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# 2012 NDIA Joint Armaments Conference

# Goal-Programming and Traditional Force-on-Force Simulations

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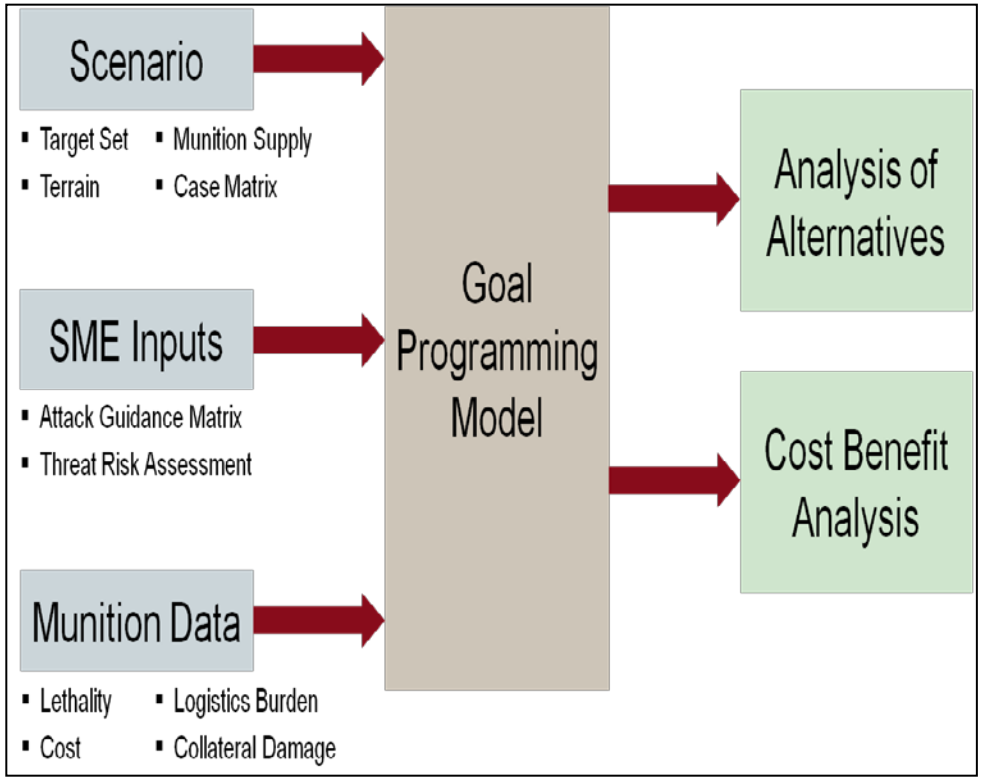
# Agenda

- Goal Programming
  - Concepts
  - Defining Optimal Mixes
  - Limitations
- Constructive Simulations
- Connectivity to Constructive Simulations
- Summary

# Goal Programming Model

- **Goal-Programming (GP) Model**
  - Math based, linear programming
  - Model analyzes alternatives based on a set of goals and constraints:
    - Cost, lethality, collateral damage, logistics, etc.
    - Weights determine the importance of each goal
  - Model identifies the "optimal" solution for the given inputs
    - Eliminate as many targets as possible while adhering to goals and constraints




- **Benefits of GP Model**
  - Very quick
  - Ability to quantify a large number of metrics
  - Ability to analyze large case matrices
  - Scenario definitions are flexible and easily modified

**Goal-Programming results in different "optimal" solutions based on the user-defined scenario, goals, and constraints**

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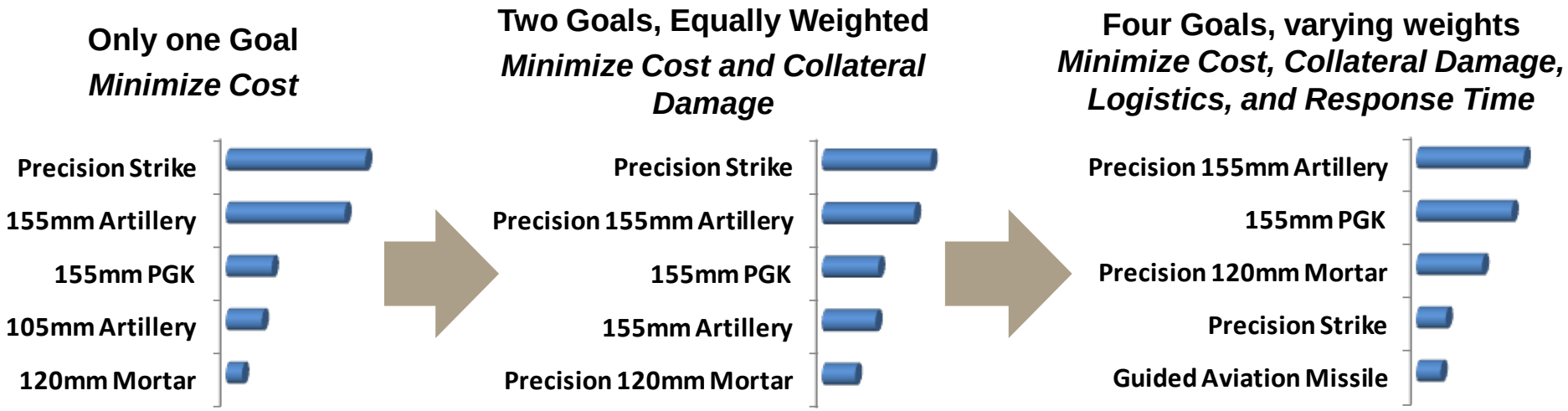
# Identifying Optimal Mixes

- Model determines an optimal solution based on the user-defined goals
  - The "weights" determine the importance of each goal
  - Weights must be matched to real-world considerations to produce valid solutions
- Constraints can be placed on the model to enforce scenario-specific limitations / preferences on munitions
  - Example: Prevent a munition from firing on certain targets due to Commander Intent / preference
- Below illustrates how goals, their weighting, and constraints can drastically change the optimal solution determined by the model

## Top 5 Munitions in Different "Optimal Mixes"



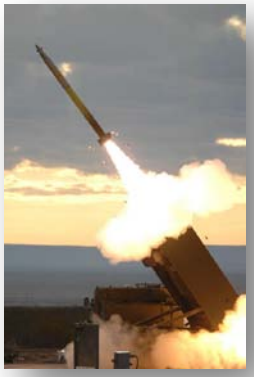

**Optimal mixes generated by the model vary greatly based on the inputs**

# Limitations of GP

- Model very subject to “garbage in, garbage out”
  - Answer only valid for given inputs
  - If inputs are incomplete or weighted incorrectly, answer is meaningless
  - Example: Defeat of a structure target

100 conventional 155mm rounds

Single Precision Rocket



**Optimize Cost**

100 x $1000

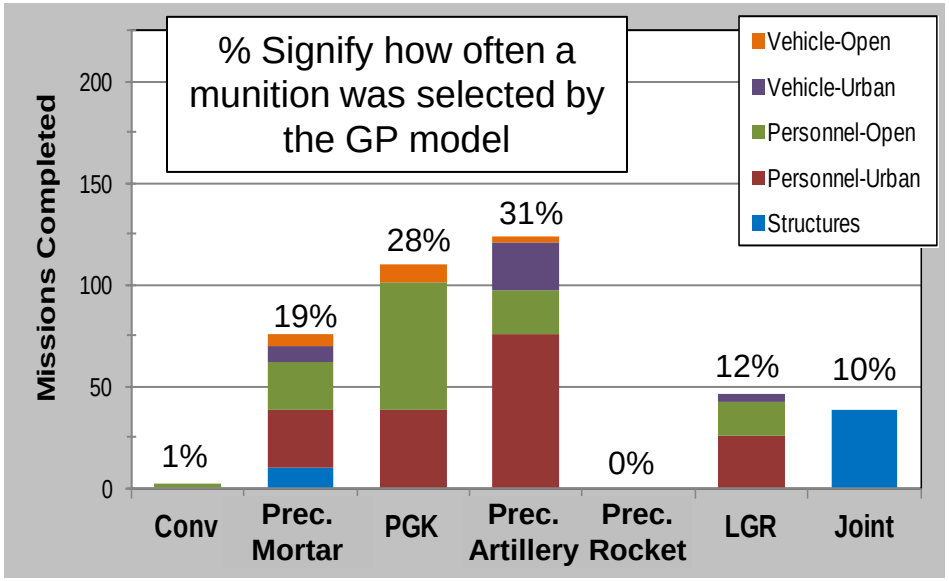
$100,000

1 x $110,000

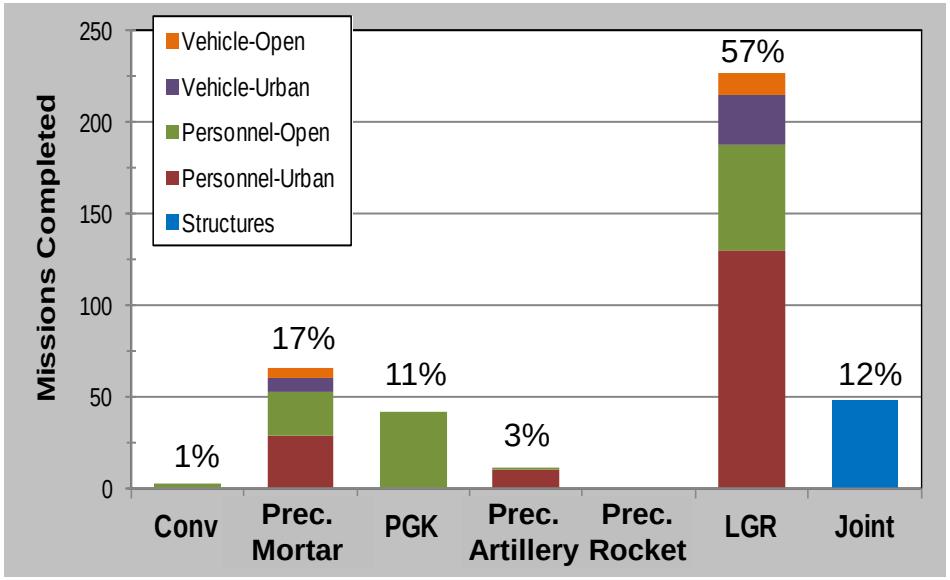
**This is a correct answer but is it valid?**

# Limitations of GP

- Leaving out the slightest of considerations in GP inputs can have drastic repercussions in the outcome
- Example:
  - Not giving any weight to the goal of reducing "response time"
  - Analysis examines effects of adding a 2.75 Laser Guided Rocket (LGR) to the precision munition portfolio
    - LGR would be launched from RW; "response time" penalty for the RW to get on station




Results if "Minimize Response Time" goal is given modest weighting of 10%




Results if "Minimize Response Time" goal is not included in the model

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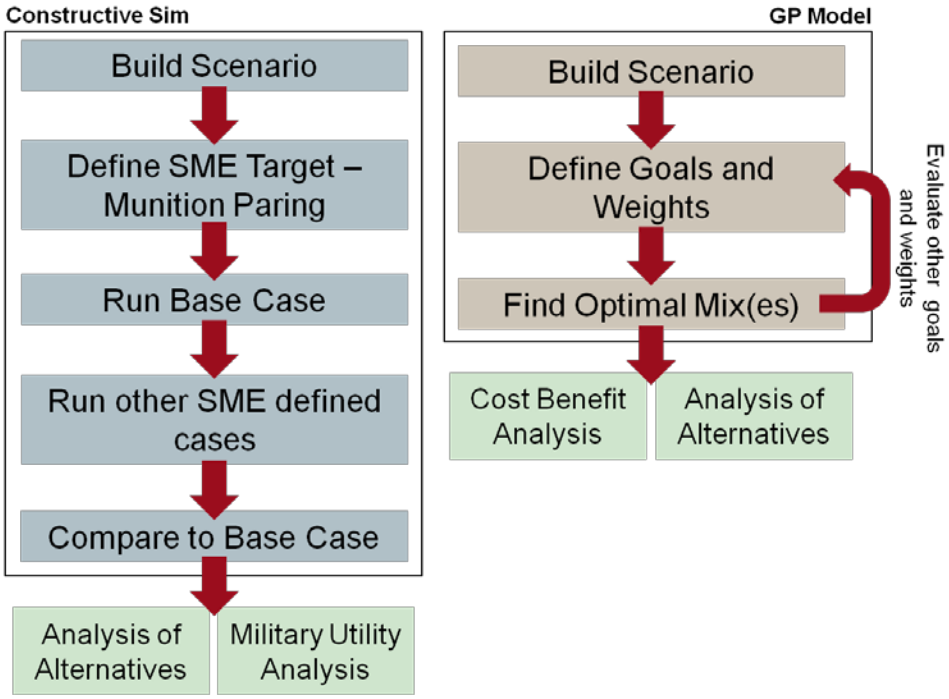
# Limitations of GP

- How do you generate realistic results in a GP model?
  1. Ensure as many real-life considerations as possible are modeled as goals
     - Logistics, collateral damage, response time, exposure, etc
     - Ensure weights match tactical considerations for specific scenario
  2. Include “Commander Preference” as a goal to force tactically sound choices
     - SMEs pair munitions and targets beforehand based on their expert experience
     - Model gives preference to these pairings
     - Problem: Can introduce biases into “optimal” mixes
     - If all considerations are represented as goals, Commander Preference is not required; let the model determine optimal pairings
- Very difficult to model operational benefits in GP model
  - How much better does this optimal mix make my force?
  - Survivability, op-tempo, etc

**Goals, their weighting, and model constraints must all match real-life considerations to produce valid mixes**

# Constructive Simulations

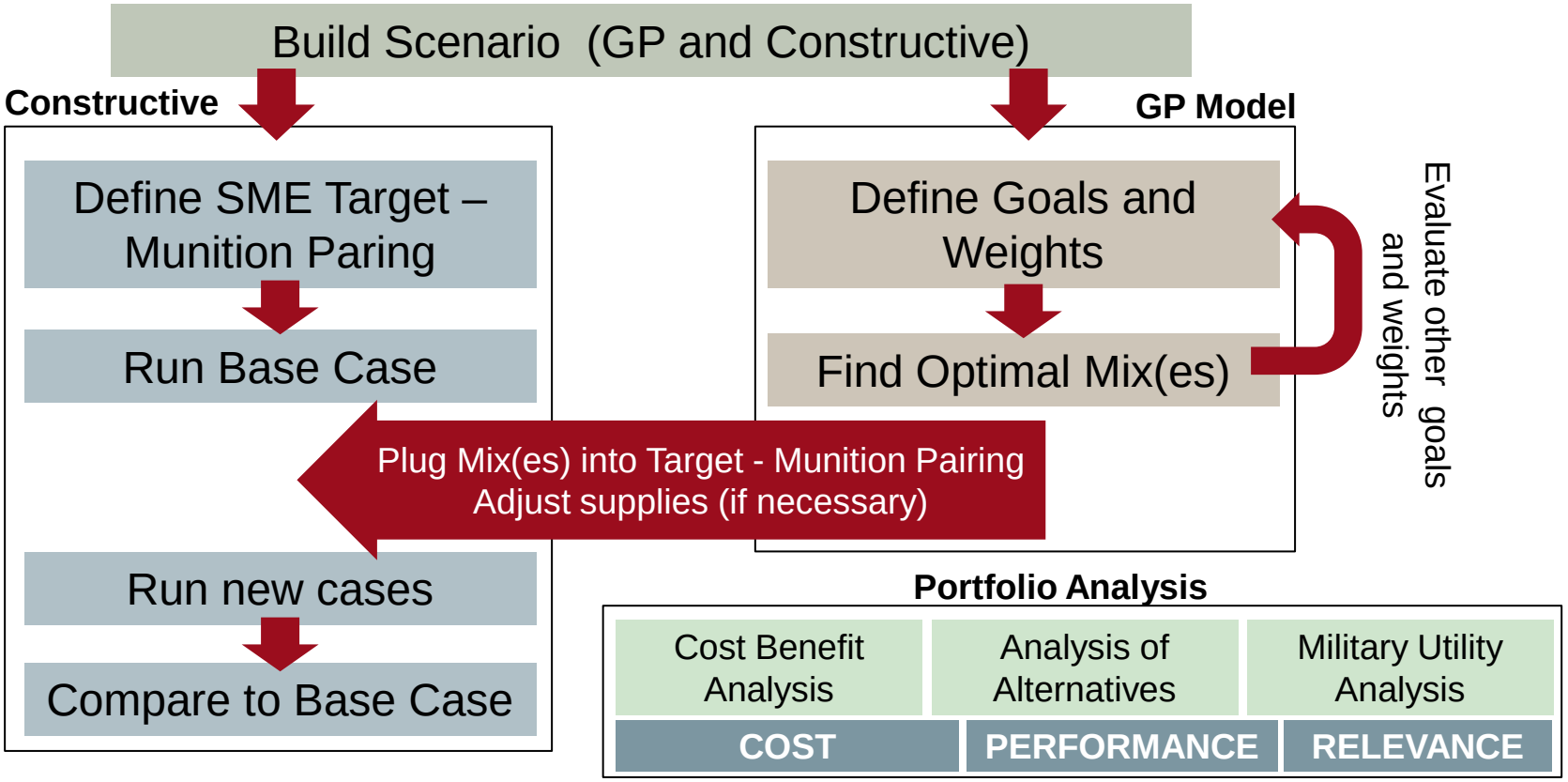
- Constructive Simulations can provide the operational benefits piece that is missing from Goal Programming
  - Quantifies the benefits to the force in a force-on-force scenario
  - Often labor and time intensive to conduct analysis with
- Require a munition – target pairing for the scenario
  - Traditionally provided by SMEs
  - Define ideal munition pairings
  - Simulation adheres to pairing as close as possible while taking all dynamic battlefield states into consideration
    - Availability, organizational hierarchy, range, etc.
- How do we combine this with GP models to produce a portfolio analysis?




**Constructive Simulations can define the operational benefits but traditionally, these model are run separately from GP Models**

# Linking GP Models to Constructive Simulations

- Proposal: GP Models replace the SME provided munition-target pairing
  - Examine the effects of the "optimal" mixes
  - Munition supply loads may also need to be adjusted




**Integrating the GP model with the constructive sim allows for the optimal mixes to be validated in a realistic force-on-force scenario**

# Summary

- Goal Programming models are efficient tools that allow one to quickly identify optimal mixes of munitions
  - Very dependent on valid inputs; scenario, goals, weights, and constraints
  - GP models should be allowed to optimize the mix, without any outside biases added into the analysis
- Constructive Simulations are powerful tools that allow one to quantify the operational benefits of systems to the force
  - Powerful but time and resource intensive for large case matrices
- Combining the two allows for the strengths of each to be applied to the analysis
  - Evaluate the optimal mixes defined by the GP model in the constructive sims
  - Reduces size of constructive simulation case matrix
- Raytheon is exploring this topic further with the Fires Center of Excellence and FireSIM

**A comprehensive portfolio analysis should include integrated results from both goal-programming and force-on-force simulations**

# Questions?

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