SPACE RENAISSANCE ACADEMY WEBINARS SERIES

“New space Economy: history, reality and perspectives"

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OVERVIEW

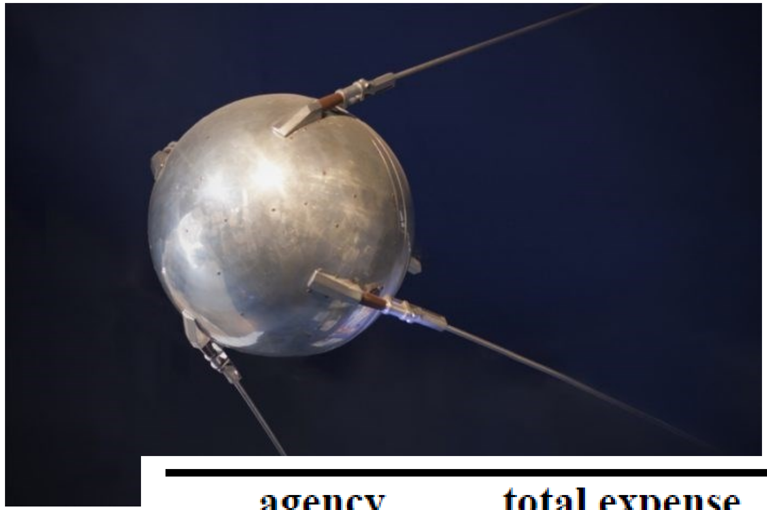
1. NEW SPACE – HISTORY, ACTUALITY, PERSPECTIVES
2. NEW SPACE AND TRADITIONAL AEROSPACE - CHARACTERISTICS AND DIFFERENCES
3. NEW SPACE ECONOMY - CURRENT SCENARIO - TOPICS OF MAJOR INTEREST AND OPPORTUNITIES

1. NEW SPACE – HISTORY, NEWS AND PERSPECTIVES

NEW SPACE: WHAT THERE WAS BEFORE

- Traditional aerospace
- Space agency captive market
- Lobby: aerospace, defense, research
- The "astronautical club": USA, Russia, China
- Earth-to-orbit transport cost: $40,000 / Kg
- Access to space: Space Shuttle, cost $200 billion

$2 TRILLION (PUBLIC MONEY) INVESTED SO FAR IN SPACE



- Born with the launch of the Sputnik satellite on October 4, 1957, space exploration has been developing for over 60 years.
- The main space agencies have spent about 1.7 trillion dollars throughout their history.
- We can estimate an approximate total of 2,000 billion dollars invested globally by the governments of Planet Earth in space.

agency	total expense (\$B)	average yearly budget (\$B)
NASA	1313,00	20.83
ESA	200,00	4.16
ROSCOSMOS	68,00	2.52
CNSA	66,32	2.65
JAXA	30,00	1.81
ISRO	16,52	0.66
total	1693,84	32.63

Table 1. Total public expenditure in space in history

- Yet, such investment is ridiculous, when compared to the global military spending = $2 trillion / year.
- An enormous figure, when compared to other public expenditures, such as education, public health and public transport systems.
- Has the space investment paid off for the taxpayers?
- The effects on daily life are of primary importance: all aspects of daily life are influenced by space technologies.
- However, only in the last few years we are seeing the opening of the high frontier to civil development.

THE MAIN REQUIREMENT OF EXPLORATION SPACE: PLANET B

- But is the goal of the space program only to improve our life on the surface of our mother planet?
- The needs of the main stakeholder of space exploration - civilization - include many other goals than improving our life on the surface of the mother planet.
- One of the main requirements is to contribute to a sustainable survival and further progress of civilization.
- 8 billion earthlings can no longer survive and continue to develop on just one planet.
- Space exploration must therefore help civilization to expand beyond the limits of Earth's atmosphere.
- As the dramatic multiple crises demonstrate - pandemics, climate change, environmental degradation, scarcity of resources and consequent conflicts, mass migrations - we certainly need one or more "Planets B".
- We are dramatically learning, the hard way, that the only sustainable development is outside our planet. That is, we shall start expanding into the solar system, as soon as possible.

William j Knight

A SERIOUS DELAY

- Space agencies are late in delivering Planet B, only partly due to technological limitations.
- From 1959 to 1968, NASA developed and tested the X-15, the first fully reusable two-stage spacecraft.
- X-15 made 199 flights, including 18 at suborbital altitudes: the same concept as ScaledComposites' SpaceShipOne and Virgin Galactic's SpaceShipTwo.
- A few years later, the first Space Shuttle project (by Krafft Ehricke) was based on the same concept, but the developed system was only partially reusable, as we know.

- Had the X-15 strategy continued:
  - we would have had reusable launch vehicles at least 40 years ago.
  - the civilization may be on its way to expanding into the solar system.
  - we could have: industries in Earth orbit, cislunar economy, use of lunar and asteroid materials, fuel production in space.
- Technology wasn't a hindrance (as demonstrated by Branson and Musk).
- Short-sighted policies and lobbies have been a huge and heavy burden on human progress.
- The cost of Earth-to-Orbit transport has been kept artificially very high for more than 40 years, to accommodate the lobbies of expendable rocket manufacturers.


United States
NASA

KRAFFT EHRICKE: "UMBILICAL TO SPACE"

- When the Nixon administration was deciding the sequel to the Apollo program, Krafft Ehricke presented a plan for a fully reusable vehicle:
  - He described it as an "umbilical cord to space".
  - Inexpensive transportation would ensure capacity to carry payloads into Earth orbit,
  - the gateway to cislunar and interplanetary destinations.
  - Ehricke also proposed a version capable of reaching higher Earth orbits.
- In 1970, Ehricke campaigned vigorously for a strong space program, including:
  - A fully reusable space shuttle (evolution of the X-15 concept).
  - an orbital space station, as a space port for every place in space
  - Industrialization of the geo-lunar region
  - Mars exploration

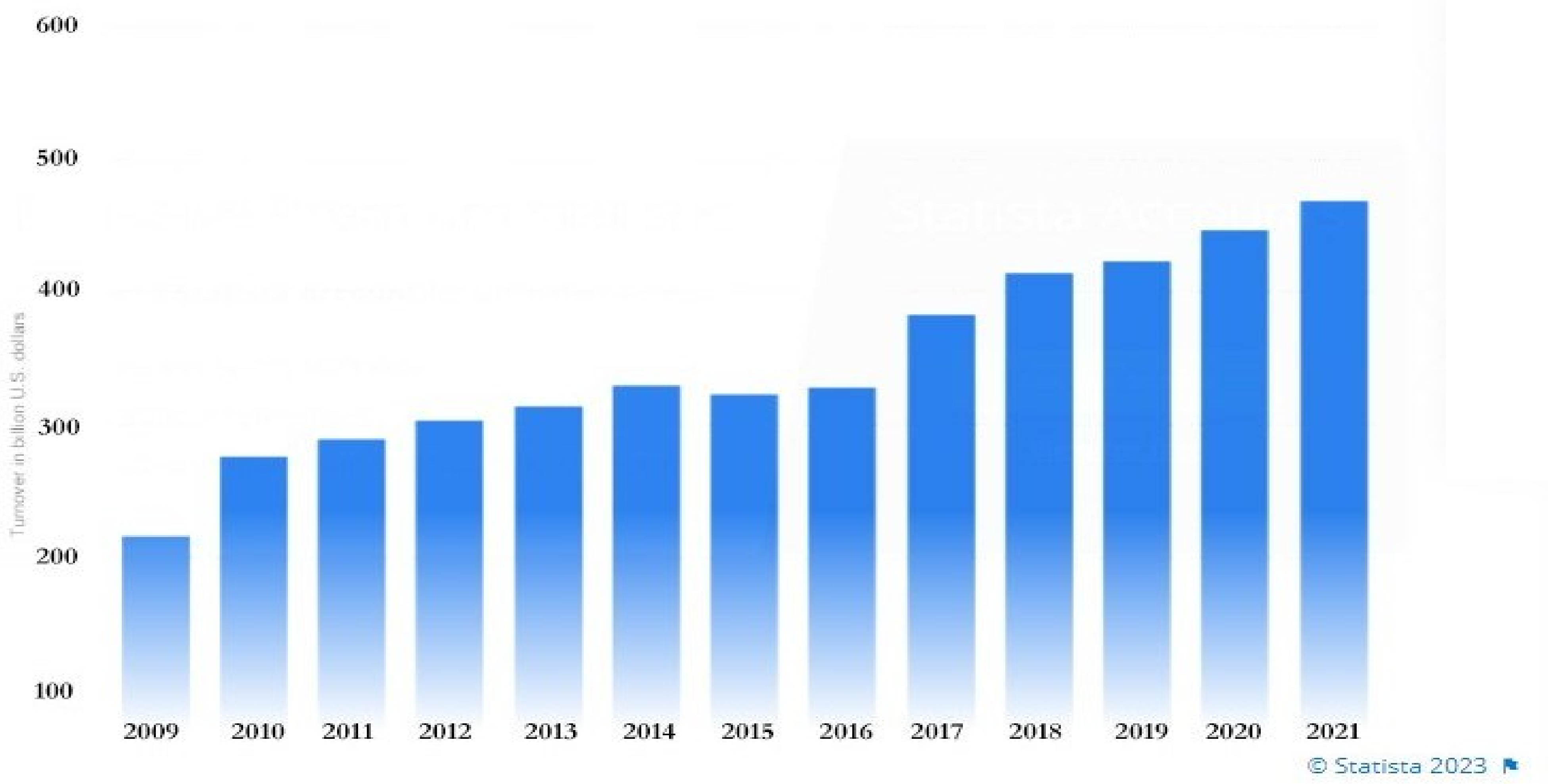
- The program was to develop in the 70s and 80s, for the benefit of the United States and all humanity,
- With full awareness that civil space development will be the only sustainable growth.
- Unfortunately Ehricke lost his battle:
  - the Space Shuttle was not 100% reusable,
  - the space station had to wait,
  - the Moon is still uninhabited today,
  - Mars was rejected as a target distant.
- The expendable rocket lobbies had won that battle.

NEW SPACE – BIRTH AND DEVELOPMENT

- 2004: Scaled Composites wins the X- Prize
- 2015: Space X kicks-off the age of reusable rockets
- 2021: Virgin Galactic and Blue Origin start suborbital tourism
- 2023: Space X launches the first 100% reusable orbital vehicle

THE SPACE ECONOMY GLOBAL TURNOVER 2009 - 2021

(Billions USD)



https://www.statista.com/statistics/946341/space-economy-global-turnover/

XPRIZE

WHO WHAT ACT STORIES DONATE

LAUNCHING A NEW SPACE INDUSTRY

PHASE Awarded

ANSARI XPRIZE

OVERVIEW ACTIVITY SPONSORS & PARTNERS

LAUNCHING A NEW SPACE INDUSTRY

$10 MILLION

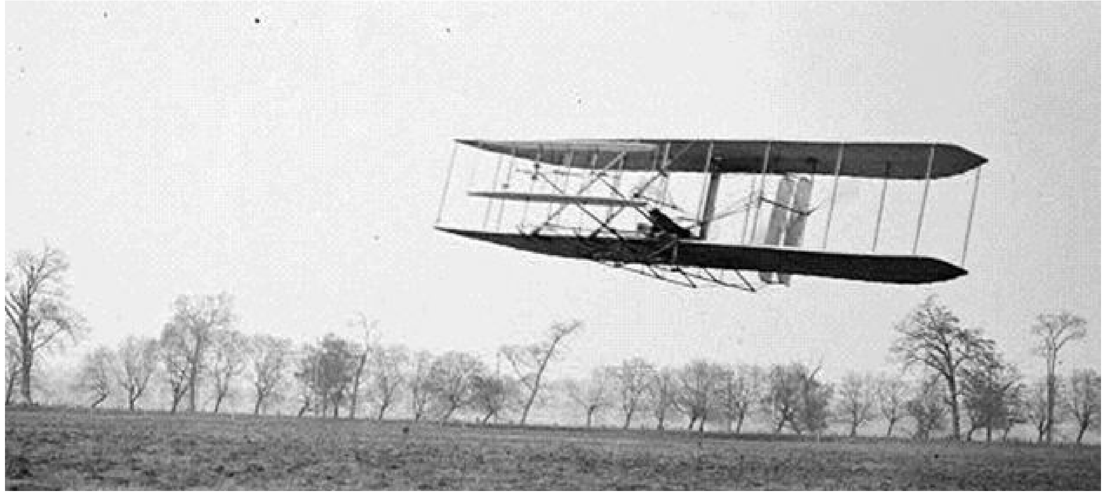
The X- PRIZE, CATALYST OF THE NEW SPACE

- The Ansari XPRIZE, worth $10 million, was conceived and funded by Peter Diamandis and Gregg Maryniak, two philanthropists
- The purpose:
  - reduce the risk and cost of going into space,
  - incentivizing the creation of a reliable, reusable, privately funded and manned spacecraft,
  - so as to finally make private space travel commercially viable.
- Before the Ansari XPRIZE, spaceflight was the sole province of governments.

https://www.xprize.org/prizes/ansari
https://www.xprize.org/about/people/gregg-maryniak https://www.diamandis.com/

- Space tourism was considered too dangerous and expensive for the general public
- Space exploration was neither possible nor affordable for the private sector
- About twenty companies participated, from all over the world,
- the X-Prize requirements:
  - to build a reliable, reusable spacecraft,
  - privately funded
  - with crew capable of carrying 3 people, reaching an altitude of 100 km,
  - and to repeat the trip within 2 weeks

1903, 2004… TWO KEY MILESTONES, A CENTURY APART…



- On December 17, 1903, in North Carolina, the Wright brothers, Wilbur and Orville, took off for a few seconds and a few meters with an aircraft propelled by a rudimentary propeller driven by a rudimentary engine.

- On September 27, 2004, in the Mojave Desert, Mike Melville reached an altitude of 100 km aboard SpaceShipOne, a suborbital vehicle privately built and financed.

https://www.aeroclubtorino.it/it/monografie/87-a-cento-anni-dal-volo-dei-fratelli-wright.html

SPACESHIP ONE WINS The X- PRIZE, IN 2004

- SpaceShipOne, designed by Burt Rutan and built by his company, Scaled Composites. Exclusively funded by Paul G. Allen (Bill Gates's partner) with $30,000.
- The 27 September 2004: first privately funded human space flight in history.
- As the X -15 of '60s, SpaceShipOne used an air-launch system.
- At about 15 km altitude, SpaceShipOne took off from its carrier vehicle (White Knight) and continued its flight to suborbital altitude.
- The hybrid propulsion system combine nitrous oxider and hydroxy-terminated polybutadiene (HTPB or rubber).
- At about 46 km altitude, engines shut down and the aircraft continues its race to the apogee: approx 103 km, also said Karman line (the border Between there Earth And the space).
- The rear part of the aircraft wings fold back towards high, to increase aerodynamic resistance and then slow down the plane, while falling in the second half of its parabolic flight.
- Flight 1: 27 September 2004 – Pilot: Mike Melvill, load: weight equivalent 2 other passengers, quote max. altitude: about 103km.
- Flight 2: 4 October 2004 – Pilot: Brian Binnie, max. altitude: 115 km (breaking the X- 15 's record, lasted 41 years).

Burt Rutan and SpaceShipOne

SpaceShipTwo – Virgin Galactic

REUSABLE ROCKETS MAKE HISTORY

- In recent years, after the disruptive advent of Space X's reusable rockets (2015), things have begun to change.
- In 2018, the total global space budget was $72.18 billion.
- Over the past three years, governments have spent a total of $216.27 billion on space activities.
- Statistics also testify that civil space budgets are exceeding defense spending.
- In 2020, the global space budget amounted to $82.5 billion, of which:
  - $50.2 billion, 61% of total spending, for civilian
  - $32.4 billion for the military.
- Even more interesting, human spaceflight is the world's largest funded space program governments around the world, with 13.2 billion dollars,
- surpassing the $11.7 billion invested in Earth observation (EO) and meteorology, which have been the most popular applications since 2012.
- Space science and exploration ranks third, with a total value of $9 billion.

THE COST OF ORBITAL TRANSPORTATION IS FINALLY COMING DOWN

- Who should we thank? At least: Peter Diamandis, Gregg Maryniak, Elon Musk, Jeff Bezos, Richard Branson...
- and, of course, the tireless work of the space advocate community, over the past 40 years!
- The cost of orbital transport is finally downsizing:
  - from $54,500/kg. (Space Shuttles) to $1,500/kg (Falcon 9 by SpaceX).
- Civilian space development should grow accordingly.
- Access to space: managed by private companies, at decreasing costs

- Starship, the first fully reusable orbital system, will further reduce the cost of orbital transportation,
- making industrialization and settlement in geo-lunar space finally feasible and sustainable.
- Starship Super Heavy will cost less than $1 million per launch.
- In perspective 20 dollars/kg for the transport of lunar payloads.
- Transporting people into space, such as tourists, workers, businessmen, will cost no more than current air flight.
- The significance of this perspective is not understood at all, assuming they are considering it, by economists.

NEW SPACE: THE NEXT MILESTONES

- 2023: 100% reusable orbital vehicles (Starship)

→ Further downsize of the orbital transport cost <1000 $/Kg

- 2025: recovery and reuse of orbital debris

→ Kick-off industrialization of the geo-lunar space

- 2030: fuel production in space, from lunar and asteroid resources

→ Further downsize of the orbital transport cost <100 $/Kg

- 2030: Humanist expansion strategy: development of life and health protection technologies in space:
  - cosmic radiation,
  - simulated gravity,
  - green environment,
  - ergonomics and comfort

→ Possibility of living and working beyond the limits of the Earth's atmosphere indefinitely

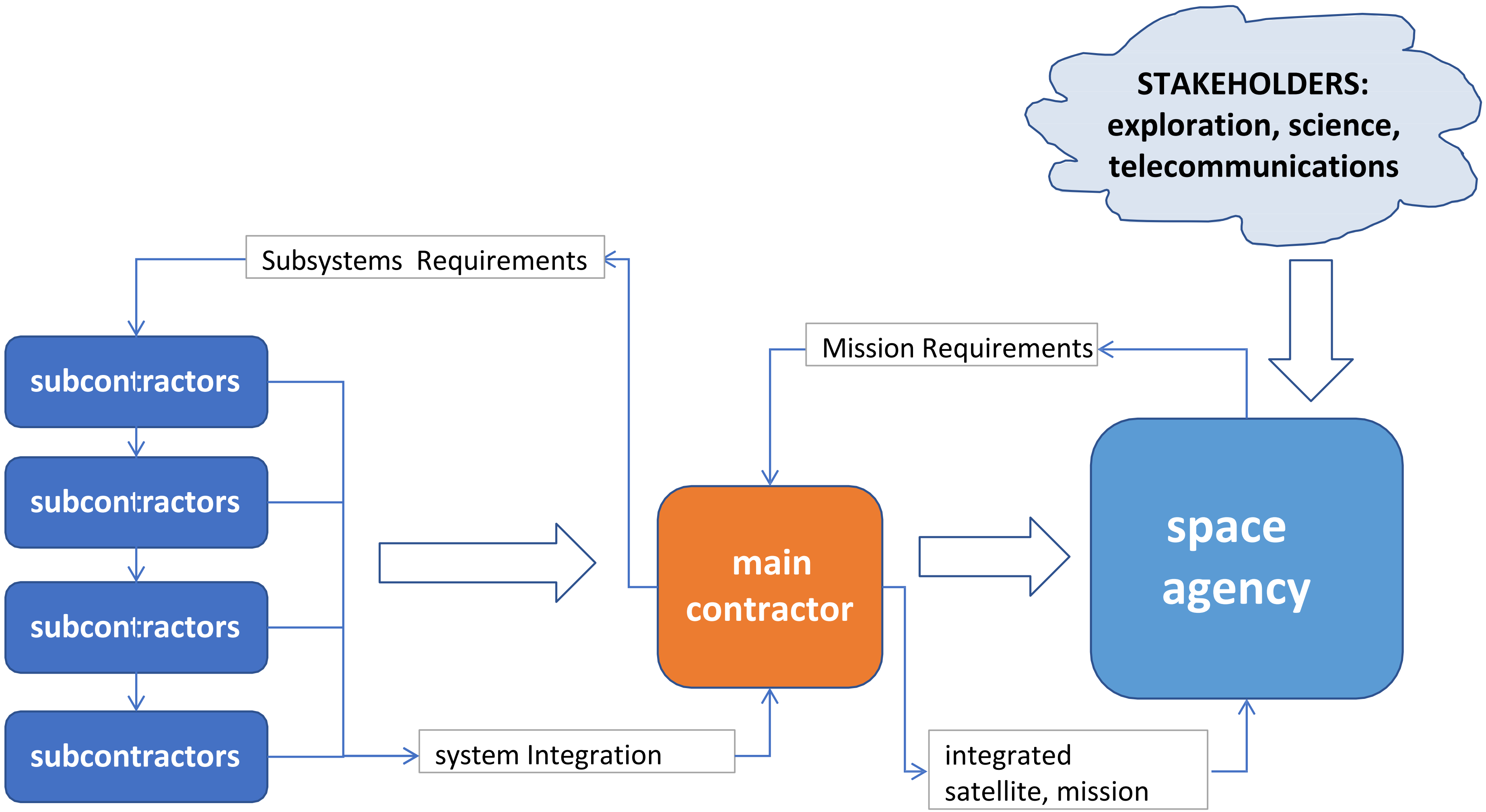
SPACE ECONOMY TURNOVER 2022

2. NEW SPACE vs. TRADITIONAL AEROSPACE CHARACTERISTICS AND DIFFERENCES


What is the new space market?
?
Do traditional subcontracting supply chains still exist?
What can my company do in the new space market?
Does my company have the skills to develop innovative products and concepts?


Engineering?
?
Humanism?
Science?
Which address will make it easier for me to find a job??
Space?
Philosophy?
PhD?
Marketing?
Communication?
Economy?

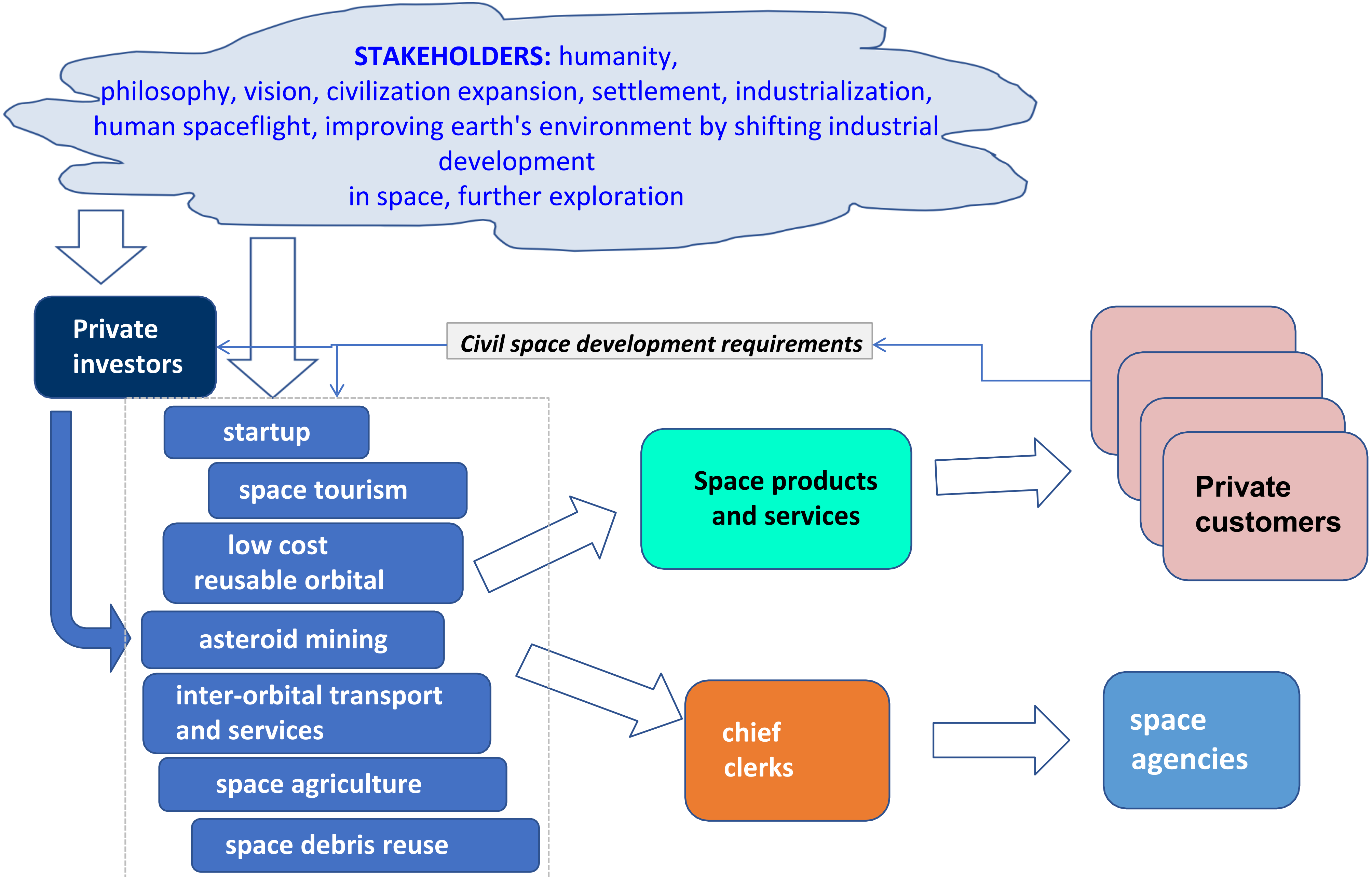
TRADITIONAL AEROSPACE - "OLD SPACE"



PARADIGM:

- high costs,
- long development times,
- public money,
- trained astronauts,
- prevailing robotics,
- full government control over space,
- monopoly of a few large companies (expendable rockets),
- market driven by public institutions

NEW SPACE



PARADIGM:

- quick, better and cheaper access to space,
- pragmatism,
- business minded,
- independence from governments,
- private capital,
- civilian space development,
- market driven by business and vision

THE PARADIGM CHANGE

OLD SPACE	NEW SPACE
Funded by public money	Private financing
Classic supply chain, driven by requirements of the agencies	Companies' mission strategies based on own ideas and innovation goals
Science, telecommunications, exploration	Space settlement and industrialization
Astronautics, by military-trained Explorers(*)	Passengers, tourists and civilian pioneers in space(*)
Expendable rockets	Reusable rockets
Mostly robotic space exploration	Human spaceflight, and settlement, with the support of robots and AI
Controlled by governments	Independent from governments
Not available to private investors	Mainly based on private investors
Care of the Earth's environment through Earth observation	Improvement of the Earth's environment by relocating industrial development into space
High cost of the mission, returns of investment far in the future	Faster and cheaper access to space, faster return on investment
Irresponsible proliferation of wreckage and debris in orbit	Avoid new debris, recover and reuse old ones

(*) KEY FACTOR carrying civilian passengers means a radical change of missionrequirements, e.g.:

- low acceleration,
- low cost,
- safer return in the atmosphere,
- protection from cosmic radiation,
- simulated gravity,
- and more.

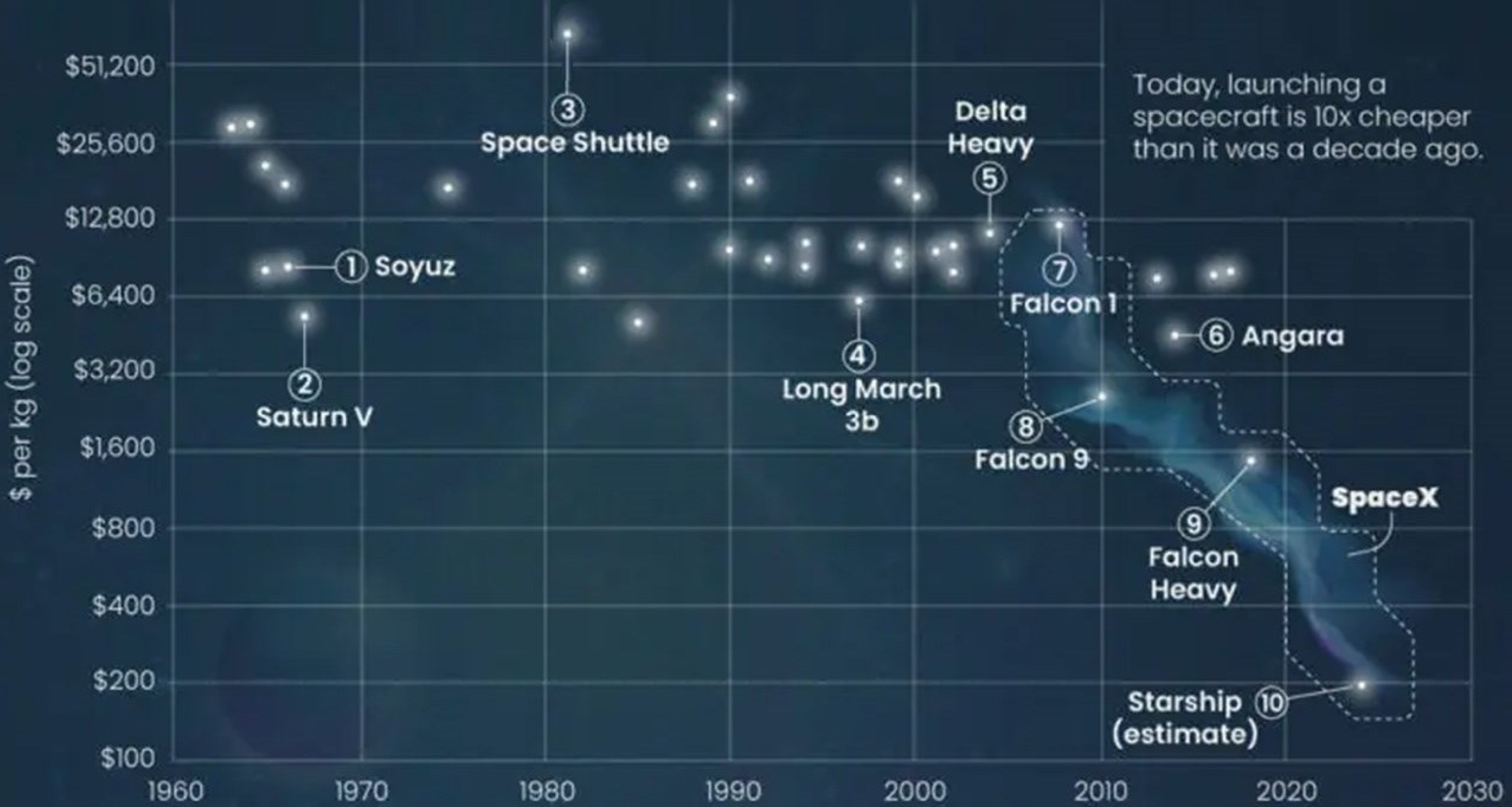
THE PARADIGM CHANGE (2)

OLD SPACE	NEW SPACE
- - -	Applications/experiences tailored to the customer
Separate space program from the Air Force	Collaboration between space, aeronautics and space tourism
Everything built on Earth and transferred to orbit	In orbit assembly, integration, testing and delivery
Transport of terrestrial materials in orbit, on the Moon and in cislunar space	Use of local, lunar and asteroid resources
Government science space stations, for up to 6 months of stay of the astronauts	Space architecture, space habitats with simulated gravity and protected from radiation, for long-term stays
Plant science experiments	Space farming
Limited technology experiments on the ISS	Wide-ranging technological development: mechanical, chemical, electronic, optical, welding, etc.
Spinoff / transfer of technology from space to Earth	Earth jobs to expand into space
Separate space program from the Air Force	Tailored applications/experiences for customers

THE PARADIGM CHANGE (3)

OLD SPACE	NEW SPACE
Ground-to-Orbit transport cost: >$50,000 / Kg	Earth-Orbit transportation cost: $1,500/Kg downhill, with Starship expected <$100/Kg
Access to space: Space Shuttle, cost $200 billion	Access to space: managed by private companies, at decreasing cost, according to the market growth
Cost of a satellite launch: > $200m	Cost of a satellite launch: < $50m trend < $5m
Each carrier is a unique piece (except the Soyuz)	Industrial production of standardized carriers

IMPACT FROM SPACE X ON THE COST OF ACCESS TO SPACE



EXPLORERS SHOULD BE THE BEST FRIENDS OF EXPANSIONISTS

Space exploration	Expansion in space
Exploration can exist without expansion	Expansion requires more advanced exploration
Exploration is a military concept	Expansion is a civilian concept
Exploration does not require industrialization or infrastructure construction	Expansion requires industrialization and infrastructure construction
Exploration can be done by robots	Expansion requires a consistent expansion of human settlements, from Earth into near space and progressively beyond.
The exploration is done with public money	The expansion is based on investors and private companies, with public support in the first phase
Exploration is made up of short round trip missions	Expansion is based on permanent settlements
Exploration does not imply growth	Expansion is a process of global and progressive civilization growth
Exploration only gives technological return	Expansion ensures continued global, economic and social growth
Exploration is based on the expendability of human life	Expansion requires a continuous evolution of technologies for the protection of life and health.
Exploration can exist without expansion	Expansion requires moving/evolving land-based jobs into space

- As highlighted in the table, the expansion will not kill space exploration,
- while exploration for its own sake can delay and even hinder expansion,
- in the context of a space program lacking an adequate strategy.

3. NEW SPACE ECONOMY CURRENT SCENARIO

NEW SPACE: OPPORTUNITIES

- space environment: defense against micrometorites, orbital debris, radiation, thermal stress
- old approach: building space stations by bringing everything from Earth, new approach: assembling stations in space, using in situ resources (ISRU)
- big data and testing
- ground-based simulated space bases, underwater settlements
- exploration bases
- infrastructure, communication, vehicles, logistics
- research infrastructure
- biotech laboratories, agriculture, greenhouses, hydroponic crops, etc...
- raw material production and processing facilities
- metal structures, tanks, pipelines, cars
- orbital debris and scrap: decommissiong, capture, reuse (scrap and debris process)
- privatization of the ISS: what will be done on the ISS once privatized?
- mining on the moon
- mining on asteroids

NEW SPACE: OPPORTUNITIES (2)

- Building in space
- New materials and processes
- NASA Friction Welding
- Welding in vacuum and zero gravity
- Layered additive manufacturing (3D printing)
- Construction using Lunar Regolith (D-SHAPE Pisa)
- Reusable Launchers (Space X)
- Orbital debris (cost of deorbiting vs value of reuse)
- NASA Lunar Orbital Platform (LOP-G), formerly known as Deep Space Gateway (DSG).

- ESA lunar village
- Orbital dumps, storage of material for future reuse, transport and towing
- aeronautics – civil astronautics evolution
- suborbital flights
- suborbital flights spaceports
- space robots, human work with humanoid robots
- hybrid engines, hypersonic flight, transport, point-to-point at sub-orbital altitude
- progressive miniaturization
- 3d printing solar cells

THE MAIN NEW SPACE SECTORS

- Reusable transport vehicles for passengers and goods
- Space tourism
- Orbital debris, recovery and reuse
- Mining on asteroids
- Mining on the Moon
- Orbital, lunar, cislunar habitats
- Zero gravity products
- Satellite transport
- Orbital, lunar, cislunar manufacturing production
- Commercial stations and orbital hotels
- Protection of life in space
- In-orbit satellite maintenance
- Hypersonic vehicles

SPACE TRANSPORT VEHICLES FOR PASSENGERS AND GOODS

ORBITAL LAUNCH SYSTEMS, MAIN MANUFACTURERS

(launches in 2022)

throw	agency	carriers	village
61	Space X	Falcon 9, Falcon Heavy	USA
53	China aerospace science and technology	Long March	China
19	TsSKB Progress	Soyuz	Russia
9	Rockets Lab electron	electron	USA
7	United Launch alliance	Atlas	USA
5	ExPace	Kuaizhou	china
3	Astra	Rockets 3	USA
3	ArianeSpace	Ariane	Europe
3	ISRO	polar Satellite Launch vehicle	India
2	orbital Sceinces corporation	Antares	USA
2	Galactic Energy	Ceres - 1	China
2	Khrunichev KBKhA	Angara	Russia
2	Airplane	Vega	Europe
1	ISRO	LVM extension	India
1	ISRO	small Satellite Launch vehicle	India

https://en.wikipedia.org/wiki/List_of_private_spaceflight_companies

PASSENGERS SPACE VEHICLES, MAIN MANUFACTURERS

Manufacturers	Vehicles	Types of spacecraft
Space X	Dragon, on Falcon 9	Orbital, partially reusable launcher reusable capsule
	Starship	Orbital, lunar, fully reusable
Northrop Grumann	Cygnus, on Antares 230, Atlas V 401	Orbital, reusable capsule, Non-reusable launchers
Sierra Nevada	Dream Chaser on Atlas V, Vulcan	Orbital, Reusable Shuttle, Non-Reusable Launchers (2023)
Blue Origin	Biconic Space Vehicle, on New Glenn	Orbital, reusable (under development)
	Crew Capsule, on New Shepard	Suborbital, fully reusable
boeing	Starliner CST-100, on Atlas V	Orbital, lunar, non-reusable
Virgin Galactic, Spaceship Company	SpaceShipTwo	Suborbital, fully reusable

SPACE x

https://www.spacex.com/

- *Mission: to take civilians into space*
- Founded in 2002
- SpaceX completed 197 Falcon 9 launches, 155 landings, 133 re-flights
- 5 Falcon Heavy launches, 11 landings, 6 re-flights
- 37 Dragon capsule launches, 33 visits to the ISS, 16 re-flights
- NASA chose SpaceX's Starship for sending humans to the moon.
- Starship is built to be completely reusable and is the more powerful launch vehicle in the world, capable of carrying more than 100 tons metrics of passengers and cargo.
- SpaceX hopes to launch the first test flight orbital of Starship in April 2023.

SPACE X - PRODUCTS

- Falcon 9 : 2-stages launcher, reusable 1st stage
  - height: 68.4m; diameter: 3.7 m.; throws: 200, touchdowns: 159;
  - payload max. 17.4t LEO; 4t GEO
  - cost per launch: $M67 (new) $M50 (re-used);
- Falcon Heavy : 2-stages launcher, reusable 1st stage
  - height: 70m; diameter: 3.66m; throws: 5, landings: 1 central vector, 8 lateral;
  - payload max. 63.8t LEO; 26.7 tGEO; Mars 16.8 t; Pluto 3.5 t
  - cost per launch: $M97 (reusable) $M150 (spendable)
- Dragon Cargo : Orbital cargo pod, reusable
  - first flight to the ISS: December 6, 2020; missions: 6
  - carrier: Falcon 9; recovery: parachute, at sea
  - Carrying capacity: 3.3 t to ISS
- Dragon Crew : Passenger orbital capsule, reusable
- Starship : 100% Reusable, Two Stages To Orbit (TSTO)
- Starlink : satellite internet network
- Starshield : security, defense

https://www.spacex.com/

space x Falcon Heavy

- launcher 2 stages, 1st stage reusable
- height: 70m; diameter: 3.66m; launches: 5, landings: 1 central vector, 8 lateral;
- payload max. 63.8t LEO; 26.7 tons GEO; Mars 16.8 t; Pluto 3.5 t
- cost per launch: $M 97 (reusable) $M 150 (expendable);

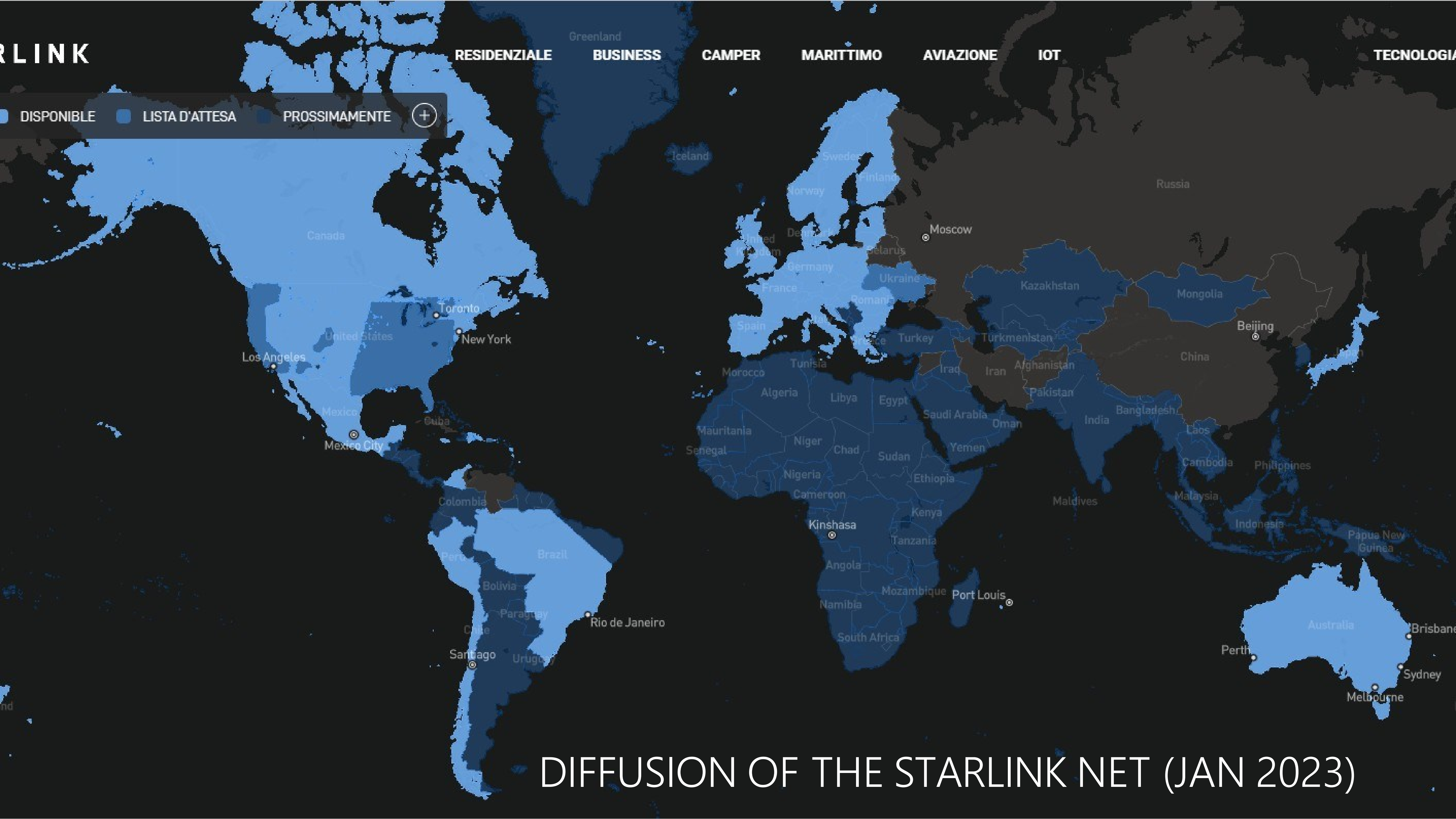
space x crew Dragon

- passenger orbital capsule, reusable
- passengers: max. 7
- first flight to the ISS: 2 March 2019; missions: 7
- carrier: Falcon 9;
- recovery: parachute, at sea

Space X Starship

- Starship + Falcon Super Heavy
- space transport vehicle, 100% reusable
- 2 stages, both reusable
- height: 120m; diameter: 9m.
- payload 100 - 150 t (depends from orbit)
- Falcon Super Heavy engines: 33 liquid methane + oxygen raptors liquid
- Starship engines: 3 Raptors, 3 Raptors vacuum, liquid methane + liquid oxygen
- destinations: Earth orbit , Moon, Mars , terrestrial connections point to point


Space X Starship



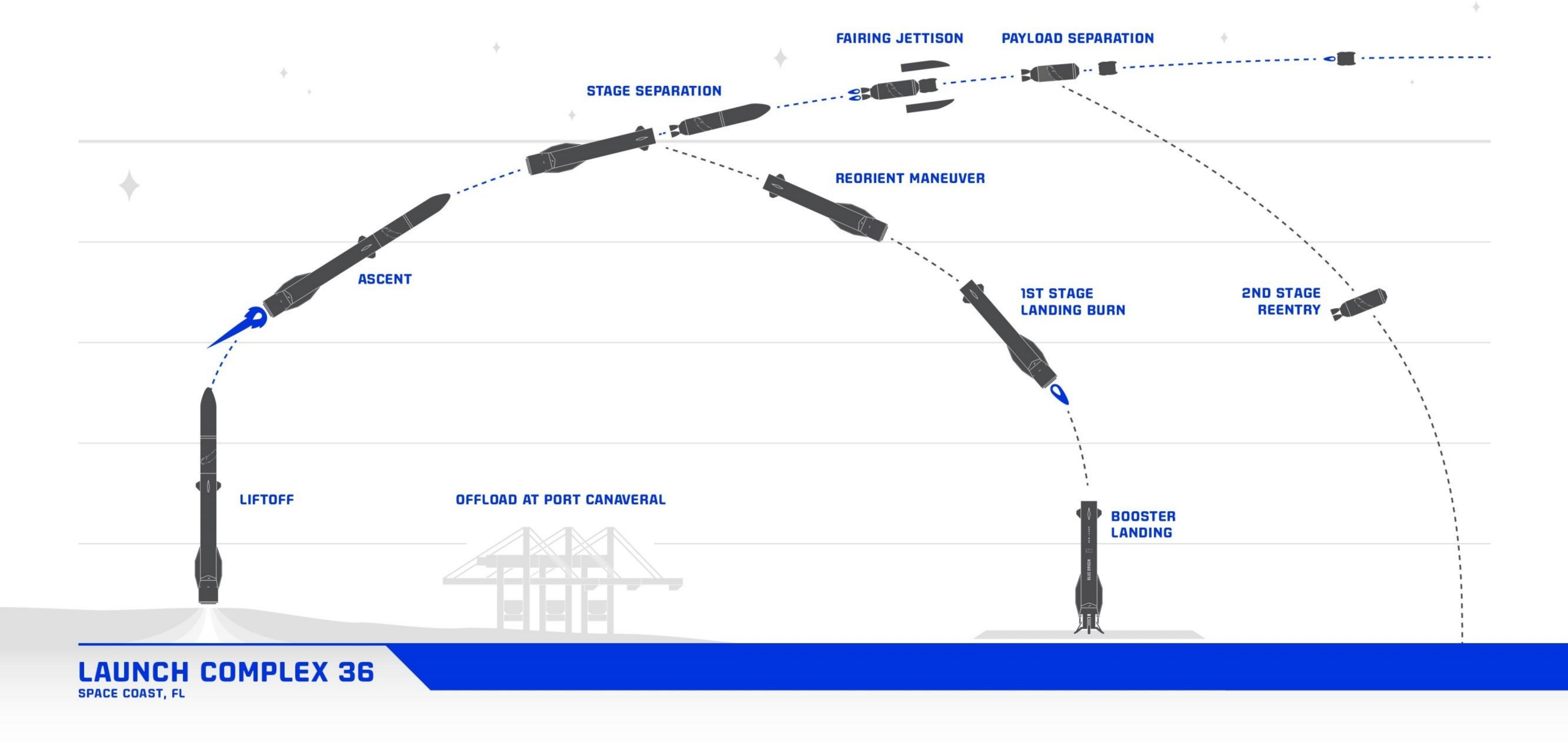
DIFFUSION OF THE STARLINK NET (JAN 2023)

BLUE ORIGIN – NEW GLENN

- Height: 98 m
- Diameter: 7 m.
- max. load useful orbit low: 70,000 Kg
- Launch from: Cape Canaveral
- First launch: 4th quarter 2023
- Thrusters: 7 blue Origin BE4
- Propellant: LCH4 / LOX

- Named after astronaut John Glenn
- heavy lift launch vehicle
- capable of carrying people e payloads in Earth orbit and beyond
- reusable first stage built for 25 missions
- 7 meter fairing = volume of payload twice superior to that of any other existing launch vehicle
- able to launch and land in 95% of conditions weather .

BLUE ORIGIN – NEW GLENN, FLIGHT

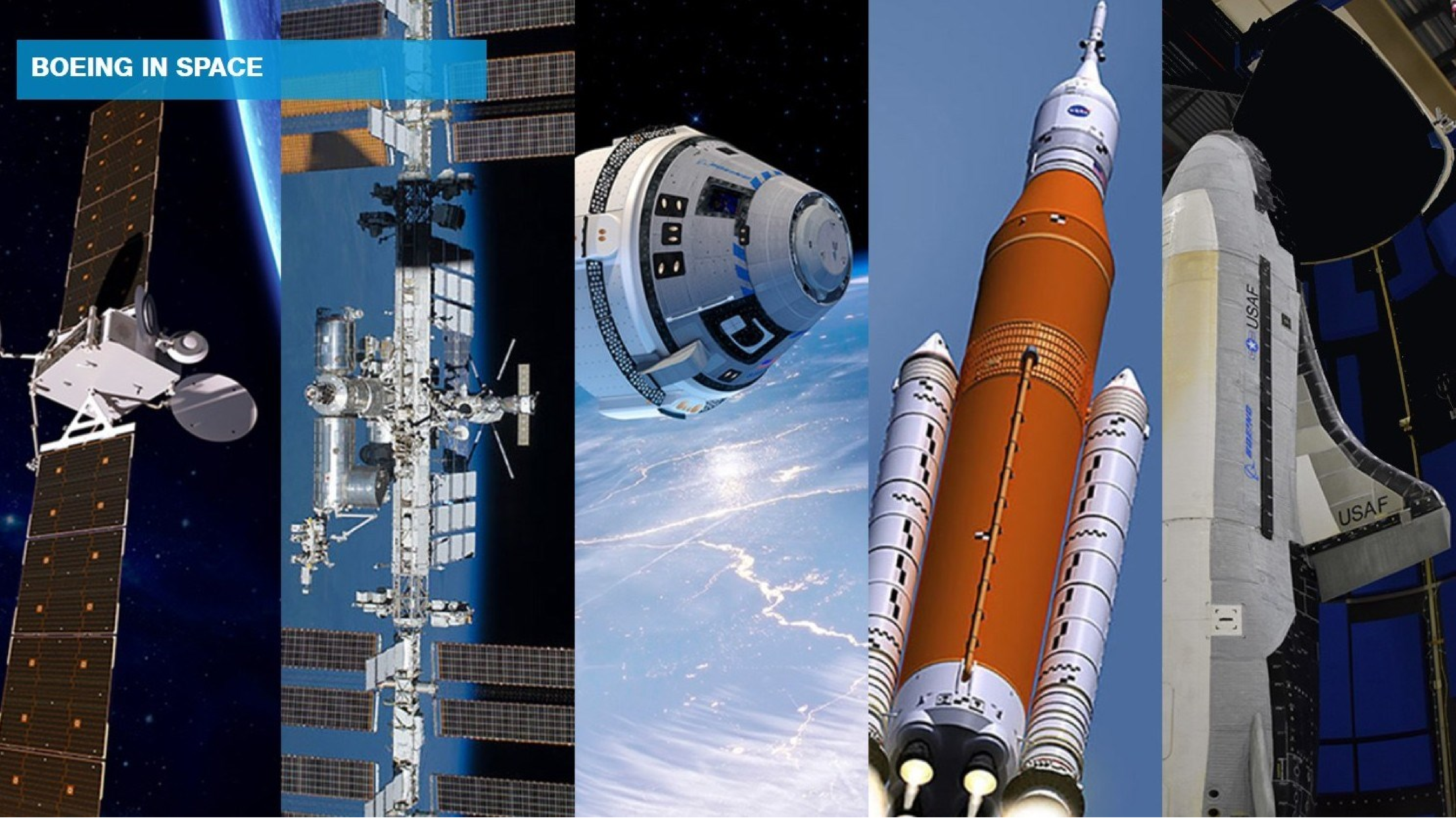


SIERRA NEVADA – DREAM CHASER

SIERRA NEVADA – DREAM CHASER

- 2 configurations:
  - robotic vehicle for cargo transportation
  - manned spaceplane
- Load capacity:
  - 5 t pressurized + 500 kg unpressurised
- Crew: 3 – 7 people
- Destination: LEO
- Function: crew supply and transport to orbital stations (ISS, Orbital Reef)
- First orbital flight: summer 2023
- Propulsion in orbit: Orbitec Vortex engine, fueled by propane and nitrous oxide
- First stage: Atlas V (ULA = Lockeed Martin + Boeing)

BOEING IN SPACE



BOEING

- ARTEMIS - NASA lunar program
- International Space Station (ISS)
- Commercial spacecraft, CST-100 Starliner, for tourism and production in low Earth orbit.
- Space Launch System - transport people and heavy cargo to the Moon and Mars: avionics, central stage and higer stages
- Gateway – cislunar station, clearing house for manned and robotic missions to the lunar surface and eventually to Mars.
- Boeing is partnered with Lockeed Martin in United Launch Alliance (ULA)

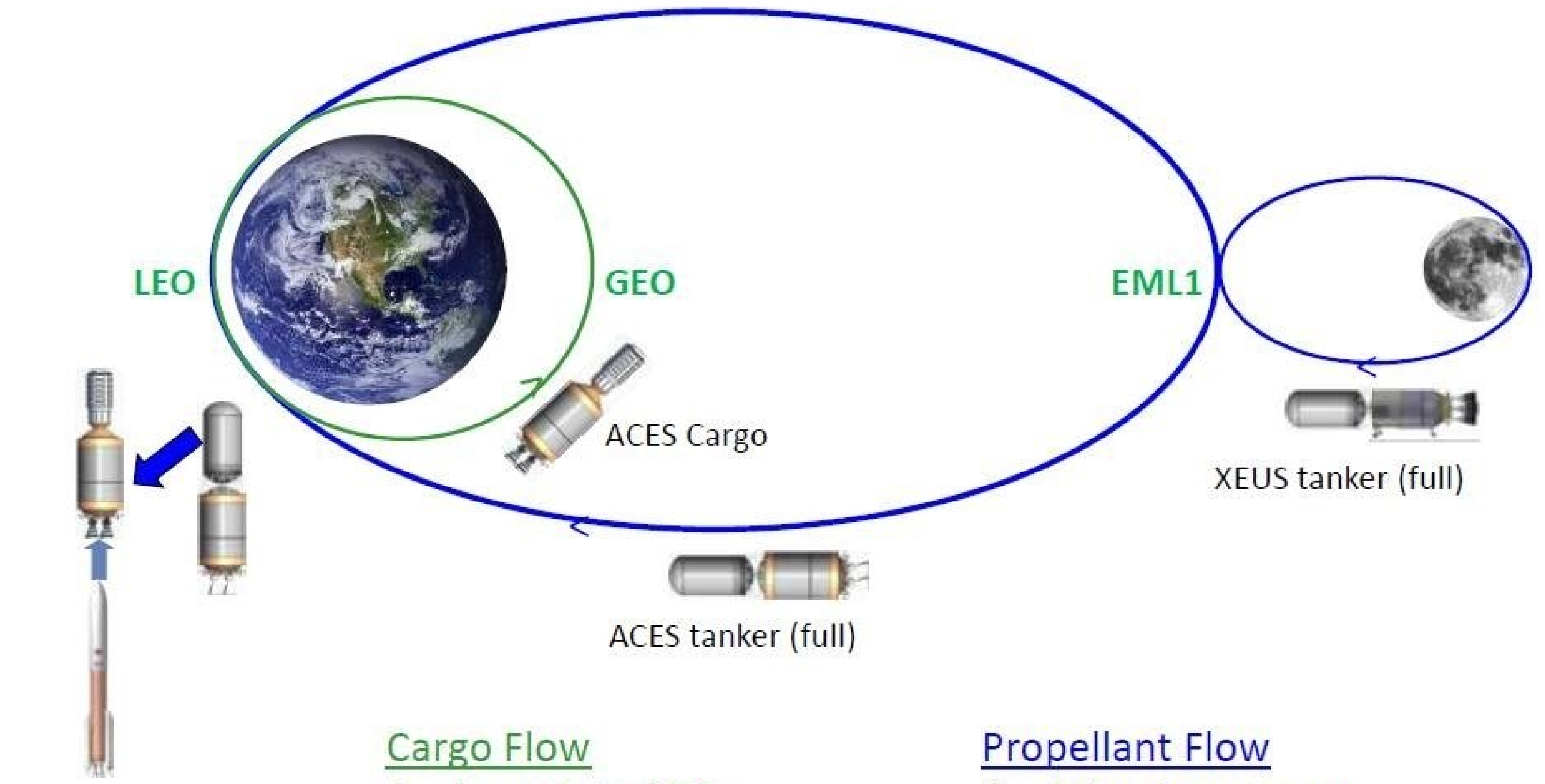
United Launch Alliance

- Boeing + Lockeed Martin
- Main operating products:
  - Atlas V , 98 flights since 2002, will be the carrier of the Starliner and Dream Chaser, RD-180 RD engines Amross , fueled by kerosene and liquid oxygen
  - Centaur , upper stage for Atlas V, for manned flights, Aerojet Rocketdyne RL10 engines, powered by liquid oxygen and hydrogen
  - Delta IV , used predominantly to deliver military payloads into orbit; two Medium versions and Heavy
  - Interim Criogenic Second Stage (ICPS) , upper stage for the SLS, under the Orion capsule.
- In development:
  - Vulcan Centaur , heavy vehicle, for launching capsules or manned spacecraft, such as Starliner and dream chaser; payload 25 t in low orbit, 15 t GEO; BE-4 Blue Origin engines (reusable), powered by liquid methane and liquid oxygen; next reusable version

VULCAN- CENTAUR - PERFORMANCE

Vehicle / Orbit *	Vulcan Centaur (2-solid)	Vulcan Centaur (6-solid)	Vulcan Centaur Heavy (2023)
LEO ER 28.7° (Ref.) 200 km circular	17800 kg [39200 lb]	27400 kg [60300 lb]	34900 kg [76900 lb]
LEO ER 51.6° (ISS) 407 km circular	15300 kg [33800 lb]	24200 kg [53400 lb]	31400 kg [69300 lb]
LEO WR 90° (Polar) 200 km circular	14300 kg [31500 lb]	22300 kg [49200 lb]	27900 kg [61500 lb]
GTO 1800 m/s 35,786 km x 185 km @ 27.0 deg	7400 kg [16400 lb]	13300 kg [29300 lb]	16300 kg [35900 lb]
GEO 35,786 km circular @ 0 deg	2050 kg [4500 lb]	6000 kg [13200 lb]	7200 kg [15900 lb]

Business Model



Payload Launch to LEO

Cargo Flow

1. Launch to LEO
2. Refuel Cargo ACES
3. Transport to GEO
4. Deploy cargo

Propellant Flow

1. Mined on moon
2. XEUS transport to EML1
3. Transfer from XEUS to ACES
4. ACES transport to LEO
5. Transfer to cargo ACES

NORTHROP GRUMMAN

- James Webb Space Telescope NASA
- Antares, launch vehicle
- Cygnus, shuttle for supply and scientific payloads to the ISS
- Mission Extension Vehicle (MEV), docking , proximity operations, satellite maintenance in orbit, to lengthen satellite's operational life
- Artemis Project :
  - solid propellant thrusters for SLS
  - mission abortion engines for SLS
  - attitude control motors for the module crewed by Orion
- Commercial Orbital Station, drawing conceptual
- Different products for defense

- ISMA - In Space manufacturing and assembly orbiting
- Orbital debris, mitigation techniques , removal, avoidance
- Participation in Remove Debris
- Spaceplane
- Service module for the capsule Orion (Project Artemis)
- Columbus module on the ISS
- Communication satellites, earth observation, science, navigation

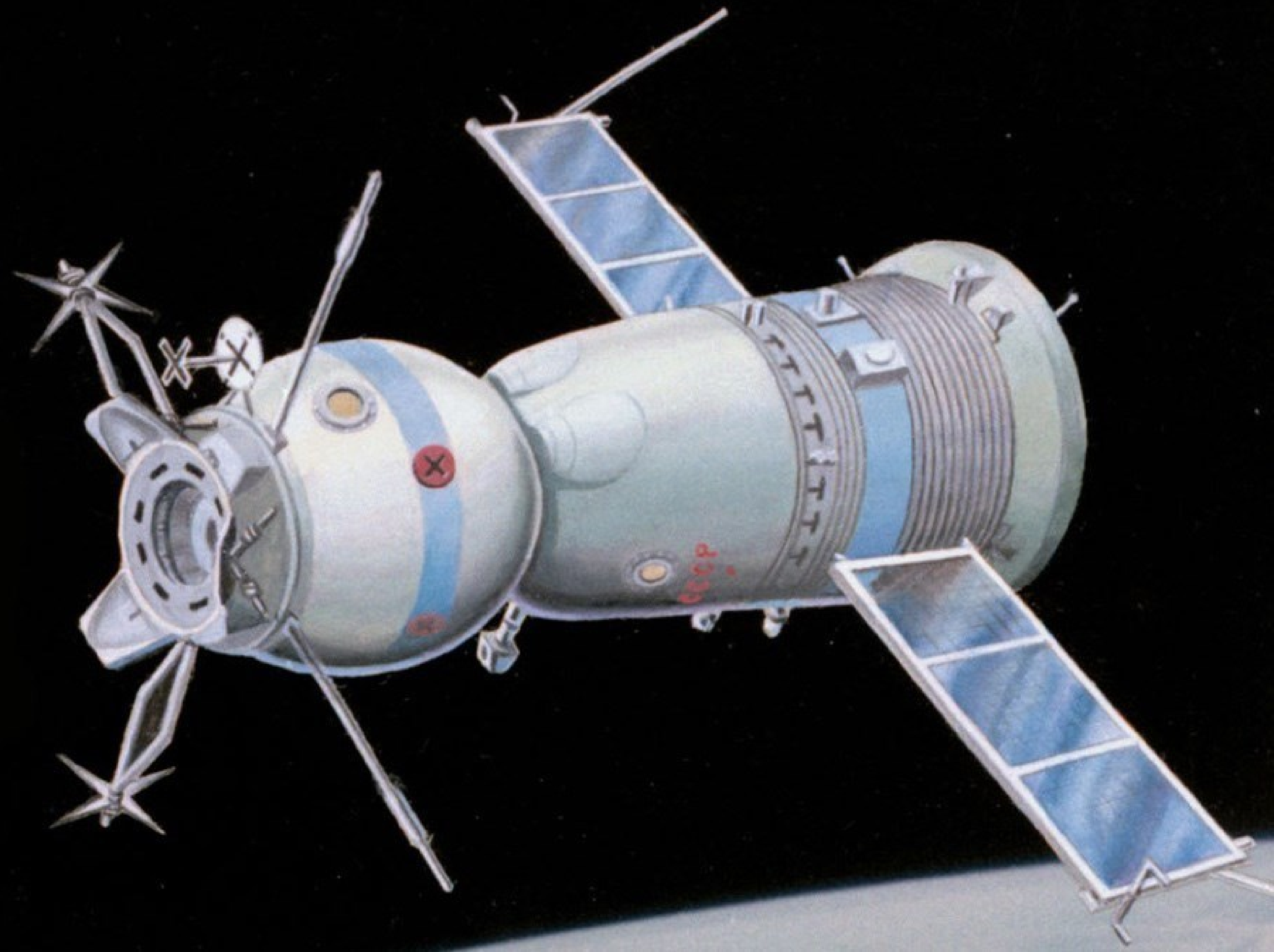
ARIANE GROUP

- Ariane 6, family of expendable launchers, 2 stages
    - LEO, GTO (Geostationary Transfer Orbit), SSO (Sun Sybchronous Orbit)
    - upper stage, Vinci motor, which allows switching off and on again
    - height: max 63 m., diameter: 5.4 m.
    - two configurations:
        - Ariane 64, 4 thrusters, 20 t in LEO, 12 t in GTO
        - Ariane 62, 2 thrusters, 7 t in LEO and 4.5 t in GTO
    - production cost 40-50% less than Ariane 5, thanks to 3d printing technologies, laser surface treatment, friction-stretch welding
- Ariane 5, expendable launcher, 2 stages
    - height: max 52 m., diameter: 5.2 m.
    - two configurations:
        - Ariane 5 ES, 2 thrusters, 16 t in LEO, 12 t in MEO
        - Ariane 5 ECA, 2 thrusters, 10.5 t in GTO

Ariane 6 **Ariane 5**

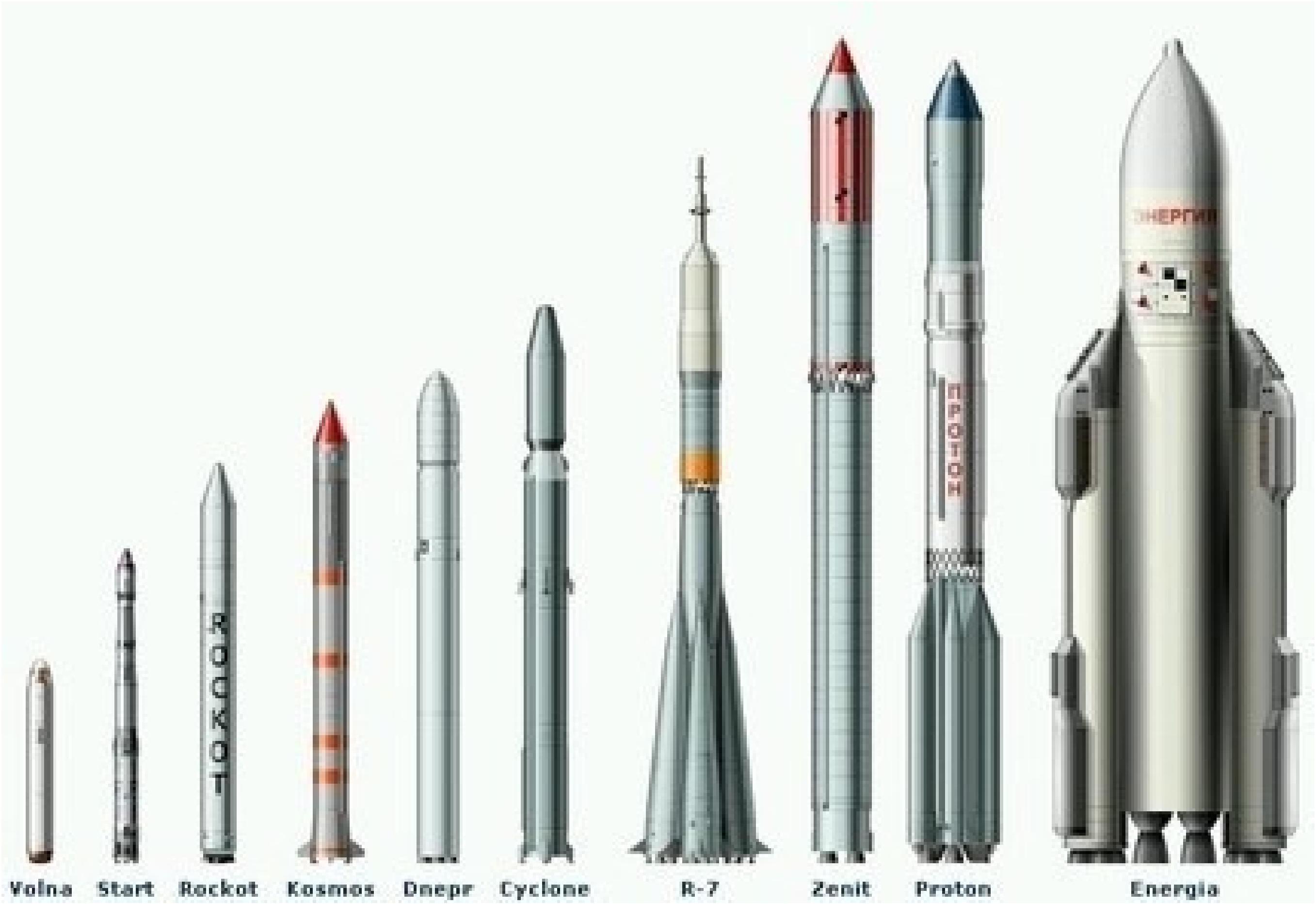
SOYUZ

- Transport vehicle for astronauts to orbital stations : Saljut, Mir, International Space Station.
- producer: RK extension Progress
- height: 49.3 m., diameter: 8.04 m.
- first flight without crew 28 November 1966
- first flight with crew 23 April 1967
- passengers: max 3
- thrusters: 1st stage 4xRD- 107; 2nd stage 1xRD- 108; 3rd stadium (there spacecraft) RD-0110, RD- 0124
- Launch sites: Baikonur, Pleseck, Vostochny, Guyana
- future: Soyuz-5, first launch 2025, 2026 lunar orbit



RUSSIANS EXPENDIBLE LAUNCHERS

- Soyuz , expendable rocket family, OKB-1 e Progress Rocket Space Centre; operating
- N1, super heavy launcher, over LEO; OKB-1; h: 105 m, diam: 17 m.; load: 95t in LEO, 23.5t trans moon; decommissioned
- Proton, launcher for government use and commercial ; Khrunichev State Research Centre; h: 53 m., diam.: 7.4 m.; load : 23.7 t in GTO, 6.3t; operating
- Energy , super-heavy launcher, for the shuttle Buran; NPO Energy; h:58.8m. diameter: 17.65 m.; cargo : 100 t LEO, 20 t GSO, 32 t trans luna ; decommissioned
- Angara, family of launchers, Khrunichev State Research Centre; 2 or 3 stages; max h: 64 m.; max cargo : 24.5 t LEO, 6.6 t GTO, 4 t GEO; operating



CHINESE LAUNCHERS

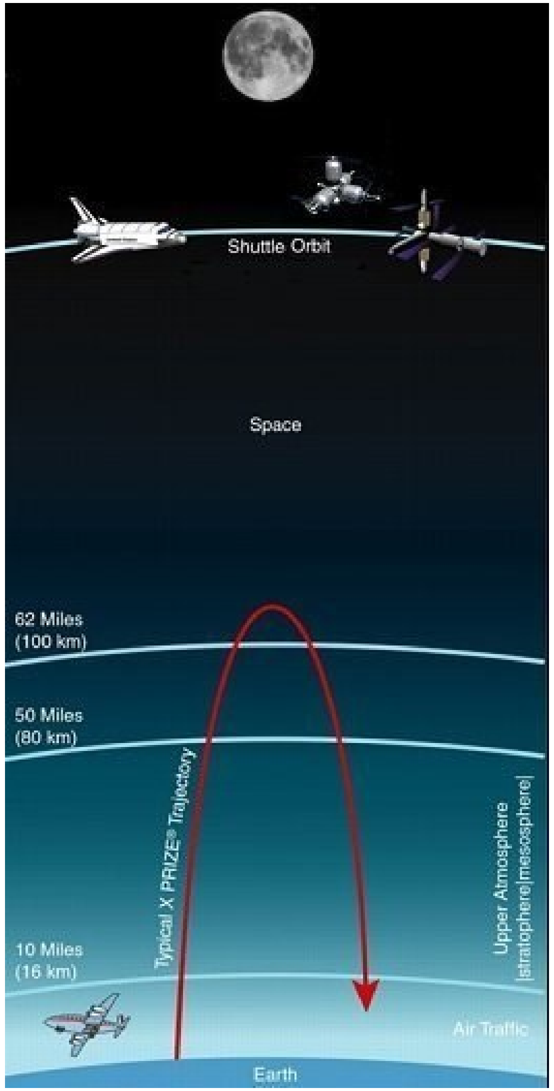
- Long March, expendable rocket family, China Aerospace Science and Technology Corporation; from 1 to 9, then 11
- Long March 5, 6, 7, new expendable rockets generation ; YF-100-class thrusters; RP1/LOX propellant ; heavy load: 25t LEO
- Long March 9, expendable heavy launcher, in development course ; heavy load: 160t LEO, 53t trans Moon, 44 t Mars; version 22 will be reusable
- New Refillable Pitcher, Academy of Aerospace Propulsion Technology, a division of China Aerospace Science and Technology Corporation (CASC); thruster: YF-100N; first flight 2026; propellant: kerosene and oxygen liquid or ; use: crew transport to the station space Tiangong and lunar missions

Since 1970 the PRC has launched 12 different versions of the Long March rocket. The eight rockets depicted above, plus one not shown, are in use today. Three new versions of the rocket are said to be in development.

SPACE TOURISM

TOURISM SPACE: MARKET AND SEGMENTATION

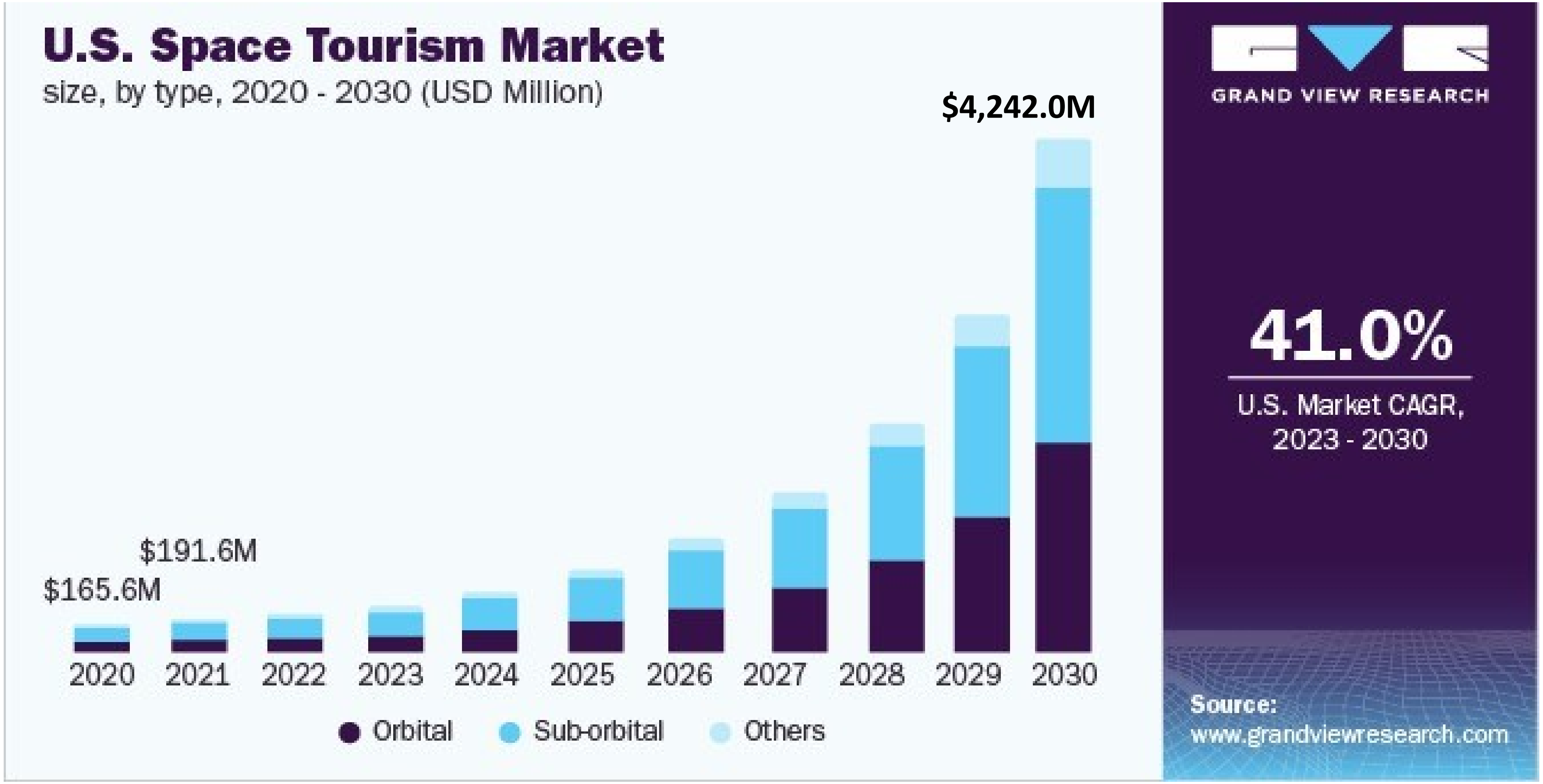
- **Suborbital tourism**
  - Exceeding the quota of 100km
  - Aircraft already tested and in series production phase
  - Start of operational activities in 2022 (Blue Origin, Virgin Galactic)
  - **Cost per person: $250k**
- **Orbital Earth Tourism**
  - Activity currently performed using Dragon Crew (Space X) pods, more ergonomic compared to the old Soyuz and Space Shuttle
  - **Cost per person: approx. 60M$**
- **Stay in Orbit in Pressurized Structures**
  - Only the ISS currently available, unsuitable for this task either commercially and for safety aspects, as to civil standards are concerned
  - Inflatable habitat under test, with reception capacity >ISS
  - Commercial orbital stations, in design stage
  - Operational start of new habitats: within 2030



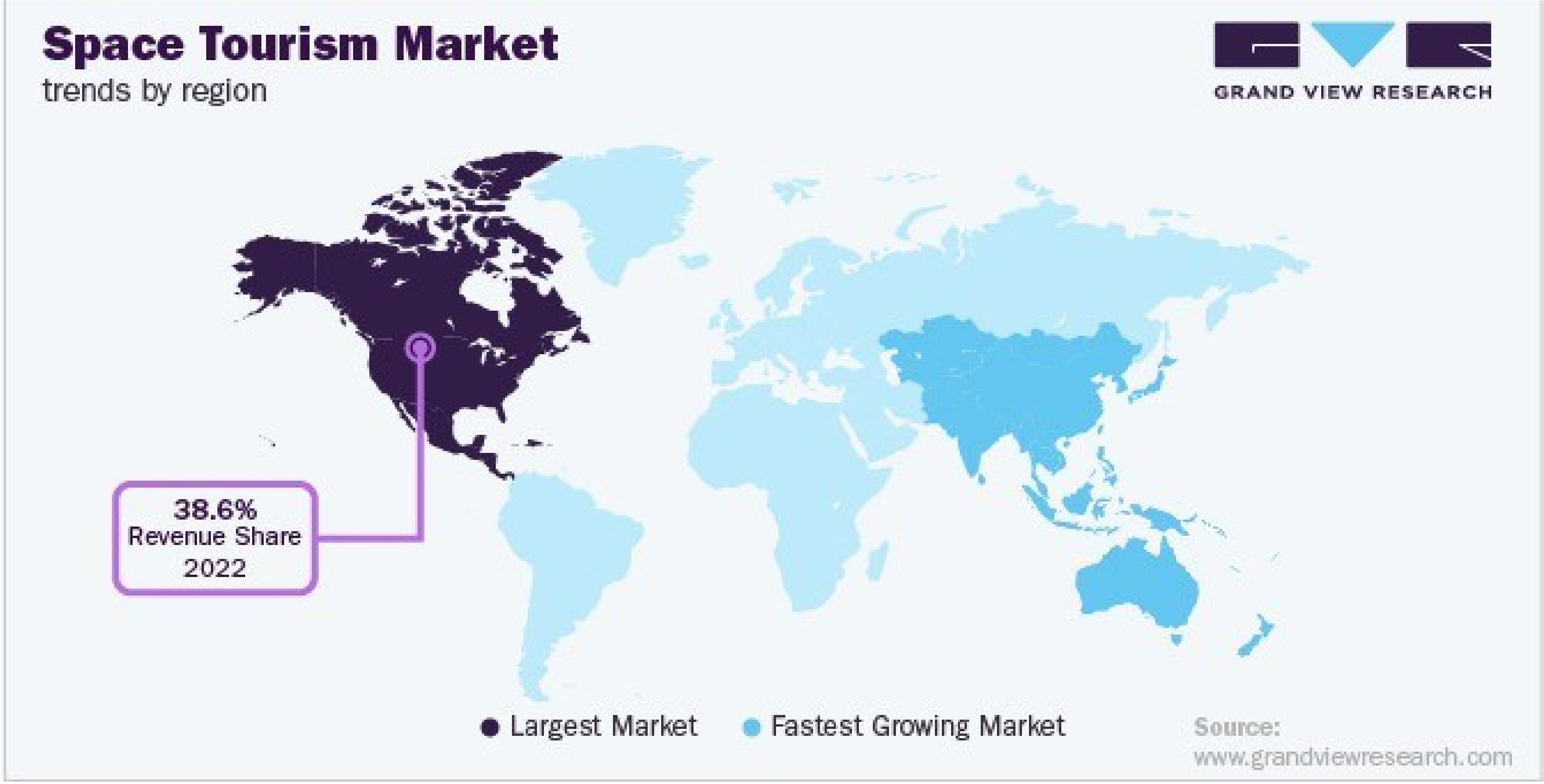
SPACE TOURISM: CURRENT GLOBAL MARKET AND FORECASTS

attribute	details
Global market value 2023	USD 815.7 million
Forecast 2030	USD 8.7 billion
Growth rate	40.2% from 2023 to 2030
Base year for the estimate	2022
Historical data	2017 - 2021
Forecast period	2023 - 2030
Areas considered	North America; Europe; Asia Pacific; Latin America; Middle East & Africa
Profiled companies	Airbus Group SE; Axiom Space; Blue Origin; Boeing; Orion Span; Space Adventures; SpaceX; Virgin Galactic; Zero2Infinity; ZERO-G

SPACE TOURISM: USA CURRENT MARKET AND FORECASTS



SPACE TOURISM: AREAS WITH GREATEST GROWTH



SPACE TOURISM: POTENTIALS CLIENTS

Distribution of the "High net Worth Individuals" (0.28% of the world population), bands of Income (2021)*

22.4M potential customers for

- Suborbital tourism
- Orbital tourism
- Stay in orbit

2.2M potential customers for

- Orbital tourism
- Stay in orbit

	Number of HNWIs 2021	Share of HNWI wealth 2021	HNWI Population Growth 2020-2021*	HNWI Wealth Growth 2020-2021*
Ultra-HNWIs US$30m+	220.1k (1% of total)	34%	9.6% (0PP)	8.1% (-1PP)
Mid-Tier Millionaires US$5m-US$30m	2,055.0k (9.1% of total)	22.8%	8.5% (0.7PP)	8.4% (0.5PP)
Millionaires Next Door US$1m-US$5m	20,183.9k (89.9% of total)	43.2%	7.7% (1.6PP)	7.8% (1.5PP)

*PP = Percentage Points denotes the change between 2020 & 2021
Source: Capgemini Research Institute for Financial Services Analysis, 2022.

* Source: https://worldwealthreport.com/pdf/Capgemini_WWR_2022_VFinal_Digital.pdf

SPACE TOURISM: MAIN COMPANIES

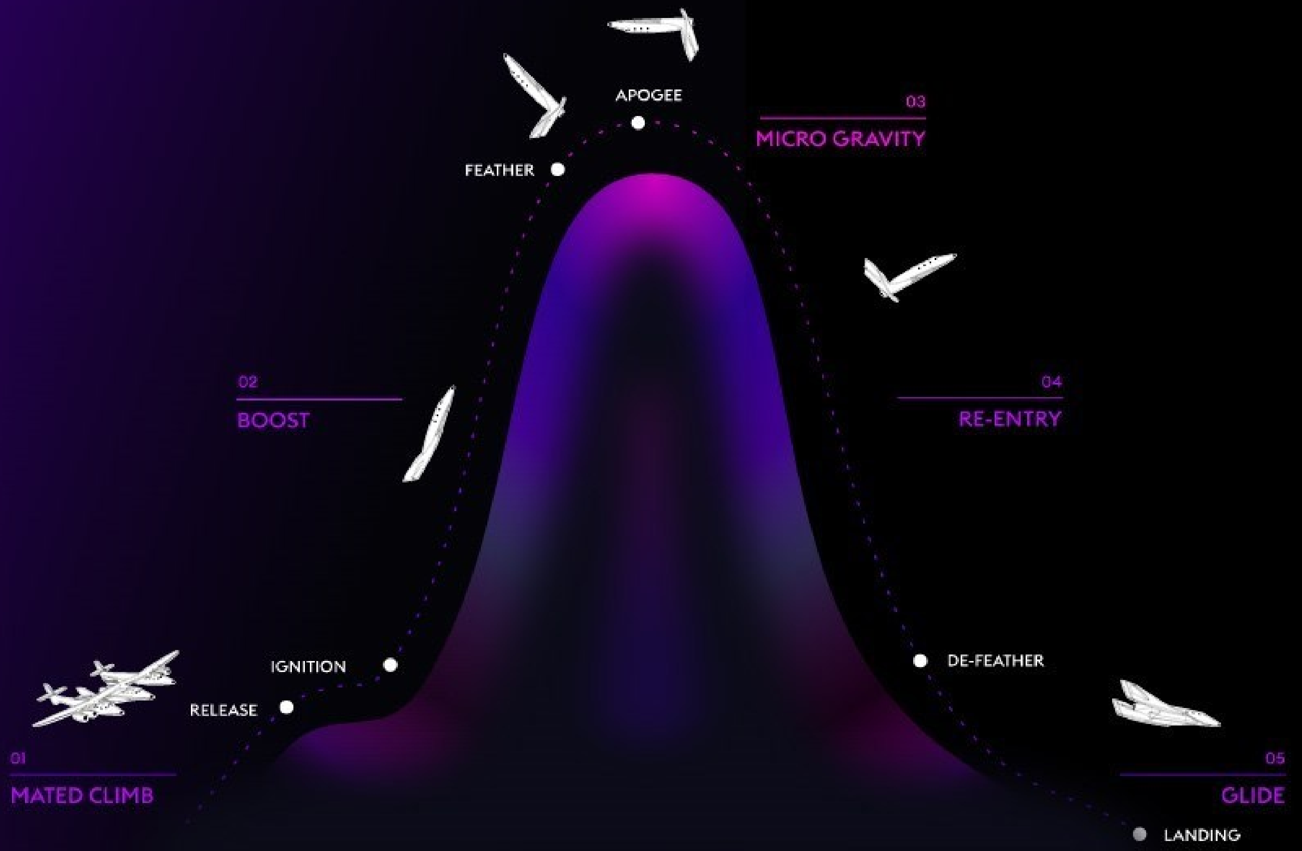
agency	offer	training	locality	trade activity	prices
Virgin Galactic	**suborbital flight** , ca. 100km, 4 passengers, on SpaceShipTwo Unity	3 days	Spaceports AmericaNew Mexico(*)	2023	250K$
Blue Origin	**suborbital flight** , ca. 100km, 6 passengers, on NewShepard	2 days	Van Horn, Texas	open	>$1 million
SpaceX	**Orbital flight** , **ISS visit** , low orbit, 4 passengers, on Falcon 9 + Dragon Crew	6 months	Cape Canaveral	open	>$50 million
	Circumlunar flight , on Starship	6 months	NP	2024	NP
Axiom Space	**Visit to ISS** , low orbit, 4 passengers, on Falcon 9 + Dragon Crew	120 days	Cape Canaveral	open	>$50 million
Space Adventures	**Visit to the ISS**, on Soyuz	NP(**)	Baikonur	open	$50-60 million
	Circumlunar flight, over Soyuz	NP	Baikonur	open	$150 million
	Zero G parabolic flights, visits to space bases	--	Various	open	>5K$
Zero 2 Infinity	**Flight at an altitude of 36 km** , 6 passengers, 5 hours on stratospheric balloon	NP	Airports in Spain	open	132K$

(*) agreements with several spaceports in the world, including Grottaglie (Puglia) (**) NP = not received

VIRGIN GALACTIC SPACESHIPTWO SUBORBITAL FLIGHT

VIRGIN GALACTIC SPACEFLIGHT

Experience weightlessness, breathtaking views of Earth, and a life-changing transformation through our unique and innovative spaceflight system, all in unparalleled comfort.

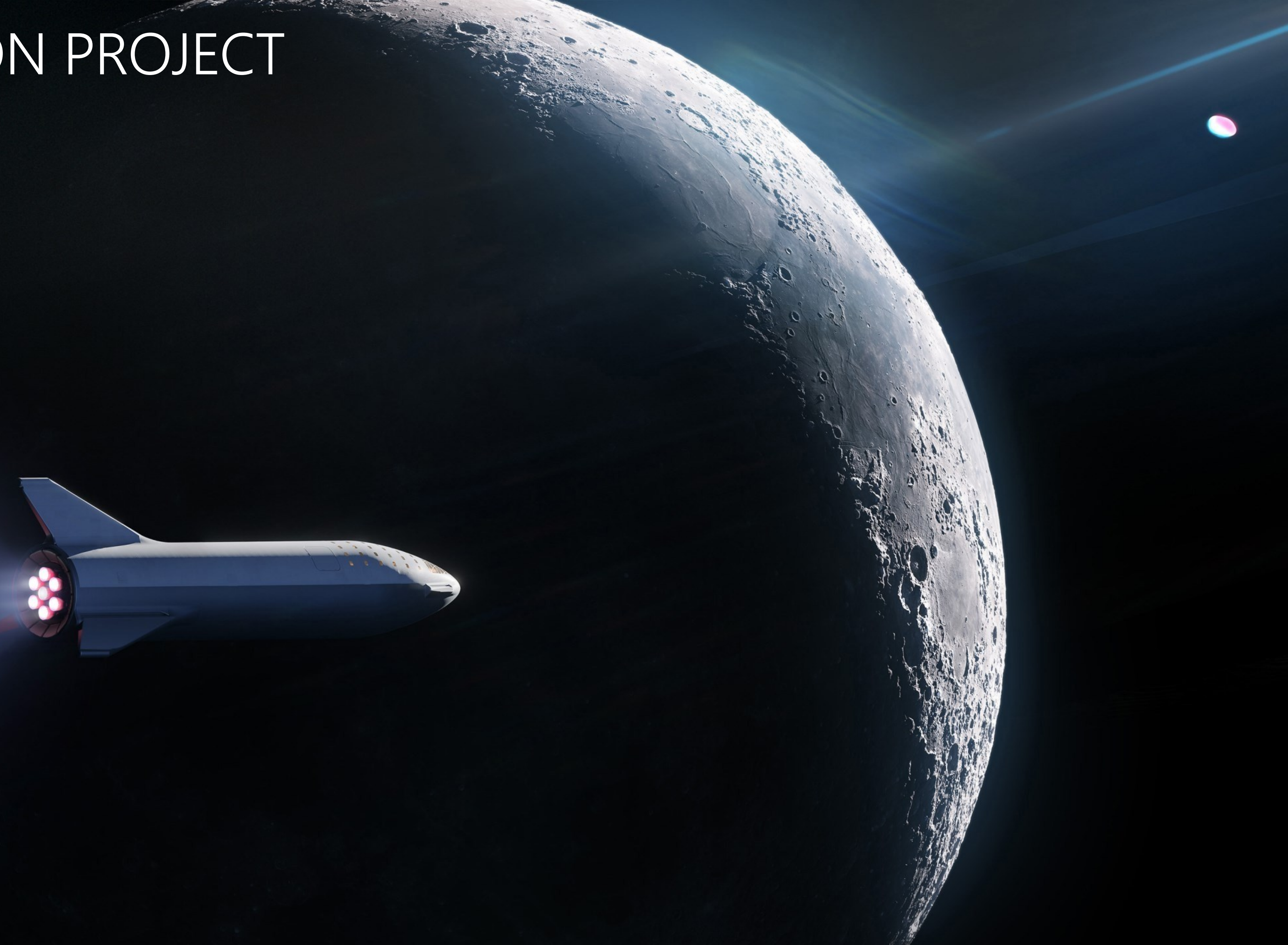


PASSENGERS	MIN SPACEFLIGHT	MPH MAX SPEED	GRAVITY
4	90	2.6K	0

Launch — Landing

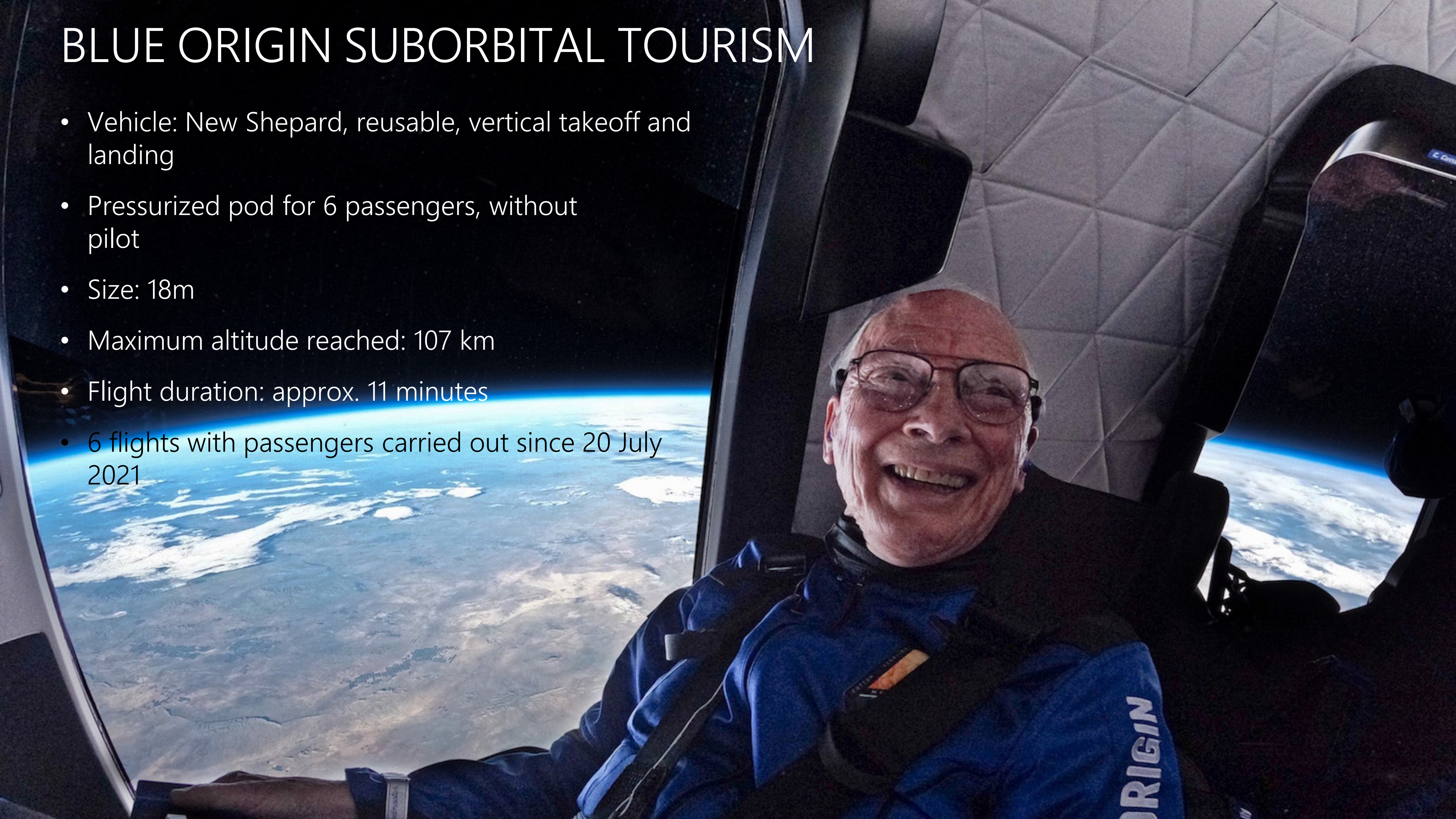
THE DEAR MOON PROJECT

- lunar tourism and project artistic conceived and funded by Japanese billionaire Yusaku Maezawa.
- SpaceX Starship spacecraft
- circumlunar journey, 6 days
- 9 civilian passengers, 2 crew
- production of artistic works during the trip
- peace promotion in the world



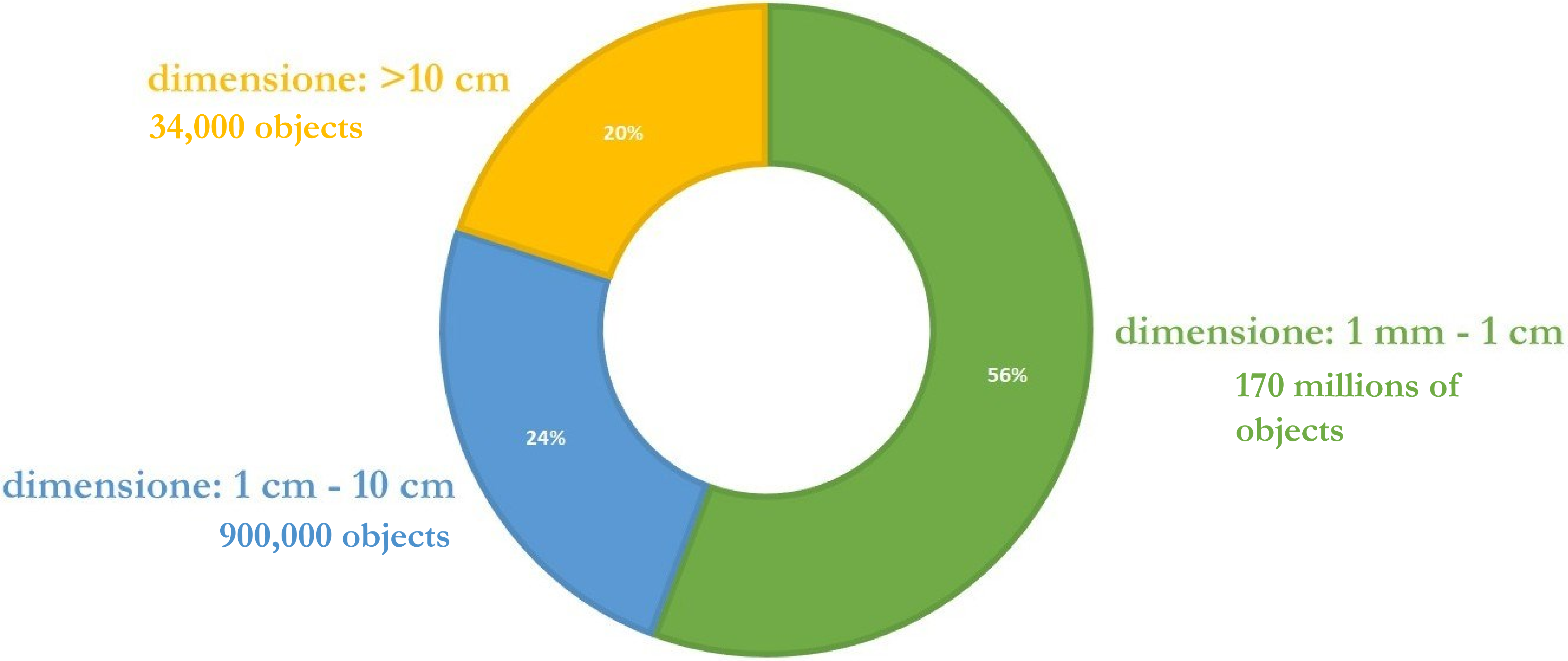
BLUE ORIGIN SUBORBITAL TOURISM

- Vehicle: New Shepard, reusable, vertical takeoff and landing
- Pressurized pod for 6 passengers, without pilot
- Size: 18m
- Maximum altitude reached: 107 km
- Flight duration: approx. 11 minutes
- 6 flights with passengers carried out since 20 July 2021



ORBITAL DEBRIS, RECOVERY AND REUSE

ORBITAL DEBRIS (2021)



SPACE DEBRIS AND SCRAP, MONITORING AND REMOVAL: THE MARKET

The market:

- Current value: approx. $1 billion
- 2029 forecast: $1.5 billion
- Expected annual growth rate: 7.15%
- Growth Factors:
  - increased demand caused by increasing number of satellite launches and of space exploration
  - growing partnership between nations key to situational alert in space
- Obstacles:
  - Lack of legal regulations for the space debris

The strategies:

- Monitor :
  - NASA tracks 27,000 objects (2021)
  - laser tracking
  - through telescopes
- Mitigate :
  - limit or prevent the creation of new debris,
  - design satellites that can withstand impacts
  - use of orbital regimes with less debris
  - extend the operational lifetime, by orbital maintenance
  - instruct spacecraft to avoid collisions with debris
- Remove :
  - de-orbit, by means of a special propulsion device, at the end of operational life
  - move to "disposal" orbits at end of operational life
- Reuse : a chapter to be written, as soon as possible

https://www.fortunebusinessinsights.com/space-debris-monitoring-and-removal-market-104070

SPACE DEBRIS AND SCRAP: COMPANIES AND RESEARCH CENTERS

- D-ORBIT SpA
- Airbus SAS (Netherlands)
- Astroscale (Netherlands)
- Clear space (Switzerland)
- Electro Optic Systems (Australia)
- Lockheed Martin corporation (US)
- Northrop Grumman corporation (US)
- Orbits Guardians (US)
- Obruta (Canada)
- Share my space (France)
- Voyager space Holdings Inc. (US)

- Surrey Research Center (UK) https://www.surrey.ac.uk/surrey-space-centre/missions/removedebris
- Center for Orbital and Reentry Debris Studies (CORDS) https://aerospace.org/cords
- Center for Orbital Debris Education and Research (CODER) University of Maryland https://spac.umd.edu/news/story/university-of-maryland-establishes-orbital-debris-research-center
- University of Padua

SURREY SPACE CENTRE, UK: REMOVE DEBRIS

- Main satellite platform (100 kg), on SpaceX Falcon 9 on the ISS, then deployed in orbit
- space debris capture experiments:
  - Harpoon
  - Net
  - Tow sail for re-atmosphere
- co-funded by the European Commission, Airbus, and others
- Seventh Framework Program of the European Union (FP7/2007-2013)
- Launched in April 2018
- End of mission: December 2021
- Program directed by Guglielmo Aglietti

https://youtu.be/_QUhCLTfXf0

Transition to a Circular Economy in Space (2050)

Servicers
- Refuel
- Assemble
- Manufacture

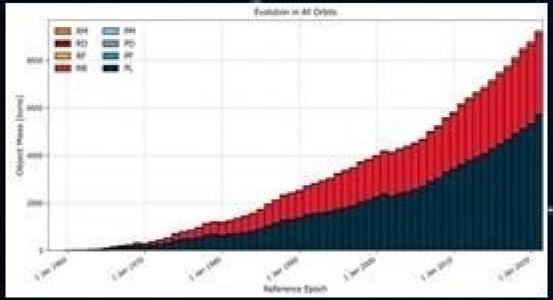
Orbital Depots
- Space logistics
- Propellant tankers
- Warehouse

Upgradable platforms
- Permanent Hosted LEO/GEO platforms
- Next generation platforms

Circular Economy: Ensuring long-term orbital sustainability through in-orbit servicing

In order to prepare for a circular economy in space, system studies and analysis is required to understand the evolutionary need on space infrastructure

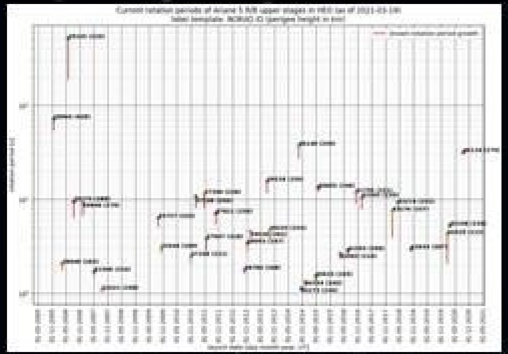
Concept



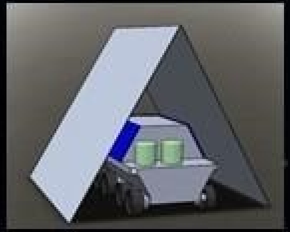
The "resource" space debris is growing exponentially. More than 9,000 tons already exists.

Dangerous objects must be removed. Upper stages are most relevant with roughly one explosion per year.

Upper stages are a great source of raw materials. The Ariane 5 ESC-A: weights 3,7t, with 2,2t of aluminium.



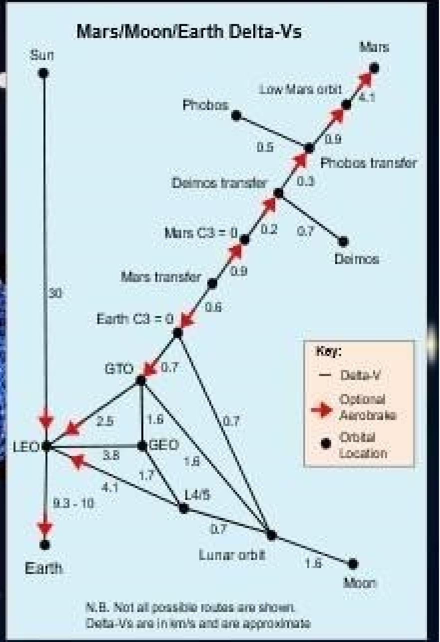
Lightcurve measurements identified upper stages with low rotation periods of >30sec. A natural deceleration was observed for all.



Lunar aluminium casting in regolith has advantages like no oxidation losses or the production of large or fragile objects.

Lunar use cases:
Walls, Power Lines,
Heat Storage Systems

The upper stages are located in GTO. Roughly 75% of the Moon transfer energy (delta-v) is already paid.



The lunar recycling Infrastructure can be launched & transported with European launcher (Ariane 6) & landers (EL3).

The required technology is currently developed or can be derived from other missions, like ClearSpace-1.

SPACE DEBRIS AND SCRAP: A HUGE VALUE

- Keywords: recycle, refurbish, reprocess, redeploy and reuse.
- There are many tons of precious materials in orbit: metals such as aluminum and titanium alloys, composite materials, etc.
- could be used to produce and assemble new generation orbital and lunar infrastructure directly in orbit
- recycling could be used temporarily, before the availability of the In-Situ-Resource-Utilization (ISRU), i.e. from lunar and asteroid raw materials.
- By in orbit materials reprocessing it will be possible to produce fuel for passengers and cargo transport vehicles.
- Orbiting materials have one key advantage: they already possess high energy gravity, which was transferred to them during launch.
- i.e. such materials don’t need to be transferred from earth's surface to orbit (the most of the price per kilogram).

ORBIT RECYCLING, GERMANY

- Over 8,000 tons of space debris endangers all space activities.
- Satellite operators pay more than 14 million euros a year for maneuvers evasive payments and $1 billion in insurance premiums.
- The Orbit Recycling program:
- Space debris will be carried from orbit to the Moon and recycled there.
- tonnes of aluminum can be recovered from the upper stages of Ariane 5.
- By such material it will be possible to build large parts of a lunar station, for example walls, power lines or heat storage systems.
- Being the materials collected in orbit, transporting them to the Moon will just require small propulsion units, which can be launched at moderate costs.
- Over 50 billion euros can be saved in transport costs.

https://www.gausssteam.com/esa-castelgauss-orbit-recycling/

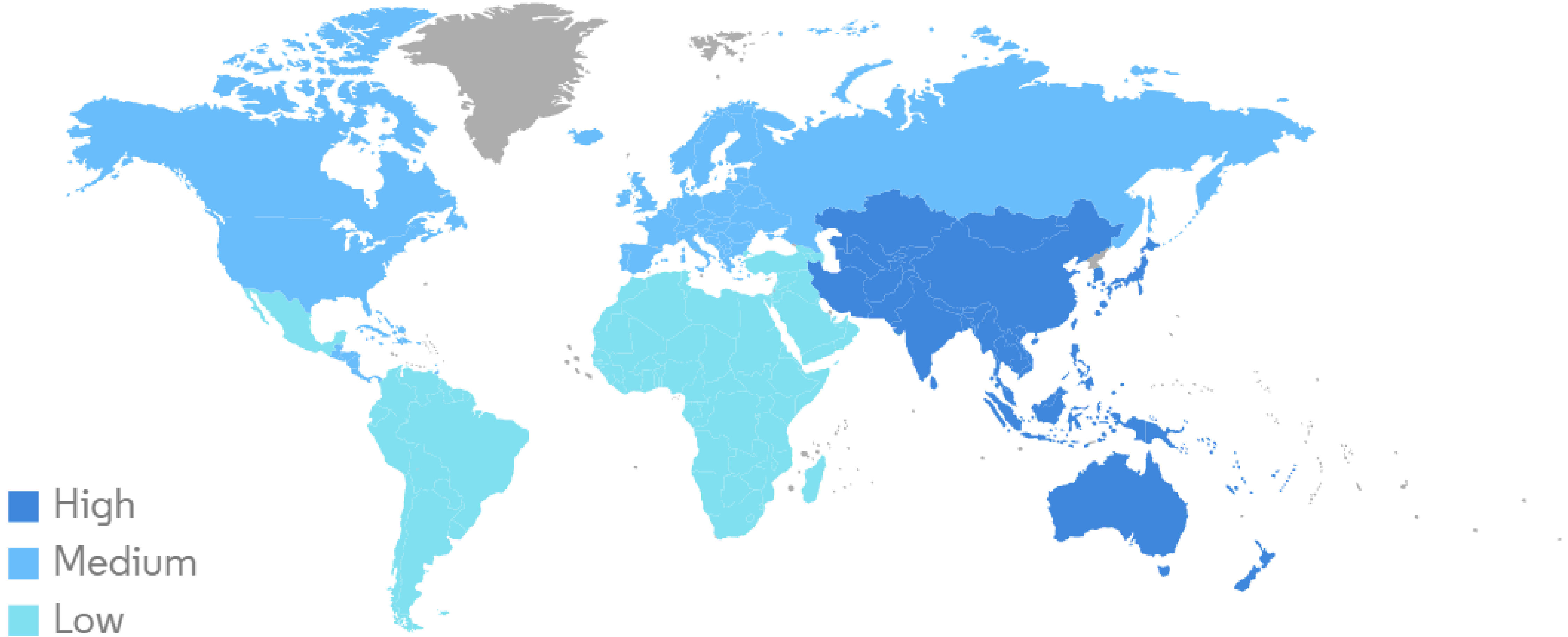
SPACE DEBRIS AND SCRAP, REUSE

- ESA:
  - 2030 goal: add zero debris net to the Earth's orbital environment (neutrality)
  - first step: apply, by 2030, the requirements of Debris mitigation to orbiting objects terrestrial low , with probability of disposal > 90% currently required
  - second step: promoting the "circular economy" in space
  - long-term orbital sustainability term through on-orbit maintenance« = to recycle, refurbish, refurbish and reuse by 2050
- US SPACE FORCE:
  - 3-year target: demonstration in space from the debris removal
  - aggressively explore these capabilities to you can then buy them as a service
  - collaboration between companies, institutions academics and non-profit
- NASA:
  - Orbital Debris Program Office (ODPO) (*): debris measurements, modeling, protection, mitigation, remediation, reentry
- USA collaborations, to create a market of space recycling :
  - Space Force, with Department of Commerce (DOC)
  - Space Force/Space Systems Command with NASA Small Business Innovation Research e Small Business Technology Transfer (SBIR/STTR)
  - NOAA Office of Space Commerce with Space Force and NASA ODPO
- ACO RECYCLING, TURKEY:
  - Waste recycling technologies produced by space habitats, by conversion into methane gas, hydrogen, CO_2

https://orbitaldebris.jsc.nasa.gov/mitigation/
https://www.dayoneproject.org/ideas/taking-out-the-space-trash-creating-an-advanced-market-commitment- for- recycling-and-removing-large-scale-space-debris/

MINING ASTEROIDS

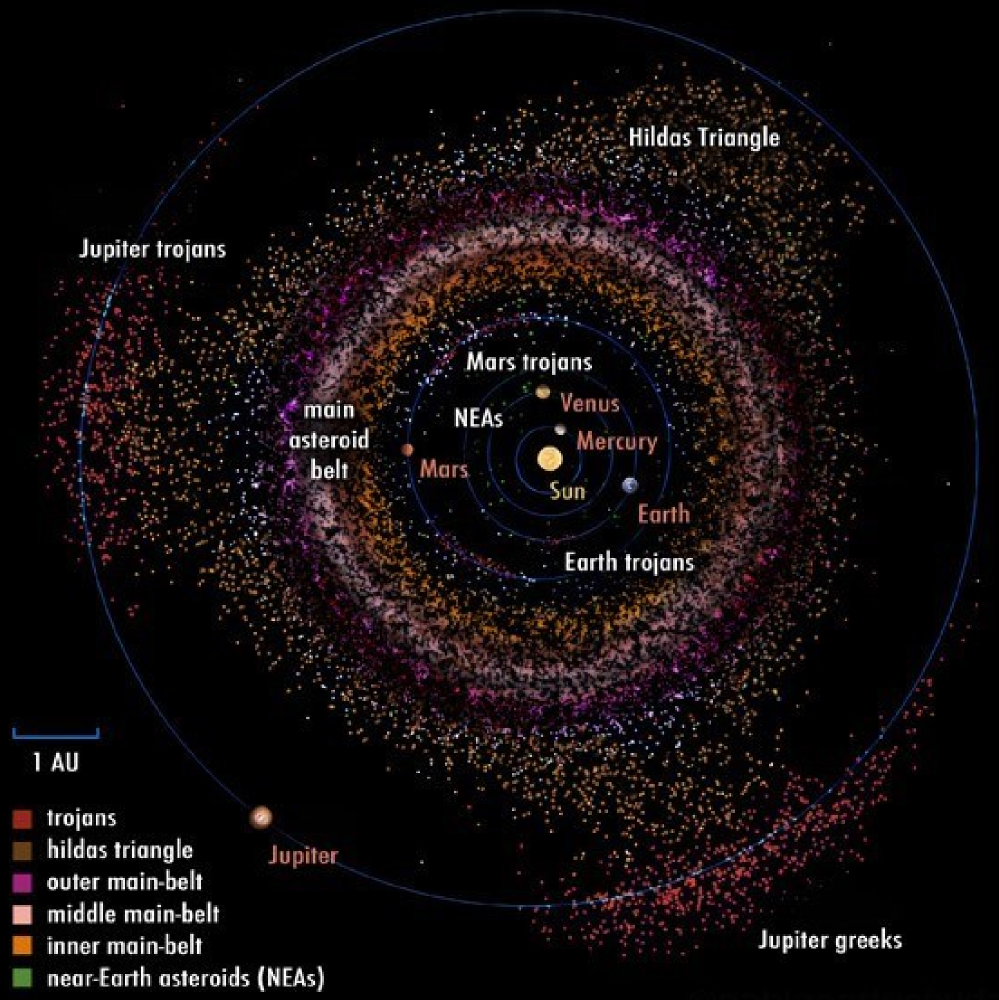
Space Mining Market - Growth Rate by Region (2022 - 2036)



Source: Mordor Intelligence https://www.mordorintelligence.com/industry-reports/space-mining- market- industry

ASTEROID MINING: COMPANIES AND PROJECTS

- Trans Astronautica Corporation , USA, https://transastra.com/
  - Optical Mining™ technology for the extraction of propellant raw materials from asteroids: water and other materials for space propulsion
  - Honey Bees, vehicle-laboratory system for the collection and production process of propellants in space
- AsteroidMiningCorporation , UK, https://asteroidminingcorporation.co.uk/
  - Asteroid Prospecting Satellite I (APS-1), 2025, observation and analysis thousands of NEA, Space Resource Database
  - Asteroid Prospecting Satellite II (APS-2), close exploration of selected asteroids
  - Asteroid Exploration Probe I (AEP-1), landing, sampling, selected asteroids
  - Asteroid Mining Probe I (AMP-1), extraction of 20 t of titanium from selected asteroids
- AstroForge, has received a $13M investment, to extract materials from an asteroid and bring them to Earth; missions, in partnership with OrbAstro:
  - April 2023 on Falcon 9, validation of extraction technologies and zero gravity materials processing
  - October 2023, in partnership with Intuitive Machines at Dawn Aerospace, circumlunar flight with Space X, to observe the chosen asteroid
- NASA, Project RAMA , Reconstituting Asteroids into Mechanical Automata, additive manufacturing (AM), in-situ resource utilization (ISRU) in-situ manufacturing (ISM).



MINING THE MOON

MOON MINING: THE MATERIALS

- Oxygen, extracted from lunar regolith
- Water, ice in poles
- Hydrogen, present in high concentrations in poles
- Metals: iron, titanium, aluminum, silicon, calcium, magnesium
- Rare earths
- Helium- 3, on all the lunar surface
- Coal and nitrogen, extracted from lunar regolith
- Regolith, for construction

MOON: COMPANIES AND COMMERCIAL PROJECTS

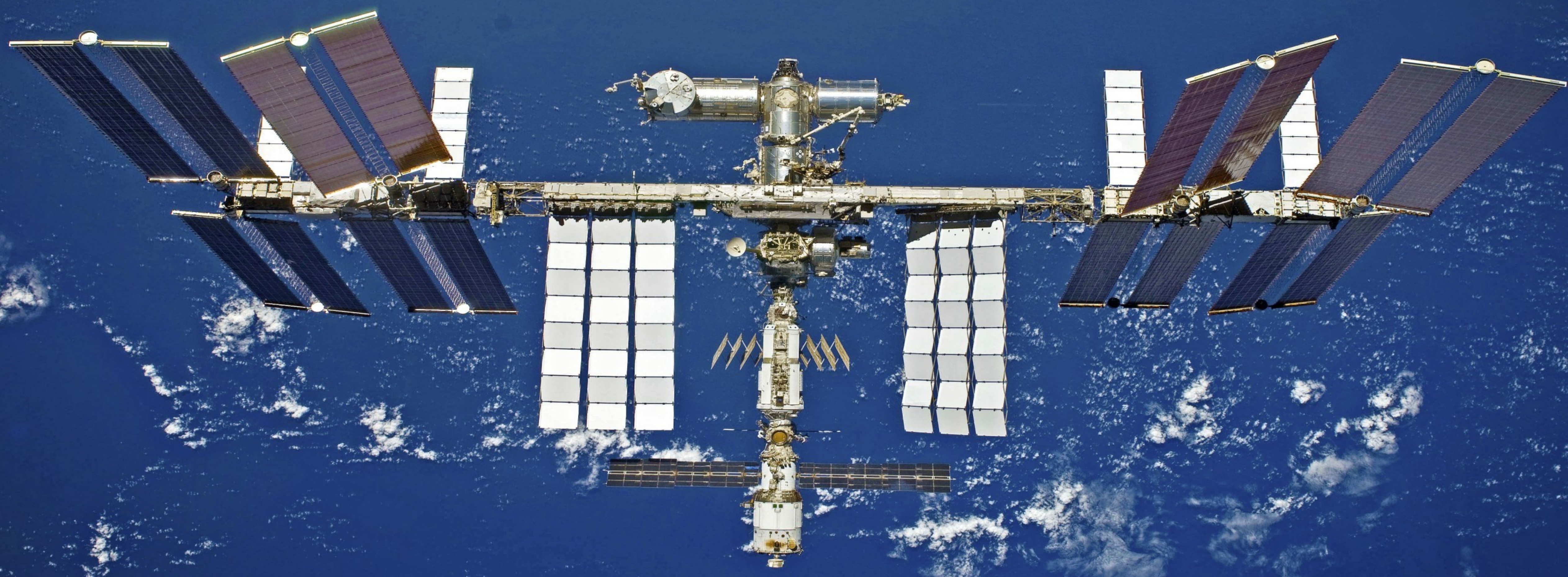
- ispace, Japan, Luxembourg, USA, https://ispace-inc.com/
  - M1 Lunar landing, January 2023
  - HAKUTO-R, mission 1: environmental information, demonstration robotic technologies, life sciences, entertainment
- Moon Express, USA, https://moonexpress.com/
  - Lunar Scout
  - Lunar Outpost
  - Harvest Moon
- Lunar Outpost of Golden, USA Colorado https://lunaroutpost.com/
  - first LTE/4G network on lunar surface, NOKIA partner, Intuitive Machines
- Masten Space Systems, USA California
  - NITE System, Thermal regulation system for lunar landers and rovers
  - Rocket Mining System, System for extracting water from lunar ice
  - PNT Network, lunar positioning, navigation, timing network
  - Fast Landing Pads, spray technology, creates a solid ceramic patina on the lunar regolith, for stable and dust-free landing on the moon

ORBITAL, LUNAR, CISLUNAR HABITATS

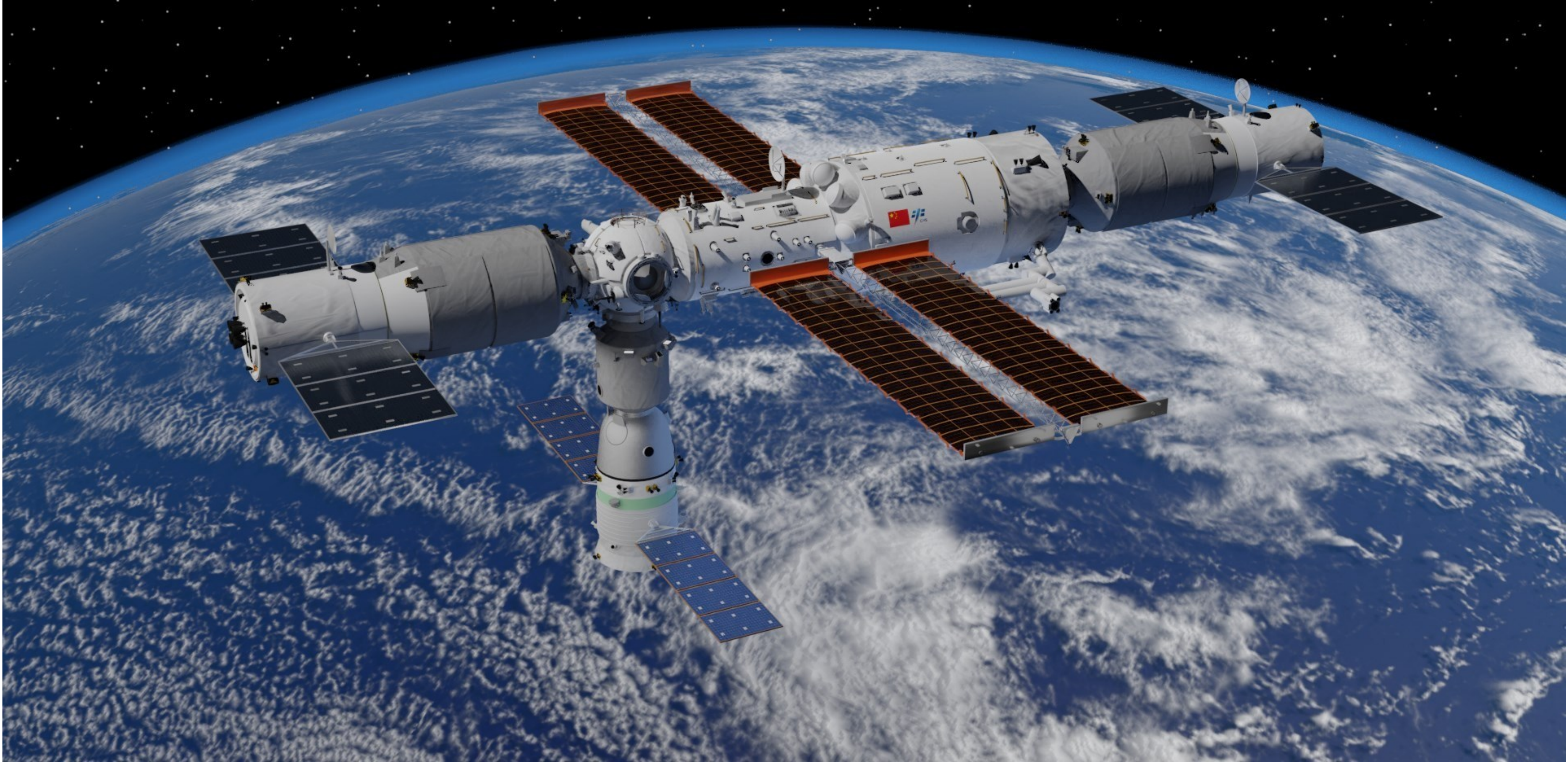
THE SPACE STATIONS TODAY IN ORBIT

first name	entity	crew	I launch	mass	pressurized volume	habitable volume
International Space Station	• NASA • Roscosmos • ESA • CSA • JAXA	7-10 _	Nov 1998	419,725 kg	1.005 m^3	388 m^3
Tiangong space Station	• CMSA	3–6	Apr 2021	96,000 kg	320 m^3	132 m^3

THE INTERNATIONAL SPACE STATION



THE TIANGONG SPACE STATION



AXIOM SPACE – THE FIRST ORBITAL COMMERCIAL STATION

Partners:

- **AXIOM SPACE (USA)**
- **Thales Alenia Space (Turin)**
- **NASA**

The launch of the first section:

- **scheduled for 2025**

The position:

- **in low orbit (LEO)**

- **Space Station Axiom will house people, research and production,**
- **for the development of numerous industries,**
- **using techniques available only in microgravity.**

ORBITAL REEF

Partners:

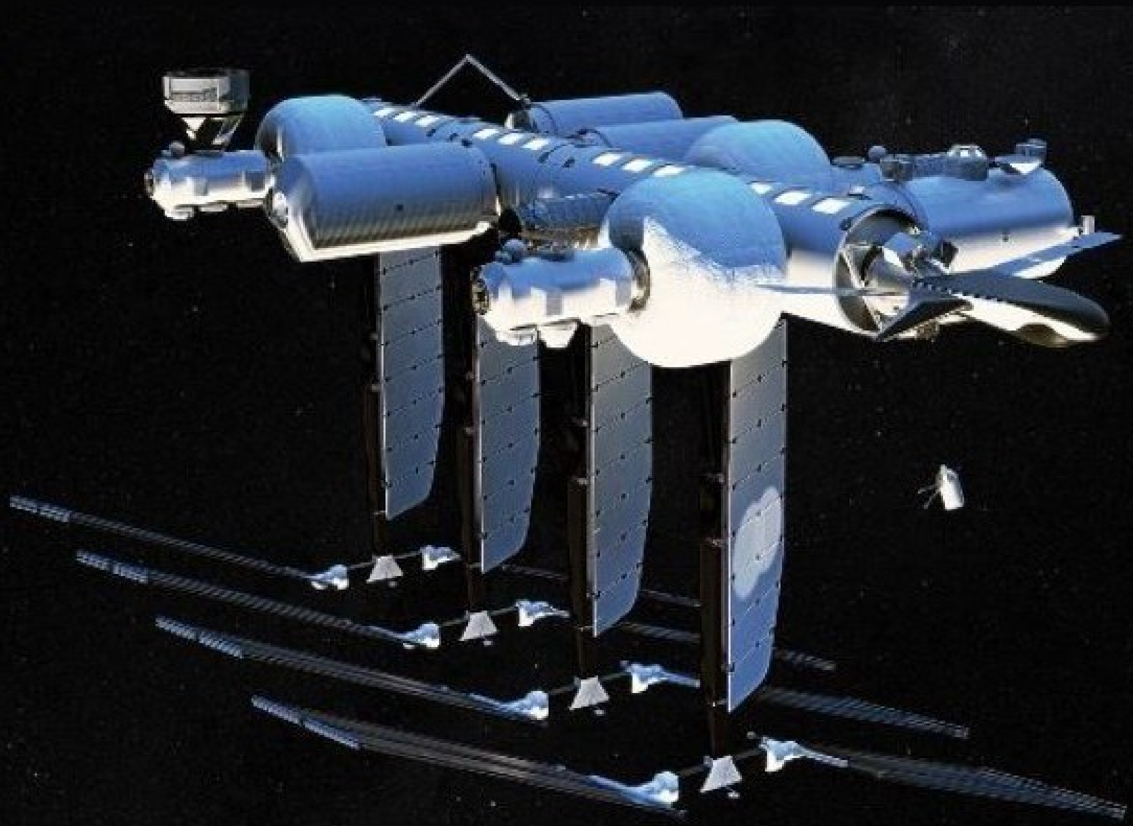
- **SIERRA SPACE (USA)**
  - Large Integrated Flexible Environment modules
  - DreamChaser spaceplan
- **BLUE ORIGIN (USA)**
  - Vehicle utility core systems
  - Large diameter modules
  - Heavy-lift New Glenn launch system (reusable)

Operation:

- **Before 2030**

The position:

- **in low orbit (LEO)**



Mission and business:

- provide access to space for everyone
- research, technological development , manufacturing
- media and advertising
- orbital residence
- transport and logistics
- space rental
- hardware systems development
- robotic operations and services e with crew
- Reef Starter incubator
- completely scalable according to market requirements

ORBITAL, LUNAR, CISLUNAR MANUFACTURING PRODUCTION

IN SPACE MANUFACTURING (in

agency	technologies	products
Blueshift (Outward Technologies) (USA)	Additive manufacturing	Components produced by 3D printing, using solar energy and regolith
Cedars-Sinai (USA)	Biotech	Production of stem cells on the ISS
Ecoatoms (USA)	Biotech	Design and development of habitats for the production of biomedical products.
Greiner Bio-One (USA)	Biotech	3D cell cultures in a microgravity environment.
MoonFibre (Germany)	Space Constr . Company	Production of materials based on fibers from lunar regolith, directly on the Moon.
Nortis (USA)	Biotech	Production of human organic tissue within micro-fluidic devices named chips.
Cislune (USA)	Space Construction Company	Swarm of rovers and excavators to build durable lunar surfaces with selected and compacted regolith.
Orbital Composites (USA)	Space Construction Company	Additive manufacturing of electronic composites for in-orbit manufacturing of large, precise and resilient space structures such as solar arrays, RF antennas and segmented optics.
Space Foundry (US)	additive manufacturing	Equipment for conductors and dielectrics printing. Standalone printers, OEM systems printing heads that can be integrated into other additive manufacturing tools and robotic arms.
TGV Rockets (USA)	additive manufacturing	Ultrasonic Additive Manufacturing (UAM) welding head for repair of damaged structures or for construction of structures. 3D print metals and metal combinations in space with energy, pressure and low temperatures.

https://www.factoriesinspace.com/manufacturing-companies

REV 1: ORBITAL FACTORIES

- **Thales Alenia Space (Torino) will develop an autonomous and reusable spacecraft,**
- **a space factory for various industries.**
- **The client: Space Cargo Unlimited (Luxembourg).**

Possible interested markets:

- **biotechnology**
- **pharmaceutical products**
- **Development of new materials in space.**
- **Agricultural experiments: grape growing and wine maturation in microgravity.**

https://spacewatch.global/2022/12/thales-alenia-space-and-space-cargo-unlimited-sign-contract-for-rev1-mission/

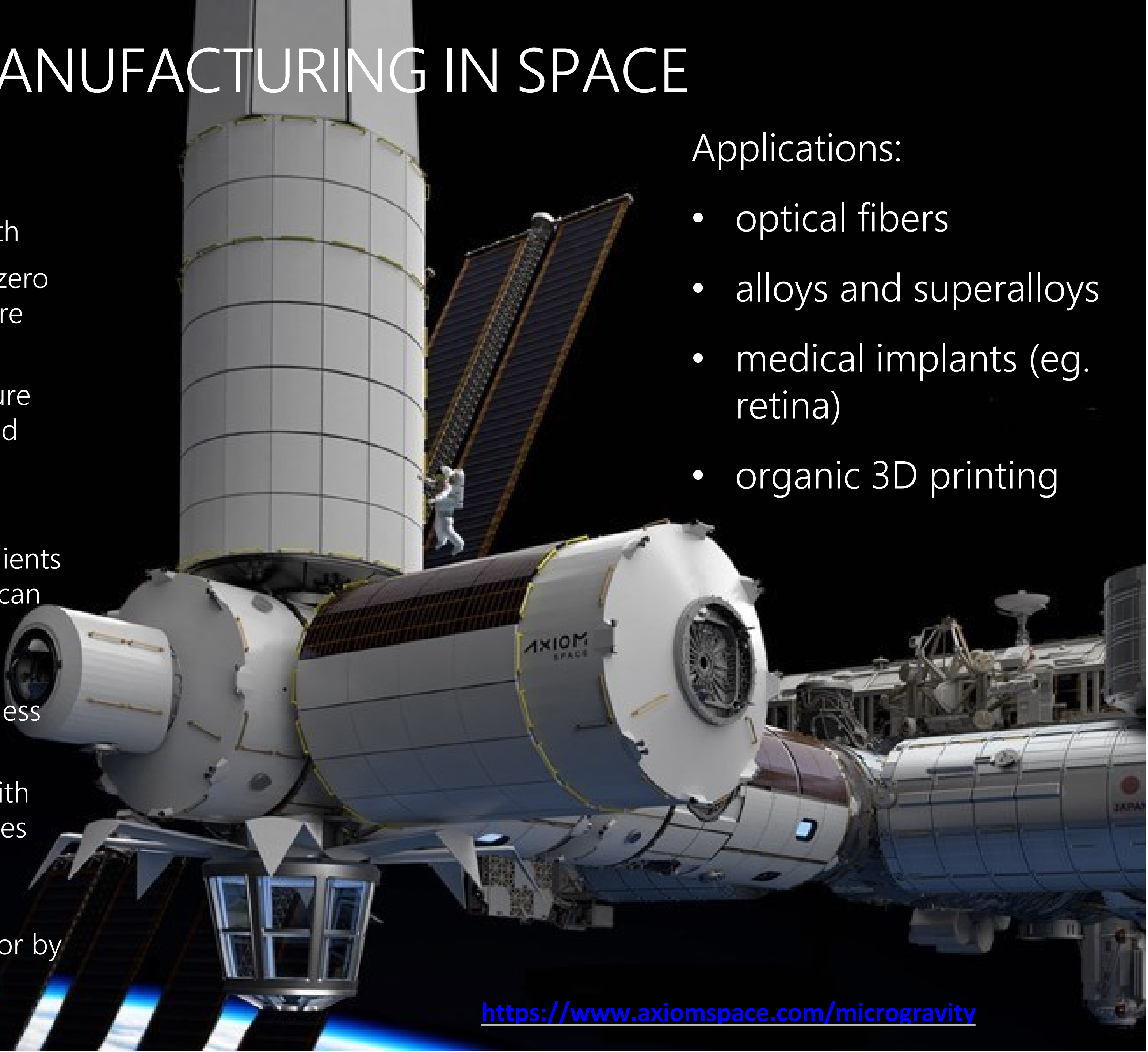
AXIOM: PRODUCTION MANUFACTURING IN SPACE

Advantages from microgravity:

- absence of sedimentation >> ease of combining any number of substances impossible to combine on Earth
- no buoyancy forces >> zero currents of convection, zero gravity -induced fluid movement a due to temperature gradients and density differences
- levitation of materials >> zero containers >> ultra pure and contaminant free environment for production and study of molten
- directionality - there is no "up" or "down«
- hydrostatic pressure – zero hydrostatic pressure gradients >> secondary forces (diffusion and surface tension) can prevail
- surface tension - the weak forces such as superficial tension can govern the behavior of fluids in a weightless environment
- shear stress – reduced superficial contact potential with fluid container >> zero shear stress (tangential stresses due to reaction on the walls of the container)
- crystallization of proteins in space - crystals of larger proteins with fewer defects >> quality crystals superior by diffraction

Applications:

- optical fibers
- alloys and superalloys
- medical implants (eg. retina)
- organic 3D printing

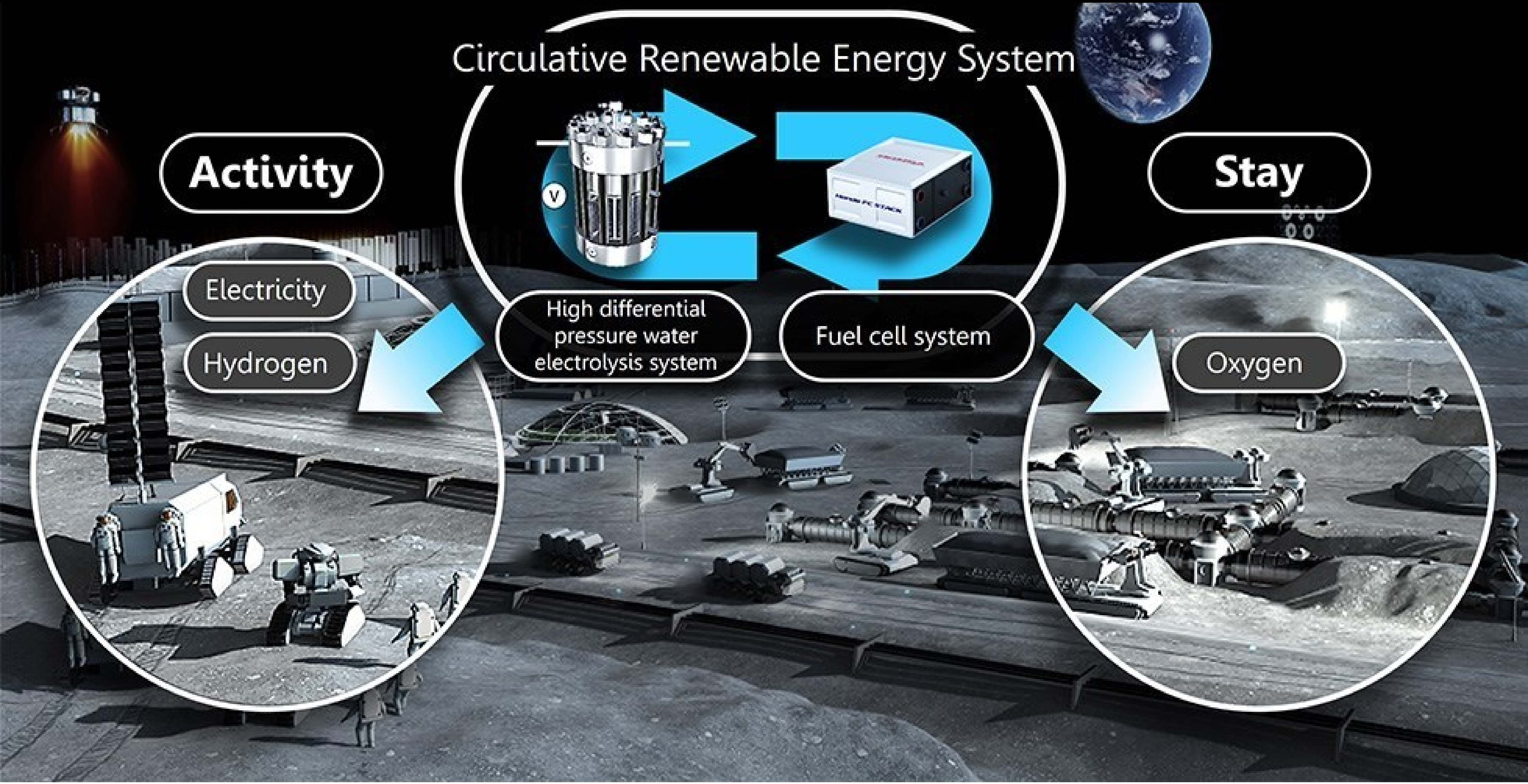


https://www.axiomspace.com/microgravity

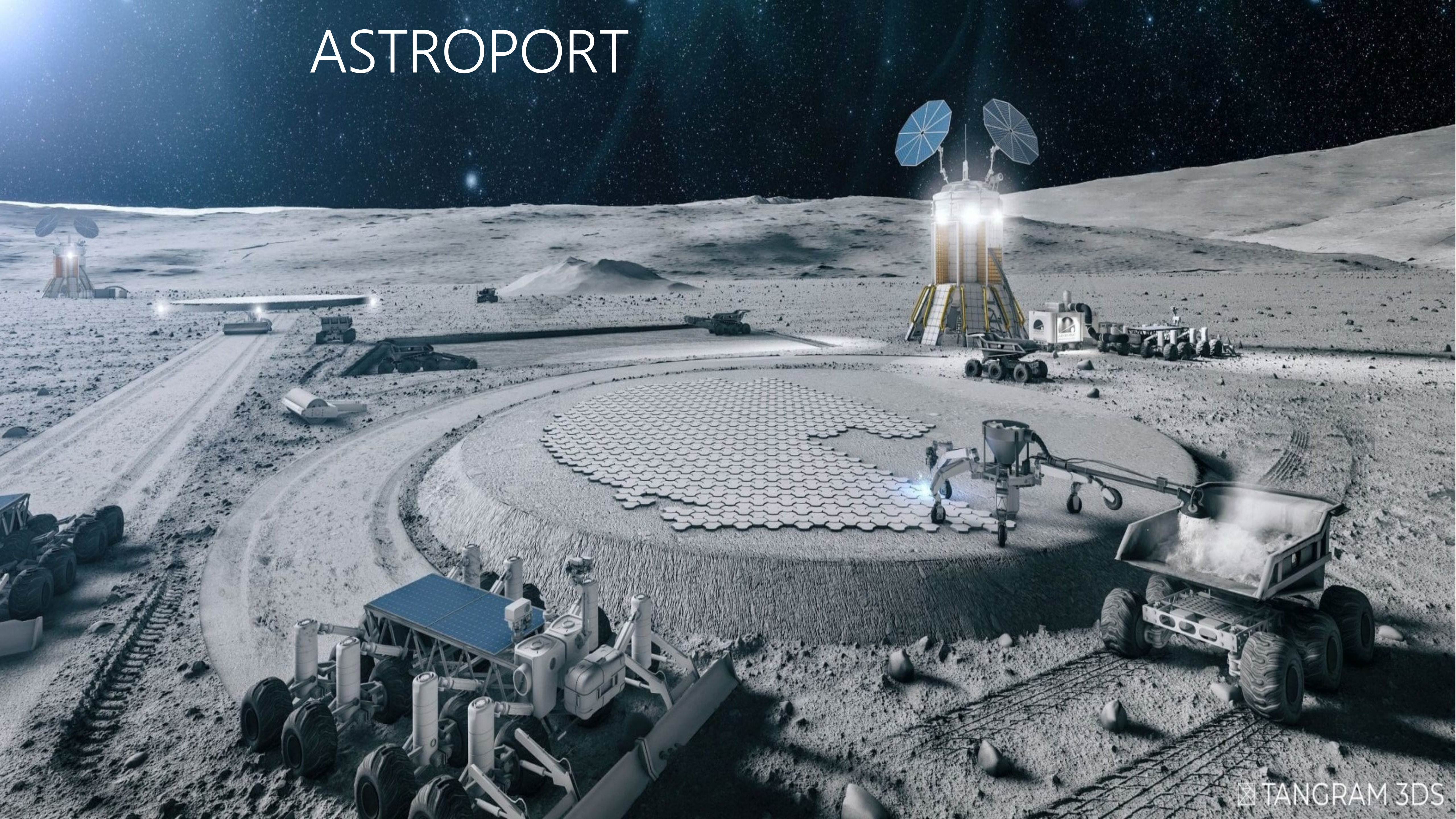
LUNAR PRODUCTION

Lunar Outpost (USA)	Propellant	System to excavate frozen lunar regolith and supply water and oxygen for propellant
Ethos Space (USA)	Propellant	Mapping lunar ice in detail. Mine it to make rocket fuel. Sell the fuel in orbit. Expand lunar production to metals and powders.
OxEon Energy (USA)	ISRU (In Situ Resource utilization)	Electrolytic ice treatment technology, hydrogen and oxygen separation, fuel production for cislunar transport.
Honda Motor Co (Japan)	ISRU (In Situ Resource Utilization)	Circular renewable electricity system, to power surface vehicles and support people's lives inside vehicles.
Space Industries (Australia)	raw material	Lunar Resource Extraction Vehicle (LREV), Helium-3, Hydrogen and Oxygen production (water) GIANT aerospace 3D printer.
Astroport Space Technologies (USA)	Space Construction Company	Using lunar regolith to produce bricks and materials for 3D printing lunar infrastructure, roads, habitats and landing pads. Treatment and regolith refining , 3D printing and placement, geotechnical site preparation
Motiv Space Systems (USA)	Space Robotics	Modular robotic arm system
Paragon Space Development Corporation (Final Frontier Design) (USA)	Space suits and clothing	Lunar space suit xEMU for Artemis mission. Purification of water derived from in situ resources and production of hydrogen and oxygen (IHOP)
Spartan Space (France)	Surface Habitats	EUROHAB, lunar habitat. Orbital EUROHAB (O-HAB) in partnership with LIQUIFER Systems Group GmbH, inflatable LEO habitat concept. Autonomous European Orbital Station, Airbus' A-LOOP and the O-HAB served by European infrastructure.
Quantum Space (USA)	Transportation Services (LEO-Moon)	QS-1 superhighways to the moon: situational awareness data products. Advanced methods of cislunar navigation.

HONDA – RENEWABLE CIRCULAR POWER SYSTEM



ASTROPORT



SATELLITES ASSEMBLY, TRANSPORT AND MAINTENANCE

On- orbit Servicing, Assembly, and Manufacturing (OSAM)

D- ORBIT SpA

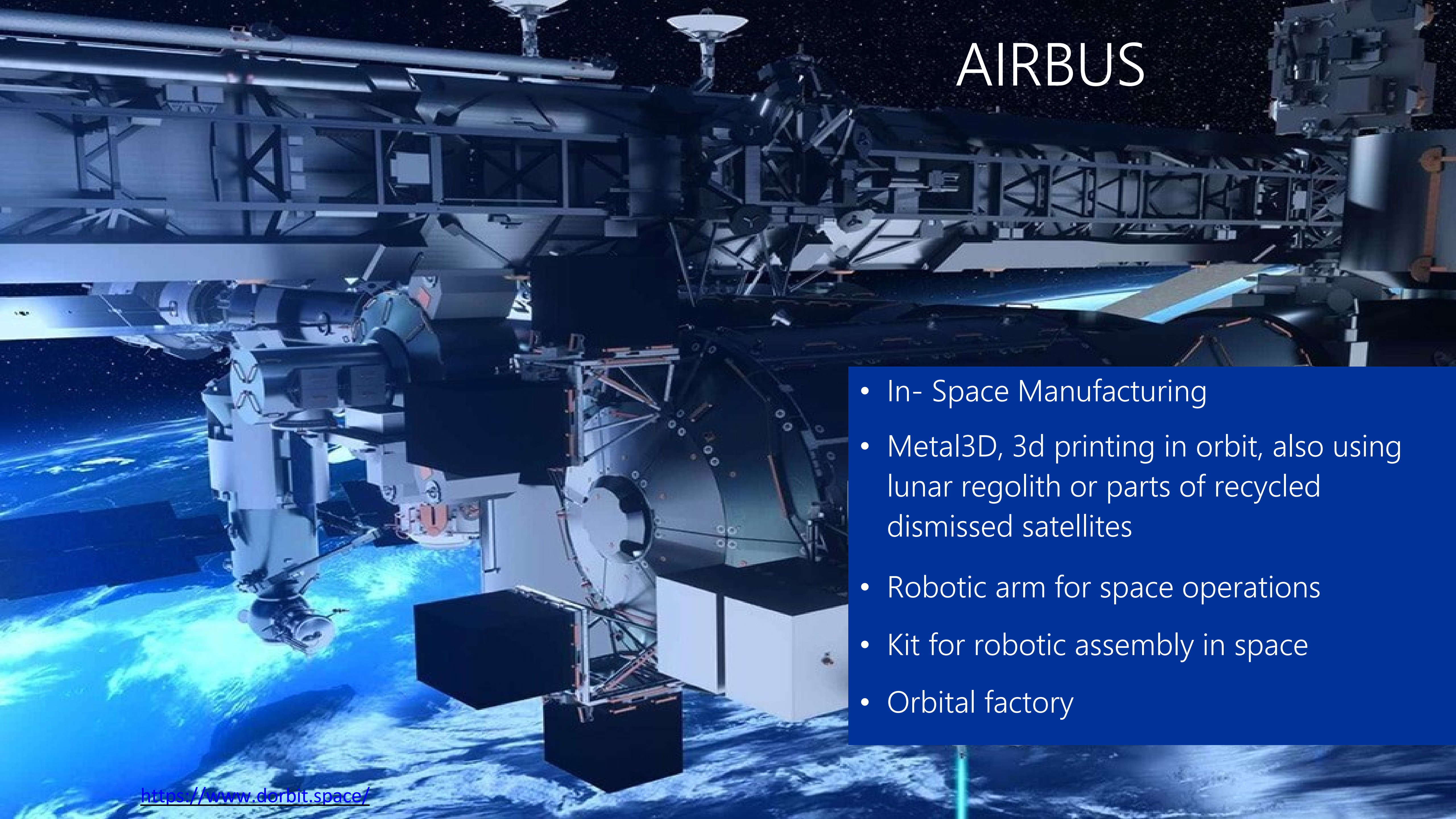
- Space logistics and orbital transport
- ION Satellite Carrier - Launch and dislocation of small satellites to predefined orbit
- Orbital service Infrastructure – for integration and test of the hosted systems

- Transportation of satellites, infrastructures, goods , supplies, raw materials
- Extension of satellites operational life through added modules providing propulsion and attitude control
- Spacecraft ed infrastructure in orbit assembly
- Restructuring in orbit of the existing vehicles, updating and replacing the components obsolete and malfunctioning
- In-orbit production of space vehicles parts from raw materials and basic components from Earth and/or from in orbit recycling
- Satellites decommissioning, at the end of operational life

SPACE LOGISTICS AND ORBITAL TRANSPORTATION SERVICES

https://www.dorbit.space/

AIRBUS



- In- Space Manufacturing
- Metal3D, 3d printing in orbit, also using lunar regolith or parts of recycled dismissed satellites
- Robotic arm for space operations
- Kit for robotic assembly in space
- Orbital factory

https://www.dorbit.space/

SPACE FOOD AND BIO PRODUCTS

Demonstrated:

Argotec (Italy)	ISSpresso - machine For expressed to capsules created for Lavazza, in partnerships with ASI; test: Samantha Cristoforetti 2015, Paolo Nespoli 2017
Nature's Find (USA)	Cultivation of mushrooms protein in space Bioreactors for cultivation of mushrooms on the ISS Test expected with Space X on the ISS In the 2025

In progress of development:

Aleph farms (USA)	Meat grown up bynatural processes, similar to the animal ones
Redwire Made in space (USA)	3D BioFabrication Facility (BFF), Redwire Advanced space Experiment Processor (ADSEP), production of biotextiles by 3d printing in microgravity
Blue Horizon (Luxembourg)	Selection And cultivation Of microorganisms - bacteria, microalgae, mushrooms, lichens and combinations, For terraforming on Earth and other planets. Creation of organic soil scabs(BSC), basis for lands cultivable and forests - spraying of biomatrices on lands abandoned.
space v (Italy)	Design of greenhouses for horticulture on space habitats and planetary surfaces

https://www.factoriesinspace.com/manufacturing-companies

SPACE FOOD AND BIO PRODUCTS (2)

First stage of development:

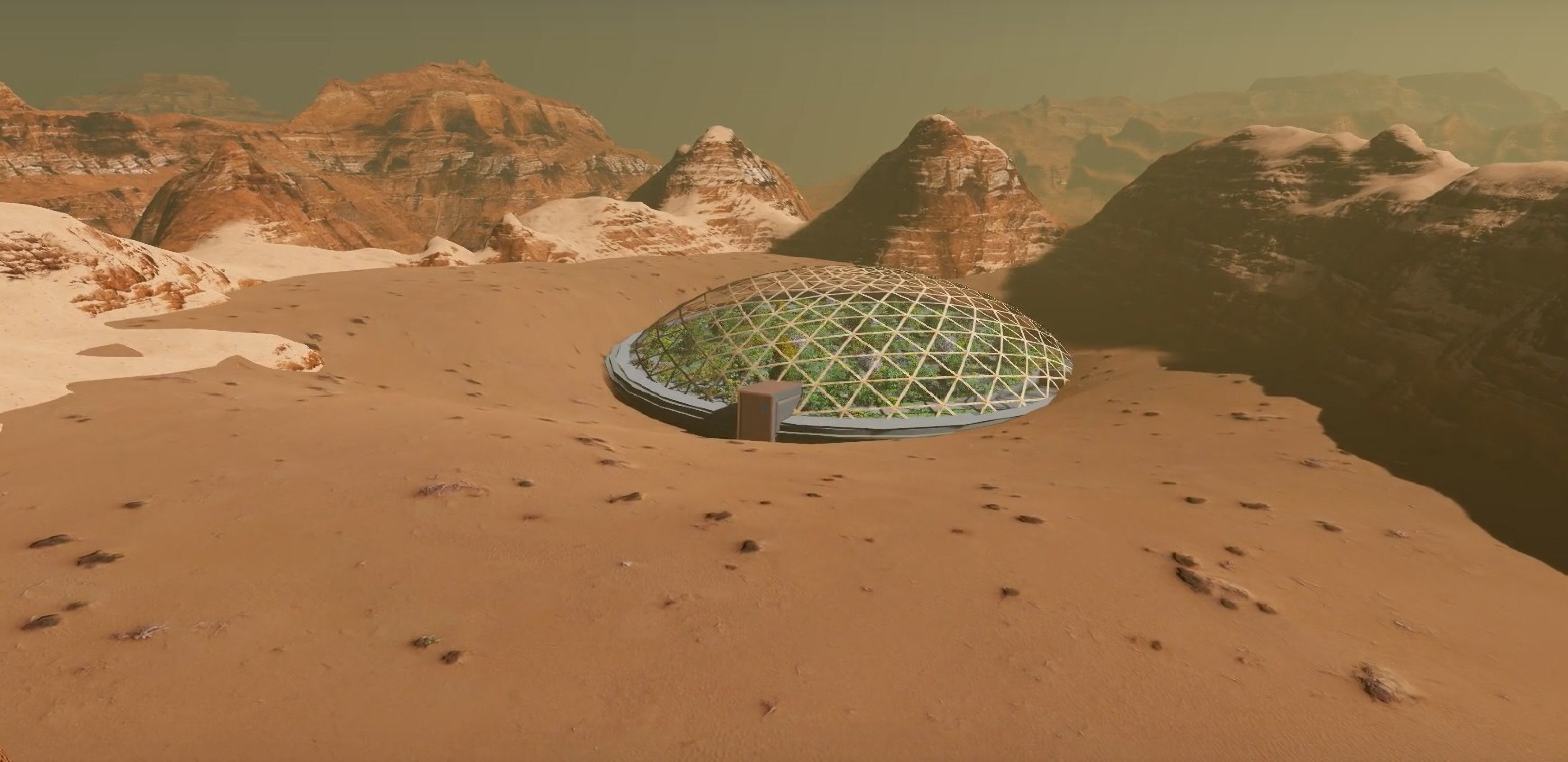
PeaPod Technologies (Canada)	PeaPod - agricultural technologies research and food production. Automated open-source growth environment, simulating any environment to grow any plant. CloudPonics - remote configuration and monitoring.
Deep Space Ecology (USA)	Robust and self-sustaining agroecological systems for the solar system. FAARM - Modular laboratory for functional astro-agronomic research, replica Terrestrial environment in microgravity. LUNAR FOOD SYSTEM – In the absence of day/night cycles and atmosphere, extreme temperatures, high radiation. MARS EPOCH X1, X2, X3 – concept for an almost closed agro-ecological system.
Orbital Farm (Canada)	Climate-independent cultivation systems Seafood, vegan proteins, animal and fish feed products, cellular agriculture
Red Planet Farms (UK)	Vertical cultivation – hydroponics and led

https://www.factoriesinspace.com/manufacturing-companies

SPACE V

- Adapting greenhouses , to accommodate the growth on the different shelves
- Micro- conditioning system separate for each shelf (temperature , humidity)
- CO_2 capture, produced by the crew and return of oxygen produced from plants

MARTIAN GREENHOUSE (DEEP SPACE ECOLOGY)




PRODUCTS FROM LOW
OR MICRO GRAVITY

MAIN PRODUCTS FROM LOW OR ZERO GRAVITY

Yearly income growth of some industries, due to their collaboration with space corporates

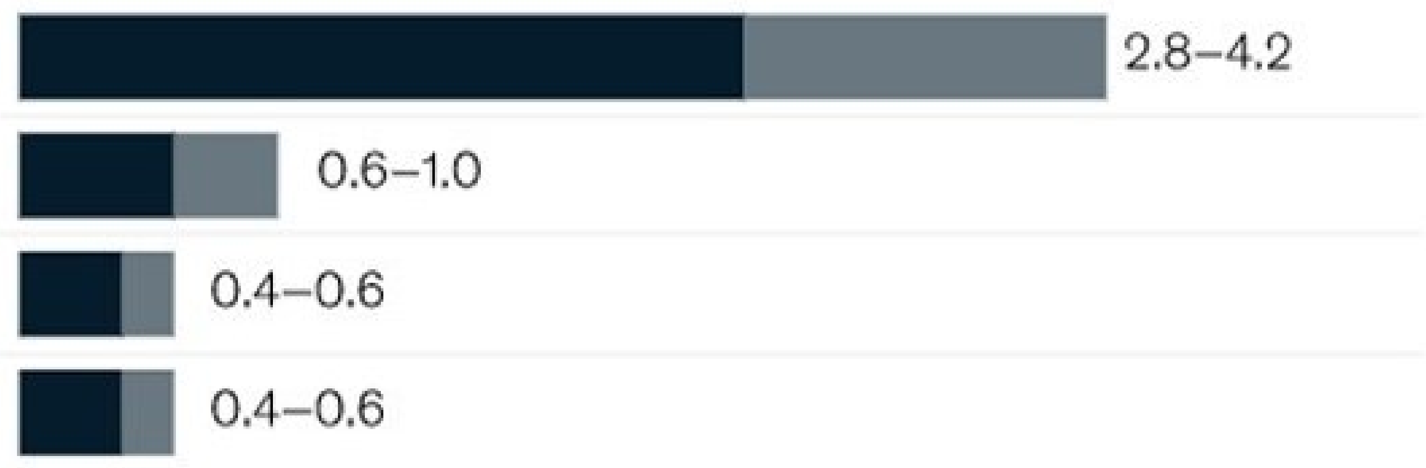
Yearly income, $ bn

Pharmaceutics

Beauty and person care

Semiconductors

Food and nutriceutics



PRODUCTS FROM LOW OR MICRO GRAVITY

Pharmaceuticals – global value $360 billion

- Objectives: to increase the yields of innovation, to improve success of the compounds under development, reduce the time of product development.
- Cell cultures for prediction of disease models.
- Organoids: miniature and simplified versions of organs, 3D models to evaluate diseases.
- Direct research on drugs, e.g. oncologicals.
- Production of retinas in space

Beauty and personal care , skin care – global value $208 billion

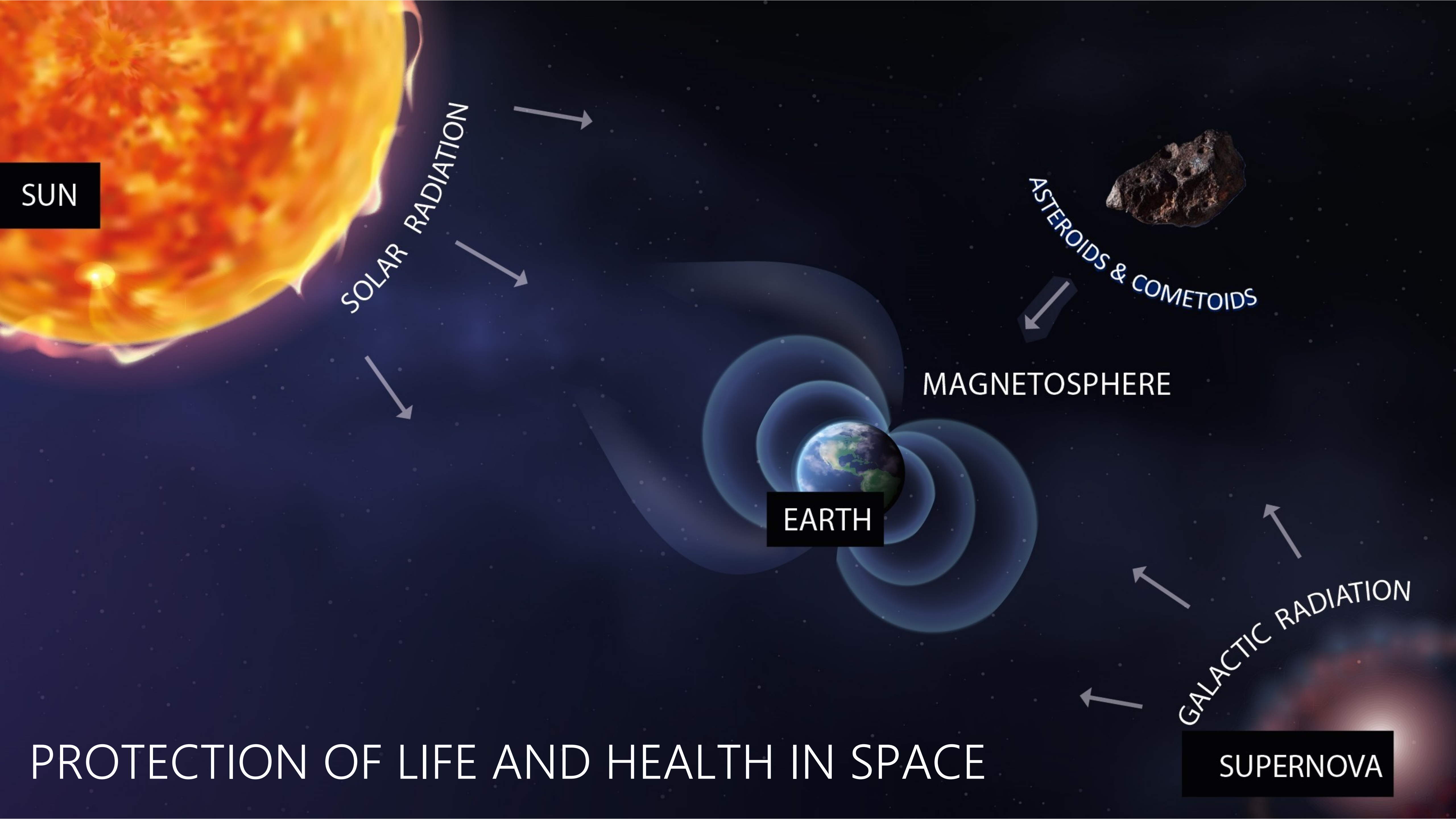
- premium skin care products, has a growing rate estimated compound annual growth rate (CAGR) of 13% through 2024 (compared to 3% of mass products).
- The space environment, due to high levels of radiation, accelerates skin aging. Therefore particularly suitable for testing the effectiveness of new products.
- Active ingredients - vitamins, retinol and other substances useful for skin care.
- Microgravity reduces settling rate and impact from the buoyancy, making it easier to combine several substances, including those contained in yeast extracts.
- Yeast grown in space have higher growth and metabolic rates.

Food and Nutrients – $10 trillion global value

- nutraceuticals - $17 billion by 2025.
- Probiotics, research and production - foods containing live bacteria and yeasts with beneficial effects on health and immune system.

Semiconductors – global value of $725 billion by 2025

- Of which $90 billion for research
- Reduce the number of defects induced by gravity and contaminants
- production increase
- creation of smaller semiconductors structures
- environmental benefits, since terrestrial production requires larger amounts of energy.


SUN
SOLAR RADIATION
ASTEROIDS & COMETOIDS
MAGNETOSPHERE
EARTH
GALACTIC RADIATION
SUPERNOVA
PROTECTION OF LIFE AND HEALTH IN SPACE

PROTECTION FROM RADIATION: RESEARCH

- Johnson's Space Radiation Analysis Group (1) (Johnson Space Center NASA, Houston), monitoring of space weather conditions: space radiation flux.
- Project SR2S , (2) (EU), develops a magnetic shield, based on superconductors, to deflect the cosmic rays, 2015. Coordinated by Prof. Roberto Battiston, attended by Dr. Luigina Feretti, INAF Bologna.
- ESA Space Weather Office . (3) provides timely and accurate information to enable mitigation of the negative impacts of space weather.
  - Lagrange CDR mission in L5, monitors solar activity, operational since 2024
- UW-Madison (4) University of Wisconsin, study for a magnetic field capable of deflecting the harmful radiation during a journey to Mars or on cislunar bases.
- A team from the University of Leoben (5) (Austria) has discovered a new aluminum alloy that can shield radiation a hundred times better than the metal alloys used so far.
- AstroRad (6) (Stemrad, Israel) anti-cosmic radiation suit. Multilayer non- metallic materials a protection of vital organs, especially the torso. The first test in space took place in 2022, in the EM-1 mission, on a dummy aboard the Orion capsule.

(1) https://srag.jsc.nasa.gov/
(2) https://cordis.europa.eu/article/id/166027-shields-up-for-a-manned-mission-to-mars
(3) https://www.esa.int/Space_Safety/Space_Weather_Office
(4) https://news.wisc.edu/scientists-undergraduates-team-up-to-protect-astronauts-from-radiation/
(5) https://www.focus.it/scienza/spazio/materiale-che-protegge-astronauti-da-radiazioni-cosmiche

PLANETARY DEFENCE

- **SPACEGUARD UK** – observatory, main source of information on near-Earth objects in UK, born In the 2001 (1)
- **HERA** - ESA planetary defense mission (2) in development . Launch October 2024. Objectives: to study the asteroid tracks Didymos , measure impact test result from the NASA DART mission . Information for future asteroid deflection
- **DART** - The Double Asteroid Redirection Test (3) , NASA Launched in November 2021, the DART crashed intentionally hit an asteroid on September 26 2022.
- **PDCO** - Planetary Defense Coordination Office (4) , NASA, early detection of objects potentially hazardous (PHO); tracks and characterizes PHOs; strategies and technologies to mitigate the impacts of PHOs; strategies of response to threats of real impact.
- **CHINA** - Test mission for deflection e the observation of an asteroid (5) ; target the NEO object 202 PN1; launch in 2025 on Lunga March 5

- **PDO** - Planetary Defense Office (6) , ESA, plot la current and future location of near-Earth objects; estimate the probability of impact with the Earth; assess the consequences of any impact; inform and develop methods to deflect any asteroids at risk.
- **CNEOS** – Center for Near Earth Objects (7) , NASA; Sentry automated collision monitoring system verify the possibility of future impacts with the Earth in the next 100 years .
- **IAWN** – International Asteroid Warning Network (8) , UN, since 2013; international network of organizations for identification , tracking and characterization of NEOs: Europe, Asia, South e North America.
- **MPC** - Minor Planet Center (9) , NASA, location of minor planets, comets and external irregular natural satellites of the major planets; identification, calculation of the orbits of all of these objects; maintenance of the main archives; at Smithsonian Astrophysical Observatory, under the International Astronomical Union (IAU).

(1) https://spaceguardcentre.com/
(2) https://www.heramission.space/
(3) https://www.nasa.gov/specials/pdco/index.html#dart
(4) https://www.nasa.gov/planetarydefense/overview
(5) https://www.space.com/china-asteroid-impact-mission-two-spacecraft
(6) https://www.esa.int/Space_Safety/About_asteroids_and_Planetary_Defence
(7) https://cneos.jpl.nasa.gov/sentry/
(8) https://iawn.net/about.shtml
(9) https://www.minorplanetcenter.net/ _

HYPERSONIC VEHICLES

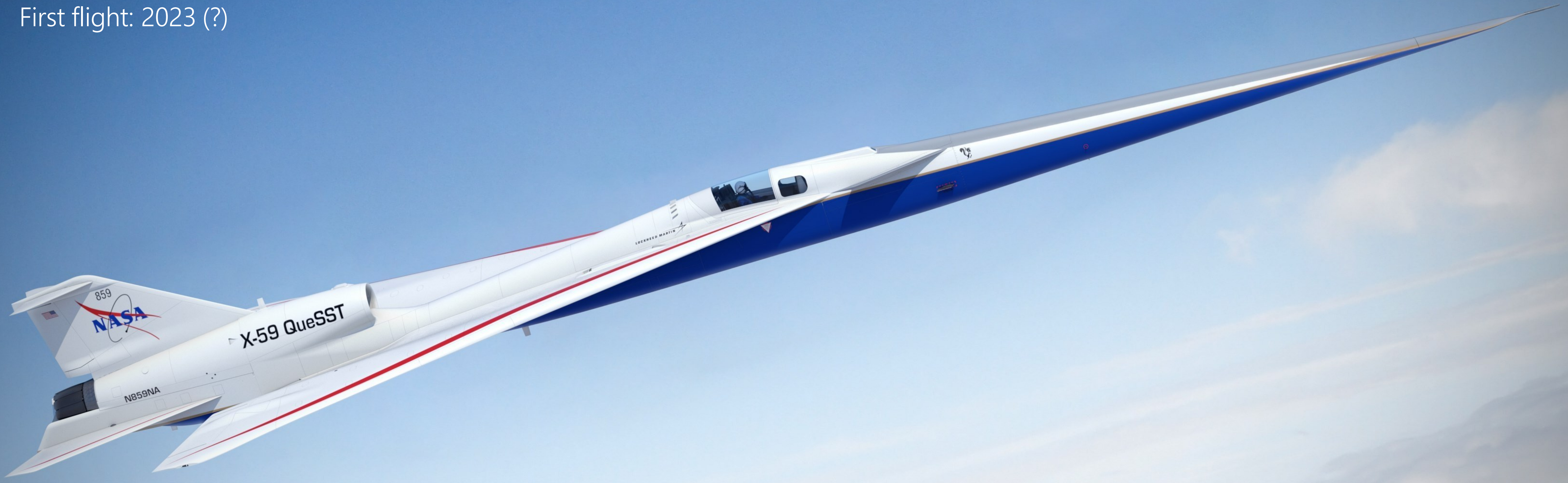
VIRGIN GALACTIC & ROLLS ROYCE

- Supersonic designed in partnership with NASA
- Built from Virgin Galactic and Rolls Royce
- From 9 to 19 places passengers
- Speed of cruise > mach 3 = 3,700 km/h
- Quote of cruise > 18,000 meters
- London – New York in approx. 2 h (Agree approx. 3 h)
- Price of the ticket: 5,000 $
- State current: certification federal Aviation Administration

BOOM OVERTURE

- Supersonic manufactured by Boom Supersonic (USA)
- From 65 to 80 passenger seats
- Cruising speed > Mach 1.7 = 2,083 km/h
- Cruising altitude > 18,000 meters
- Maximum distance approx. 7900km
- London – New York in approx. 3 h
- Zero CO_2 emissions
- Zero supersonic boom (supersonic flight only over the ocean)
- Ticket price: $5,000
- Operational in 2029

- Supersonic producted by Locked Martin and NASA (USA)
- 1 pilot
- Speed of cruise > mach 1.4 = 1. 700 km/h
- Quote of cruise > 16,800 meters
- Zero supersonic boom
- First flight: 2023 (?)



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4. SPACE ECONOMY IN ITALY

MAIN AEROSPACE COMPANIES IN ITALY

agency	activity	Sales
Leonardo SpA	Optical systems, photovoltaic panels, control systems and robotics devices	€13 billion
Avio Aero	Design, construction and maintenance of aeronautical systems, civil and military, turbines, combustors and propulsion systems, solutions to reduce fuel consumption and CO_2 emissions	€2 billion
Thales Alenia Space	The largest European manufacturer of satellites for telecommunication, navigation, earth observation, environment, exploration, science, orbital infrastructure. Exploration of the Moon and Mars. 67% Thales, 33% Leonardo	€2 billion
Telespace	Leonardo (67%), Thales (33%) Among the world leaders in satellite systems, management of launch systems and in-orbit control of satellites. Programmes: Galileo, EGNOS, COSMO-SkyMed. Manage the *Center Spaziale del Fucino .*	€300m
Avio SpA	Space transportation systems and thrusters. Small Vega launcher. Space Rider program, orbital module.	€350m
D-ORBIT SpA	World leader in logistics and space transport, scrapping satellites at the end of its operational life.	€22m
Argotec Srl	Lunar communication network	€12m

THE NATIONAL AEROSPACE TECHNOLOGICAL CLUSTER (CTNA)

Districts Technological Regional: Others Associates:

- Abruzzo - ICT/Aerospace domain Abruzzo
- Basilicata - CLAS – Lucanian Cluster of Aerospace clusterlucanoaerospazio.it
- Campania - DAC - Aerospace Technological District from the Campania from campania.com
- Emilia-Romagna - ART-ER Attractiveness Research Territory art-er.it
- Emilia-Romagna - IR4I Aerospace Technology Cluster ir4i.it
- Lazio - Lazio Innova Spa lazioinnova.it
- Liguria - SIIT – Ligurian Technological District on Systems Smart Integrated siitscpa.it
- Lombardia - Aerospace Cluster aerospacelombardia.it
- Brands - EXPLOORE exploremarche.it
- Piedmont - DAP – District Aerospace Piedmont aerospace districtpiemonte.com
- Puglia - DTA – Scarl Aerospace Technological District dtascarl.org
- Sardinia - DASS – Aerospace District of Sardinia dassardegna.eu
- Tuscany - GATE 4.0 Aerospace Technological District from the Tuscany districtgate40.it
- Umbria - Aerospace Cluster umbriaerospace.com
- Veneto - CO.SI.MO

- AIAD – Federation of Italian Aerospace Companies, the Defense and Security aiad.it
- ASI – Italian Space Agency asi.it
- CIRA – Italian Aerospace Research Center cira.it
- CNR – National Research Council cnr.it
- GE Avio Srl avioaero.com
- INGV – National Institute of Geophysics and Volcanology ingv.it
- LEONARDO Spa leonardocompany.com

AEROSPACE EUROPE

- Sales total space economy EU: approx. 94 bln$ (USA 131, Asia 102)
- One of the sectors with higher added value to European economy
- Occipied in aerospace sector in Europe: approx. 3.6 millions
- Forecast 2023: general growth, following the increase of world-wide investments
- ESA: budget 2023 7.8 billions, 16.9 billion for the coming 3 years (+16.6%)
- The ESA «*new space economy*» strategy: space activity to advantage citizens on Earth and For a greener and more digital Europe
  - Earth observation and fighting climate changes,
  - future astronautic missions,
  - navigation satellites,
  - launchers: last missions of Ariane 5, coming Ariane 6 and Vega C,
  - working to the next generation launchers (reusable?...)

AEROSPACE ITALY

- The ASI 2021-2022 catalogue includes 153 companies, of which 21 large companies, 105 SMEs and 21 start-ups.
- The Italian aerospace sector is seventh in the world and fourth in European level (2021)
- Italy third state contributing to ESA programs, after France and Germany
- The sector employs over 50,000 people, rising to 200,000 if the entire supply chain is considered
- Average annual turnover >15 billion euros, of which almost 5.8 billion in exports
- Forecast 2023: +2000 new jobs
- Most sought-after profiles: engineers, designers, systems engineers and IT
- New recruitment notices for the entire sector, including European Space Agency (200 new hires)

PROGRAMS:

- Italy collaborates and participates in the Artemis lunar program at European level the Earth Observation programmes, e.g. the future constellation Iris
- Spaceport of Grottaglie, in Puglia, in agreement with Virgin Galactic

https://www.agendadigitale.eu/mercati-digitali/pmi-spaziali-le-eccellenze-italiane-motore-del-rinascimento-industriale/

https://www.asi.it/wp-content/uploads/2021/09/Catalogo-ASI_160921_LOW.pdf

THANK YOU FOR THERE YOUR ATTENTION! ☺

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https://spacerenaissance.space/membership/international-membership-registration/

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