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Multi-Domain Dynamic Targeting

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Targeting

Definitions

- Targeting:
  - The process of selecting and prioritizing targets and matching appropriate responses to them.
- Target:
  - An entity considered for possible engagement or action to alter or neutralize the function it performs for the adversary
- FIVE-O:
  - Facility
  - Individual
  - Virtual
  - Equipment
  - Organization

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The Targeting Problem

Deliberate vs. Dynamic, Kinetic vs. Non-kinetic

- Targeting is ideally a deliberate process
  - Time intensive, not time-critical
- Dynamic targets are time-critical
  - Estimate 1-3 hours spent developing dynamic targets
  - May miss window of opportunity
- Kinetic solutions are not universally superior
  - Cyber effects, EW may be more effective or safer
- Needs to be faster
- Needs to accommodate non-kinetic solutions

Proposed Solution

Leverage Optimization Technology

- Reduce targeteer workload for dynamic targeting
- Create tool that suggests targeting solutions
  - Processes current battlespace
  - Provides recommendations
- Targeteers select most appropriate recommendation
  - Full override power
- Adjust based on mission necessity and commander's intent

Pros and Cons of Optimization

- Pros:
  - Higher accuracy than humans
  - Faster than human decision-making
  - Theory-driven; can (potentially) guarantee solution
  - Statistical methods can grant insight even with synthetic data
- Cons:
  - Verification/validation can be difficult
  - Only as robust as designed to be
  - Complicated decision space leads to longer solution times

Optimization

Overview of Components

- Requirements: decision variables, objective function, constraints, data
- Objective function: what we're trying to minimize or maximize
- Constraints: boundaries - physical, financial, legal, self-imposed, etc.
- Data
  - Information targeteers currently use
  - Do we need additional data to facilitate a machine?
  - Can we process enough data quickly?

Classical Problem: Weapon-Target Assignment

A Simple Starting Point

- Commander has N weapons, M targets
- Each weapon has a likelihood of destroying each target
- Assign a weapon to each target, maximizing number of targets destroyed
- Can be solved exactly using branch-and-bound with relaxation (classical optimization method)
- Many heuristics can solve in polynomial time

Adaptation to Platform-Weapon-Target Problem

Adapt to Our Needs

- Platforms
  - Mobile entities carrying weapons to perform tasks
- Weapons
  - Notional constructs for affecting targets; kinetic or non-kinetic as appropriate
    - Deceive, Degrade, Deny, Disrupt, Destroy
    - Target/Commander's objective determine weapon effectiveness
- Constraints
  - Flight pathing/flight time
    - Platforms must travel to targets
    - Airspace may be denied
  - Weapon capacity
  - Target vulnerability window

Objective Function

What We Are Solving

$$maximize\ f(A) = \sum i=1 \uparrow p \blacksquare \sum j=1 \uparrow w \blacksquare \sum k=1 \uparrow t \blacksquare A \downarrow ijk$$

Where

$p \in P$

denotes a platform,

$w \in W$

denotes a weapon,

$t \in T$

denotes a target, and

$A \in P \times W \times T$

with

$A \downarrow ijk = \{ \blacksquare 1,$ platform i carries weapon j targeting $k 0,$ otherwise

subject to constraints

$C \geq 0$

Assumptions

Defining the Design Space

- Commander desires maximum mission throughput
- Commander (or other entity) sets maximum allowable collateral damage
- Disruption to the ATO and the JIPTL should be avoided if possible
- Platforms carry up to 2 total weapons
  - Missile salvos, Cyber capabilities, EW capabilities, etc.
- Platforms move in simulation-time, while the optimizer runs (may affect results)
- Platforms cannot and will not enter restricted airspace
- Target vulnerability is known *a priori*
- Deliberate targeting has been performed, and targets are being prosecuted accordingly

Example Problem Configuration

Starting small

- Randomly generate weapons and targets
- Allocate platforms to prosecute 10 targets
  - Determine 7 beforehand, and add 3 during mission execution
- Solution time: ~2.5 seconds

- 8 targets successfully prosecuted
  - 1 in no-fly area, 1 weapon failed to affect target (no generated weapons could)
- Dynamic targets required re-tasking of 2 platforms for optimal effect

Simulation

Creating a Scenario

- Developing a scenario using AFSIM
- Enables platform, weapon, target creation
- Enhances realism, handles physics and location tracking
- Allows airspace restriction
- Runs in real time while querying optimizer
    - Implements results, outputs new information
- Developing plugin to interface autonomously between AFSIM and optimizer

Future Plans

Looking Forward

- Complete AFSIM integration
- Realistic Weapons, Targets, Platforms
  - AFSIM models exist
- Evaluation of trade-off spaces
  - Minimal disruption is ideal, but some may be required
  - Combinations of weapons may be a better solution, but require more platforms allocated
- Larger scenario
  - Orders of magnitude more platforms, targets
  - Simulate full air-tasking cycle (72 hrs)
- Perform deliberate targeting using optimizer first
  - Shorten the gap between deliberate and dynamic targeting