GEO Patrol Rule Book

Current as of April 2024

Introduction

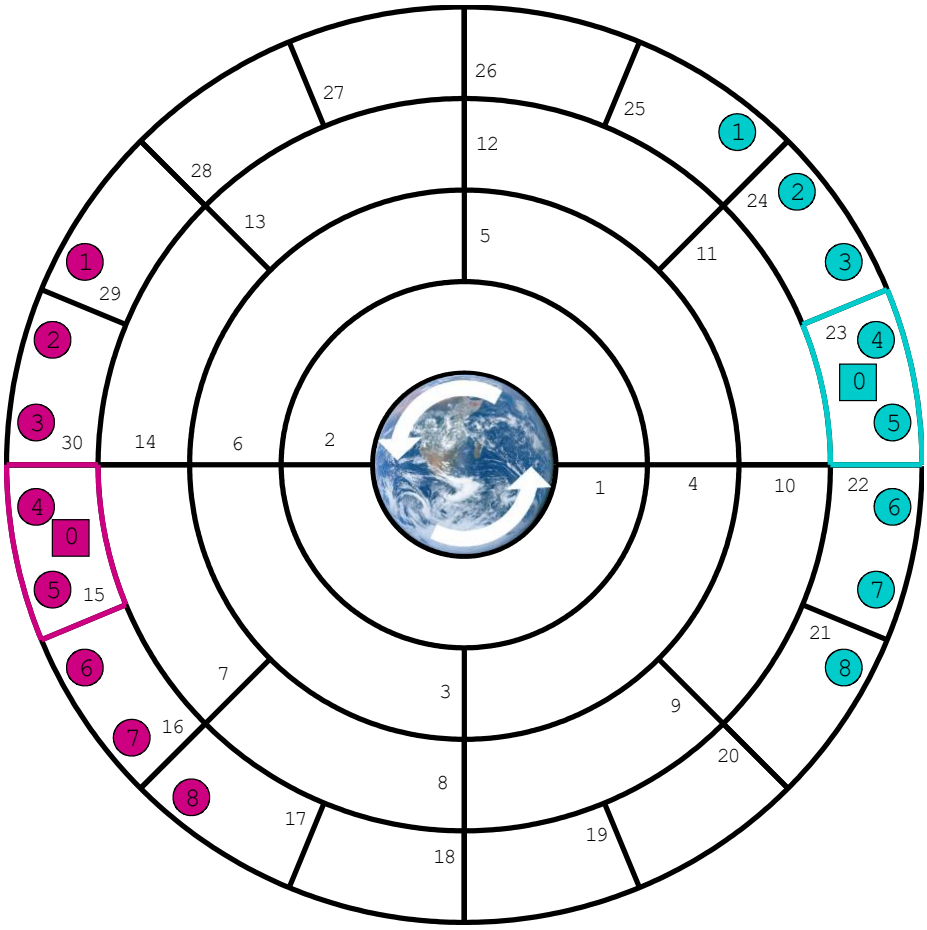
GEO Patrol is a two-dimensional board-game-style game for modeling non-cooperative satellite interactions. The game is based on the Orbit Defender-2D environment developed by the Massachusetts Institute of Technology Lincoln Laboratory (MITLL). The original environment code can be found on GitHub here: https://github.com/mit-ll/spacegym-od2d

This game models two opposing sides. Each has a valuable but unarmed geo-satellite (High Value Asset - HVA) that needs to complete its mission for Earth. There are also a number of smaller Patrol satellites that can be used to attack the opposing HVA and defend their own HVA.

Setup & Objective

Board Setup

The board's four concentric circles represent four different orbital altitudes. To represent the longer time it takes to complete one revolution in an orbit farther from the Earth, the higher orbits have more sectors, and the lower orbits have fewer sectors. All sectors are numbered to distinguish satellite locations. A rendering of the board is shown below



Tokens

The pink satellites (Bravo player) represent a fleet of satellites, and the blue satellites represent the opposing fleet (Alpha player). The larger, square satellites represent each player's "High Value Asset-HVA" (labeled satellite 0), and the ten smaller ones represent the "Patrol" satellites (labeled satellites 1-10). Each HVA and two of the player's Patrol satellites lie within a highlighted sector at the beginning of the game. This highlighted sector we will refer to as the goal sector.

Objective

Your goal is to end the game with more points than your opponent. You can gain points by keeping your HVA in the goal sector (goal sector points, 10/turn) or an adjacent sector (adjacent goal sector points, 3/turn). At the same time, use your Patrol satellites to attack and destroy the opponent's satellites while defending your own HVA and avoid running out of fuel. The goal sector points are cumulative, add will add to your total points until one side reaches the win score or loses its HVA.

Conserving fuel is rewarded by fuel points, which are recalculated at the start of each turn based on the sum of remaining fuel in all your satellites times a weighting factor for patrollers and a different weighting factor for the HVA. Fuel decreases as the game progresses and the satellites use up their fuel, so make sure that as you use up your fuel your HVA is still scoring goal sector points.

The game ends when the max score is reached (350 points), when either side's HVA runs out of fuel, or when the turn limit is reached (50 turns).

Game Play

Each turn consists of three phases: **Movement**, **Engagement**, and **Drift**. GEO Patrol is a simultaneous move game; that is, both players select their moves for a given turn phase independently, and then the game engine executes the moves for the phase and advances gameplay to the next phase. All moves entered are irreversible.

The three phases are explained more in detail below.

Movement Phase

In the movement phase, you can choose to individually move each satellite, including the HVA. You may also choose to keep a satellite where it is. Note that it is beneficial to keep your HVA in the goal sector; see *Scoring* for details.

The five different actions you can take are **No-Op, Radial In, Radial Out, Prograde,** and **Retrograde.**

- **No-Op (NOOP) –** Short for No Operation. This keeps the satellite where it is.
- **Radial In –** Move the satellite into a lower orbit, i.e. the next ring of sectors that is closer to the Earth.
- **Radial Out –** Move the satellite into a higher orbit, i.e. the next ring of sectors that is farther from the Earth. Note that the satellite will always move to the outer sector with the lower number (the retrograde sector).
- **Prograde –** Move the satellite into the next sector in the same orbit, counterclockwise (up one number).

- **Retrograde** – Move the satellite into the previous sector in the same orbit, clockwise (down one number).

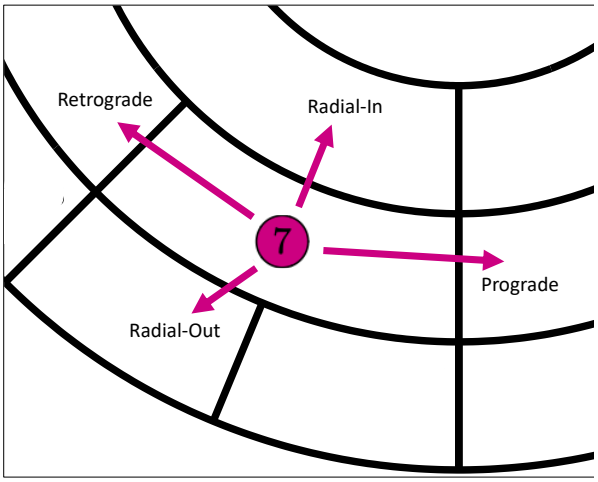
The following table shows fuel costs associated with different movement actions.

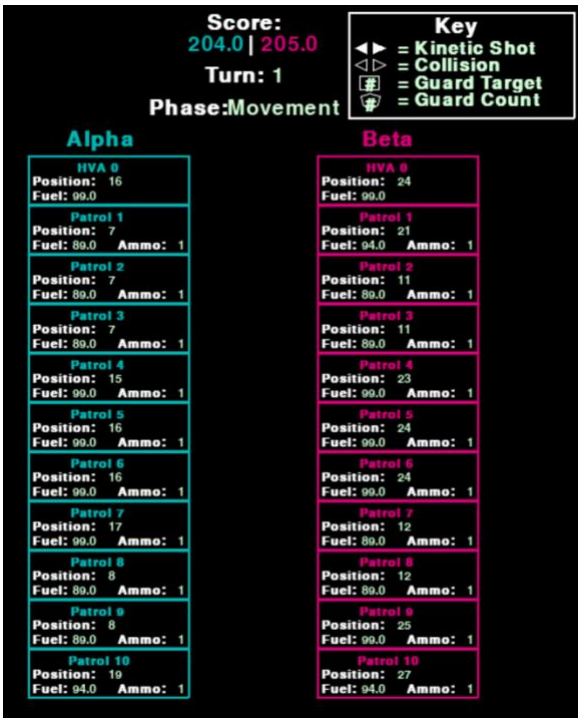
Movement Phase Fuel Costs	
No-Op	0
Radial In	10
Radial Out	10
Prograde	5
Retrograde	5

```
Turnphase: movement
Token: alpha:HVA:0
Select an action from the list
0 - NOOP
 1 - Prograde
 2 - Retrograde
 3 - Radial In
 4 - Radial Out
Select action: 0
```

The figure to the left shows what your terminal will look like when you start the game and enter the first movement phase. The "Token" line shows you which satellite you are selecting a movement for. The HVA is zero, and the Patrol satellites are numbers one through ten. To select an action, type the corresponding number and press enter. The game will automatically send you to the movement selection for the next satellite. Continue until you have selected a movement for all of your satellites.

There are two tables on the side of the board that tell you the current position of each satellite, along with its fuel and ammo status.





Engagement Phase

In the engagement phase, which occurs after both players have completed their movement phase, you can act against your opponent. These actions can only be completed if you are in the same or an adjacent sector as one of your opponent's satellites. Actions directed diagonally are illegal.

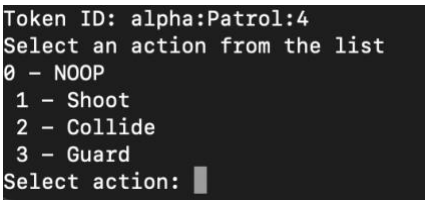
The three actions you can complete are **Guard, Shoot,** and **Collide**. The success of these actions depends on the probabilities shown in the tables on the next page. **Guard** – This action allows a Patrol satellite to protect its HVA from adversary fire. If the opposing side successfully shoots at a HVA the Patrol satellite guarding the HVA is destroyed instead of the HVA. Guarding takes fuel even if the target satellite is not attacked. Guarding, may or may not be successful (see table or probabilities). Even if a guard it is unsuccessful, guarding moves your Patrol satellite into the guarded sector.

- **Guard** – If multiple shots are taken at a guarded HVA, the probability that the guard is successful is changed by $(probability\ of\ guard) * 0.5^{n-1}$, where n is the number of shots taken at the HVA. In essence, the more times the HVA is shot at, the less likely the guard will be successful.
- **Shoot –** Use a satellite's ammo against an opposing satellite. If successful, the opponent satellite will be shot down, and your satellite will survive this engagement. Regardless of the outcome, your satellite will lose one unit of ammunition and the fuel cost of shooting.
- **Collide –** Collide with a satellite. If successful, both your satellite and the adversary satellite will be destroyed. If the target satellite is in an adjacent sector, Collide moves the attacking satellite to the sector of the target satellite.

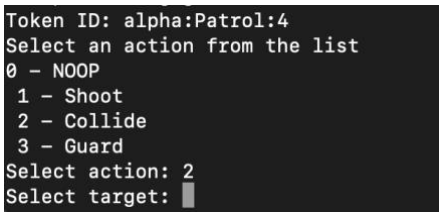
The game processes the engagement outcomes in the following order **Guard -> Shoot -> Collide**. For example, a successful shot can destroy a satellite before it has a chance to try to collide with the shooter. The following tables show the fuel costs associated with different engagement actions for the same and adjacent sectors, and the probability of success of these actions, respectively.

Fuel Costs for Actions WITHIN a Sector		**Fuel Costs for Actions against an ADJACENT Sector**	
Shoot	5	Shoot	7
Collide	20	Collide	30
Guard	5	Guard	10

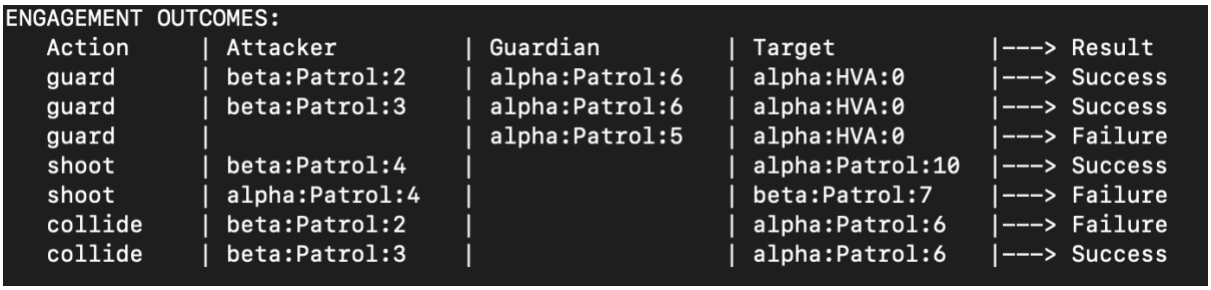
Probability of Success for Actions WITHIN a Sector		**Probability of Success for Actions against an ADJACENT Sector**	
No-op	1.0	No-op	1.0
Shoot	0.8	Shoot	0.4
Collide	0.8	Collide	0.4
Guard	0.8	Guard	0.4



The image on the left shows what your terminal will look like when you start the game and enter the first engagement phase. To select an action, type the corresponding number and press enter. If you select NOOP, the game will automatically send you to the next engagement selection.



For each action, the screen will look the same. For shoot or collide, enter the number of the opposing satellite you want to attack. Press enter to save your choice, and repeat for all satellites that have valid moves.



The picture above shows the engagement outcomes after both players have completed the engagement phase. As stated before, guard outcomes are determined before the shoot outcomes, and shoot is determined before collide. For guard, if it is successful, the guardian becomes the target and the HVA will not be hit.

Drift Phase

In the drift phase, which happens immediately after the engagement phase has been completed, the earth spins and every satellite on the board shifts one sector counterclockwise. **Each active satellite loses 1 fuel every drift phase.** This is to simulate normal operations and station-keeping fuel costs. This means that the two goal-sectors for each player will always be directly across the board from one another, and satellites in different orbits will move different amounts due to varying sector size.

Scoring

Points are added to the total score for each player at the end of every turn.

The HVA starts the game in its goal sector, and it is to your benefit to keep it there for as much of the game as possible. The HVA models a geo-satellite that must maintain a specific longitude (the longitude of the goal sector) to perform its mission.

You will receive **ten points** at the end of your turn if the HVA is still in its goal sector. If you have moved your HVA, but it is in an adjacent sector to the goal sector, you will receive **three points**. If the HVA is in any other sector, you receive no points. The only way you can score points during the game is through the HVA's position.

The initial score is 200 points. Each satellite starts with a fuel level of 100. The total fuel of the Patrol satellites, 100, is divided by how many Patrol satellites there are, 10; these sum to 100 points. This is then added to the total fuel from the HVA, which is also 100 points. (100+100=200) After each turn, the score is recalculated by the new fuel sum from the 11 satellites. When a satellite dies, its fuel is automatically decreased to 0.

Each satellite will lose one fuel per turn regardless of which movements or actions that satellite completes.

To win the game, you must have a total score of 250 points.

Winning the Game

The game ends when one player's HVA is destroyed or when an HVA completes its mission (it attains the high score of 350 points). Alternatively, it can also end when the turn limit (50) is reached. There is a draw if both players have the same number of points when fuel runs out or when both players reach 250 points at the same time.

Strategy

Plan Ahead

The satellites will always drift one sector counterclockwise before the end of every turn (after the movement and engagement phases). Consider where you will drift ahead of time and where you want your satellites to end up.

Weigh Costs and Benefits

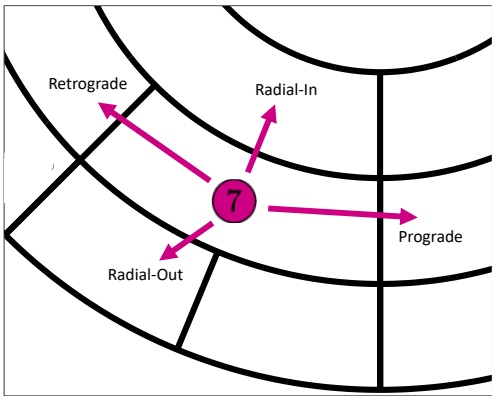
Satellites can be moved radially inward or outward. Though it costs fuel to move inward, the periods of orbits closer to Earth are much smaller. Therefore, it will take you less turns to move around the board.

Protect Your HVA

The HVA is your main asset; losing your HVA terminates the game. Avoid moving your HVA from the goal sector unless necessary to keep from being destroyed.

Quick Reference

Important Terms



- **HVA –** High Value Asset. The large square satellite in the goal sector for each player. HVA is representative of a geo-satellite that must carry out a mission. The goal is to protect your own and destroy your opponent's.
- **Patrol–** The small satellites that can be used to defend your own HVA and attack your opponent's Patrol satellites and HVA.

Movement Phase

- **No-Op (NOOP) –** Short for No Operation. Satellite doesn't move.
- **Radial In –** Moves the satellite into a lower orbit, i.e. the next ring of sectors that is closer to the Earth.
- **Radial Out –** Moves the satellite into a higher orbit, i.e. the next ring of sectors that is farther from the Earth. Note that the satellite will always move to the outer sector with the lower number (the retrograde sector).
- **Prograde –** Moves the satellite into the next sector in the same orbit, counterclockwise (a higher number).
- **Retrograde** – Moves the satellite into the previous sector in the same orbit, clockwise (a lower number).

Engagement Phase

- **Guard** – Protect the HVA from opposing engagements. If the opponent successfully shoots at a guarded satellite the guard satellite is destroyed instead of the guarded satellite.
- **Shoot –** Fires a Patrol satellite's ammo against the adversary. If successful, your satellite will survive this engagement.
- **Collide –** Collide with a satellite. If successful, both your satellite and the target satellite will be destroyed.

Winning the Game

- The goal is to end the game with more points than your opponent.
- You receive 10 pts at the end of your turn if the HVA is still in its goal sector, or 3 pts if it is in an adjacent sector. The initial score is 200 points (initial fuel points). After each turn, the score is recalculated by the new fuel sum from the satellites. When a satellite dies, its fuel is set to 0. Each satellite will lose one fuel per turn regardless of its actions. The game ends when a player reaches 350 points, or when an HVA runs out of fuel.

Fuel Costs and Engagement Probabilities

```
Turnphase: movement
Token: alpha:HVA:0
Select an action from the list
0 – NOOP
 1 – Prograde
 2 – Retrograde
 3 – Radial In
 4 – Radial Out
Select action: 0
```

```
Turnphase: engagement
Token ID: beta:HVA:0
Select an action from the list
0 – NOOP
 1 – Shoot
 2 – Collide
 3 – Guard
Select action:
```

Fuel Costs for Actions WITHIN a Sector		**Fuel Costs for Actions in an ADJACENT Sector**	
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Collide	20	Collide	30
Guard	5	Guard	10

Probability for Actions WITHIN a Sector		**Probability for Actions in an ADJACENT Sector**	
No-op	1.0	No-op	1.0
Shoot	0.8	Shoot	0.4
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Movement Phase Fuel Costs	
No-Op	0
Radial In	10
Radial Out	10
Prograde	5
Retrograde	5