Satellite target for demonstration of space debris manoeuvre by photon pressure

Benjamin Sheard
EOS Space Systems Pty. Ltd. / Space Environment Research Centre

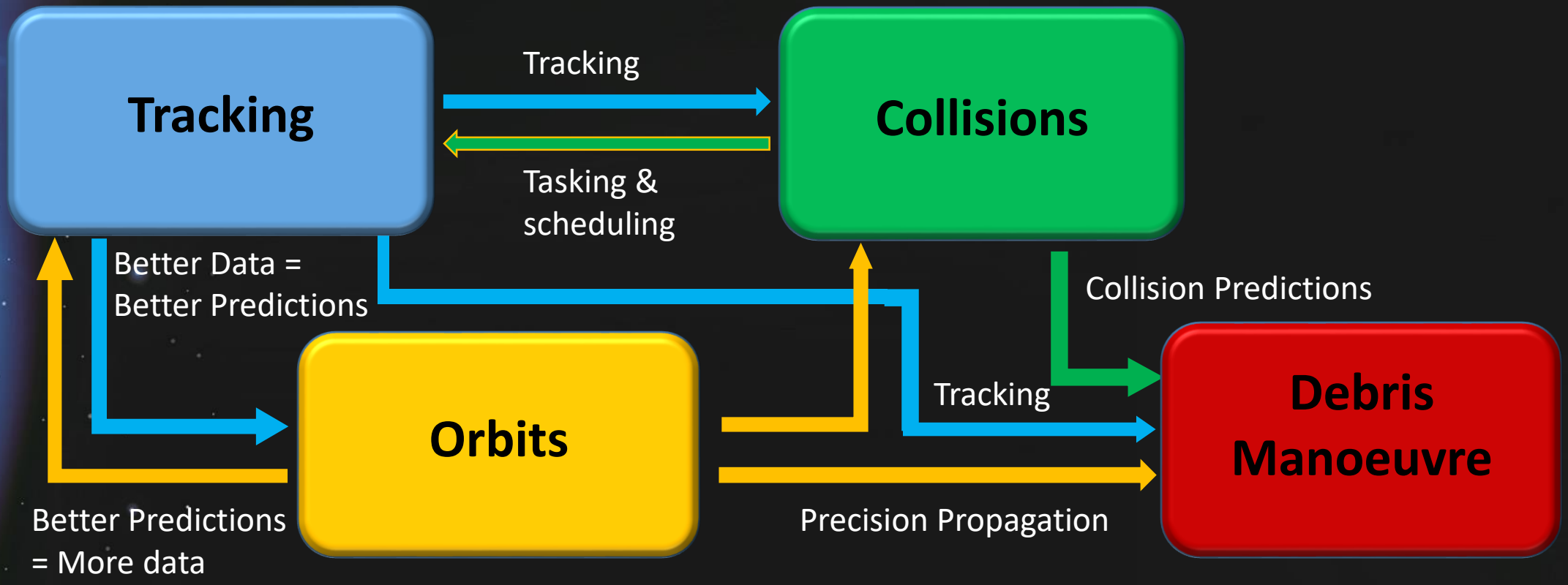
Space Environment Research Centre (SERC):

- Not-for-profit international research collaboration funded by the Australian government and other participants
- Objective to improve safety of navigation in space and develop technologies to mitigate the threat of space debris to space infrastructure
- Brings together expertise & resources from universities and industry
- SERC operates research programs for space object & environment characterization, tracking, collision prediction, as well as optical techniques for space debris mitigation

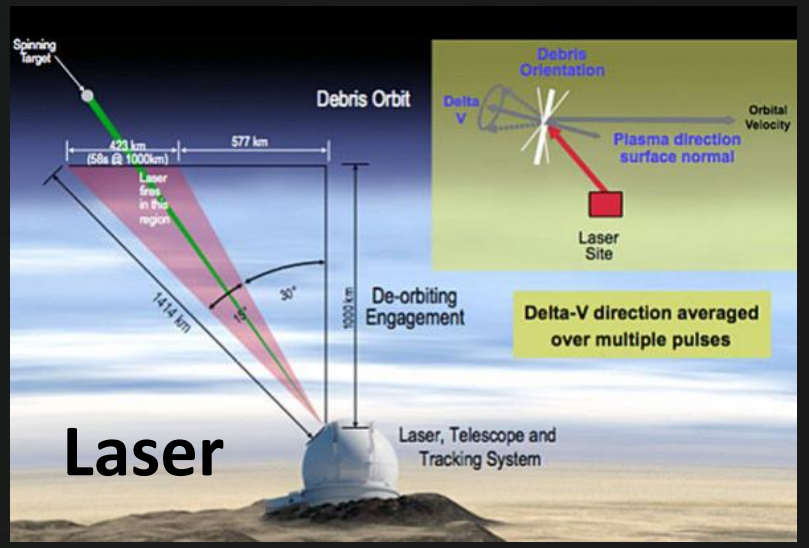
SERC Founding Participants

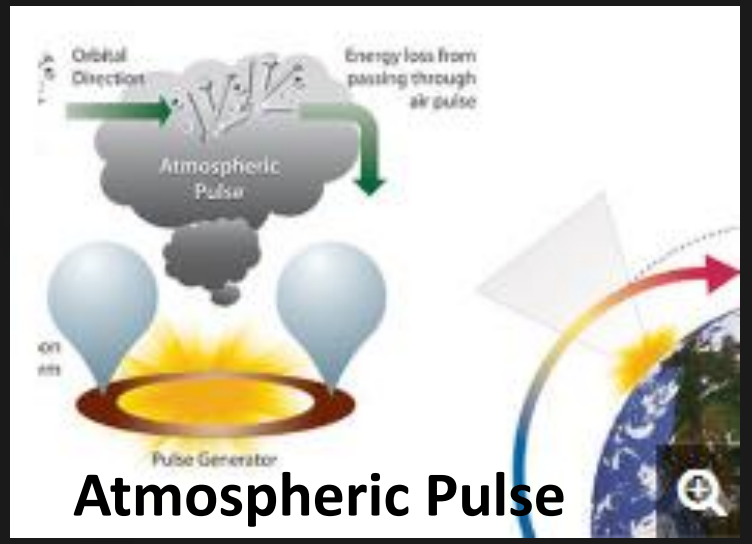
SERC members represent government, industry and universities across several countries.

Key SERC Programs

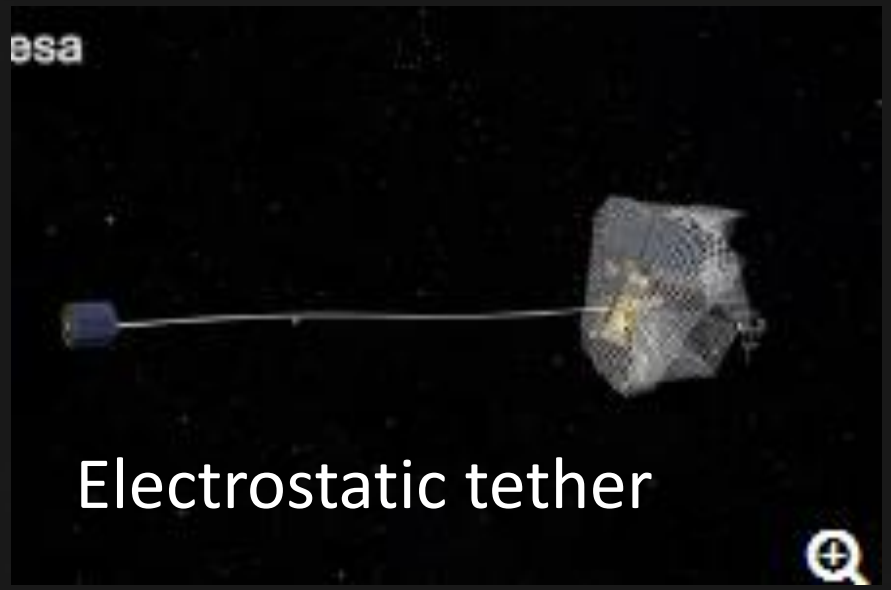


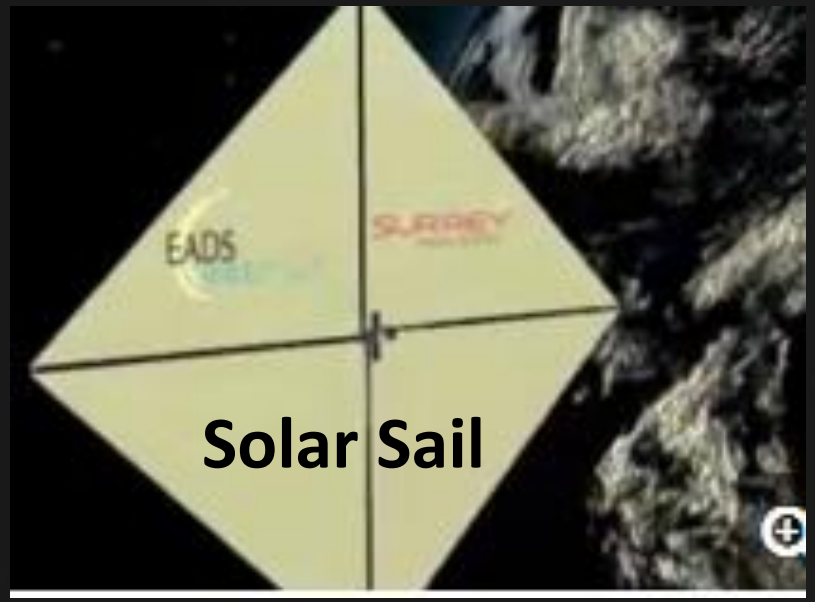
EOS Space Research Centre at Mount Stromlo, Canberra, Australia





Debris removal: Many schemes have been proposed but most are 10-20 years away and very expensive

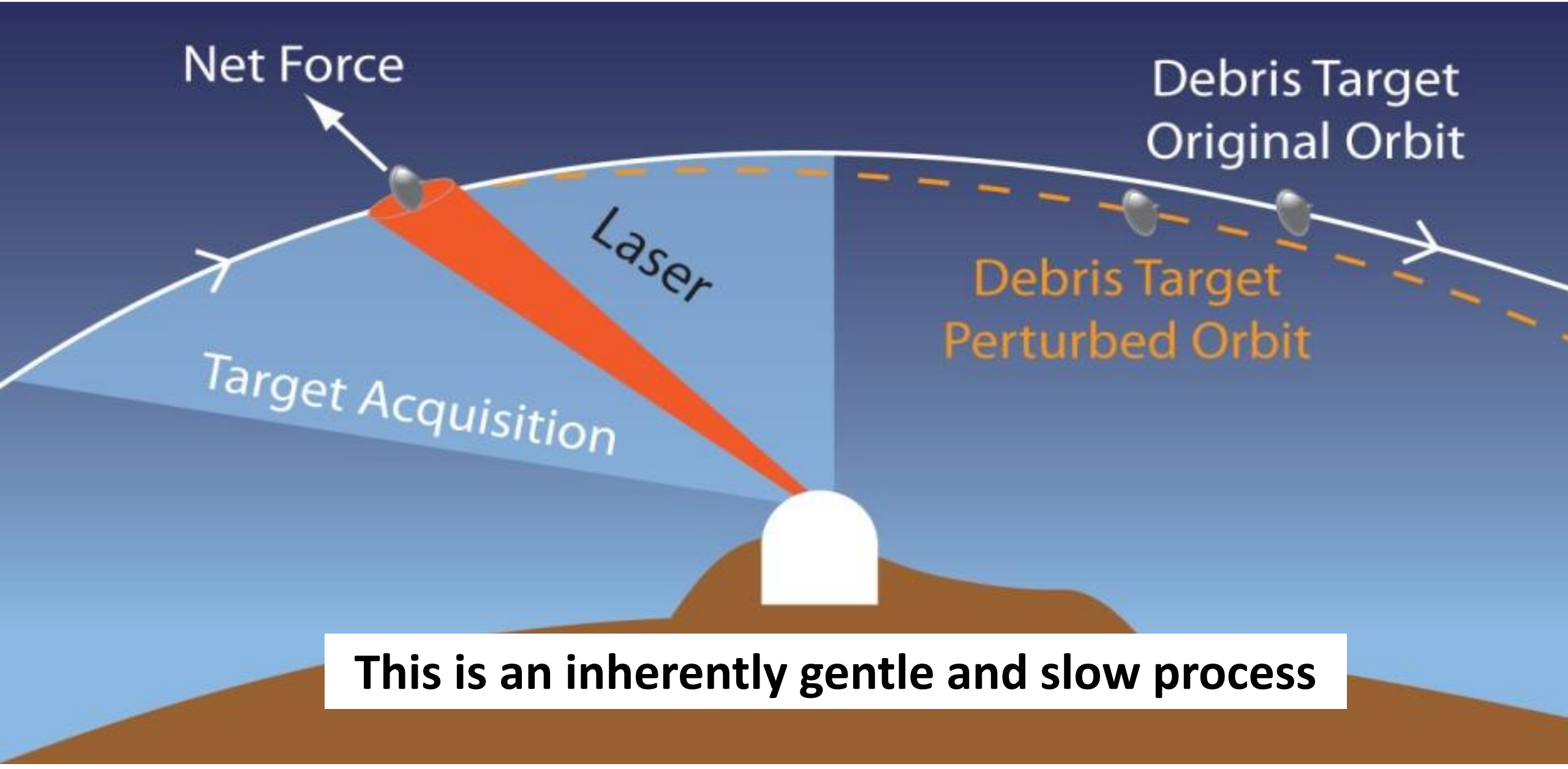




Avoidance vs Removal

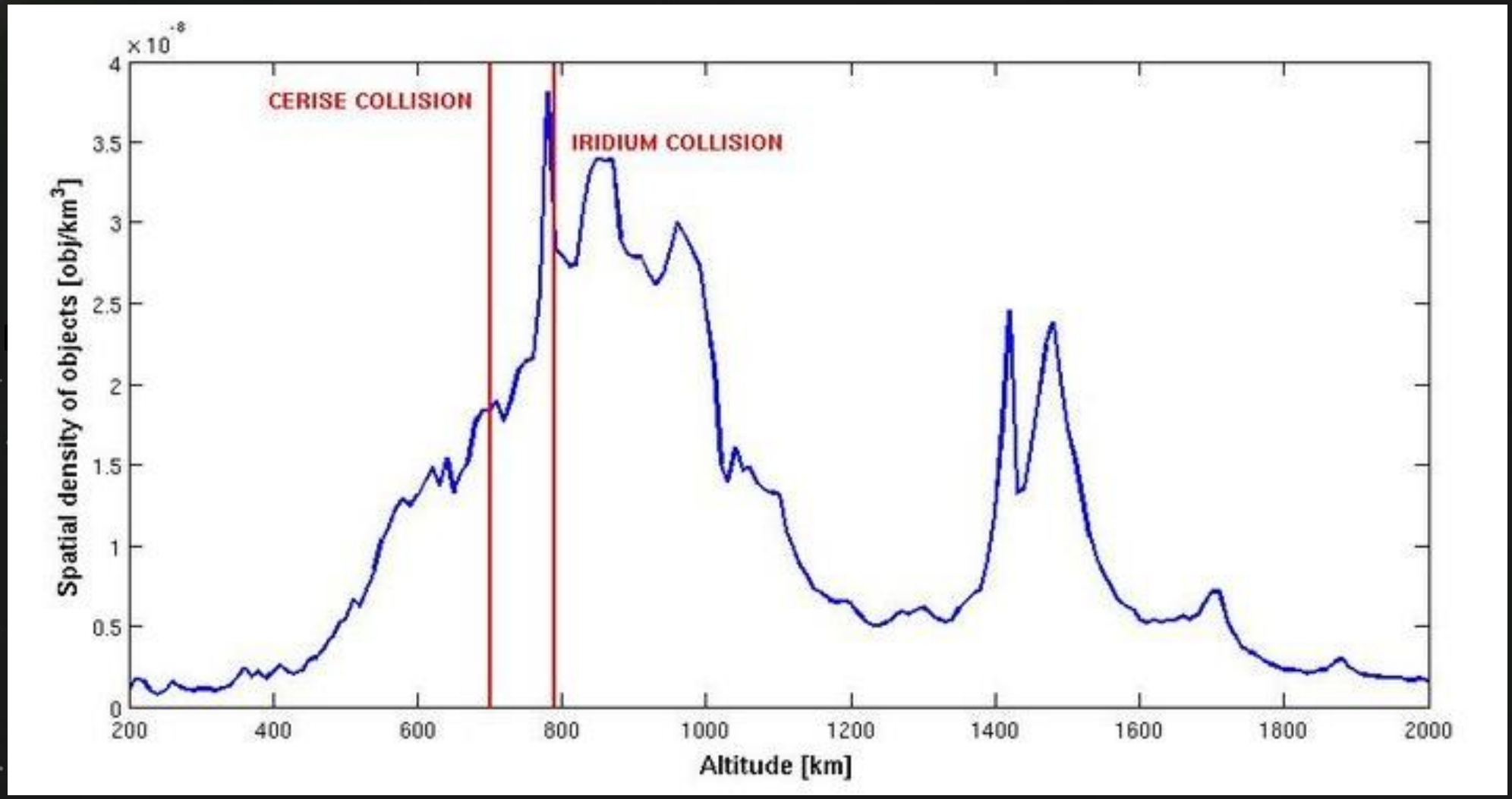
- SERC has funding to demonstrate the feasibility of reducing the rate at which collisions occur by altering debris orbits using ***non-threatening*** ground based CW lasers
- CW lasers of ≈10's kW produce radiation on orbit similar to solar radiation and apply radiation pressure.
- Not a deorbiting system or using ablation – aim to alter orbit just enough to confidently avoid a collision
- It's a temporary solution, but it buys time while more permanent solutions are developed and implemented.

Manoeuver by CW Laser Radiation



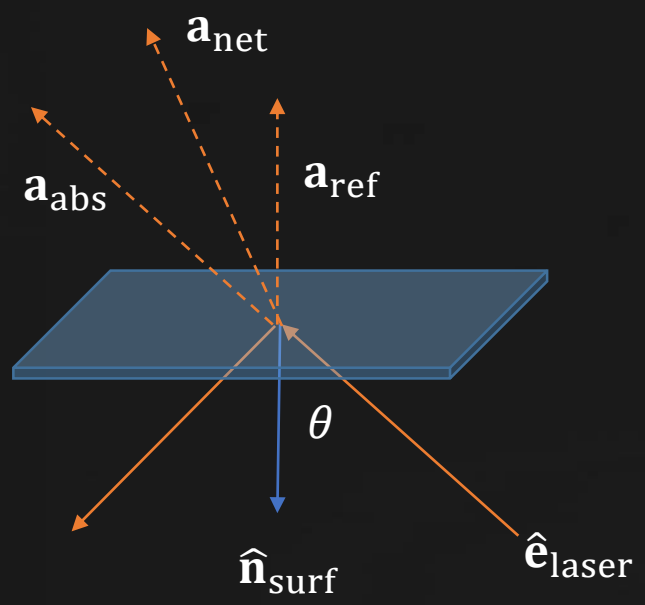
This is an inherently gentle and slow process

Laser intervention will be most effective < 1,000 km:
- this covers the most congested orbits



Avoidance vs Removal

- Acceleration due to photon pressure scales linearly with area-to-mass ratio (for uniform irradiance)
- Reflectivity properties affects the net acceleration direction.
- A 1mm/s along-track ΔV provides a ≈260m along-track separation after 1 day.
- Laser engagements may need to be repeated a number of times for the same targets to achieve avoidance



Demonstration

- Demo system being developed at the Mt Stromlo debris tracking station with ≥10 kW laser and adaptive optics for investigating feasibility and model validation
- Key technologies:
  - Accurate laser tracking to lock the target
  - High power laser and beam delivery system
  - Adaptive optics to concentrate the energy
- Cubesat as an instrumented target to support demonstration

Test Satellite(s)

SERC aims to build and launch a test satellite(s) to calibrate laser beam properties in space and to serve as a target with known properties for testing manoeuvre by photon pressure.

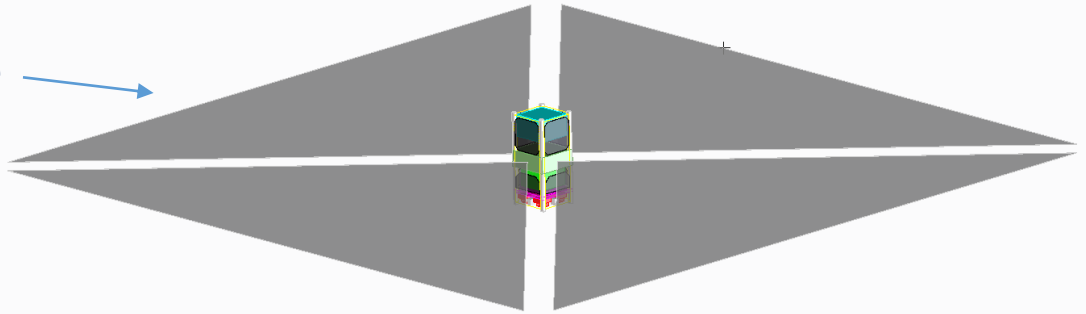
Primary satellite payloads are laser irradiance measurement equipment, corner cubes, precision navigation, and radiation sails.

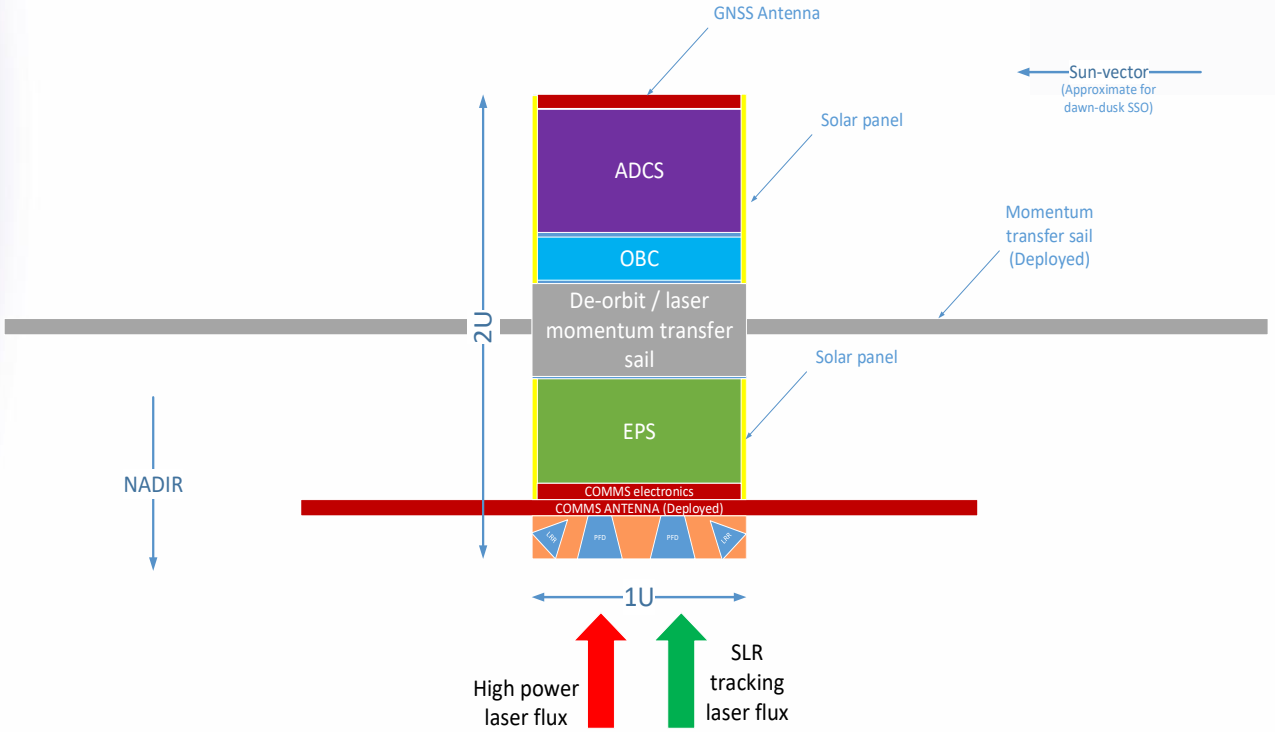
Require a 3 axis attitude stabilized cubesat bus to support payloads

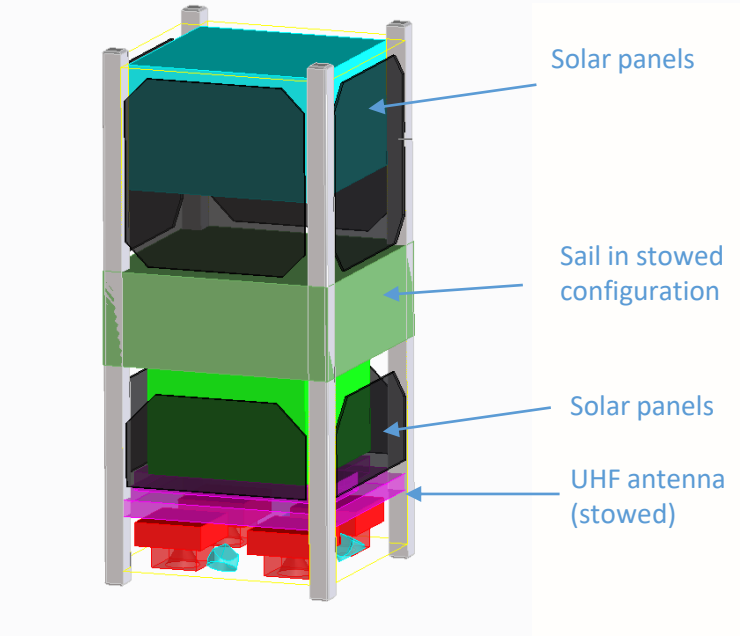
Orbit altitudes under consideration are 600-800 km

Preliminary satellite concept

Deployable sail for de-orbit and photon pressure



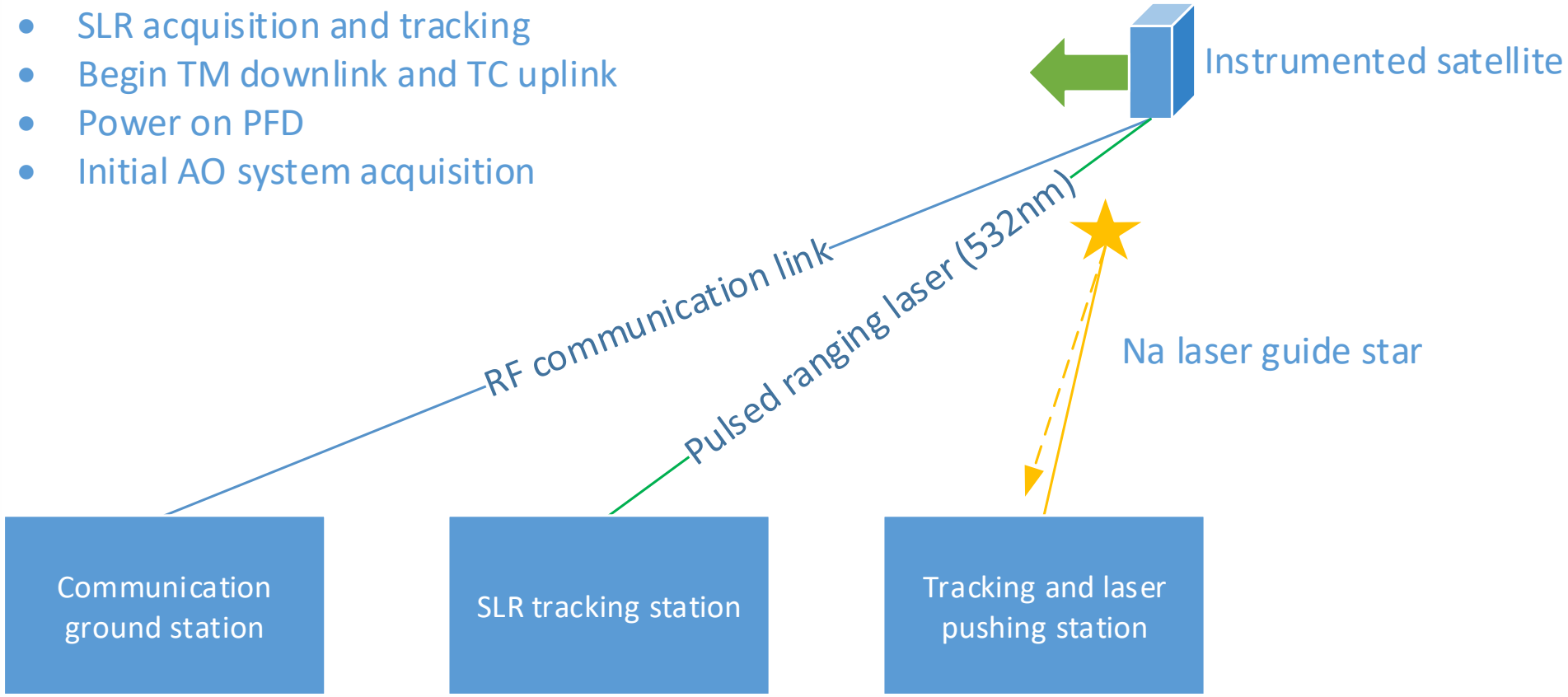




Preliminary conops for laser engagement

(1) Beginning of pass

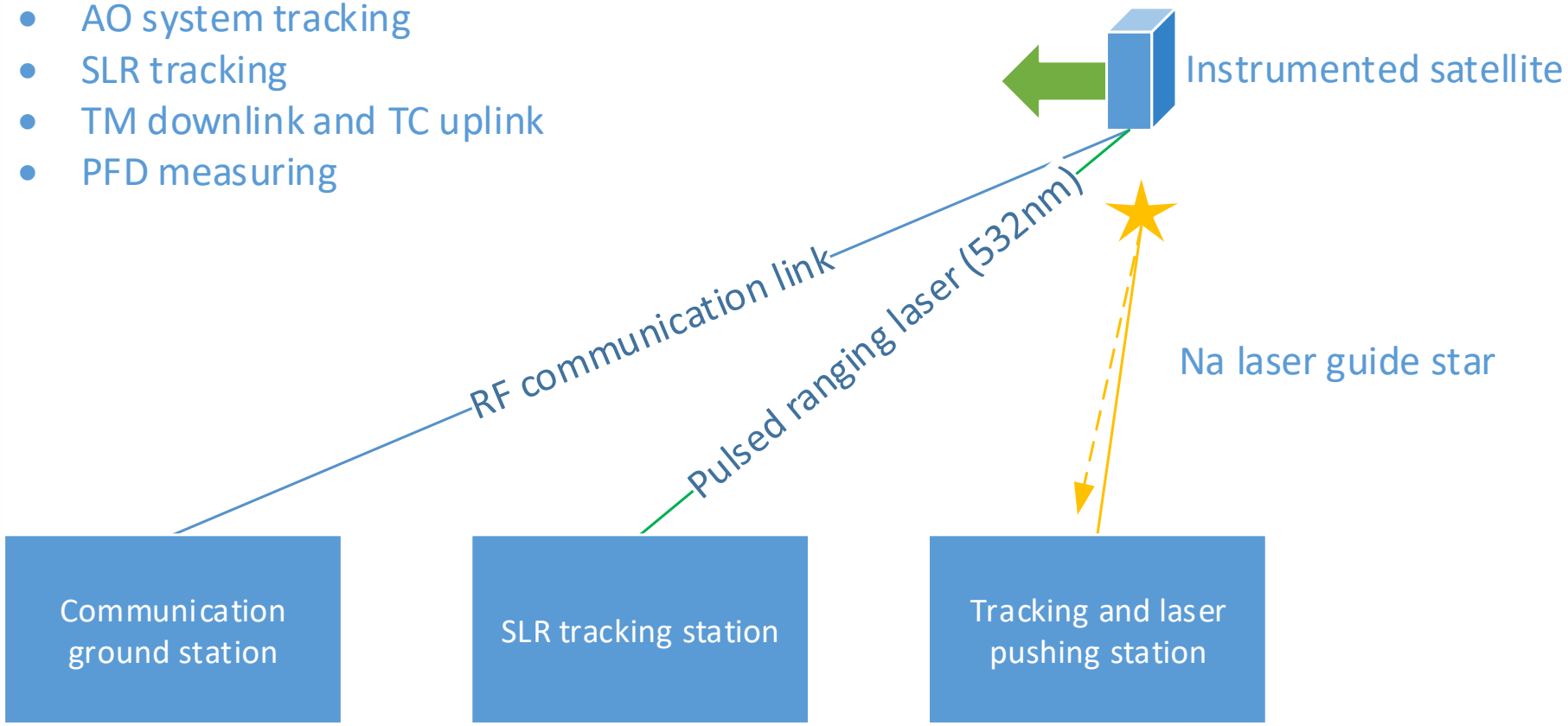
- SLR acquisition and tracking
- Begin TM downlink and TC uplink
- Power on PFD
- Initial AO system acquisition



Preliminary conops for laser engagement

(2) Active tracking

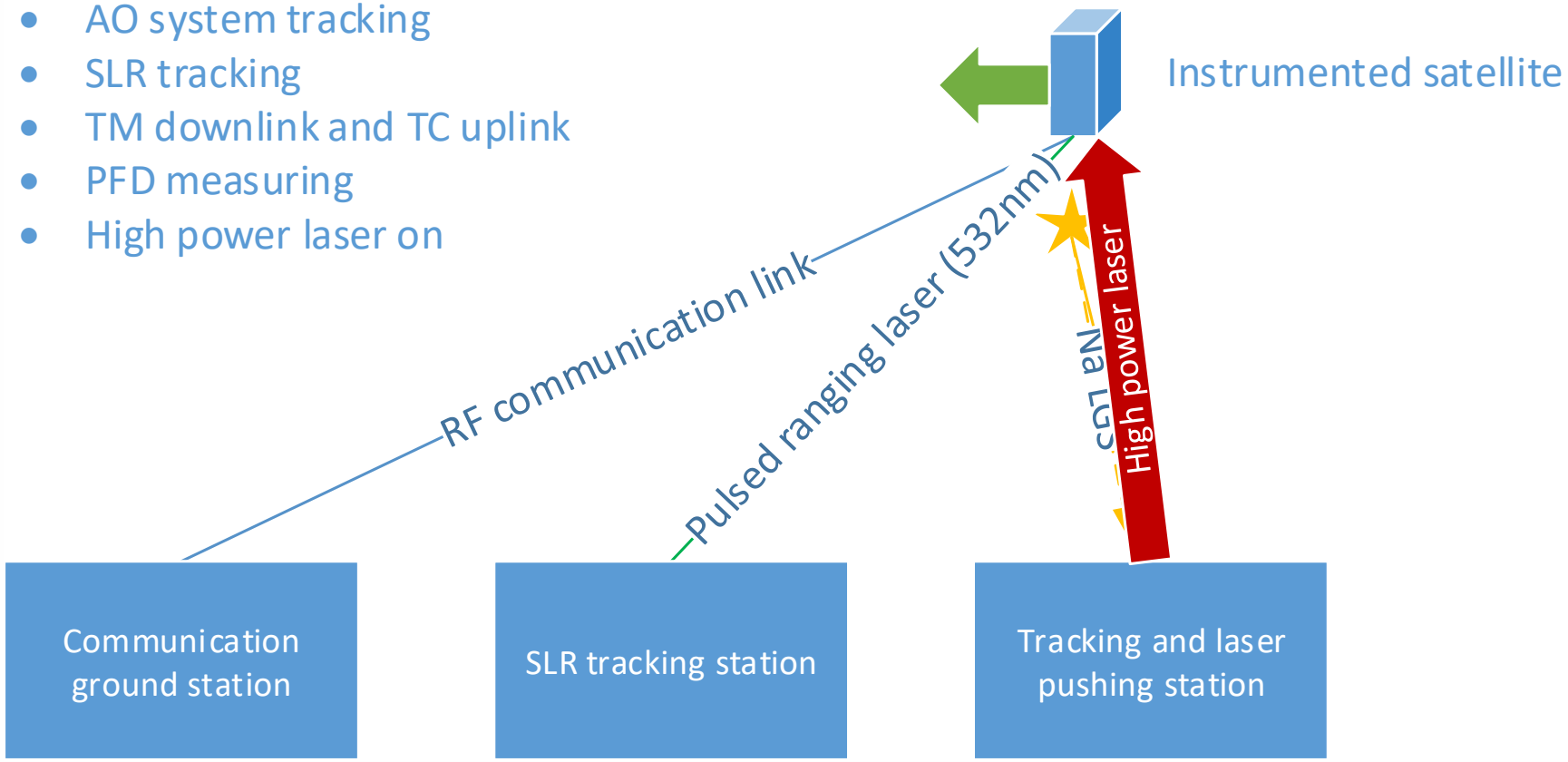
- AO system tracking
- SLR tracking
- TM downlink and TC uplink
- PFD measuring



Preliminary conops for laser engagement

(3) Initiate laser engagement

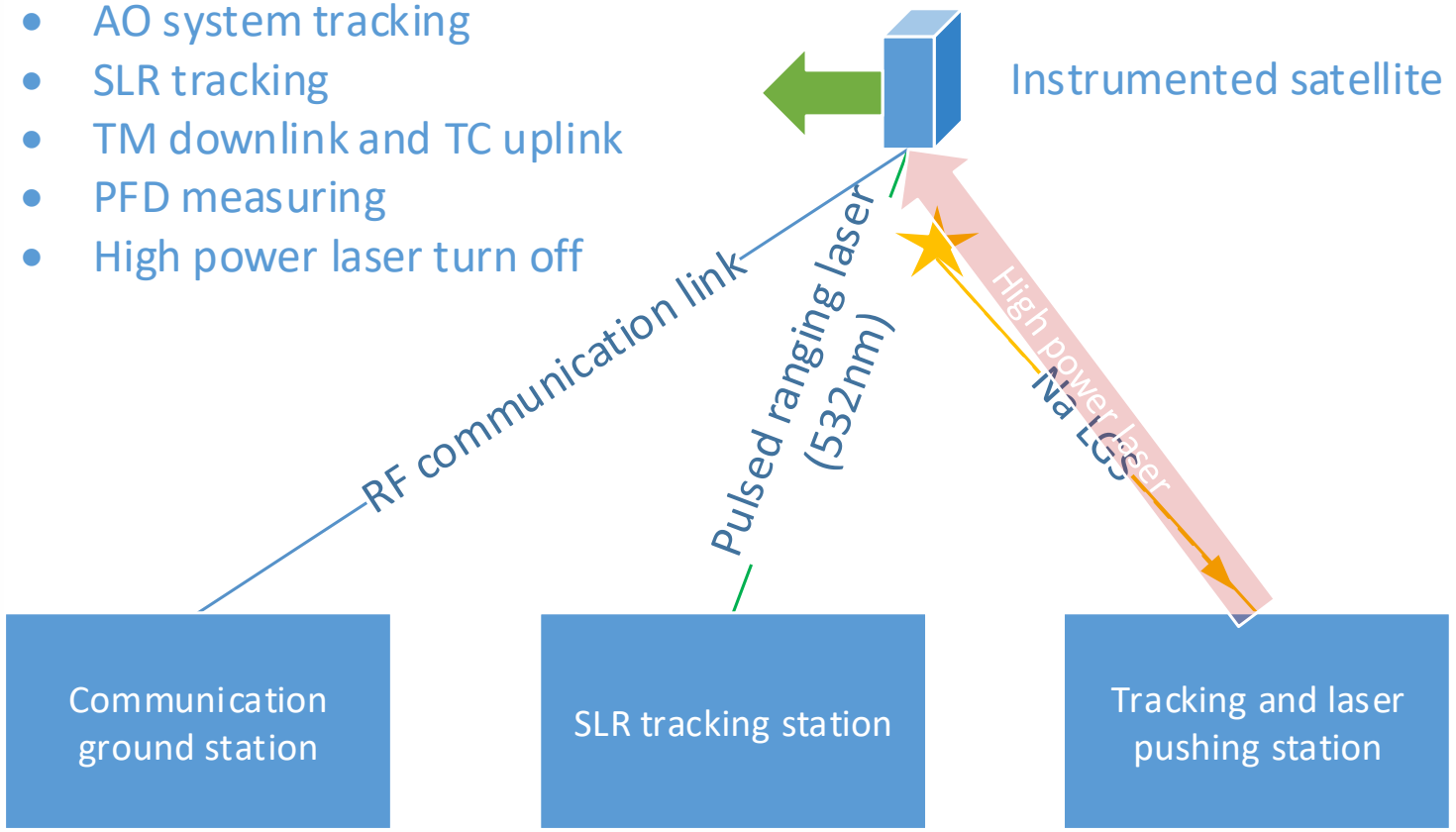
- AO system tracking
- SLR tracking
- TM downlink and TC uplink
- PFD measuring
- High power laser on



Preliminary conops for laser engagement

(4) End of laser engagement

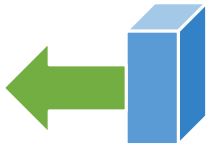
- AO system tracking
- SLR tracking
- TM downlink and TC uplink
- PFD measuring
- High power laser turn off



Preliminary conops for laser engagement

(5) End of pass

- SLR shutdown
- COMMS system shutdown
- PFD power down
- High power laser off



Instrumented satellite

Communication ground station

SLR tracking station

Tracking and laser pushing station

Summary

1. Demonstrate that photon pressure can be used to modify the orbit of smaller debris objects to reduce collision risk and buy time
2. Collision avoidance by photon pressure requires:
   - Precision tracking
   - Accurate orbit propagation
   - Energy Concentration (beam director & AO).
3. Working to develop and launch a cubesat to support system test

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