Elements of Set-Based Design for Effective Decision Making in Army Vehicle Applications

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US Army Interests

Winning in a Complex Battlefield

(Army Operating Concept and Force 2025 & Beyond)

The modernization priorities of the Army (memo by the Secretary of the Army, 10/3/17) expect the appropriate balance between firepower, protection, mobility, and power generation capabilities for the next generation of combat vehicles (NGCV)

Key Outcomes from ***TARDEC's 30 year strategy*** seek a balanced approach between mobility, lethality, and protection.

Need to balance competing requirements

Elements Highlighted in this Presentation

- Holistic metric for vehicle performance
- Performance in different battle fields
- Single point Design vs Search algorithm based on Set Based Design (SBD) principles
- Understanding the design space and creating feasible requirements
- Elimination of highly dominated and highly infeasible designs
- Diversity in retained designs

Probability Tree (PT) Diagram for an Engagement Scenario and Computation of Successful Assessment of Mission (SAM)

Envisioned GXV-T Protection

from DARPA GXV-T program

Different stages of engagement

Vehicle Detected?

Vehicle is engaged?

Vehicle is hit?

Vehicle is killed?

No

Yes

No

Yes

No

Yes

No

Yes

Probability of Failure

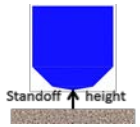
Separate upper and lower bounds are defined at each stage of each engagement

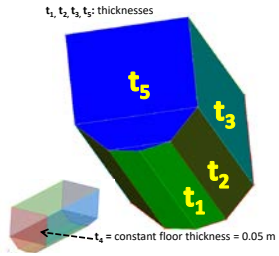
Vehicle characteristics and performance metrics impact the probability range of each engagement

Each engagement scenario is represented by a different probability tree and different functions linking vehicle characteristics with probability ranges

Single Point Design

Total mass must be less than the mass corresponding to all thicknesses at mean values.





Design Variables

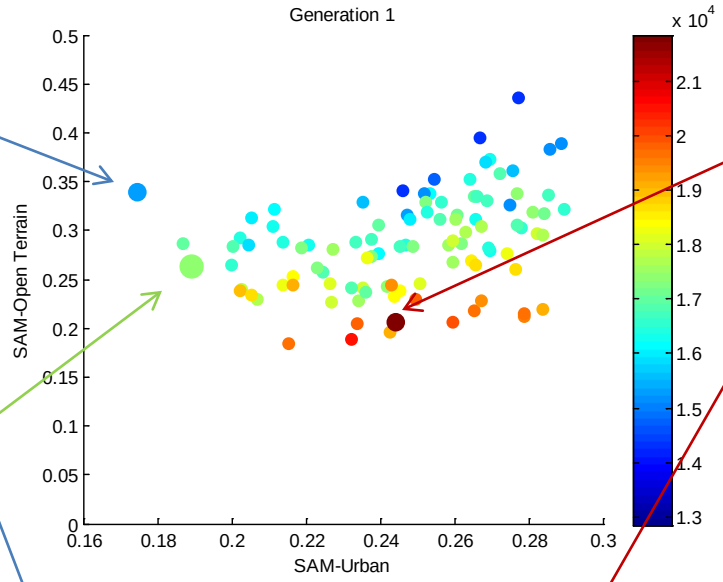
	t1	t2	t3	t5	s
Urban opt design	0.0499	0.0499	0.0251	0.0250	0.750
Open Terrain opt design	0.0251	0.0254	0.0424	0.0415	0.752
Balanced optimal design	0.0466	0.0457	0.0426	0.0278	0.750

	Mass constraint	SAM Urban	SAM Open Terrain
Urban opt design	inactive	0.175	0.340
Open Terrain opt design	active	0.221	0.203
Balanced optimal design	active	0.187	0.266

Lower SAM is better

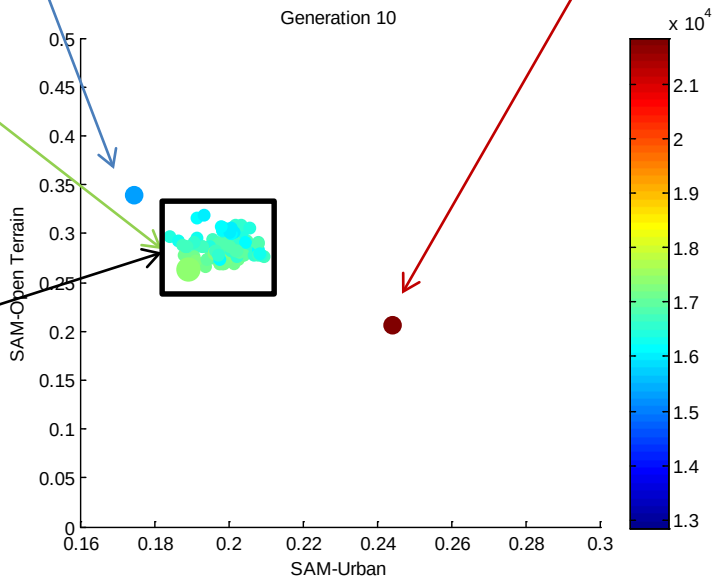
Results from SBD Search Algorithm

Optimal for maximum mobility



Optimal for minimum probability of being killed in the Urban terrain

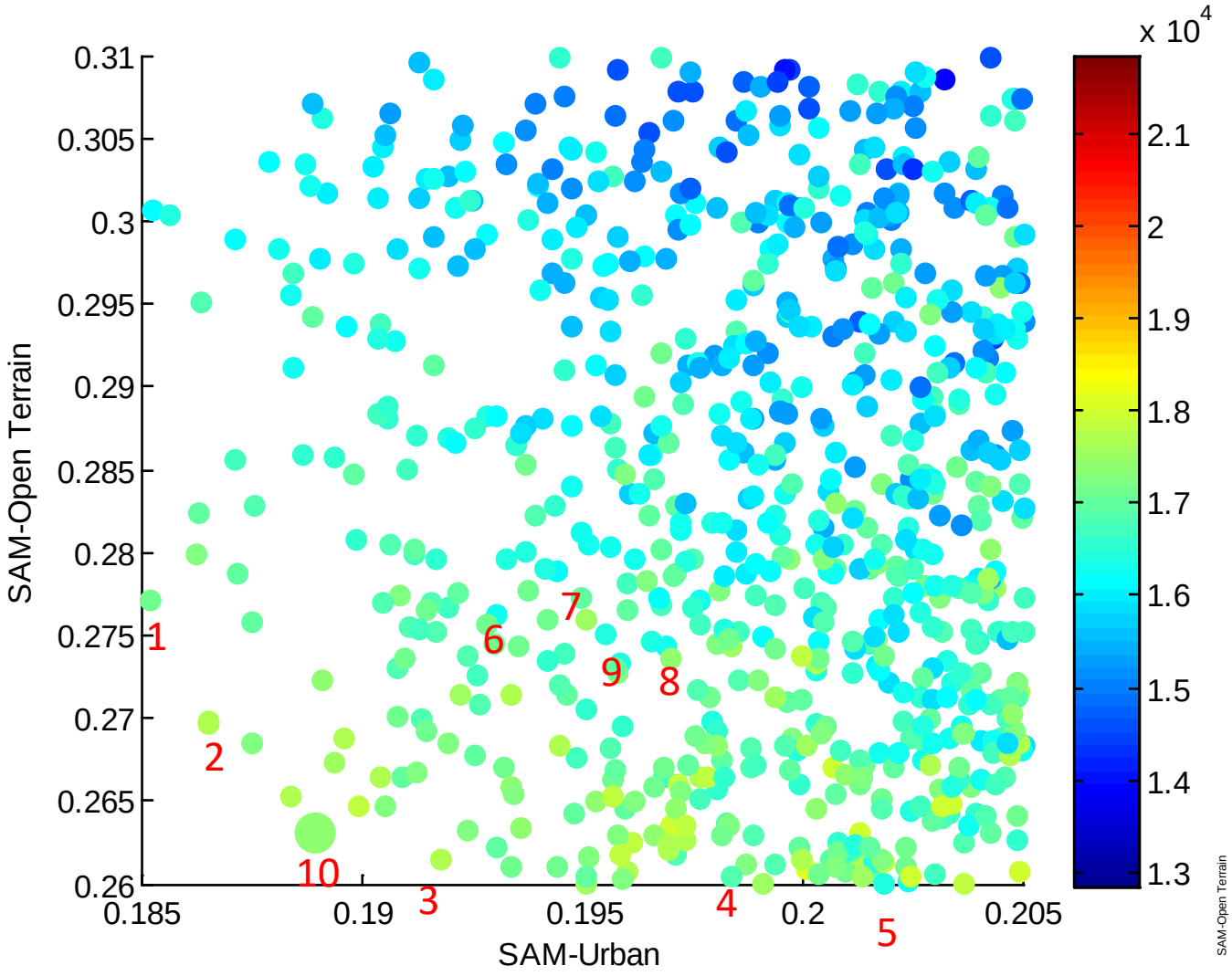
Balanced Optimal from Single Point Design

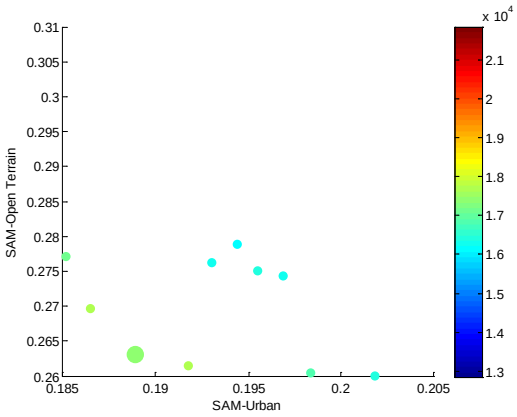


Mass used for the color scale

Focused Design Space for further Study identified by the SBD algorithm

Focused Design Space

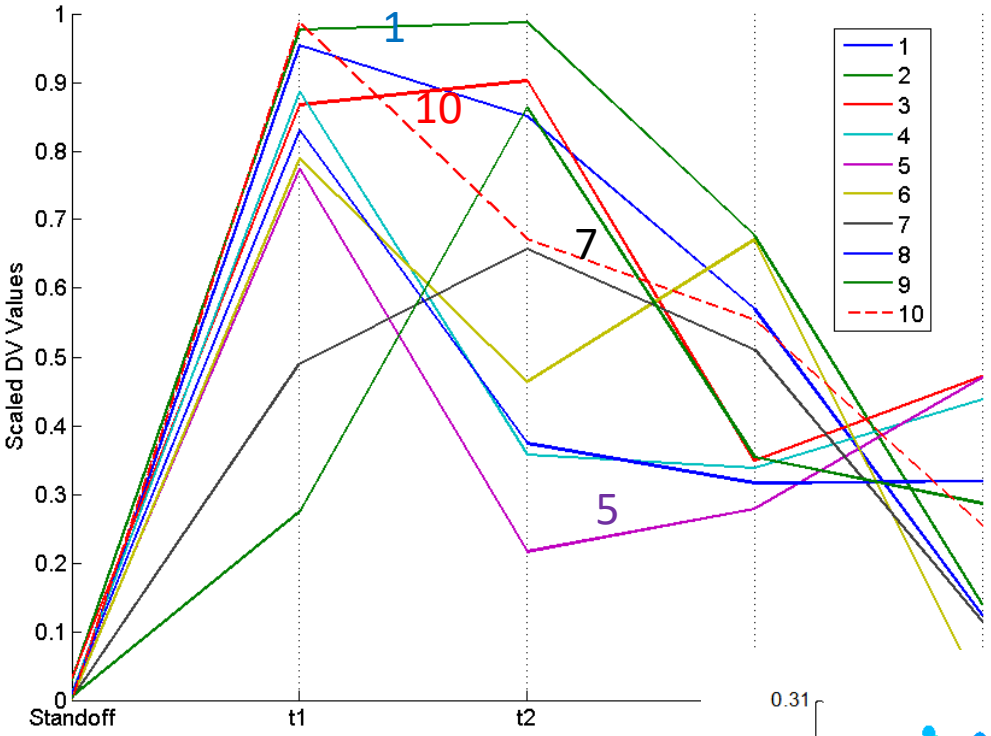




Establishing requirements for acquisition with confidence that many feasible / viable solutions exist

Design variables

Upper and lower bounds

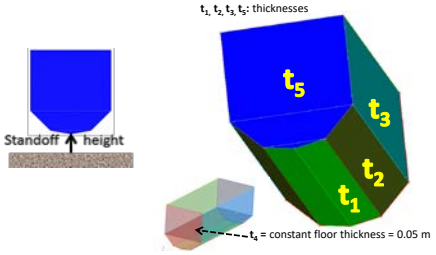


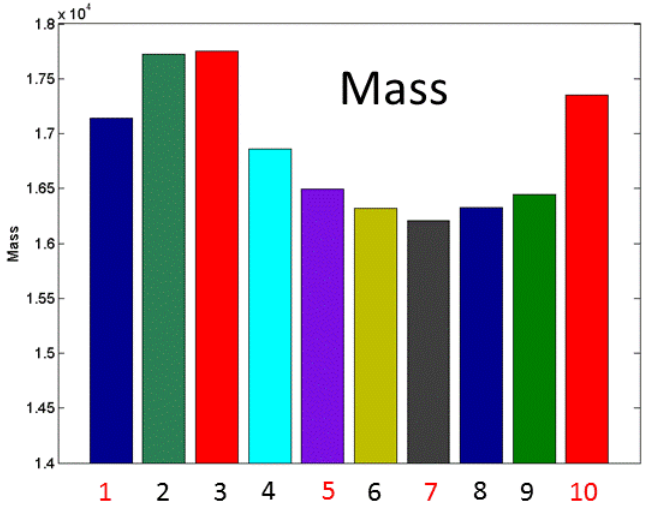
All designs have small stand-off

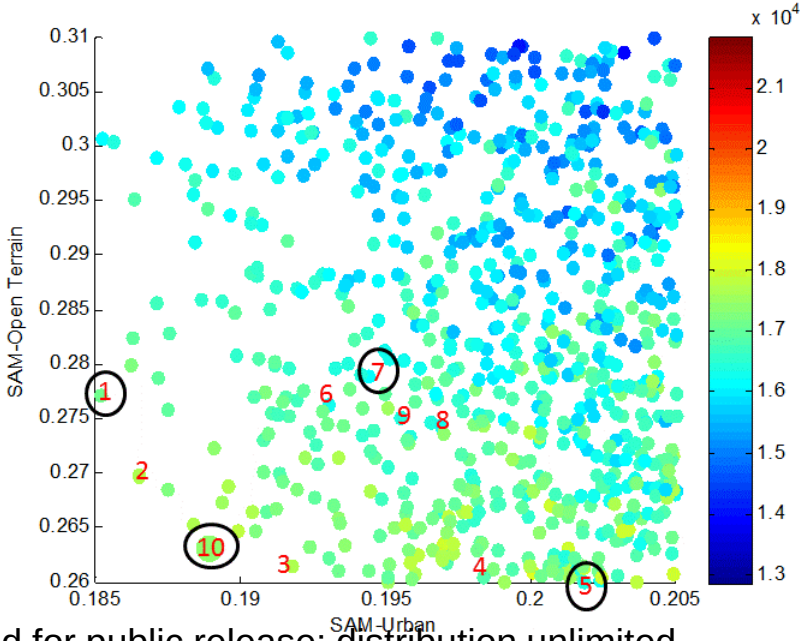
10 & 7 very similar except for t1

5 & 7 have opposite selections

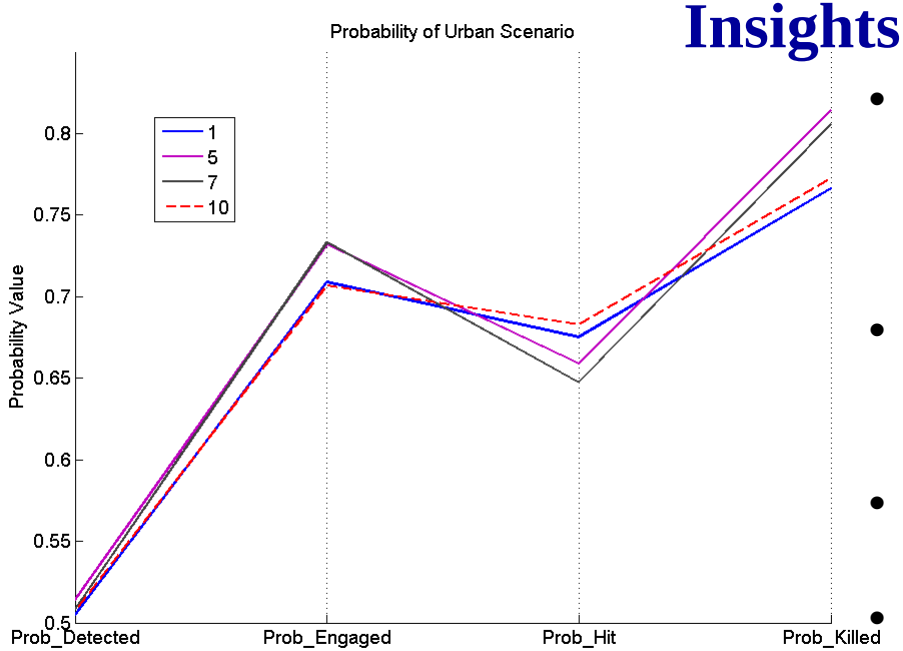
1, 5, 7 mass < mass of 10

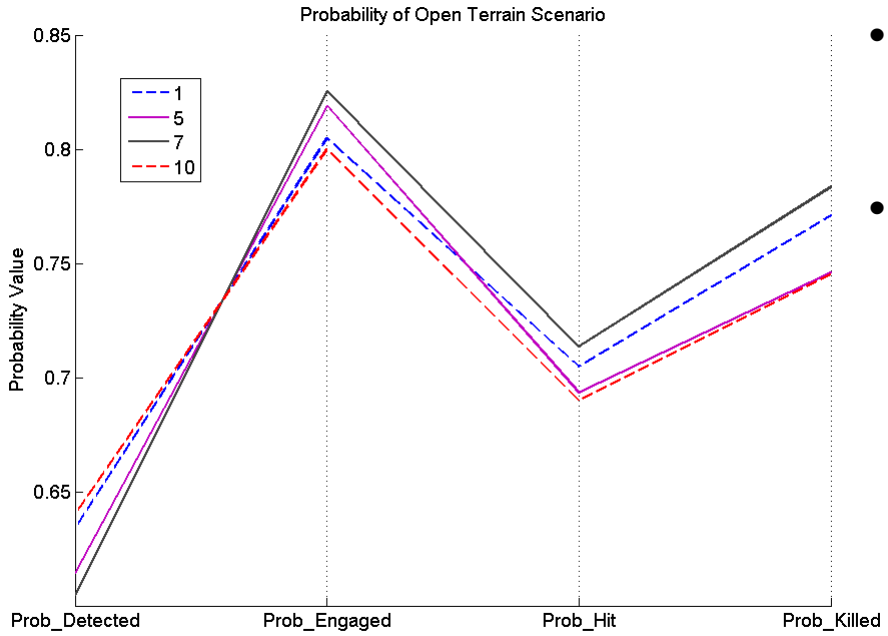




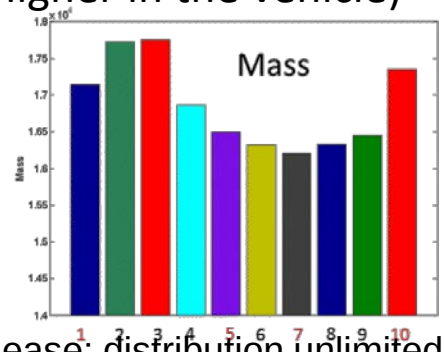


Insights





- In the Urban battlefield (1 + 10) & (5+7) are very similar in terms of conditional probabilities. In the Open battlespace there are no similarities.
- The probability of being detected is the lowest one and the probability of being hit the second lower in both battlespaces.
- In the Urban terrain the probability of being killed is the highest.
- In the Open terrain the probability of being engaged is the highest.
- In the Urban battlespace 1+10 (highest weight of the four) have the lowest probability of being killed.
- In the Open battlespace 5+10 have the lowest probability of being killed (larger weight higher in the vehicle)



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