Sequential Updating of Decisions and Games/Plans under Uncertainty

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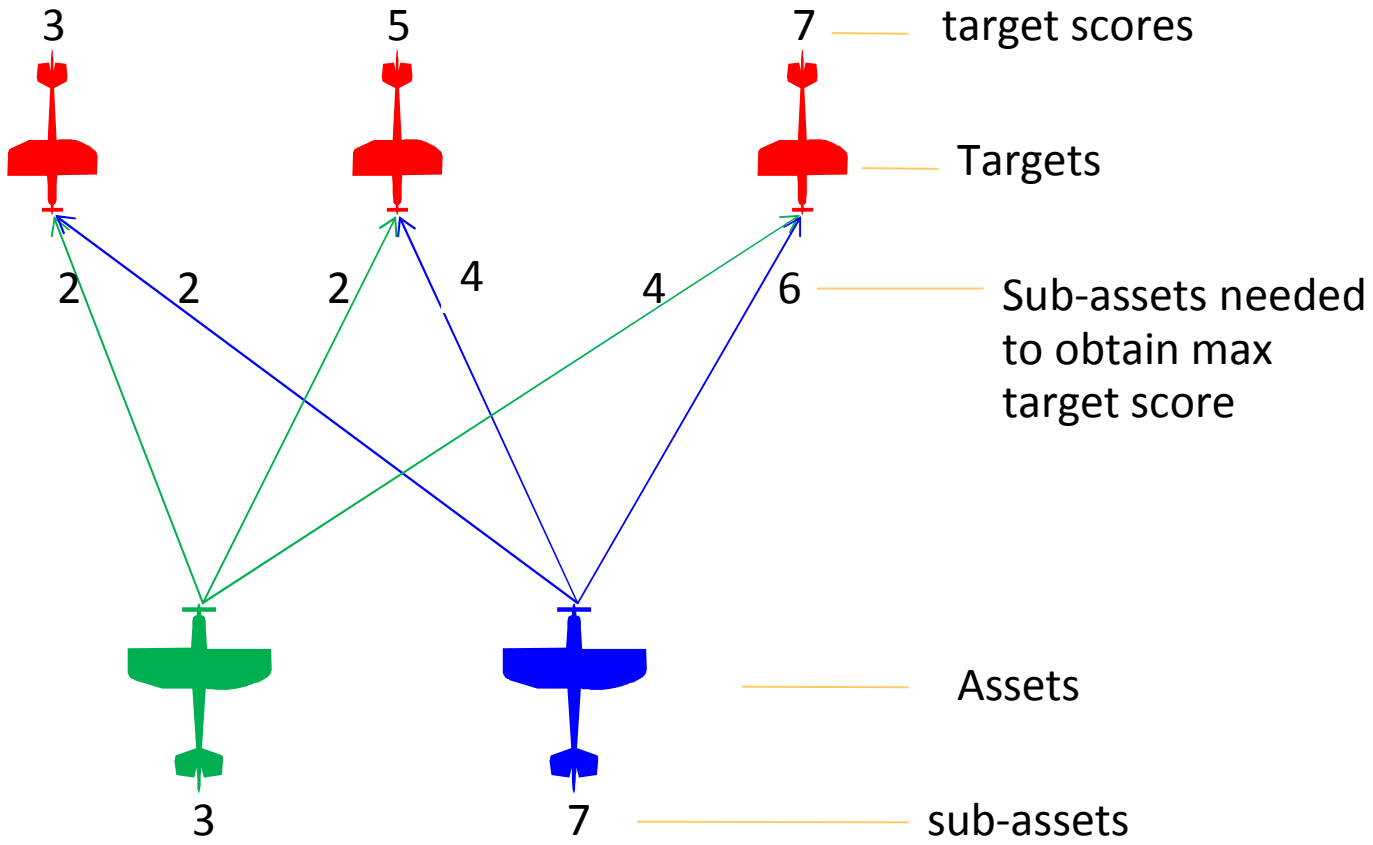
Agenda

- Multiple asset allocation to targets
- Central planning without complete information at the center
- Decisions in a Dynamic Setup

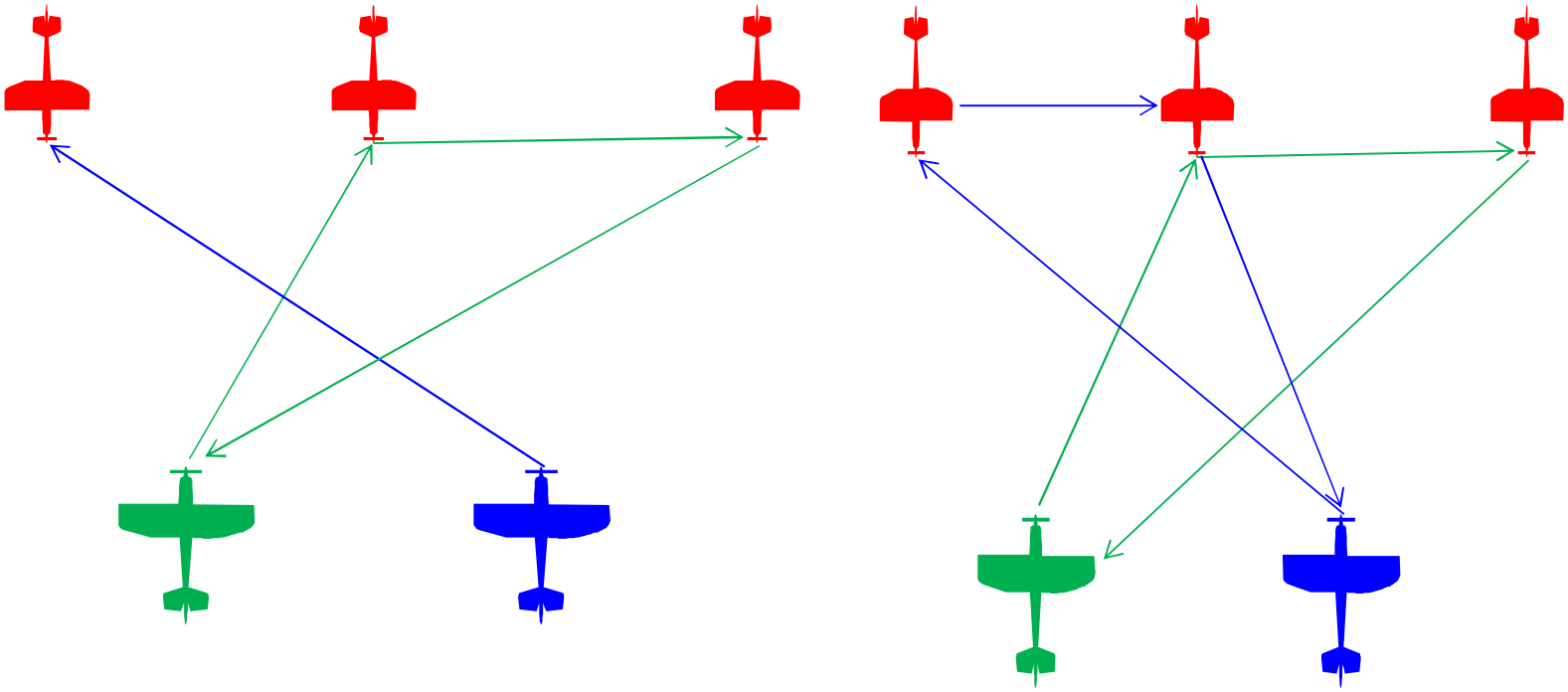
Assignment of multiple assets

- Allow multiple assets to visit targets
- Higher probability of mission success
- Framework : target score and MILP

Assignment/routing example



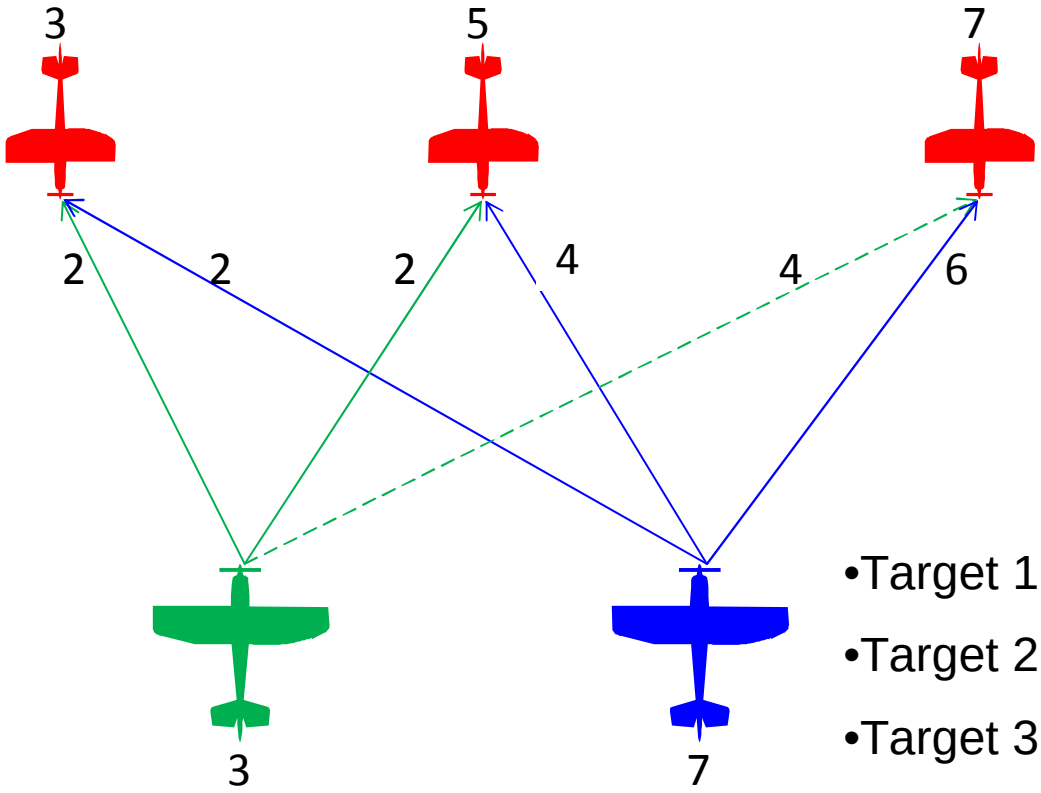
Assignment / routing



Target score maximisation

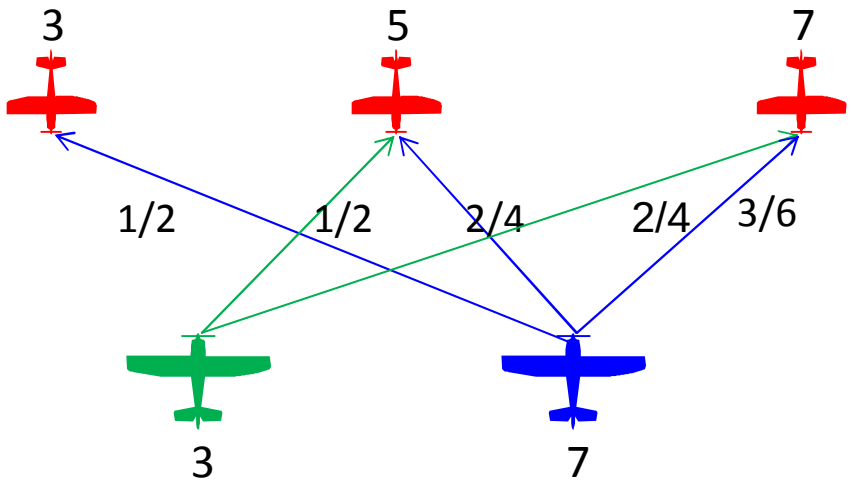
- Objective : sum of target score for each target visited
- Constraints : do not exceed capacity

Assignment/Routing Constraints



- Target 1 reachable by assets 1,2
- Target 2 reachable by assets 1,2
- Target 3 reachable by asset 2
- Maximum score achieved : 12

Allow multiple assets to visit a target

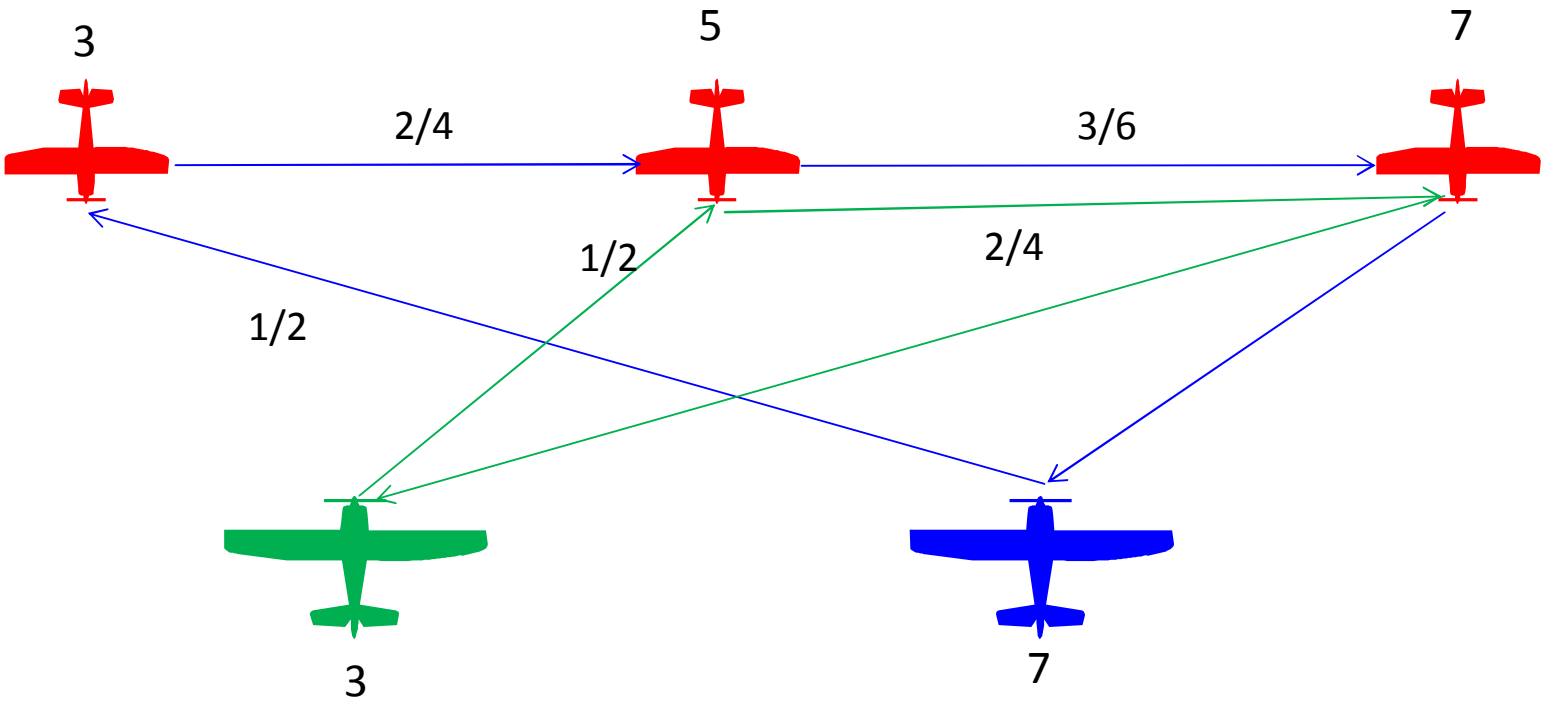


v	t	m_{vt}/tm_{tv}	Completion	Score
1	2	1/2	50%	2.5
1	3	2/4	50%	3.5
2	1	1/2	50%	1.5
2	2	2/4	50%	2.5
2	3	3/6	50%	3.5
			Total Score	15

Vehicle routing

- Assignment decides which vehicle visits which target.
- Routing decides the order with which a vehicle visits a target.

Routing example



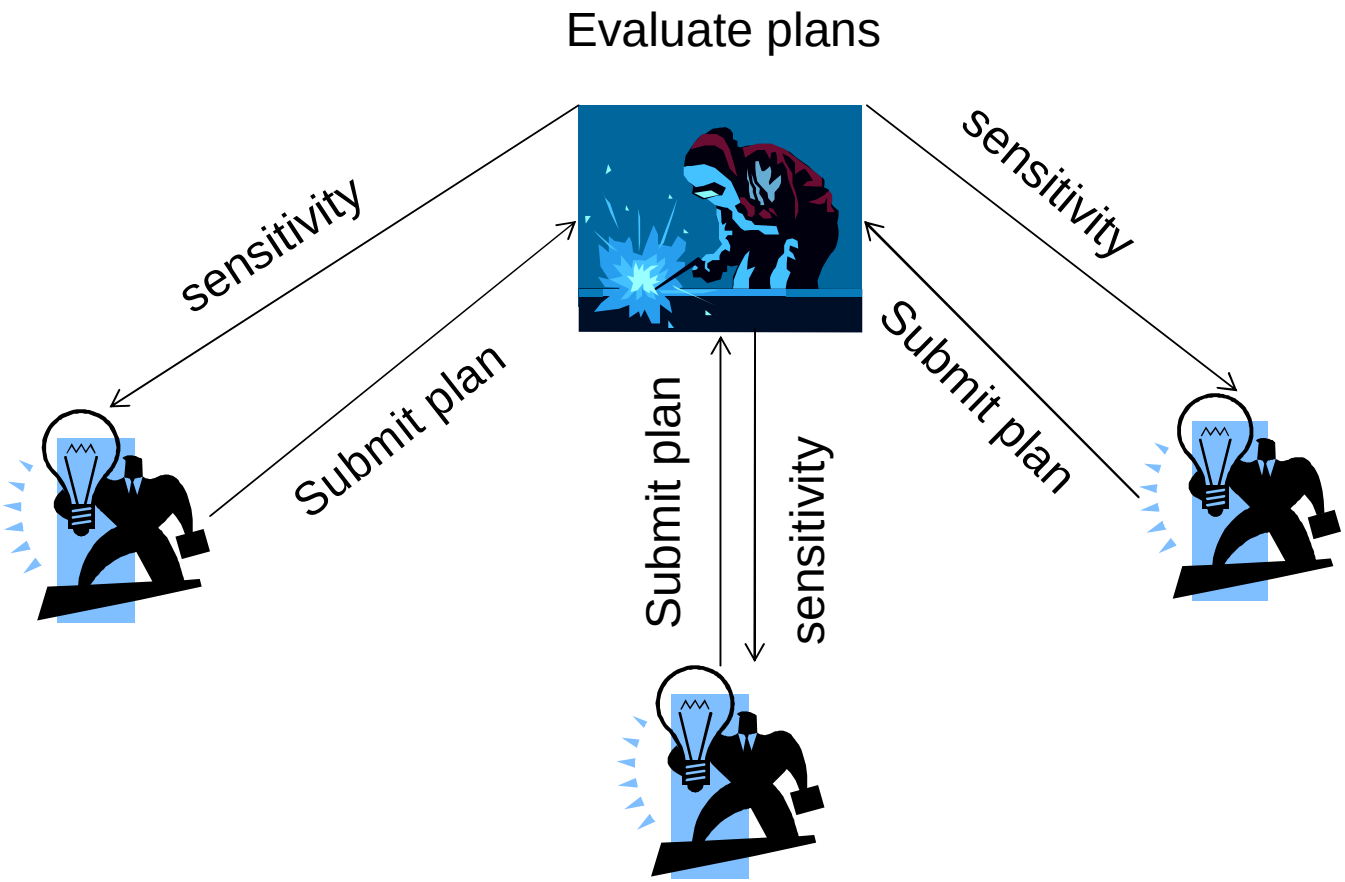
Routing

- Routing demands a larger number of constraints
- Problem is more difficult to solve due to dimensionality
- Problem has an exploitable pattern

Dantzig Wolfe Decomposition

- Parts of the overall problem are independent
- Problem is split into
  - Subproblems : independent part of problem
  - Master problem : ties together subproblems

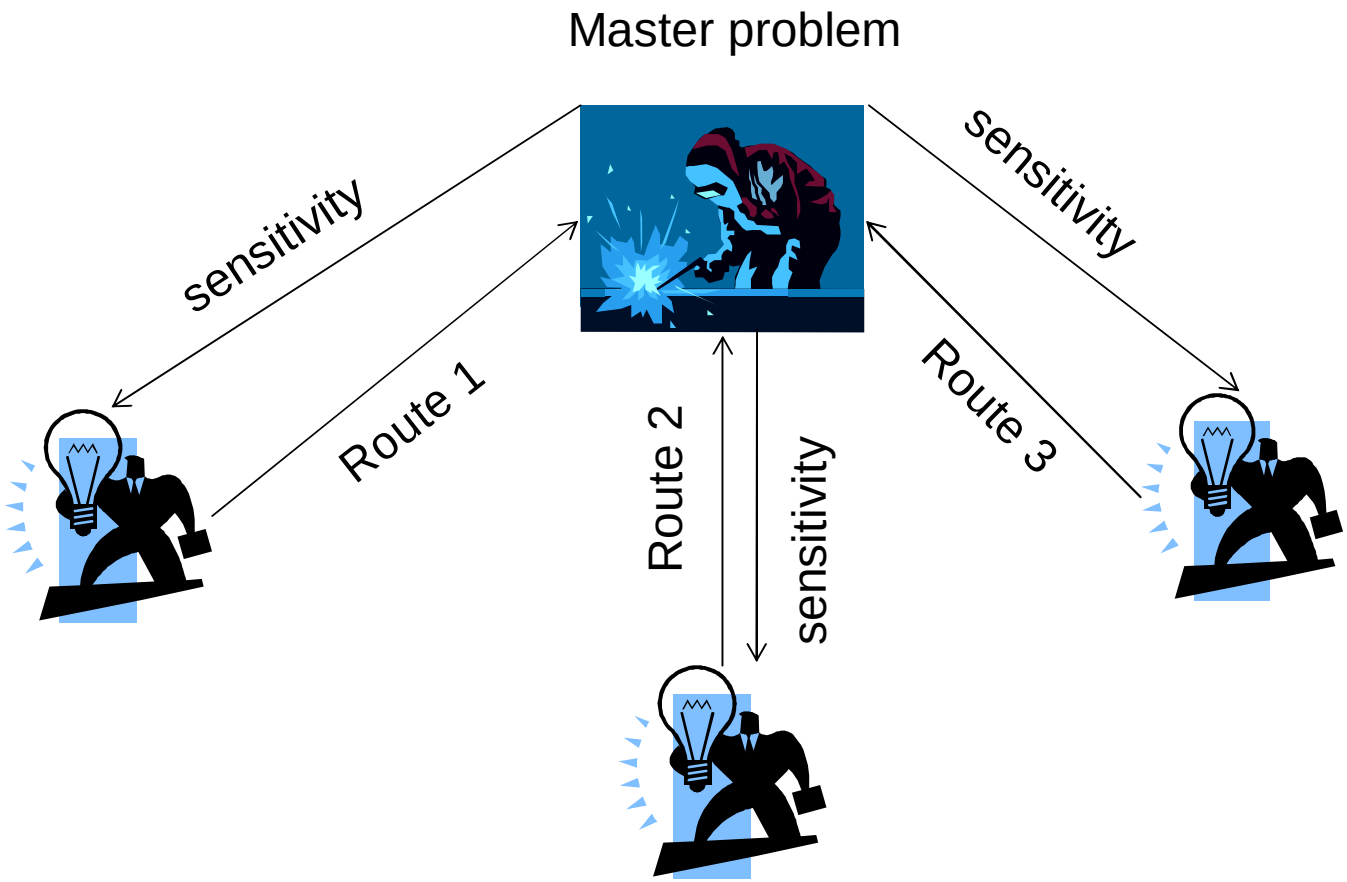
Central Planning without complete information at the center



Dantzig Wolfe Decomposition & Routing

- subproblem : calculate best route for a vehicle. Objective contains sensitivity information from master problem.
- Master problem : decides which routes (subproblem solution) will be used. Also calculates sensitivity information.

Central Planning without complete information at the center



Decomposition Stopping criterion

- Newly generated routes do not contribute to optimality.

Independence of subproblems

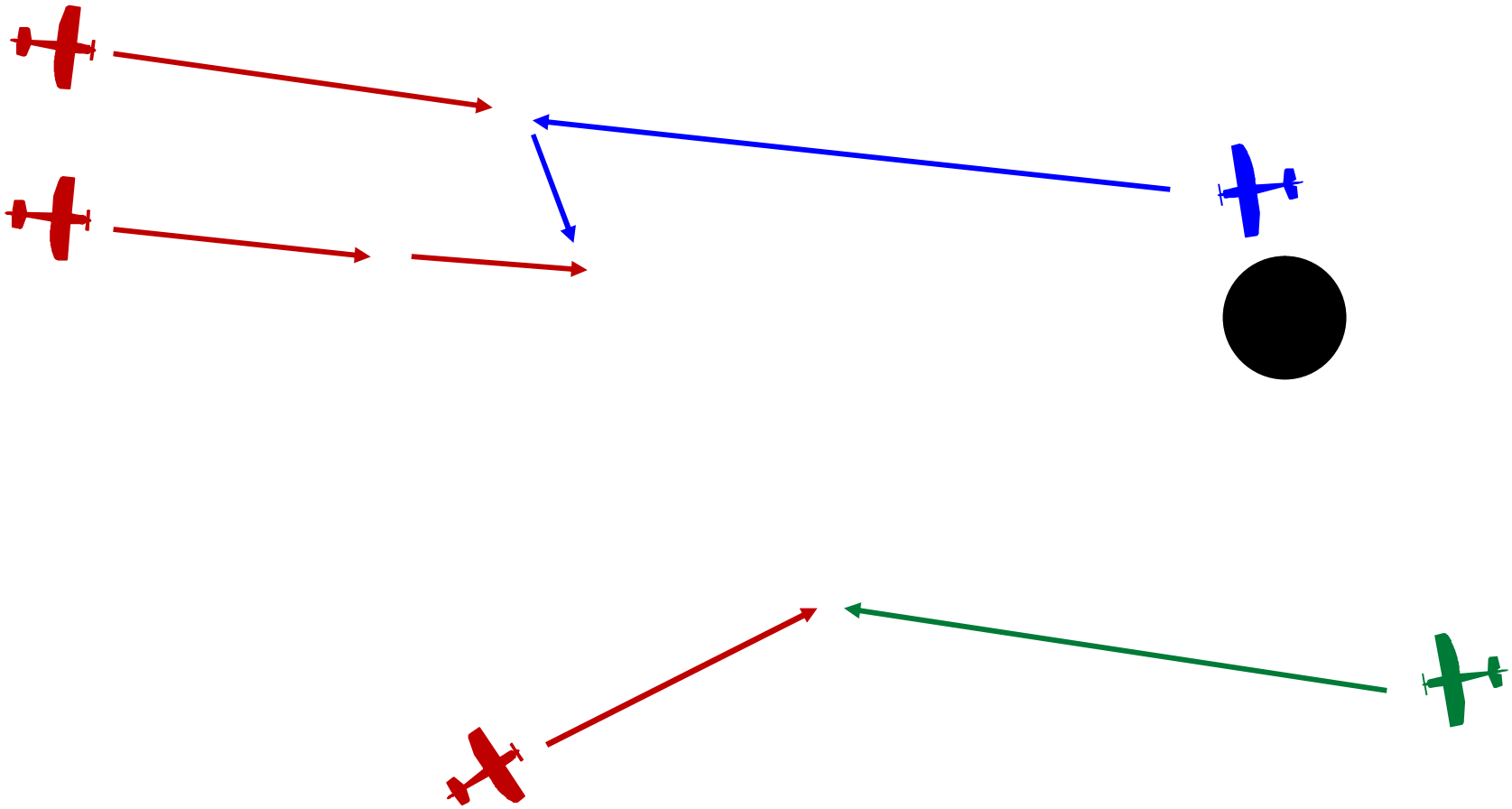
- Block Angular Form
- L_i, A_i, b_i, c_i refer to vehicle i (i=1,2,3)

C_1	C_2	C_3	
L_1	L_2	L_3	b_0
A_1			b_1
	A_2		b_2
		A_3	b_3

Decisions in a Dynamic Setup

- Updating Decisions for Setup Changes (Repair)
- Anticipating Opponent's Strategy (Games)

Updating Decisions for Setup Changes (Repair)



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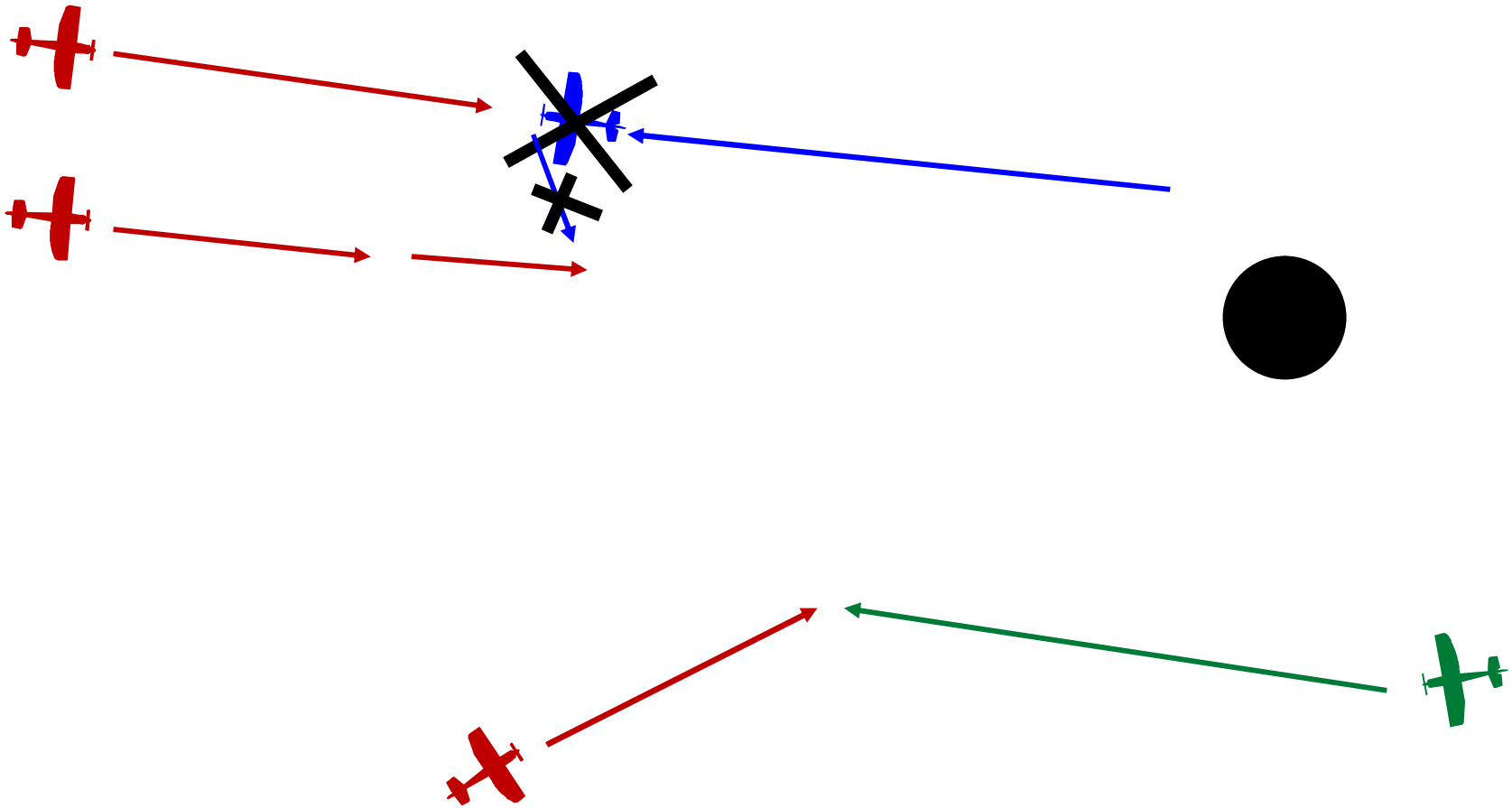

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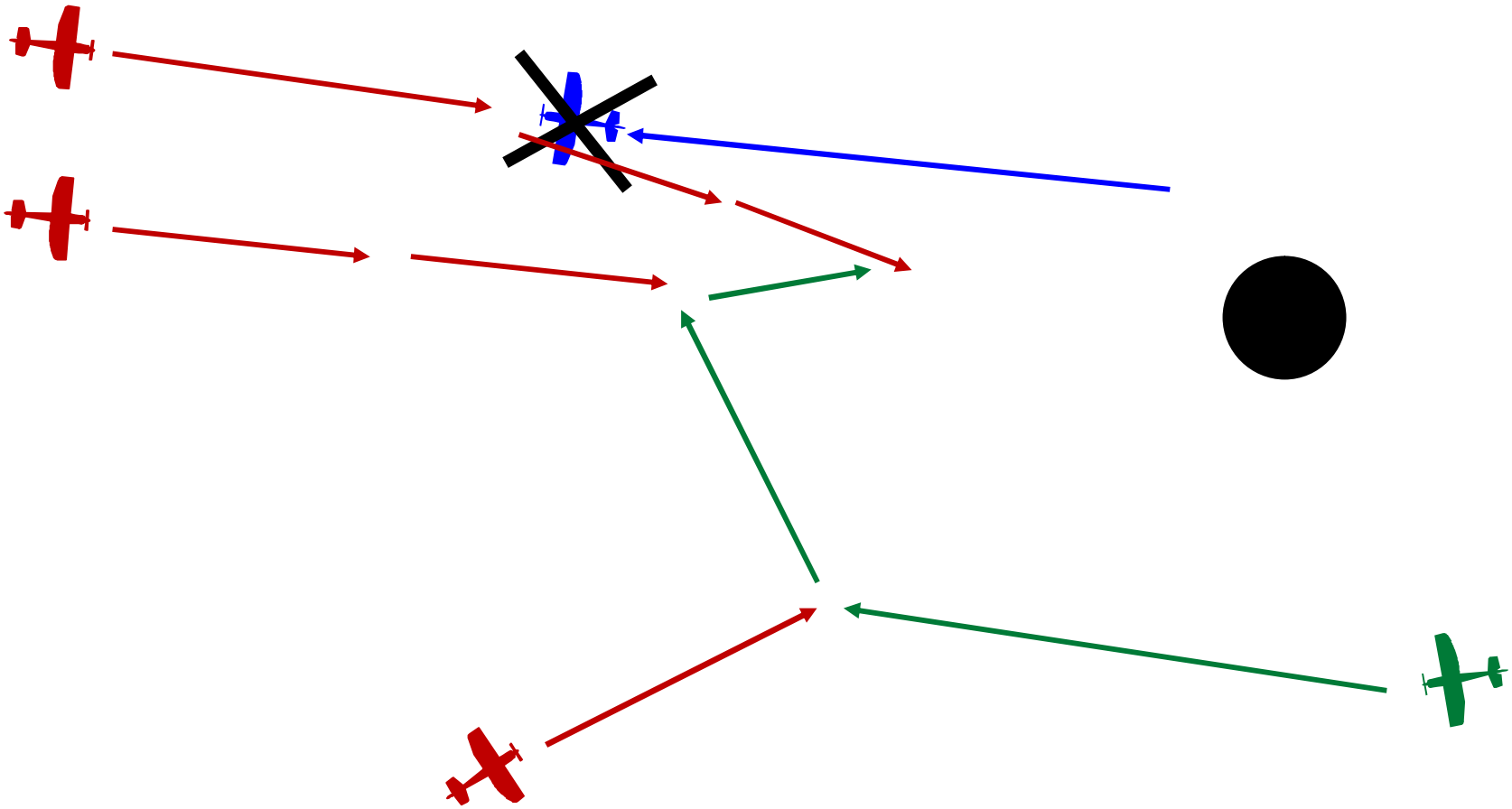
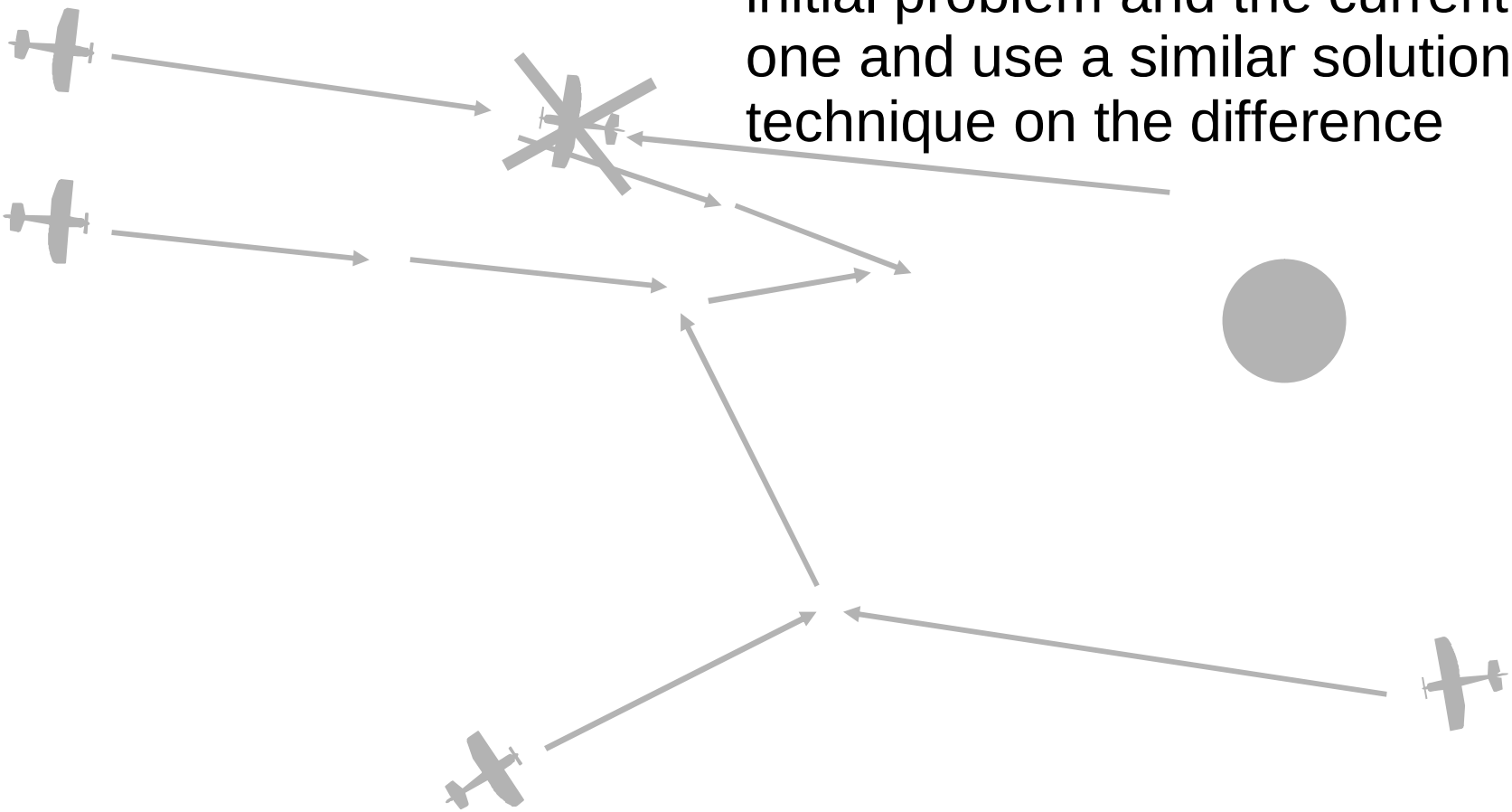


Updating Decisions for Setup Changes (Repair)

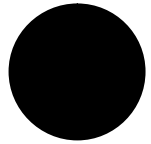
Solution method:
Find the difference between the initial problem and the current one and use a similar solution technique on the difference



Anticipating Opponent's Strategy (Games)

Opponent

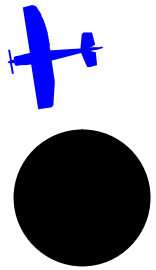
Asset



Defended Area

Asset

Anticipating Opponent's Strategy (Games)



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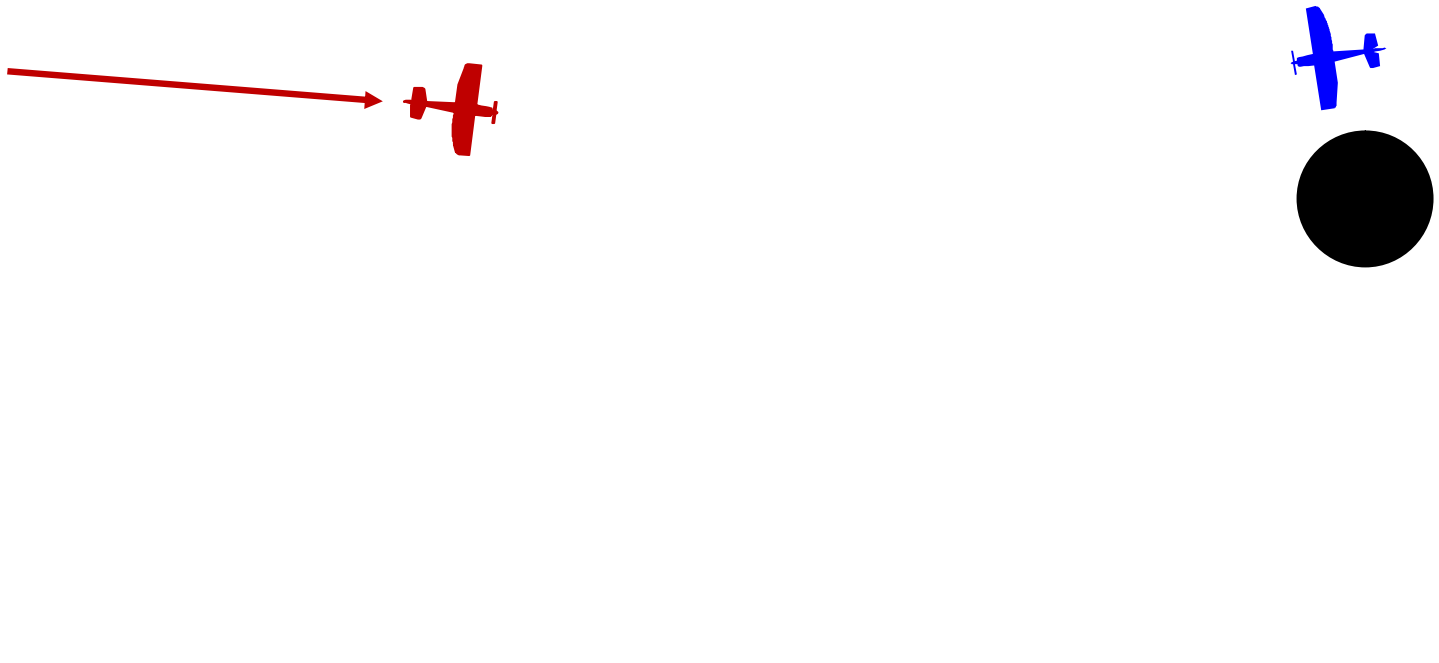

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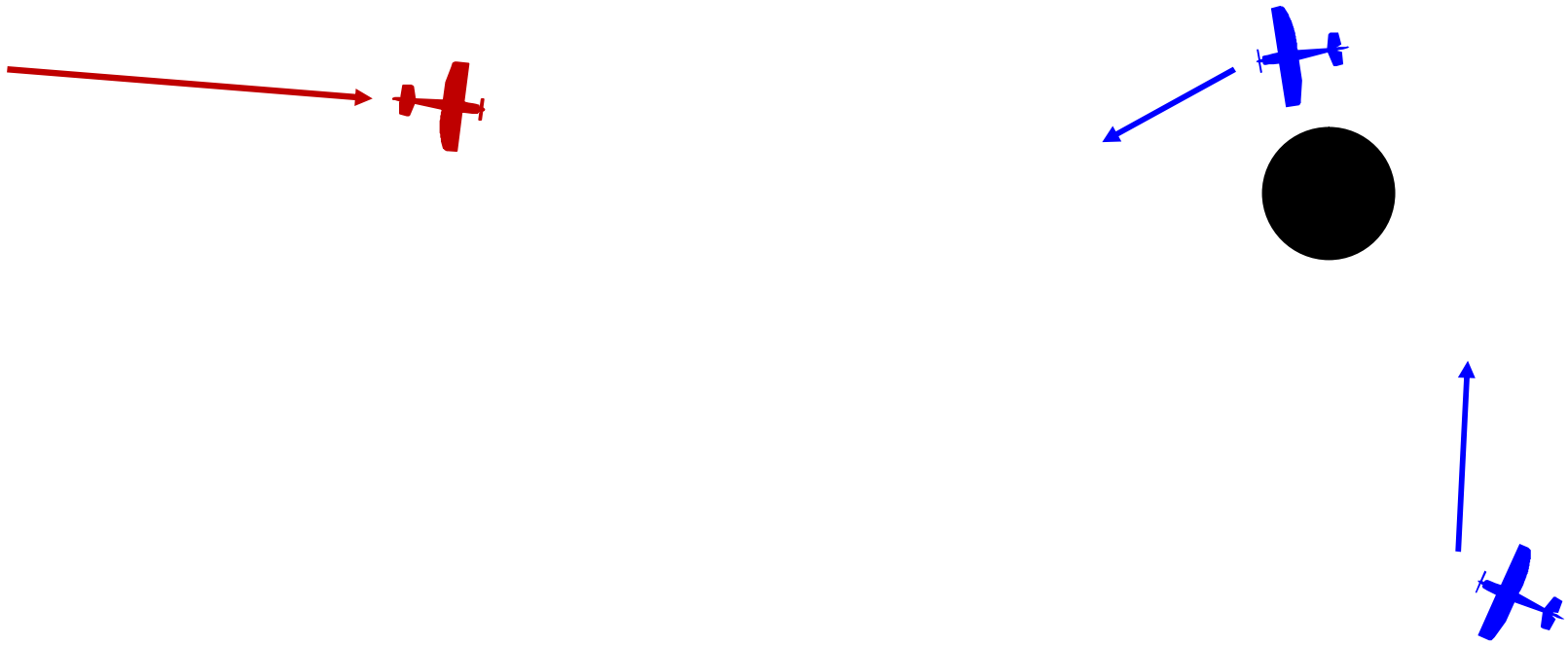

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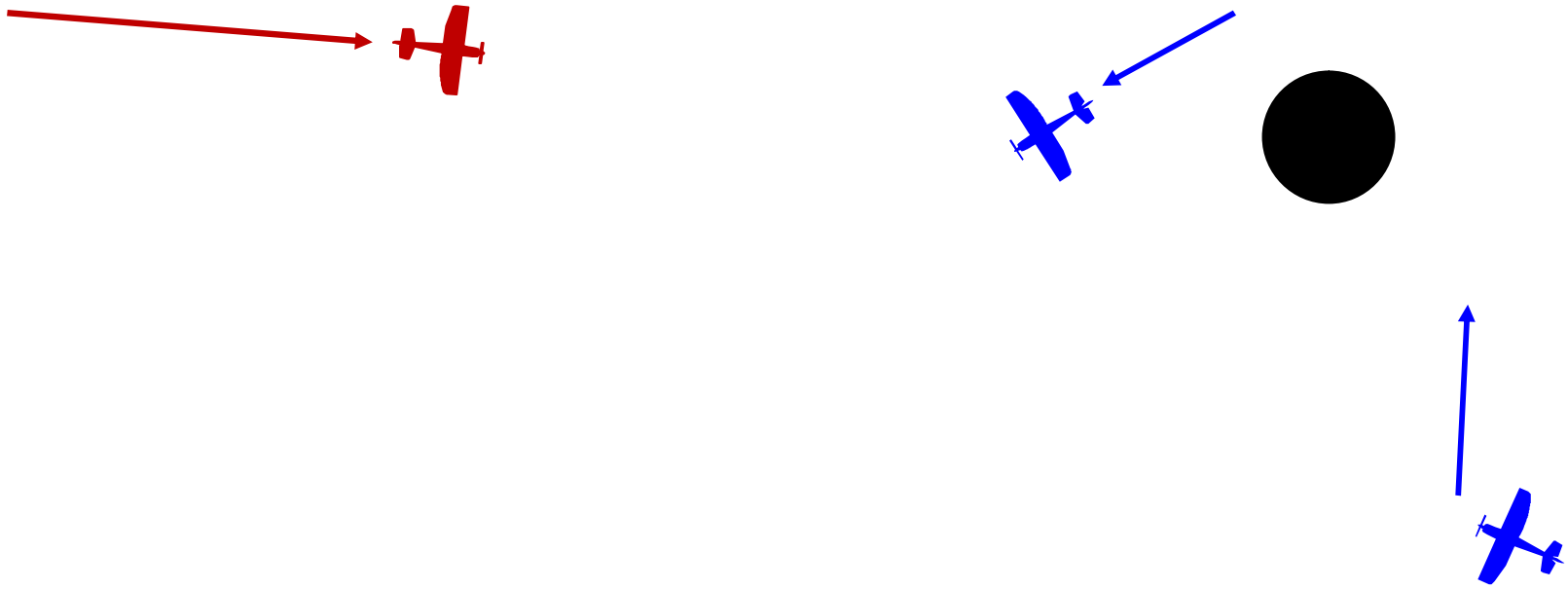

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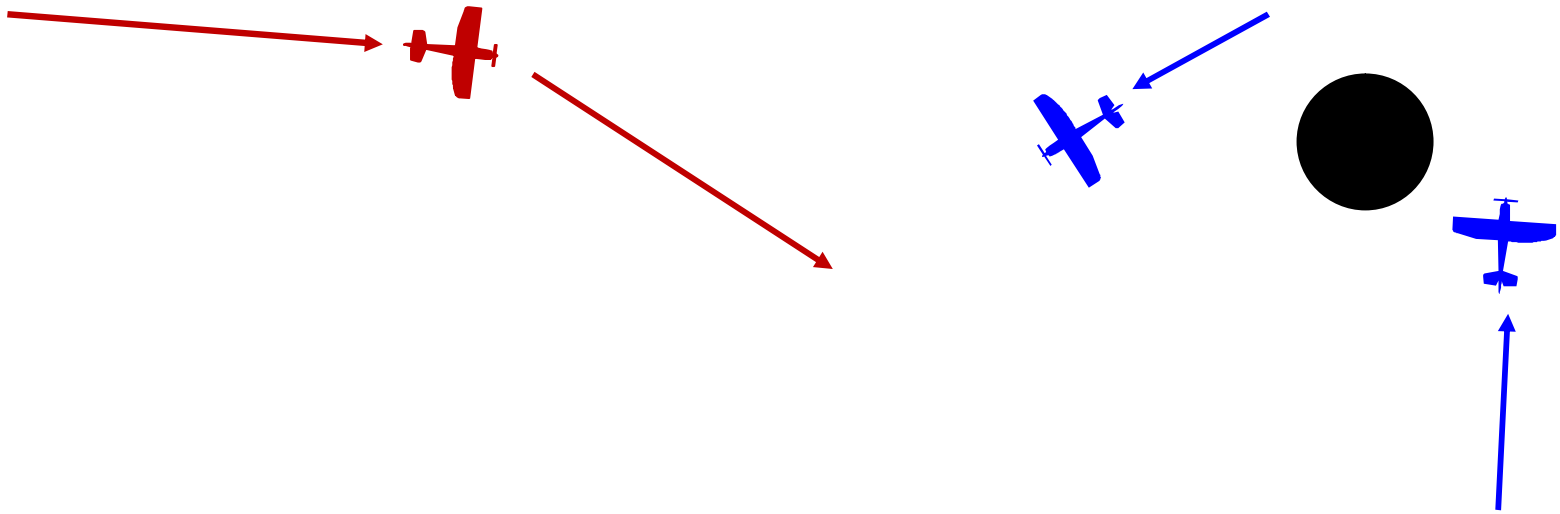

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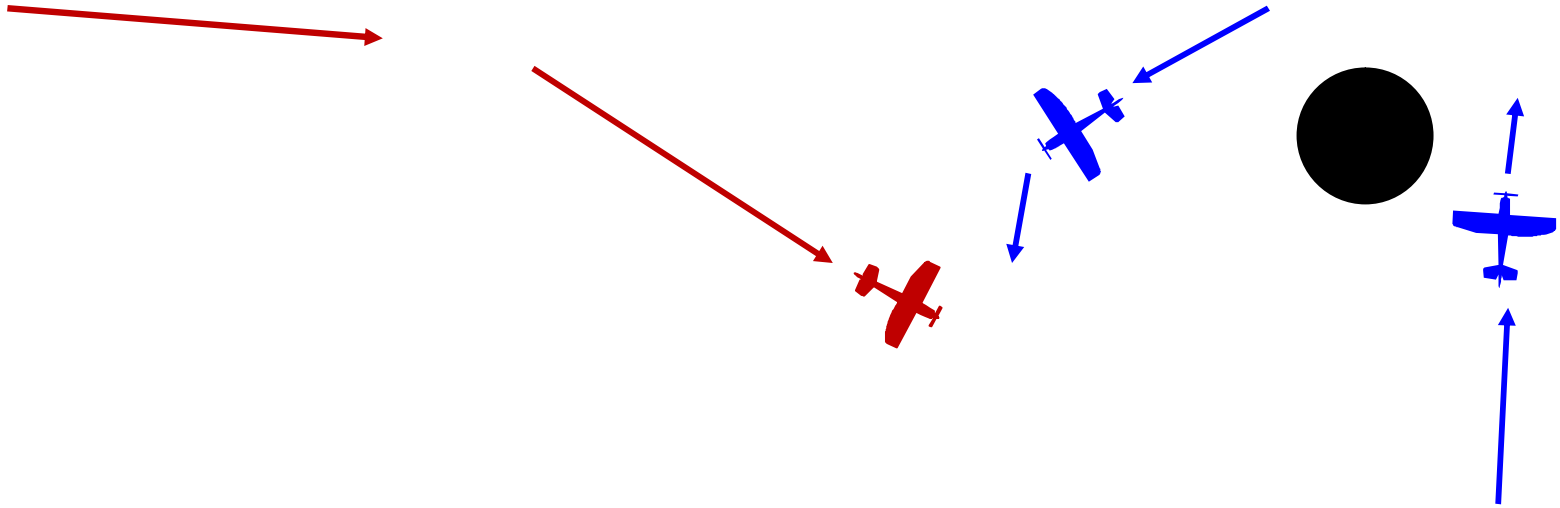

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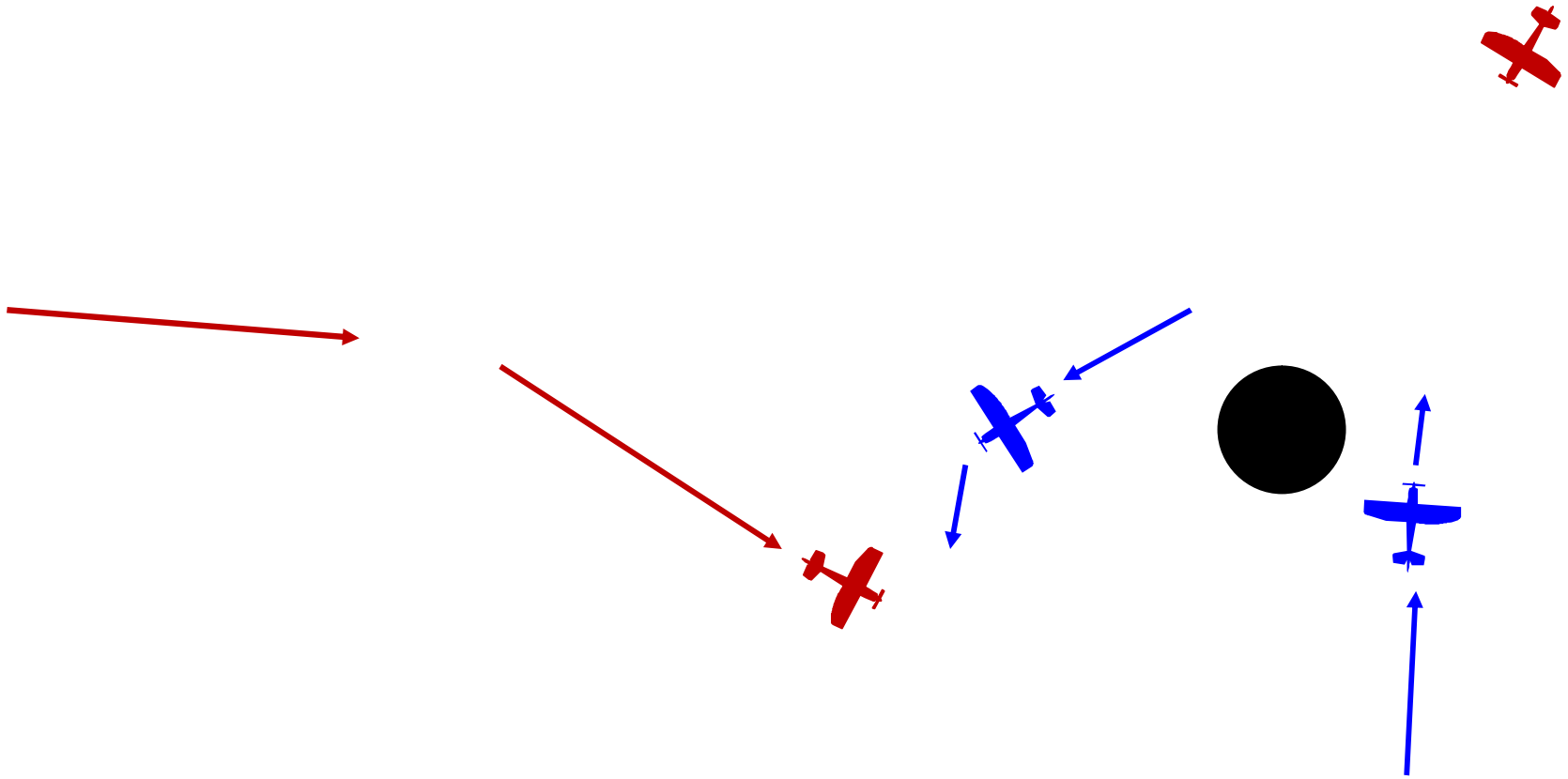

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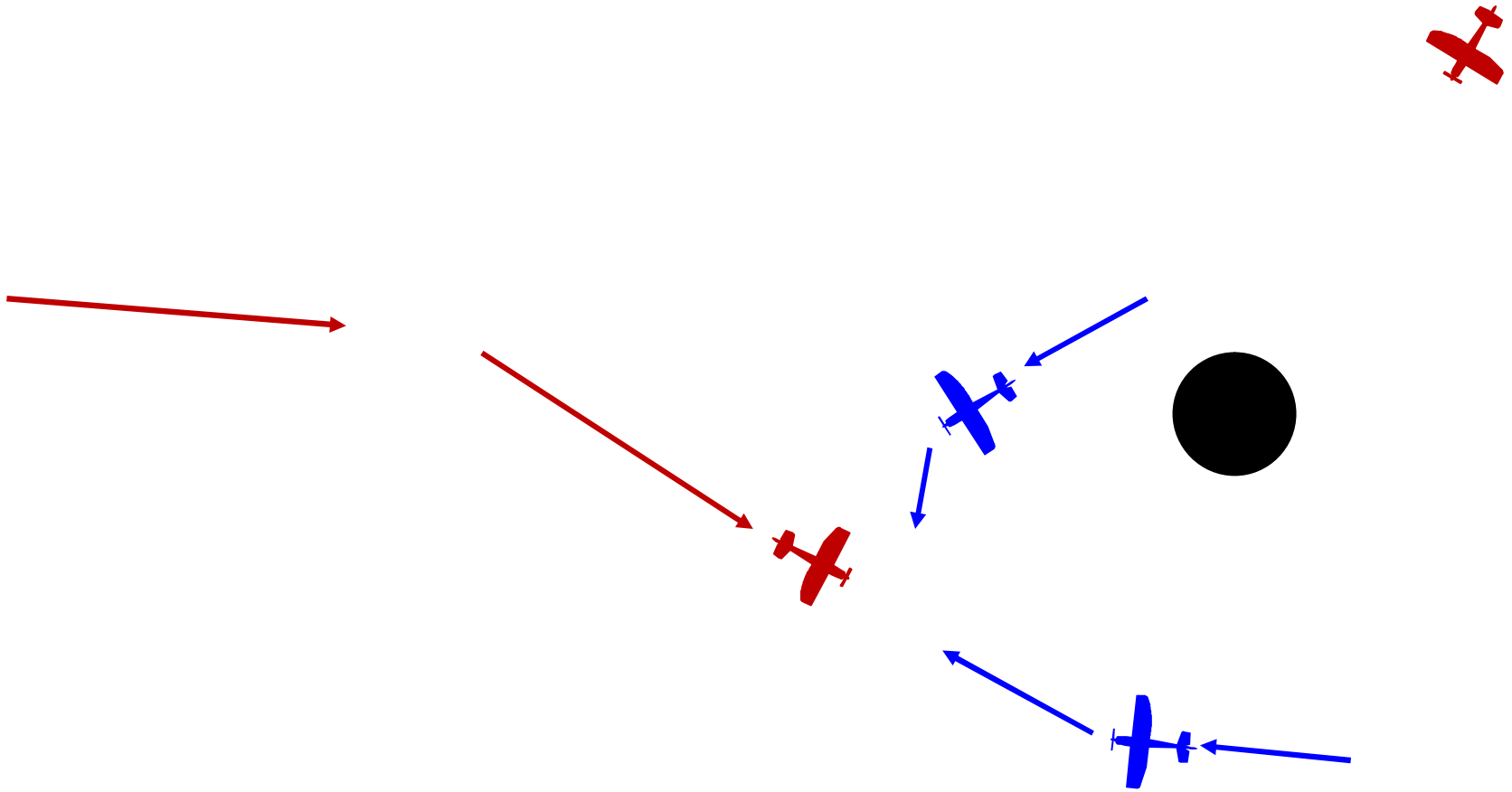
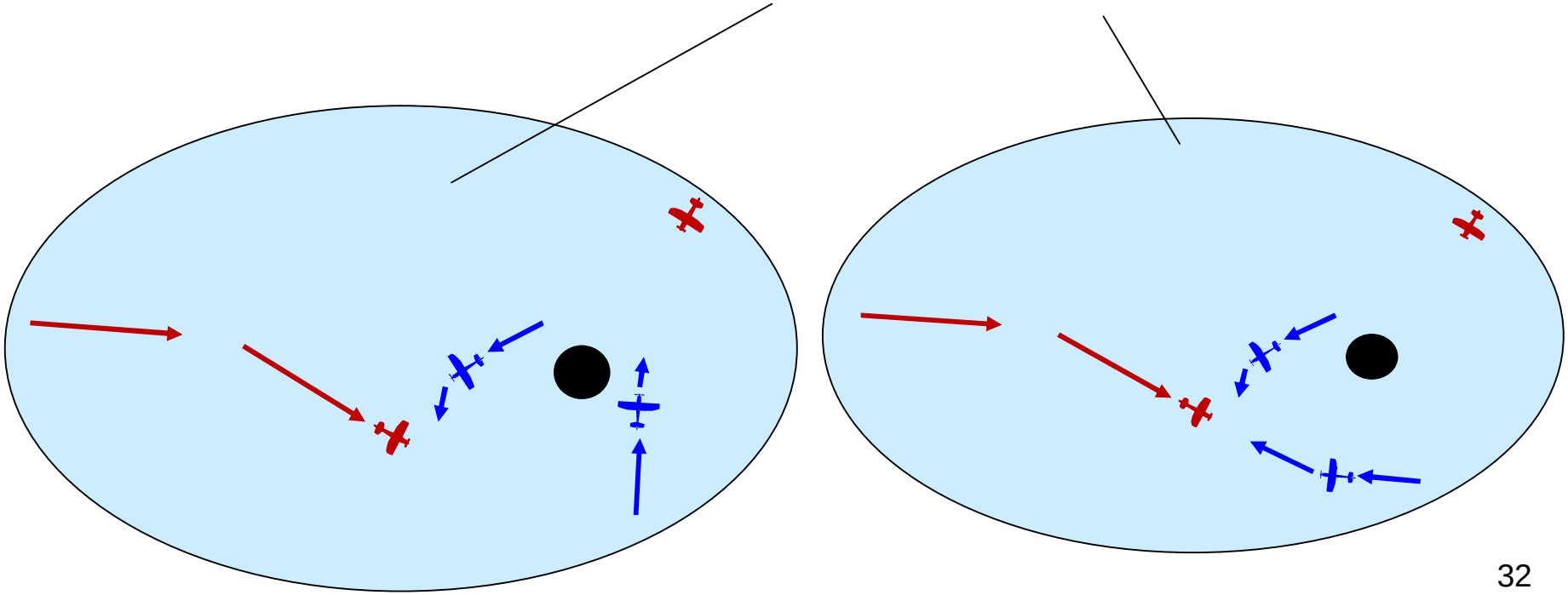


Anticipating Opponent's Strategy (Games)

Choose the Best Strategy amongst
All Possible Strategies



Dynamic Decisions

		Strategy: Static	Strategy: Dynamic
Setup	Static	Integrated	Games
	Dynamic	Repair	Repair of Games

Re-optimisation and Repair

- Respond to dynamic changes to the environment
  - Vehicle malfunction
  - New observation, better knowledge of the opponent
  - …

Re-optimisation and repair techniques

- Sensitivity analysis
- Robust Linear Programming (not analyzed)
- Warm starts
- Constraint Programming

Summary

- Integrated Task Assignment & Routing
  - Multi Asset Assignment
  - Routing Calculus
- Decisions in a Dynamic Setup
  - Anticipating Opponent's Strategy (Games)
  - Updating Decisions for Setup Changes (Repair)
  - Sensitivity Analysis
  - Warm Starts