modernization strategies



**Goal: The integration of the highest performing most cost effective technologies into the current force that enable the to transform and meet the future threat**

# Assessing Improvements to Current Force Capabilities Against Future Force Requirements

Force Operating Capability	Capability Needs Assessment - Required Capabilities	Gap	Metric (MOE, MOP, KPP, TPM)
11 F.O.C.s	31 R.C.s	60 Gap Areas	
<b>Battle Command</b>	Ability to Command and Control BA Assets	Real-Time CombatID	Percent CID Coverage
<b>Battle Space Awareness</b>		<b>Capability Needs Assessment (Gaps)</b>	
Ground Maneuver			
Air Maneuver			
Lethality			
Maneuver Support			
<b>Protection</b>			Survival Rate
Deployability			
<b>Maneuver Sustainment</b>			Operational Availability (Ao)
Training			
Human Engineering			



## Solutions Sources (Near & Long Term)

TRADOC/ARCIC C.N.A. Solutions



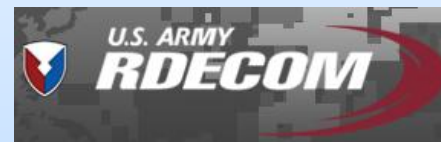
PEO 1-N List



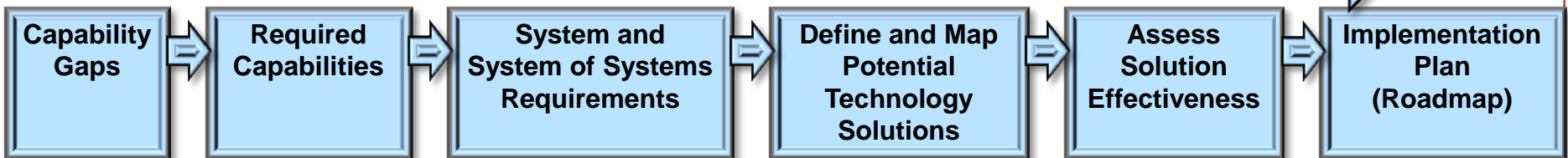
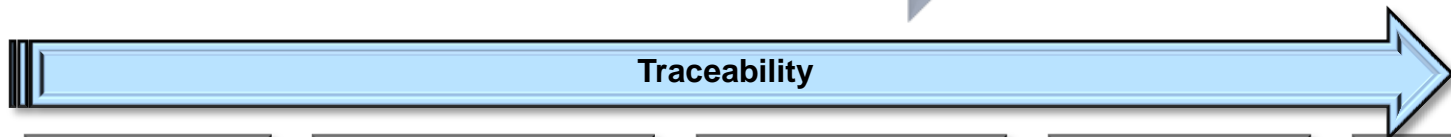
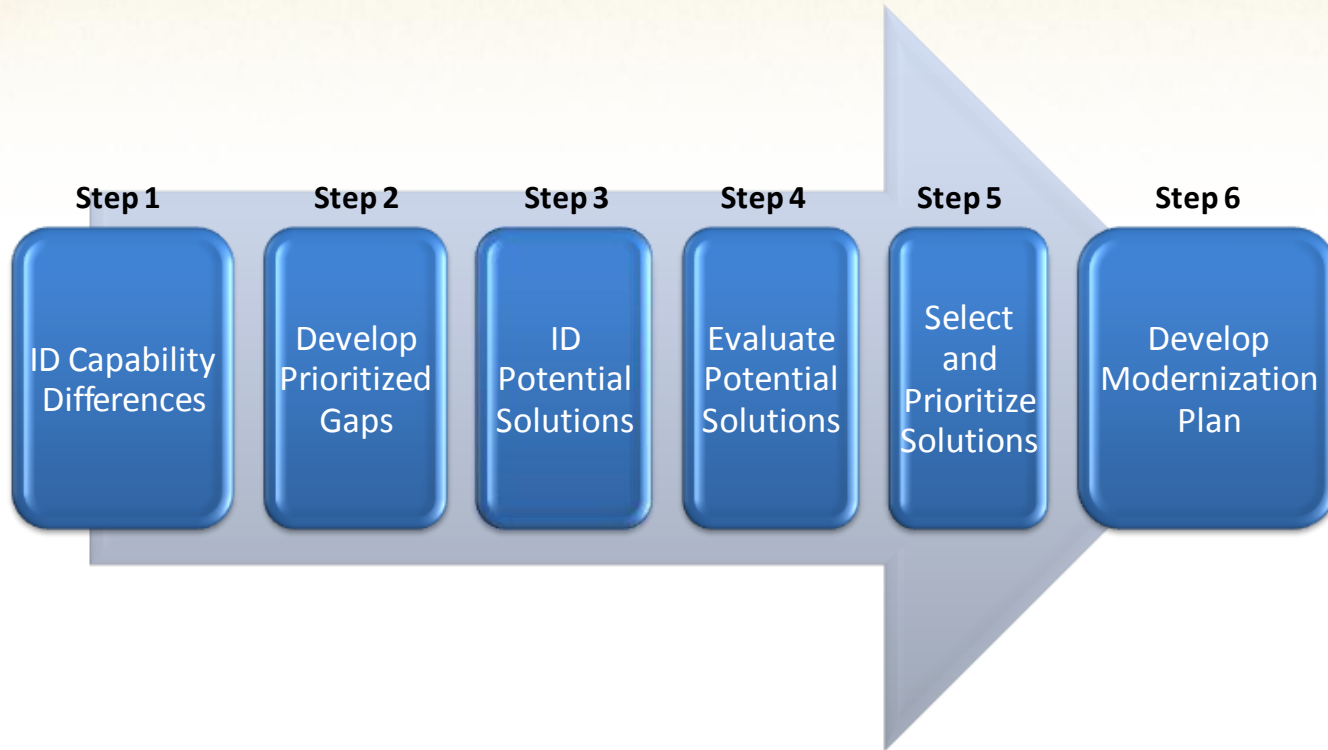
PEO-I Spinouts



RDECOM RDECs & ATOs



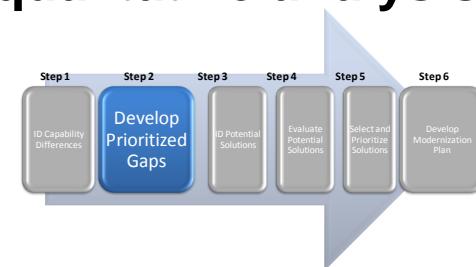
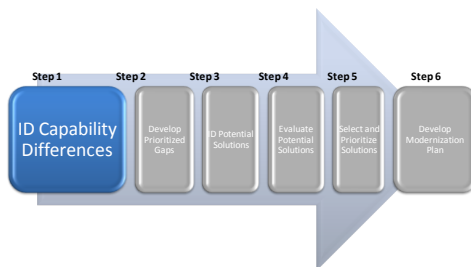
# Systems Engineering Process



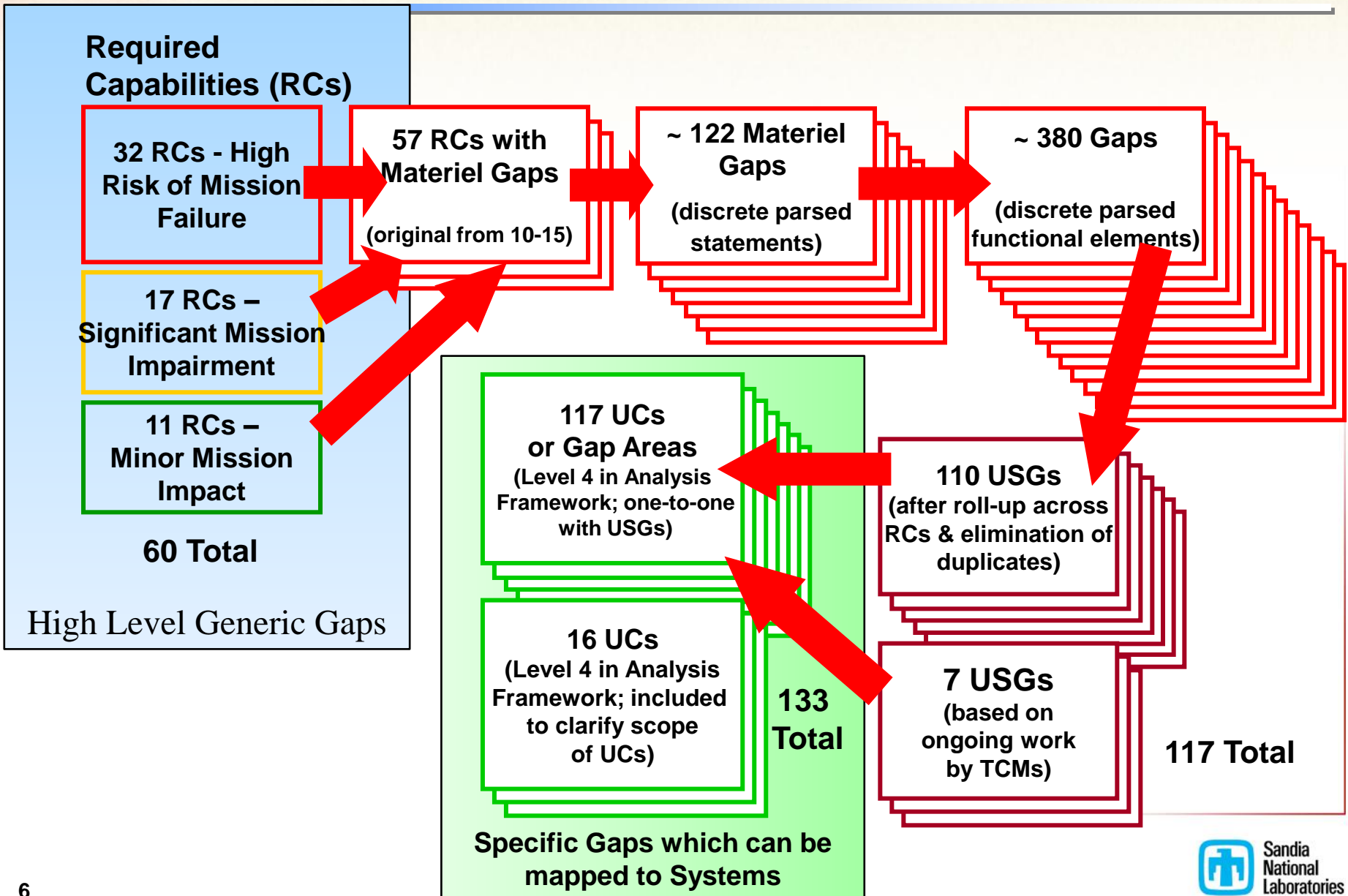
**Rigorous systems engineering process provides traceability from documented needs (capability gaps) to most cost effective solutions**

# ID Capability Differences & Develop Prioritized Gaps (Steps 1 & 2)

- **Capability baseline for current force (CF) is defined**
  - Baseline documented “as-is” condition used as comparison for all solution and trade study evaluations
- **Identified and assessed differences between CF and future force (FF) requirements**
- **Required involvement from experts within PEO GCS and information**
  - Composition of Brigade Combat Teams (BCTs)
  - Required Mission Sets
- **Analyzed Army-wide materiel gaps from U.S. Army Training and Doctrine Command’s (TRADOC) 08-13 Capability Needs Assessment (CNA)**
- **Distilled CNA materiel gaps into distinct parts to remove redundancy in RCs**
  - Distinct parts rolled up across RCs to form unique simplified gap statements (USGs) and unique capabilities (UCs)
- **Resulting framework is used for qualitative analysis**

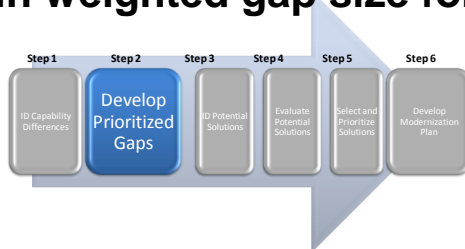


# Capability Gap Analysis (Steps 1-3)



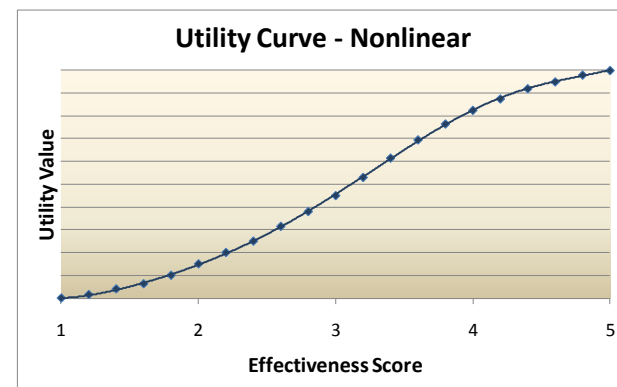
# Step 2: Develop Prioritized Gaps

- **Qualitative assessment performed separately by BCT subject matter experts within program manager (PM) and TRADOC capability manager (TCM) communities**
  - Weighted relative importance of UCs to BCTs based upon required mission scenarios
- **Importance factors (scale of 1 to 5, 5 for high importance) normalized across UCs for each BCT and mission**
  - Allows effectiveness scores to be rolled up to various levels of analysis framework
- **BCT's current effectiveness to perform UC assessed against desired performance (*effectiveness values*)**
  - Resulting scores converted to utility using nonlinear curve
- **Combination of importance and effectiveness result in weighted gap size for each UC**



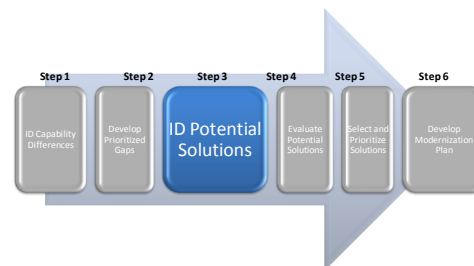
## BCT Effectiveness Values

Value	Description
5	Ability to perform UC meets objective requirements
4	Ability to perform UC meets threshold requirements
3	Ability to perform UC does not meet threshold requirements – materiel solutions needed
2	Ability to perform UC does not meet threshold requirements – revolutionary materiel solution needed to replace capability
1	No materiel solutions present within BCT to provide UC



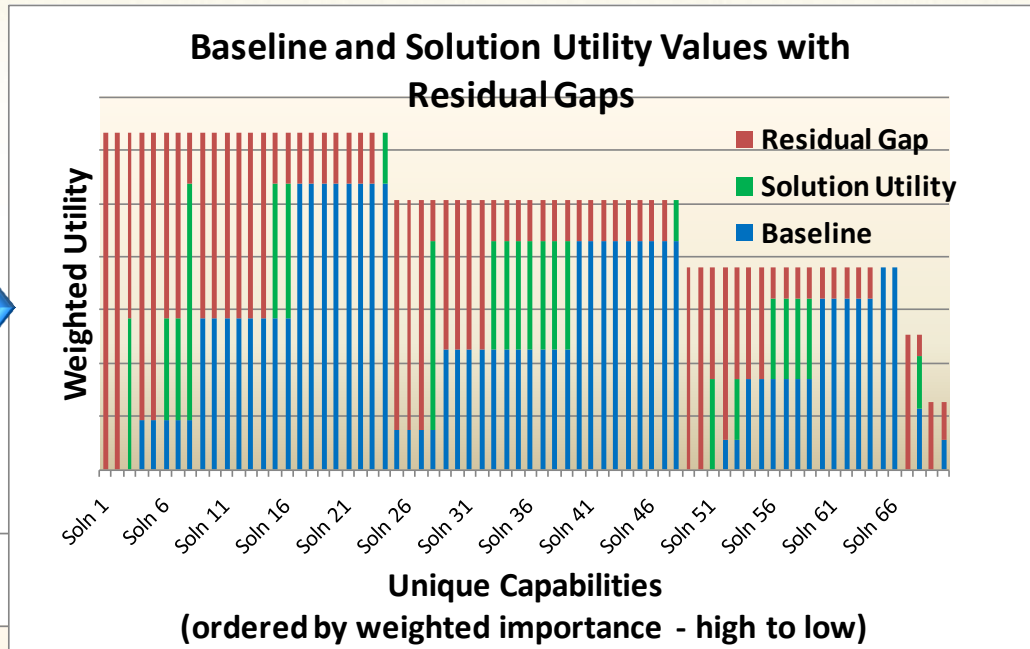
# Step 3: ID Potential Solutions

- Using baseline gap size calculated in step 2, an evaluation of potential solutions to fill gaps was performed
- Potential solutions - doctrine, organization, and materiel solutions – were identified and associated with UCs and gaps
- A second assessment of BCTs effectiveness performed assuming implementation of identified solutions
  - Further prioritizes solutions that are quantitatively evaluated in step four
- Qualitative evaluation of potential solutions was performed by assessing expected improvement in BCT mission effectiveness assuming implementation of solutions
  - This assessment was again performed with BCT experts providing another set of BCT effectiveness scores.

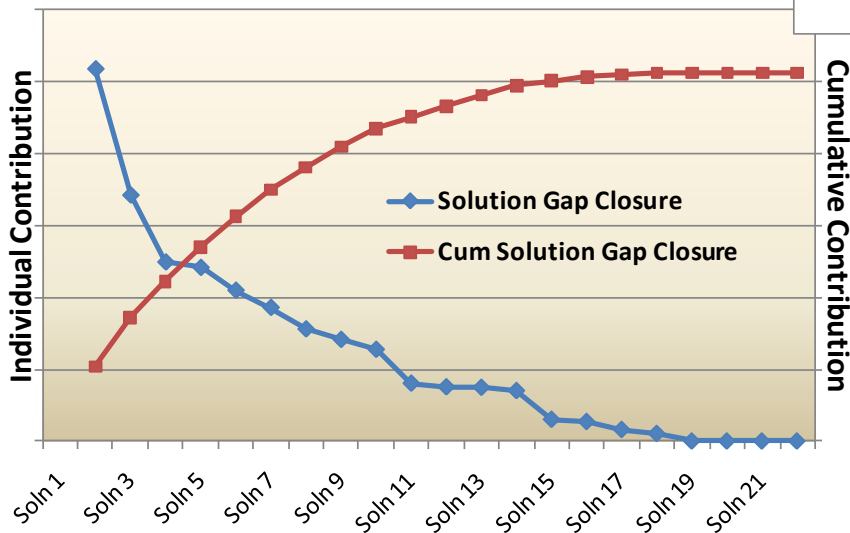


# Step 3: Prioritized Gap Results

- Baseline values, solution utility, and residual gaps are calculated for each potential solution



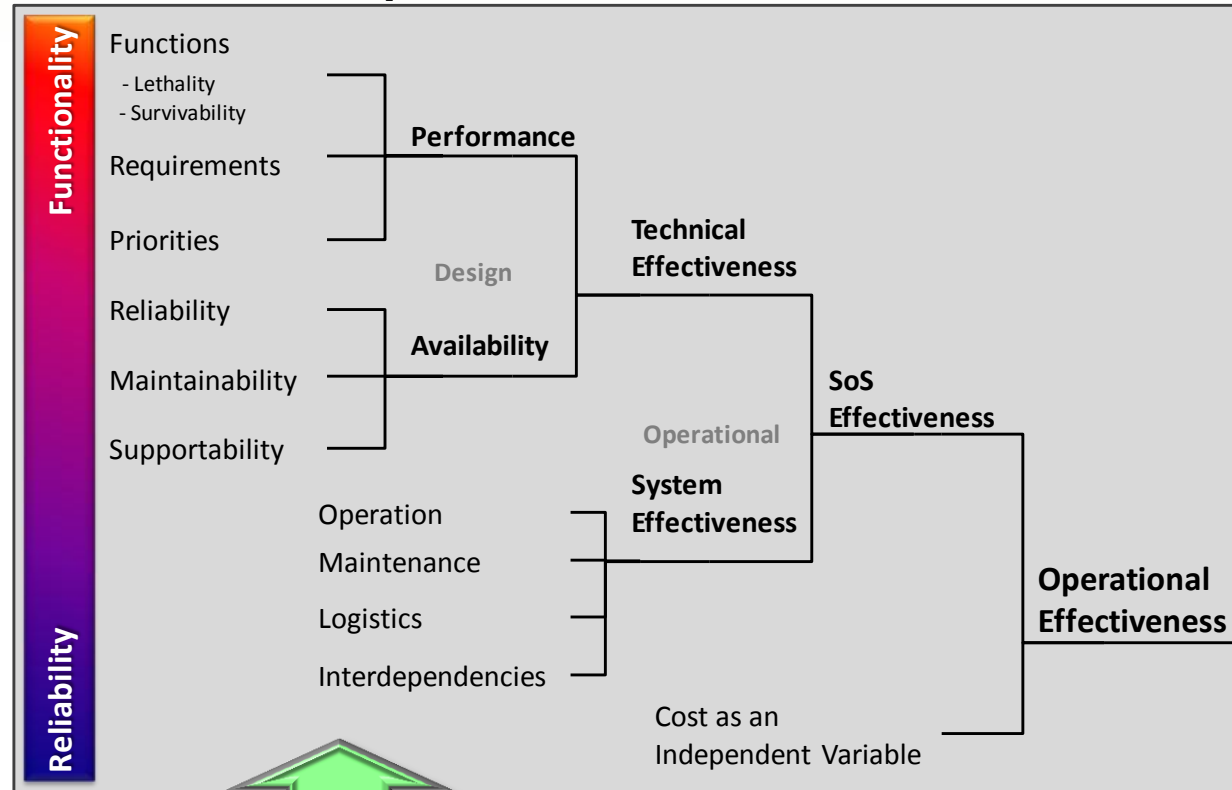
Gap Closure as a % of Baseline Gap



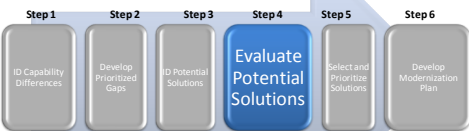
- Potential solution contribution to gap closure determined
- Qualitative results assist in prioritization of capability gaps to be assessed in quantitative assessment

# Step 4: Evaluate Potential Solutions

- Using the focused scope defined in step 3, a modeling toolset and analysis plan for evaluating solutions was developed
- Working meetings with subject matter experts within BCT PMs and TCMs occurred
  - Collected specific data on solutions and expected benefits
  - Determined which M&S tool(s) were appropriate for each solution assessment
  - Developed metrics and measures to evaluate solutions

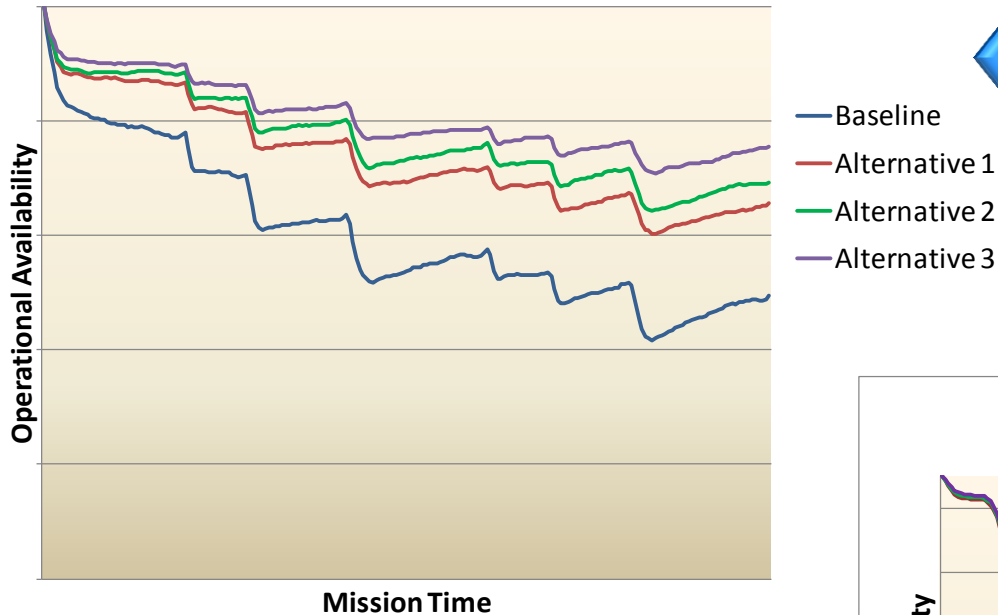


**CASTFOREM\* used to model performance of technology insertions (functionality) and SoSAT\* used to analyze logistics and sustainment technologies (reliability) to produce an overall effectiveness.**



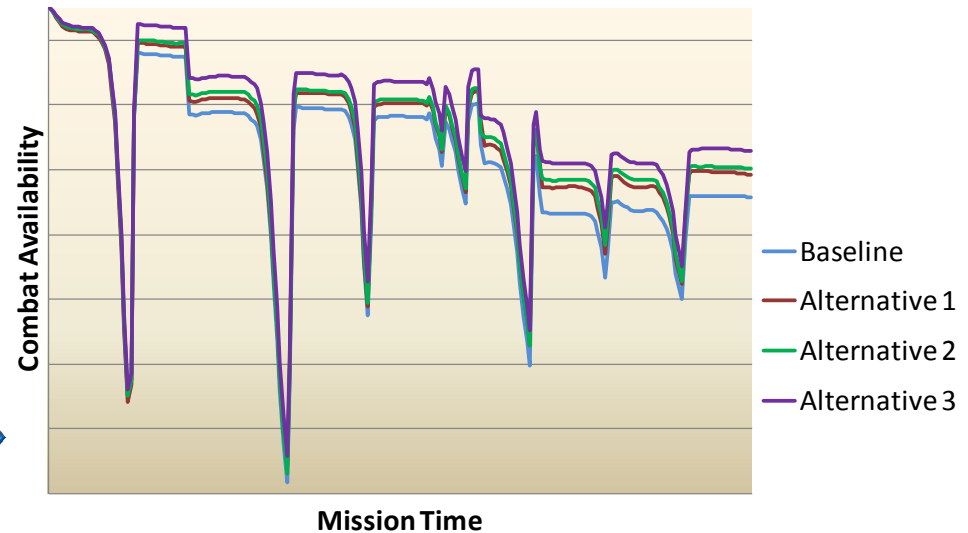
# Step 4: Evaluate Solutions Examples

Ao vs. Time Results for Solution of Capability Gap

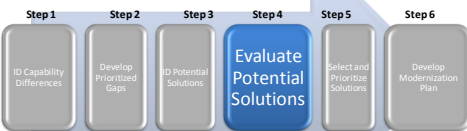


- SoSAT analysis determines Operational Availability ( $A_o$ ) for BCT (SoS) against baseline case and several solution alternatives
- Provides sustainment metrics to support overall assessment

Combat Availability vs. Time Results for Solution of Capability Gap

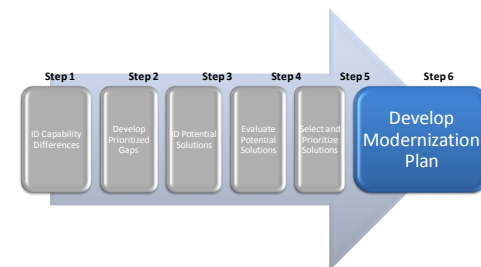
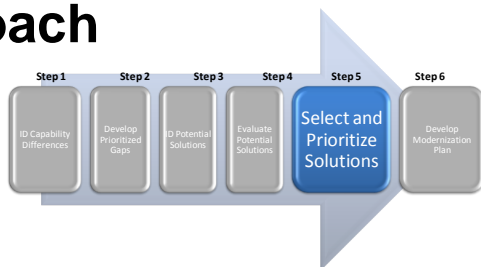


- CASTFOREM results (*not shown*) incorporated into SoSAT models to determine combat availability
- Provides metrics across reliability and functionality

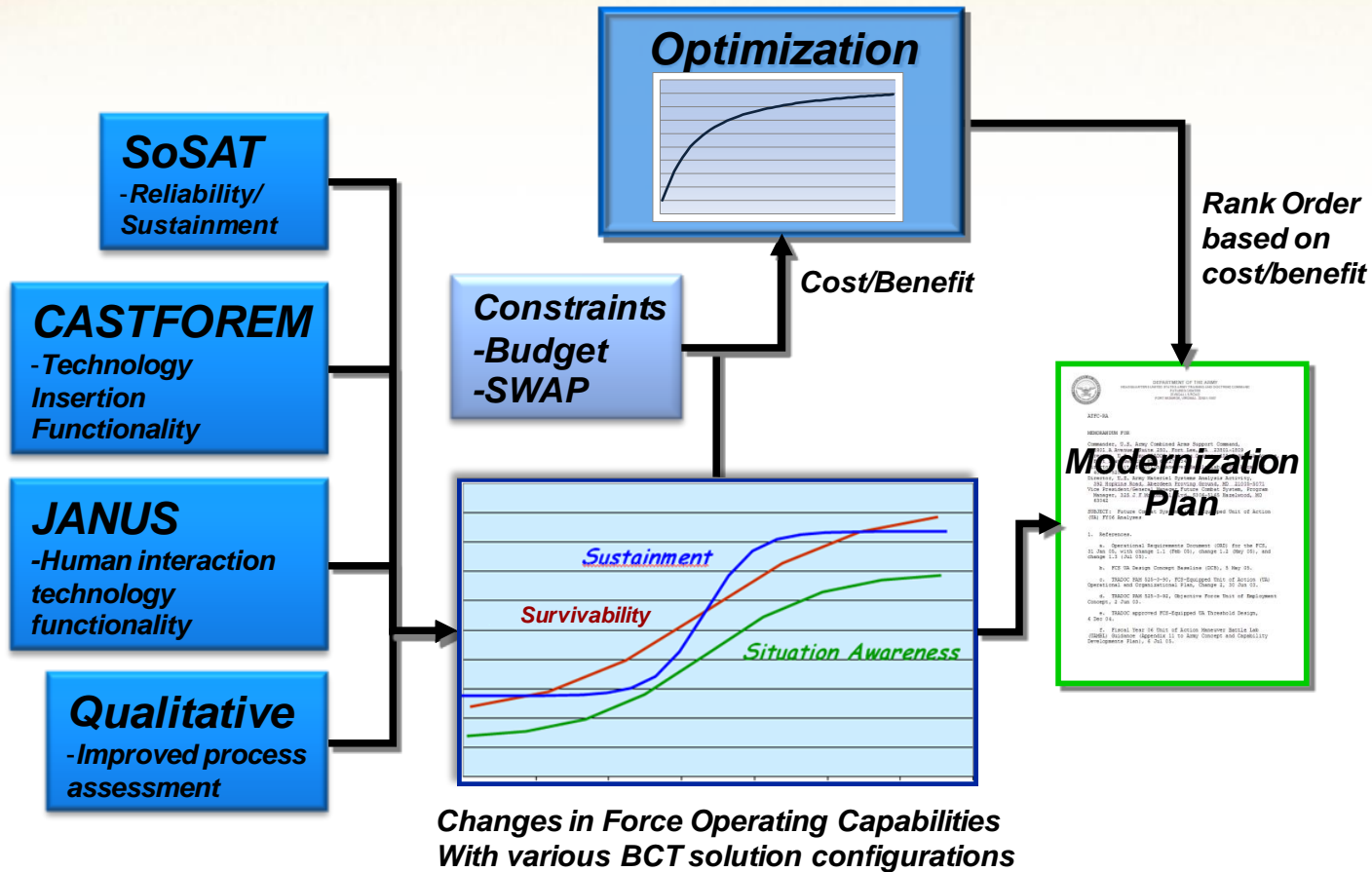


# Select and Prioritize Solutions & Develop Modernization Plan (Steps 5 & 6)

- **Compiled quantitative modeling analysis results for priority gap study questions**
  - Reviewed by subject matter experts
- **Report provided customer**
  - Analytical underpinnings to support potential solution alternatives
  - Traceability to Army-wide capability gaps
- **Quantitative performance results, qualitative schedule, cost estimates, and other available data feed optimization approach**
- **Example optimization model provides ability to explore cost, schedule, and performance trade space**
  - Objectives are either to maximize SoS performance or minimize cost over time
  - Objectives subject to constraints:
    - Ability of systems to perform mission roles
    - Budget(s)
    - Schedule (of upgrading vehicles with solutions)
    - Mission capabilities defined for each system



# Integrated Analysis to Maximize Operational Effectiveness (Steps 4-6)



Bringing together multiple analytic capabilities to support SoS quantitative assessments across capability gaps

# Summary

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- **Modernizing the Army's current force to meet future capability needs and to face future threats is a challenging task that requires SoS performance assessment rather than typical platform-centric evaluation**
- **Systems Engineering process developed for Army modernization depends upon qualitative and quantitative SoS assessments which require many SME's, multiple M&S tools and capabilities**
- **Process provides high quality analytical support that ties results to required capability gaps to support modernization decisions**
- **The process is iterative (e.g. along POM cycles), aligns with the DoD JCIDS process, and provides traceability back to documented needs (e.g. C.N.A.)**