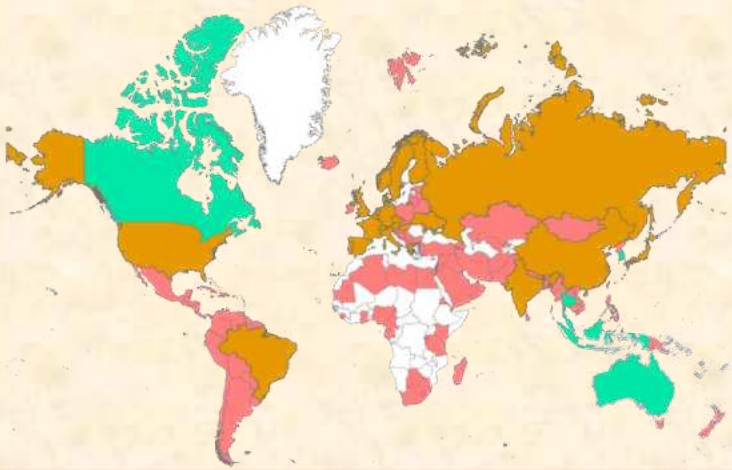
INTRODUCTION TO GLOBAL SPACE ACTIVITIES AND SPACE COMMERCE

Paper

Space Commercialization and legal Issues

Master of Space & Telecommunications Law

NALSAR



GLOBAL SPACE ACTIVITY

1957 to 2020:
Over 10000 satellites launched
More than 300 human beings in space

12 Countries capable of independent access to space
80 nations/ consortia launched satellites
More than 100 countries use space services

EVOLUTION OF SPACE COMMERCIAL CONCEPT

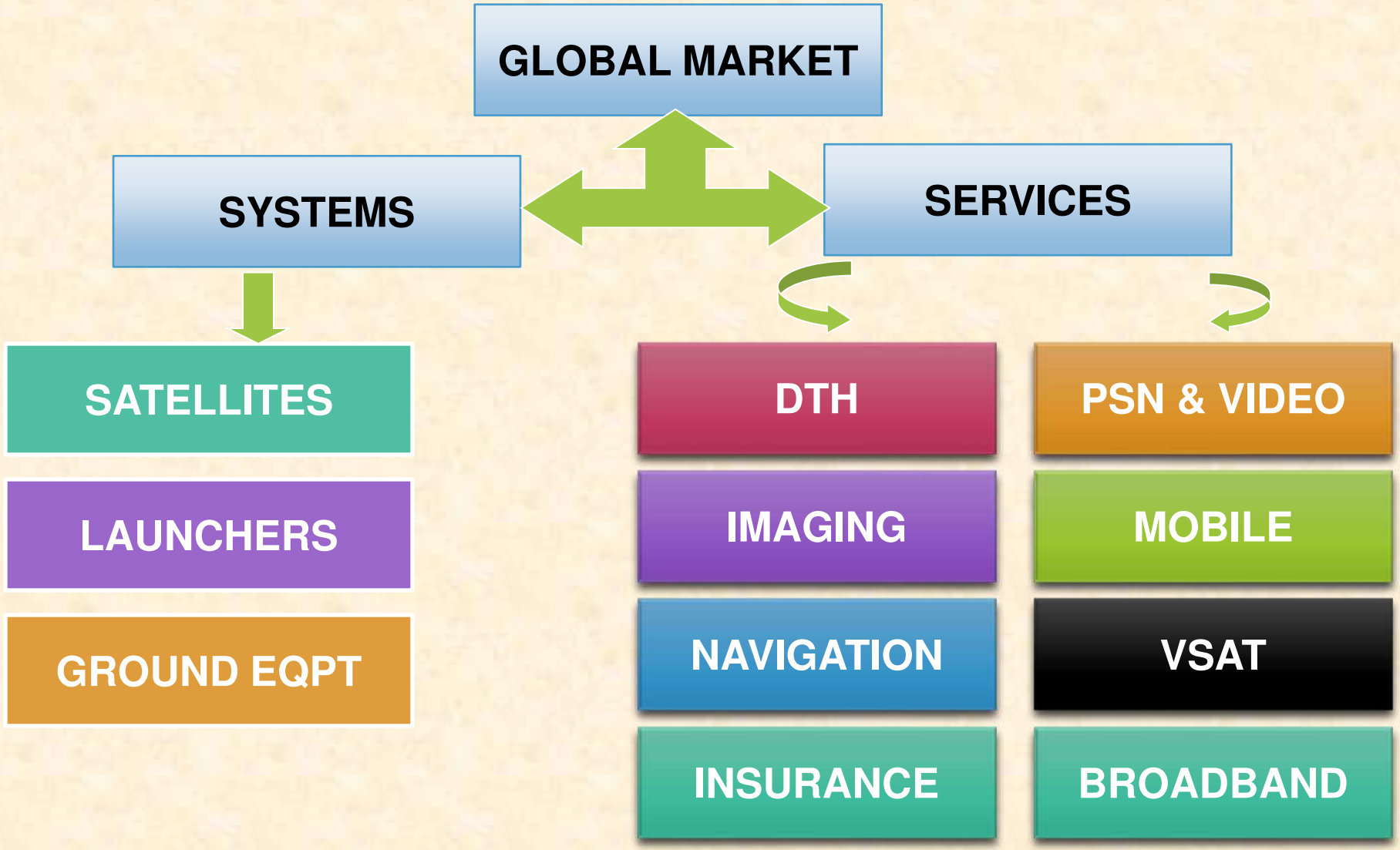
- GOVERNMENT FUNDED R&D, INFRASTRUCTURE IN INDUSTRY
- Adapting facilities, technologies and HR expertise
- Commercial Use Of Space technology-Space products & service (COST ADVANTAGE OF REUSE OF TECHNOLOGIES DEVELOPED)
- Domestic & International market servicing
- ***IMPACTS OF COMPETITION, ALTERNATE TECH, ACCESS /Technology transfer POLICIES***

DEFINING COMMERCIAL ACTIVITIES

- Access to Capital
- Market driven : risk taking, efficiency seeking, subject to free market forces
- Existence of non government customers
- Risk responsibility
- Independence from government : reliance on government property, design purpose

- *Reference: Do Commercial Space Companies exist, Ken Davidian, New Space, 2016*

SEGMENTS IN SPACE COMMERCE



VALUE CHAIN OF SPACE BUSINESS (2019)

- Space segment (Space craft and Launch) : 12.5+4.9 =17.4 B$
- Ground Equipment: =130.3 B$

(GNSS 97.4 + TV, Radio, Mobile 17.9 + Network 15)

- Application Services: =123 B$

(TV 92 + FSS 17.7 + Radio 6.2 + BB 2.8 + Imaging 2.3 + Mobile 2)

Value chain extends from basic raw materials to components to equipment to systems assembly to launch service to satellite control operations to application oriented ground systems to data aggregation to application services

SPACE ECONOMY

- Space economy includes many commercial activities that have been derived over the years from the space sector's research and development (R&D) missions. Several mature downstream activities have reached mass markets, and include information technology products and services, such as satellite television and GPS receivers. Even tourism-related packages are starting to be commercialised.

Ref OECD (2011), *The Space Economy at a Glance 2011, OECD Publishing.*

http://dx.doi.org/10.1787/9789264111790-en

2019 State of the Satellite Industry

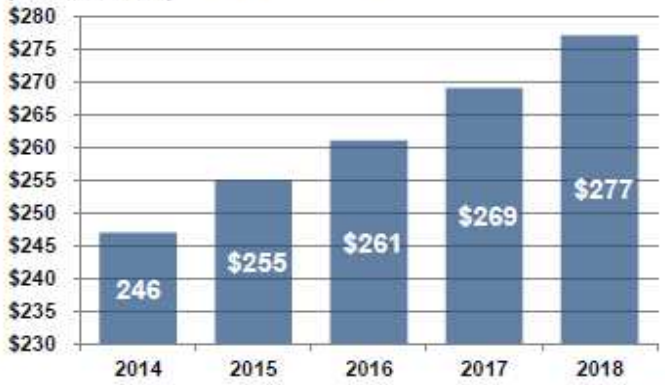
2018 Growth

Satellite manufacturing and launch

Markets for value-added services across multiple segments

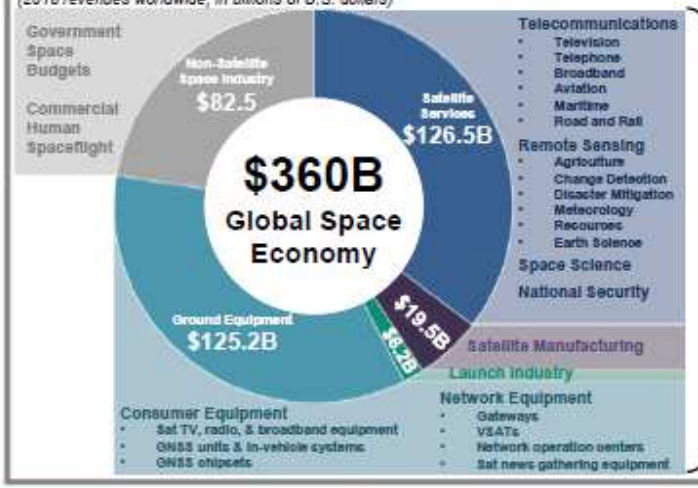
Global Satellite Industry Revenues

(billions of U.S. dollars)



The Satellite Industry in Context

(2018 revenues worldwide, in billions of U.S. dollars)



Satellite Services

1.7%

2018 Revenues
$126.5B

Television	$94.2B
Radio	$5.8B
Broadband	$2.4B
Fixed	$17.9B
Mobile	$4.1B
Remote Sensing	$2.1B

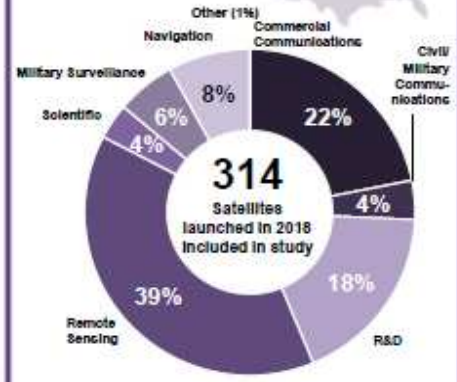
Satellite Manufacturing

26%

2018 Revenues
$19.5B

$8B

$11.5B

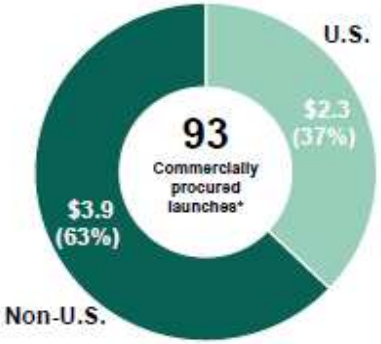


Satellites Launched by Mission Type

Launch Industry

34%

2018 Revenues **$6.2B**



** There were 114 total orbital launches in 2018. Of these, 93 were commercially procured, 15 involved space vehicles, and 6 were not commercially procured*

Commercial Launch Revenues by Region

Ground Equipment

5%

2018 Revenues **$125.2B**

$18.1B
Consumer Equipment

$93.3B
GNSS Equipment

$13.8B
Network Equipment
(VSATs, gateways, etc.)

BRYCE
space and technology

EMERGING SCENARIO

- Dominance of Non-Governmental Sector activities – New Space Era- Start-Ups
- Nano Satellite/ Small Satellite Constellations
- Active Debris Removal Techniques
- Space Mining – Celestial Resources
- Space Tourism
- Asteroid Redirect Missions
- Lunar Gateway Project
- NASA's recent announcement on commercialization of ISS (June 06, 2019)

CELESTIAL RESOURCES MINING

- **Utilization of Celestial resources**
  - **USA-Space Resource Exploitation and Utilization Act (SERU Act 2015)- Popularly known as Asteroid Mining Act *(As part of U.S. Commercial Space Launch Competitiveness Act, 2015)***
  - **Luxembourg's Law on the Exploration and Use of Space Resources (2016-18)**
  - **Hague Space Resources Working Group**
    - **Development of Building Blocks**

CELESTIAL RESOURCES MINING*(… CONTD..)*

- **SERU Act 2015- (<u>Asteroid Mining Act</u>)**
  - **Establishes a legal right to resources U.S. citizens obtain from asteroids consistent with current law and international obligations.**
  - **Directs the President to facilitate and promote space resource exploration and recovery.**
  - **Definitions –**
    - **‘asteroid resource’ means a space resource found on or within a single asteroid.**
    - **‘space resource’ means an abiotic resource in situ in outer space. It includes water and minerals.**
  - ***Disclaimer: (Sec. 403) It is the sense of Congress that the United States <u>does not</u>, by enactment of this Act, assert sovereignty or sovereign or exclusive rights or jurisdiction over, or ownership of, any celestial body*.**

IISL'S POSITION PAPER ON SPACE RESOURCE MINING, 2015 *(EXCERPTS)*

- **… .. in view of the absence of a clear prohibition of the taking of resources in the Outer Space Treaty one can conclude that the use of space resources is <u>permitted</u>.**

- **<u>Viewed from this perspective, the new United States Act is a possible interpretation of the Outer Space Treaty</u>.**
  - **Whether and to what extent this interpretation is shared by other States remains to be seen.**

CELESTIAL RESOURCES MINING

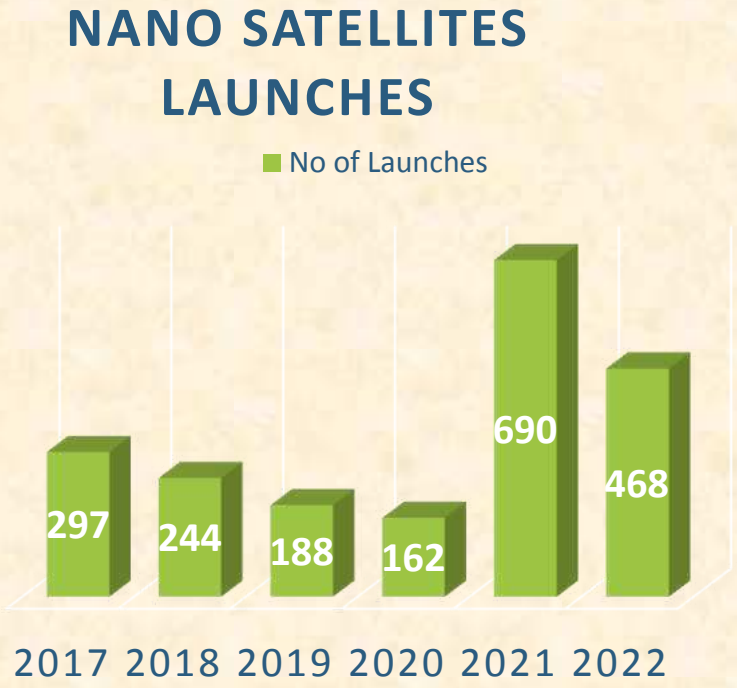
Luxembourg Law on Space Resources, 2017

- **Luxembourg aims to play a leading role in the exploration and utilization of these resources- Encouraging entrepreneurs**
- **Passed the law on 13 July and came in to force on 1st August 2017,**
- **Law provides a unique legal, regulatory and business environment enabling private investors and companies to explore and use space resources**
- ***"Its goal is to ensure that space resources explored under its jurisdiction serve a peaceful purpose, are gathered and used in a sustainable manner compatible with international law and for the benefit of humankind. Luxembourg's vision is built on support for advanced research activities and technological capabilities, drawing on the country's existing expertise in the space sector and its ongoing strategy of economic diversification into future-oriented high-tech industries"***

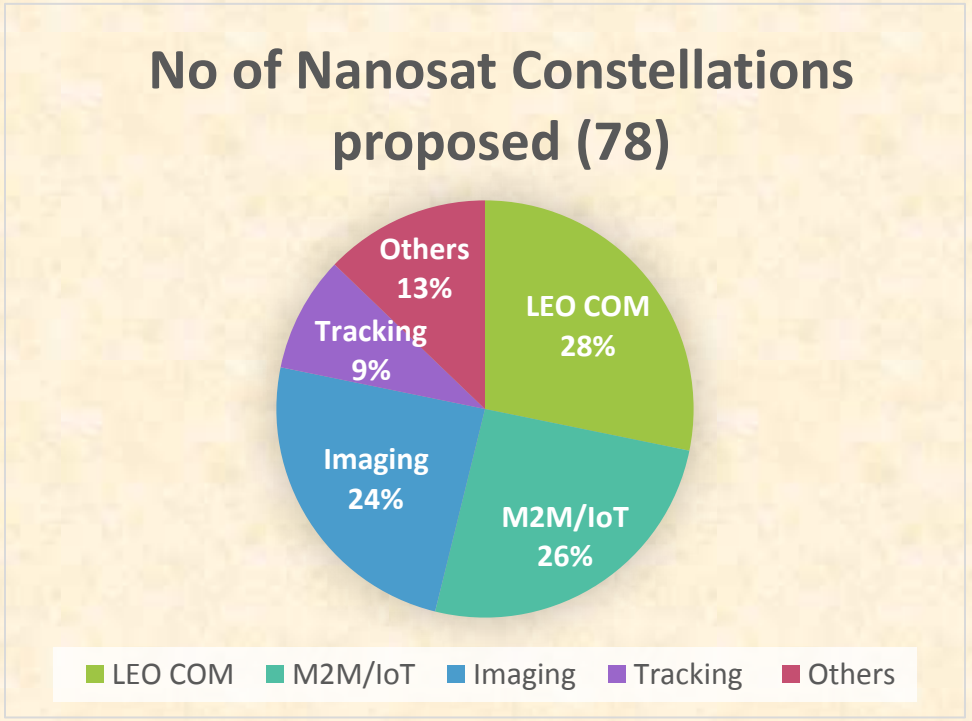
Small satellite Constellations

MICRO/ NANO SATELLITES GROWING RAPIDLY

Market size worth 4.8 Bi $ by 2025



Ref: www.nanosats.eu



All proposed number of micro/ nano satellites : 25000

USP'S OF SMALL SATELLITES

- Affordability – use of widely available & reliable microelectronics
- Constellation approach- robustness, redundancy. Easier to replace, frequent revisit
- Lead time for development and deployment – significantly reduced; easier replacement
- Using advantage of new technologies- 3D printed structures/components, electric propulsion, agile models

TYPICAL CUBESAT CONFIGURATION

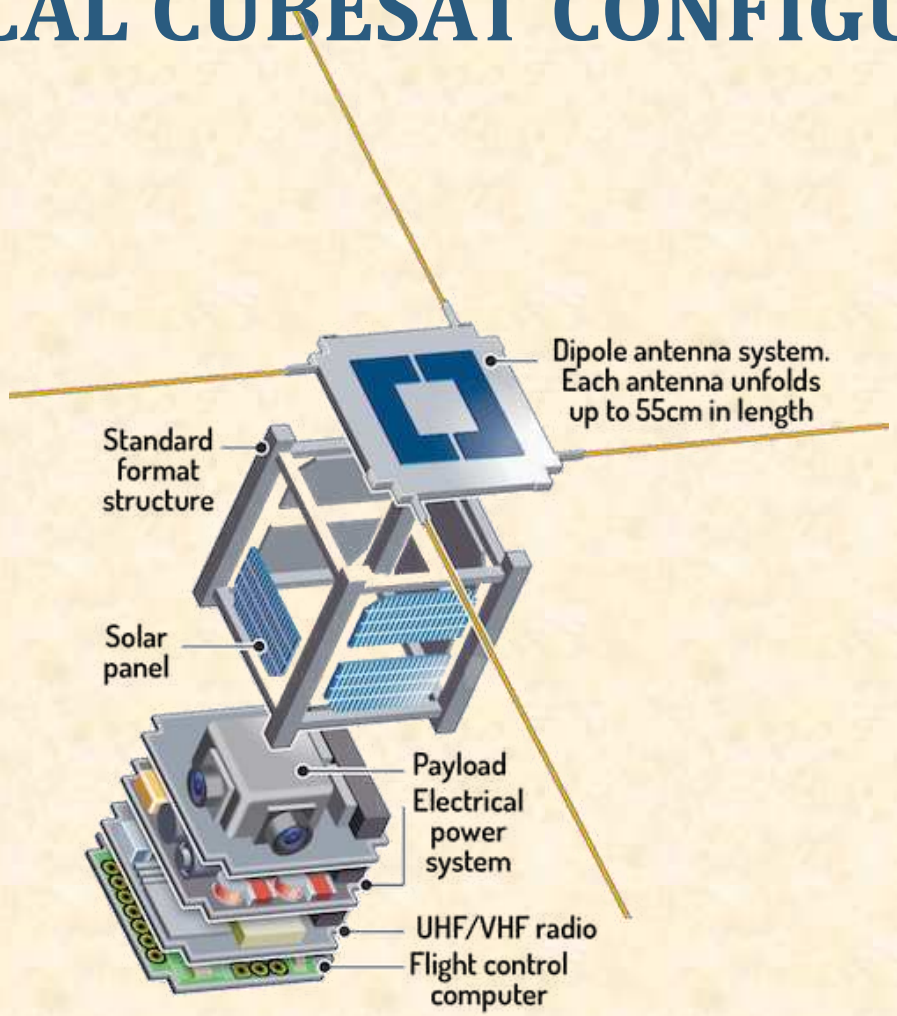


Image credit: https://alen.space/basic-guide-nanosatellites/

IMPACT OF “COTS “ APPROACH TO CAMERA

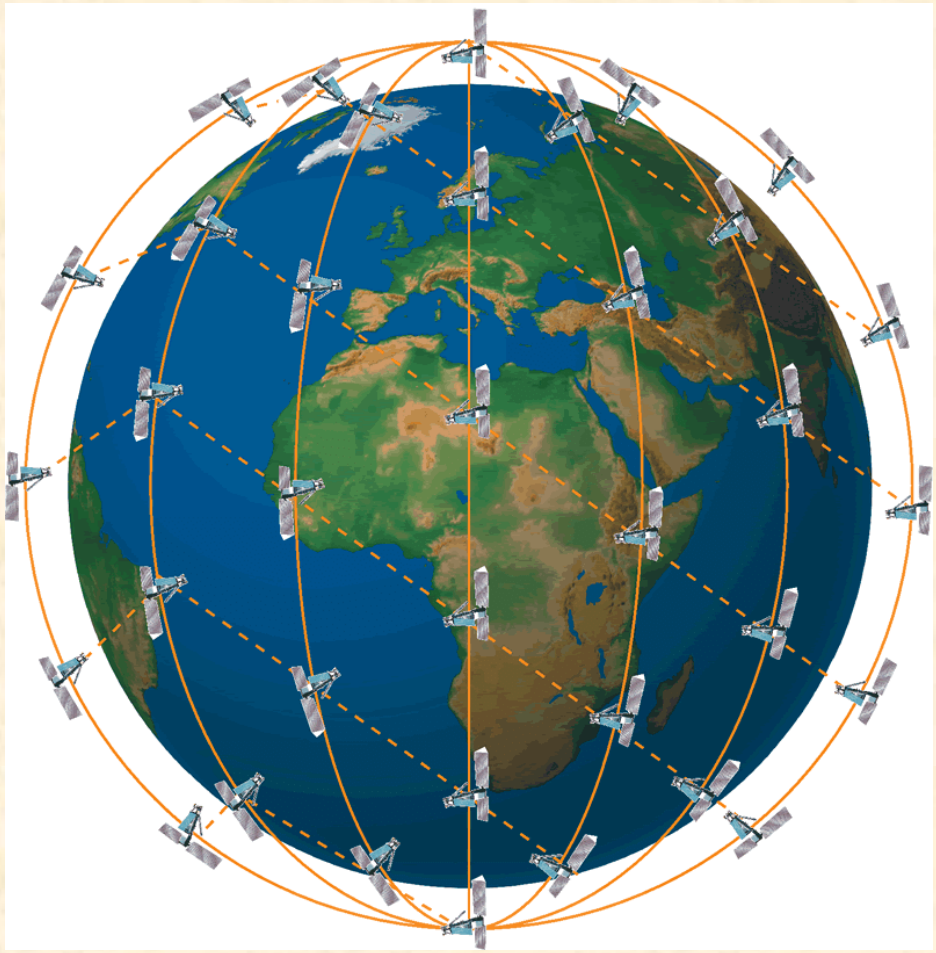
LISS III SENSOR (RESOURCESAT)

Medium Resolution
4 bands
23 meter spatial res.
70W power
140 km swath
106 Kg

CUBESAT Camera

High resolution image & video
5m spatial resolution
3388 x 2712 pixel frame (9MP)
5.1 w power, 398 gram
Model: Imperx B 3412 DX Mirror
Optics SY: 500mm f/6.3

LOW EARTH ORBIT CONSTELLATION CONCEPT



Reference/ credits:

Modelling and Performance Analysis of 2.5 Gbps Inter-satellite Optical Wireless Communication (IsOWC) System in LEO Constellation - Scientific Figure on ResearchGate. Available from: https://www.researchgate.net/figure/Low-Earth-Orbit-LEO-satellite-constellation_fig1_328133212 [accessed 18 Feb, 2021]

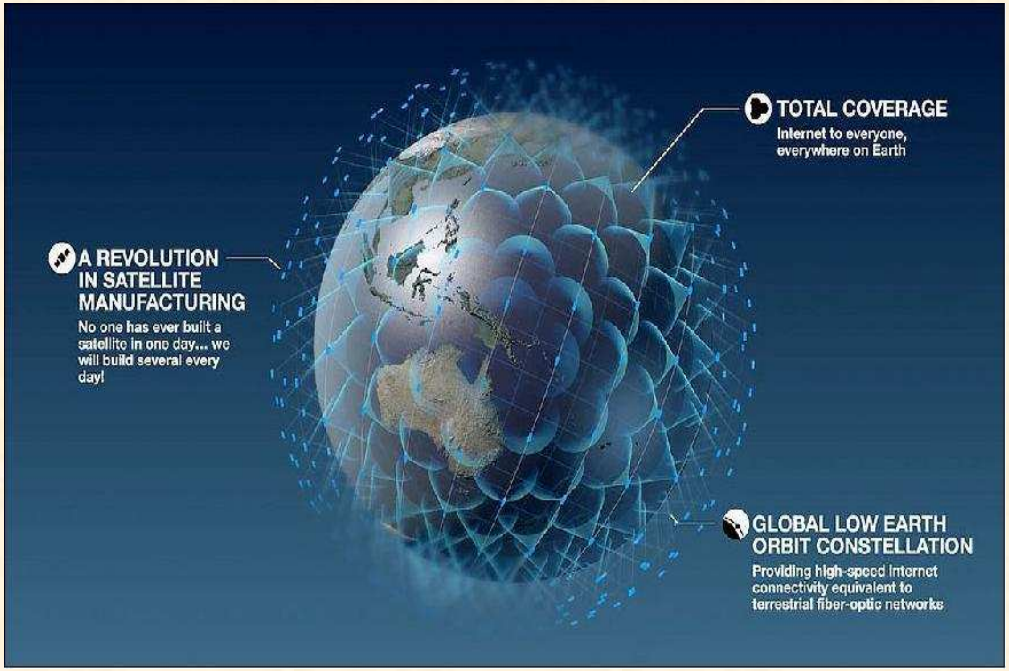
SMALL SAT APPLICATIONS

- Remote sensing
  - Mapping
  - Urban planning
  - Crop yield forecasting
  - Hyper spectral imaging
  - RADAR data
  - Video imaging
- SCIENCE
  - Astronomical mapping
  - Auroral plasma
  - Education/ capacity building
- SECURITY
  - ELINT/SIGINT
  - Reconnaissance
  - Technology validation
- Communications
  - IoT and Machine to Machine data exchange
  - Data store &forward (Global)
  - Mobile communications
  - Communications relay, Internet
- Disaster Support
  - Disaster Monitoring
  - Flood mapping
  - Fire detection
  - Space Debris monitoring
- Mobile Assets
  - Tracking of ships (AIS)
  - Tracking aircraft in flight using ADS-B Remote monitoring & control

STARLINK SATELLITES IN ORBIT

A train of SpaceX Starlink satellites are visible in the night sky in this still from a video captured by satellite tracker Marco Langbroek in Leiden, the Netherlands on May 24, 2019, just one day after SpaceX launched 60 of the Starlink internet communications satellites into orbit. (Source: Space.com; Image: © Marco Langbroek via SatTrackBlog)

ONE WEB AND GOOGLE CONSTELLATIONS



OneWeb intends to cover the Earth with a nominal constellation of 648 LEO mini satellites built by Airbus Defence and Space (image credit: Airbus DS)

Of the constellation, 648 of them will be placed in18 orbital planes with an altitude of about 1200 km. ..(Source : eoPortal Directory- https://directory.eoportal.org/web/eoportal/satellite-missions/content/-/article/oneweb

Google plans to launch a constellation of 1000 satellites orbiting around Earth, covering 75 % of its surface … to spread the reach of internet across the world (source: USPTO)

EXCERPTS OF STATEMENT OF ROYAL ASTRONOMICAL SOCIETY, UK

- The Royal Astronomical Society notes with concern the launch of the new SpaceX Starlink constellation of satellites into low-Earth orbit, and the **potential impact of this and other programmes on views of the night sky and on astronomical research**.
- ….
- **There appears to have been no consultation** between SpaceX and the scientific community in advance of the Starlink launch, though since initial press reports we note that Elon Musk has responded indicating he wishes to minimise the impact on astronomy.
- The Society welcomes this offer. We urge SpaceX, and other satellite providers, to work with scientists, engineers and others to mitigate the effects of the new constellations. We also ask that the provider companies consider the impact on human heritage too – an issue that goes far beyond the concerns of the astronomical community
- Source: https://ras.ac.uk/news-and-press/news/ras-statement-starlink-satellite-constellation

CASE OF SPACE LAUNCH WITHOUT FCC AUTHORIZATION.. *CONTD*

FCC fines Swarm $900,000 for unauthorized smallsat launch

by Caleb Henry — December 20, 2018

One of Swarm Technologies' "SpaceBee" picosatellites. The company wants to operate a constellation of 100 tiny satellites for Internet of Things services. Credit: Swarm Technologies

Space News https://spacenews.com/fcc-fines-swarm-900000-for-unauthorized-smallsat-launch/ Dt. Dec 20, 2019

- **Other Developments**
  - ***Lunar Gateway Project***
  - ***Commercial Utilization of ISS***

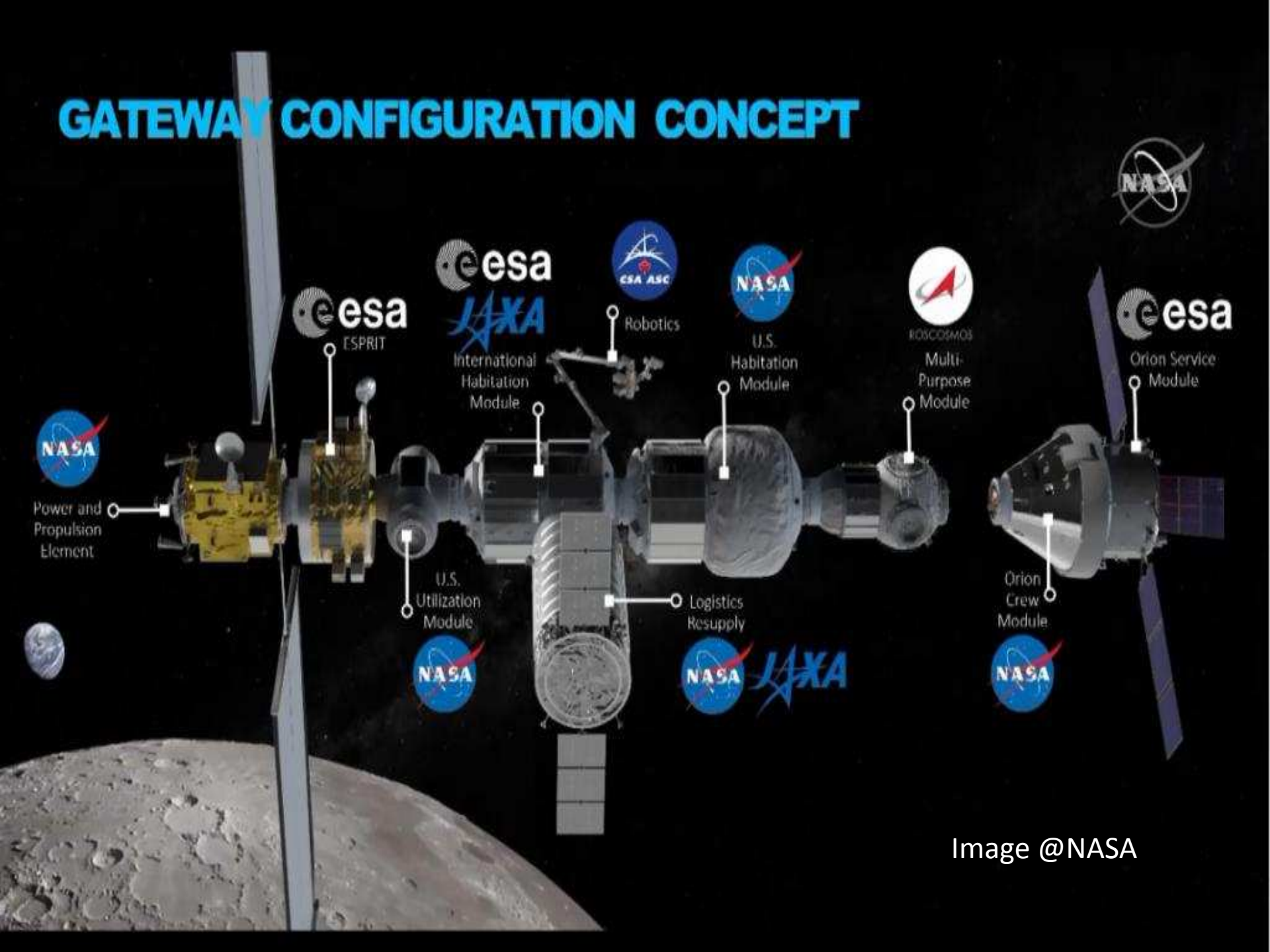

GATEWAY CONFIGURATION CONCEPT
esa
ESPRIT
esa
JAXA
International Habitation Module
CSA ASC
Robotics
NASA
U.S. Habitation Module
ROSCOSMOS
Multi-Purpose Module
esa
Orion Service Module
NASA
Power and Propulsion Element
U.S. Utilization Module
Logistics Resupply
Orion Crew Module
NASA
NASA
JAXA
NASA

Image @NASA

NASA INTERIM DIRECTIVE (NID) ON USE OF ISS FOR COMMERCIAL AND MARKETING ACTIVITIES

NASA Opens International Space Station to New Commercial Opportunities, Private Astronauts ***(Release 19-044 Dt June 09, 2019)***

- *With this new policy, U.S. Entities will have the ability to pursue the following:*
  - *Manufacturing, production, transportation, or marketing of commercial resources and goods, including products intended for commercial sale on Earth*
  - ***Inclusion of private astronauts on USG or commercial missions to the International Space Station and associated on-orbit activities, including commercial and marketing activities***
  - *U.S. government astronauts conducting coordinated and scheduled activities in support of commercial and marketing activities*
  - *Purchase resources available for use on the International Space Station for commercial and marketing activities*

Source: https://www.nasa.gov/leo-economy/commercial-use/introduction-to-policy

TREND OF SPACE LAW MAKING

- Outer Space gaining strategic importance , with More spacefaring, space- active nations
- **More non-governmental players – State Responsibility – Liability- Authorization and Continuing Supervision by State Party- National Space Legislation**
- UN Treaty making process – By consensus -No Treaty formulations after Moon Agreement in 1979-
  - *Code of Conduct, TCBMs, Guidelines on Long Term sustainability of outer Space activities...*
- *Will Soft Law practice tending towards establishing a Customary law ?*

COMMERCIAL SPACE 2010-2020

- Robotic ISS resupply missions- NASA funding for commercial cargo deals.
- SpaceX -19 missions with its Dragon capsule and Falcon 9 rocket (from 2012)
- Northrop Grumman's 11 launches after debut operational run with Cygnus spacecraft and Antares rocket (January 2014) the recovery and reuse of orbital hardware by a private company.
- SpaceX booster touchdown began in December 2015.
- 48 landings, many on specialized ships at sea.
- Multiple re-flights of first stages

FALLING COSTS OF LAUNCH TO ORBITS

- SpaceX Falcon 9 launch costs $62 million (Payload of 22,800 kilograms in Low Earth orbit (LEO))
- Falcon Heavy launch at $90 million. (63,800 kg to Low Earth orbit (LEO)

- Above translate to $2,720 per kg to LEO for the Falcon 9, and $1,410 per kg for the Falcon Heavy.
- In comparison, the cost to LEO for NASA's space shuttle orbiters was about $54,500 per kg,

BLUE ORIGIN

- Jeff Bezos' Blue Origin - landing and re-flights from 2010s.
- Beginning with November 2015, Blue Origin's **New Shepard** suborbital vehicle - 11 successful touchdowns.
- Latest version of the reusable New Shepard - six missions.
- 100 customers for use of suborbital flight and back

- **Rocket Lab** –a private launch provider in the past decade
- pioneering dedicated missions for small satellites via its 57-foot-tall (17 meters) Electron rocket.
- The two-stage Electron since maiden flight in May 2017 completed 10 flights

MANUFACTURING IN SPACE

- 3D printer built by Made In Space rode to the ISS in September 2014 (aboard a SpaceX Dragon capsule).
- Made In Space has also launched other equipment that manufactures the high-value optical fiber ZBLAN to the orbiting lab
- Developing in-space assembly technology known as Archinaut, for **repair, upgrade and refuel satellites in orbit** and build new structures.
- NASA's award of $74 million for Archinaut orbital test, by early 2022.

IMAGING & COMMUNICATIONS

- Doves (nanosatellites) - their use by analysts to keep tabs on the North Korean and Iranian rocket and missile programs
- SpaceX launch of first 120 Starlink spacecraft in 2019
- Aims to orbit 12,000 satellites
- Similar goals by other companies, such as OneWeb and Amazon

LUNAR HUMAN PRESENCE

- NASA's reserving space on commercial lunar landers
- Private robotic craft missions for delivery of scientific experiments and technology demonstrations to the moon
- NASA's aim for human landing on the lunar surface by 2024
- A sustainable human presence on Moon by the end of the 2020s

PRIVATE CAPITAL BOOST

- $24.6 billion investment in the commercial space sector since 2009
- $5 billion of above came in the first three quarters of 2019.
- SpaceX's Crew Dragon and Boeing's Starliner - to provide taxi service to ferry NASA astronauts to and from the ISS.

DEFINING SPACE COMMERCE

- Diverse definitions used

- US National Space Policy (June 28, 2010)
  - The term “commercial,” for the purposes of this policy, refers to space goods, services, or activities provided by private sector enterprises that bear a reasonable portion of the investment risk and responsibility for the activity, operate in accordance with typical market-based incentives for controlling cost and optimizing return on investment, and have the legal capacity to offer these goods or services to existing or potential nongovernmental customers.
  - Reference: SPACEPOLICYONLINE.com

CATEGORIES

- Private investments and private consumers
  - Space communications- New Skies, Intelsat, Thaicom, DirectTV
- Government infrastructure, private consumers
  - GPS based services, positioning devices, car navigation
- Private/ Public -Private investments, Government services
  - Contract manufacturers like Boeing, Astrium

- Reference: SPACEPOLICYONLINE.com

COMMERCIAL SPACE POLICIES USA

- Dept of Commerce as one stop shop for commercial space regulations(June 18, 2018)
- Executive order on Encouraging International Support for the Recovery and Use of Space Resources (April 6, 2020)
- National Space Transportation Policy (Nov 21, 2013)
- Policies on Commercial Remote Sensing satellites(2003)

- Reference: SPACEPOLICYONLINE.com

US LAWS ON COMMERCIAL SPACE ACTIVITIES

- 1984 Commercial Space Launch Act
- 1988 amendments- govt indemnity 500million $ to 2 Billion $
- 2004 amendment regulation of commercial human space flight
- 2015 Commercial Space Launch Competitiveness Act

- 1992 Land Remote Sensing Policy Act(Landsat system back to govt, DoC/NOAA oversight of commercial Remote Sensing satellites)
- 1998 Commercial Space Act- Dept of Transport regulatory authority on Launch and return of Commercial spacecraft

2015 COMMERCIAL SPACE LAUNCH COMPETITIVENESS ACT

- A number of changes to U.S. commercial space policy, including granting property rights to U.S. companies that mine resources from asteroids.
- Also extends the “learning period” during which the FAA may not issue new commercial human spaceflight regulations until 2023
- Extends third party indemnification until 2025.
- Title I is the Spurring Private Aerospace Competitiveness and Entrepreneurship (SPACE) Act, and some refer to it that way.
- Reference: SPACEPOLICYONLINE.com

STATUS IN CHINA

- 78 commercial companies in China.
- Of these, 29 focus on satellite manufacturing, 21 are part of the launch sector, 8 are remote sensing operators, 17 focus on communications, and 33 emphasize areas such as ground stations, downstream analytics, and other applications.1
- The entire sector focuses on the launch and use of small satellites (satellites under 500 kg).
- investment in the commercial space sector is between about $600– 900 million in the years 2014–2018,
- Possible dominance of subsidiaries of State Owned Enterprises

- Reference

Evaluation of China's Commercial Space Sector; IDA Document D-10873

EUROPEAN SPACE INDUSTRY

- 2017 STATUS
- LAUNCHERS 990 mE
- Spacecraft 2136 mE
- Ground eqpt 252 mE
- Others 74 mE
- Major actors Airbus Defence and Space, Safran, Thales Alenia Space, AVIO, OHB, QinetiQ
- SES, Eutelsat, Ariane Space, Reaction Engines Ltd. RUAG Space, Jena-Optronic
- New/ Start ups: PLD Space, Active Space Technologies, Arquimea etc.

REFERENCES

- **As indicated in slides**
- **The Private Spaceflight Decade: How Commercial Space Truly Soared in the 2010s,** Mike Wall, SPACE.COM, December 20, 2019
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- Global Space Industry at a glance, https://www.industry.gov.au/