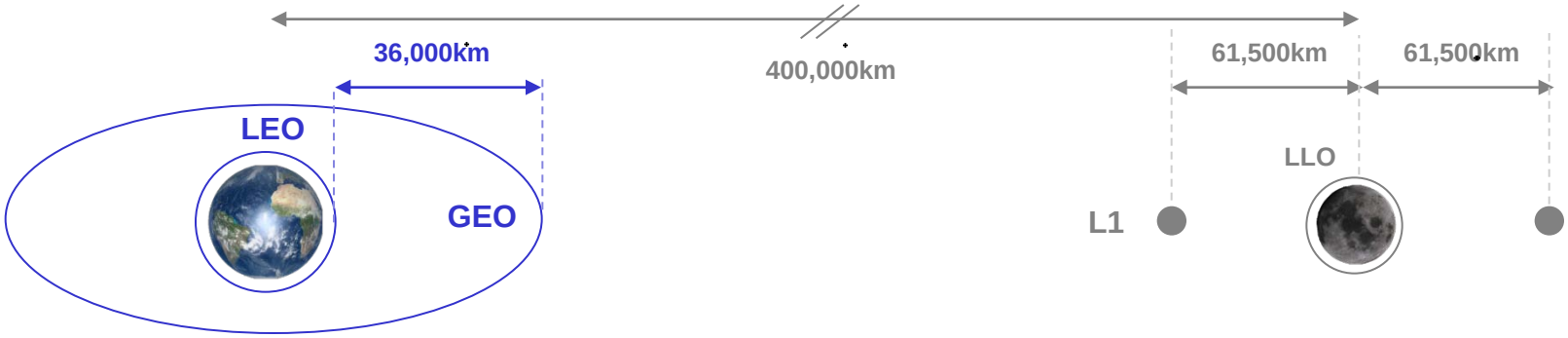
SPACE VENTURES INVESTORS

SPACE RESOURCES

Due Diligence for Investing in Space Resources



- Space Resources General Overview
- The Business Case
- Competitors
- Business Models
- Emerging Space Resources Companies

Scope of this Due Diligence

The following ‘Due Diligence for Investing in Space Resources’ report is for people and companies who are known in Space Ventures Investors Ltd’s network, to be in this network means to be at least in email contact, including on a mailing list with an opt-in to receive further information like requests for your feedback on this document.

The analysis of space resources business model and operations, were performed with diligence by Space Ventures Investors Ltd.

The goal of this report is that you the reader, an individual or company, can:

- Decide if an investment in space resources (in general) is for you,
- The risks involved, and
- the potential returns (not only monetary).

Copyright Notice

Limitations

This document and any analysis, opinions, results, evaluations or recommendations herein or accompanying it, was prepared by Space Ventures Investors for the benefit of SVI’s Network.

Any statements made in this document that are not historical fact are based on data and information provided by others. Space Ventures Investors has not verified the accuracy of any such data and information unless otherwise specified. This document may contain forward-looking statements regarding future events such as ‘forecast’, ‘expect’, ‘believe’, ‘estimate’, ‘anticipate’, ‘will’, ‘could’, ‘may’ or ‘might’ and the negative of such terms or similar expressions. By their nature, forward-looking statements involve risks and uncertainties, because they relate to events and depend on circumstances that may or may not occur in the future and that are beyond the control of Space Ventures Investors. We caution you that forward-looking statements are not guarantees of future performance. No allowance has been made for changes in government policy or regulation; economic performance; price; taxation; company failure; strategic change; ownership change; or other external factors that could cause actual results to differ materially from those shown in the document. Space Ventures Investors specifically does not guarantee or warrant any estimate, forecast or projected outcome contained in this document.

The information contained in the document was finalised on march March 31st, 2018 and is based on the conditions encountered and information available at that time.

A Quick Guide to this Document

This document is a shortened version of a more extensive longer version.

Contents:

Short Version (this document): Basic overview of investing in space resources, ideal for people and companies conducting basic research.

Longer Version: Overview of possible companies to invest in, including strategies and market opportunities. Ideal for people and companies conducting pre-investment research or evaluation of existing investments.

For more information, get in contact: spaceventuresinvestors.com/contact.html

Reader Awareness

This document is not to educate the reader on anything but the subject matter of ‘Due Diligence for Investing in Space Resources’.

For further clarification of technical matters, please do your own research.

Historical Precedents

Key Points

- Raising funding for extra-ordinary resource ventures was more 'normal' in previous eras of Western Civilisation
- Space Resources is essentially extracting resources from the Moon and Asteroids.
- As time goes on, more people want to invest in space related companies
- History shows, there will always be Entrepreneurs undertaking capital-intensive and high-risk ventures

	History: 15th – 19th Century	Now: 21st Century
First Level Exploration	▪ Typically from Monarchs (Kings, Queens) increasing their Empire	▪ Typically from Governments, e.g. Defence, Science, Communications
Transport	▪ Ships had been under development for over 2,000 years	▪ Launch and remote vehicles have been around 50+ years.
Technology	▪ Small well-organised and high-tech European forces had massive leverage over indigenous populations	▪ Scaled-down computer hardware, increased computing power, robotics, 3D-Printing and communications make it easier to plan remote operations
The Entrepreneur	▪ Trade in spices, materials and labour was massive ▪ Merchants often were at the forefront of exploration, seeking new trade routes. ▪ Dutch East India company the first to issues shares.	▪ There is increasing awareness in space commerce, meaning more investors will 'come to the party' ▪ This broadens the investor base and supports existing ventures in need of bridging capital

"We shouldn't only be mining the Earth, we should be thinking of the Moon as our eighth continent."

Naveen Jain, Co-founder and Chairman of Moon Express

Source: http://www.wired.co.uk/news/archive/2016-01/05/space-mining-a-reality-in-2016

Long Term, It's All About Resources

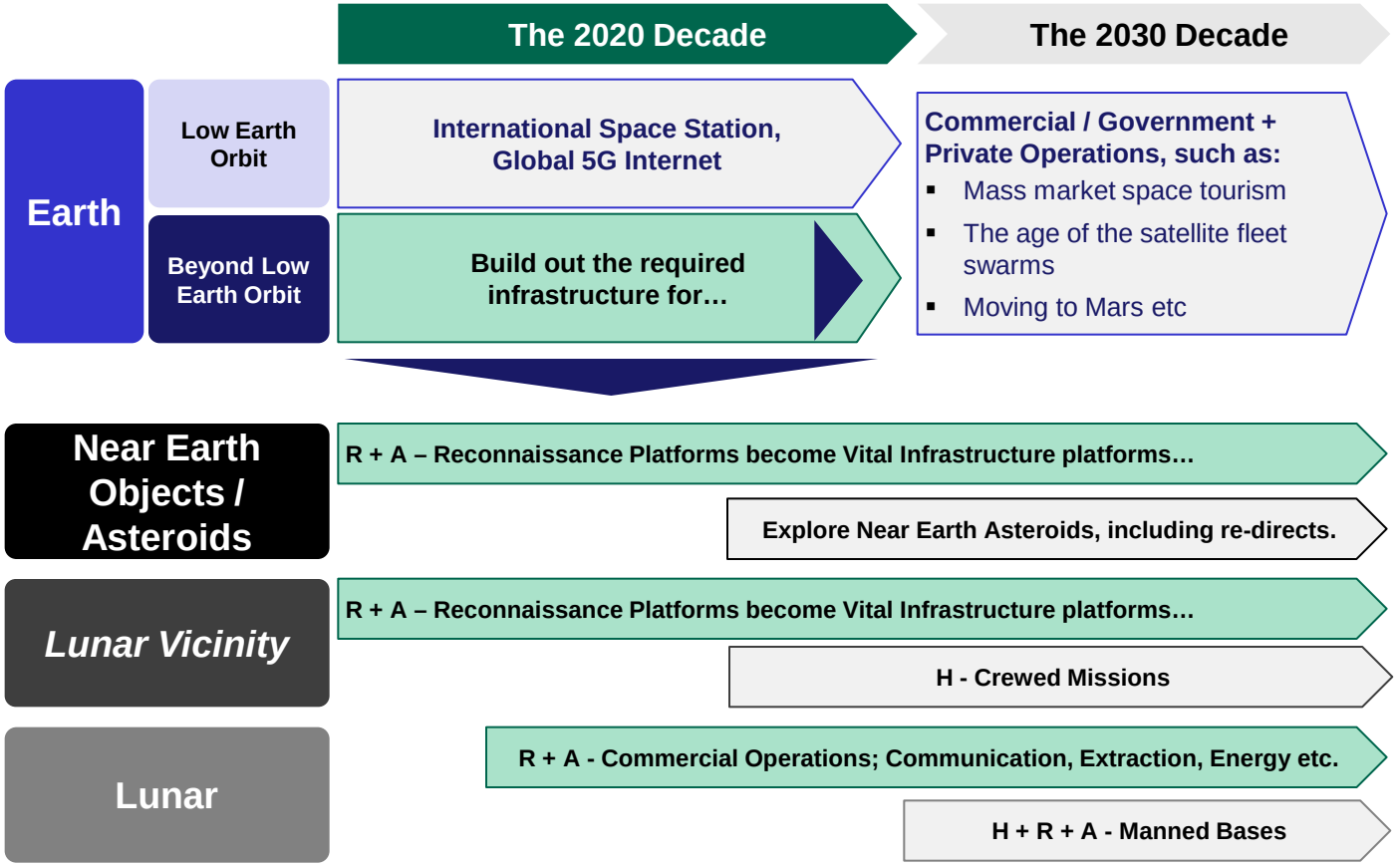
Demand for Resources is Constant….	
Problem	The Earth has a finite amount of resources, and historically there is always increased technological competition to meet that demand…
Solution	Mine the Moon and the Asteroids to unlock a new supply of resources.

Commercial Ventures are the Solution…	
Problem	An international base on the Moon, space tourism and space travel is difficult because there are no ready resources to exploit and resupply is expensive.
Solution	Mine the Moon and the Asteroids, develop their natural resources (water etc) for our use; energy, life, a barrier against radiation.

The Space Map, the Territory, the Entry Points

Notes

- The increasing roles of private initiatives (e.g. SpaceX) in low-Earth orbit has laid the foundation for scaled-up missions with greater pay-offs.
- The 2020 Decade is the ideal Entry Point to invest for equity in the companies that will have the leading edge going into The 2030 Decade.
- The 2020 Decade is also reliant on Robots and Autonomous technology, avoiding costly Manned Missions.

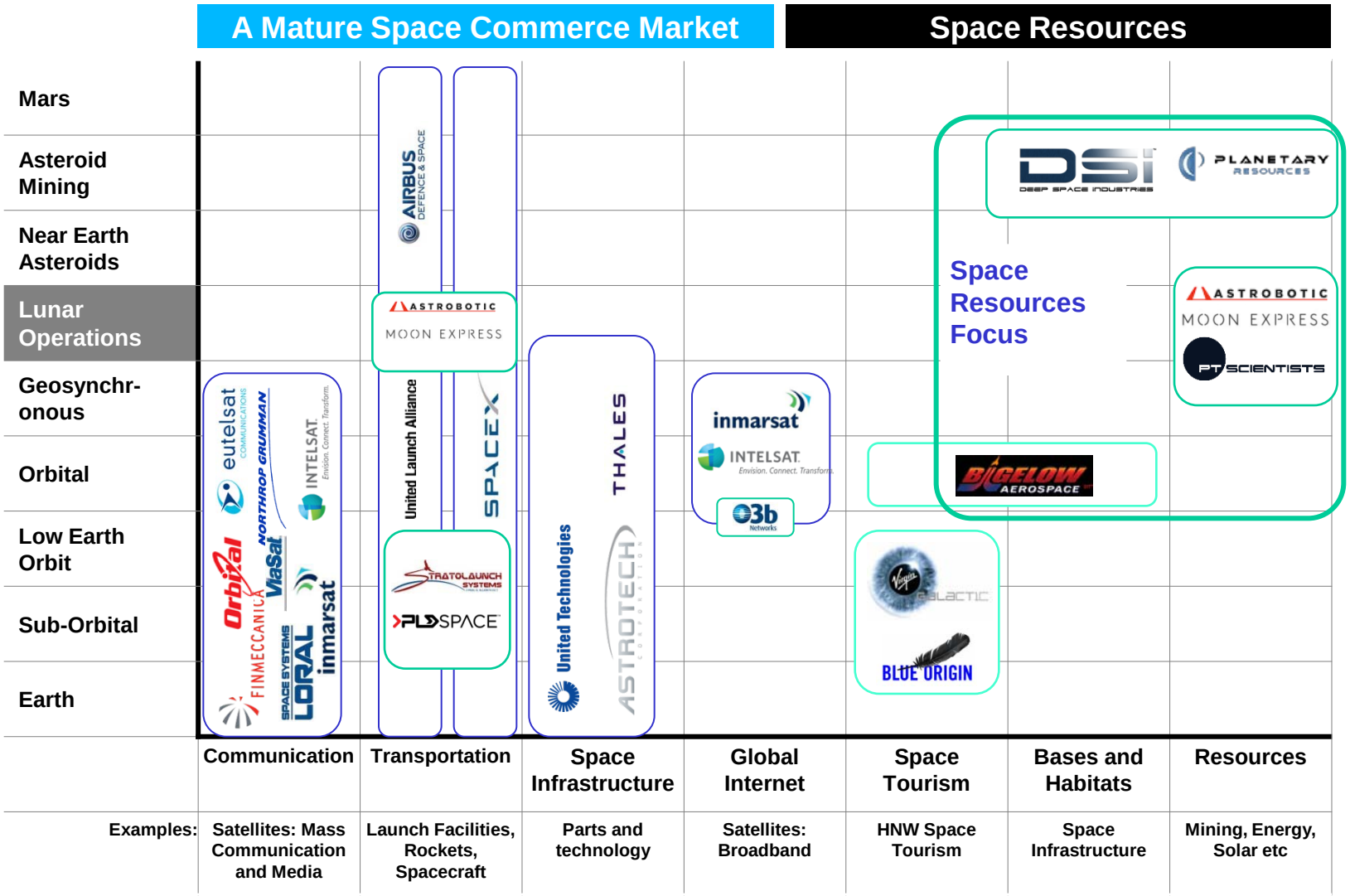


Key: **H = Humans** **R = Robots** **A = Autonomous**

For more detailed information, visit www.globalspaceexploration.org

Space Industry vs Space Resources in Context

Key: Established Businesses Funded, but not yet Operational



The Drivers for Space Resources

Investor Demand

- Retail: From space-spectators to High New Worth individuals
- Corporate investors looking for the next tech breakout area

Better Investing Climate

- Existing equities are at high valuations – Space Resources is the next thing
- Crypto-currencies & Blockchain are an extension of the Dot-Com wave
- The Digital Revolution and Industry 4.0 lead into space….

Technology

- New Tech: Advances on all fronts (3D Printings, new materials, A.I.) makes space tech more possible
- A gradual lowering of costs makes space tech affordable

The People Pushing It

- Baby Boomers: Apollo needs to be re-done…
- Gen X, Y: We have the technology…
- Millennials: We've never done exploration – let's do it

	Lunar Operations	Asteroid Mining
Positive	▪ Easy to communicate with and travel to (3-days) ▪ ESA, NASA, Japan, China, Russia, India and private companies are leading the way	▪ A scalable business (when manufacturing in space) ▪ Lucrative returns
Negative	▪ Government space agency spend relies on political factors ▪ Commercial ventures can be held back by macro economic events	▪ Technologically difficult ▪ Public and Private investors must first accept the risk of entering a Wild West environment; less regulation, target asteroids have extremely varied orbits and profiles
CAPEX (Capital Expenditure)	▪ The Moon requires higher CAPEX but this in term is accumulating mining infrastructure that can be re-positioned on other sites.	▪ Asteroids have lower CAPEX but can't build up extensive mining infrastructure after the resources have been extracted

The Drivers for Actual Investing in Operations

Value on Earth vs Extraction Cost Off-Earth

If the supply of Platinum Group Metals and or other exotic minerals is constrained due to supply or geo-political pressure (e.g. China chokes supply) it may be cheaper to extract them off-world.

Technology Transfer to the Entrepreneurs

- When smaller satellites can be pre-ordered and 'off the shelf' for space resources missions, Entrepreneurs will utilise them in new ways

The Rush to Be In…

New industries create new waves of investors. Space Resources is no different, but has to compete with competing waves;

- Equities in Bull Markets
- Faith in Fiat Currencies, Crypto-Currencies
- Sector demand, e.g. industrial metals

Valuations

If Monetary Metals like Gold rise from $1300 oz to $5,000 per oz, it may be realistically cheaper to extract it off-world.

Industrial use Nickel can be extracted from M-type Asteroids.

Water, the propellant in space, may be easier to extract (from C-type Asteroids) and sell in space.

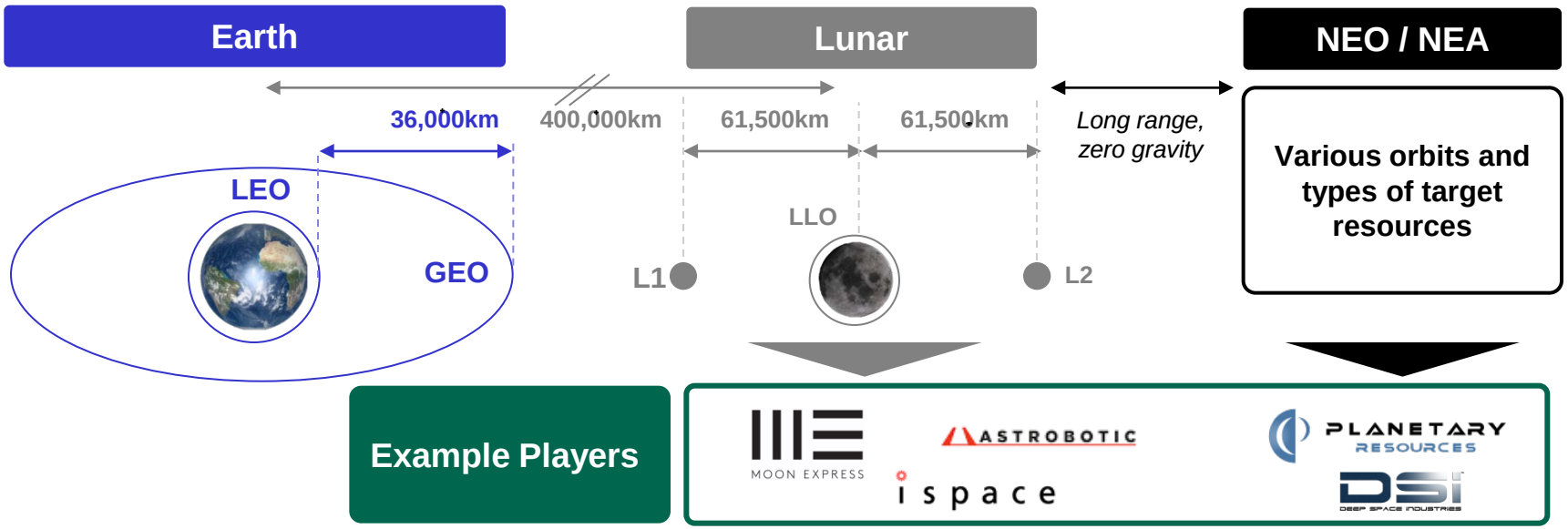
	Lunar Operations	Asteroid Mining
What to Expect	▪ Lunar Bases as Resources Operations ▪ Exploration and Detection, followed by: ▪ Extraction and Return, which causes: ▪ A second wave of operations.	▪ Focussed operations: Defined targets and expectations, e.g. A Mission to Mine Asteroid XYZ in the Year 2030 using a specified process ▪ Follow up Missions as a business model, similar to Mining Companies opening new mines.
Legal Aspects	▪ The Moon can be a capital magnet because it is close, but will be a… ▪ Regulatory Grey Zone / Wild-West scenario for first movers ▪ Space Heritage is a No. 1 issue, e.g. protecting previous landing sites like Apollo, USSR landers.	▪ Asteroids are the scrap of the Solar System. ▪ Raising capital is more difficult but regulations are easier.

The Path to Invest and Build Out

Space Resources Segments

		Lunar, L1, L2	NEO / NEA
Infrastructure	Detection	Deployable fleets of: ▪ Mission specific lunar observation satellites ▪ Orbiting communications & data processing platforms	▪ Fleets of various hive-mind artificial intelligence Robot satellites, some expendable, others functioning as a command and control space craft.
	Acquisition	▪ Rovers must establish a perimeter or presence at resource site to set a precedent for: ▪ Legal recognition of ownership of site for a designate purpose (resources extraction)	▪ Spacecraft must land and establish a presence to set a precedent for: ▪ Legal recognition of ownership of site on asteroid for a designate purpose (resources extraction)
	Extraction	Equipment must: ▪ Mine in low-gravity ▪ Be designed for Moon geography regolith, ice ▪ Survive Moon day and nights	▪ Equipment must be designed for each particular NEO / NEA ▪ A resource extraction operation may last as long as the orbit of the object around the Earth, e.g. years
	Return	Return Craft must: ▪ Operate in Earth's orbit, or to and back, from the Moon's ▪ Enter Earth's atmosphere repeatedly ▪ Be a small cost factor of the entire process	Return Craft must: ▪ Endure long-distance transfers with own propulsion ▪ Enter Earth's atmosphere repeatedly ▪ Be a small cost factor of the entire process

Space Resources: Lunar and NEO / NEA



	LEO	GEO	Lunar, L1, L2	NEO / NEA
Market Stage	▪ Mature for Military and Communications ▪ Emerging Earth Observation, Internet of Things, Global Internet players	▪ Mature for Military and Communcations ▪ Regulated	▪ Space agencies have the experience ▪ Private companies raising funding, developing business models	▪ Only space agencies have mission experience ▪ Commercially massive potential
Execution Risk	▪ Space Debris ▪ New legislation	▪ New technology ▪ New Legislatoin	▪ Unknown costs ▪ New technology, e.g. custom mining equipment required	▪ New terrain, tech and paradigms ▪ Minimum 5 years until operations.

Government Space Resources Agreements

Notes

- Activity and Investment is increasing
- Momentum from a wide base of investors is growing
- Government space agencies are all vying for some kind of leading position / facilitator service
- Luxembourg, a financial oriented economy, is active
- United Arab Emirate, plans less dependence on oil and is investing in being space resources ready

Nov-2017: Luxembourg and Japan Agree to Cooperate on Exploration and Commercial Utilization of Space Resources
Source: http://www.spaceresources.public.lu/en/actualites/2017/Luxembourg-and-Japan-Agree-to-Cooperate-on-Exploration-and-Commercial-Utilization-of-Space-Resources.html

Oct 2017: Luxembourg And The United Arab Emirates Sign MoU On Space Resources
Source: http://www.spaceresources.public.lu/en/actualites/2017/MoU-UAE.html

Jul 2017: Luxembourg and Kleos Space sign A MoU to co-operate within the Spaceresources.lu Initiative
Source: http://www.spaceresources.public.lu/en/actualites/2017/News_Kleos_Space.html

Jun 2017: Luxembourg and ESA announce enhanced cooperation on space resources
Source: http://www.spaceresources.public.lu/en/actualites/2017/Luxembourg-ESA-Cooperation-signed.html

Apr 2017 Space May Be Next Frontier for Earth's Crude Oil Giants
Source: https://www.bloomberg.com/news/articles/2017-04-23/space-the-final-frontier-seen-for-earth-s-crude-oil-giants

Mar 2017:Luxembourg and iSpace sign MoU to co-operate within the spaceresources.lu initiative
Source: http://www.spaceresources.public.lu/en/actualites/2017/ispace-luxembourg-mou.html

Mar 2017: China and Saudi Arabia to cooperate on lunar explore, MOU for Chang E-4 lunar mission signed
Source: https://defence.pk/pdf/threads/china-and-saudi-arabia-to-cooperate-on-lunar-explore-mou-for-chang-e-4-lunar-mission-signed.484510/

June 2016: Luxembourg and Planetary Resources sign MoU
Source: http://www.spaceresources.public.lu/en/actualites/2016/luxgov-sign-mou-dev-activities.html

May 2016:. Luxembourg and Deep Space Industries sign MoU.
Source: http://www.spaceresources.public.lu/en/actualites/2016/memorandum-understanding.html

Who Plans Resource Operations on the Moon?

- **Military Spending:** US and USSR activity was tied to Cold War goals.
- **Transportation Opportunities:** Previously the Moon was seen as done (Apollo) and dead (no life), so exploration moved to seek life on Mars. Now there is renewed scientific interest in the Moon, meaning private companies have a paying customer (Government, research, entrepreneurs) requiring **transport to the Moon and back**
- **Resource Opportunities:**
  - NASA, ESA, Japan, India, China and are going back to the moon with an emphasis on returning samples – *Geo-political competition is good sign.*
  - Extracting **Water from the lunar surface** will be a game changer, e.g. when used as a fuel to support operations and life; manned bases like the ESA's planned Moon Village..
  - Helium 3 is often cited as a reason to go back to the Moon, H3 could be used on Earth as a 'clean energy' alternative to nuclear.

ESA's Moon Village: Planned Lunar Base

European Space Agency

- ESA has announced plans to establish a Moon Village.
- The 'Moon Village' envisioned for 2030s, home to Humans and Robots, utilising 3D Printing to build habitats, would be research and commercial.
- A company that operates on the Moon, sources resources, and can transport material back to Earth can offer massive cost savings for ESA.
- ESA has hinted at importance of Helium 3.
  http://www.esa.int/Our_Activities/Preparing_for_the_Future/Space_for_Earth/Energy/Helium-3_mining_on_the_lunar_surface

European Wide Infrastructure

- A European off-world infrastructure spend is not so different from empire building and colonial trade posts from centuries before
- An ESA pro-active initiative factors in drawing on a ready pool of:
  - Talent: Scientists and Engineers; hardware and software
  - Small – Medium Sized Businesses that can undertake the precision work to build the supply chian
  - Larger Aerospace & Space companies to executive a Moon Village / Lunar Base.

esa

"Moon Village is not a single project, nor a fixed plan with a defined time table. It's a vision for an open architecture and an international community initiative."

"By 'Moon Village' we do not mean a development planned around houses, some shops and a community center. Rather, the term 'village' in this context refers this: a community created when groups join forces without first sorting out every detail, instead simply coming together with a view to sharing interests and capabilities."

March 2016, ESA's Director General Jan Wörner interviewed on his proposal of a Moon Village

Lunar Payloads: Infrastructure as an Enabler

Delivering Commercial Payloads to the moon is the next wave of innovation

- A reliable transport service from the earth to the moon will form the foundation on which to build up new entrepreneurial businesses
- Astrobotic's goal is to have ongoing missions to the Moon where payload price is fixed at $1.2 million per Kilogram, payloads are mixed, and Landers can be customized, like delivering Rovers.

Lunar Payload	Infrastructure	Science	Detection & Extraction	Marketing
Commercial Example	Landers can be a network, a base of infrastructure assets: ▪ Mini-bases, offering Communications, Energy / Power, aids for Navigation ▪ Establishing 'legitimate presence' for territorial claims	▪ Testing platform for instruments, R&D purposes ▪ First stepping stones to Lunar Research Stations	▪ Rovers customised for detection and extraction of material	▪ Branded presence via sponsoring of a practical payload. ▪ Perfect option for Public Relations ▪ 1st movers have a 'media-frenzy' advantage, ideal for sponsorship
Revenue Possibility	▪ From Private and Government sources	▪ From Private and Government sources	▪ From Resources focussed enterprises, e.g. Lunar Mining	▪ Mostly Private sources

Planned Lunar Operations

The NASA / Russian Deep Space Gateway

- NASA intends to build and begin testing systems needed for challenging deep space missions.
- A Crewed spaceport in a lunar orbit would serve as a gateway for missions to deep space and the lunar surface.
- The three primary elements of the gateway, the power and propulsion bus and habitat module, and small logistics modules, would take advantage of the cargo capacity of the SLS and the crewed deep space capability of Orion.
- NASA has selected five U.S. companies to conduct studies for a power and propulsion elements that can be used as part of the deep space gateway concept.
- Requirements are three-times more powerful than the capabilities available currently for future human missions.
- The selected companies are:
  - Boeing
  - Lockheed Martin
  - Orbital ATK
  - Sierra Nevada Corporation's Space Systems
  - Space Systems/Loral
- The next phase is for deep space transport spacecraft that use electric and chemical propulsion, and are specifically designed for long duration crewed missions to destinations such as Mars.
- NASA and Roscosmos have signed a joint statement supporting research that can lead to Cis-lunar habitat development
- The agreement is to develop international technical standards for a possible space station in lunar orbit. This could extend existing standards for a docking unit for a future station.
- Extrapolating on Russia's extensive experience in developing docking units, the station could be based on Russian designs, yet developed using international technical standards, leading to a potential space station in lunar orbit.

Detecting Water on the Lunar Surface

- NASA intends to build the systems required for challenging deep space missions.
- The US Clementine probe (using a bistatic radar experiment) showed that the Lunar surface was rather icy than rocky, but results were inconclusive.
- A Lunar prospector mission in 1998 used a neutron spectrometer to measure hydrogen in the Lunar regolith near lunar poles. Concentrations were detected near North and South Poles.
- In 2007 the Kaguya used gamma ray spectroscopy to detect abundances of various elements on Lunar surface, yet did not detect signs of water.
- China's Change E-1 produced detailed photographs of polar regions.
- In 2008, the ISRO's Chnadrayaan-1 mission released a Moon Impact Probe (MIP) in Shackleton Crater. The mass spectrometer payload (CHACE) on-board indicated the presence of water. NASA confirmed the presence of water from the data by the Moon Minerology Mapper (M3) on-board the Chandrayaan-1 orbiter. A Mini-SAR on-board diagnosed the 40 darkened craters in north pole, resulting in an estimation of 600 million metric tons of water as ice.
  - CHACE is a quadrapole mass spectrometer capable of exploring gaseous constituents.
  - M3 is one of the instruments contributed by NASA to the Chandrayaan-1. It is an imaging spectrometer, operating from visible to near infrared (0.42- 3 μm) and is capable of high resolution spatial and spectral mapping.
- Water vapor in a debris cloud was also detected by NASA's LCROSS mission. This mission confirmed the presence of water in the South Pole's Cabeus crater.
- Miniaturized mass spectrometers are being developed to be used on CubeSats.

Space Based Mineral Detection

- **A nuclear spectrometer** on-board micro-satellites can be used for near earth asteroid evaluation.
- Nuclear spectroscopy supported on neutron and gamma-ray spectrometers (NGS) is a powerful tool for evaluation the composition of potential targets
- Spectroscopic analysis of neutron and gamma-ray fluxes emitted from the surface can measure trace elements, surface elements and volatile elements like hydrogen.
- The NGS consists of a neutron and a gamma-ray spectrometer. Two kinds of gamma-ray spectrometers are possible: one employs a high purity Ge detector (HPGe) cooled by a small mechanical cooler, and the other is a scintillation detector.
- The neutron detector measures neutron fluxes in three different energy ranges; thermal (< 1 eV), epithermal (1 eV-500 keV), and fast neutron (< 500 keV).
- HPGe is better than CeBr3 as gamma-ray spectrometer. However, both the HPGe and CeBr3 are arguably better depending on the exact nature of the mission.
  Source: http://meetingorganizer.copernicus.org/EPSC2017/EPSC2017-206-1.pdf

- Probes can also use a pulsed neutron generator to probe sub-surfaces, and neutron and gamma-ray spectrometers to detect the resulting moderated neutrons and gamma rays. The neutron and gamma-ray energy spectra are used to determine bulk properties and the material composition.
  Source: http://etd.library.vanderbilt.edu/available/etd-04012013-115436/unrestricted/Bodnarik_PhD_Thesis_2013.pdf
- Gamma ray spectroscope records intensity and wavelengths of gamma rays coming from a surface; the resulting spectrum can be analyzed to determine the concentrations of elements, including elements detectable in the sub-surface.

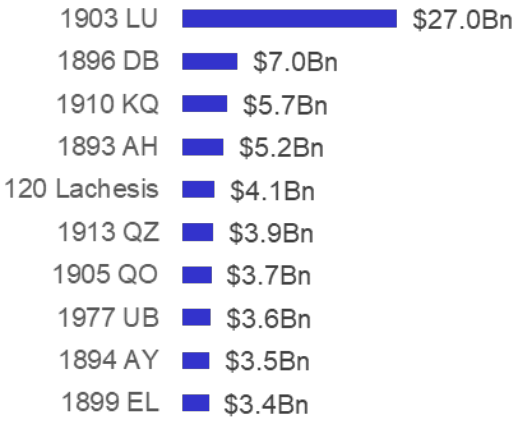
Minerals to Focus on:

Platinum Group Metals:
Platinum
Osmium
Iridium
Ruthenium
Rhodium
Palladium

Made-in-Space
Nickle

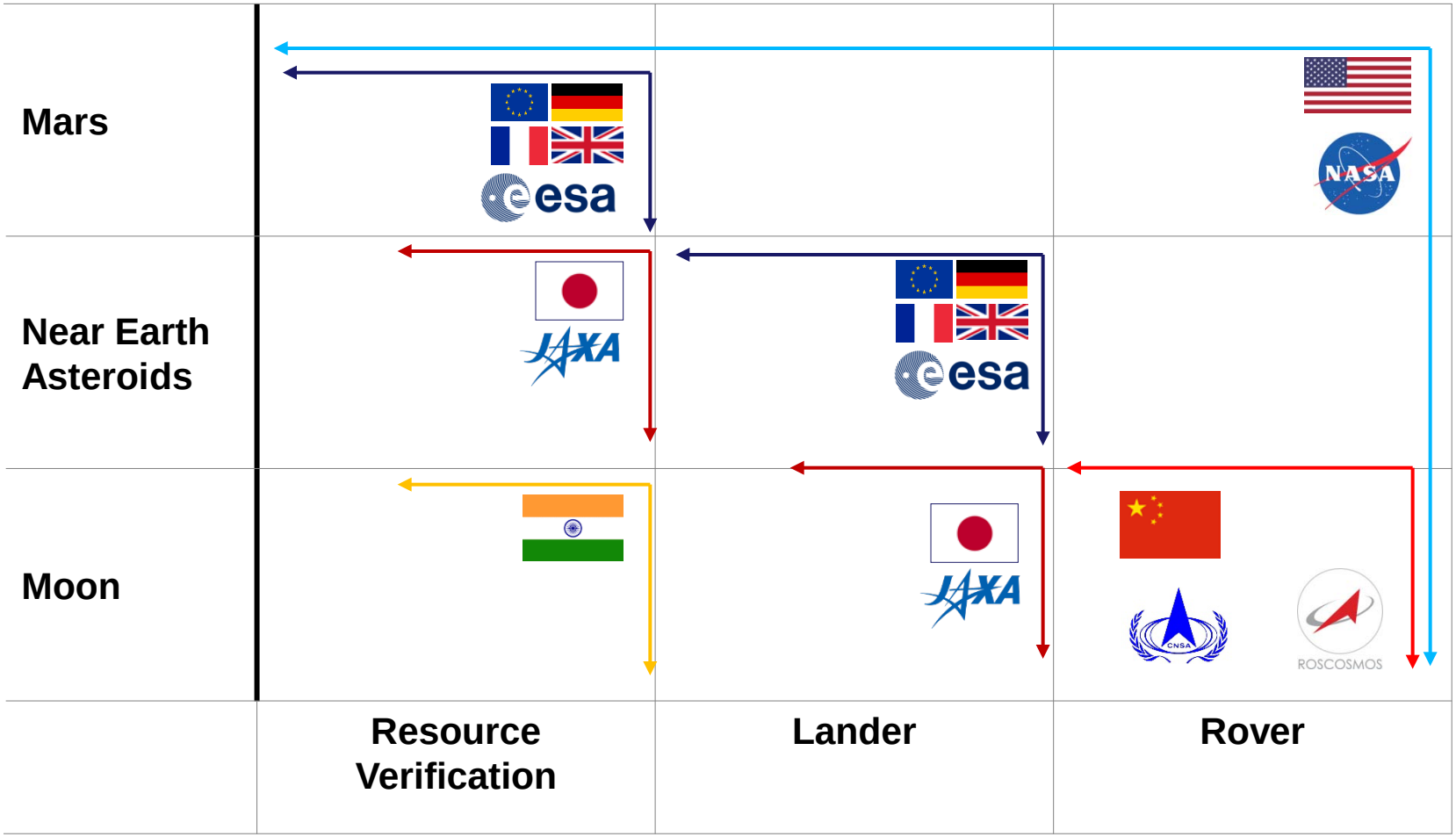
Monetary Metals:
Gold

Top 10 Most Valuable Asteroids

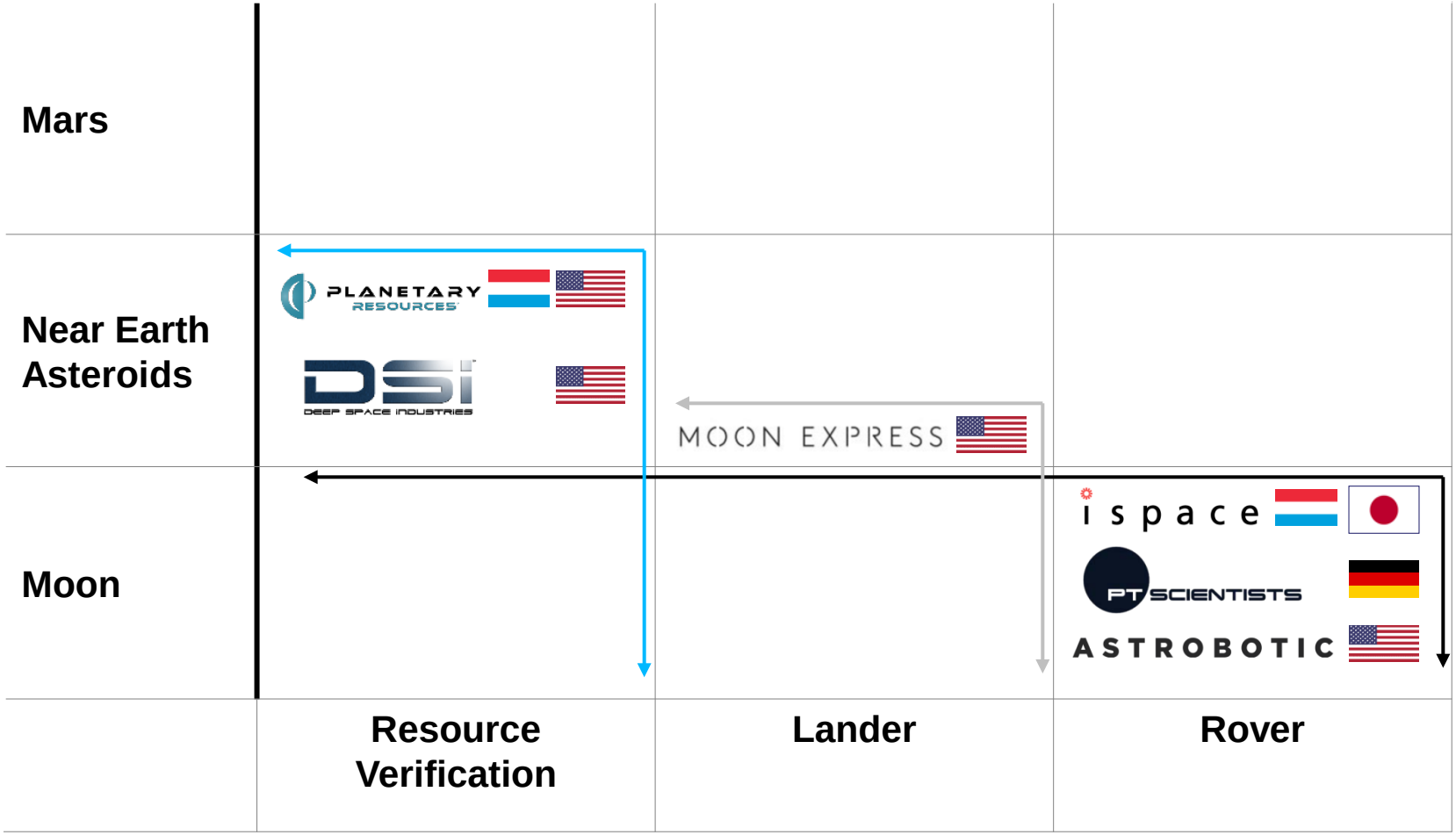


Source: Astrarank.com, which was acquired by Planetary Resources

Space Agencies are Leading the Way…



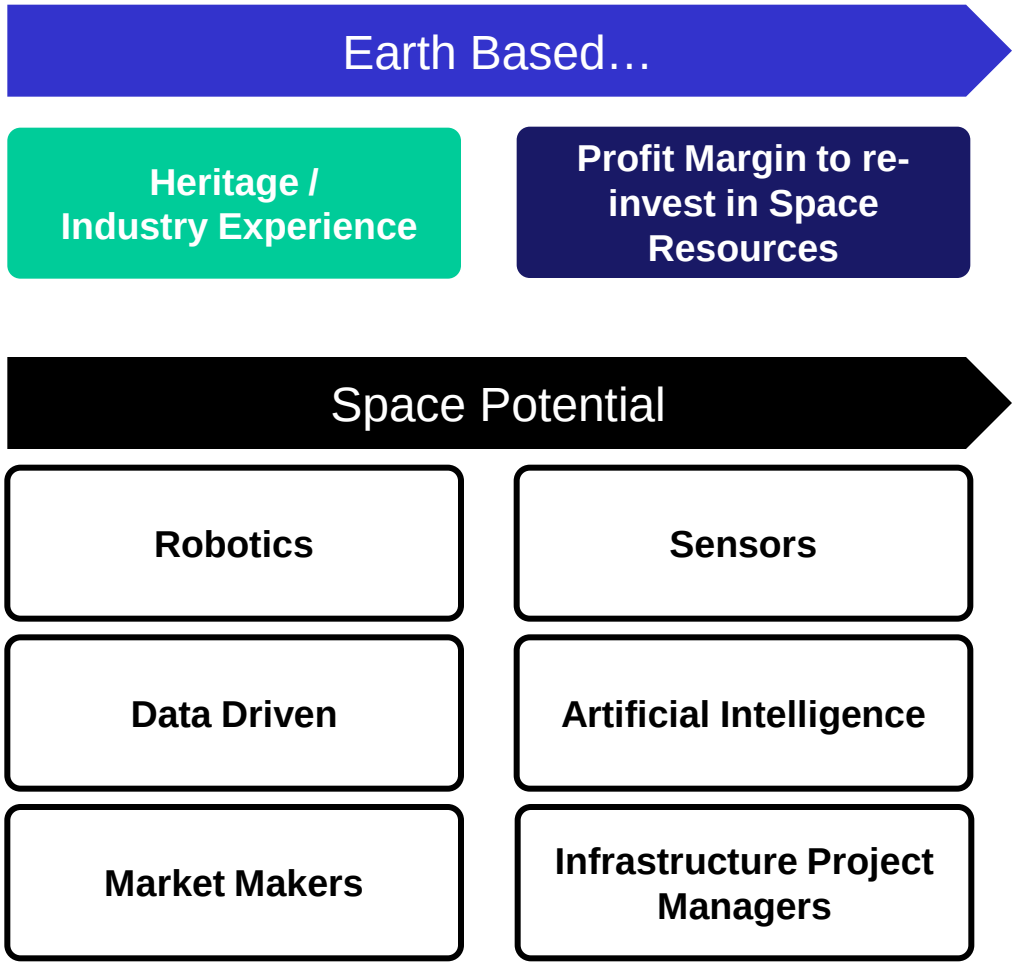
Private Companies Planned Mission in 2020s



Companies That Can Step In & Step Up

Notes

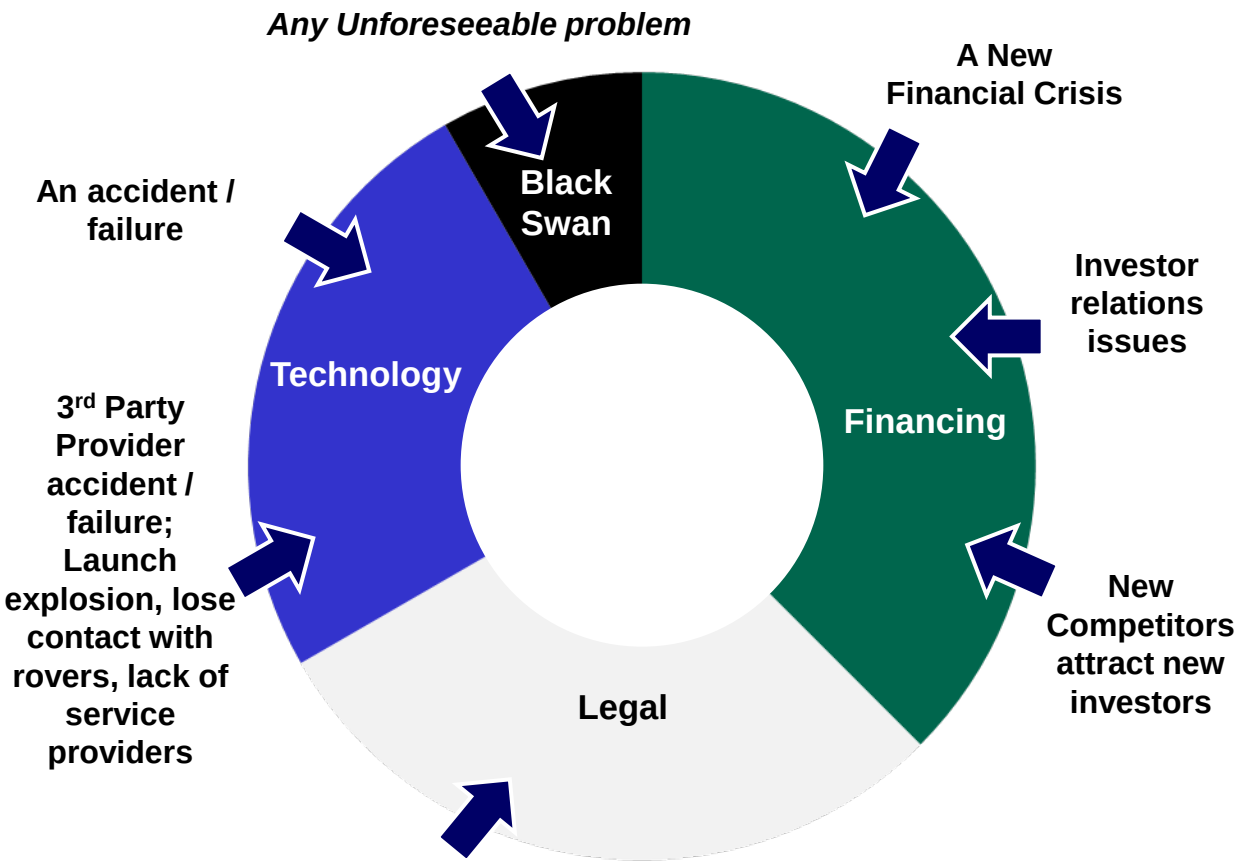
- Various technologies and processes only to need to be re-tooled to be used on the Moon.
- Example: Companies that have extensive experience in mining, and supply NASA with robotic equipment, are best positioned to ‘step up’ or ‘step in’ to the role as a technology supplier.



Liability & Risk Profiling

360º of Liability and Risk = Opportunity

- Because space missions are difficult and expensive, investors that want to minimise Liability and Risk should support technical-heavy companies.
- Accidents can cause expensive blow-outs to diminishing investor-fed cash supplies.
- Liability includes what can not so easily be factored into risk analysis, e.g. change in commercial and political attitude to 'exploit the Moon'.
- Minimising and mitigating dangers has to be built-in into planning and modelling.



Get in Contact with…

SPACE VENTURES INVESTORS

Management

Co-Founder, Managing Director

Simon Drake
drake@spaceventuresinvestors.com

- Co-Founder, Investor, Managing Director
- Focused on research strategies for international investors (Private and Institutional)
- Looking for Space Start-ups and Space companies seeking funding
- Previous experience includes:
- Marketing: Print, Online, Brands, Data Mining
- Investment Banking: Support roles at Goldman Sachs, Houlihan Lokey, Jefferies, Rothschild
- M&A, Advisory, Re-structuring
- Has Compliance Certifications.

Research

Space Commerce Researcher

Prachi Chandravadan Kawade
kawade@spaceventuresinvestors.com

- Master in Space Studies, International Space University.
- Previous experience includes:
- Intern at Physical Research Laboratory and Hindustan Aeronautics Limited
- Various research projects related to space and aeronautics.

Space Ventures Investors Limited
Company Number: 09340453
Registered in England,
United Kingdom

Registered Address:
207 Regent Street
London'
W1B 3HH
United Kingdom

Postal Address:
Postfach 600754
60337 Frankfurt am Main
Germany