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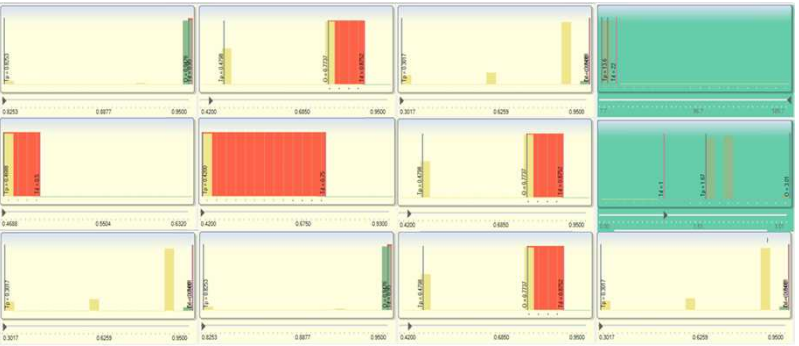

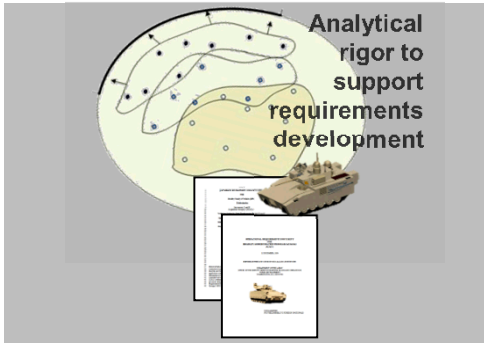

Innovative Analytic Approach to Requirements Development for Acquisition Programs

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MORS Symposium 2016

U.S. DEPARTMENT OF ENERGY | National Nuclear Security Administration | LCRD

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Overview

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- ARIES Problem Space
- When is ARIES Used
- ARIES Purpose
- ARIES Methodology
- How ARIES Works
- ARIES Results
- Next Steps

Advanced Requirements Integration and Exploration System (ARIES) is the product of a Sandia funded R&D project

ARIES Problem Space

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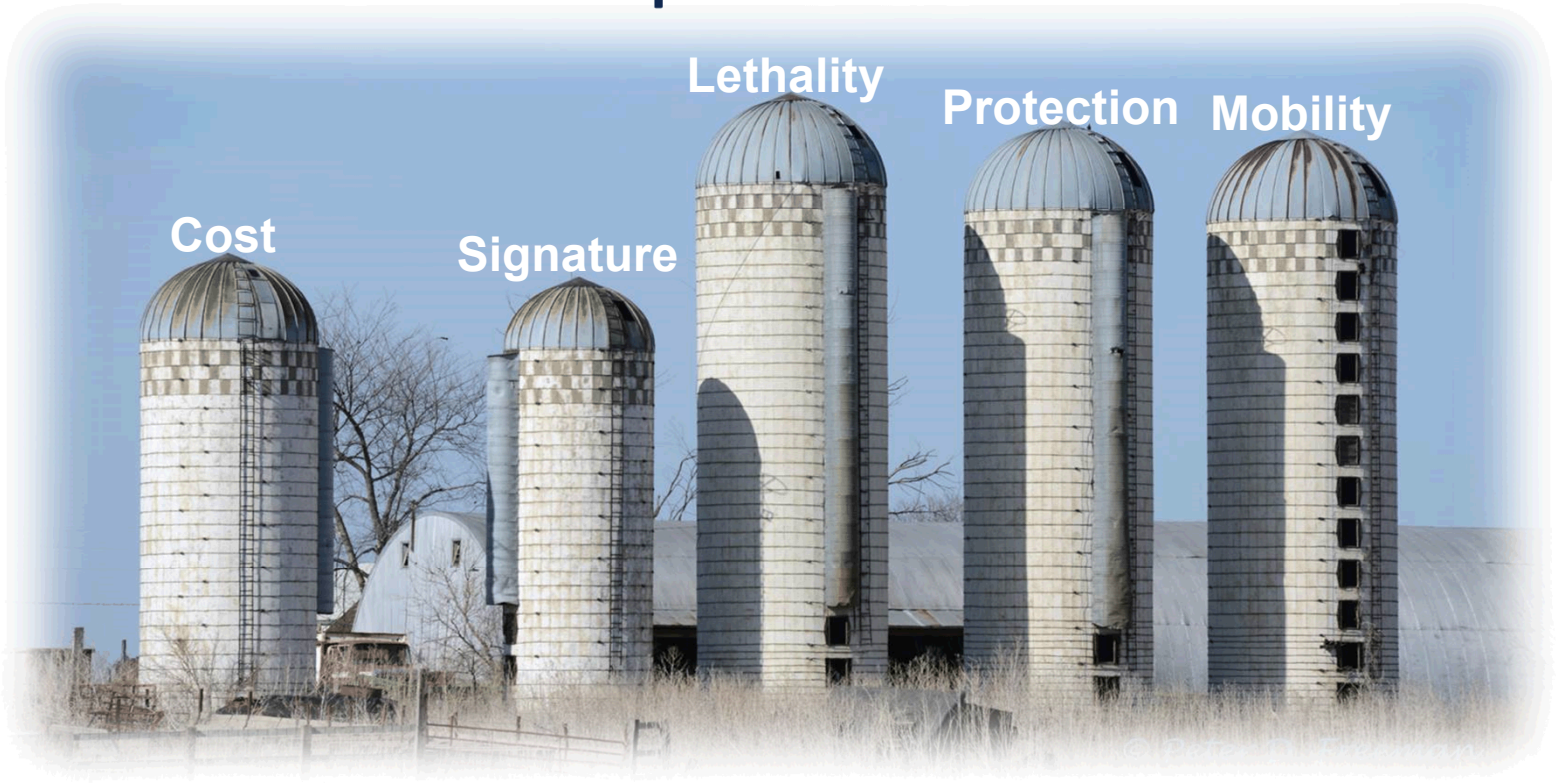
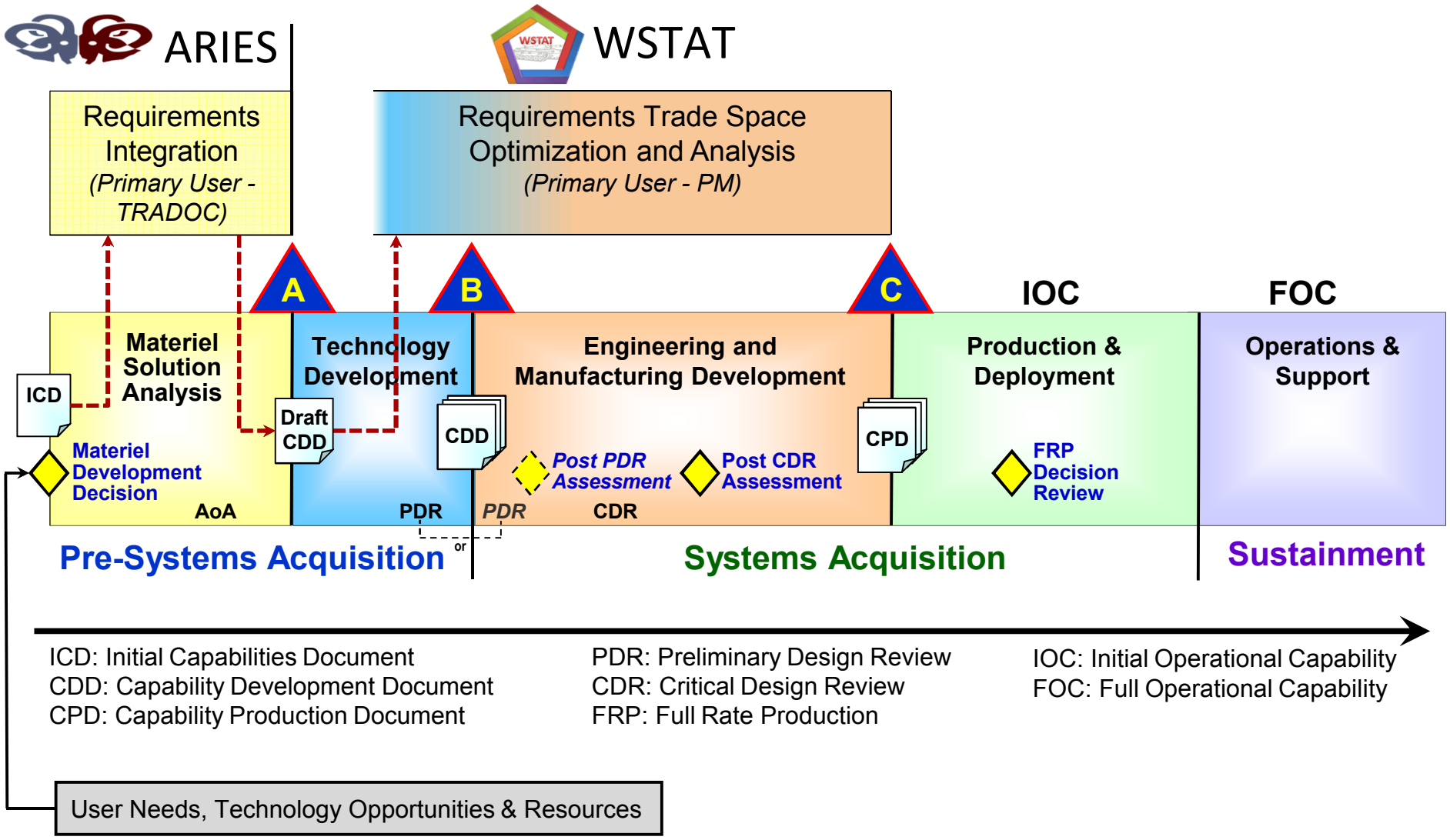


- Early in defense acquisition programs, an increasingly complex set of requirements is developed
- Each individual requirement possesses solid rationale and analytical backing
- However, different groups of requirements (lethality, mobility, etc.) are typically developed independently and are sometimes incompatible, putting successful fielding at risk

ARIES provides unique analytic capability to integrate individual requirements into a simultaneously achievable set

When is ARIES Used?



ARIES Purpose

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- ARIES is a tool to be used by requirements development community
- ARIES provides insight to help requirements development stakeholders integrate desired capabilities into a set of requirements
  - Accounting for budget, schedule, and technology constraints
- Goals
  - Set of achievable requirements (targets can be met)
  - Set of challenging requirements (not infinite ways to meet the targets)
  - Set of robust requirements (multiple ways to meet the targets)

ARIES Optimization Approach

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- Stage 1
  - Separate, independent, single-objective optimizations are performed for each desired capability
  - Finds “best” configurations to satisfy each capability, at expense of others
  - Solutions from Stage 1 feed into Stage 2
    - Bounds Stage 2 search space to ensure full range of values is explored
- Stage 2
  - Ultra-high-dimensional optimization explores trade space between all desired capabilities simultaneously
  - Innovative algorithms ensure thorough exploration of each dimension
    - Good coverage is MAJOR problem with traditional many-objective optimizations
  - Resulting solutions each represent set of achievable requirement values
  - Solution values used to create distribution charts, one for each capability
    - Distributions are basis for understanding interactions

ARIES Methodology

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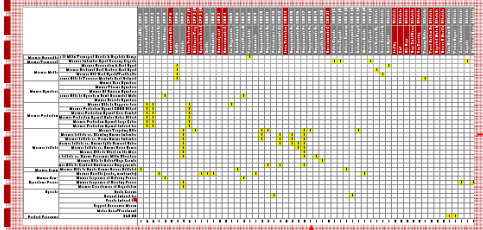
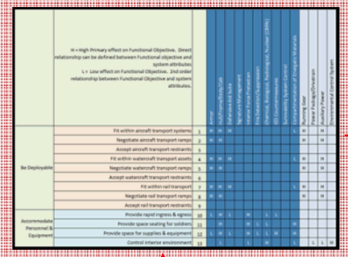
Map Desired Capabilities to Metrics

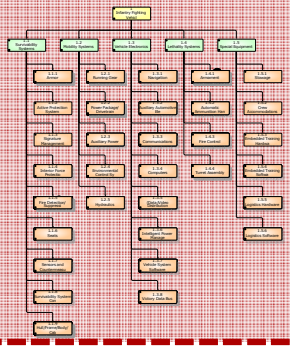


Develop Metrics

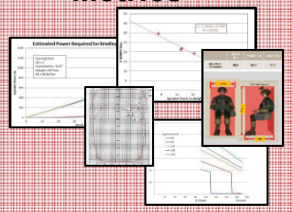
Map Metrics to Product Structure



Establish Product Structure



Define Metrics



Identify Technology Options

Single-Objective Optimizations

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Capability	Upper Bound
A	5
B	60.5
C	25

Ultra-High-Dimensional Optimization

ARIES

Generate Results & Conduct Negotiation

Understand Needs/Desired Capabilities

ICD

Similar to WSTAT

ARIES Capability Distribution

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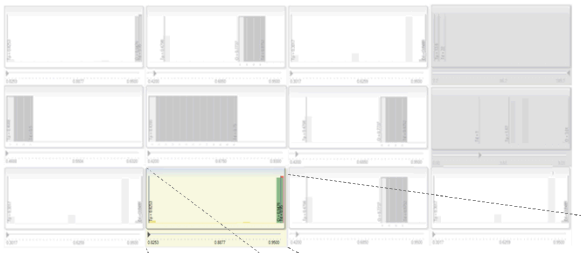
ARIES Grid



Worst possible Weight Available (Possible Threshold, Tp)

Best possible Weight Available (Objective, O)

Desire at least 6000 lbs of Weight Available (Desired Threshold, Td)

Filter slider is currently set at its loosest value (0 lbs). Triangle indicates that bigger is better for this capability.

Histogram shows distribution of values found for Weight Available (for Growth) capability.
Pareto optimal solutions exist with Weight Available between 0 lbs and 22,190 lbs.

ARIES Capability Distribution

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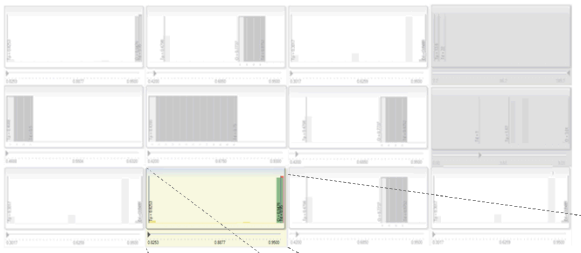
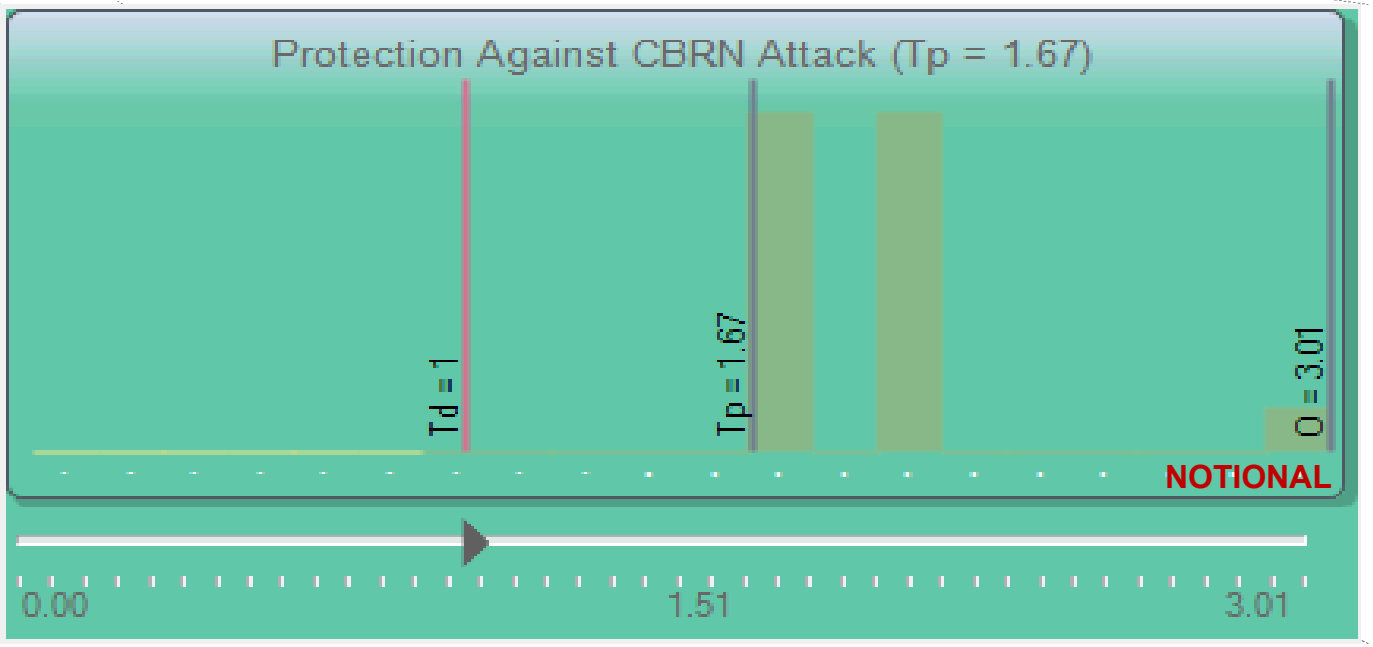
ARIES Grid





When all solutions are better than desired level, entire histogram turns green.
In this case, ideal threshold will always be satisfied.

ARIES Capability Distribution

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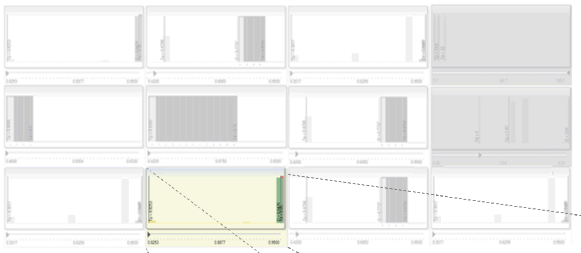
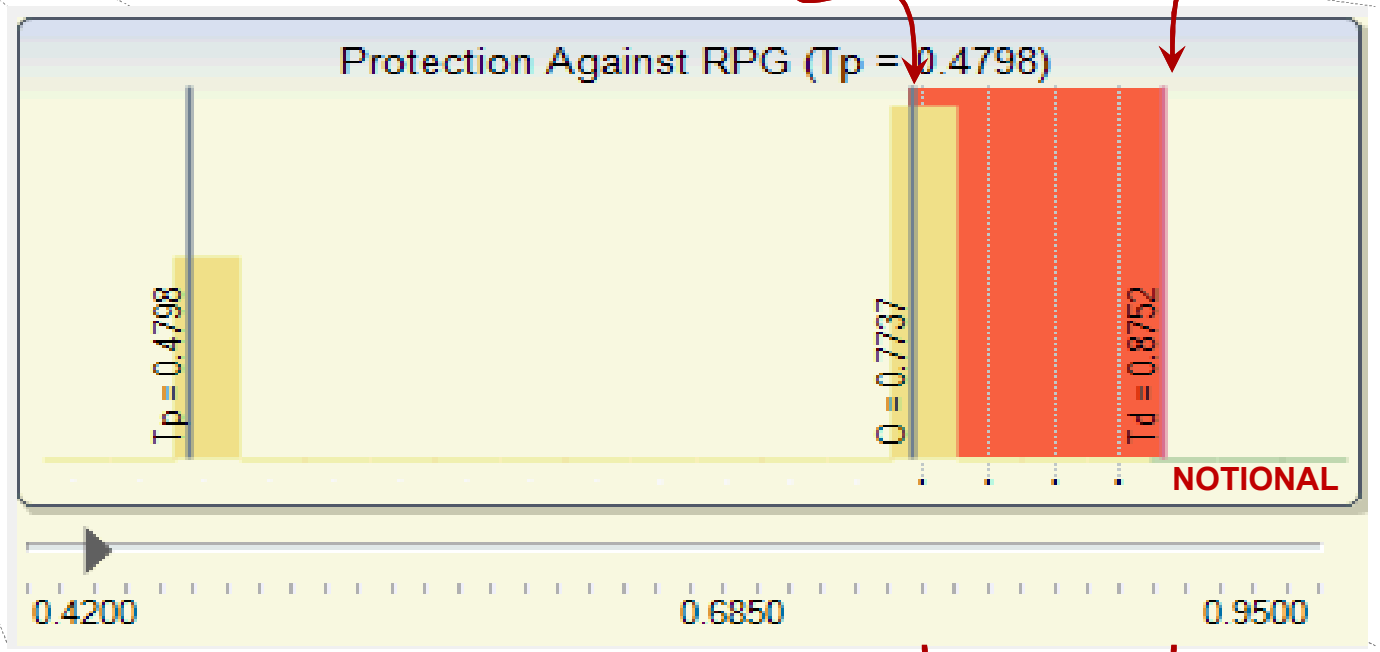
ARIES Grid



You desire an RPG protection score of at least 0.8752

But the best possible RPG score is 0.7737



We plot a red “desert” region indicating the gap between the best available and desired values

How ARIES Works

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- **Distribution plots for each capability form ARIES Grid – user interface for ARIES Panel**
- **ARIES Panel is a real-time, interactive process involving stakeholders for the program – a negotiation between dozens of requirements competing to simultaneously achieve their goals**
- **Improving one requirement Threshold often comes at expense of one or more competing requirements – ARIES shows these interactions immediately**
- **ARIES facilitates analytically-backed exploration and compromise to develop an integrated set of Threshold and Objective values that are feasible with respect to all requirements and constraints (budgetary, technological, etc.)**

ARIES Grid

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This grid is primary collaborative workspace for requirements integration

One histogram for each capability

Plots show distribution of optimal solution scores across observed range

Background shading used to denote groups of related capabilities to reduce cognitive load

ARIES Grid

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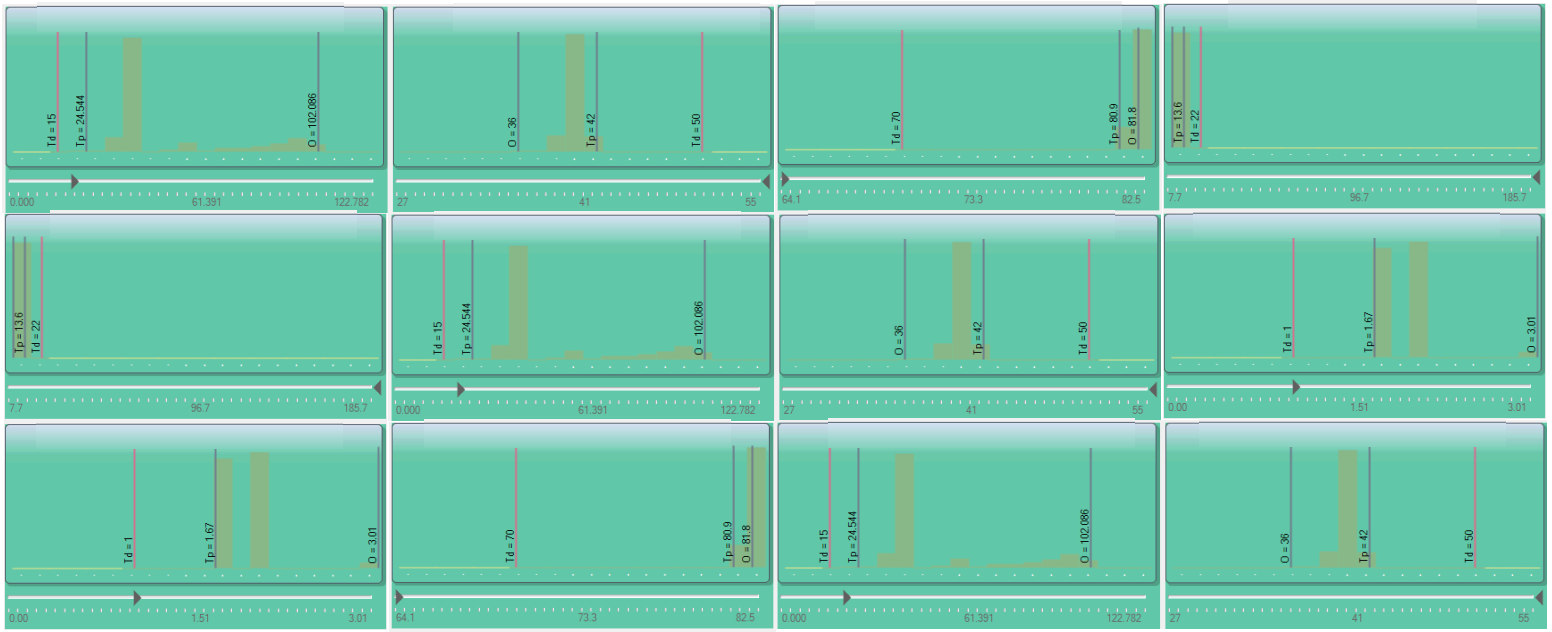
Each visible solution represents a set of simultaneously achievable requirement values

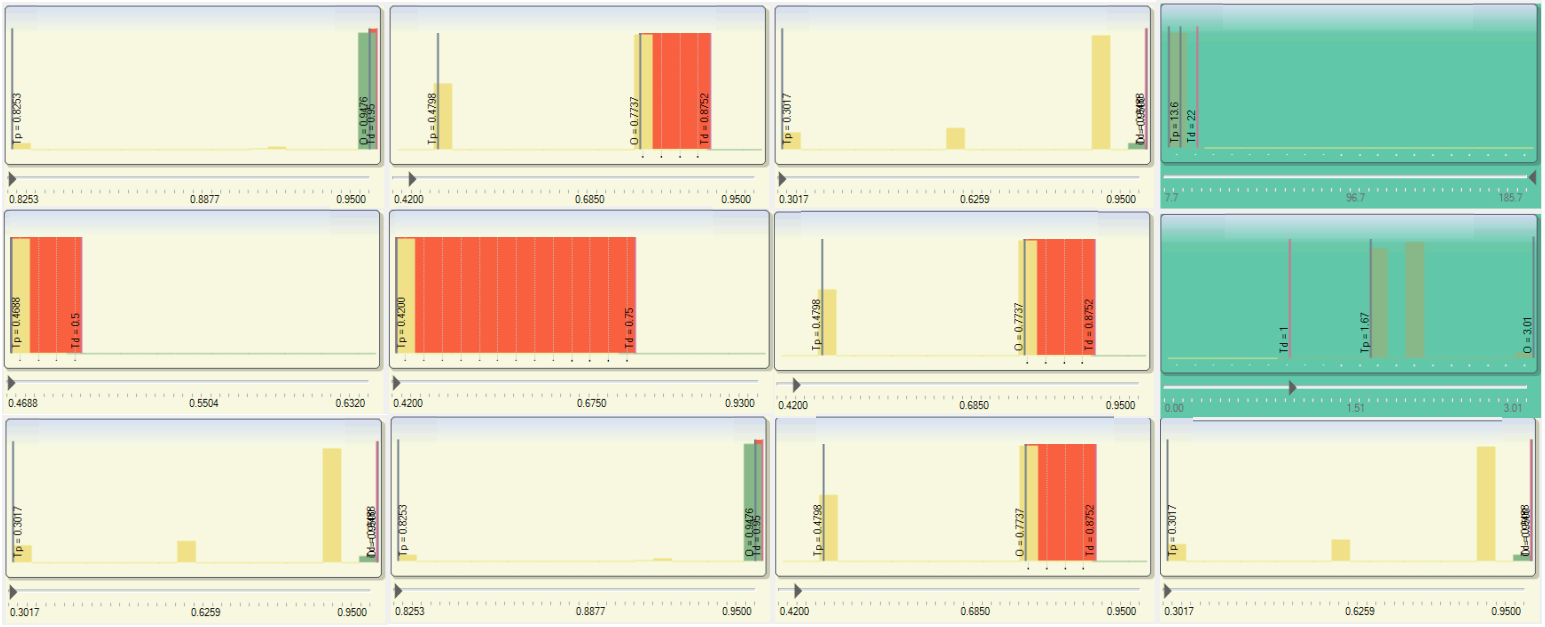
Set of Tp lines (minimum score achievable for each capability with applied constraints and available technologies) **represents minimum simultaneously achievable thresholds** (solutions exist that meet or exceed all those values)

ARIES Grid – Best Case End State



Under some scenarios, there may be solutions that meet or exceed all desired threshold values
BUT THIS IS EXTREMELY UNLIKELY

ARIES Grid – Likely End State



Under this scenario, only a few requirements are totally satisfied and most have had to compromise their desired values to get any feasible solutions

ARIES Results

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FO Distributions Summary **NOTIONAL**

Functional Objective Name	Tp	O
Ability to Fit Within Transport Assets & Negotiate Ramps	6.625	13.500
Weight Available	0	22,190
Power Available	0.000	122.782
Frequency of Refueling Pauses	43	32
Infantry Squad Carrying Capacity	6	11
Acceleration & Dash Speed	35.1	7.7
Sustained Hard Surface Road Speed	62.6	137.1
Off-Road Speed/Trafficability	32.3	18.5
Ability to Traverse Worldwide Road Network	66.1	82.5
Protection Against Medium Caliber	0.8253	0.9476
Protection Against RPG	0.4200	0.9500
Protection Against Under Vehicle Attack	0.3017	0.9500
Protection Against CBRN Attack	0.00	3.01
Protection Against Tank Fired Round	0.4688	0.6320
Protection Against EFP/SAIED	0.4200	0.9300
Protection Against ATGM	0.4204	0.9510
Protection Upgradeability	1	2
Targeting Ability	0.53	1.23
Lethality vs. Standing Enemy Infantry	0.05	0.59
Lethality vs. Prone Enemy Infantry	0.04	0.53
Lethality vs. Enemy Lightly Armored Vehicle	0.26	1.55
Lethality vs. Enemy Heavy Armor	0.04	0.90
Lethality vs. Enemy Personnel Within Structure	3.909	7.629
Ability to Conduct Simultaneous Engagements	30	100
Lethality Upgradeability	0.0	0.8
Frequency of Reloading Pauses	0.79	2.95
Ability to Reload Under Armor	0	2
Visual Signature	17.7	-2.5
Thermal Signature	171.4	17.3
RF Emission Signature	232.1	17.1
Acoustic Signature	0.0	-92.0
Ability to Operate in Silent Overwatch Mode	0.02	3.00
Estimated AUMC	11.053	7.577
Schedule Risks	4.50	0.25
Estimated O&S Cost	19.297	6.102

- ARIES process provides set of Threshold and Objective values for all requirements
- At minimum, Threshold values are simultaneously achievable
- Outcome based on compromises, programmatic, and technological constraints
- Result provides achievable, yet challenging requirement values to inform a CDD

Next Steps

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- ARIES is a prototype capability
  - Final product can still be shaped
- Planned improvements
  - Cleanup User Interface to improve usability
  - Refine process
  - Define measures to aid process
    - Quantify robustness of requirement set
    - Inform when to stop negotiation