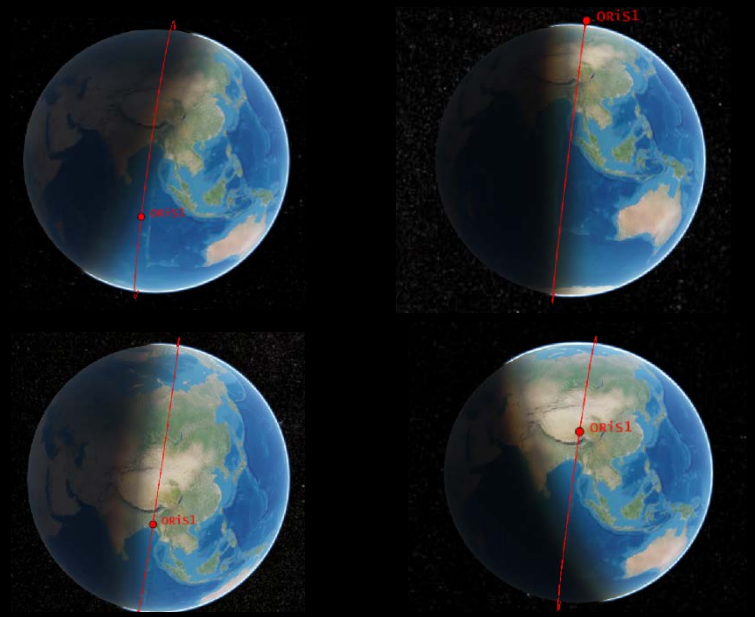
Orbital Recharge in Space

Lopez Francesco
Mauro Anna
Monteleone Giuseppe
Sfasciamuro Domenico Edoardo
Villa Andrea

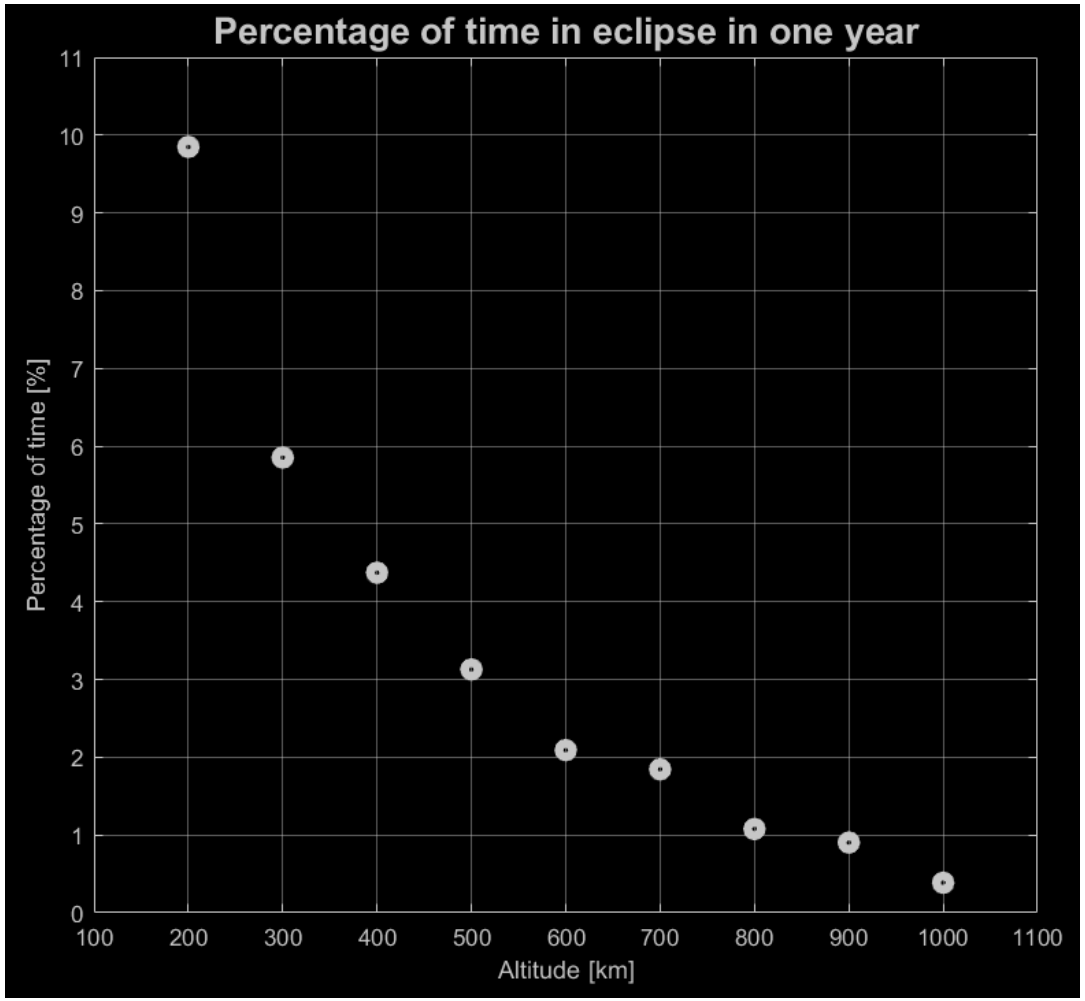
What does ORiS do?

ORiS want to distribute power in space

We studied the design of a particular orbit that will allow ORiS' satellites to remain exposed to the sun for the maximum time possible.

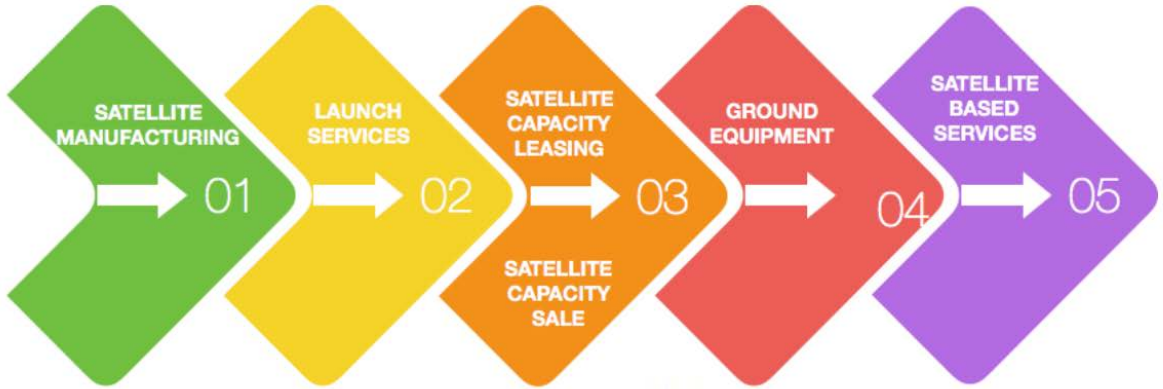


Calculate eclipse time in dawn-dusk orbit



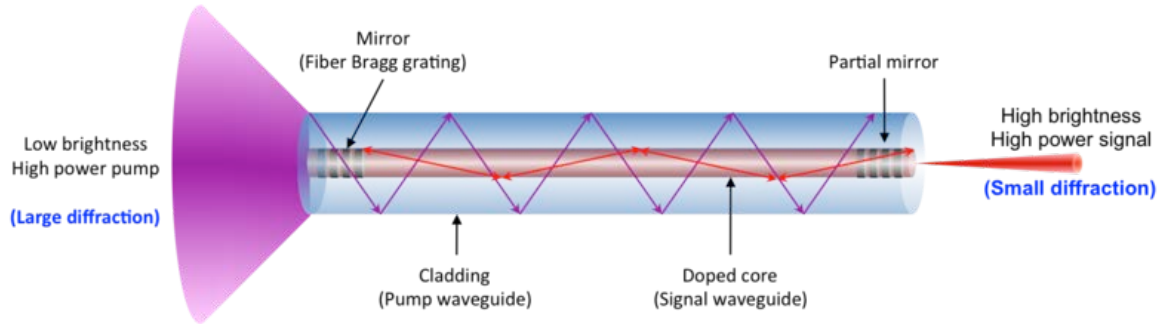
ORiS's Value proposition

- The possibility of having a space power station will enable a wide range of applications, operations, exploration missions not previously possible
- We can reduce mass, volume & complexity, and increase reliability and maintenance
- Augmentation of power to satellites with degraded solar arrays will be one of the first applications of the service



Laser Power Beaming

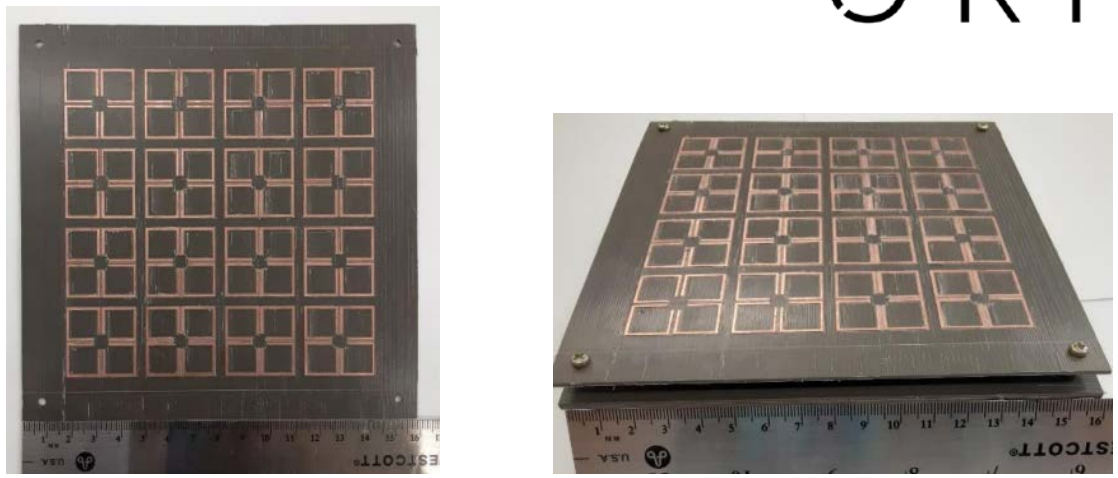
- Laser is the best means of transferring power for space power beaming. Different types of laser devices will be explored to determine the best fit for an on-orbit laser: mainly solid state lasers and fiber lasers.
- Powerful Fiber Lasers with outputs of up to 10 kw at a 1070 nm wavelength (near infrared) are now commercially available.



High power fiber laser

Optical Rectennas

- Rectennas have been studied for decades as a better alternative to conventional solar cells
- 100% theoretical efficiency for monochromatic light
- However, market-ready solutions could be cells specially-designed for the transmitting laser frequency



Fabricated MTM-integrated rectenna

Only recently, demonstrations of the use of rectennas as solar cells have been made in the infrared, due to improvements in nanofabrication of both antenna and diode

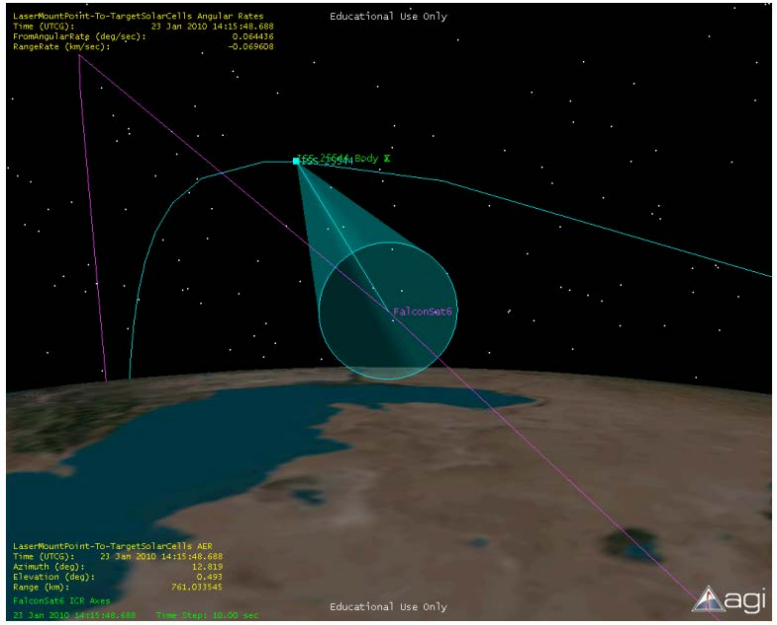
ORiS

Concept:

- Constellation of ORiS satelllites in sun-synchronous dawn/dusk orbits
- Laser transmission of energy
- Reception of this energy through rectennas/ad hoc conversion cells

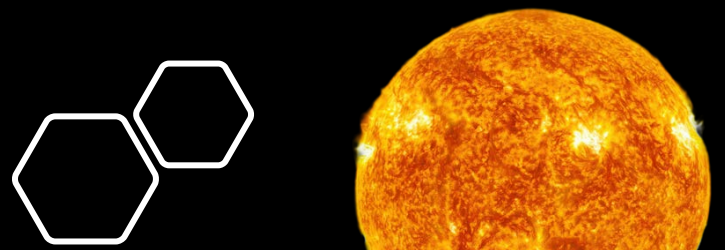
Pros:

- Less mass & volume for each spacecraft, therefore less aerodynamic drag, especially in LEO
- No restrictions due to eclipse periods → simpler systems
- No dependence of earth-pointing or station-keeping requirements from power generation requirements



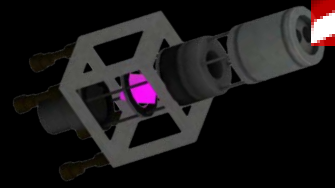
Space-to-space case study

ORIS



1365 W/m^2

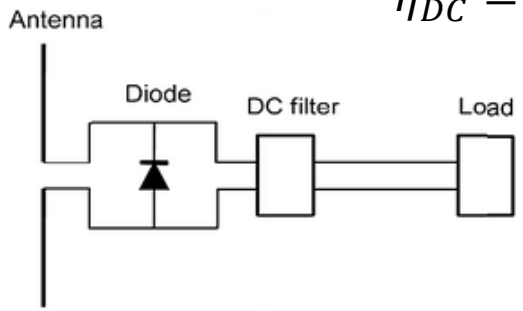
$\eta_{SA} = 0.32$



$\eta_L = 0.6$

Path Losses and Strehl Ratio

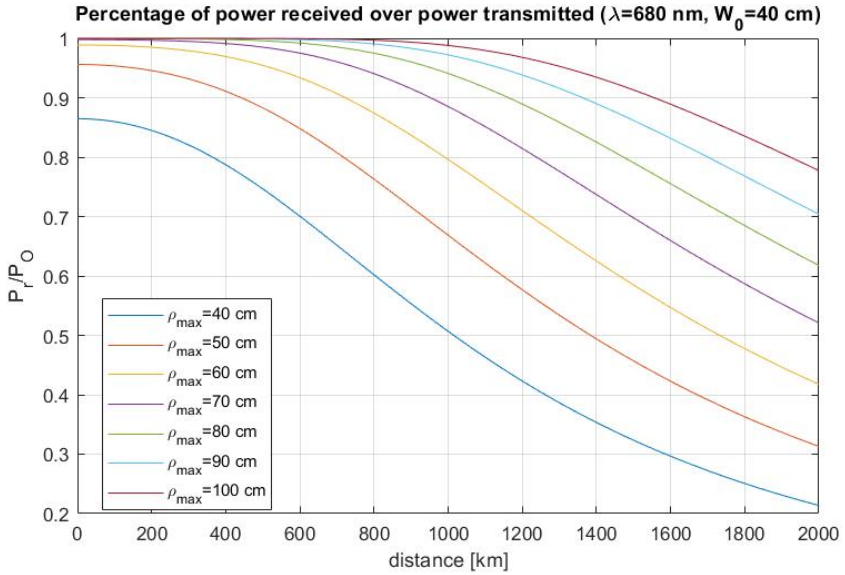
$\eta_{DC} = 0.62$

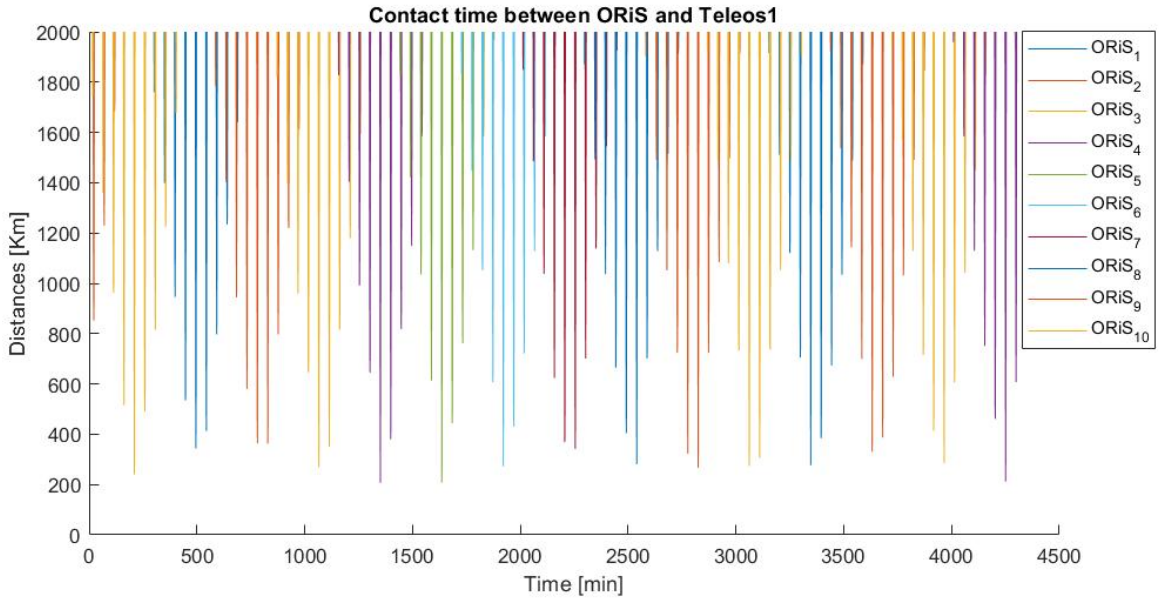


Space-to-space case study

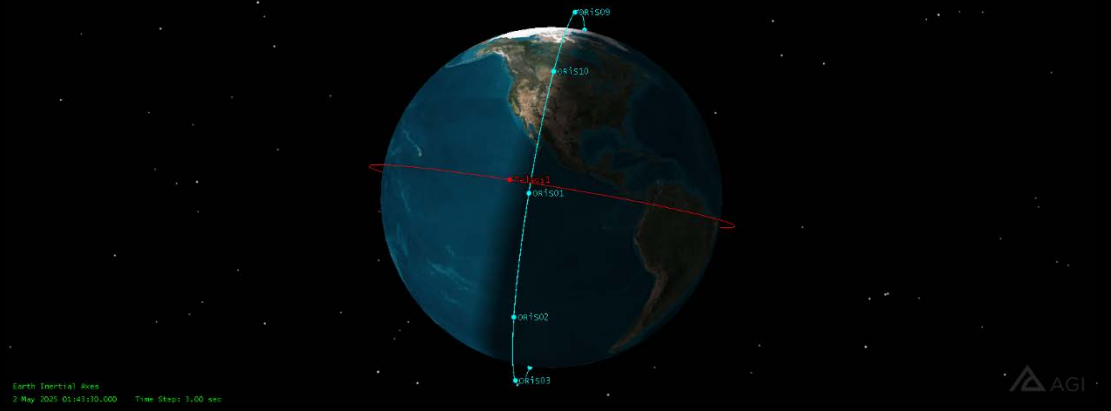
Step 1: Analize the Gaussian beam model to size the transmitting laser and the receiver device

Step 2: Define the admissible distances for transmission to analize the contact time

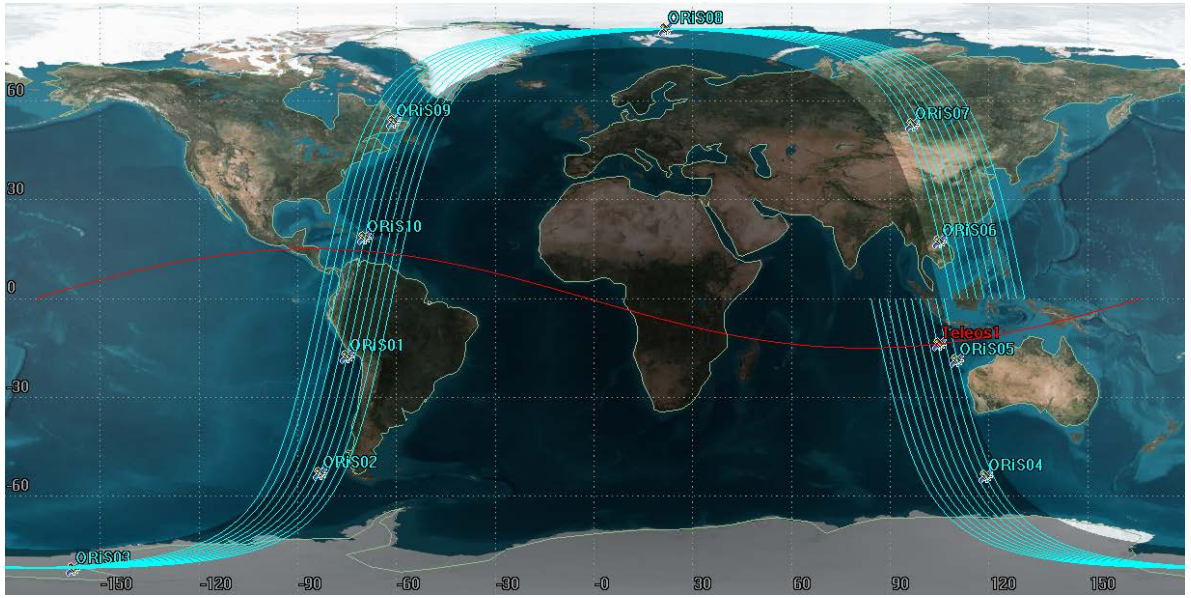




Space-to-space case study



Step 3: Establish the number of satellites and the size of the solar panel's surface to guarantee the total power supply to about n-customers



Our simulation with 80 ORiS in orbit show us that we could guarantee about 40 kW to distribute among our customers' satellites (with various power demands).
We expect to provide this distribution for five years, beaming up to a distance of 2000 km.
The surface of the solar panels of each satellite is about 5 m^2.

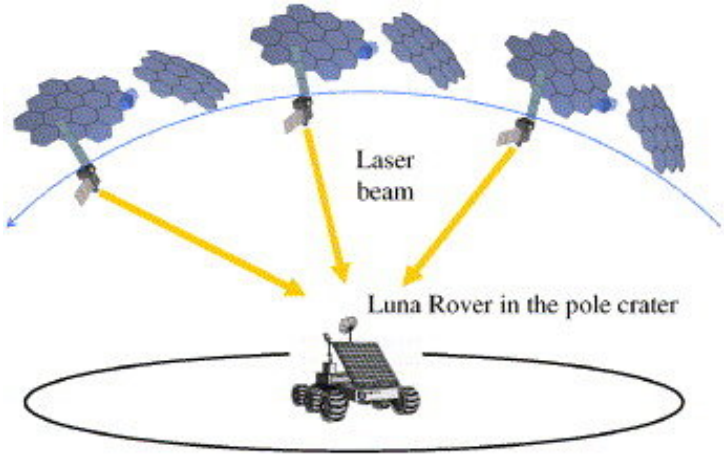
Cislunar space & beyond case study

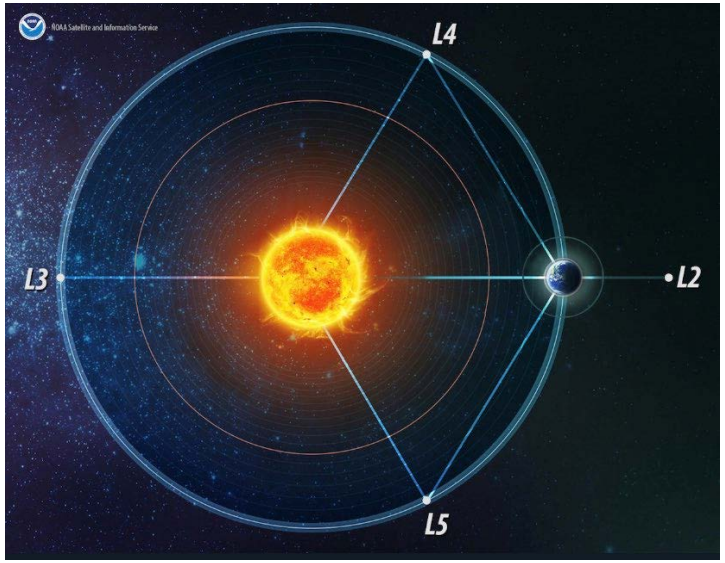
Concept:

- Constellation of ORiS satellites in lunar orbit / L1,L2 points
- Laser transmission of energy
- Reception and convertion of this energy through rectennas or ad hoc cells

Pros:

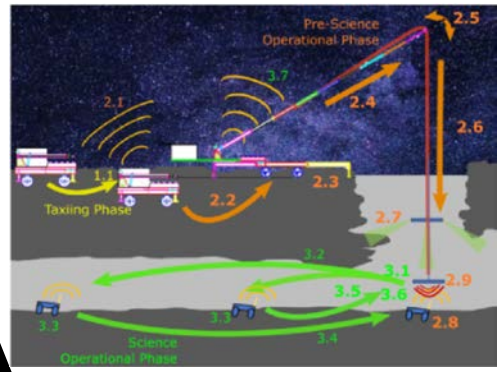
- Beam frequencies penetrates dust, increasing system end-to-end power collection efficiency
- Reduced mass and volume of deployed rovers/surface equipment
- Minimal operational limits and constraints allow continuous, long-duration operations for increased equipment utilization efficiency
- Electric propulsion and interplanetary missions power supply





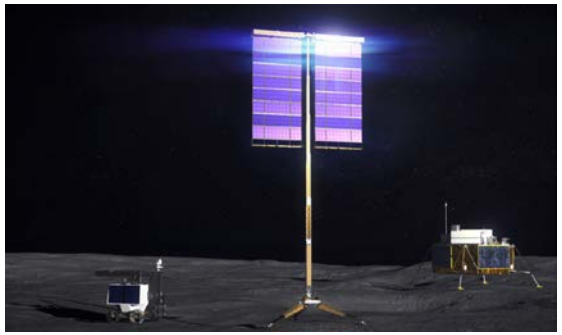
Lunar/martian exploration case study

- Lower mass and volume of rovers relative to long-life batteries
- Removal of cables, increasing reliability and improved system safety
- Increasing system reliability and reduced maintenance
- Reduced system and logistic complexity, and increased safety relative to nuclear options



Very complex system, could be improved and made more reliable without moving parts and cables running along the whole system to transport electrical energy.

Vertical solar panel developed to provide solar energy for the Artemis mission at the lunar South Pole



A more efficient power generation and distribution system in the Martian environment, where climatic events carrying dust and debris would cover the solar panel surface and inhibit the irradiation from the sun

Space to ground applications

- ORiS sees the potential, with its infrastructure, in supporting the energy demand of countries during the transition process towards green energy
- *How?* By sending clean energy in places on earth where it would be too costly or complicated with traditional infrastructures and exploit regions with made-ready infrastructures to convert energy supply into clean energy

Technical challenges

- Laser and rectenna development for our application
- Minimize losses due to laser beam divergence
- High pointing precision and reliability over long distances

Near term demonstration

- Test on laser and rectenna device system using market-available components

Mid term demonstration

- Development of optimize device and test in space environment

Contacts:

Anna Mauro: anna.mauro.am@gmail.com

Andrea Villa: villa.andrea98@gmail.com

Francesco Lopez: francesco.lopez89@gmail.com

Giuseppe Monteleone: giuseppe.monteleone1998@gmail.com