Space for Evolution

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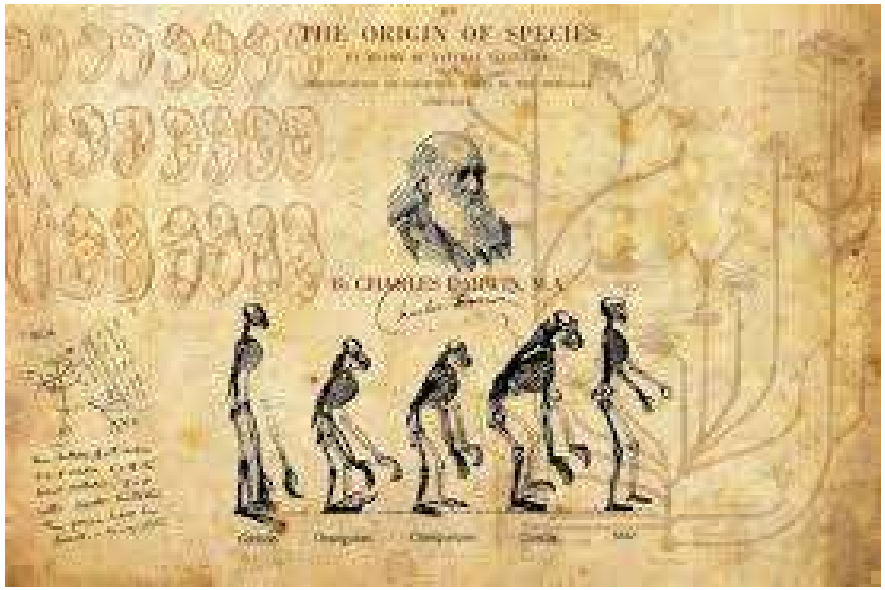
AGENDA

- The concept of evolution
- Space activities related evolution
- Current trends in space
- The lesson learnt on Earth: principles to inspire space activities

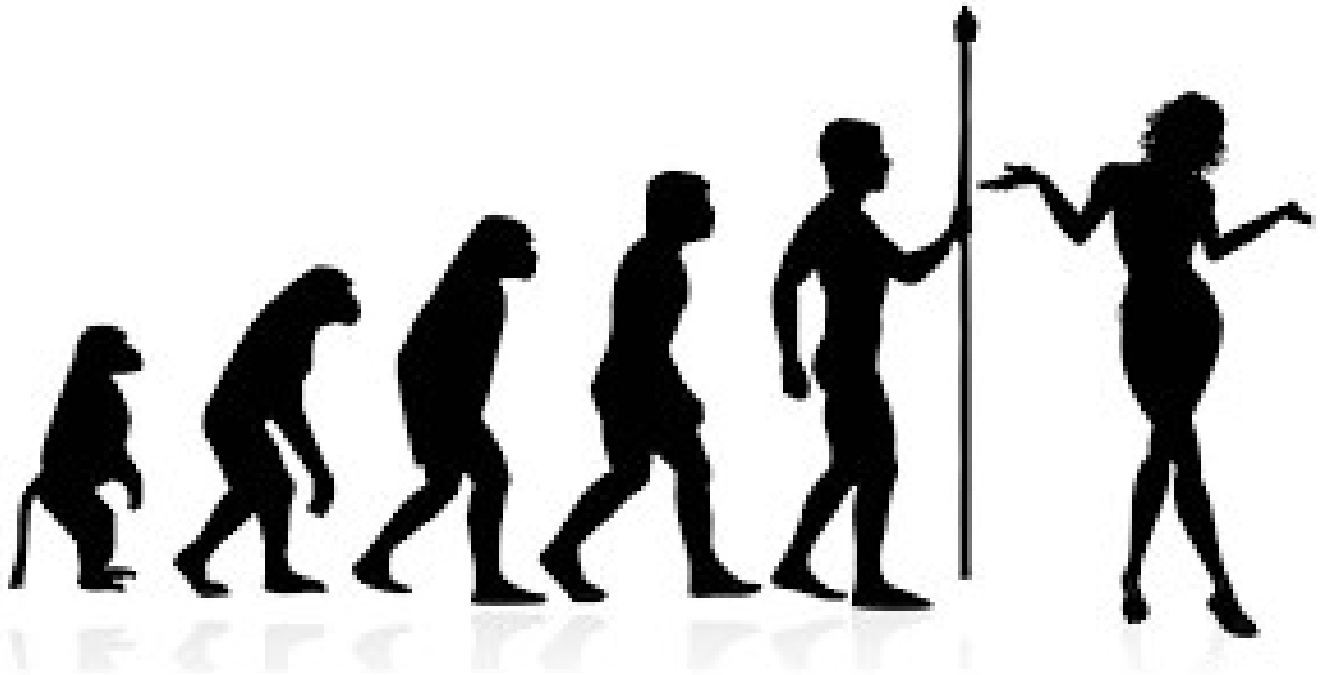
THE CONCEPT OF EVOLUTION

Noun from **Latin evolutio**, "*an unrolling or opening*," combined from the prefix **e-**, "*out*," plus **volvere**, "*to roll*."

Although the modern theory of evolution has its source in Charles Darwin's book *"On the Origin of Species"* (1859), the word evolution does not appear in the original text at all. Darwin avoided using the word evolution, preferring to refer to the process of biological change as 'transmutation'.



By the end of the 18th century, *evolution* had become established as a general term for a process of development, especially when this involved a gradual change ('evolutionary' rather than 'revolutionary') from a simpler to a more complex state.



Why and How evolution?

- **To guarantee survivability** - A natural process resulting in the evolution of organisms best adapted to the environment. For a lineage to survive over long time periods, it must sometimes change. This has given rise to the term *evolvability*, meaning *the tendency to produce adaptive variation,* deleterious variation also matters.
- **To increase quality of life** - Improving knowledge and capabilities.
- As an unexpected effect of **looking for solutions to other issues**.

How can evolution be feasible with Space ?

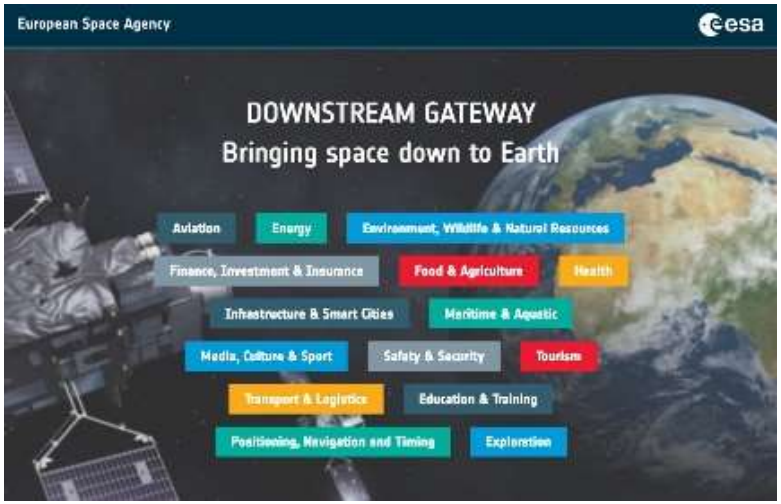
2 main options:

a. Space activities driving evolution
b. Evolving versus space

The OECD (Organization for Economic Co-operation and Development) Space Forum defines three space segments setting up the perimeters of space activities, products and services as follows:

1. **Upstream**
2. **Downstream**
3. **Space related segment**

Each segment can support evolution:



The **upstream segment** includes: research, space manufacturing and ground systems (*fundamental and* applied research activities, scientific and engineering support activities, material and components supply, *manufacturing of space systems, subsystems and equipment, telemetry, tracking and command stations*).

The **downstream segment** includes: space operations for terrestrial use and products and services which rely on satellite technology, signal, data to function (e.g. satellite broadcasting, selected GIS, GNSS-enabled devices).

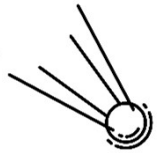
The **space-related segment** finally includes space applications, products and services from spin-offs or technology transfer from the space sector, which use satellite technology but do not depend on it (low incorporated quantities of “space” components).

Human space exploration supports getting awareness about our place in the Universe and the history of our solar system and improving technology and competitiveness.

Enabling conditions for human space exploration are for instance: experience with International Space Station, exploration in translunar space and study of asteroids or missions to other planets of the solar system.

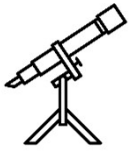
- ***International Space Station*** experience can support training for astronauts for long-duration flight and the permanent expansion of human exploration.

- ***Exploring in translunar space***, beyond the protection of the Earth's geomagnetic field, will provide experience in deep-space operations, allowing research in galactic cosmic radiation–potentially the most threatening element to humans exploring deep space–and develop mitigation strategies that may also lead to medical advancements on Earth.



- The ***Lagrange points–places*** in cislunar space where the gravitational influences of the Earth and moon cancel each other out, are areas useful for research in which almost no propulsion is required to keep an object or spacecraft stationary.

- The ***Lagrange point on the far side of the Earth-Moon system***, called L2, also provides a "radio silence" zone for astronomical observations.



Mars has always been a source of inspiration for explorers and scientists:

- Searching for signs of life and investigate Mars' geological evolution, results in research and methods that could be applied here on Earth.

- Providing the opportunity to demonstrate that humans can live for extended, even permanent, stays beyond low Earth orbit.
- The technology required to transport and sustain explorers will drive innovation and encourage creative ways to address challenges.

- The challenge of traveling to Mars and learning how to live there will encourage nations around the world to work together to achieve such an ambitious undertaking. The International Space station has shown that opportunities for collaboration will highlight our common interests and provide a global sense of community.

Asteroids are sites where potentially find valuable resources available in space, and further develop ways to use them in our need for more efficient and affordable exploration.

ESA's **Space Safety & Security activities** aim at preventing and mitigating the effects of hazards from space, protecting earth and its critical infrastructure – like satellites in orbit and power grids on the ground.

- ***Space Weather (SWE):*** monitoring and predicting the state of the Sun and the interplanetary and planetary environments, including Earth's magnetosphere, ionosphere and thermosphere, which can affect spaceborne and ground-based infrastructure thereby endangering human health and safety.

- ***Near-Earth Objects (NEO)***: detecting natural objects such as asteroids that can potentially impact Earth and cause damage.

- ***Space Surveillance and Tracking (SST):*** watching for active and inactive satellites, discarded launch stages and fragmentation debris orbiting Earth.

- ***Improved robust surveillance and communication services*** will support for security hazards.

Space Traffic Management STM is becoming more and more an issue facing with an increasing numbers of space systems

A comprehensive vision of the STM landscape will progress upon the building blocks already developed at European level, for example:

- Policy & Framework in terms of: Objectives, principles and organized distribution of tasks and responsibilities among relevant stakeholders
- Capabilities in terms of: necessary infrastructure, systems, technologies, data, services, models and expertise
- Regime in terms of: Set of rules, norms and recommendations specifying how to conduct launch and space operations

- By 2030, Europe will be able to ***protect vital infrastructure in space and on the ground*** from extreme space weather events, ensuring societies are resilient to threats from Sun

- By 2030, Europe, with partners worldwide, will ***have a fleet of spacecraft in orbit around Earth***, resilient to the hazards of space debris, ***capable of removing and avoiding debris***, understanding and assessing risks, and able to applying end-of-life measures for sustainable use of space.

- ESA will enable the ***safe operation of individual satellites and large constellations*** by developing and demonstrating an Automated Collision Avoidance System, free from causing damage.

- ESA will support the ***monitoring and safe management of space traffic*** and the application and verification of the necessary debris mitigation measures according to internationally agreed guidelines, standards and best practices

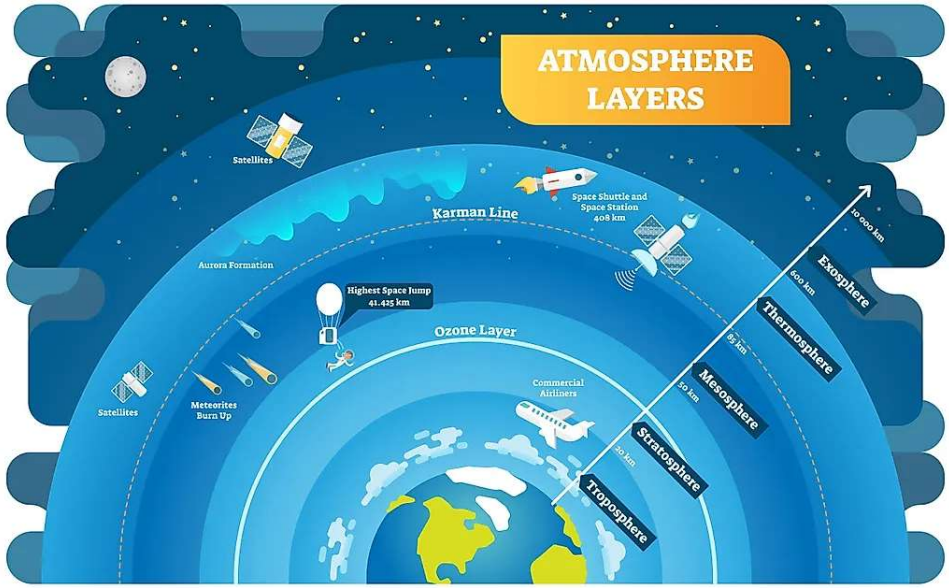
- ESA's Space Debris Office will continue to ***assessing, model and mitigate the risks due to debris and re-entries*** through development of new sensor and monitoring technology for radars, laser ranging and optical space surveillance, based in orbit and on ground, to include 'piggyback' hosted payload and small sat options.

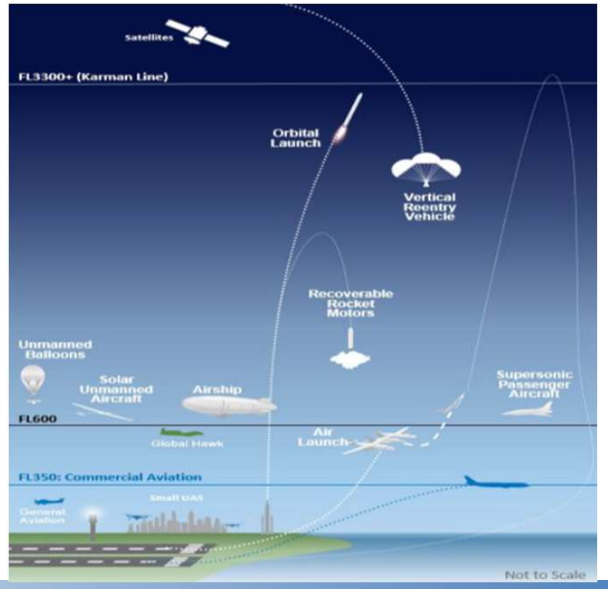
Through the **Clean Space initiative**, ESA is promoting an ***eco-friendly approach to space activities***, adopting greener industrial materials, processes and technologies on earth and preserving Earth's orbital environment as a safe zone, free of debris.

- **Active Debris Removal/In-Orbit Servicing**: ability to safely de-orbit satellites at the end of their lives. The new vehicle will also be able to refuel satellites, manoeuvre them and ultimately demonstrate the technologies needed to extend the lifespan of missions from space.
- **CleanSat** ESA initiative is focusing on reducing the production of space debris.
- **EcoDesign** ESA initiative is addressing environmental impacts and will foster green technologies through the establishment of a common eco-design framework for the European space sector.

- **Higher Airspace (HA) region**, located between the airspace normally used by aircraft and the beginning of space, is no longer an exclusive transition zone, but an area where operations will increase as a result of the emergence of a complete new aviation domain, business and technical opportunities and more, representing business values in the order billions per year.

- The expected operations in the Higher Airspace represent an ***emerging market*** like for the early days of aviation where providing rules, including structural procedures regarding traffic and operations management, is now considered as the key enabler of this international healthy business of $900b/y which worldwide connect people and civilisations.





CURRENT TRENDS IN SPACE ACTIVITIES

- ***New-entrants represent a wide range of vehicles and associated operations*** including: unmanned balloons, airships and solar planes capable of persistent (months) of flight, collectively known as high altitude pseudo-satellites (HAPS), super and hypersonic aircraft, trans-atmospheric and suborbital vehicles.

- Innovations are also taking place in ***space operations:*** new ways of launching for example from high altitude aircraft or balloons, the ability to recover boosters and the uptake of commercial space operations.

- These evolutions in the space and suborbital faring capabilities have contributed to ***drive down costs for satellite launches and have opened a new market for private passenger transportation*** thus increasing the number of space launches and suborbital flights.

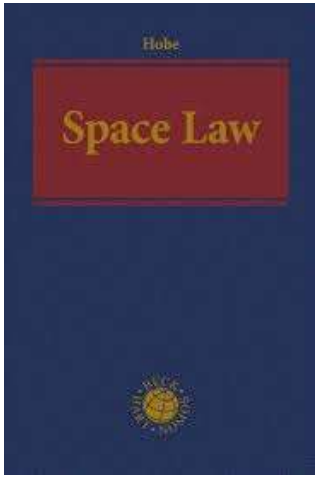
- The growth trend is likely to continue given the strategic and economic importance of space access, the ***new services*** available to space capable countries/regions and the international and intercontinental dimension.

-> All these innovations and developments are changing the demand for the HA and require the management of the operations in HA to be reviewed and defined.

Current constraints and challenges to face with:

- ***Difficulties in estimating new users demand*** over time i.e level of unmanned operations or new space technology demand.
- ***Compatibility, interoperability and data policy between*** Air Traffic Management (***ATM***) ***and*** Space Traffic Management (***STM***).
- ***National sovereignty*** and the role of individual States including the legal status of the vehicles that operate within or transit through HA .
- ***Existing ICAO*** standards and recommended practices.
- ***Global operations and their requirements*** that may have an effect on Europe.
- ***Environmental aspects relating to the Stratosphere and Mesosphere*** i.e. effects of the sun, solar winds and weather that can affect the operation of vehicles.
- *European Space Situational Awareness* (SSA) capabilities currently under development.
- ***Military operations and capabilities*** to fulfil national and collective defence obligations.

A globally harmonized framework to perform missions and related operations in the HA is necessary to guarantee some basic principles for ***safe, sustainable, fair, competitive Higher Airspace operations***:



- Adaptability to multiple countries
- Use of performance-based separation minima between operational intents of vehicles
- The availability of a conflict severity framework based on probability, time to resolution (performance dependent) and loss of separation severity
- The availability of Conflict management fallback rules in case of non-cooperative resolution
- Guaranteed capability of minimum performance for each type of HA vehicle, including reliability and handling of identified contingencies
- A key regulators agreement to oversee operational trials which can be shared through ICAO as a best practice for these ongoing operations
- A common approach to identify, detect, communicate, manage and record risks and impacts (to be confirmed) to build a knowledge basis informing future developments

Space law treaties and principles driving a fair, sustainable evolution

- The Committee on the ***Peaceful Uses of Outer Space*** is the forum for the development of international space law. The Committee has concluded five international treaties and five sets of principles on space-related activities.
- These five treaties deal with issues such as the **non-appropriation of outer space** by any one country, arms control, the **freedom of exploration**, **liability for damage caused** by space objects, **the safety and rescue** of spacecraft and astronauts, the prevention of harmful interference with space activities and the **environment**, the notification and registration of space activities, scientific investigation and the exploitation of natural resources in outer space and the s**ettlement of disputes**.
- Each of the treaties stresses the notion that outer space, the activities carried out in outer space and whatever benefits might be accrued from outer space should be devoted **to enhancing the well-being of all countries and humankind**, with an emphasis on promoting international cooperation.

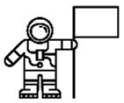
Space exploration is expensive and a common complain is that there are still many issues to solve on earth.

This oversimplification ignores that the added value of space related activities can be high in terms of progress to improve lives on earth, **provided that the lesson learnt from earth will be capitalized and the previous principles will be properly implemented and guaranteed.**

- Without space programs, we wouldn't have **GPS, accurate weather prediction, solar cells, or the ultraviolet filters in sunglasses and cameras**.
- There's also **medical research** happening in space right now that could cure diseases and prolong human lives, and these experiments can't be done on Earth.

- **Capability to deflect big dangerous asteroids** which in the past caused a mass extinction, must be developed.

- **In case of a huge disaster on Earth, living species could be wiped out**. Colonizing other bodies in the solar system (or building our own orbiting habitats) is a way to create a "backup" of humanity that will survive no matter what happens to Earth.
- ***The extraction of minerals*** on earth has led to environmental problems, while there's a wealth of precious materials ***in space*** which could supply raw materials that are rare on Earth





Exploration is the basis of evolution not only to discover new worlds and build advanced technologies, but to work together toward a larger goal irrespective of nationality, race, or gender. If we stop exploring, we mortify our curiosity which is in the nature of the human being.

Vademecum for Space evolution collecting hints by previous Key note speakers.

- Impact measuring for evolution, common approach to measure results and effects with an independent role
- Inclusion and openess to new participants because evolution needs sometimes to differentiate
- Gender dimension as a research theme (gender: a dimension of research)
- More openess and more transparency (communication with the general public)
- Synergies with other sectors (not at the end or only at the beginning but by exchanging results and working together to overcome barriers and benefit each other domain
- Care to national level to guarantee implementation of actions at lower granularity
- Sharing of information to build and progress upon it