SAND2022-3254D

Sandia Academic Alliance Spring UT Austin Research Poster Session | Sandia Day 2022

Advanced Decision Analytics Capability Development and Analysis Support

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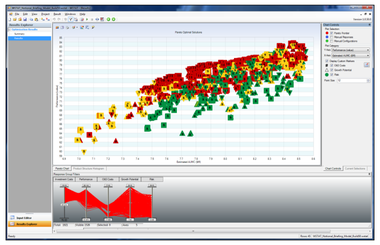
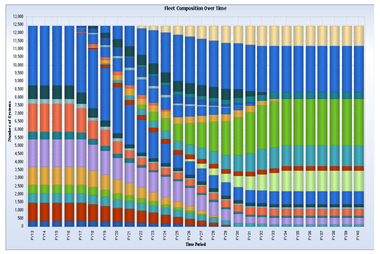
Advanced Decision Analytics

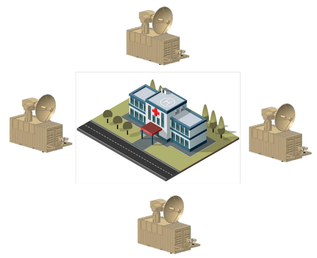
My work support the Advanced Decision Analytics department to inform and influence next generation military technology design optimization and development for our national security mission. And works with the military from the from concept through design development to operations and sustainment, and into modernization. We do this by

- Exploring early stage design tradeoffs for requirements.
- Optimizing detailed system designs over multiple objectives
- Optimizing portfolios of systems with competing objectives across time.





Application for Directed Energy Tradespace



How do we design a defensive High Powered Microwave System?

- How many antenna?
- What size diameter?
- What frequency do we use?
- How much power in each shot?
- How frequently do we shoot?
- Number of rapid shots?
- How big of a battery?

Trade off metrics include:

- Lethality Range against 3 targets
- Antenna Slew Rate
- Power System Volume
- Weight (Per Antenna)
- Total Cost

Constraints/Considerations include:

- General RF Physics
- Air Breakdown (2.4e10 W/m^2)
- Target Coupling
- Maximum Gain (50 DB)
- Pulse Width to Pulse Repetition constraint.

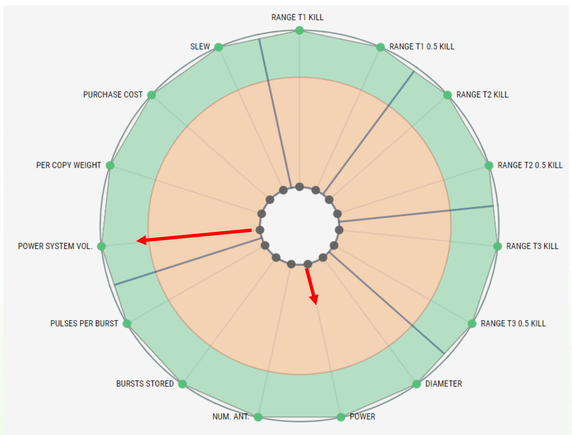
Simplification:

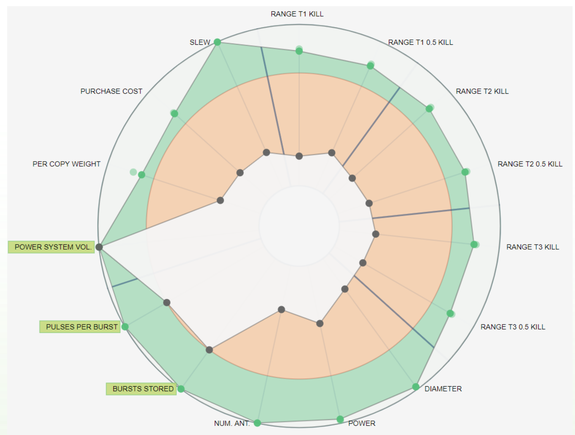
- Multi-Antenna Power on Target ignores Array Layout
- Pulses hit target at the same range.

- Rather than simplifying to one or two aggregated preference functions, we wish to learn about tradeoffs in all designs and all objectives.
- This will occur in early stage analysis before requirements have been established for military systems.
- To solve the problem use ultra-high dimensional (15+ objectives) optimization using a genetic algorithm

Current Status / Results

- Using the ultra-high dimensional "Space Filling" algorithm we generate 10,000 solutions to allow for real time discussion of trade offs between conflicting objectives.





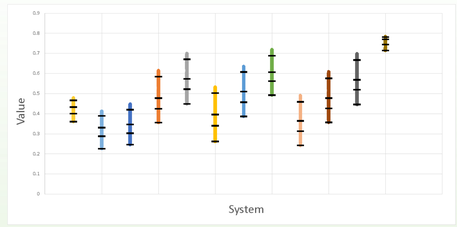
If we want the power system and power to be smaller, how does this affect the other metrics

Challenges

- In ultra-high dimensional analysis, a large portion of designs are pareto optimal.
- Representing a large design space with limited solutions requires choosing solutions based on "space-filling" that selects pareto optimal solutions that maximizes the distance between solutions.
- The next challenge is how to improve fidelity in the model.
- There are a variety of ways we can expand, but we need a way to prioritize where improvements are added.

Next Steps / Future Work

- Explore methodology and insights that can be gathered in the early stage of the process with partial or no stakeholder preference information.
  - Potentially identify where increased modelling fidelity/ complexity should be added.
  - Potentially eliminate dominated design options earlier in the analysis.
  - Identify design driving value metrics early in the process with partial or no preference information.



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National Nuclear Security Administration

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