# Space Debris Identification, Classification and Aggregation with Optimized Satellite Swarms


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21 October, 2016
Sports and Wellness Resort Kamchia
Bulgaria

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- Concept of Operations
- Risks
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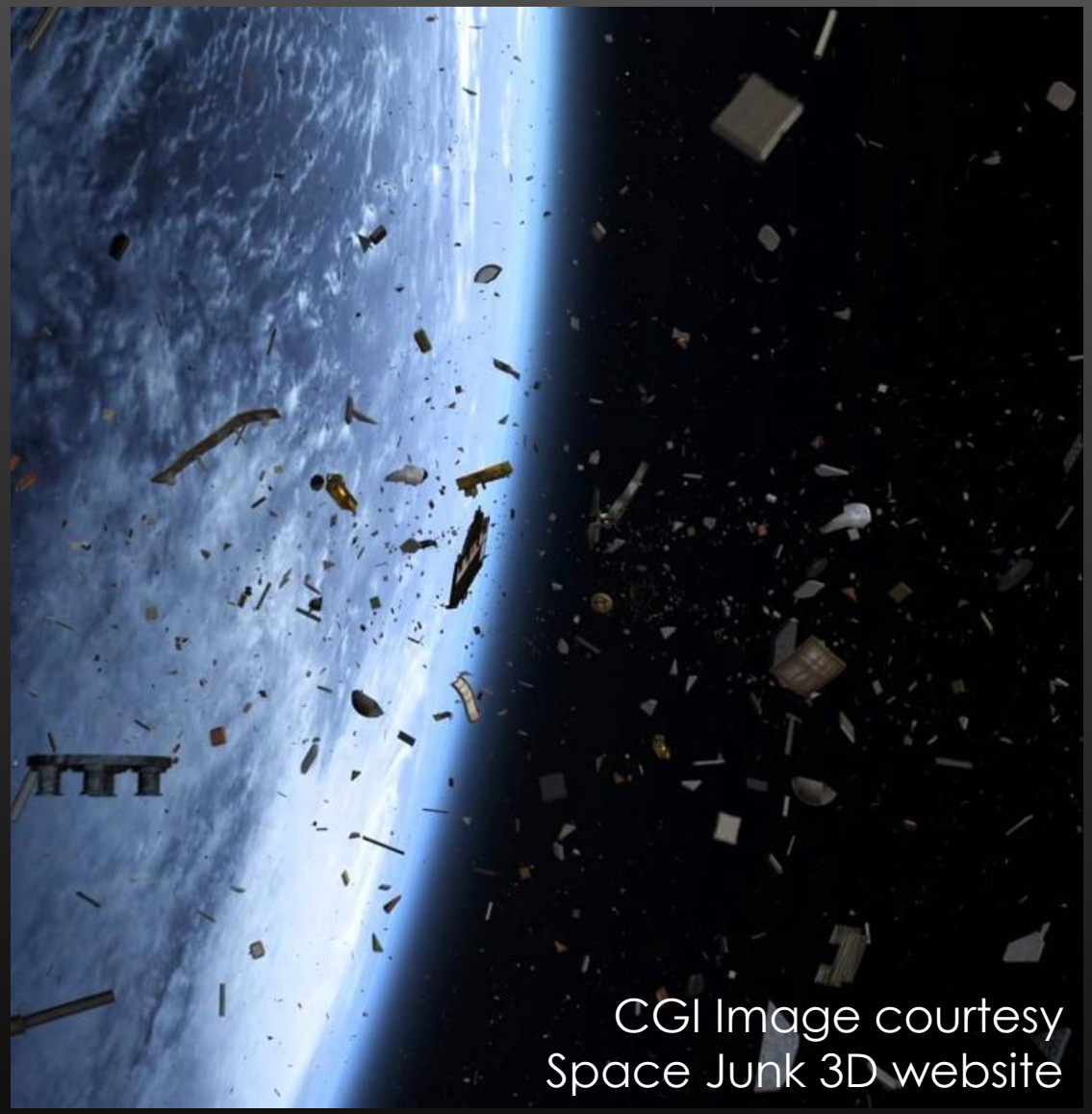
# Space Debris

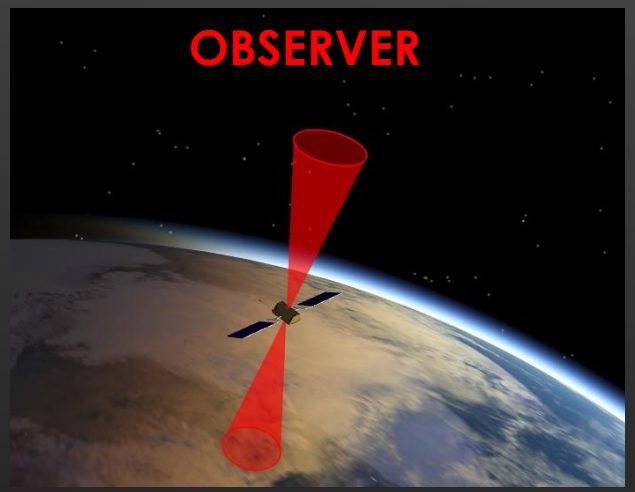
- Decommissioned satellites and upper stages
- 6% of the orbit population are operational spacecrafts
- Explosion of tanks created more than 600 000 objects larger than 1cm



CGI Image courtesy Space Junk 3D website

# Mission Objectives

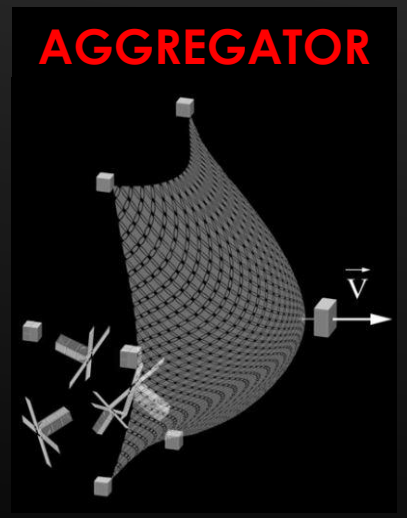
OBSERVER SUB-MISSION
3-5 years





AGGREGATION MISSION PLANNING

AGGREGATOR SUB-MISSION
days / months

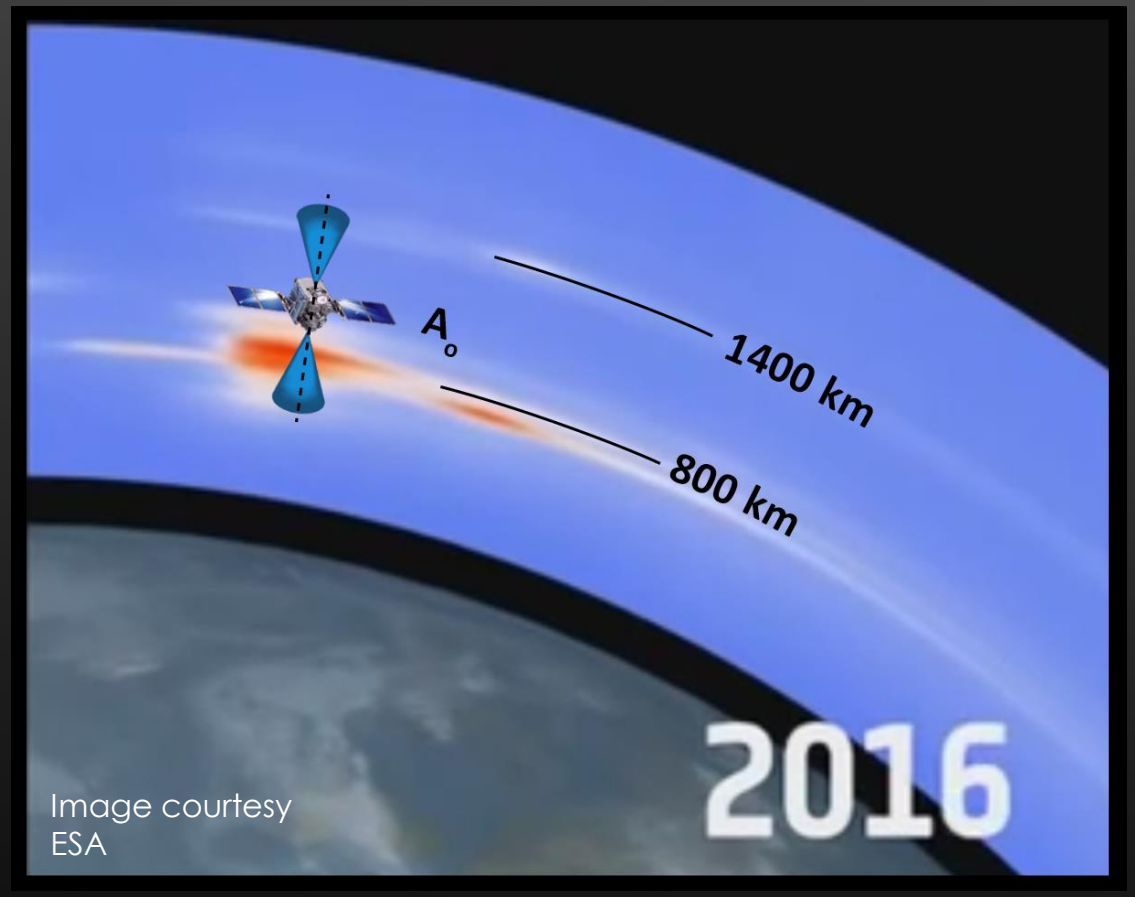




# Observer

- Possible sensors: LIDAR, Optical Telescope, Multispectral camera

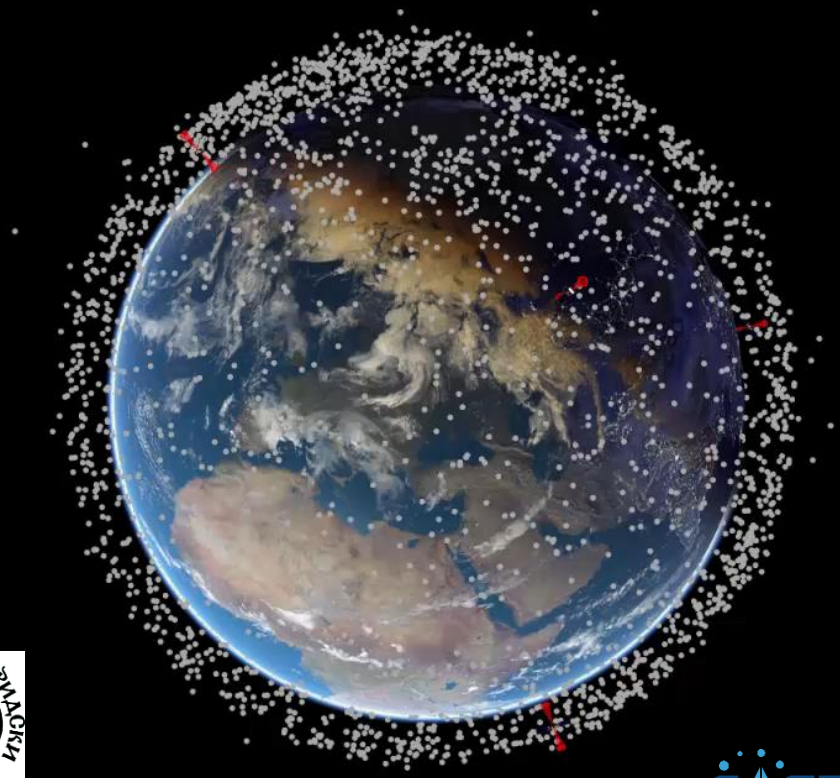
- Orbital parameters:
  - Orbit type: circular
  - Inclination: 82°
  - Altitude: 1050 km

- LIDAR: 400 km range
  - 20° cone angle

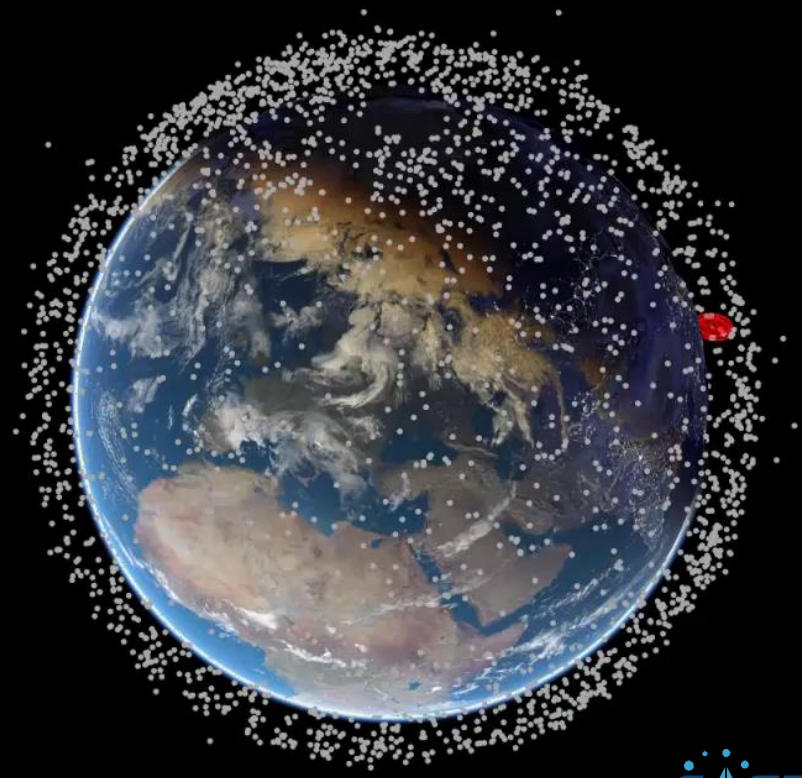


# Observer – Debris Detection Simulations

6 Observers with 2 LIDARs
pointed at Nadir and Zenith



3 Observers with spinning LIDARs
around linear Velocity Vector



GRAY points - **UNDETECTED** RED points - **DETECTED**

# Observer – Detection Simulations RESULTS

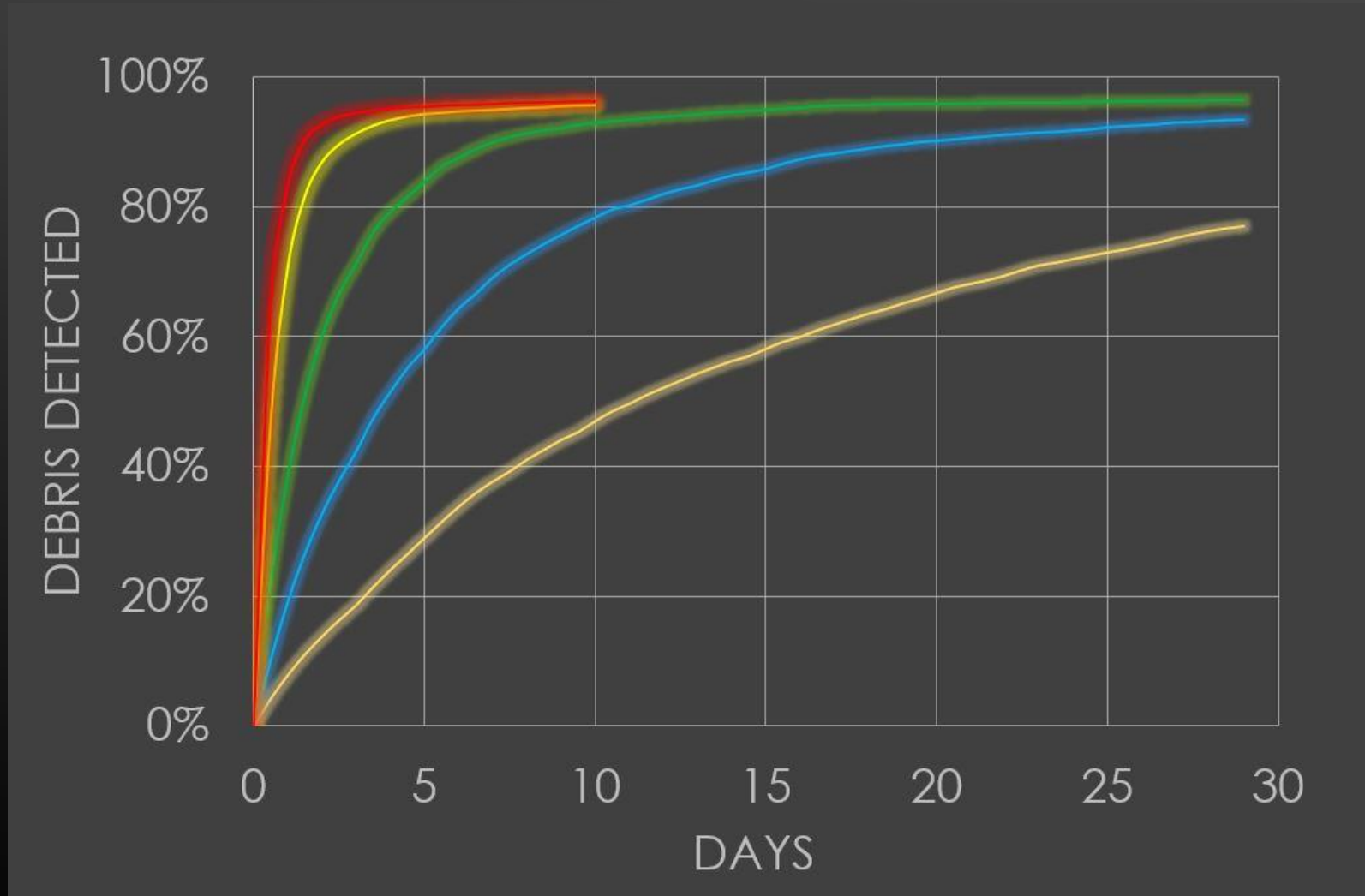
6 Observers, spinning LIDARs

3 Observers, spinning LIDARs

6 Observers, 2 LIDARs

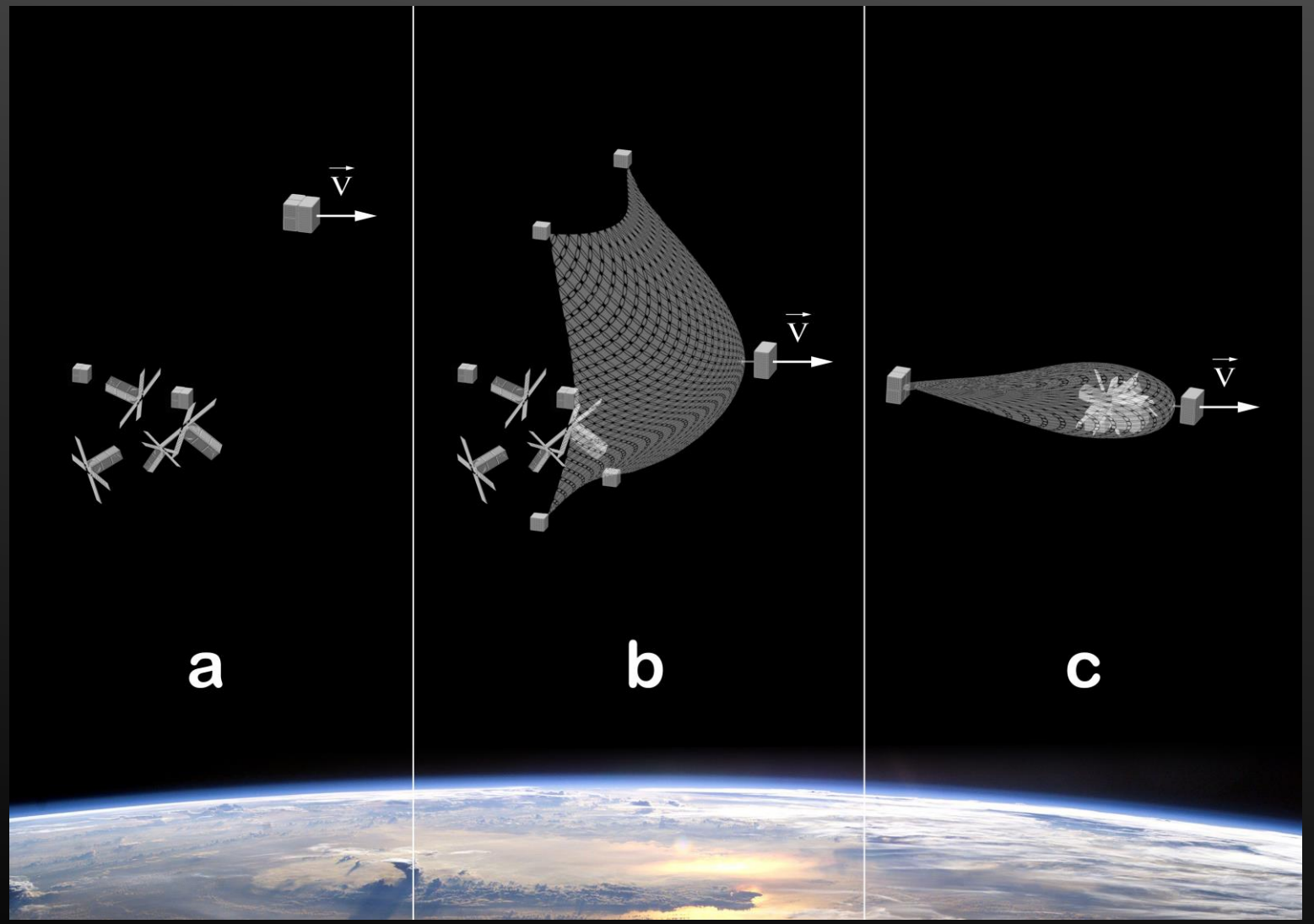
3 Observers, 2 LIDARs

1 Observer, 2 LIDARs



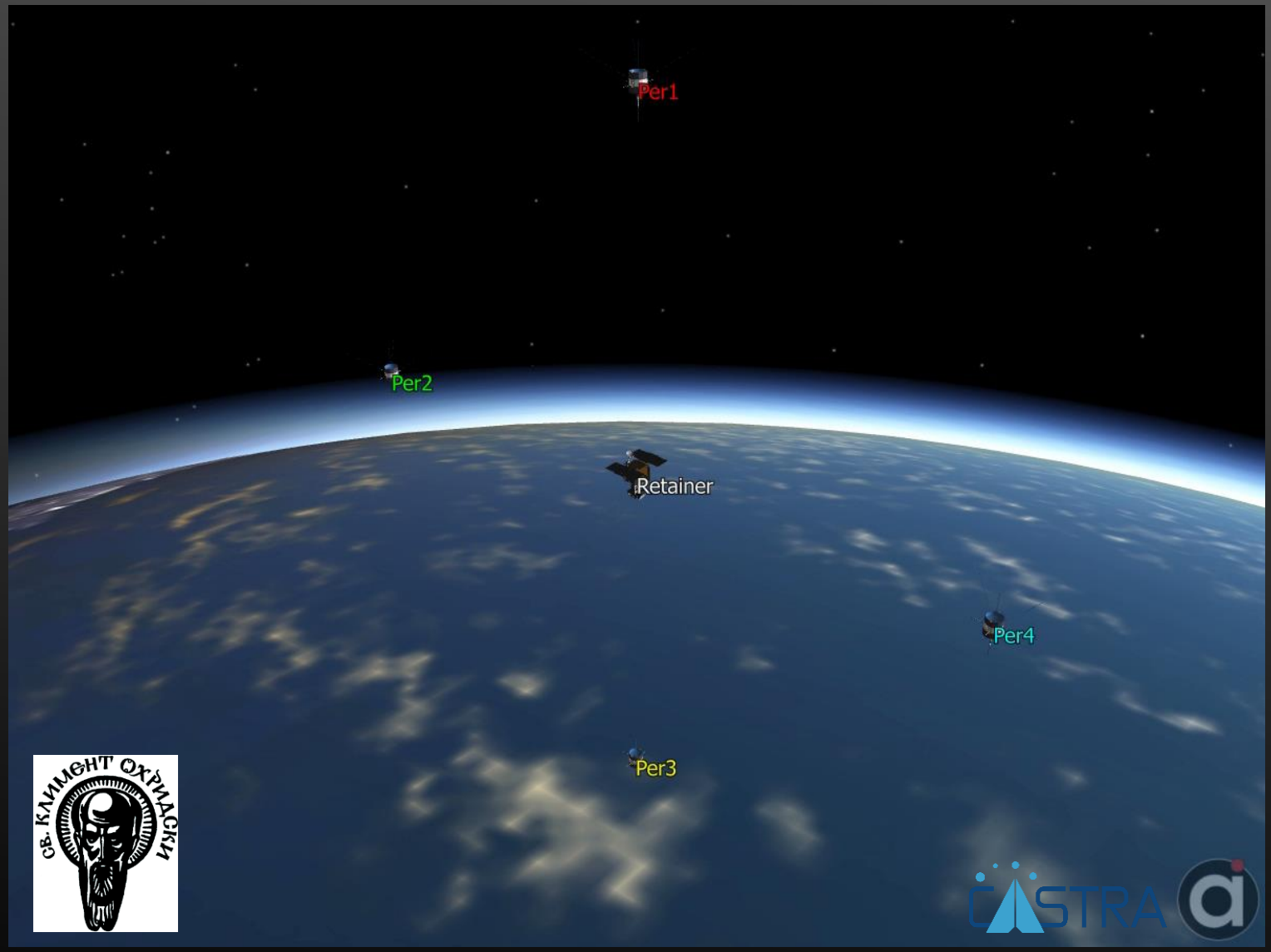
# Aggregator

- 5 autonomous units
- Total mass: ≈ 50 kg
- Payload: Net
- Net side: ≈ 140 m



# Aggregator

- Bottom satellite is faster
- Top satellite is slower
- Left and Right satellites oscillate around the Retainer



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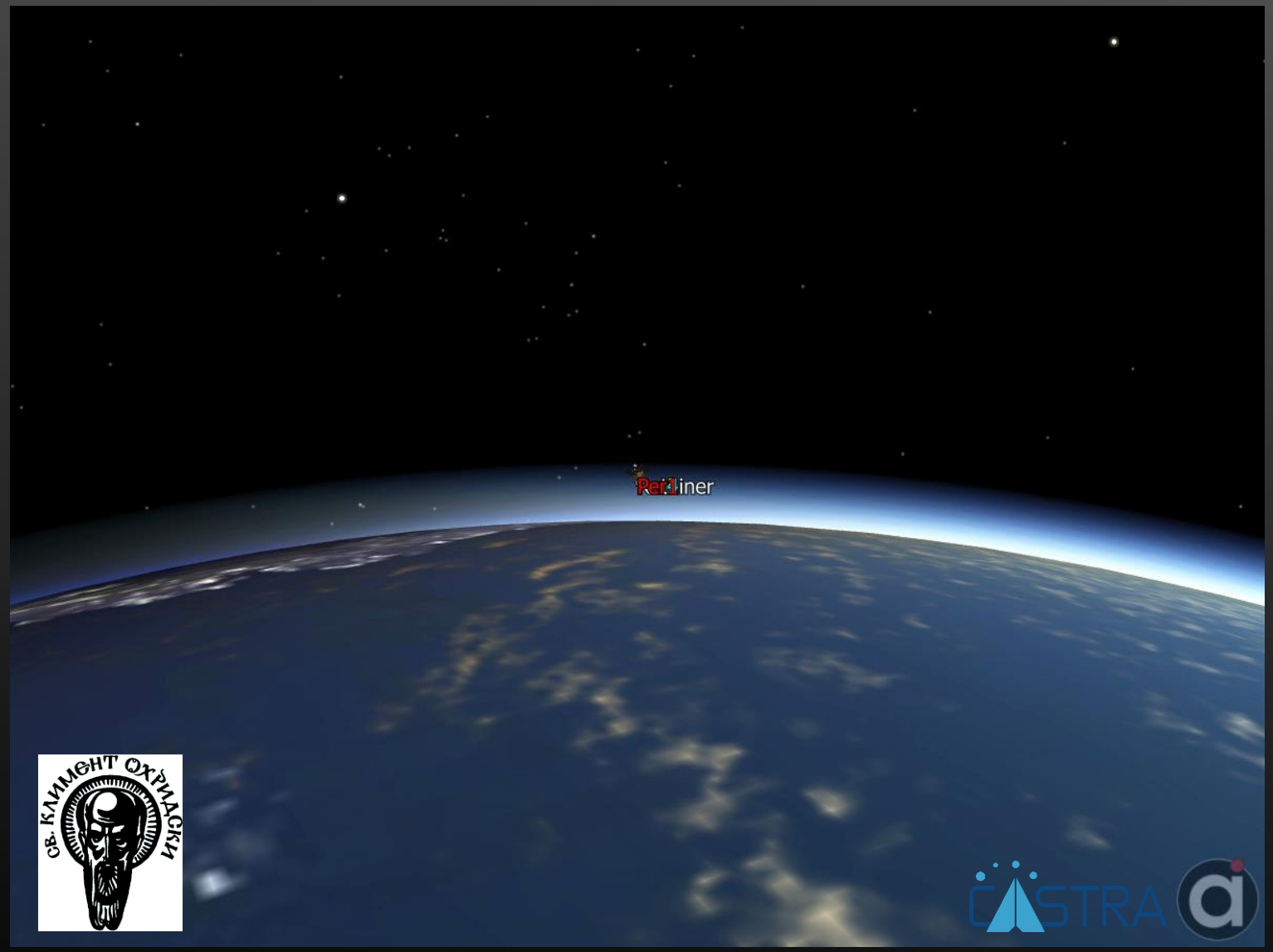
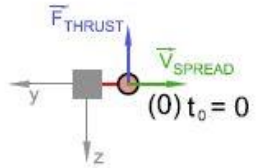


# Aggregator

- (0) Peripheral satellites are pushed out and thrusters are turned on

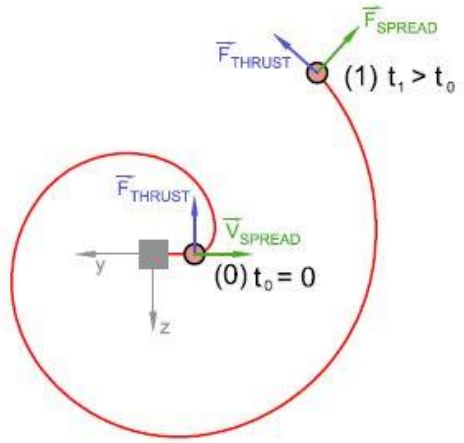


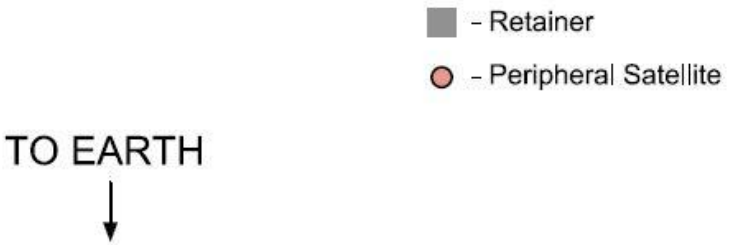

- Retainer
- Peripheral Satellite

TO EARTH

# Aggregator

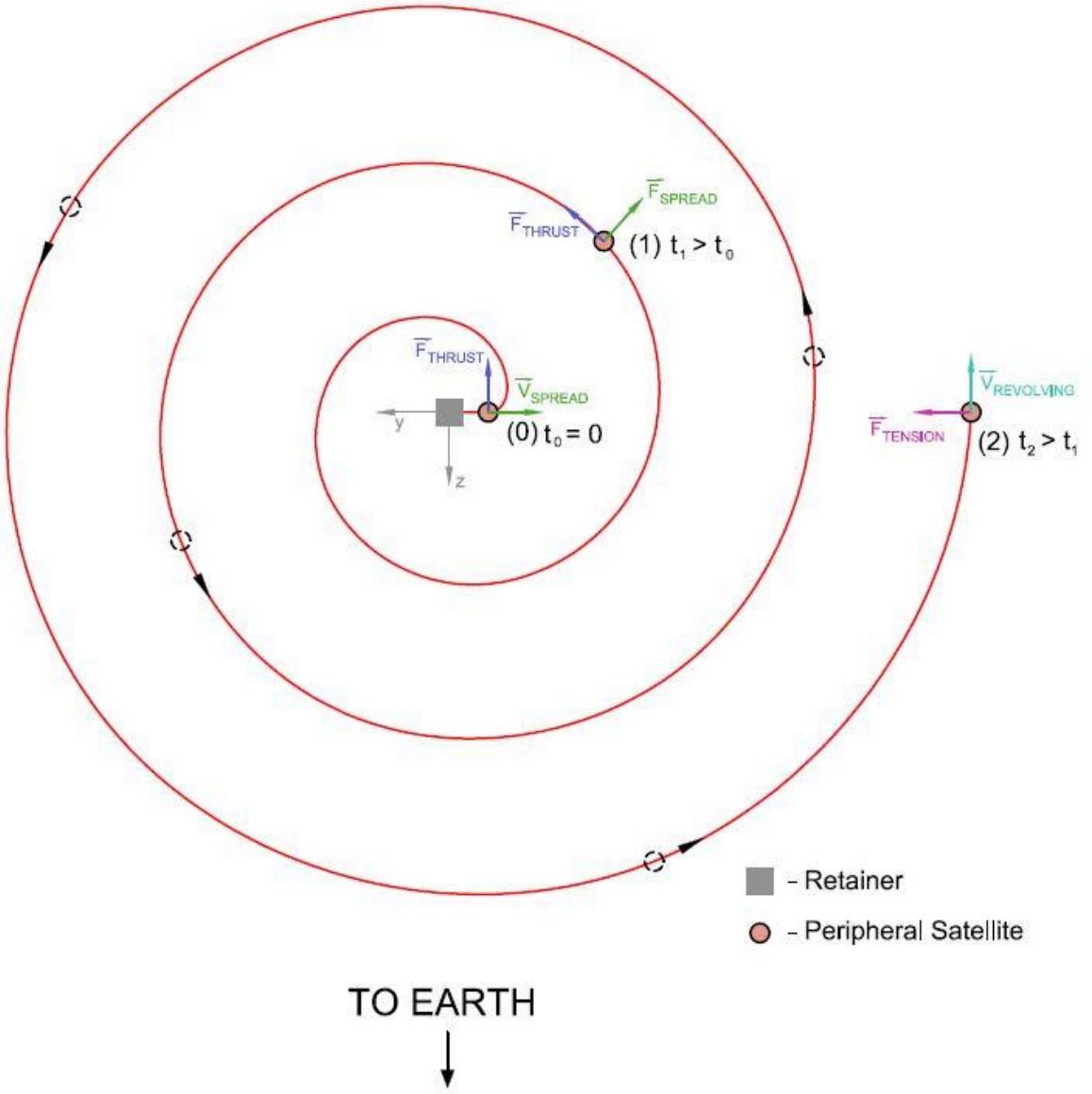
- (0) Peripheral satellites are pushed out and thrusters are turned on
- (1) Propulsion maintains spiral motion



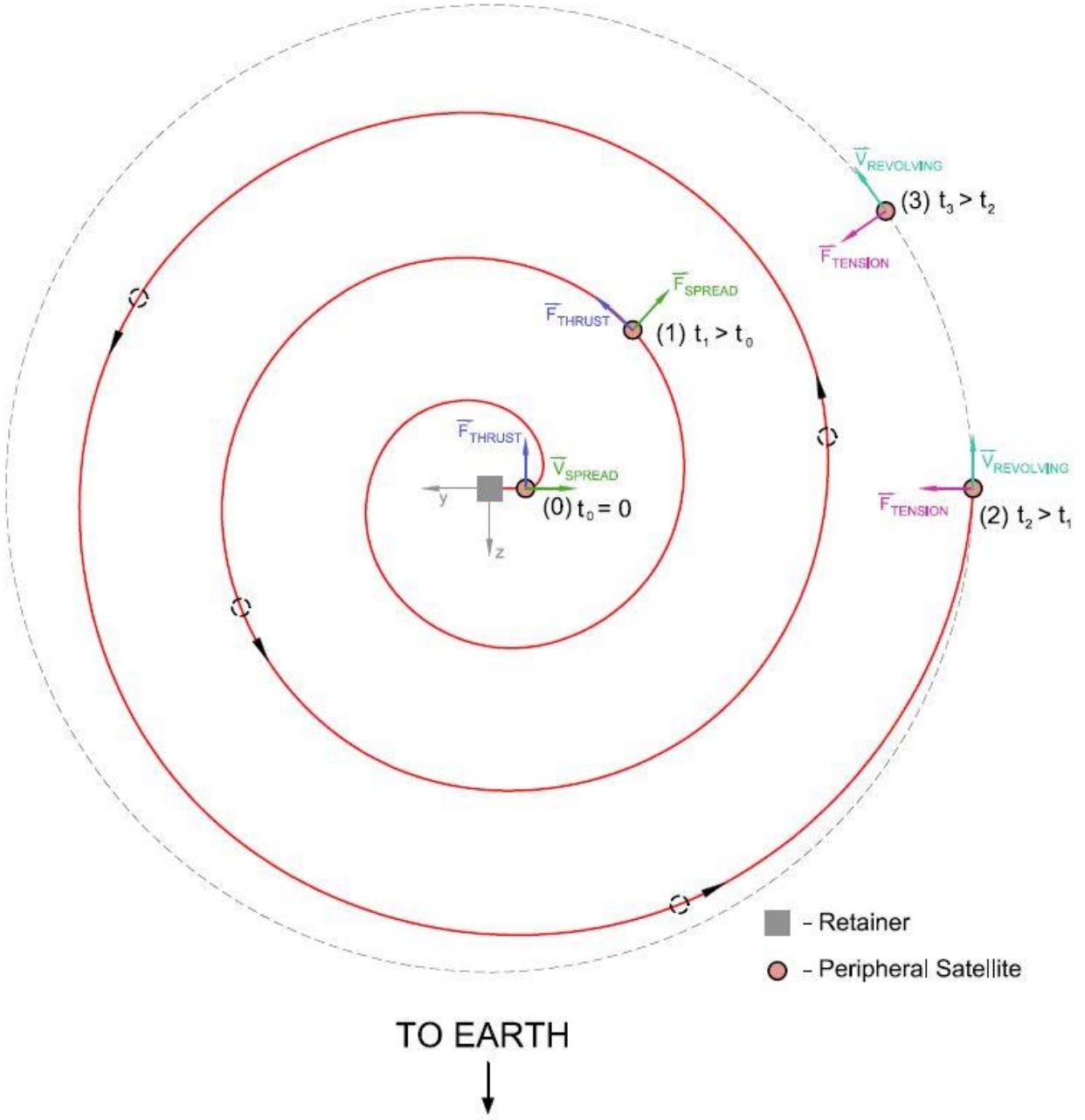
# Aggregator

- (0) Peripheral satellites are pushed out and thrusters are turned on
- (1) Propulsion maintains spiral motion
- (2) Net size limit is reached



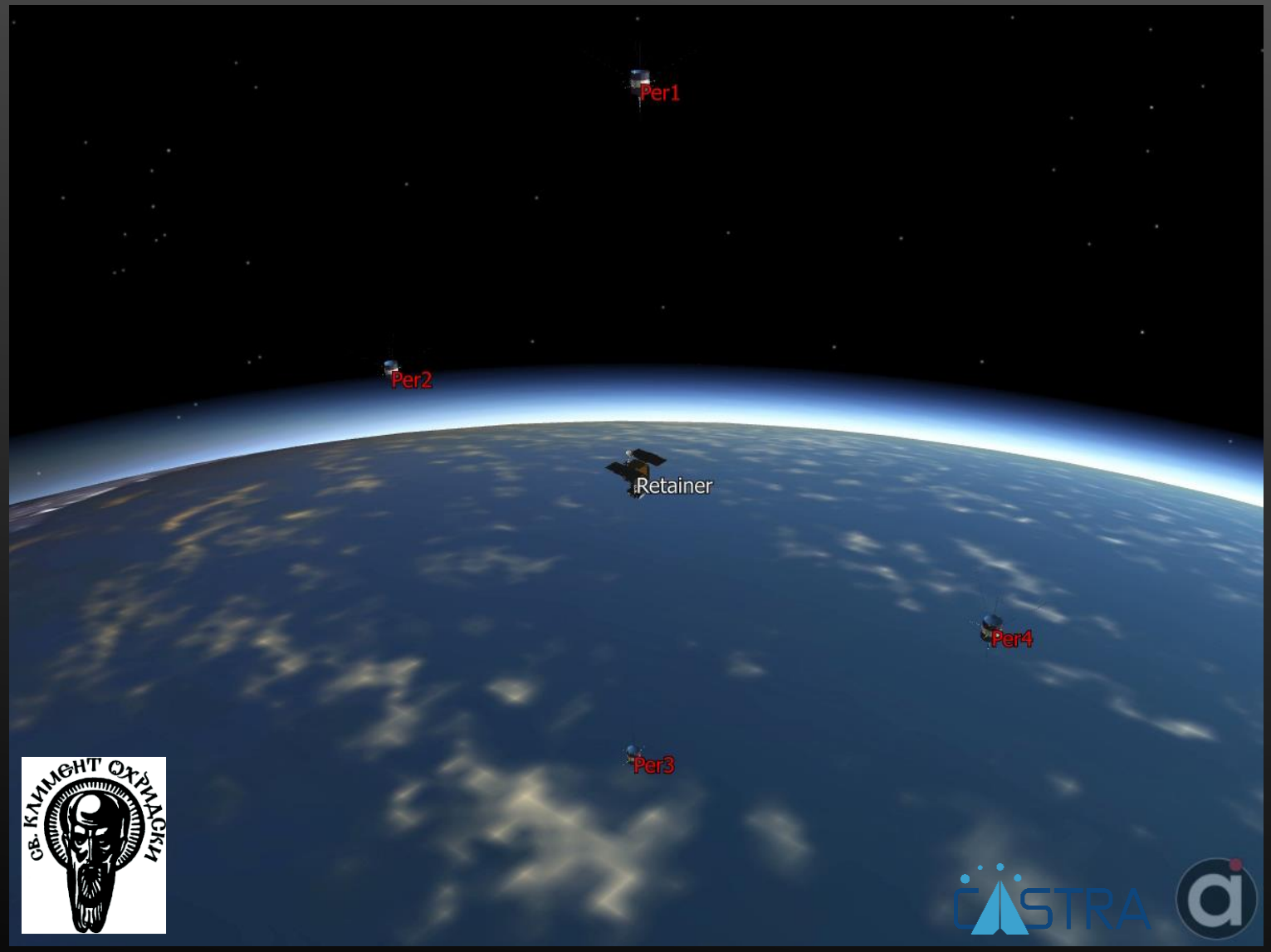
# Aggregator

- (0) Peripheral satellites are pushed out and thrusters are turned on
- (1) Propulsion maintains spiral motion
- (2) Net size limit is reached
- (3) Stabilized motion?



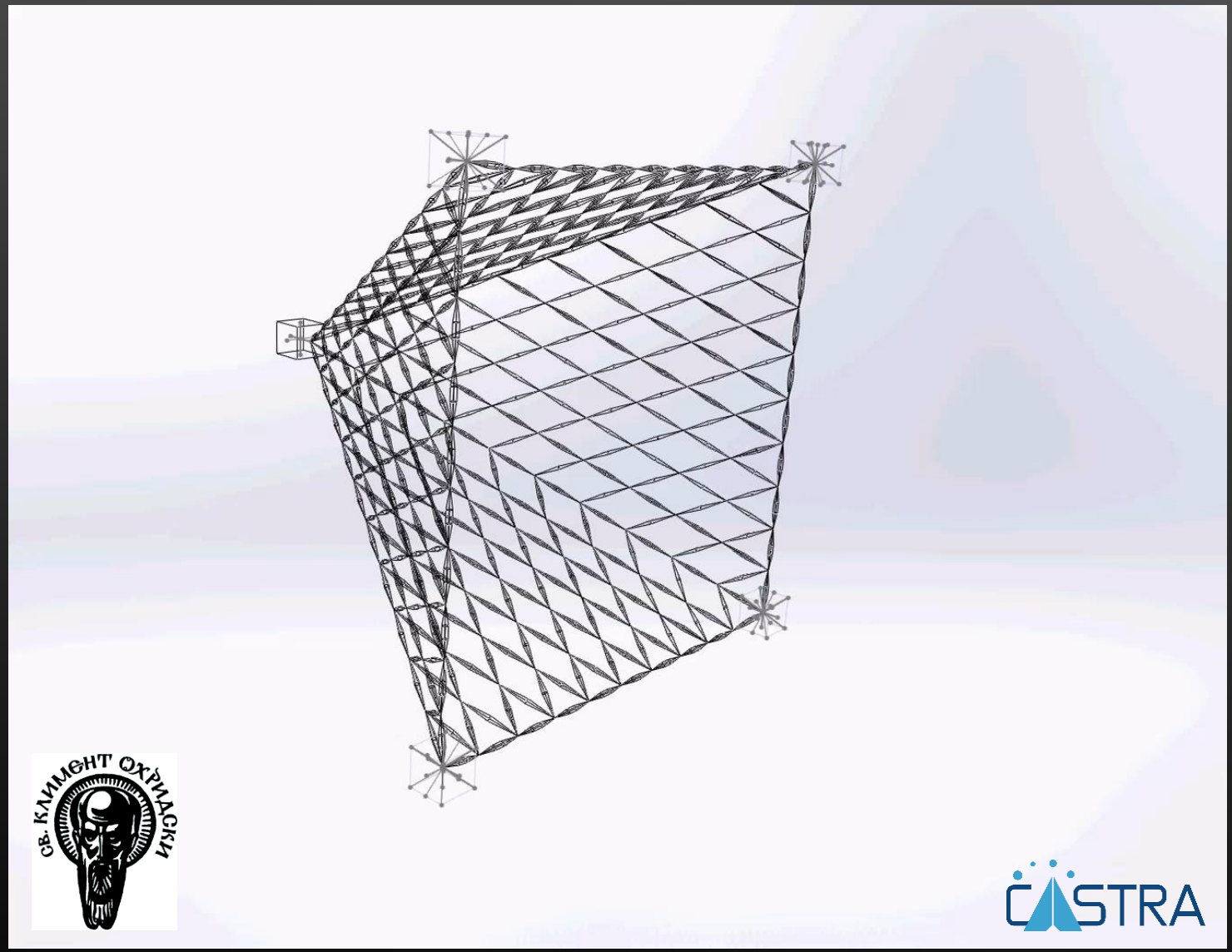
# Aggregator

- Stable configuration
- Equal average paths and speeds of peripheral satellites
- More precise simulation is yet to be done



# Aggregator

- Net behavior simulation
- Debris impact simulation



# Risks

- Complex mission planning for Aggregator's flight
- Difficult and risky deployment and closing of the net
- Possible net breakage
- Unpredictable behavior of captured debris

# Conclusion

- End to end mission with small satellites
- Novel concept for satellite constellation stability
- Applicability of satellites swarm intelligence

# THANK YOU!