ICCRTS 2007

Course of Action Scoring and Analysis

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Chris Egan, SAIC

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CASA Overview

- CASA is a task for the AFRL to explore ways to score divergent courses of action (COA) while accounting for effects based operations (EBO).
  - Implement a prototype solution for use in further research.
  - COA: taking a series of actions to secure a desired set of outcomes.

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EBO

- Effects-based operations (EBO) are actions that achieve the desired results through often indirect and non-obvious means.
  - May often allow for achievement of desired results with less cost or negative results.

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CASA goals

- The goal of the prototype was to create a system that could process data from a simulation run and generate a score based on how well that simulation achieved the desired outcome.
- This involved not only evaluating how well individual actions were achieved but also how the actions affected the overall goals.

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Scoring Approaches

- Bayesian Networks
- Attrition-based scoring
- Task/effect based scoring

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Bayesian Network

- Utilized Netica software from Norsys for the network modeling
- Developed a simple subset of a COA for comparison

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Bayesian vs. Ontology

- Pros
  - Easy to see big picture for small data-sets
  - Flexibility to customize scoring using equations
- Cons
  - Even medium sized data-sets become unwieldy
    - No hierarchy to facilitate information partitioning
  - Greater difficulty in analyzing the network to find score drivers
  - Data as compared to information

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Attrition-based Scoring

- Focuses on the kinetic results of actions, both positive and negative.
- Hard to account for overall desired effects and goals generically.
- There are many exceptions to kinetic force results that are hard to describe generically.
  - Bombing a enemy building is good.
    - Unless that building has civilians in it.
      - Except for when the civilian causalities are merited by the value of the targets disrupted/disabled and destroyed.

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Task / Effect Based Scoring

- Adds in the concept of higher level goals and objectives.
- Successful COAs don’t just inflict more casualties than sustained but achieve the intended goals.
- Facilitates scoring EBO actions by accounting for overall results.

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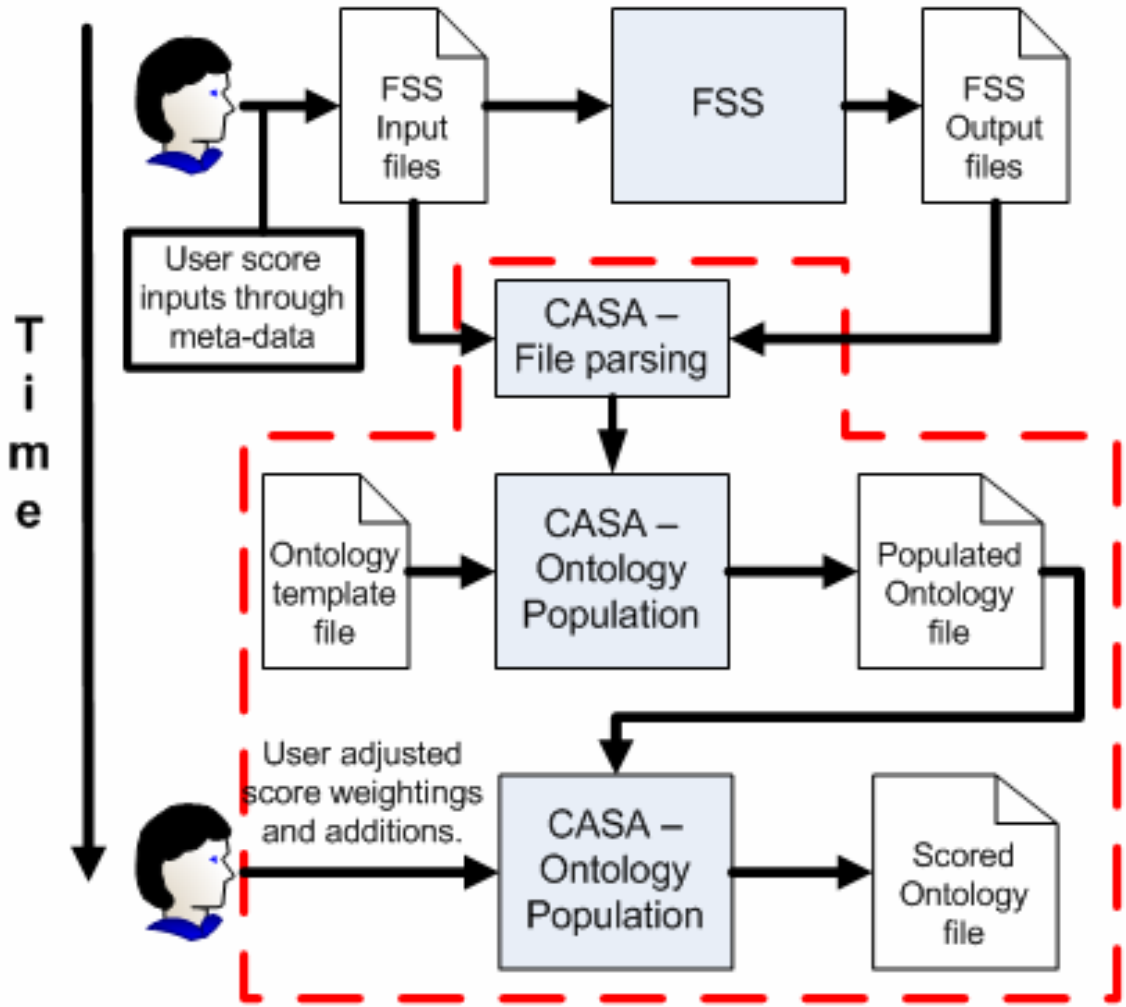
Prototype Solution



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Metrics Breakdown

- In order to facilitate multiple users entering scoring criteria a metrics breakdown was created.
  - Allows levels where a single user can fully understand it’s function.
- This also helps facilitate comparison of disparate COAs by breaking down different possibilities into common sets of metrics.

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Metrics Breakdown

- Commander's Intent
- Strategic Effect
- Operational Effect
- Operational Task
- Mission
- Measure of Merit: Efficiency; Effectiveness Timeliness
- Measure of Effectiveness: Groups MOPs
- Measure of Performance: Maps to data

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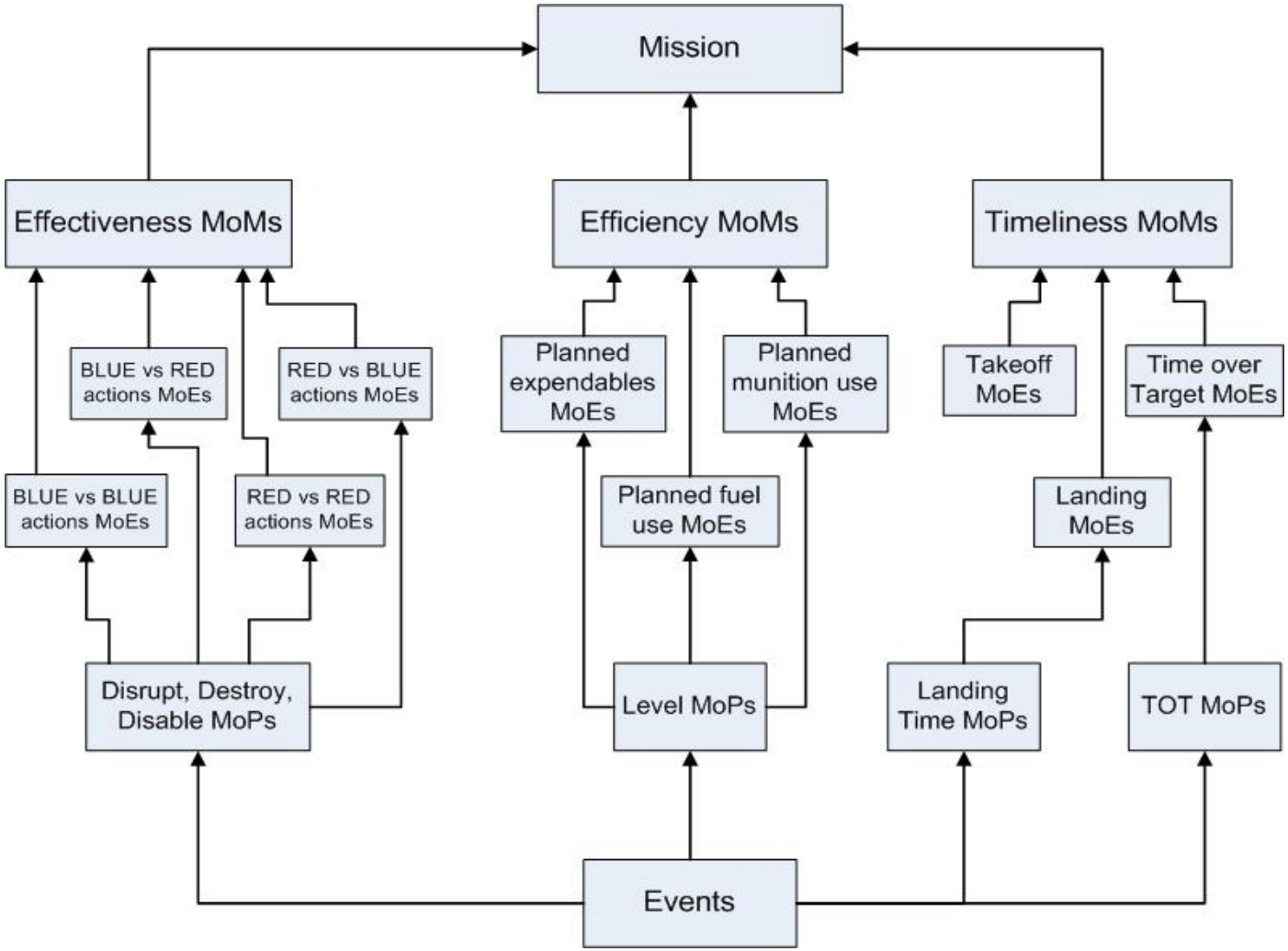
Sample breakdown



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Scoring MOPs

- After the breakdown has been completed the first step in scoring is to score the MOPs
  - Each MOP will be scored from 0.0 - 1.0
  - A MOP's score is based on how well its actual value achieved the desired value
  - MOPs are populated with data from the sim
  - The desired values come from either meta-data, user-entered values from the GUI or defaults

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Score Roll-up

- Once all MOPs are scored, the higher-level scores can be calculated
- Every score-able measure is comprised of a weight and a value
- The score of a higher-level measure is the weighted average total of its constituent measures

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Score Roll-up Example

- The mission to bomb the command post has three measures of merit
  - Efficiency MOM: value = .973; weight = .05
  - Effectiveness MOM: value = .793; weight = .7
  - Timeliness MOM: value = .625; weight = .25
  - Value of mission = (.973*.05) + (.793*.7) + (.625*.25) = .76
  - If the weights specified do not sum to 1 they are normalized such that they do sum to 1

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Influences

- Mechanism to adjust score outside of the straight roll-up
- Influences provide a means to ensure actions that you wanted to happen did occur and to bias the score accordingly (and vice versa)
- They operate as a multiplier on a specific measure in the score breakdown that is applied contingent upon certain conditions being met

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Influences (Cont.)

- If you had an operational task whose goal was to disable a certain center of gravity (communications), you could add an influence to ensure that goal was met
  - Missions could all score well but still leave communications intact
  - Without an influence the operational task would score well even though its true goal was unmet
  - With an influence the conditions would fire and the multiplier could bias the score accordingly

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Influences (Cont.)

- Allows users at different levels of the breakdown to identify relationships that they know about without having to fully understand all of the levels in between.
- Influences operate as a multiplier on the score
  - Commutative
    - Ordering not important if multiple influences are applied
    - Useful when multiple users are specifying influences.,

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Scoring Assumptions

- One of the driving goals in the prototype solution was to allow for the creation of a reasonable score without specifying every detail in metadata
  - This was achieved through assumptions
    - e.g. destroying civilian non-targetable assets is bad; destroying opposing military targets is good
  - Tried to minimize the number of assumptions while still giving a reasonable score

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Benefits of using an Ontology

- Captures both the language used in the domain as well as data for specific instances.
  - Extremely useful for sharing information amongst multiple users.
  - Helps avoid confusion from mis-use of terms or differing definitions.
- Allows for inheritance of other Ontologies.
  - Useful for leveraging off of other work and helping achieve data independence.
- Useful for work with living documents
  - Global definition of slots allows for simple propagation of changes throughout the document.

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Experiments

- We created a scenario where a red force was mobilizing WMD and conventional forces along it's border in order to negotiate concessions.
- Three COAs were developed to address the threat and eliminate the red WMD threat.
  - Restrain – low ops tempo
  - Pinion – medium ops tempo
  - Overwhelm – high ops temp
- Three commander profiles were created as scoring templates
  - Conservative – high premium on avoidance blue-force and civilian casualties.
  - Aggressive – high tolerance for causalities.
  - Typical – medium tolerance for causalities.

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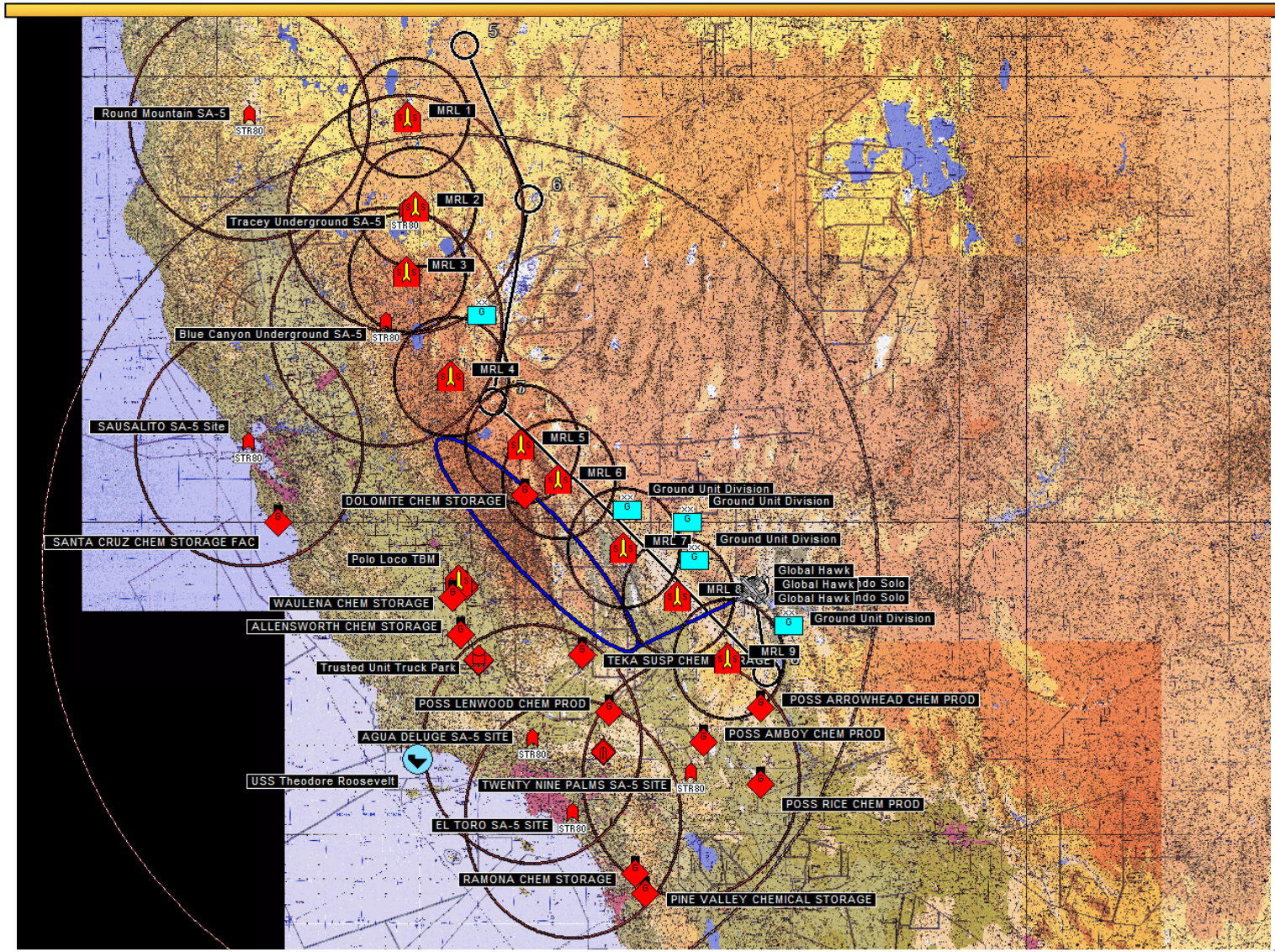
General Force Laydown



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Year 3 COA Results

	Conservative	Typical	Aggressive
Overwhelm	0.88735867	0.8983078	0.8766911
Pinion	0.86579984	0.8911031	0.8708272
Restrain	0.78576326	0.9665829	0.8980264

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Future Areas of Research

- Score tolerance on simulation results
  - Compile high, low, average as well as standard deviation from multiple seed runs
  - Run the same scenario through multiple simulations to identify and account for simulation limitations and assumptions.
- Score tolerance on User Inputs
  - Run the same scenario with multiple teams to identify the difference between the scores.
  - Repeat the experiment at intervals to determine if the teams vary amongst themselves over time.

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Conclusion

- The prototype solution developed provides a basic capability of accounting for EBO effects in COA scoring but much more work remains.
  - Must develop experiments using the tool to identify what works and what requires additional research.

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Acknowledgement

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