ECO-SPHERES Game Manual

Basic Game Overview (210 seconds total)

Stage 1: Debris Navigation (30 seconds)

SPHERE must navigate through debris field, contact between SPHERE and debris will result in thruster damage, affecting maximum thruster speed.

Stage 2: Rendezvous (60 seconds)

User SPHERE must approach target SPHERE and meet “rendezvous conditions.” Once rendezvous conditions are met, space debris will disappear and the target sphere will stop moving and uses its thrusters to actively hold its position

Stage 3: Hooking (90 seconds)

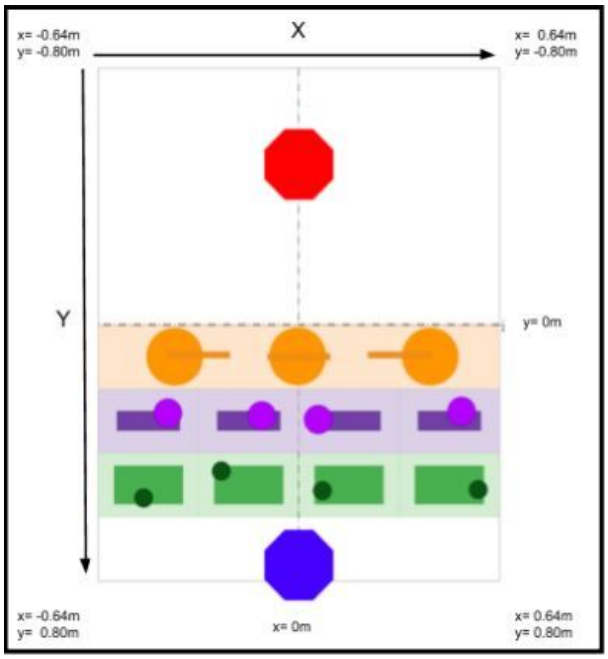
User SPHERE will attempt to use its hook to capture the target SPHERE

Stage 4: Return Target (30 seconds)

User SPHERE returns to safe zone with target SPHERE.

Playing Field & Things to Know:

Diagram:



Initial Positions:

SPHERES:

	2D	3D	Alliance
Player SPHERE [B]			
X [m]	0.0	TBA	TBA
Y [m]	0.75	TBA	TBA
Z [m]	0.0	TBA	TBA
Target SPHERE [R]			
X [m]	0.0	TBA	TBA
Y [m]	-0.5	TBA	TBA
Z [m]	0.0	TBA	TBA

Nominal Properties:

Property	Value	Unit
Radius	0.11	m
Diameter	0.22	m
Mass	4.0	kg
Single Thruster Force	0.11	N ($kg \cdot \frac{m}{s^2}$)

The single thruster force is affected by how many thrusters are open at one time, varying up to 20% of the nominal force. In addition, while every attempt was made to align the thrusters with the satellite body axes, there are imperfections in the alignment (within 2°), therefore not all the force goes in the exact desired direction.

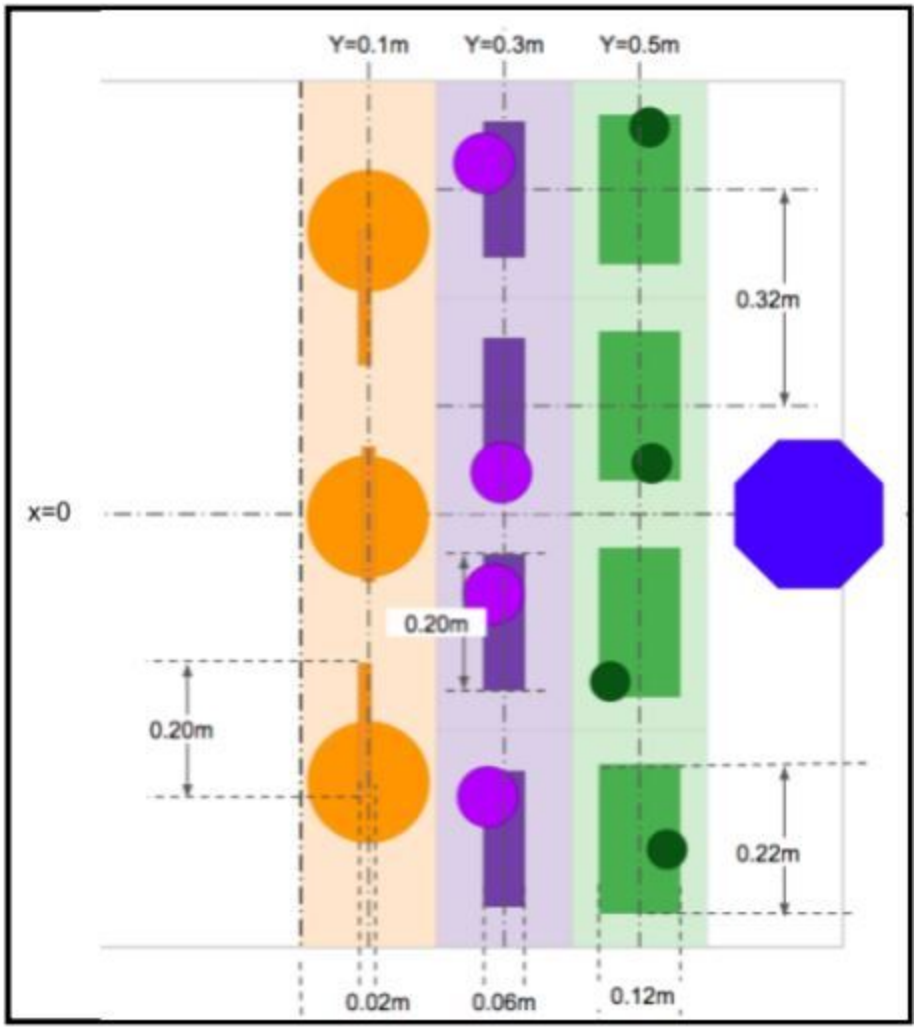
Fuel:

Each player is assigned a virtual fuel allocation of 60 seconds of total accumulated thruster firing time. This is calculated by summing individual thruster firing during the game. Once the allocation is consumed, the satellite will not respond to the player SPHERES control commands. It will fire thrusters only to avoid leaving the Interaction Zone or colliding with the other satellite. Any action that requires firing the thrusters (rotating, accelerating, decelerating), whether it was commanded by the player, due to activate collision avoidance or out-of-bounds breaking, or other penalties of the game play, will consume virtual fuel allocation.

DEBRIS:

Debris ranges in positions of 0m < y < 0.7m

Diagram:



Sizes:

Debris radii goes from 0.03m, 0.045m, to 0.09m.

Damages:

Thruster damage based on the size of debris goes from 10%, 25%, 50%, respective to the debris sizes

Debris Type	2D	3D	Alliance
Effect	Reduce in total thrust power (Position and Altitude) by subtracting %'s	TBA	TBA

Small	10%	TBA	TBA
Medium	25%	TBA	TBA
Large	50%	TBA	TBA

Scoring:

Baseline Scoring

Phase	Time	Min Score	Max Score
Debris Field	30s	0.25	0.5
Rendezvous	60s	0.25	0.5
Hooking	90s	0.5	1.00
Return Target	30s	0.5	1.00

Variables

Symbol	Description
$p_{0,L}$	Minimum points for crossing debris field
$p_{0,U}$	Points awarded for crossing field in 0 time
$\Delta T_{0,ref}$	Time for crossing debris field which causes minimum score
$p_{1,L}$	Minimum points for achieving rendezvous
$p_{1,U}$	Points awarded for achieving rendezvous in 0 time
$\Delta T_{1,ref}$	Time for achieving rendezvous which causes minimum score
$p_{2,L}$	Minimum points for achieving hooking
$p_{2,U}$	Points awarded for achieving hooking in 0 time
$\Delta T_{2,ref}$	Time for achieving hooking which causes minimum score

$p_{3,L}$	Minimum points for returning target SPHERES
$p_{3,U}$	Points awarded for returning target SPHERES in 0 time
$\Delta T_{3,ref}$	Time for returning target SPHERES which causes minimum score

$$pn,L + (pn,U - \frac{pn,U-pn,L}{\Delta Tn,ref} \Delta T\,n)(\Delta T\,n < \Delta T\,n,ref)$$

Where pn,L is the baseline score earned when phase n is complete, pn,U is the maximum possible score that could be earned (if the phase was completed in zero time), Δ Tn is the time elapsed since the phase began, and Δ Tn,ref is the time at which no more than the min score will be awarded for that phase.

Bonus Points

Rendezvous Bonus Points:

At the end of the rendezvous phase (when the player calls game.completeRendezvous successfully) a bonus or penalty will be scored based on how close the hook of the target is pointing to the center of the player. The bonus/penalty is assessed as follows:

- Determine the “pointing vector” between the target to the player

- Take the dot product of the normalized “pointing vector” and the ZR attitude of the target (which is itself a normalized pointing vector)

- Square the dot product magnitude (which increases the effect of misalignment)

- Scale by 2.5 (so 2.5 is the maximum bonus and -2.5 the maximum penalty)

Symbol	Description	Max Bonus	Max Penalty
b_r	Bonus points granted in rendezvous stage	2.5	-2.5

Fuel Bonus Points:

Once the SPHERES return to the “Safe Zone”, additional points will be awarded for any remaining fuel. More weight will be given to remaining fuel in the players SPHERES than in the target SPHERES ($f_{player} > f_{target}$) The additional fuel points will be calculated by multiplying the percentage of remaining fuel (expressed as a decimal) by the fuel weights as follows: $\omega_{player} * f_{player} + \omega_{target} * f_{target}$

Symbol	Description	Value
ω_{player}	Percentage of remaining player SPHERES fuel	Derived From Game
ω_{target}	Percentage of remaining target SPHERES fuel	Derived From Game
f_{Player}	Multiplier for player SPHERES fuel	TBA
f_{target}	Multiplier for target SPHERES fuel	TBA

Scoring Equation:

$$Score = \sum_{n=1}^{4} [pn,L + (pn,U - \frac{pn,U-pn,L}{\Delta Tn,ref} \Delta T\,n)(\Delta T\,n < \Delta T\,n,ref)] + (\omega_{player} * f_{player} + \omega_{target} * f_{target}) + b_r$$