“I lost 80 kilos in 30 seconds without dieting and I feel great!” GM, St. Louis, Missouri
Exponential Space

and unlimited abundance

Gregg Maryniak
Co-Chair, Energy and Space
Summary

• Space is the key to abundance for our species

• The real solar system is *surprisingly different* than the one you learned.

• Changing the *style and goals* of spaceflight will enable exponential increases in the value produced by space activities that will have massive impact on the world.
Something Interesting!
CHALLENGE:

MOBILIZE $90 TRILLION IN CAPITAL OVER THE NEXT 15 YEARS
Scarcity vs. Abundance
The two reasons that launch is expensive:

ONE: We don’t launch very often (because it’s expensive!)

TWO: Geography and Physics (which we will examine in a moment)
Part II: Exponential Spaceflight

- Exponential **Payloads**
- Exponential **Markets**
- Exponential **Abundance**
Moore’s law effects are improving the economics of existing space activities by decreasing the mass and cost of satellites.
Exponential Spaceflight

- Exponential Payloads
- Exponential Markets
- Exponential Abundance
WHAT IS THE PERFECT COMMERCIAL SPACE PAYLOAD?
Why did we start XPRIZE?

• Open a nearly infinite set of material and energy resources to solve Earth’s physical problems in an equitable and just way.
• **Reduce cost of spaceflight** by creating industries beyond traditional telecom and earth observation to increase the flight rate to space.
• **Remove the barrier** that “everyone knows” that Governments are the only space-capable entities.
• Demonstrate a **new style** of spaceflight with a new set of players
Part II: Exponential Spaceflight

- Exponential Payloads
- Exponential Markets
- Exponential Abundance
The problem with terrestrial solar power is that the Earth gets in the way of the Sun most of the time!

These folks have gone over to the dark side

These folks have solar power now
Changing SCARCITY to ABUNDANCE

The most important fact about space travel and the solar system
Gravity Well model of the solar system
Lunar launch requires only $1/22$ of the energy of terrestrial launch.
The resources we need to live, work and build exist on the Moon

- The moon contains oxygen, silicon and metals essential for construction, power collection and propellants

- *Lunar Prospector* found abundant hydrogen at the permanently-shadowed poles to complete the inventory of feedstocks needed for exploration and colonization
The Second Most Beneficially Disruptive Space Fact that you will hear today:
The Second Most Beneficially Disruptive Space Fact: **Water** is abundant *in and near* free space.
NASA Lunar Prospector
Launched January 1998

Lunar Prospector mockup at design review, in May, 1990
Omni Systems, El Segundo, California
Earth-Moon Teleoperation

• The moon is only 1.35 light-seconds from the Earth

• Humans easily adapt to the 2.7 round trip signal delay

• Many lunar workers will “phone it in” from home on Earth.
Next project... The moon!
Approx. size of Earth ➔
Carbon-free ultra-fast global travel
Dr. Robert Forward’s *Starwisp* Concept

Microwaves beamed into space . . .

Carrying its own fuel will make *Starwisp* much too heavy to go fast; instead, it will get power from microwaves generated by a huge solar-powered satellite. In between launches, the satellite would send the power down to Earth to be sold.

. . . and focused through a huge lens . . .

Made from rings of aluminum and floating far out in space, the lens will focus the microwaves on *Starwisp*. Concentrated energy will fling the ship starward with 185 times the force of gravity.

. . . may someday launch a spacecraft to the stars

After two weeks of microwave blasting, *Starwisp* traveling at one-fifth the speed of light would coast to Alpha Centauri in 21 years. Once it arrives, another short burst of microwaves would provide electricity to run the ship’s microprocessors, letting *Starwisp* transmit images back home.

**Starwisp** Although it spans four miles (6 km), *Starwisp* weighs only one ounce (28 g). To carry passengers, ships, and cargo stations, it would have to be a hundred times bigger. It could be possible—in 500 years or so...
More Video References

- [https://vimeo.com/143258691](https://vimeo.com/143258691)
- [https://vimeo.com/143175173](https://vimeo.com/143175173)
“All I’m saying is now is the time to develop the technology to deflect an asteroid.”
Overcoming scarcity

• We now know that space is more like a bountiful ocean than a barren desert.
• Energy is abundant
• Materials are abundant in Free Space outside of planetary gravity wells
• Water is surprisingly abundant
• We can do amazing things once we overcome scarcity of materials in free space.
Conclusions

• Space offers unlimited abundance, options and hope for humanity.

• To really benefit from space we need to change the target locations to FREE SPACE from planetary surfaces (stay out of gravity wells!)

• Use materials already in space for propellant, construction and shielding.

• Exponential (partially self replicating) systems can yield large benefits
No Growth, No World? Think About It

by Eduardo Porter

Best Quote: “Anyone who believes exponential growth can go on forever in a finite world is either a madman or an economist.”

Kenneth Boulding as quoted by Paul Erlich.
Extent of Human Radio Broadcasts

Thanks to Nick Rickman for the artistic conception of the Milky Way.
Takeaway Concepts Checklist

- Spaceflight is presently costly and dangerous due to the difficulty of escaping deep planetary gravity wells.
- The Gravity Well Model of the solar system depicts the exponential advantage of being on or near the plateau of Free Space.
- We live in a two-world system with our moon near the plateau of Free Space.
- The three essential ingredients for economical space operations are
  - Energy, Intelligence and Materials
- There is a surprising abundance of water and other frozen volatiles at our Moon’s poles
- The resources available to civilization in Free Space utterly dwarf those of the Earth.
- Space resources will enable future growth and permit us to bio-remediate our home planet
Thank You!

Gregg.Maryniak@singularityu.org
References

• **Please** see the 4-page energy and space reference (on the portal)

• In particular for space, read *The High Frontier* (Kindle edition) and *2081* (buy used)
United Launch Alliance

Cislunar Plan (excerpts) addendum
Road Map to the Cislunar-1000 Economy

Part 1: TODAY
- International Space Station
- LEO (Low Earth Orbit)
- GEO (Geostationary Earth Orbit)
- Crew
- Cargo
- Research, Imagery
- Expendable Launch Vehicles
- Gross Space Product: $330B/yr
- Population: x 5

Part 2: 5 YEARS
- Space Manufacturing
- Commercial Habitats
- Commercial Research
- Prospecting (lunar, asteroids)
- ACES Long Duration Upper Stage
- Gross Space Product: $500B/yr
- Population: x 20
Lunar Water

- Water at Lunar poles
  - Cold Traps in Craters
  - ~10B mT per pole

- Fuel, Water, Oxygen

Lunar Reconnaissance Orbiter

New polar lighting studies
LROC WAC composite images

Credit: LRO Camera Team
Paul Spudis
 Costs of Resource in Cislunar Space

- GEO
- LEO
- EML1
- L1
- Moon

Cost From Earth
- Earth: $0.0011/kg
- LEO: $5k/kg
- GTO: $15k/kg
- GSO: $20k/kg

Cost From the Moon
- L1: $10k/kg
- Moon: $0.5k/kg

Cost: $35k/kg
• Unlimited, green, constant, worldwide source of energy
• Energy is a $6T / yr growing business

Transportation Cost per Station
• $320B Traditional
• $190B Vulcan ACES
• $110B Lunar Propellant
Standing on the Threshold of Robust Cislunar Economy

- Government
  - National Security
  - Science
  - Communication
  - Remote Sensing
  - Research
  - Education
  - Exploration

- Commercial
  - Communication
  - Remote Sensing
  - Research
  - Manufacturing
  - Tourism
  - Mining
  - Solar Power Beaming

Credit: Golden Spike
Credit: John C. Mankins
See the longer ULA presentation at: