Chapter 23
Future Space Technologies for Sustainability on Earth

Stefano Ferretti, Barbara Imhof and Werner Balogh

Abstract The United Nations 2030 Agenda for Sustainable Development is based on 17 Sustainable Development Goals with 169 targets and indicators. Space science, technology and its applications can provide a wide range of solutions to help achieve the Sustainable Development Goals and thus contribute to achieving economic, social and environmental sustainable development. This paper addresses the contributions of space activities from three different perspectives: policy, strategy and technology. It focuses on a sub-set of challenges linked to the Sustainable Development Goals, namely global health, water, energy and urban development. The proposed strategy perspective considers elements, such as interdisciplinarity, spin-in and spin-off transfers, open innovation processes, and sustainability at large. Space exploration programmes are usually conceived around space mission requirements and technologies with a maturity level that allows for their implementation into planned technology roadmaps. Therefore, it is discussed how such roadmaps could better integrate policy and strategic aspects linked to sustainability on Earth. What if a system is efficiently designed to operate in space and at the same time allows for sustainable development on Earth? The further integration of key enabling technologies (big data, artificial intelligence systems, advanced robotics) are opening a new era in the exploration of other planets where autonomy is an essential requirement. At the same time such developments can become an integral part of the future developments on Earth, providing smart solutions to the citizens of tomorrow and opening up new business sectors associated to these spin-offs. For example, the development of Additive Layer Manufacturing technology will simplify the production of mechanical components and their logistic chain. However, it will also open up new ways of thinking on a large scale, for instance in the construction of buildings and structures using local materials, such as Moon regolith or Earth sand. Other examples are In

S. Ferretti (✉)
European Space Policy Institute (ESPI), Vienna, Austria
e-mail: stefano.ferretti@esa.int

B. Imhof
LIQUIFER Systems Group, Vienna, Austria
e-mail: barbara.imhof@liquifer.com

W. Balogh
World Meteorological Organization (WMO), Geneva, Switzerland

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Situ Resource Utilisation and viewing a building or a city as a spaceship system, which will not only allow space habitats to include self-regenerative functions, but also allow smart cities on Earth to become greener and more sustainable, especially in view of the expansion of population, the resulting densification and increase of urban areas. The aim of the strategy proposed in this paper is to approach sustainability for development from a holistic perspective looking not only at a product of space technology and how one could transfer this into a terrestrial application but also at strategies for achieving spin-offs in compliance with the most urging topics of this century.

23.1 Introduction

Since the beginning of the space age in the last century we have developed technologies that allow us to explore outer space, to live permanently on board of the International Space Station and to even safely land humans on the Moon.

The technological developments of humankind have been staggering, but at the same time, we are reaching the limits of many of Earth's planetary boundaries, depriving the options available to future generations and limiting their possibilities to live on our planet having the same resources available to them as their ancestors did.

Our home planet is subject to increasing pressures on environment and resources mainly due to the growth of the population, which is projected to increase from currently 7.5 billion to reach 8.5 billion by 2030, 9.7 billion by 2050 and 11.2 billion in the year 2100.[1]

To address these challenges, we cannot take a "business-as-usual" development approach, but we will require the help of new technologies in moving towards a trajectory for sustainable development. It is therefore important and timely to start changing the way we live. One possibility is to create a link between new space exploration ventures and sustainable living here on Earth.

Space is entering a new age, which in Europe is now called Space 4.0. At the same time, the world delegations at the United Nations, just approved the Agenda 2030 for sustainable development.[2]

The Agenda is a call and plan for action for people, planet, prosperity and peace to be achieved in partnership with no one left behind. Taking into account the lessons learned in the implementation of the Millennium Development Goals (MDGs) in

[1] United Nations. Department of Economic and Social Affairs, Population Division. World population prospects: 2015 revision. https://esa.un.org/unpd/wpp/. Accessed September 7, 2016.

[2] Resolution adopted by the General Assembly on 25 September 2016. Transforming our world: The 2030 Agenda for Sustainable Development. A/RES/70/1, 21 October 2015.

Fig. 23.1 SDGs and Agenda 2030

the 2000–2015 period,[3] the 2030 Agenda encompasses the three dimensions of sustainable development, namely, economic, social and environmental development.

This agenda is based on 17 Sustainable Development Goals with 169 targets and indicators (see Fig. 23.1).[4]

The 2030 Agenda is applicable to countries at all levels of development. Its successful implementation will require all stakeholders to contribute, national and international institutions and organizations as well as the individual citizens of this World. Achieving the SDGs will be essential for the future of our planet and its inhabitants.

Space science, technology and its applications can provide a wide range of solutions to help achieve these Sustainable Development Goals and will be essential for successfully implementing the 2030 Agenda. Several space-related organizations have published documents or undertaken studies that assess how space applications can contribute to achieving the SDGs. Among them are the European Space Agency (ESA),[5] the European Space Policy Institute (ESPI),[6] the Group on Earth Observations (GEO),[7] the Committee on Earth Observation Satellites

[3]United Nations. Millennium development goals. https://www.un.org/millenniumgoals/. Accessed September 7, 2016.

[4]United Nations. Sustainable development goals. https://sustainabledevelopment.un.org/sdgs. Accessed September 7, 2016.

[5]European Space Agency and the Sustainable Development Goals. http://www.esa.int/Our_Activities/Preparing_for_the_Future/Space_for_Earth/ESA_and_the_Sustainable_Development_Goals. Accessed September 7, 2016.

[6]European Space Policy Institute. (2016, June) *Space for Sustainable Development.* ESPI Report 59.

[7]Group on Earth Observations and the 2030 Sustainable Development Agenda. http://www.earthobservations.org/geo_sdgs.php. Accessed September 7, 2016.

(CEOS)[8] and DigitalGlobe, in collaboration with UNOOSA, GEO and the United Nations Committee of Experts on Global Geospatial Information Management (UN-GG IM).[9]

Information and Communications Technology (ICTs) is also making use of space technology, satellite telecommunications and space-based positioning, navigation and timing services.[10]

Space technology can support the 2030 Agenda implementation in two ways:

(a) By providing data, information and services that directly or indirectly contribute to achieving particular SDGs.
(b) By providing data and information on particular SDG indicators that allow us to assess and measure the status of the implementation progress.

It is, therefore, key that a constructive dialogue is built between space and terrestrial sustainable development actors, in order to exploit the full potential of space by providing technologies and services that address the needs in the field.[11]

The United Nations are well placed at this interface and the following paragraph will address the UN perspective.

23.2 The Larger Perspective Leading to UNISPACE+50 and the United Nations Plans for Future Space Applications

The United Nations have been involved in space activities since the beginning of the space age in the 1950s. As a result of the launch of the first Earth-orbiting artificial satellite, the Member States of the United Nations agreed to establish the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS), which remains the only Committee of the General Assembly exclusively concerned with international cooperation in the exploration and peaceful uses of outer space.

The Committee is supported by the United Nations Office for Outer Space Affairs of the Secretariat (UNOOSA), located at the United Nations Office at Vienna. Among its wide range of responsibilities, UNOOSA is implementing the United Nations Programme on Space Applications, the United Nations Platform for Space-based Information for Disaster Management and Emergency Response (UNSPIDER) and

[8]Committee on Earth Observation Satellites. http://ceos.org/ourwork/other-ceos-activities/sustainable-development-goals/. Accessed September 7, 2016.

[9]DigitalGlobe. (2016). *Transforming our world—Geospatial information key to achieving the 2030 agenda for sustainable development*.

[10]Sustainable Development Solutions Network. (2016, May) *The Earth Institute Columbia University and Ericsson. ICT & SDGs—How information and communications technology can accelerate action on the sustainable development goals.* Final Report.

[11]Ferretti, S., Feustel-Büechl, J., Gibson, R., Hulsroj, P., Papp, A., & Veit, E. (2016, June) *Space for sustainable, development*. ESPI Report 59.

acting as the Secretariat for UN-Space, the inter-agency mechanism for the coordination of space-related activities in the United Nations, and for the International Committee on Global Navigation Satellite Systems (ICG).

The mandate of the Programme on Space Applications is to assist Member States, in particular the developing countries, in using space science, technology and its applications.[12]

The Programme focusses its activities on three initiatives (Basic Space Science Initiative, Basic Space Technology Initiative, Human Space Technology Initiative) and several thematic priorities (Biodiversity and Ecosystems, Climate Change, Disaster Management, Environmental Monitoring and Natural Resource Management, Global Health).

The Programme is implemented through the organization of workshops, training courses, technical assistance missions, long-term fellowship programmes and through activities of the Regional Centres for Space Science and Technology Education, affiliated to the United Nations.

Presently the Office, in consultation with Member States and COPUOS, is considering its future strategy towards assisting Member States with implementing the 2030 Agenda for Sustainable Development. Linked to this agenda is the Sendai Framework for Disaster Risk Reduction and the Paris Climate Change Agreement.

COPUOS is addressing a wide-range of issues linked to the applications of space technology in addressing global issues, which is reflected in the items on the agenda of the annual sessions of its main committee, which include "Space and sustainable development", "Spin-off benefits of space technology: review of current status", "Space and water", "Space and climate change", and "Use of space technology in the United Nations system".[13]

In this context the Office and the Committee held in 2018 the fourth United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE), entitled UNISPACE+50, celebrating the 50th anniversary of the first UNISPACE Conference, held in 1968.[14,15,16]

UNISPACE+50 charted the future role of the Committee on the Peaceful Uses of Outer Space, its subsidiary bodies and the Office of Outer Space Affairs at a time of an evolving and increasingly complex space agenda, when a growing number

[12] United Nations. (2012, September). United Nations Programme on Space Applications. ST/SPACE/52/Rev 1, V.12-55442.

[13] Committee on the Peaceful Uses of Outer Space: 2016. http://www.unoosa.org/oosa/en/ourwork/copuos/2016/index.html. Accessed September 7, 2016.

[14] United Nations, General Assembly, Official Records Twenty-Third Session, Agenda item 24, Report of the Committee on the Peaceful Uses of Outer Space, Annex II "Documentation on the United Nations Conference on the Exploration and Peaceful Uses of Outer Space", A/7285, New York 1968.

[15] Resolution adopted by the General Assembly on 9 December 2015. (2015, December 15).*International cooperation in the peaceful uses of outer space*. A/RES/70/82, p. 14.

[16] UNSPACE+50 webpage. http://www.unoosa.org/oosa/en/ourwork/unispaceplus50/index.html. Accessed September 7, 2016.

of new actors, both governmental and nongovernmental, are getting involved with space activities.

It provides concrete deliverables of space activities for the development of nations under the four pillars space economy, space society, space accessibility and space diplomacy. It is built around seven thematic priorities:[17]

1. Global partnership in space exploration and innovation;
2. Legal regime of outer space and global space governance: current and future perspectives;
3. Enhanced information exchange on space objects and events;
4. International framework for space weather services;
5. Strengthened space cooperation for global health;
6. International cooperation towards low-emission and resilient societies; and
7. Capacity-building for the twenty-first century.

These thematic priorities are linked to the 2030 Agenda. There are various opportunities for development actors to contribute to the work of the Committee and the Office, either by participating in relevant discussions of COPUOS, its subcommittees, working and expert groups, by contributing to the activities of the United Nations Programme on Space Applications, UN-SPIDER, ICG and the open informal sessions of UN-Space and by participating in UNISPACE+50 and its High Level Fora.

23.3 Future Challenges and Space Technologies

Space activities can contribute to the Agenda 2030 from three different perspectives:

1. policy
2. strategy
3. technology.

The current major role played by space, concerns the majority of challenges linked to the Sustainable Development Goals, for example global health, water, energy and urban development.

Global health can be tackled making use of telemedicine, via satellite communications links, for primary and secondary care, tele-epidemiology tools based on Earth Observation (EO) data, spin-off technologies developed for human spaceflight missions.

But we should also keep in mind the policy tools offered by space, such as the Charter of Space and major disasters, which has been activated in case of major health crises around the world, providing support information to key stakeholders and decision makers.

[17] United Nations. Report of the Committee on the Peaceful Uses of Outer Space, Fifty-ninth session (8–17 June 2016), A/71/20, pp. 296–297.

Similarly, water management can be enhanced by the exploitation of EO data, but water can be purified by using ISS derivative technologies, as in the case of the Melissa technology transfer project in developing countries.

In the field of energy, space offers a number of effective solutions and efficient technologies, particularly for solar photovoltaic installations. But space can also offer tools to precisely estimate the solar energy potential of an area, the wind power or the assessment of geothermal reservoirs.

Infrastructure management and planning as well as smart city development can highly benefit of integrated space services, linking energy, mobility, clean air, waste management, education and e-health services in an inextricable nexus.[18]

The overall strategic perspective presented in this chapter, considers elements, such as interdisciplinarity, spin-in and spin-off transfers, open innovation processes, and sustainability at large, as key factors for success.

23.4 From Policy to Strategy: How Top Level Policy Objectives Can Become Embedded in Roadmaps and Fit into a New Model of Thinking and Doing

In order to implement the policy objectives reflected in Agenda 2030, Space Agencies are developing strategies and roadmaps, which aim to integrate space and society to the maximum extent. The European approach consist in the full deployment of Space 4.0, which is based upon:

- Seizing the potential of growth and cooperation
- the dynamics of innovation
- full integration of digital technologies
- new business models leading to smart integrated services

This innovative approach includes further development of existing partnerships with non-traditional space actors and the creation of new ones, in order to enhance the exchange between the suppliers of (space) services and the demand side (e.g. civil society, non-governmental organizations, development actors).[19]

In this context space could become an enabler of economic growth, political and strategic alliances, particularly in the domain of sustainable development and environmental protection, where Europe can play a leading role in the global context. In order to achieve this enabling function at best, Space needs to move from its comfort zone of a technology push approach, towards a new model based on a technology demand pull model, which puts the end user at the centre. In this pull-model the end user's role would entail participating in the requirements definition and conceptual design phase including the operational activities and full services

[18] Aliberti, M., Ferretti, S., Hulsroj, P., Lahcen, A. (2016, January) Europe in the Future and the Contributions of Space, ESPI, Report 55.

[19] See Footnote 11.

provision. This can be well achieved through the implementation of open innovation and open service innovation models.[20]

In order to open up space to a co-creation culture, as advocated in the open innovation models, the key is interdisciplinarity. Space has been quite interdisciplinary so far, involving all sorts of knowledge areas: from science and engineering to social sciences, from business and management to economy and finance, from history and art to law and ethics. However, since the 1980s there has been a dominance of engineers over the other disciplines so a new era of Space 4.0 in a co-creation environment would give each player and discipline a more democratic importance.

It is important that all these professional fields receive equal chances of active contribution so that the full potential of Space 4.0 can be released for the benefit of future generations. This concept can be taken further, as intended by the European Space Agency, which is developing the Space 4.0i, "Innovate! Inform! Inspire! Interact!" (see Fig. 23.2).

In this context, it is worth considering how new roadmaps could better integrate policy and strategic aspects linked to sustainability on Earth.

In the specific case of space exploration programmes, they are usually conceived around space mission requirements and technologies with a maturity level that allows for their implementation, not only in space but also on Earth.

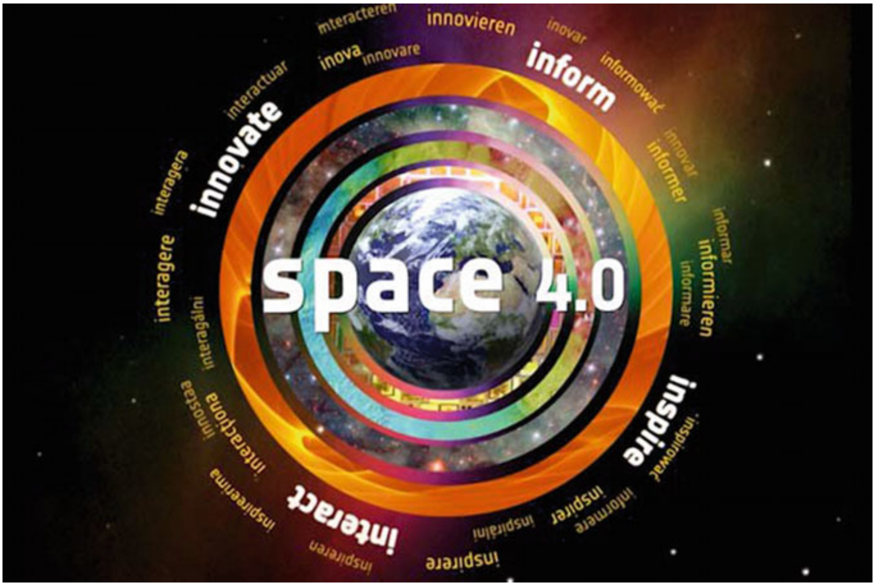

Fig. 23.2 Space 4.0, "Innovate! Inform! Inspire! Interact!". *Credits* ESA

[20]Chesbrough, H. (2003). Open Innovation: The new imperative for creating and profiting from technology. Harvard Business School Press.

MELiSSA (Micro-Ecological Life Support System Alternative) is a European Project to develop a closed life support system, aiming at producing food, water and oxygen for manned space missions. But in fact this project demonstrates that a system efficiently designed to operate in space, can in principle allow for sustainable development on Earth as well.

The further integration of key enabling technologies (big data, artificial intelligence systems, advanced robotics) are opening a new era in the exploration of other planets where autonomy is an essential requirement.

At the same time such developments can become an integral part of future developments on Earth, providing smart solutions to a future generation and opening up new business sectors associated to these spin-offs.

For example, the development of Additive Layer Manufacturing technology will simplify the production of mechanical components and their logistic chain, offering new options for space exploration missions.

In this context, the examples of companies such as “D-Shape”, “Made in Space” and “Field Ready” demonstrate that developing 3D printing solutions for space create know-how that can be transferred to the logistic and manufacturing sectors on Earth.

On a larger scale and broader horizon, it can be noted that developing concepts for 3D printing constructions blocks for the “Moon Village” out of lunar regolith, could also take us a step further in 3D printing from sand on terrestrial grounds.

An example for this is the spin-off of the company “D-Shape” who works in the field of construction of structures using local materials, such as Earth sand.

Other examples of In Situ Resource Utilisation are related to viewing a building or a city as a spaceship system. This idea is thought around five parameters or ecologies which are inherent to a spaceship and should also be defining buildings on our spaceship earth.

23.5 The Paradigm of the City as a Spaceship (CAAS) as Inspiration Towards a Sustainable Use of Space Technologies

As first change of paradigm we have to establish Buckminster Fuller‘s notion of the fact that we are in space, whether we live on earth or on ISS. We are astronauts living on spaceship earth.[21]

As a human species we have exploited our home base since the dawn of humankind and today, with a constant increase of the world’s population and the fast advancement of technology we have become extremely efficient in milking the earth’s resources in a dangerous way.

Fast climate change can be observed, a surge of disasters and destruction of natural environments and eco-systems.

[21] Buckminster Fuller, R. (1968). Operating Manual For Spaceship Earth.

Humans refer to the countermeasures as a need to protect and guard the environment. But it is not so much about the environment than our species we need to protect. The environment will survive once we are long gone, earth, too—but humans are in danger.

With this premise in mind, it seems useful to start efforts to flee our spaceship to another, maybe the moon or Mars. Will humans then and on foreign terrains be able to find a sustainable way of living there? It seems advisable to start here and now and not delay the protection of humankind to another time or another place.

However, mainly current launch technologies and their costs keeps people on earth. Reusable rockets, cheaper launches, more efficiency with propellant and optimised rocket structures to reduce the weight, will support more affordable lift-offs with greater mass.

If a space station or spaceship is conceived from these constraining parameters of a launch system then the requirements include light-weight materials, limited habitation space and closed-loop life support systems to recycle every ounce of scarce resource and sustainable energy sources. This leads to primary spaceship parameters defined in.[22] "City as a Spaceship (CAAS) inspires technological human innovation by positioning the spaceship as an analogy of the modern densely built urban space with its complex structures and technologically-intelligent infrastructure".[23]

Currently, there is only one permanently inhabited spaceship, the International Space Station. Therefore, CAAS takes the ISS as reference and with this example the authors derived five parameters which they called ecologies. In a space terminology they could be interpreted as sub-systems.

Shelter as Transformable: a space that allows for multi-functionality, which defines interior and exterior and distinguishes private from public. The ISS is in an orbit 350 km above the earth's surface, in micro-gravity with an outside temperature range of −250 to +150 Degrees Celsius. In addition it orbits our planet in a near vacuum. As in a city every m3 of space must be used in many ways, it might be transformed during missions and needs to offer a lot of storage space. The main themes whether we live in space or on terrestrial grounds are: transformability of spaces, multi-functionality of furniture and systems including mobility, important to design and planning in all scales.

Energy as Renewable: with the advancement of technology and the increase of equal distribution amongst humankind the energy demand will rise especially in urban areas. Fossil fuel resources are limited and will be dry in the near future or too expensive to harvest. Three strategies can therefore be adopted: technologies requiring less energy, being more careful in using energy, energy sources from clean and renewable sources. A spaceship energy ecology implies to use clean and renewable energy sources, as exemplified on the International Space Station where all energy is harvested from the sun.

[22] CITY AS A SPACESHIP (CAAS), Fairburn, S., Mohanty, S., Imhof, B. (2014). 65th International Astronautical Congress, Toronto, Canada. IAC-14-E4.2.8,#20927.

[23] See Footnote 22.

Fig. 23.3 ISS Canadarm2 grapples the SpaceX Dragon. *Credits* NASA

Technology, Automation, and Infrastructure: the ISS was assembled solely through support of the robotic device, namely the 'Canadarm' (see Fig. 23.3) and through automated docking processes. Further, the whole space of ISS resembles a technologized envelope in which the crew lives in. Space Station can be viewed as precursor to the development of future smart homes on our planet.

All on-board ISS life support systems are automatic. If needed astronauts can manually override the system and control it. A diagnostic tool has been installed that allows detailed on-orbit monitoring and logging of all avionics bus messages; the nerve system of the Space Station. CAAS renders the view of spaceflight parameters feeding into future smart city designs.

Construction, communication, health, traffic and infrastructure support and maintenance will be controlled by intelligent systems.

Inhabitants: the ISS crews come like citizens in conurbations from different professional and cultural backgrounds. They come from the US, Canada, Russia, European countries, and Japan and are medical doctors, engineers, and scientists. Living together, in these tight spaces in extreme environments bears its' challenges. On ISS they are mitigated through cultural training and extensive work time together preparing for the mission. Cities are faced with the challenges of integration of very different groups of population especially in times of migration and war refugees. Cultural training is nothing superfluous but essential and the costs will pay off in the future.

Life support systems: water and air, essential to life are only available in a very limited way in closed environments. These and all other resources need to be treated carefully, responsibly, and sustainably through recycling. On Space Station astronauts drink purified water recycled from their urine. When going for long duration missions on extra-terrestrial surfaces we will need a sustainable food system that securely produces nutrition for the crew. In the loop of air, water and food we also need to integrate the waste management that is up to now still "messy" and not treated as part of a closed-loop system. Intensification of harvest in limited space, reducing the amount of waste and recovering waste into useful material will become essential factors to address.

We will not be able to ship food to Mars once we have settled there. Cities on our home planet are market places, however, fresh goods are better taken from the close environment.

When cities grow into mega-structures, space will be sparse like on a spaceship so we need functioning greenhouse systems. Spaceflight could help to visualize the concept and even technologies and knowledge originally developed for the extreme requirements of space could be implemented on our home spaceship.

These parameters were established as part of the project CAAS with the intention to show the sustainability of space exploration. These five ecologies as presented above can become a conceptual role model for how humans live together, cities are built and available resources used (see Figs. 23.4 and 23.5).

They can also be set against Sustainable Development Goals (SDGs) as defined in[24] or put in reference to UN's 17 Goals for Sustainable Development.

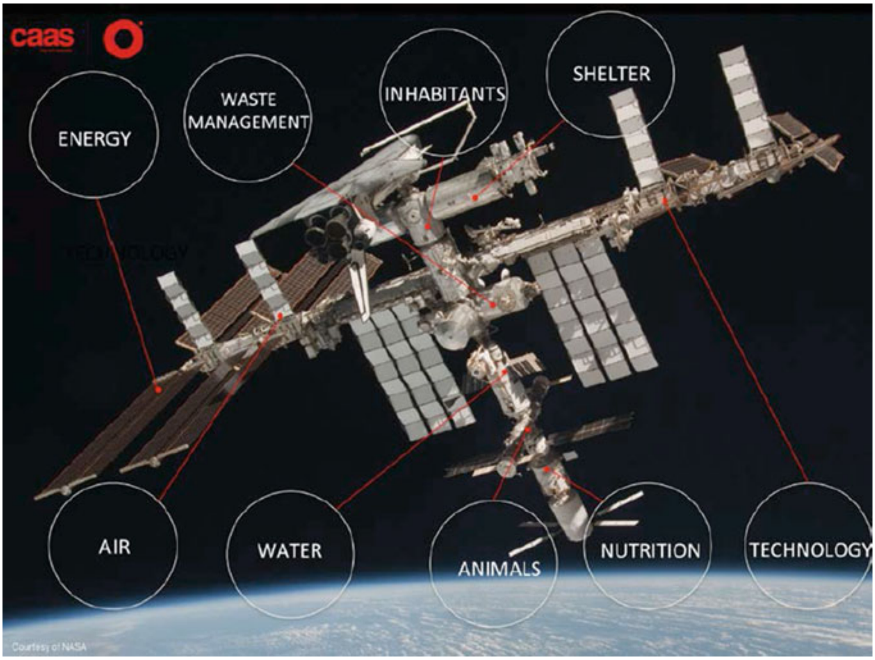

Fig. 23.4 Spaceship parameters (ecologies) displayed with the example of the International Space Station, background photo. *Credit* NASA

[24]See Footnote 11.

Fig. 23.5 Spaceship parameters (ecologies) overlaid on a future vision of a city. *Credit* Damjan Minovski/LIQUIFER Systems Group, 2013

The table below shows how the five CAAS ecologies can be related to SDGs under the condition that the SDGs are expanded in their meaning and implication, interpreted in a broader sense and are not only limited to the utilization of Earth Observation Data.

CAAS ecologies	SDG	Rationale
Shelter as transformable	SDG 11: Sustainable cities and communities	Mega-cities in Asia. South America and Africa have only limited land available, a comfortable living in small and crowed spaces through a careful planning as one would do for a spaceship levitates the stresses of dense population
Energy as renewable	SDG 7: Affordable and clean energy	The paradigm of ISS to harvest energy from a renewable source (the sun) can serve as role model for clean and affordable energy

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CAAS ecologies	SDG	Rationale
Technology. automation, and infrastructure	SDG 9: Industry, innovation and infrastructure	The fact that the whole ISS was constructed via robotic arms and automated processes can show an alternative model to building processes that after a building's life time are also easily to deconstruct in a clean manner
Inhabitants	SDG 17: Partnerships SDG 16: Peace and justice—strong institutions	The ISS is model for international cooperation and many different nations, cultures and work attitudes play together On a daily basis this can be challenge but cross-cultural training the necessity to work together make people overcome differences, learn and thrive
Life support systems	SDG 6: Clean water and sanitation SDG 2: Zero hunger	From anticipated closed-loop life supporting systems we can leam to re-use water, cleanse air. and optimise food production within the city that can help solving issues of large populated areas also where they occur

23.6 Conclusion

This chapter has shown how current and future Space technology is interconnected with Sustainable Development, and it provides examples to look forward towards a wider horizon that encompasses a holistic view, underlining the importance of interdisciplinarity in looking at the sustainable development theme and space.

The aim of the strategy proposed is to approach sustainability for development from a holistic perspective looking not only at a product of space technology and how one could transfer this into a terrestrial application but also at strategies for achieving spin-offs in compliance with the most urgent topics of this century.

Space 4.0 and the Agenda 2030 will be inextricably linked in defining our global future! New innovation models are increasingly spread across sectors and disciplines, including Space, which is becoming an integral part of many societal activities (incl. telecoms, weather, climate change and environmental monitoring, civil protection, infrastructures, transportation and navigation, healthcare and education).

It can be argued that innovation drivers are definitive enablers of new functions, and Space 4.0 may certainly be essential in the successful evolution of Europe and the full implementation of the Agenda 2030 worldwide.

It is clear that it is now the time to look at how the wider perspectives and strategies can be implemented in actionable programmes in the coming years.

The future steps will be to review the outcomes of the ESA Council at Ministerial Level and the EC Space Strategy for Europe, and construct a roadmap, involving key stakeholders and civil society, in order to map out the available options and summarize the ideal programmatic conditions for successful implementation of the Agenda 2030, presented at the UNISPACE+50 conference in 2018.

These conditions may include future innovative frameworks and collaborations around Sustainable Development, to be further explored and proposed in addition to the already existing ones (e.g. ESA-World Bank agreement; the United Nations Framework Convention on Climate Change (UNFCCC) and the IAA joint Space Agencies declaration on Climate Change; the 2016 CNES-ISRO Delhi Declaration underlining contributions by the space sector in support of the COP21 outcomes; ESA-EPB agreement).

The second recommendation is to analyse how Space Agencies could improve the dialogue with NGOs and civil society in order to make them aware of the potentialities of space, and how Space actors may listen to the field and collect its needs, in order to fully implement and exploit future space programmes.

For example, designing new Copernicus services around citizen´s needs, while targeting sustainable development, may open up opportunities for Europe to play a new role worldwide.

Considering that, in the coming years, Galileo will see its full implementation, this system may be used beyond its original intent, addressing new needs and services (e.g. new vehicles like drones and self-driving cars).

SATCOMS are also on the verge of a revolution, which will impact our societies: high flying drones will be able to provide connectivity to underserved countries, satellite operators will develop new connectivity concepts and business cases (e.g. e-health and tele-education), mobile applications and innovative services will be made available to the users at an increasing pace.

The United Nations, through its Committee on the Peaceful Uses of Outer Space, provides a framework for addressing these issues at the global level. Making full use of the opportunities provided by UNISPACE+50, the Office for Outer Space Affairs, as the Secretariat of COPUOS, stands ready to assist Member States with developing the future of space governance and with implementing the capacity building actions necessary to address the global challenges of our rapidly changing world in the XXI century.[25]

Finally, it can be argued that Space is already becoming the link among systems of systems, and its enabling function may therefore represent the new element that

[25] United Nations General Assembly Seventieth session, Transforming our world: the 2030 Agenda for Sustainable Development, UN A/RES/70/1 (2015).

will help to bring our societies towards the goal of a sustainable living on this planet for all.

The views expressed herein are those of the authors and do not necessarily reflect the views of the United Nations. This paper was presented at the 67th International Astronautical Congress, 26–30 September 2016, Guadalajara, Mexico, https://www.iafastro.org