JSASS Space Vision 2050

(Highlight version)

March, 2019

The Japan Society for Aeronautical and Space Sciences

JSASS Space Vision 2050 shows the development of the near Earth activities, the activities at the moon and Mars, and evolution of deep space exploration and scientific activities, supported by Space Technology Roadmap and Space Policy Roadmap. In the following, the highlights of this vision are shown as three image diagrams

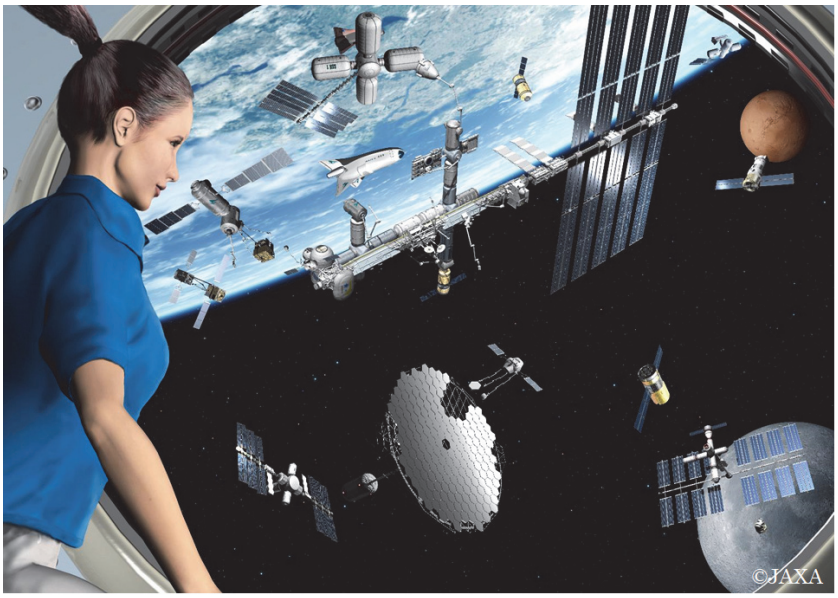


Image of space usage around Earth in 2050

Space activities in the near-Earth orbits (LEO, GEO, etc.) are accelerating. Ballistic flight Space travel becomes common, and multiple manned bases based on state and private capitals are used in business. The realization of revolutionary reusable spacecraft activates both ballistic flight for tourism and frequent access to the near-Earth orbits. A space transportation network consists of multiple manned bases, fuel supply ports, spacecraft maintenance ports, etc., and their construction is realized by orbital service drones (robots). Large observation sensors of a scale which previously could not be realized, due to the dimensional constraints of rockets in the past, are able to be assembled on orbits.

Image of space activity at lunar base in 2050

The number of human beings who have moved to space, has increased exponentially. Human beings are living outside the Earth, not only in near-Earth orbits but also in the near-by regions of Lunar and Mars, where water, energy, propellant etc. are locally produced for in-situ utilization.

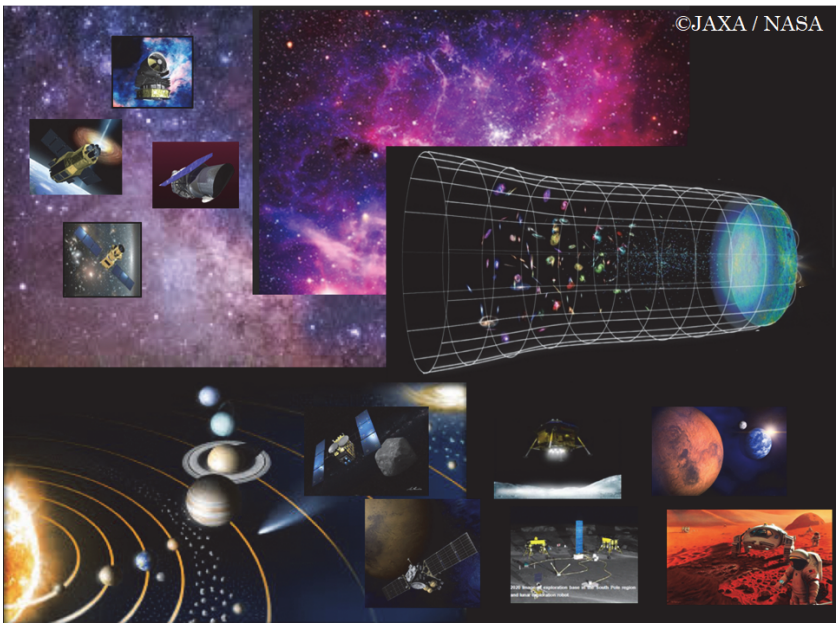


Image of space science development in 2050

To reveal the origin of space and our solar system, unmanned explorers beyond Mars and some clusters of astronomical satellites observe and elucidate the beginning of the universe and the birth of life. Further development of intelligence and science is continuing with international cooperation.

Contents

1. Introduction

The Japan Society for Aeronautical and Space Sciences (JSASS) changed its name from its predecessor, the Japan Society for Aeronautics, in July 1968 and celebrated its 50th year in 2018. The 50th Board of Directors made a decision to propose the Long-Term Space Vision from JSASS, taking advantage of the 50 years since incorporating "Space" into the name of the academic society. The goal is to make the vision public at the annual meeting to be held in April 2019, and the Aerospace Vision Committee has been responsible for conducting the study. The Aerospace Vision Committee is an ad hoc committee that examines the vision in both fields of aeronautics and astronautics. The committee has two subcommittees for each field. The Long-Term Space Vision focuses on the astronautics field, thus the Space Technology Vision subcommittee and the Space Policy Vision subcommittee support strongly by examining the vision.

Currently, the target age of the Long-Term Space Vision is assumed to be 2050 and after. The year 2050 is about 30 years into the future. On the contrary, if we think 30 years into the past, we are able to realize there were various social and technological developments during this period. Imagining 30 years into the future, we can expect many developments, so we decided to consider 2050 and beyond. Therefore, we have included the year 2050 in the name and made it the "Space Vision 2050". Furthermore, since JSASS is an academic society, we hope to formulate the vision for researchers and practitioners, and we also desire them to work on innovative R & D and new creative business.

In addition to formulating the Space Vision 2050, we decided to develop a roadmap that shows the path of development leading to it. The roadmap consists of two elements, "Space Technology Roadmap" with the development of science and technology in mind, and "Space Policy Roadmap" with issues of humanities and social sciences such as laws and international relations in mind. Therefore, the relation of Space Vision 2050 and two Space Roadmaps is shown in the figure, and we decided to call "JSASS Space Vision 2050" as a whole. The Space Vision 2050 incorporates the opinions of experts not limited to specialized fields, and draws ideal space activities on 2050 or later. Therefore, top-down study was performed. On the other hand, the two Space Roadmaps show what can be realized after 10 or 20 years based on experts' current recognition. This was a bottom-up review. After these procedures, we connected the Space Vision 2050 and the Space Roadmaps and concluded the JSASS Space Vision 2050.

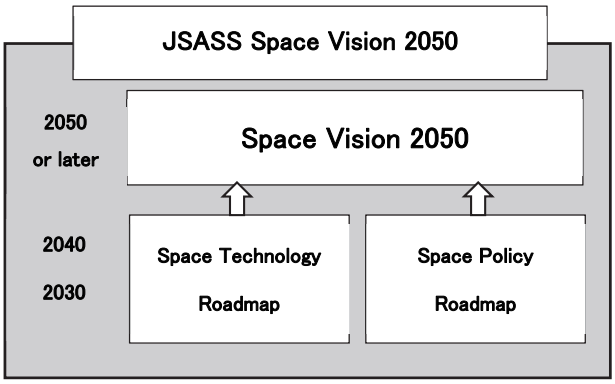


Figure 1. The structure of JSASS Space Vision 2050

It is very difficult to predict the future. Sudden progress may be predicted on premised assumption, such as “if something is developed”, or “if this problem is solved”. We do not include such detailed assumptions in this vision, and we believe that it is the responsibility of the researchers and practitioners who are the readers of this vision to propose and realize the assumptions. Sometimes steady efforts push the development, and unexpected challenges sometimes produce rapid progress. It is our hope that researchers and practitioners in various fields, who are leading society and are filled with hope for the future, continue the challenge of creating an affluent human society utilizing JSASS Space Vision 2050.

2. Space Vision 2050

1) Outline of Space Vision 2050

Space Vision 2050 starts with the image of what kind of space activities humans are doing in 2050 and what the activities are bringing about, and outlines the items that compose each activity. The definitions of the term used in the Space Vision 2050 are as below.

【1】 Researcher / Practitioner

Researchers are those who specialize in academic research related to space regardless of science or literal arts, and includes engineers. Practitioners are people engaged in actual work related to space.

【2】 Space worker

People engaged in work in space, such as pilots, engineers, and scientists. Astronauts certified by national and private organization are also included.

【3】 Space travelers and families of space workers staying in space

People staying in space for the purposes other than work.

I. Where do humans work?

【Near Earth】

The human society that was limited to the ground is spreading to the universe near the Earth. We have access to space in various ways, and people other than space workers or researchers / practitioners also participate in space activities.

【Moon】

There are multiple lunar bases built and operated by national and private capitals, and a human society is formed by space resident, mainly space workers. People other than space workers or researchers / practitioners also stay short-term as a space traveler on the moon.

【Mars】

Astronauts will be promoting the Mars exploration program and are expanding the space area of human activities.

【Solar system】

Human beings have acquired the ability to go anywhere in the solar system using unmanned probes. In addition, due to the development of information technology, exploration capability has improved dramatically.

【Out of the solar system】

Human beings face the challenge of creating a means of transport outside the solar system.

II. Who is doing space activities?

【Nation / Space Agency】

The national space agency regularly sends astronauts to stay on the moon and Mars. The space area of mankind has expanded throughout the solar system and is spreading beyond the solar system.

【Researcher / Practitioner】

Researchers and practitioners cooperate with each other and are committed to the sustainable development of space activities. Researchers work on various academic fields deepened and expanded, providing new perspectives and issues. In addition, we are engaged in advanced technology development and sometimes create unexpected change to society. Practitioners are working on social implementation of new technologies and solving new problems.

【Space resident】

Space workers in space are active around the Earth, the surface and the orbit of the moon and Mars, to expand the area of activity of mankind. Especially at lunar bases, space workers and their families form a human society, and space tourists visit regularly.

【Industry】

Business that supports all people participating in space activities is developing. Private companies are developing multiple businesses based on a space port on earth, low-earth-orbit, and moon, and space workers working. The establishment of a new transportation system realizes the mass transportation of people and products so the industry based on data, materials and energy produced in space develops in various fields and everyone benefits from it.

【People other than space workers or researchers / practitioners】

For those who are interested in space travel, suborbital flight experience and stay at a low-earth-orbit manned space station are nothing out of ordinary, and short-term stay on the moon is also possible. Also, people who are not directly interested in space are also participating in space activities through various information devices, and are gaining benefit from it.

III. What does space activity bring?

【Solution to a challenge of humanity】

Space activities are contributing to the realization of sustainable development goals (SDGs). In addition, space activities overcome the challenges of the next generation industry and are helping to improve the convenience and comfort of human life.

【Innovation in industrial structure】

Mass transportation between the ground and space, the evolution of information and robot technology are changing the industrial structure. Not only enterprises of different industries and start-ups but also exploitation of new fields by existing enterprises, are boosted by various private capital, and related legislative development etc. are proceeding.

【Fostering new values】

As the sphere of human habitation expands from the ground to the near earth, new values are developed for the "advancement of the space of mankind" and "protection of the global environment", etc.

【Acquisition of knowledge】

Through space activities including outside the solar system, academic fields deepen and expand, and understanding of the origins of life and the universe is deepening. Experts in science, engineering, humanities and social sciences bring knowledge and contribute to the promotion and development of human space activities (including the activities on earth).

【Expansion of the sphere of human habitation】

The residents of Moon and Mars away from the earth are taking the first step toward establishing a human society outside the earth.

【Securing sustainability of space activities】

By addressing the problems manifested as a result of space activities and protecting the space environment, we are realizing sustainable human activities in space. Unified space traffic management beyond national boundaries is realized, and everyone is able to perform space activities safely.

IV. Summary

The outline of Space Vision 2050 is summarized by answering to the following questions: what kind of space activities human beings are doing, and what is the activity bringing about? We have imagined such a future that, all human beings live with connection to space activities regardless of interest in space in 2050.

It is deemed desirable that researchers and practitioners will make efforts to pass on the research outcome to society, by creating new industries and solving human problems. When facing exciting and challenging space activities, it is important for researchers and practitioners to actively seek support from society, and to work together. To that end, it is necessary not only to have favorable achievement in research, but also to deliver the “excitement of research” and “benefit of space development” to society. For that purpose, it is also important to train communicators that convey the significance of space activities.

The JSASS Space Vision 2050 will not be realized without international collaboration. With our Space Vision 2050 and roadmaps, we hope to share the perspectives of space activities with international partners so that we will realize sustainable development of these respective space activities together as humankind.

JSASS Vision 2050

Space Technology Roadmap

JSASS Vision Committee
Space Science and Technology Roadmap Subcommittee

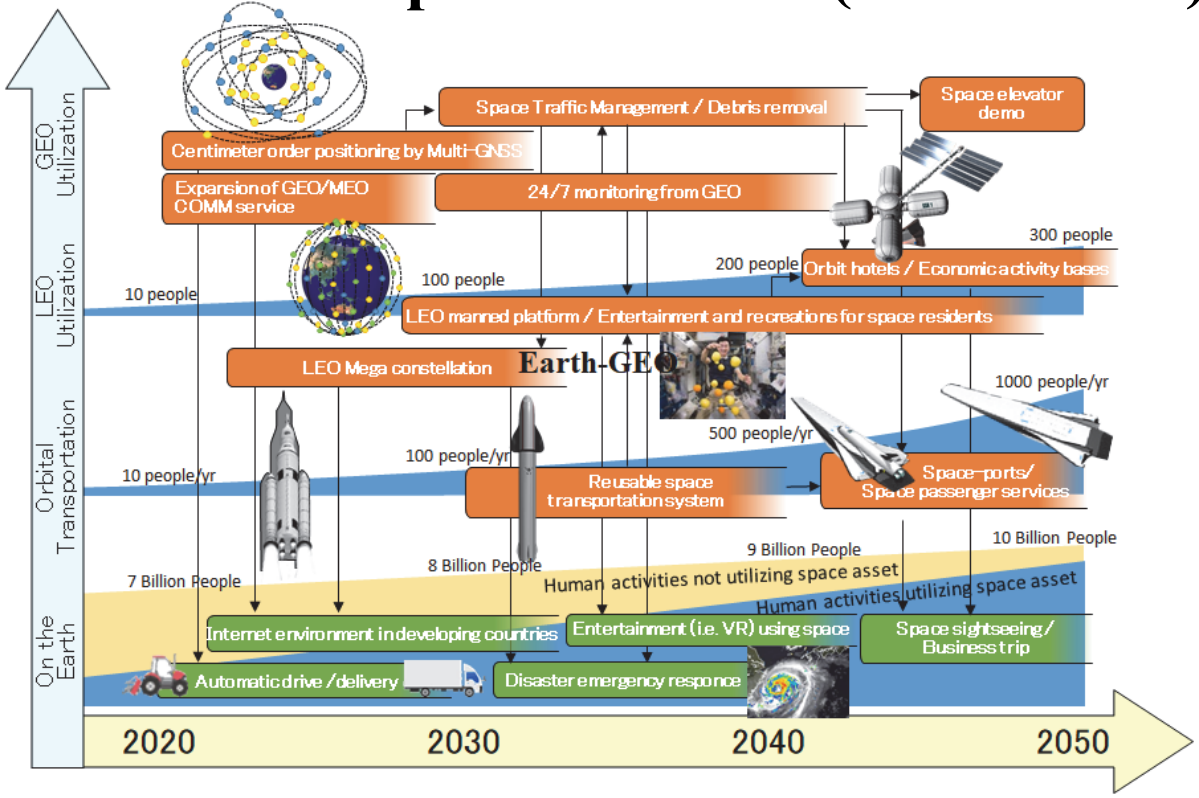
Space Technology Roadmaps

1. **Evolutions of Space Activities**
   - **Space Utilization:** LEO passenger and residents rapidly increase and civilian activities will spread to space.
   - **Space Exploration:** Construction of infrastructures and advancement of medical research will enable long term residency on the Moon and manned Mars exploration.

2. **Five Fields of Space Technology**
   - Space Transportation
   - Space Architecture
   - Spacecraft Technology
   - Space Information and Robotics
   - Space Science

1. Evolutions of Space Activities

Evolutions of Space Activities (Earth-GEO)



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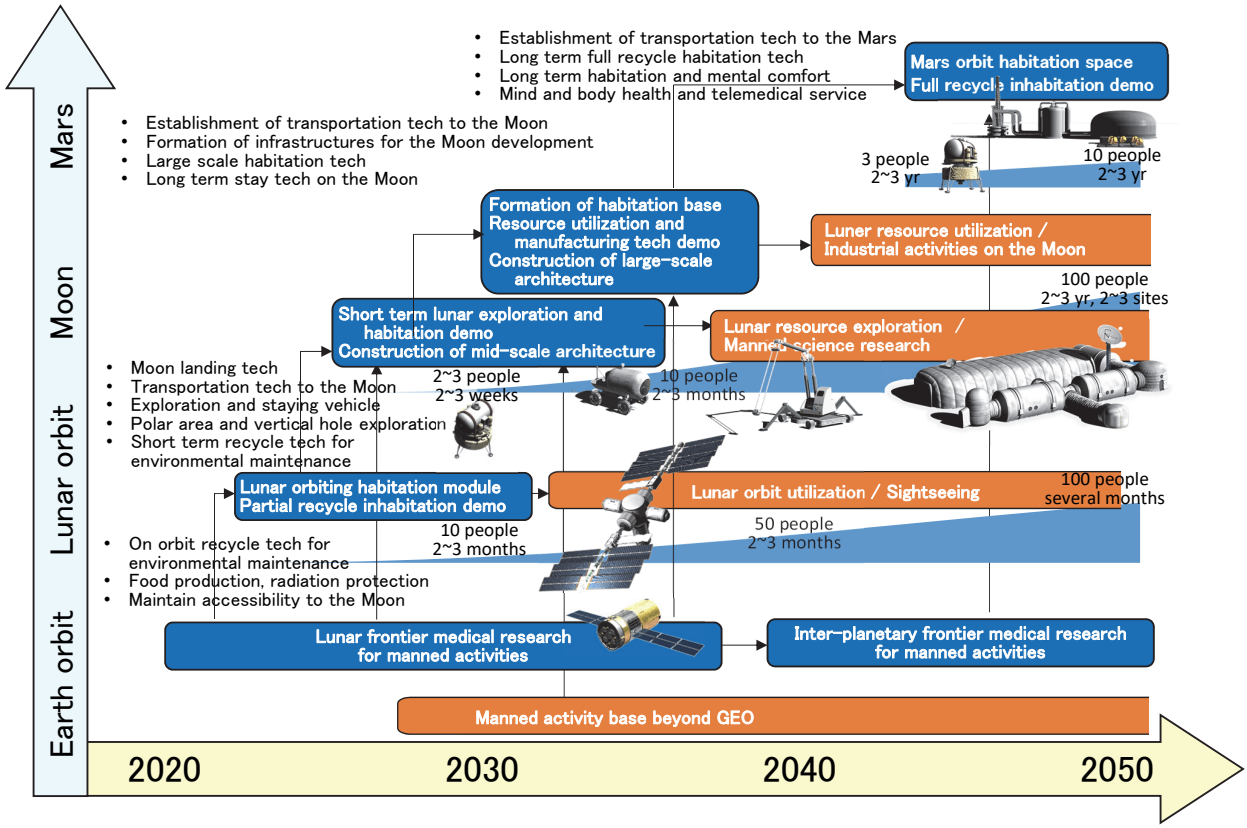
Evolutions of Space Activities (Earth-Mars)



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2. Five Fields of Space Technology

Space Transportation

Popularization of the use of near-Earth region and expansion of the sphere of humankind activity by a significant improvement of transportation efficiency.

Space Architecture

From making on earth to making in space. / Realizing sustainable space structure system by reuse/recycling structures and materials. / Assembly of large deployable modules in space

Spacecraft Technology

Spacecraft technologies will develop toward two directions to enhance their mission and performance. One is by enlarging their structure and instruments, and the other is by forming constellation with small satellites. Between those two directions, we set flows on relevant technologies supporting those activities, such as autonomy, automation and space debris mitigation measures.

Space Information/VR and Robotics

Progresses in information and communication technologies will enhance the growth of both space transportation and spacecraft. Unmanned space probes with VR/robotics enable real-time participation by citizens into solar system explorations

Space Science

Unmanned space exploration will have been expanded so that more flexible activities in the extreme regions of the Moon/Mars and longer distance cruising for the Saturn system and outer planet's moons can be realized.

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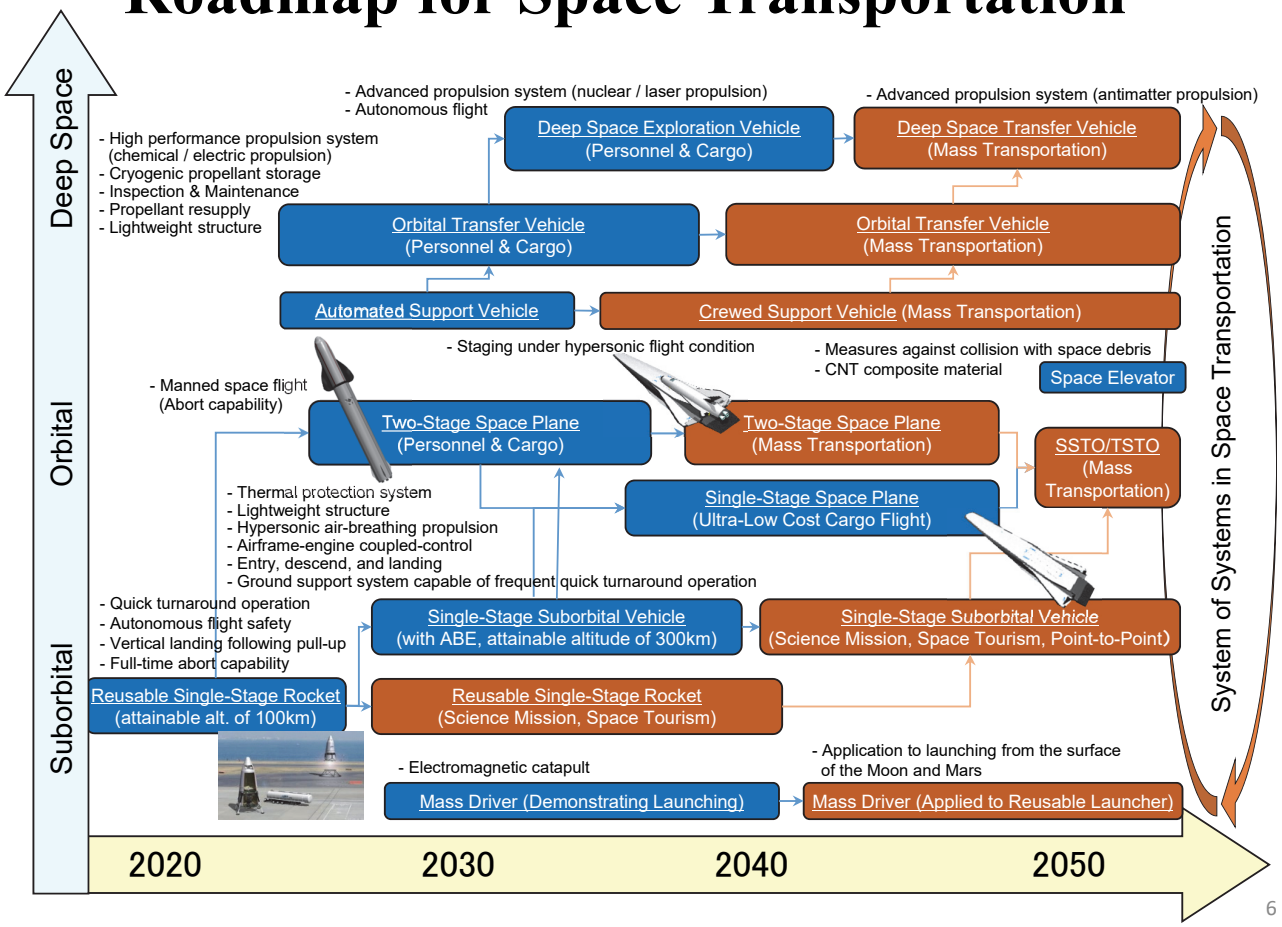
Roadmap for Space Transportation



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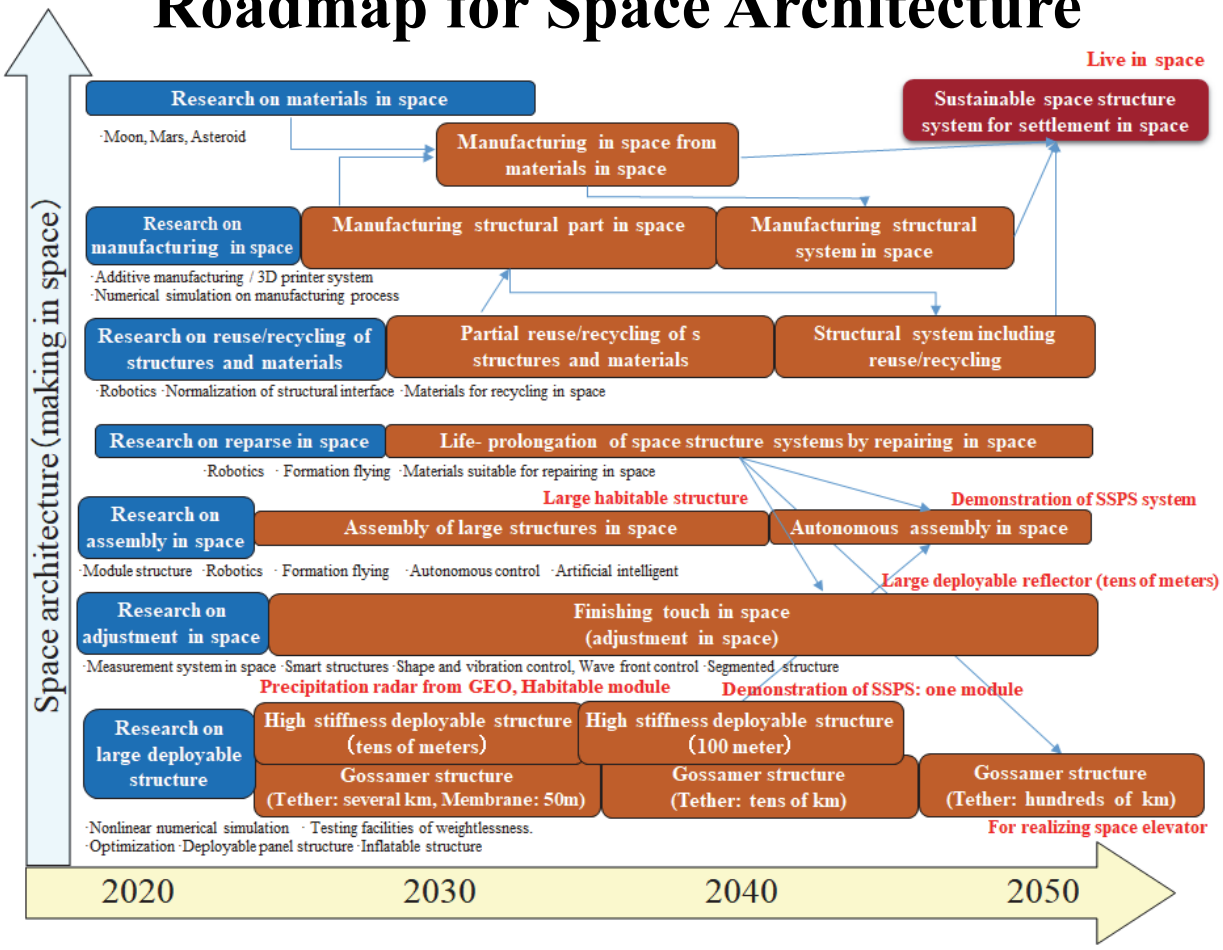
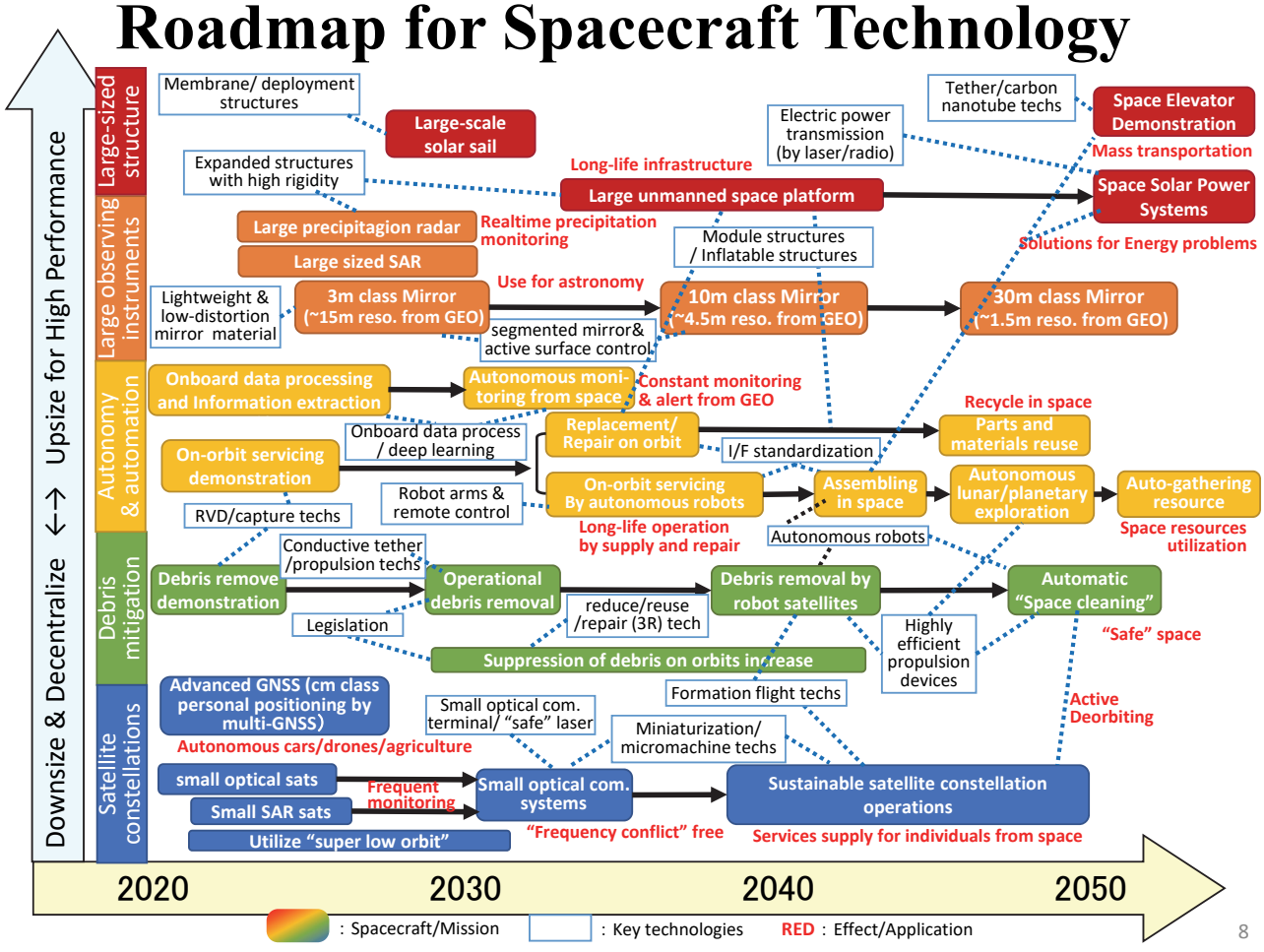
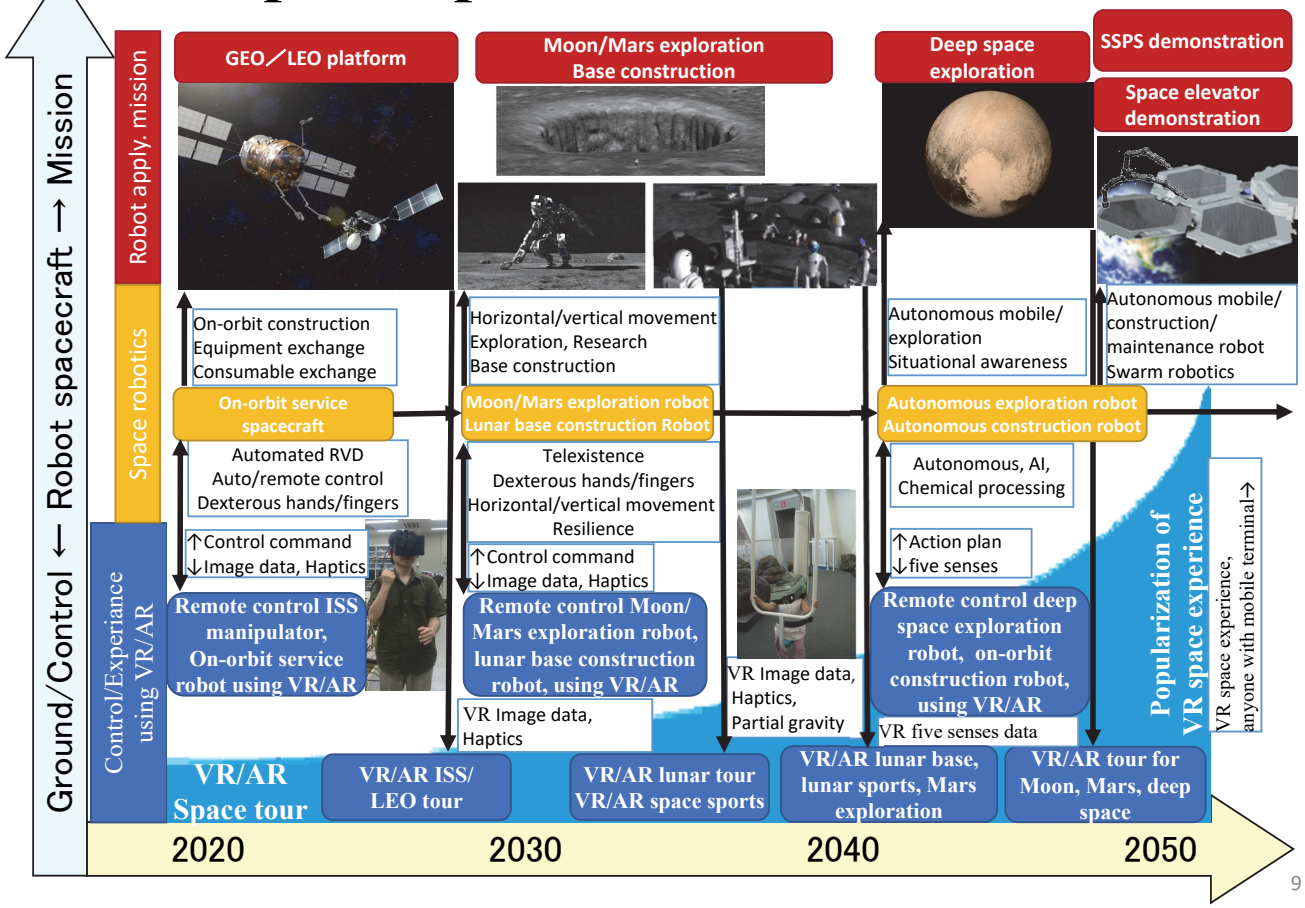
Roadmap for Space Architecture



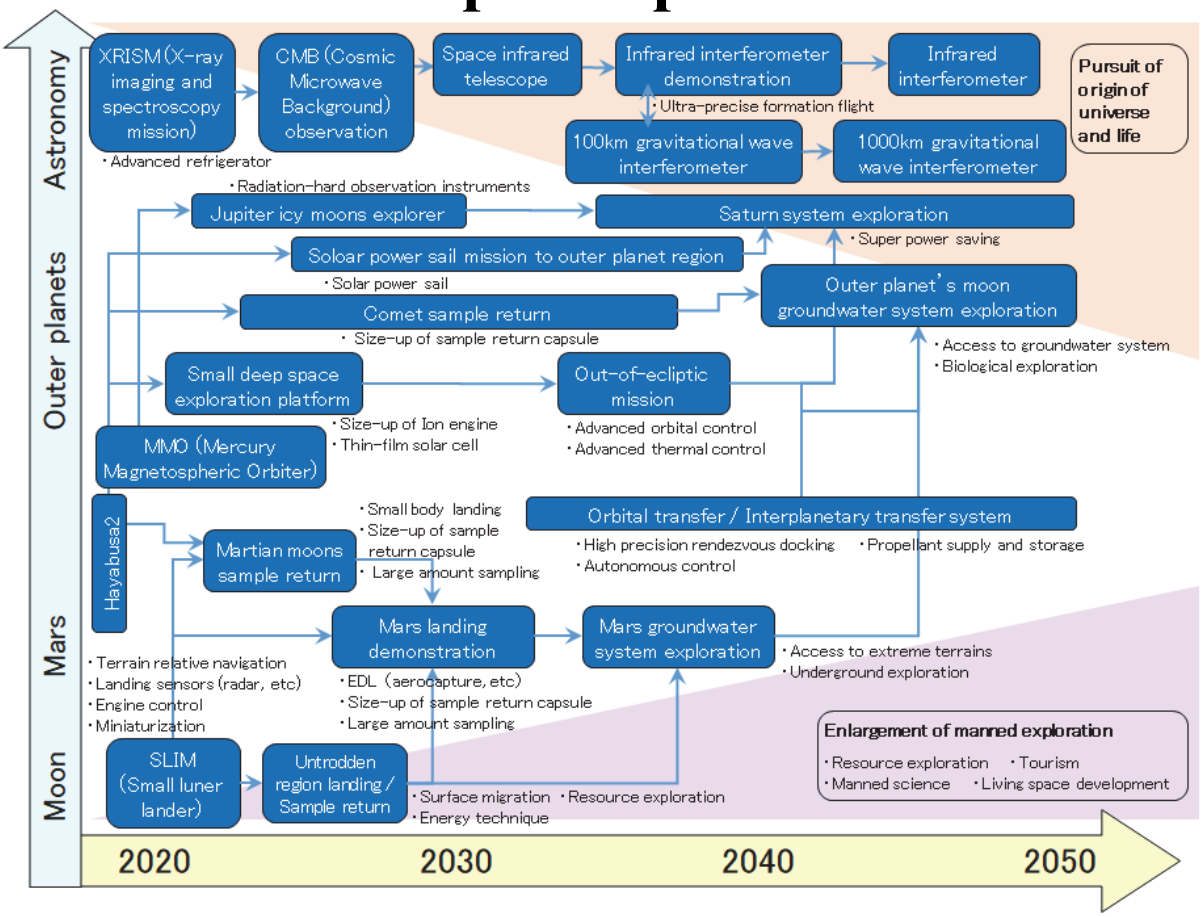
Roadmap for Spacecraft Technology



Roadmap for Space Robotics & Information



Roadmap for Space Science



JSASS Space Vision 2050

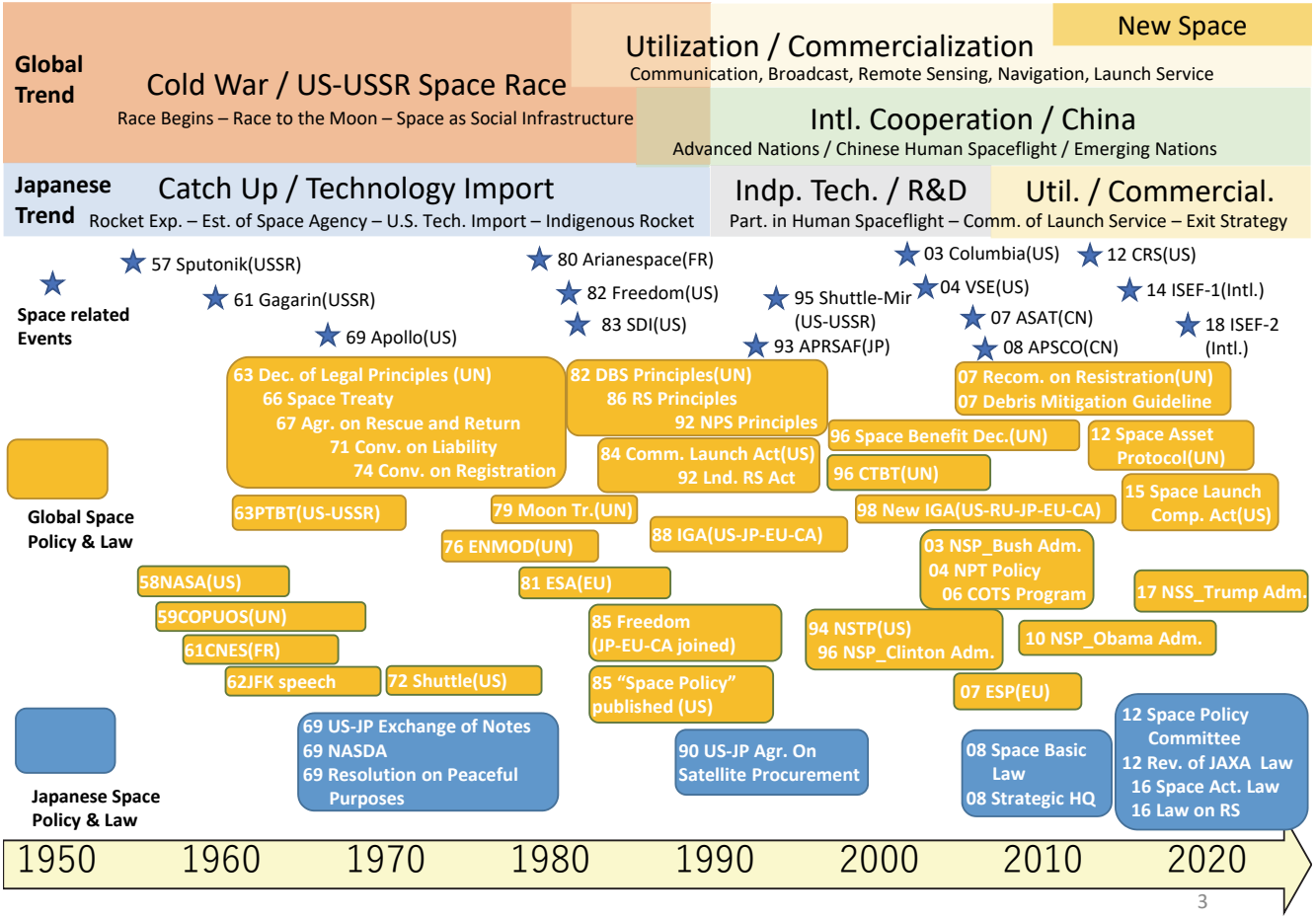
Space Policy Roadmap

JSASS Aerospace Vision Committee
Space Policy Vision Subcommittee

Space Policy Roadmap

- We started consideration on Space Policy Roadmap with reviewing the history of space policy and law.
- Question:
  - How have space policies and laws been developed along with the development and expansion of space activities?
  - Based on the history, what kind of discussion and studies will be needed to realize JSASS Space Vision 2050?
  - How can humanities and social sciences other than policy and law contribute to space activities?
- Space Integrated Policy Roadmap indicates the direction of studies which will be needed in the near future for the researchers and practitioners in the various areas of humanities and social sciences.

History of Space Policy and Law



Studies to realize JSASS Space Vision 2050

Moon / Mars Development and Expedition

- Review of Space Treaty regime
- Application of domestic laws
- Consideration on new legal concepts
- Principles / rules for competition and collaboration
- Inclusion of new players

Human Challenges (Environment, Energy, etc.)

- EO / climate change monitoring network
- EO data policy
- Privacy (RS / NPT / Bigdata)
- Safety of space solar power system (SSPS)
- National security (SSA / NEO / MDA / Resilience)

Space Resources Exploration

- Review of Moon Treaty
- Registration system for business
- Proprietary rights
- Balance of benefits to business / developing countries
- Planetary protection (COSPER guideline)

Industry Transformation

- Sustainability of domestic industry / anchor tenancy
- Enhancement of competitiveness
- Sustainable expansion of commercial market
- Roles of space agency
- Inclusion of new players

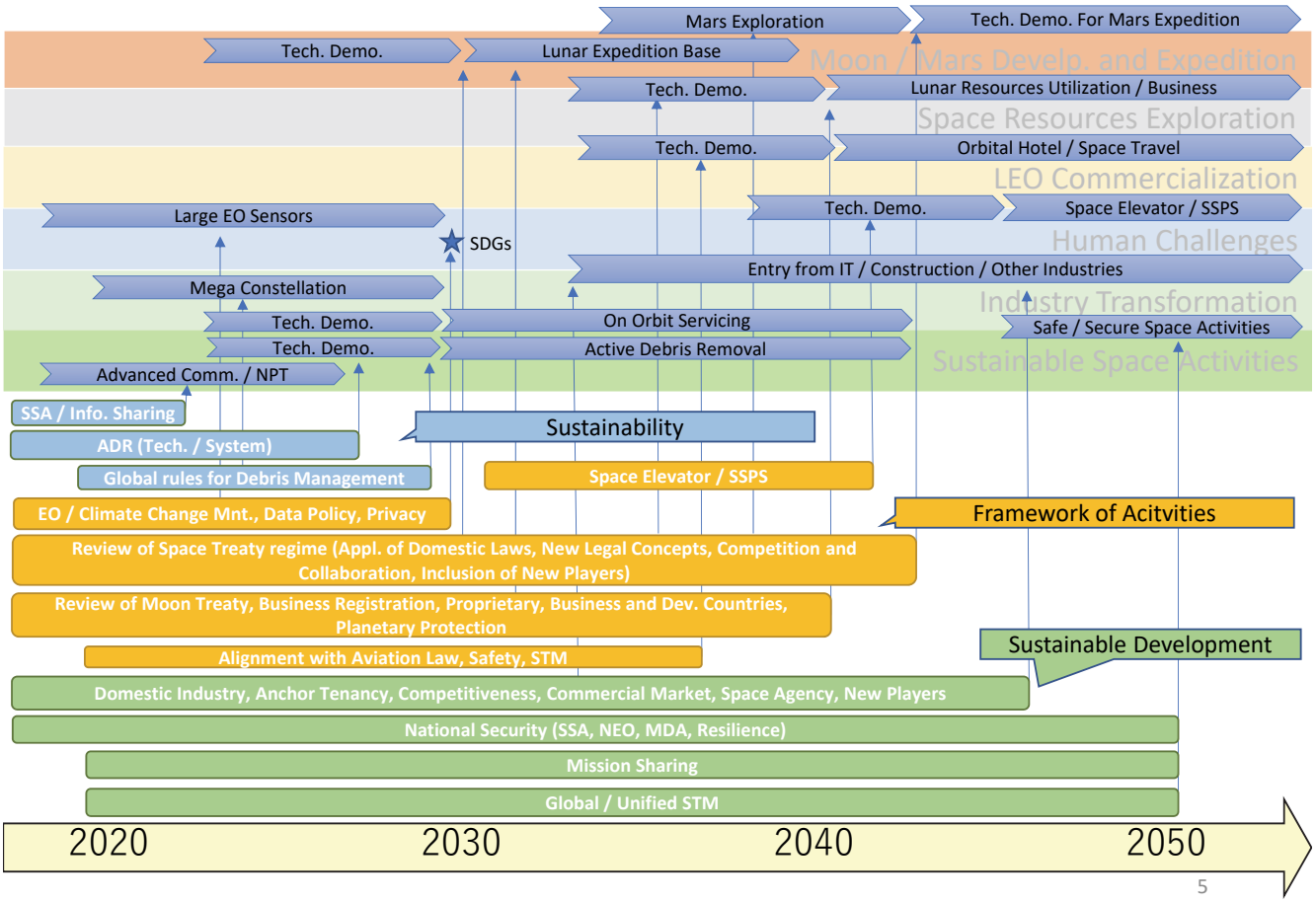
LEO Commercialization

- Alignment with aviation laws / ICAO
- Safety
- Space Traffic Management (STM)
- Laws for mega-constellation programs

Sustainable Space Activities

- Intl. rules for debris management (Ref: Environment laws)
- SSA and information sharing
- Active Debris Removal (Technology / System)
- Mission sharing
- Global / Unified STM

Roadmap for Space Policy and Law



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Possible Studies on Space Policy and Law

- Mechanisms for Legal Norms Formation
  - It would be possible to study on clarifying the roles of international organizations and enhancing their functions from the viewpoint of Governance.
  - It would be useful to review COPUOS mechanisms from the viewpoint of international organization laws like ITU.
  - We will also need to study universal scheme of space activities in comparison with the other areas of activities.
- International Regime for Private Business
  - Homogenization of regulations by domestic laws will be needed.
  - Mechanisms other than UN (consensus-based approach) that regulate commercial business need to be studied (ex. STM).
- Domestic Laws for New Space Business
  - Is it possible for Japan to have informed consent regulations for sub-orbital space travel? It would be intriguing to study the differences in legal cultures of each country.
  - It would be useful to study best practices or legal techniques to match technology development or unprecedent technology.

6

Possible Studies on Space Policy and Law

- Laws and Public-Private Partnership to Promote Private Business
  - Government and public agencies are the biggest customers or sponsors for space business. We will need to study administrative methods to promote private space business.
  - PPP/PFI or contract/procurement methods will need to be studied from the viewpoint of contract/administrative law, business study, or financial engineering.
  - IP, standardization, technology/knowledge management, or education/business study for human resources will need to be discussed.
- Space Debris Management
  - Studies on the regime to manage space debris properly taking into consideration industrial development are urgent.
  - Studies will include practical rules / best practices, standardization through ISO, or suggestion from environment law.

Possible Studies on Space Policy and Law

- Base on Moon / Mars
  - Coordination mechanisms to prevent disputes, for example, derived from competition to develop resource exploration plant near the pole of the Moon.
- Space Resources Development and Utilization
  - Moon Treaty should be reviewed though less countries have signed it.
  - Declaration on Space Benefit by UN or draft international rule for space resource exploration by Hague Space Resources Governance Group should be studied.
- New Legal Concept
  - In 2050, human community beyond LEO, independent from the Earth, may produce original laws for that community.
  - Interdisciplinary studies that include humanities and social sciences will be needed.

Studies on Humanities and Social Sciences

- Question:
  - Will expansion of human society to space make our society affluent?
  - What is social affluence? Is it measurable?
  - What have been studied on how to realize social affluence when human society expand to space? What should be studied to realize JSASS Space Vision 2050?

Theme / Study Area	Life	Health	Education	Business /Personal	Governance	Society	Environment	Risk
Cultural Anthropology						○		
Ethics	○					○		
Religion	○					○		
Philosophy			○			○		
Education						○		
Archeology						○		
Information	○						○	
Synthetic Science					○	○		○
Intl. Relations	○				○		○	○
Psychology		○	○					
Art	○			○		○		
Economy	○			○		○		
Statistics			○					
Law				○	○		○	○
Policy			○			○		○
Social Science				○	○	○		
Business	○		○					
Finance	○				○			○

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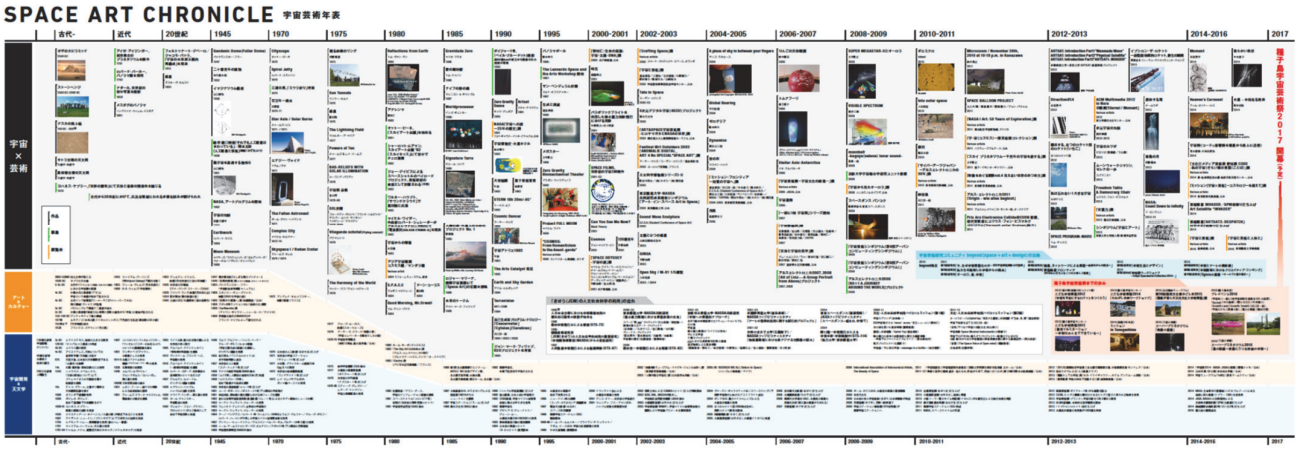
History of Space Art

http://space-art-tanegashima.jp/pdf/chronology.pdf



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