

BUILDING AN ENERGY INDUSTRY IN SPACE FOR THE BENEFIT OF HUMANKIND



**JIM KERAVALA
SHACKLETON ENERGY COMPANY
OFF-WORLD CONSORTIUM**

**ASCE EARTH AND SPACE 2016
12TH APRIL 2016**

The Reality

The Problem

The Solution

EARTH'S POWER CONSUMPTION WILL INCREASE SUBSTANTIALLY THIS CENTURY

2015

WORLD POWER CONSUMPTION

17 TERAWATTS



2100

WORLD POWER CONSUMPTION

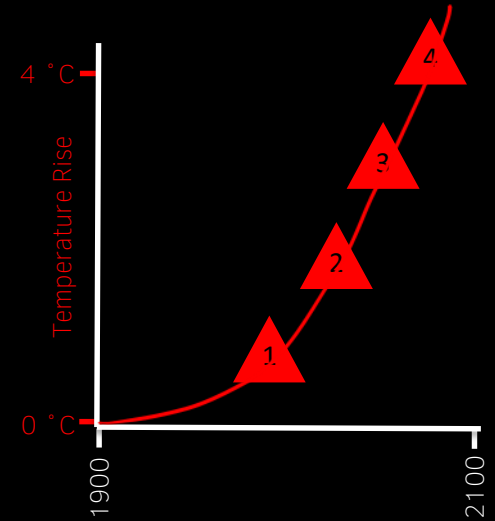
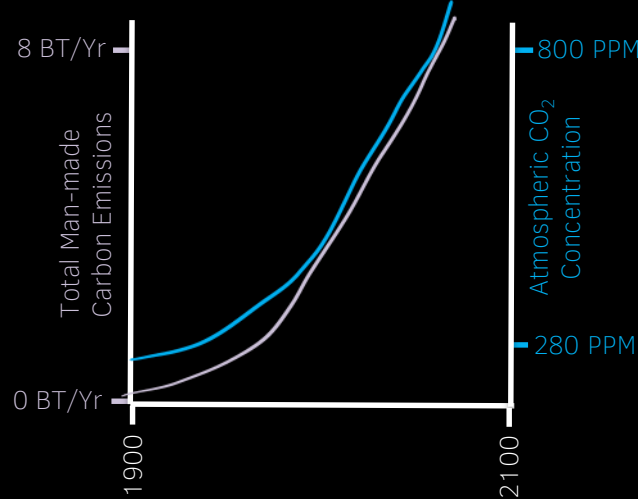
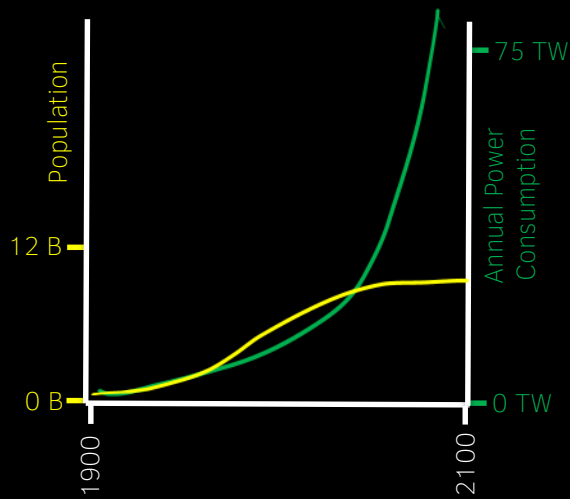
50+ TERAWATTS

POPULATION EXPANSION IS UNDISPUTED



2050 **9.5+** BILLION PEOPLE

OUR EXISTING ENERGY STRATEGIES ARE IN QUESTION







Population growth is expected to reach over 9 billion people by 2050 and 12 billion by 2100. Corresponding net global energy consumption is expected to double or triple over this period. Emerging nations will experience the greatest growth and will resort to cheap energy solutions.



If our civilization continues to utilise hydrocarbon fuels as is currently projected, global industry will emit 8 billion tons of carbon every year by 2100. This may triple the atmospheric CO₂ to over 800 parts per million. Current projections indicate that our species is already unable to reduce the additional man-made carbon emitted into the atmosphere.



Temperature rise directly corresponds to the level of atmospheric CO₂ present. The environmental impact is high:

-  1.5° increase leads to loss of 8% of US fish stock and 9-31% of coral reefs
-  2.5° increase: major loss of Amazon rainforest and its biodiversity
-  2.8° increase: extinction of coral reefs, 21-52% of species extinct
-  >4° increase: major global extinctions

IT IS TIME - G7 COUNTRIES AGREE TO PHASE OUT FOSSIL FUELS BY 2100



The Reality

The Problem

The Solution

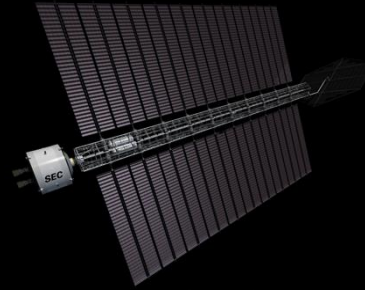
TERRESTRIAL SOLAR IS NOT A SCALEABLE SOLUTION



BUT IMAGINE THESE SOLAR FARMS IN SPACE.

CAPTURING SOLAR ENERGY IN SPACE IS 10-40 TIMES MORE EFFICIENT.

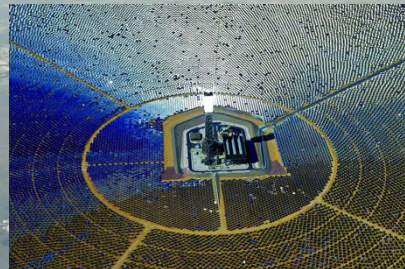
GEOSTATIONARY ORBIT
36,000 km



1,440

WATTS PER M²

- DAY-NIGHT CYCLE
- ATMOSPHERIC LOSSES
- SUNLIGHT ANGLE



36-144

WATTS PER M²



**WE'LL NEED 10-40X LESS
INFRASTRUCTURE**



- #1: ELECTRICITY FOR 10 BILLION PEOPLE**
- #2: EXCESS POWER FOR WATER DESALINATION**
- #3: 100X INFORMATION BANDWIDTH**

**“GREAT. EXCEPT...
IT WILL NEVER HAPPEN.”**

GEOSTATIONARY ORBIT

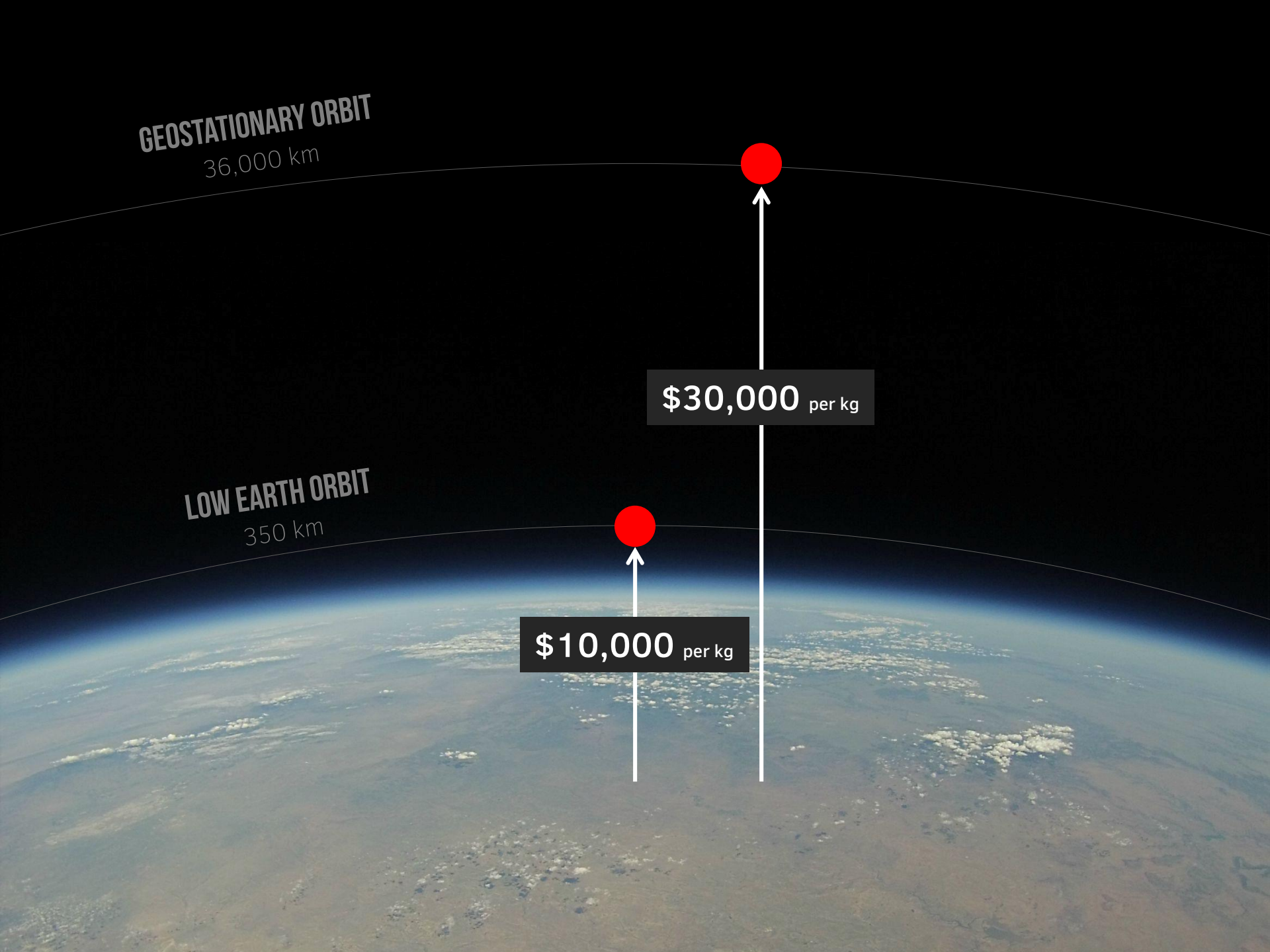
36,000 km

\$30,000 per kg

LOW EARTH ORBIT

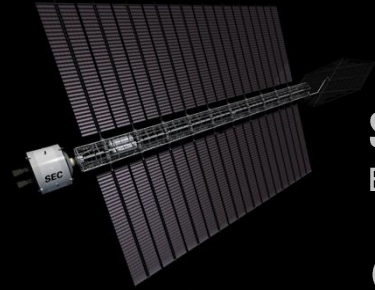
350 km

\$10,000 per kg



TRANSPORTING INFRASTRUCTURE UP FROM EARTH IS PROHIBITIVELY EXPENSIVE.

GEOSTATIONARY ORBIT
36,000 km



SOLAR FARMS IN GEO
BUILT ON & LAUNCHED FROM EARTH

\$30
TRILLION CAPEX

\$30,000 per kg



**“WELL, MAYBE ONE DAY,
WHEN LAUNCH COSTS DROP BY 95%...”**

OR...

**WE THINK BIGGER,
IN SYSTEMS AND
DOWN, NOT UP.**

The Reality

The Problem

The Solution

THE OFF-WORLD LONG TERM ARCHITECTURE

THE MOON HAS AN ABUNDANCE OF RAW MATERIALS

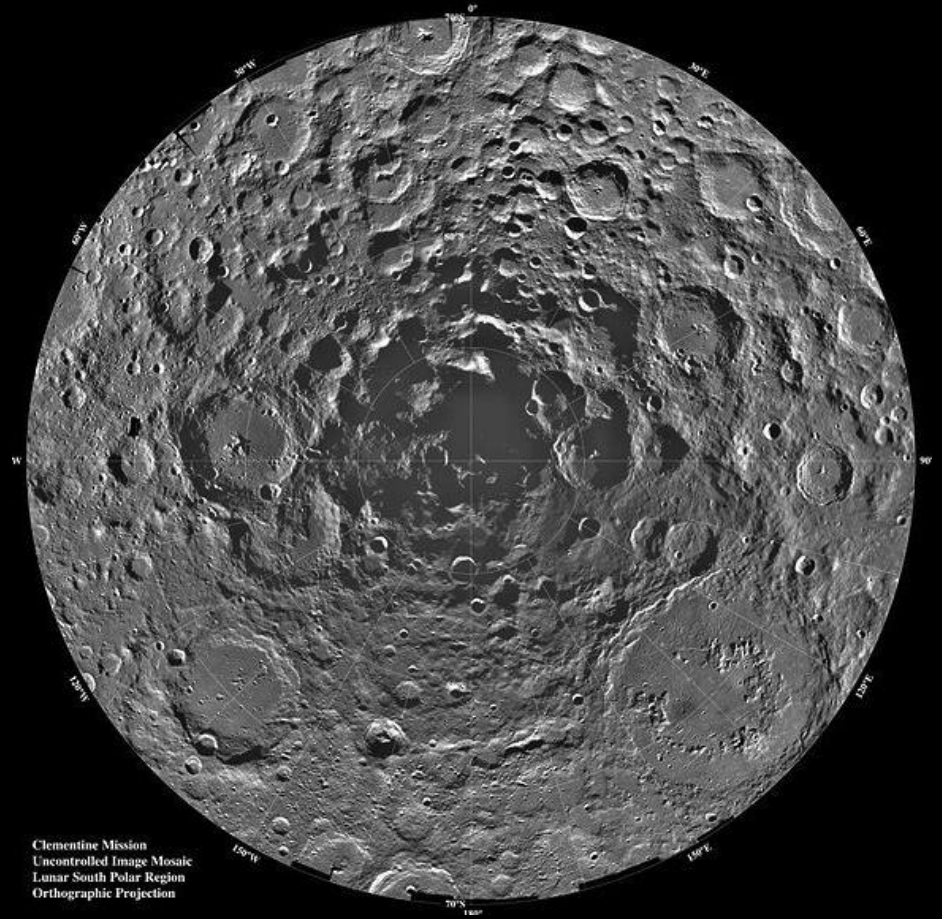
DIRECTLY SERVING A MARKET OF 10 BILLION PEOPLE

WE HAVE THE RIGHT RESOURCES ON THE MOON.

**1.6 BILLION TONS OF WATER ICE
FOR FUEL**

+

**99% OF STRUCTURAL
MASS MATERIALS FOR
SOLAR POWER SATELLITES
AND INFRASTRUCTURE**



Clementine Mission
Uncontrolled Image Mosaic
Lunar South Polar Region
Orthographic Projection

USING LUNAR RESOURCES TO BUILD SOLAR POWER STATIONS MAKES THE IDEA ECONOMICALLY VIABLE.

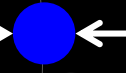


\$30,000 per kg

SOLAR STATIONS
BUILT ON & LAUNCHED FROM EARTH

\$30
TRILLION CAPEX

GEOSTATIONARY ORBIT
36,000 km



\$250 per kg

SOLAR STATIONS
BUILT ON & LAUNCHED FROM THE MOON

\$0.17
TRILLION CAPEX

MOON
385,000 km



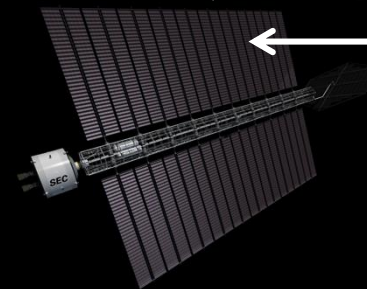
ECONOMIC VALUE OF THE MOON: \$250 PER KG

WE CAN SOLVE WORLD'S ENERGY, WATER AND INTERNET CHALLENGES IN ONE GO.



GEOSTATIONARY ORBIT
36,00 km

MOON
385,000 km



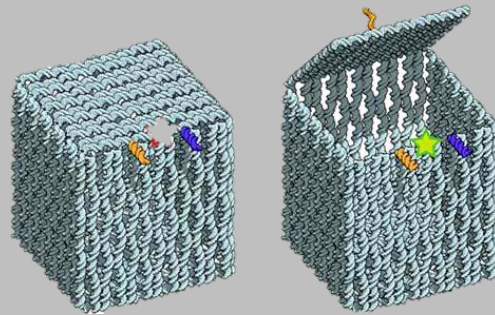
Solar stations, doubling as communications platforms in geostationary orbit (36,000 km above Earth's surface) are the cleanest, most efficient and most elegant way to supply 30 terawatts of power to 10 billion people by 2100. Excess power can be used to desalinate water. Gigabit internet trunk communications can be modulated on to the transmission beam. The addressable market for this combined infrastructure by 2050 will be almost \$3 trillion for wholesale electricity alone.

INTEGRATED SCIENCE, TECHNOLOGY AND COMMERCE — AN INDUSTRIAL REVOLUTION

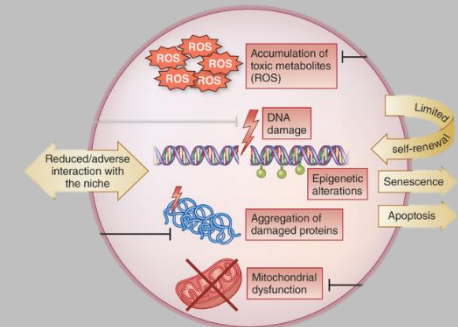
Machine Intelligence and Augmented Human-Computer Interfaces



Advanced Fabrication and Manufacturing Systems



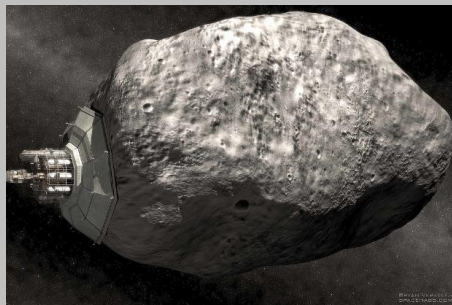
Space Medicine Needs Lead to Extended Human Longevity



Industrial Robotics to Redefine Earth & Space Economy



Space Resources and Materials Fabrication on Moon and Asteroids



Space Construction, Settlement and Power Systems Infrastructure

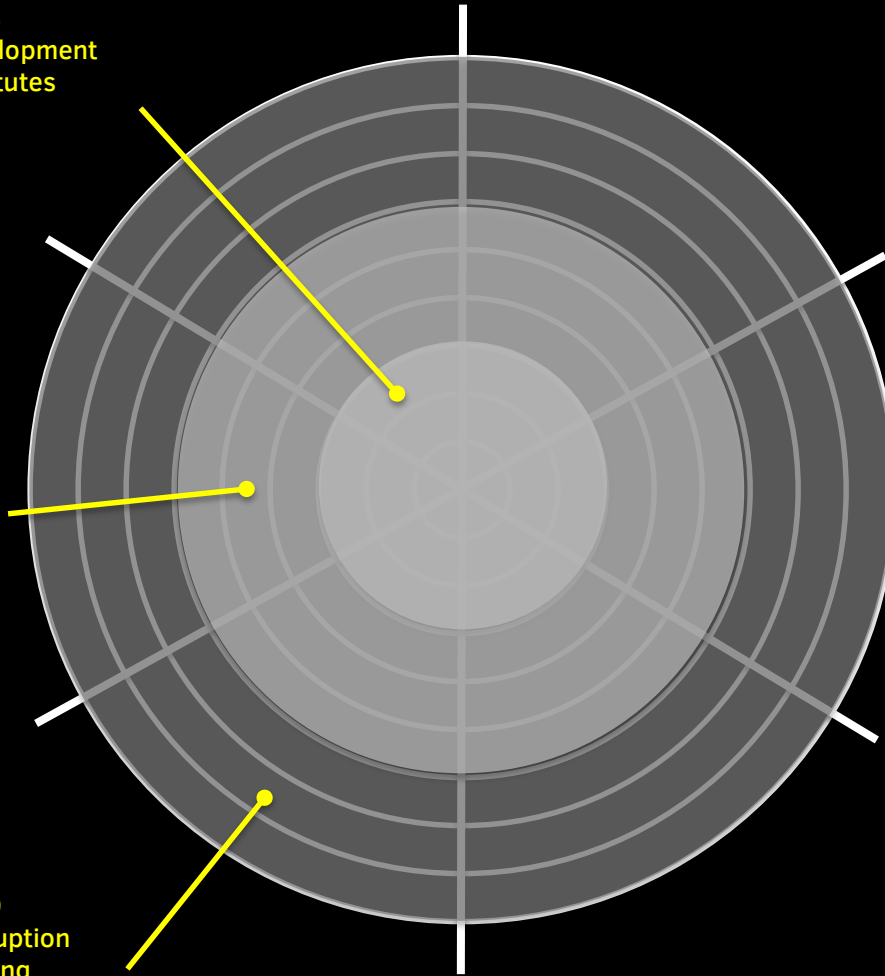


SCIENCE, ENGINEERING AND INDUSTRIALIZATION AS A GRAND UNIFICATION

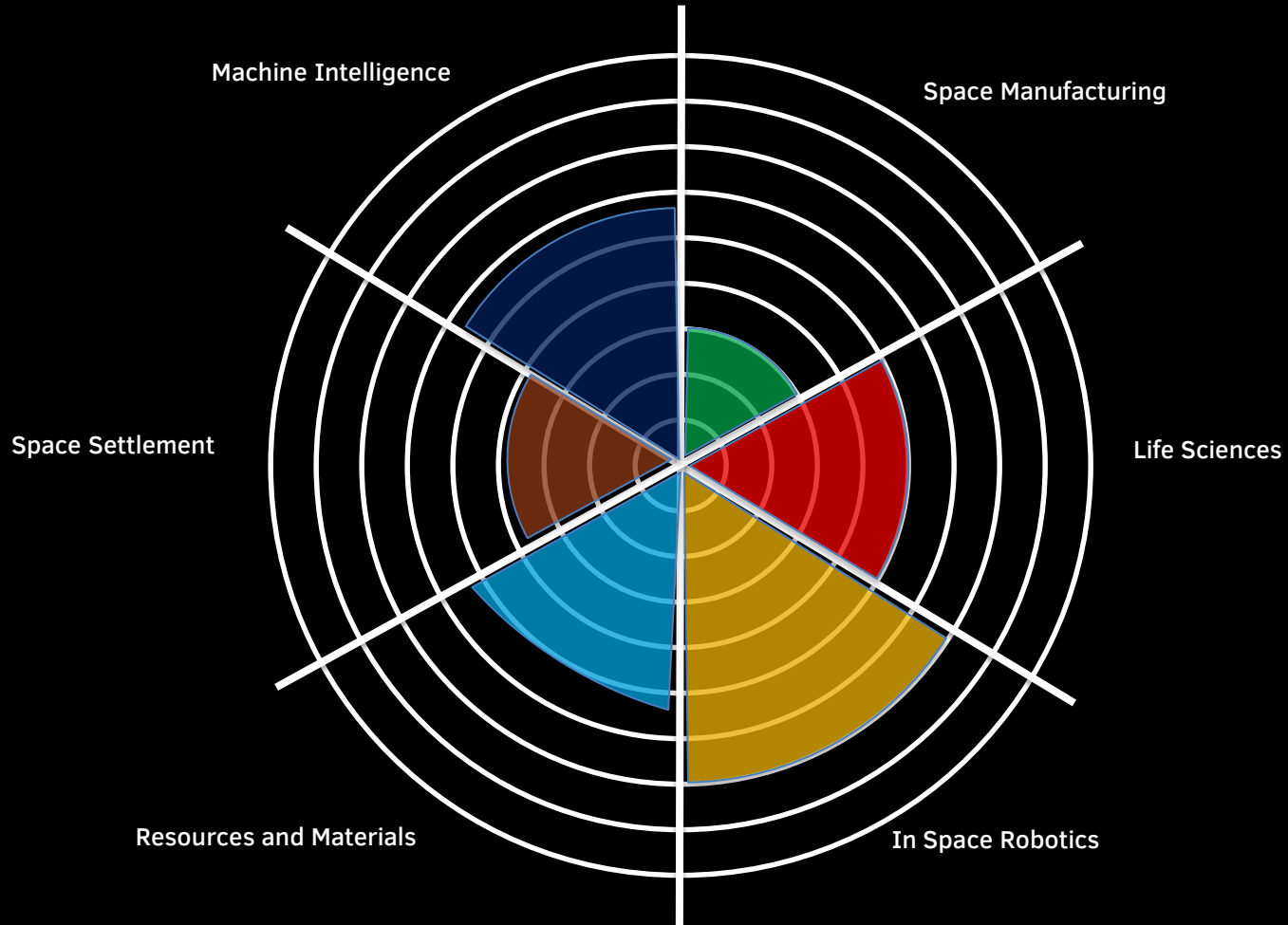
- Domains 1 to 3
- Research Development
- Research Institutes

- Domains 4 to 6
- Commercial Development
- Scaling commercial companies

- Domains 7 to 9
- Industrial Disruption
- Industrial scaling



ENGINEERING / MARKET MATURITY FOR PROGRAM SEQUENCE SELECTION



**ECONOMIC VALUE OF THE MOON:
\$250 PER KG TRANSPORTATION COST TO GEO**

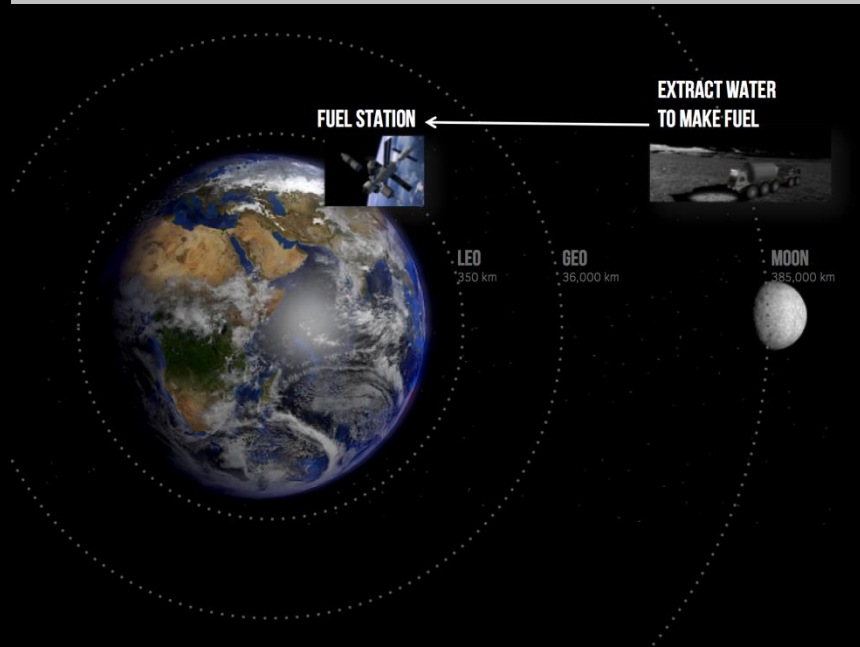
PROGRAM 1 WILL CREATE TWO REVENUE-GENERATING ASSETS.

Asset #1:

**Fuel station in LEO
with a lunar supply chain of fuel**

1,040
METRIC TONNES
OF FUEL

Total annual production capacity of lunar supply chain, consisting of 71 spacecraft and lunar modules.

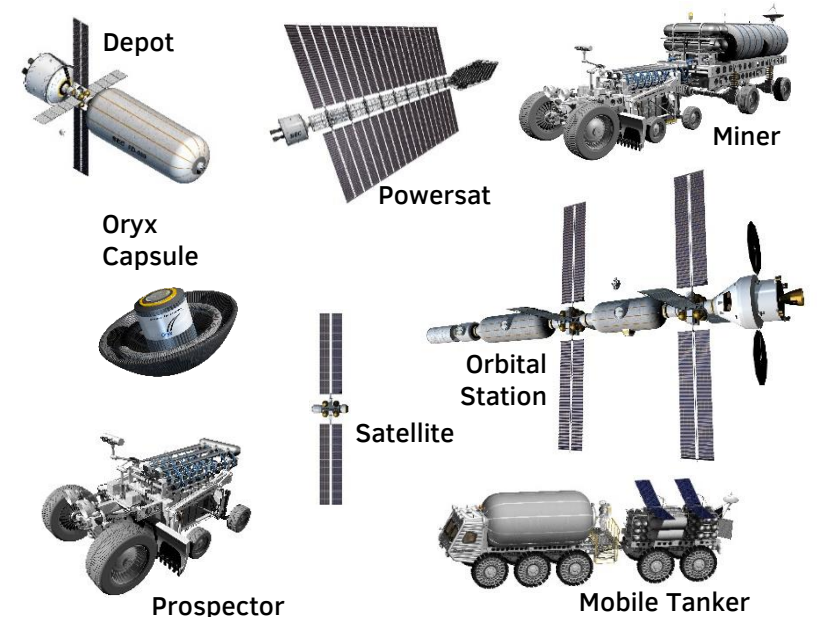


Asset #2:

**Production line for
a new generation of reusable spacecraft**

30
SPACECRAFT

Total annual production capacity of facilities used to produce SEC's new generation of modular, reusable and refuelable spacecraft and modules.



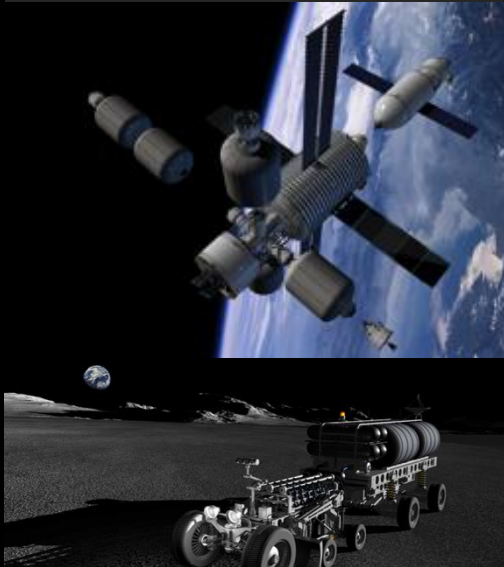
WE WILL PROCEED IN THREE PROGRAMS.

2022>>

PROGRAM 1

Fuel Station & Lunar Supply Chain

Estimated cost \$18 billion



2028>>

PROGRAM 2

Manufacturing on the Moon

Estimated cost \$40 billion



2040>>

PROGRAM 3

Space Based Solar Power & Internet

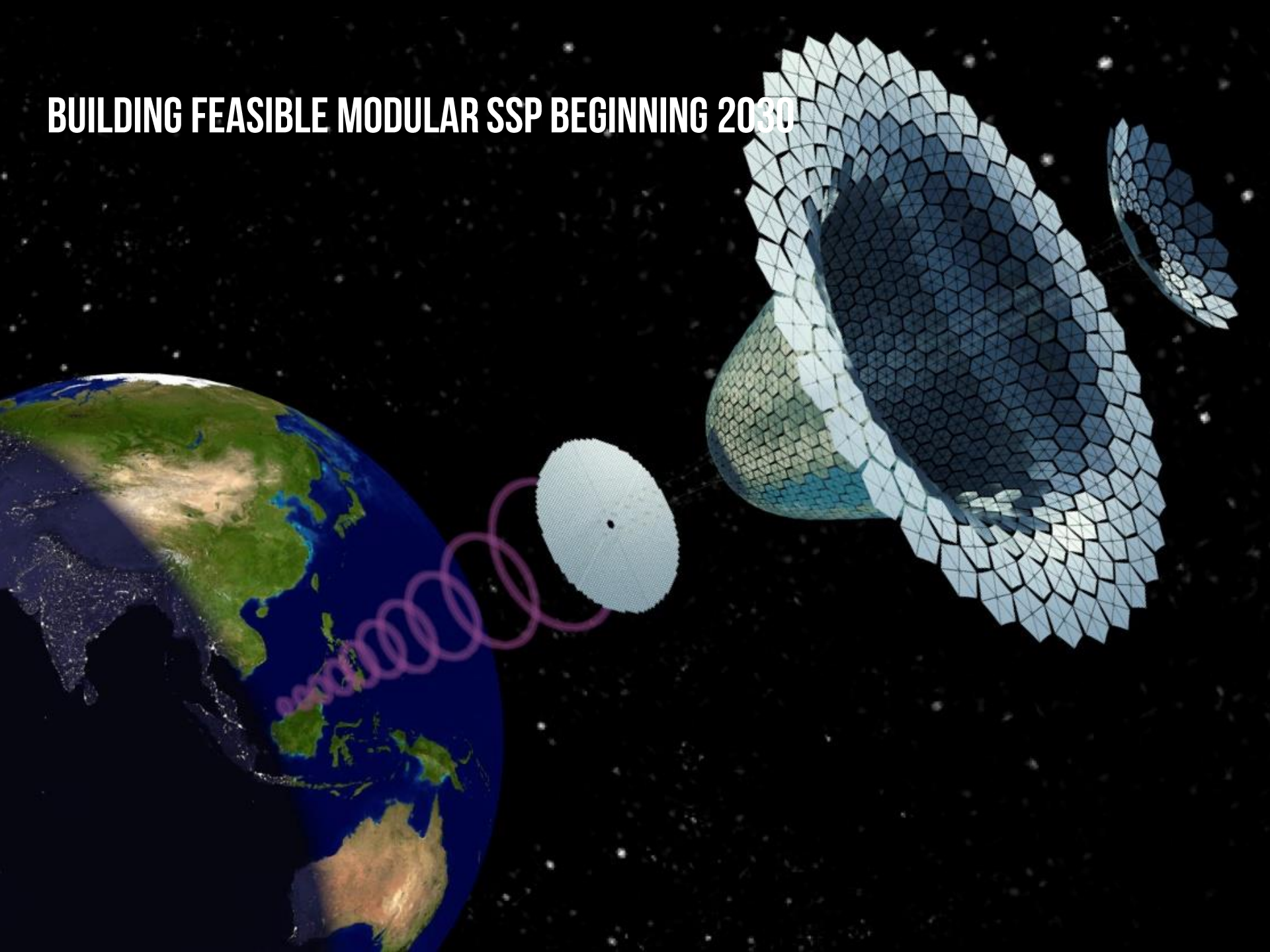
Estimated cost \$270 billion

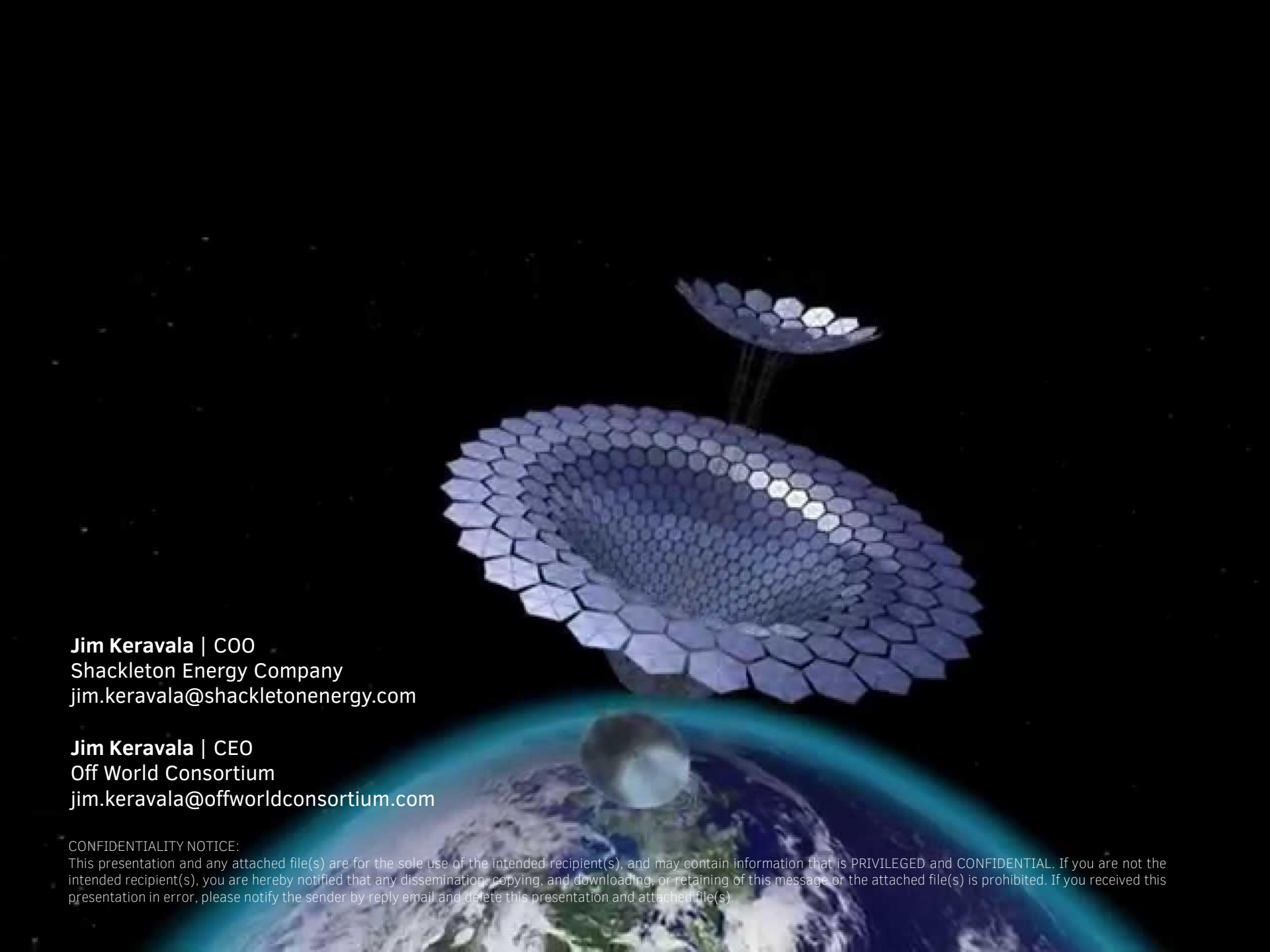


**USE LUNAR RESOURCES
FOR THE COMMON BENEFIT OF ALL HUMANKIND.**

ESTABLISH A PLATFORM FOR EXPANSION INTO THE SOLAR SYSTEM

BUILDING FEASIBLE MODULAR SSP BEGINNING 2030





Jim Keravala | COO
Shackleton Energy Company
jim.keravala@shackletonenergy.com

Jim Keravala | CEO
Off World Consortium
jim.keravala@offworldconsortium.com

CONFIDENTIALITY NOTICE:

This presentation and any attached file(s) are for the sole use of the intended recipient(s), and may contain information that is PRIVILEGED and CONFIDENTIAL. If you are not the intended recipient(s), you are hereby notified that any dissemination, copying, and downloading, or retaining of this message or the attached file(s) is prohibited. If you received this presentation in error, please notify the sender by reply email and delete this presentation and attached file(s).