IAC-19-E3.1.3

PRIORITY ITEMS FOR THE UNITED NATIONS SPACE2030 AGENDA FROM THE PERSPECTIVE OF THE ECONOMIC SOUTH

Author: Mr. Thien Nguyen
International Space University, Australia, thien.nguyen@community.isunet.edu

Ms. Sandra Vogt
International Space University, France, sandra.vogt@community.isunet.edu
Ms. Hamda Alhosani
International Space University, United Arab Emirates, hamda.alhosani@community.isunet.edu
Dr. Valentina Tamburello
International Space University, Switzerland, valentina.tamburello@community.isunet.edu
Mr. Ryan Benson
International Space University, United States, ryan.benson@community.isunet.edu
Mrs. Megala Senthilkumar
Indian Space Research Organization (ISRO), India, megala.senthilkumar@community.isunet.edu
Mrs. Jenny Franulovic
International Space University, Australia, jenny.franulovic@community.isunet.edu
Mr. Pierre-Alexis Lagadrilliere
DLR (German Aerospace Center), Germany, pierre.lagadrilliere@dlr.de
Ms. Joanna Ruiter
International Space University, The Netherlands, joanna.ruiter@gmail.com
Prof. Christopher Johnson
Secure World Foundation, United States, cjohnson@swfound.org
Mr. Eamon Lawson
International Space University, Australia, eamon.lawson@community.isunet.edu

Abstract

Space2030 is an agenda under the United Nations Committee on the Peaceful Uses of Outer Space, with the vision of using space as a driver for peace and the Sustainable Development Goals. The agenda aims to strengthen the contributions of space technologies by addressing global development challenges, building stronger partnerships, and bridging the space divide between developed and developing States.

This paper is an extension of the Team Project 'Space2030'; a major component of the 2019 Southern Hemisphere Space Studies Program, which was jointly coordinated by the International Space University and the University of South Australia, hosted in Adelaide, Australia.

It identifies and recommends priority items to be included in the Space2030 Agenda from the perspective of the Economic South. These are States on or south of the Tropic of Cancer, which consists of developed and developing States, emerging space powers, and States of a growing influence on the world stage.

Research and analysis of priority items fall under the established four pillars: Space Economy, Space Society, Space Accessibility, and Space Diplomacy; and a number of recommendations are presented for each pillar. These recommendations can serve as discussion points as the United Nations develop the structure for the implementation plan of the Space2030 Agenda.

Keywords: UNCOPUOS, Space2030, legislation, Sustainable Development Goals

Acronyms/Abbreviations

APG	Asia Pacific Telecommunity Conference Preparatory Group
API	Advance Publication of Information
APRSAF	Asia-Pacific Regional Space Agency Forum
APSCO	Asia Pacific Space Cooperation Organization
BIU	Bring-Into-Use
CEMA	European Agricultural Machinery Association
CETE	Clean Energy Technology Entrepreneurship
COPUOS	Committee on the Peaceful Uses of Outer Space
CR/C	Coordination Request
CRED	Centre for Research on the Epidemiology of Disasters
DLR	Deutsches Zentrum für Luft- und Raumfahrt
EARSC	European Association of Remote Sensing Companies
EM-DAT	Emergency Events Database
EO	Earth Observation
ESA	European Space Agency
EU	European Union
FSS	Fixed Satellite Services
GDP	Gross Domestic Product
GEO	Geostationary Orbit
GEO	Group on Earth Observation
GEOSS	Global Earth Observation System of Systems
GFDRR	Global Facility for Disaster Reduction and Recovery
GIS	Geographical Information System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GSO	Geostationary Orbit
IAS	Indian Administrative Service
IMT	International Mobile Telecommunications
IPCC	Intergovernmental Panel on Climate Change
ITU	International Telecommunications Union
LED	Light Emitting Diodes
MDGs	Millennium Development Goals
MIFR	Master International Frequency Register
ML	Machine Learning
MOOC	Massive Open Online Course
NASA	National Aeronautics and Space Administration
NGSO	Non-Geostationary Orbit
OCO	Orbiting Carbon Observatory
OFDA	Office of U.S. Foreign Disaster Assistance
RCMRD	Regional Centre for Mapping Resources for Development
RMB	Renminbi
SDA	Sustainable Development Agenda
SDG	Sustainable Development Goal
STEM	Science, Technology, Engineering, and Mathematics
STS	Scientific and Technical Subcommittee
SWG	Special Working Group
UAE	United Arab Emirates
UN	United Nations
UNDESA	United Nations Department of Economic and Social Affairs
UNECA	United Nations Economic Commission for Africa
UNFCCC	United Nations Framework Convention on Climate Change
UNGA	United Nations General Assembly
UNISDR	United Nations International Strategy for Disaster Reduction
UNOOSA	United Nations Office for Outer Space Affairs
US	United States
USAID	United States Agency for International Development
USGS	United States Geological Survey
VCS	Venture Catalyst Space
WRC	World Radiocommunication Conference
WRC-07	World Radiocommunication Conference 2007
WRC-15	World Radiocommunication Conference 2015

1. Introduction

In 2015, all United Nations (UN) Member States adopted the 2030 Agenda for Sustainable Development. The document outlines 17 Sustainable Development Goals (SDGs), 169 targets, and 232 indicators focusing on improving health and education, reducing inequality, and spurring economic growth worldwide (UNDESA, 2019). Space plays an important role as an enabler in achieving and monitoring the SDGs, providing valuable data, and advancing technologies for the benefit of humankind as a whole (UN General Assembly resolution 73/6; UNOOSA, 2018a).

To strengthen the contributions of space activities and tools in addressing global development challenges, building stronger partnerships, and bridging the space divide between developed and developing nations, the UN are developing a "Space2030" Agenda (UN, 2018b, pp.6–7). The agenda-setting process takes place at a time of rapid change in the space sector, with an increasing number of private actors entering the scene and major technological advances.

Space2030 presents a unique opportunity to insert ideas into the discussion about the next ten years of space collaboration and, in particular, about how to advance the Sustainable Development Goals through the use of space science and technology.

This report focuses in particular on the perspectives of the Economic South and their priorities for a vision for the next decade. It also provides practical examples which highlight how space technology and applications create environmental, economic, and social benefits for all and help to attain the goals of the international development agendas.

1.1 Objectives

The ethos of this paper is driven by the following objectives:

- Raise awareness among policymakers and society at large of the needs and ambitions of the Economic South in the context of space;
- Identify priority topics for the Economic South to be included in the Space 2030 agenda;
- Include the voice of countries in the discussion which have not, or not often, been heard;
- Highlight the link between Space 2030 and the Sustainable Development Goals and show how particular SDGs can be advanced and/or measured by space.

1.2 The Economic South

The term "Economic South" refers to States south of or on the Tropic of Cancer. It includes the States of the Global South as well as Oceania. The "Economic South" consists of a unique mix of developed and developing States, emerging space powers, and States with a growing influence on the world stage. It includes some of to the world's most densely populated, resource-rich and economically competitive States As well as some of the poorest, most polluted, and poverty-stricken States. The term "Economic South" is used rather than "Global South", since not only developing but also developed States such as Australia are considered.

1.3 The Space 2030 Agenda

During its sixty-first session in June 2018, COPUOS endorsed the draft Resolution Fiftieth anniversary of the first United Nations Conference on the Exploration and Peaceful Uses of Outer Space: space as a driver of sustainable development which invites the Committee to continue to develop a "Space2030" Agenda and implementation plan (UNOOSA, 2018e). Following this, COPUOS established a Working Group on the Space2030 Agenda which reports to the Committee and is mandated with developing the agenda. Discussions about the structure of the Space2030 document have commenced within the COPUOS Working Group. The group is currently preparing a draft structure for the agenda and will submit a consolidated draft Space2030 Agenda to UNCOPUOS at its sixty-second session in 2019. A final draft agenda will be submitted during UNCOPUOS' sixty-third session in 2020. The UN General Assembly shall consider the outcome of the work in 2020 during its seventy-fifth session (UNOOSA, 2018e).

As a proposal for a draft structure of the Space2030 Agenda is being debated at the time of writing of this report during the fifty-sixth session of the Scientific and Technical Subcommittee, and further work on the draft agenda is about to commence. the Space2030 Working Group has identified four overarching pillars under which the strategic objectives of Space2030 will be presented (UNOOSA, 2019b):

Space Economy: Enhancing space-derived economic benefits and strengthening the role of the space sector as a major driver for a sustainable economy;

Space Society: Advancing societal benefits of space-related activities and making the best use of space technologies and space-based services and applications for improving the quality of life on Earth;

Space Accessibility: Improving access to space for all and ensuring that all countries can benefit socio-economically from space science and technology applications and space-based data, information and products;

Space Diplomacy: Advancing space diplomacy by building partnerships and strengthening international cooperation in the peaceful uses of outer space.

1.4 The SDG's and the Role of Space

The 17 Sustainable Development Goals (SDG) initiated at the United Nations Conference on Sustainable Development in Rio de Janeiro in 2012 aim to overcome 21st-century challenges in areas such as the economy, the environment, and society by 2030. The SDGs build on the Millennium Development Goals (MDGs), which started as a global effort in 2000 to overcome poverty, hunger, disease, and inequality by 2015. The success of the MDGs was the driving force to establish the SDGs and to move toward sustainability to deal with the challenges that are facing our world today, and to provide a better life for future generations (UNDP, 2019).

The 2030 Agenda for Sustainable Development constructs a long-term vision for new approaches, both in governance and technological innovations. The agenda is one of the key drivers for development toward sustainability and better living conditions on Earth.

Space technologies have been viewed as integral to SDG achievement and they can be used to support most goals. Space programs, such as Earth Observation (EO) and Global Navigation Satellite Systems (GNSS), can make significant contributions in different areas, including natural disaster forecasting, air and water quality monitoring, emergency response, search and rescue operations, and more. In addition, the use of data contributes to building stronger partnerships and coordination for the peaceful uses of outer space, and helps to reduce the space divide (UNOOSA, 2018d).

Space is to be a critical tool for advancing and measuring the UN SDGs and their targets. As outlined in UN Resolution 73/6, the Space2030 Agenda aims to strengthen “the contribution of space activities and space tools to the achievement of the global agendas addressing long-term sustainable development concerns of humankind” (UNGA Resolution 73/6, 2018). Both Space2030 and the 2030 Sustainable Development Agenda 2030 (SDA) are closely linked and, for a large part, have common goals and a common reporting date in 2030.

Accountability aspects play a key role in the SDGs. Targets and indicators to measure the success of the implementation of the goals were included from the very beginning and a link to space was established in the 2030SDGAgenda itself. Article 76 of the SDA highlights the importance of Earth Observation and geospatial data as integral for achieving the SDGs (UN, 2015). Other space technologies that support the implementation and monitoring of the goals include Satellite Communication, Satellite Positioning and Navigation, Human Spaceflight and Microgravity Research, Technology Transfer, Research and Education (Wood, 2018).

2. Space Economy

Space technology and its applications are a powerful factor for economic development, and a crucial driver for the advancement of developing States in the Economic South. The space economy can make substantial contributions to the prosperity of emerging space States. In the context of the “New Space Economy” and space technology developments, new opportunities present themselves to the Economic South. As a key enabler, the space economy functions as the driver and connector of all four pillars. Finance and funding, social business, the emerging CubeSat market and the potential of clean energy are addressed in the following sections and deemed relevant for the Economic South.

2.1 Finance and Funding for Startups

Space enabled technologies have the potential to increase efficiency and promote economic growth. However, the high cost of building satellites deters the participation of private entrepreneurs (de Selding, 2015). Technology startup incubators have already attracted significant investment and growth of entrepreneurship within Southeast Asia (Nikkei Asian Review, 2018). Space startup incubators, modelled in the same manner, provide entrepreneurs in the Economic South the opportunity to develop and launch their own satellite systems. Australia, for example, created the Venture Catalyst Space (VCS) initiative, providing seed money to promote new ideas in the space sector (VCS, 2018).

These startup incubators serve as expert advisory panels to ensure that business models are viable, sustainable, and accountable, and follow good business practices. Accountability is vital in securing continued funding support as the NewSat Ltd. bankruptcy in 2015 caused significant losses to the US and France export credit agencies (de Selding, 2015). Therefore, a Special Working Group (SWG) with expertise in the space sector could be created within these space startup incubators for the purpose of assessing upcoming space ventures and ensuring accountability in funded ventures. Potential sources of development funds are export-credit agencies, angel investors, venture capital funds, and government grants (Nikkei Asian Review, 2018; de Selding, 2015).

Successful space startups emerging from incubators and funding initiatives can positively impact SDG 2 (Zero Hunger), measurable by increased food production as a result of precision agriculture. Innovative and disruptive business ideas, nurtured by these initiatives, benefit SDG 9 (industry, innovation and infrastructure),measurable through an increase in medium and high technology industry value. States in the Economic South, as individuals or collaboratively, could create startup incubators that help potential space entrepreneurs secure expert advice and funding.

2.2 Social Business for the Benefit of the Economic South

The relative lack of space activities in the Economic South compared to the Economic North limits the development of industries evolving from space technology, and consequently meaningful employment. However, an increase in space research and education in the Economic South could lead to the creation of more highly skilled jobs. This, combined with capacity building, is particularly important for developing States and satisfies Sustainable Development Goal 8 (Good Jobs and Economic Growth).

Looking towards the future, the 'social business' model may be implemented in the space industry to stimulate social changes as envisioned in the SDGs. Social businesses can be characterized as "businesses which contribute to solving social problems in a financially sustainable way" (Yunus, 2010). Social businesses have the potential to be used to finance space companies, especially if the need to foster space startups is seen as a pressing, urgent need (Yunus, 2010).

A key principle of social businesses is that they must be financially sustainable; not requiring continuous funding in the form of charity, increasing the likelihood of eventual economic growth. The principles of social business could be used to establish manufacturing infrastructure in developing States from the Economic South. This will transfer into economic growth through technology by 2030.

2.3 The Emerging CubeSat market

Advances in microelectronics, microelectromechanical systems, materials, and production techniques have stimulated investment into small and micro-satellites (Wekerle et al., 2017), and commercial launch markets (Xue, 2018). There are numerous proposals for large constellations of small satellites and, if they mature, this development would radically change both the Communications and Earth Observation (EO) space sectors (Figure 3) (Sweeting, 2018). Currently, the majority of States in the Economic South has an insufficiently developed or utilized small and micro-satellite market. Most of the small satellites in orbit are developed and launched by States in the Economic North (Figure 4) (Sweeting, 2018). One important use case for the introduction of micro and small satellites in the market of the Economic South is their capability of enabling ubiquitous telecommunications coverage to unserviced remote areas. EO satellites support precision agriculture, management of natural resources, and disaster monitoring which are of great importance to States in the Economic South due to their geographical location and levels of development.

Interest is growing in satellites weighing less than 2,500 kg and a mission life of five to seven years. These satellites require substantially lower capital investment than other types of satellites. They could be operated in clusters allowing greater agility, quicker replacement of damaged/decommissioned satellites, and lower individual launch costs (Sweeting, 2018). The reduced cost of entry increases the feasibility of financial support from public funds or development bank initiatives.

At this point in time, many developing States in the Economic South have limited space capabilities. The lower cost of CubeSats compared to regular satellites could improve the likelihood of public funding and development bank initiatives, opening up a market for these States. States of the Economic South could pursue these initiatives, which could be vital for economic growth.

States in the Economic South could facilitate the emerging market involving small and microsatellites by forming an intergovernmental or non-government advisory committee working collaboratively with the UN to establish financial mechanisms to support commercial and non-commercial space activities.

2.4 Clean Energy Through Remote Sensing

The demand for energy in developing States is increasing. An increasing trend indicates that energy consumption has surpassed the supply output of many developing States within the Economic South (Catherine Wolfram et al., 2012). In order to achieve sustainable economic development, States must initiate research into clean energy. Primarily, clean energy includes solar energy, wind energy, hydropower, tidal energy, and geothermal energy (McKenna, 2018).

Different clean energy sources have different characteristics. Clean energy technology entrepreneurship (CETE) is incorporated into all elements of the supply chain to reduce emissions (Malen and Marcus, 2016). EO supporting energy decision-making mainly includes: prospecting sites for energy plants and facilities, optimizing the design of plants and facilities, extending/harmonizing in-situ datasets, as well as creating energy yield forecasts based on near real time data and modelling (Zoltan Bartalis, 2013).

Clean energy construction supported by space observations can advance SDG 13 (Climate action) and SDG 7 (Affordable and Clean Energy) by helping to provide more sustainable forms of energy and reducing energy construction cycle lengths and costs. The construction of space observing systems and clean energy stations can create new industries for developing

States, which in turn will drive economic development. Clean energy will gradually replace traditional energy sources. Some types of clean energy can be supplied continuously (for example solar energy).

The detection cycle of space observation clean energy is shorter than traditional energy sources. Satellite observations provide a low risk solution as direct observation is different from and less costly than traditional energy indirect detection. Space observations for prospecting of clean energy sites require less personnel and equipment, so testing costs are lower. (Zoltan Bartalis, 2013)

Space observations of clean energy are a great help for developing States and should be addressed in the discussion about the Space2030 agenda and a vision for the future. States of the Economic South could promote international cooperation and data sharing, and establish a space clean energy observation organization. States with clean energy construction needs can join the organization. Support should be provided to each State participating to establish the required observing systems, especially in States facing challenges in accessing clean energy. Space agencies from States with advanced technologies as well as NGOs and private entities could be encouraged to join the organization to provide data and assistance.

3. Space Society

Space society is about using space applications and technologies to benefit society. Applications and space technologies can improve environmental management and quality of life, encourage international cooperation, and enable change in the structures of society. We have identified the following priorities under the "space society" pillar for the Economic South: Earth Observation for Disaster Management, Global Navigation Satellite Systems (GNSS) for precision agriculture, and Climate Change Carbon Emission Monitoring.

3.1 Disaster Management through Earth Observation

Natural disasters have an impact that can be measured in terms of human lives lost and a negative impact on the economy. In the report Economic Losses, Poverty & Disasters: 1998– 2017, the United Nations Office for Disaster Risk Reduction (UNISDR) and the Centre for Research on the Epidemiology of Disasters (CRED) found that in the last 20 years more than 1.35 million people died and more than four billion either lost their homes, were injured, or found themselves in an emergency situation due to natural disasters. Resulting economic losses have risen by 151 percent in the last two decades compared to the previous 20 years (1978–1997). Despite geophysical events such as earthquakes and tsunamis being responsible for the majority of fatalities, they only account for nine percent of all disasters. The remaining 91 percent have been caused by floods, storms, droughts, heatwaves, and other extreme weather events (see Figure 5). According to the Emergency Events Database (EM-DAT), the majority of States most affected by natural disasters are in the Economic South (including, for example, India, China, Indonesia, and the Philippines). Disaster management is an essential tool to prevent, or at least to reduce, mortalities, mitigate environmental impact, and reduce economic losses.

The disaster management cycle consists of four phases: mitigation, preparedness, response, and recovery (Wisner and Adams, 2002). The United Nations International Strategy for Disaster Reduction (UNISDR) "ensures the coordination and synergies among disaster risk reduction activities of the United Nations system and regional organizations and activities in socio-economic and humanitarian fields" (UN General Assembly resolution 56/195). In March 2015, the Third UN World Conference on Disaster Risk Reduction adopted the Sendai Framework for Disaster Risk Reduction 2015–2030, which is supported, monitored, and reviewed by UNISDR. The Sendai Framework explicitly promotes the use of Earth Observation (EO), which has proven to be an effective tool in all phases of the disaster management cycle. It provides the necessary data on hazard exposure, vulnerability, and risk and it is indispensable in supporting decision-making in emergency situations (see Guo, 2010). Data is provided for emergency response at local, regional, and international levels. EO can provide synoptic (large area) coverage, as well as diverse spectral, spatial, temporal, and potentially three-dimensional information

(Kerle, 2013) fundamental for disaster management. "Reducing disaster risk is a crosscutting issue for all the Sustainable Development Goals (SDGs), especially SDG 1, on the eradication of poverty in all its forms, everywhere" (UNISDR and CRED, 2018). Moreover, effective disaster management through the use of EO improves the safety and wellbeing of citizens in line with SDG 3 (Good Health and Wellbeing)

Since many UN Member States do not have a space program, it is essential to provide access to space-based technologies for disaster risk reduction. This task is fulfilled by UN-SPIDER, the United Nations Platform for Space-based Information for Disaster Management and Emergency Response Activities. The system could be strengthened by increasing training for civil protection agencies and the number of Regional Support Offices in risk areas.

Timely, accurate, and reliable data must be freely accessible at all times to monitor high-risk areas and to forecast natural disasters in a similar manner to the ESA Copernicus program. Satellite temporal resolution of high-risk areas can be improved, through the development of more multi-satellite constellations. Satellite images can be classified and analyzed by Machine Learning (ML) algorithms and used to predict natural disasters, as shown by Lary et al. (2018). Other case studies have been reported by the Global Facility for Disaster Reduction and Recovery (GFDRR) (GFDRR, 2018), demonstrating the value of ML in management and analysis of EO data. Finally, to improve disaster recovery activities and coordination efforts, public participation through citizen science can be used to increase temporal and spatial coverage. Local volunteers can collect data with mobile devices on-site, which can be combined with satellite images to improve information to aid disaster recovery activities and coordination efforts (case studies reported by Kotovirta et al., 2015).

It is recommended to increase numbers of multi-satellite constellations to improve temporal resolution of high-risk areas. Global collaboration among EO stakeholders (public and private) should be encouraged, following the example of the European Association of Remote Sensing Companies (EARSC). The vast quantity of satellite data could be managed by ML techniques, which have proved to be powerful in analyzing images of any resolution. In the future it is recommended that optimized ML algorithms are installed directly on satellite computers (on-board processing) to reduce image analysis time. This will allow satellites to send immediate emergency notifications to the ground, as soon as significant changes on the surface of the land or sea are detected.

3.2 Earth Observation with the Global Navigation Satellite Systems for Zero Hunger

SDG 2 set by UN aims to end hunger and all forms of malnutrition. The prevalence of world hunger has marginally declined from15 percent in 2002, to 11 percent in 2016. More than 790 million people worldwide still lack regular access to food that meets dietary requirements (UNOOSA, 2018). At this pace, the target of “zero hunger” set by the UN as its foremost Sustainable Development Goal will unlikely be met by 2030.However, the use of EO and GNSS in precision farming is a beacon of hope for achieving this seemingly unreachable target.

Precision agriculture is a modern agriculture practice involving the use of technology in agriculture like remote sensing, Global Positioning System (GPS) and Geographical Information System (GIS) for improving productivity and profitability. It uses precise agricultural inputs with respect to soil, weather, and crops in order to improve productivity, quality, and profitability in agriculture. It increases tillage and harvest efficiency in addition to the targeted application of pesticides and fertilizer. More effective inputs will lead to increase crop yield while reducing pollutant runoff and will lead to increased agricultural and development sustainability. GNSS helps in optimization of inter row spacing and improved fertilizer application. GNSS is mainly known for navigational aid but can also be used for measuring soil moisture using L-band microwave radiometry (Rodriguez-Alvarez, 2009). By precisely measuring soil moisture through GNSS, farmers can use their water resources more effectively; especially in dry periods. EO satellites in association with GNSS can provide early warning of drought and forecast crop yield and quality, assisting governments in food planning. Adoption of precision agriculture in developing States like India is not an easy task. High capital costs may discourage farmers from adopting this method of farming. The small landholdings for most Indian farmers limits economic gains from currently available precision farming technology (IAS Express, 2018). Governments should focus on creating space-based infrastructure for collecting data to develop tools for visualising and analysing with special emphasis on addressing national, regional and local needs. Governments could offer free or subsidised access to GNSS and EO for agriculture purpose and also assure availability of low-cost equipment. By doing so, farmers could increase yields by 10 percent or more, as well as reduce wastage of fertilisers, fuels, and pesticides by 15–20 percent (UNOOSA, 2018).

3.3 Carbon Emissions Monitoring for Climate Change

Climate change is to be understood as global citizens to better address desertification, land degradation, sustainable land management, and food security. Developed States have contributed more than 70 percent of the world’s carbon dioxide (CO2) emissions over the last half of the twentieth century, while developing States have contributed only two percent of the world overall CO2 emissions (IPCC, 2014). In 2017, the Intergovernmental Panel on Climate Change (IPCC) identified that CO2 levels have increased, since preindustrial times by 40 percent (IPCC, 2017).

Target 13.2 of SDG 13 (Climate Change) requires integrating climate change mitigation mechanisms into policy considerations. The Paris Agreement, signed by all parties to United Nations Framework Convention on Climate Change (UNFCCC) in 2015, recognizes and advances this goal and other related SDGs. The Paris Agreement, aims at combating climate change by investments needed for a sustainable low carbon future. The agreement requires States to develop long-term low greenhouse gas emission strategies (UNSDGs, 2018, p. 1–2). The indicators of target 13.2 have a direct and indirect impact on SDGs 2 (Zero Hunger), 3 (Good Health and Wellbeing) and 6 (Clean Water).

UNFCC focuses on the least developed and African States. UNFCC and the Green Climate Fund have both contributed to USD 10.3 billion (UN SDG, 2018, p. 2).

Under Articles 4 and 5 of the UNFCC, Parties to the Convention have agreed to promote and cooperate in global satellite observation for climate change monitoring and mitigation (WMO, 2015, p. 24). The Paris Agreement recognized that human health and the health of the planet are linked. In 2017, the Rockefeller Foundation and UNFCC secretariat launched a three-year project to address this issue (UNFCC, 2019). At present, there are 58 global applications on planetary health (UNFCC, 2019).

States should recognize that climate change is a global issue, which requires collective action through international cooperation and the utilization of space technologies. Climate change policy makers must acknowledge equity, justice, and fairness while addressing ethical considerations (IPCC, 2014). The 2030 Agenda emphasized the need for high quality, timely, and accessible data to meet the SDGs at all levels, by using multiple types of new data sources of data (Marc Paganini and Ivan Petiteville, 2018, p 9). For example, the second Orbiting Carbon Observatory (OCO-2) Spacecraft was designed to provide better precision, resolution, and coverage to measure regional carbon sources and sinks. The OCO-2's enhanced instruments provide scientists with new information about CO2 emissions. The data will enable decision makers to better manage our planet's natural resources in order design and implement strategies to minimize humanity's carbon emissions

Data received from these satellites must be shared with all relevant non-government and government organizations at all levels. The data retrieved will provide scientists with unprecedented new information about CO2 emissions on regional scales (Karen Yuen et al. p.5).

Kenya has the Regional Centre for Mapping Resources for Development (RCMRD) which works with the United Nations Economic Commission for Africa (UNECA) and the Africa Union. The RCMRD has more than 20 contracting states in eastern and southern Africa regions for all are members of the Pacific Group of States. At present, the RCMRD through SERVIR Global has "a partnership between the United States Agency for International Development (USAID) and National Aeronautics and Space Administration (NASA) using Earth Observation" data to better understand climate change (SERVIR GLOBAL, 2018). To meet SDGs 2, 3, 6 and 13, developing States require new technology frameworks and enhanced capacity building toward regional and national priorities. Data must be shared between all states to better understand and respond to climate change

In order to ensure that carbon emissions information is accurate, a UN body of Earth Observations must be formed to specifically monitor carbon emissions and the impacts on all regions of the Earth. The aim is to serve larger communities of end-users to emphasize knowledge sharing for the benefit of humanity (UN, 2004, p. 47).

4. Space Accessibility

Access to space for the Economic South will be greatly assisted through cooperation and coordination with the Economic North. States in the Economic South are in need of education and professional training, access to space data and assets, ground station infrastructure, and links to space networks in the North. We have identified five areas as priorities for the Space2030 agenda, to ensure greater access to space for the Economic South in the next decade.

Access to space does not only include access to the space environment, but also access to data, technology, and financing which allow States to take part in and benefit from the space economy. For the developing States of the Economic South, access to data, knowledge and technology is a more pressing issue than launch capabilities and flight opportunities. However, States with an existing technological know-how which are keen to develop their space capabilities also need to be considered in the discussion about space access.

4.1 Knowledge Sharing and Skills Training

Quality education is a Sustainable Development Goal (SDG 4), and one of its targets is to "substantially increase the supply of qualified teachers, including through international cooperation for teacher training in developing countries, especially least developed countries and small island developing States" (United Nations, 2018). This target can be facilitated through the use of satellite technology; distance and open learning can bring education to rural and geographically remote communities, as well as provide pedagogical training for in-service or pre-service teachers in developing States. Cooperation on issues of remote access for education should be increased on global and regional levels. Space literacy gained through such measures may allow future generations of developing States to improve their nation's economic situation and participation in the space sector. Adopting new tools and technologies, such as Massive Open Online Courses (MOOCs), is one way to increase the reach and impact of education and training.

International cooperation can allow teachers from developed States to participate in teacher training in developing States. It is recommended to develop a framework and policy whereby government, industry, and private funding sources from participating States can work cooperatively to allow teachers from developed States to participate in teacher training in developing States. It is recommended to increase such efforts.

4.2 Technology Transfer Between States

Developed States with advanced technology and economies can support their own space programs. States without access to space, data, and advanced technologies are often left behind when it comes to participation in the international market (Tyler, 2018).

The Asia Pacific Space Cooperation (APSCO) is a successful example of technical cooperation for promoting space technology in the Economic South (APSCO, 2019). APSCO member states include Pakistan, Bangladesh, Iran, Mongolia, Peru, Thailand, Sri Lanka, Turkey and China (APSCO, 2008). These members share space technology. Currently, the group has set up a ground-to-air observation network, an earthquake monitoring network, a data sharing network, an education and training network, and a disaster monitoring network.

The Asia-Pacific Regional Space Agency Forum (APRSAF) similarly works to achieve UN SDGs with the emphasis of sharing information. APRSAF was formed in 1993 with government and international organizations, private companies, universities, and research institutes from more than 40 States and regions (APRSAF, 2019).

Technology transfer can promote and achieve SDG9 (Industry, Innovation, and Infrastructure) by promoting inclusive and sustainable industrialization to drive the development of space capabilities in the Economic South. Global partnerships can improve technology transfer between governments. It is recommended that the UN facilitate a technology transfer cooperation mechanism based on the principle of equality and mutual benefit, for developed States to work collaboratively with States in the Economic South to promote the development and application of space technologies.

4.3 Data Sharing

Data that is archived for the purpose of disaster warning and relief is often shared openly and freely. However, for purposes such as Earth Observation (EO) and natural resource management, enterprise data policies become far stricter and commercialized. This is particularly disadvantageous for developing States, and those in the Economic South that cannot afford the cost of entry into these markets. Data available for use in decision making has either low resolution or is extremely expensive. Regions like Africa, Latin America, the Caribbean and the Middle East have less satellite coverage compared to other regions, (UNCOPUOS A/AC.105/1196, 2018). Developing States that wish to utilize space data often cannot use it because the information is not disseminated in a user-friendly manner. Ultimately, those States without an active space program lack services provided by space data and lack the infrastructure or finance to support their populations through space technologies. This deficiency has begun to form a divide between the Economic North and South. It is recommended that the United Nations may encourage a discussion on the opening of data sharing between States to make space data affordable or free. The promotion of an open and free data policy is a priority item for the Space2030 agenda to bridge this global economic divide and foster international cooperation.

4.4 Ground Segments for the Economic South

Due to the increase of satellites launched every year, particularly nanosatellites in Low Earth Orbit (LEO), the need for communication links with those satellites increases. Considering the advantages that space accessibility could provide to the Economic South, improving the ground segment appears necessary and could also provide opportunities to sell ground services to advanced or other emerging space States in need of them.

Around half of the States in the Economic South are tropical and close to the equator, while the other half are mostly arid or semi arid. The closer they are to the equator, the easier it is to launch rockets. Besides, the absorption of RF signals increases with humidity and optical signals are blocked by clouds. Thus, dry regions are perfect for satellite communication. Due to their geographical location, States in the Economic South thus provide conditions which are of great interest to players in the space sector. Combining those natural advantages through regional cooperation and partnerships could allow States in the Economic South to pool their resources and to become a powerful player in the space sector, potentially even a key actor in the development of new communication systems like optical link communication. For this to happen, States with a geographically opportune position could pair up with more advanced space States who have the technological capacity to develop the technologies needed.

4.5 Access to Space Assets

As of January 2019, there are 1,957 satellites orbiting Earth (Union of Concerned Scientist, 2019). Thirty-one States in the Economic South own assets in space, but only China, India and Iran have launch capabilities. China and India are examples of States that are developing their space capabilities at a rapid speed, largely due to sustained investment in the aerospace sector by their respective governments. However, other States in the Economic South face large economic and technological hurdles for placing assets into space. Currently there are insufficient policies, pathways, and processes for engaging States of the Economic South in international cooperation projects. Involving these

States in global projects over the next ten years will be useful for developing their assets and capabilities.

Development in aerospace technology and organisational models has opened up new possibilities for States to participate in space projects, such as QB50. QB50 is an international network of CubeSats used for multi-point, in-situ measurements in the lower thermosphere, and re-entry research (QB50, 2018a). Currently, 36 cubesats from all over the world are involved in the project, and seven of the CubeSats are manufactured in the Economic South, including Australia, South Africa, Israel and China. (QB50, 2018b).

Other models of cooperation that could be implemented are hosted payloads on other satellites and shared launch vehicles. The application of such models needs encouragement of the standardization of spacecraft and launch vehicle interfaces by COPUOS. This model of cooperation satisfies SDG 9 (Infrastructure, industrialization), measurable by the growth in the technology sector as well as SDG 17 (Partnerships for the Goals), recognizable from improved trade relations and cooperation.

5. Space Diplomacy

Due to shortages in technical expertise and financial capabilities, space diplomacy is an important focus for States in the Economic South seeking to develop their emerging space sectors through increased international coordination and cooperation. Under this pillar we explore the need for equitable access to orbit spectrum resources for the Economic South and the revitalization of orbital debris mitigation policies.

5.1 Equitable Access to Orbit Spectrum

The space industry benefits the Economic South by providing telecommunications connectivity and broadcasting to remote areas not reached by terrestrial infrastructure, developing a knowledge-based economy as well as providing employment opportunities for highly skilled professionals. This section examines satellite network filing activities and considers how States of the Economic South access orbit spectrum resources.

The space industry is undergoing a transformation in which the status of geostationary orbit (GSO) satellites as primary satellite communications service providers is being challenged by Large Non-Geostationary orbit (NGSO) constellations such as One Web, SpaceX, and LEO Sat (Alleven, 2017). The International Telecommunications Union (ITU) is the regulatory body responsible for all radiofrequency spectrum allocation and maintains the Master International Frequency Register (MIFR), which contains a database of radiofrequency spectrum usage. The satellite filings submitted to the ITU by Member States fall under two categories: prioritization by order of application time, or a planned equitable access approach, which applies only for GSO satellite networks (Vallet, 2018).

Figure 13 shows Non-Geostationary Satellite Orbit (NGSO) network filings to the ITU have been steadily increasing since 2014. By 2017, the percentage of Advance Publications of Information (API) and Coordination Requests (CR/C) for NGSO satellite networks grew to 17.8 percent of the total GSO and NGSO publications of the two types, illustrating the shift in focus from GSO to NGSO satellite networks. (Note that only CR/C publication has been taken into consideration for GSO satellite networks, because API is no longer in use since 1 January 2017 as an outcome of WRC-15) (ITU BR, 2018).

Based on the 2017 ITU Radiocommunication Bureau annual report to the Scientific and Technical Subcommittee (STS) of the Committee for the Peaceful Uses of Outer Space (COPUOS), there are a total of 4182 satellite network filings valid to date from 94 State administrations, of which 45 are members of the Economic South (ITU BR, 2018). The Economic South is responsible for 30.3 percent of the total satellite filings still valid as of 31 December 2017. However, satellite filings by China, India, and the United Arab Emirates account for almost half of the Economic South's share. It can be argued that, although the satellite network filing data shows that access to outer space is not an immediate priority for the governments of the Economic South, safe guards must be put in place to ensure these

States' equitable access to outer space for the future. This is especially true for the NGSO segment, which currently has no equitable access measures in place compared to the GSO segment. Equitable access measures safeguard the Economic South's access to outer space and reduce the risk of inequalities in knowledge, economy, and connectivity that result as a result of disadvantaged access to space. Thus, SDG 10 (Reduced Inequalities) SDG 9 (Industrial, Innovation, and, Infrastructure), and SDG 8 (Decent Work and Economic Growth) can be addressed with equitable access to space. States of the Economic South require international cooperation to develop in space and should collaborate to champion their rights to access orbit spectrum resources with a common voice, since each State has a vote without discrimination at the World Radiocommunication Conference (WRC) (Maniewicz, 2016).

A successful example of this was during WRC-07 and WRC-15, in which Pacific Islands cooperated to successfully safeguard their satellite telecommunications interest and vote against mobile allocations in the C-band used by satellites (PTC, 2018). Furthermore, States in the Economic South should closely monitor Agenda Item7 Issue A ofWRC-19 to ensure the bringing-into-use (BIU) procedures for NGSO satellite networks do not allow spectrum “grabbing”, which entails launching part of a constellation of satellites to claim that the entire system has been brought-into-use, thus blocking access to others. The BIU regulations are used to ensure that satellite operators can only protect the frequency bands they are capable of operating in orbit to promote efficient use of the spectrum. However, current regulations allow NGSO satellite networks to claim completion of BIU with the launch of one single satellite within the constellation (Laurenson, 2018) and refinement of the regulations is being discussed in WRC-19.

5.2 Promoting Active Space Debris Removal

Currently, the level of orbital space debris has the potential to jeopardize missions and space assets where even tiny collisions can cause catastrophic damage. In time, this series of collisions could cause a cascading effect wherein outer space becomes difficult to utilize (Space Debris Mitigation Guidelines, 2010). Future access to orbital zones is of particular importance to States in the Economic South who are developing emerging space sectors and will require a healthy space climate over the long term.

Dialogue continues on the international stage in furtherance of firmer debris mitigation policies aimed at slowing down the creation of new orbital debris; however, a truly sustainable outer space climate will require action beyond mitigation and the commencement of active debris removal (European Space Agency, 2018). Beyond the financial and technological hurdles this challenge presents, is the even more difficult legal and political problem of State ownership. Consequently, the promotion of international engagement and discussion toward active debris remediation is a key priority of the Space2030 Agenda. This engagement should be focused on the creation of a recognized system for the abandonment of untraceable minor space debris and the streamlining of a process for acquiring launching State consent to remove larger defunct objects. Solving space debris does not directly connect to the UN Sustainable Development Goals; however, monitoring and verification of all space-related goals, present and future, are contingent on a healthy orbital environment.

While the current treaty regime remains mostly silent on the matter of space debris, the indirect operation of its provision creates a scheme wherein State ownership creates a roadblock to debris clean-up efforts. Article VIII of the Outer Space Treaty provides that each State retains ownership and control over objects launched into space that are added to its registry (See also Registration Convention, 1975). A "space object", as defined under both Article I(d) of the Liability Convention and Article I(c) of the Registration Convention, extends to any "component parts of a space object as well as its launch vehicle and parts thereof." No investigation is made as to the working functionality of the material; thus, no distinction is drawn between an “intact satellite or an errant paint chip” (Muñoz-Patchen, 2018). Article IX of the Outer Space Treaty operates to prevent a State’s “harmful interference” with the property of another state without consent. Ultimately, a scheme exists where a launching State retains enduring ownership, even over tiny fragments of materials that may no longer be traceable. Gaining consent to remove debris therefore proves an issue where efficient removal of larger objects calls for disclosure of classified satellites build-specifications, and the owner of smaller debris is unable to be readily ascertained. Ultimately, there is little incentive for States to consent to disposal, nor for other parties to develop technology to remove space debris, where there is an ever-present risk of creating international tension.

A revitalization of the current system is clearly necessary and would see the ownership of space debris treated differently than the ownership of space assets. Commentators have identified several rationales for establishing this distinction and noted the role that the doctrine of abandonment may play in setting the stage for a new international scheme (Muñoz-Patchen, 2018). If designed as abandoned property, space debris would no longer be subject to property rights of the launching State. It is likely that an international agreement would be required to provide sufficient certainty to States engaging in clean up efforts that no claims of ownership would be raised against them. This scheme would require the creation of a measure by which small debris could automatically be categorized as abandoned and stripped of State ownership. It will be necessary to retain a system of consent for larger objects; however, further developing the currently ad hoc sanctioning system is important to facilitate a wider removal effort. One means of achieving this goal may be through increasing the functions of the Register of Objects Launched into Outer Space (The “Space2030” Agenda and the Global Governance of Outer Space Activities, 2017). A more comprehensive register of abandoned objects would not only assist clean-up efforts, but also work to increase transparency and improve the efficiency of the registration mechanism. One incentive for a collective agreement may stem from the State-based liability caused by orbital debris. Article VII of the Outer Space Treaty, in coupling with the Liability Convention, establishes a system by which one State is liable for damage caused by its space debris to another State’s space assets. Liability is tied to a launching State’s enduring ownership, meaning that alongside the accumulation of debris in orbit, is the accumulation of potential State liability for damages. An agreed international system that recognized abandonment, would allow States to distance themselves from their space debris, opening up opportunity for interested parties to begin disposal.

Allowing States to relinquish their property rights of debris also allows for the effective abandonment of responsibility, but without responsibility there exists a greater need to incentivize parties to undertake the expensive act of debris removal. Currently, there exists no direct enforceable instrument by which to compel States to clean-up orbital debris, and it is unrealistic to expect that States will provide support for a new treaty that would see them obliged to engage in costly space clean-up (Kurt, 2015). One avenue commentators have explored is investigating how existing treaties may be used to tackle this issue (Muñoz- Patchen, 2018).

Article IX of the Outer Space Treaty requires that States "shall conduct all their activities in outer space…with due regard for the corresponding interests of all other State Parties"—a sentiment reflected across the space treaty series. The creation of debris that diminishes free access to space could readily be said to violate this fundamental principle. Evidence of diminished access is already noticeable: delayed launches, risk posed to the International Space Station, and over-crowding of the geostationary orbit (Kurt, 2015). In short, the very act of a State creating debris limits and another State's right to free use of space and may violate the current treaty regime (Muñoz-Patchen, 2018). How this fundamental principle of free access may be adapted on an international level to compel national action is a question worth investigating.

The recommendation made is that a priority item for the Space2030 Agenda should be the enhanced safety, security, and sustainability of outer space activities. Debris management is not only a long-term sustainability issue but impacts present day activities; requiring increased protection of space assets, space systems, and critical infrastructures (The "Space2030" Agenda and the Global Governance of Outer Space Activities, 2017). The creation of a system for the permissible removal of space debris will foster increased international accountability and ensure that States can continue to utilize space for economical and societal growth into the future.

6. Recommendations

From these discussions held under each of the four pillars of space activities, the authors have generated key recommendations to be considered by the United Nations.

6.1 Recommendations for Space Economy

Space technology and its applications are powerful tools for economic development and crucial drivers for the advancement of developing States in the Economic South. The space economy can make a substantial contribution to the prosperity of emerging space States. As a key enabler it functions as the driver and connector of all four Space2030 pillars. Issues which are considered to be of particular importance to States in the Economic South, which should be discussed in the context of the Space2030 agenda, are funding, social business, as well as developments in the CubeSat and renewable energy sectors.

Recommendation 1: encourage the creation of startup incubators in the Economic South, potentially as joined partnerships between States or Regions, that help future outer space entrepreneurs to secure expert advice and funding;

Recommendation 2: use the principles of social business to establish manufacturing infrastructure in developing States in the Economic South to achieve economic growth through technology by 2030;

Recommendation 3: encourage the formation of a small/micro-satellite market in States of the Economic South by forming an intergovernmental or non-government advisory committee working collaboratively with the UN to establish financial mechanisms to support commercial and non-commercial space activities;

Recommendation 4: promote international cooperation and data sharing by establishing an outer space renewable energy observation organization and supporting each State to establish the required observing systems, especially in States which are facing challenges in accessing renewable energy.

6.2 Recommendations for Space Society

Space activities are not only about looking away from our planet, but also about looking towards our planet and seeing it in a new light—whether that be from an electromagnetic or philosophical perspective. Space applications and technologies can improve environmental management and quality of life. This is especially true for States in the Economic South, which can benefit from space applications that assist in disaster management, precision farming, and monitoring carbon emissions and the effects of climate change. Space can also have positive social benefits, such as fostering international cooperation, inspiring the public, and enabling positive change in the structures of society.

Recommendation 5: mitigate climate change through enhanced international cooperation in the area of carbon emission monitoring;

Recommendation 6: use machine learning to analyze satellite images and provide early warning systems for natural disasters;

Recommendation 7: develop a mechanism for global collaboration among EO stakeholders, both public and private;

Recommendation 8: initiate programs that promote STEM education for girls during childhood in developing States.

6.3 Recommendations for Space Accessibility

Access to space does not only include access to the space environment, but also access to data, technology, and financing which allows States to take part in and benefit from the space economy.

Access to space for the Economic South will be greatly assisted by cooperation and coordination with the Economic North. States in the Economic South are in need of education and professional training, access to space data and assets, ground station infrastructure, and links to space networks in the North. Priority areas for the Economic South which have been identified include knowledge sharing and skills training, technology transfer, data access, development of ground station capabilities, and access to space assets.

Recommendation 9: extend capacity-building efforts for the Economic South in the area of space education;

Recommendation 10: increase global cooperation on the issue of satellite access for remote education and teacher training;

Recommendation 11: maximise opportunities for technology transfer between the Economic North and South;

Recommendation 12: encourage a discussion at UN level on data sharing between States and on how to make space data more readily available and free;

Recommendation 13: ensure States in the Economic South receive training in data analysis so they can utilize EO data;

Recommendation 14: establish more ground stations in the Economic South and create cooperative networks with satellite operators in the Economic North;

Recommendation 15: build a path toward payload carrying, launch vehicle sharing, idle time reuse, and joint programs, so States in the Economic South can more readily access space assets.

6.4 Recommendations for Space Diplomacy

The cooperation of States and the establishment of partnerships relies on diplomacy. Space diplomacy is an important focus for States in the Economic South seeking to develop their emerging space sectors through increased international coordination and cooperation. Under this pillar, the issue of increased equitable access to orbit spectrum resources, the pursuit of free and open data policies for Earth Observation, and the revitalization of orbital debris management policies were identified as key areas.

Recommendation 16: ensure equitable access to orbit spectrum resources;

Recommendation 17: ensure a sustainable outer space climate for developing States through the creation of an international system for the organised removal of space debris.

7. Conclusions

The Space2030 Agenda and implementation plan will outline, under the pillars of space economy, space society, space accessibility, and space diplomacy, proposals for a common vision on space activities for the future. In the debate surrounding the agenda, it is of utmost importance to ensure that all voices are heard and that the views of all States with an interest in space activities are taken into account.

In this report, the authors have identified priority areas for discussion from the perspective of the Economic South, which they hope will contribute to the discourse about the Space2030 agenda and the way in which space activities can contribute to the global goals for sustainable development. Topics of particular concern are the creation of space-derived economic and societal benefits as well as access to space assets and data, especially for States in the Economic South. Increased international cooperation and new partnerships are imperative for progress in all four pillars of the Space2030 Agenda.

Acknowledgements

This project was firstly completed at the 2019 Southern Hemisphere Space Studies Program, a program jointly organised by the University of South Australia and The International Space University.

Research undertaken for this report has been assisted with a grant from the Sir Ross and Sir Keith Smith Fund (Smith Fund) (www.smithfund.org.au). The support is acknowledged and greatly appreciated.

The Smith Fund by providing funding for this project does not verify the accuracy of any findings or any representations contained in it. Any reliance on the findings in any written report or information provided to you should be based solely on your own assessment and conclusions.

The Smith Fund does not accept any responsibility or liability from any person, company or entity that may have relied on any written report or representations contained in this report if that person, company or entity suffers any loss (financial or otherwise) as a result.

References

Alleven, M., 2017. From Boeing to SpaceX: 11 companies looking to shake up the satellite space. [online] Available at: <https://www.fiercewireless.com/wireless/from-boeing-to-spacex-11-companies-looking-to-shake-up-satellite-space> [Accessed 6 February 2019].

Asia-Pacific Space Cooperation Organization, 2008. APSCO Held Reception in UN. [online], Available at <https://web.archive.org/web/20100620201421/http://www.apsco.int/>, [Access 6 February 2019].

Bartalis, Z., 2013. Earth Observation and Renewable Energy. [online] Available at: <https://www.esmap.org/sites/esmap.org/files/03-KEF2013-REM_Bartalis_ESA.pdf> [Accessed 7 February 2019].

Bean, Q. 2018. NASA - 3D Printing in Zero-G Technology Demonstration. [online] Available at: <https://www.nasa.gov/mission_pages/station/research/experiments/1115.html> [Accessed 6 February 2019].

Bryce Space and Technology, 2018. State of the Satellite Industry report 2018. [online] Available at: <https://brycetech.com/download.php?f=downloads/SIA_SSIR_2018.pdf> [Accessed 6 February 2019].

CEOS, ESA , 2015. Satellite Earth Observations in support of disaster risk reduction. [pdf], Available at: <www.eohandbook.com/eohb2015/files/CEOS_EOHB_2015_WCDRR.pdf> [Accessed 5 February 2019].

Committee on the Peaceful Uses of Outer Space (COPUOS), 2017. The “Space2030” Agenda and the Global Governance of Outer Space Activities. United Nations General Assembly. Available at: <http://www.unoosa.org/res/oosadoc/data/documents/2018/aac_105/aac_1051166_0_html/AC105_1166AEVE.pdfl> [Accessed 8 February 2019].

Committee on the Peaceful Uses of Outer Space, 2010. Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space. [online] United Nations Office for Outer Space Affairs. Available at: <http://www.unoosa.org/pdf/publications/st_space_49E.pdf> [Accessed 05 February 2019].

Convention on International Liability for Damage Caused by Space Objects, 961 UNTS 187, opened for signature 29 November 1971, entered into force 1 September 1972.

Convention on Registration of Objects Launched into Outer Space, 1023 UNTS 15, opened for signature 14 January 1975, entered into force 15 September 1976.

de Selding, P., 2015. NewSat Bankruptcy is Costly for U.S. Ex-Im Bank. [online] (updated 2 June 2015) Available at: <https://spacenews.com/newsat-bankruptcy-is-costly-for-u-s-ex-im-bank/> Accessed [10 February 2019]

Dunn, J., et al 2010. 3D Printing in Space: Enabling New Markets and Accelerating the Growth of Orbital Infrastructure. Space Manufacturing. [pdf] 14, pp.1–14. Available at: <http://ssi.org/2010/SM14-proceedings/3D-Printing-in-Space-Enabling-New-Markets-Made-In-Space-Inc.pdf> [Accessed 6 February 2019].

Earth Observations, 2017. Member Map for the year 2017. [image online] Available at: <https://www.earthobservations.org/members.php> [Accessed 6 February 2019].

EO for Society, 2018. Towards a European AI4EO R&I Agenda. [tech.] Towards a European AI4EO R&I Agenda. European Space Agency. Available at: <https://eo4society.esa.int/wp-content/uploads/2018/09/ai4eo_v1.0.pdf> [Accessed 11 Feb. 2019].

ESA, 2018. Mitigating Space Debris Generation. [online] Available at: <http://www.esa.int/Our_Activities/Operations/Space_Debris/Mitigating_space_debris_generation> [Accessed 10 February 2019].

European Commission, 2018. Socio-economic impacts from Space activities in the EU from 2015 and beyond. [online] Available at: <https://publications.europa.eu/en/publication-detail/-/publication/1cb4a8e4-0d4b-11e8-966a-01aa75ed71a1/language-en/format-PDF> [Accessed 2 February 2019].

Federal Ministry for Economic Cooperation and Development, 2018. Education in developing countries. [online] Available at: <https://www.bmz.de/en/issues/Education/hintergrund/bildungsituation/index.html> [Accessed 9 February 2019].

Galactic Energy, 2018. Analysis of the Path of Commercial Launch Vehicle Technology. [online] Available at: <http://www.sohu.com/a/284131166_100300954> [Accessed 6 February 2019].

GEO, 2016. Earth Observation for Disaster Risk Management, GEO 2017-2019 Work Program. Available at: <https://www.earthobservations.org/activity.php?id=87#> [Accessed 5 February 2019].

GEO, 2017. Earth Observations in Support of the 2030 Agenda for Sustainable Development. [pdf] Available at: <https://www.earthobservations.org/documents/publications/201703_geo_eo_for_2030_agenda.pdf> [Access 07 February 2019].

Gibbs, G., Pryke, I., 1998. International Space Cooperation Applied to New Space Markets. Space Studies New Space Markets, pp.95–106.

Grandview Research, 2017. Report GVR-1-68038-876-3. [image online] Available at: <https://www.grandviewresearch.com/industry-analysis/satellite-payloads-market> [Accessed 06 February 2019].

Group on Earth Observations, 2008. The Global Earth Observation System of Systems [image online] Available at: <http://www.eohandbook.com/eohb2008/GEOSS.html> [Accessed 06 February 2019].

Group on Earth Observations, 2016. Maximize the value of Earth Observation Data in a Big Data World. [image online] Available at: <https://www.slideshare.net/BYTE_EU/maximize-the-value-of-earth-observation -data-in-a-big-data-world> [Accessed 07 February 2019].

Guo, H., 2010, Understanding global natural disasters and the role of earth observation. International Journal of Digital Earth, 3(3), pp.221-30.

Harris and Baumann, 2015. Open Data Policies and Satellite Earth Observation. Space Policy, 32, pp.44-53.

Harrison, B., et al., 2018. Earth observation. 1st ed. Melbourne: Australia and New Zealand CRC for Spatial Information, pp.63-94.

Henri, Y., 2016. WRC-15 Outcome. [pdf] Available at: <https://www.itu.int/en/ITU-D/Regional-Presence/AsiaPacific/Documents/Events/2016/Sep-ISS2016/Presentation/Yvon%20Henri%20Session%201.pdf> [Accessed 7 February 2019].

IAS Express, 2018. Precision Farming in India - Features, Merits, Demerits and Challenges. Available at: <https://iasexpress.net/precision-farming-in-india-features-merits-demerits-and-challenges> [Accessed 7 February 2019].

Intergovernmental Panel on Climate Change, 2013. Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. [online] Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. Available at: <https://www.ipcc.ch/report/ar5/wg1/> [Accessed 6 February 2019].

International Astronautical Federation (IAF). 2016. IAF '3G' International Platform For Diversity And Equality In Astronautics (Idea) – 3G Geography – Generation – Gender. Available at: http://www.iafastro.org/activities/iaf-3g-international-platform-for-diversity-and-equality-in-astronautics-idea [Accessed 31 December 2018].

International Telecommunications Union Radiocommunication Bureau (ITU BR), 2018. 2017 Annual Space Report to the STS-18 on the use of the geostationary-satellite orbit (GSO) and other orbits. [pdf] Available at: <https://www.itu.int/en/ITU-R/space/snl/SNLReport/SNS-ref-list-2017_e.pdf> [Accessed 5 February 2019].

International Telecommunications Union, 2016. Radio Regulations Volume 1. [online] Geneva: ITU. Available at: <http://search.itu.int/history/HistoryDigitalCollectionDocLibrary/1.43.48.en.101.pdf>

IPCC, 2014. Summary for Policymakers In: Climate Change 2014: Mitigation of Climate Change, Contribution of Working Group III to the Fifth Assessment Report of Intergovernmental Panel on Climate Change. [pdf] Available at <https://www.ipcc.ch/site/assets/uploads/2018/07/sr2_background_report_final.pdf>. [Accessed 6 February 2019].

IPCC, 2017. Special Report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gases fluxes in terrestrial ecosystems. [pdf] In SR2 Scoping Meeting. Available at <https://www.ipcc.ch/site/assets/uploads/2018/07/sr2_background_report_final.pdf>. [Accessed 6 February 2019].

ITU, 2014. Collection of the basic texts of the International Telecommunication Union adopted by the Plenipotentiary Conference. [pdf] Available at: <http://handle.itu.int/11.1004/020.1000/5.21.61.en.100> [Accessed 3 February 2019].

Kerle N., 2013. Remote Sensing of Natural Hazards and Disasters. Encyclopedia of Natural Hazards [online] Available at <https://www.researchgate.net/publication/236888964_Remote_Sensing_of_Natural_Hazards_and_Disasters> [Accessed 07 February 2019].

Kisione W. Finau, n.d., The Satellite Communications Perspective in Pacific Island Countries. [pdf] Nadi, Fiji. Available at: <https://www.unescap.org/sites/default/files/The%20Satellite%20Communications%20Perspective%20in%20Pacific%20Island%20Countries%2C%20USP_0.pdf> [Accessed 7 February 2019].

Kotovirta, V. et al., 2015, Citizen Science For Earth Observation: Applications In Environmental Monitoring And Disaster Response, Volume XL-7/W3, [online] Available at <https://www.researchgate.net/publication/277306754_Citizen_Science_For_Earth_Observation_Applications_In_Environmental_Monitoring_And_Disaster_Response> [Accessed 06 February 2019].

Kulu, E., 2019. Nanosatellite & CubeSat Database. [online] Available at: <https://www.nanosats.eu> [Accessed 6 Feb. 2019].

Kurahara, N., 2018. Satellite Fleet Operations Using a Global Ground Station Network. [online] Available at: <https://www.spacefoundation.org/sites/default/files/tech-track-papers/Kurahara-Naomi_Satellite%20Fleet%20Operations%20Using%20a%20Global%20Ground%20Station%20Network.pdf> [Accessed 07 February 2019].

Kurt, J., 2015. Triumph of the Space Commons: Addressing the Impending Space Debris Crisis Without an International Treaty. William & Mary Environmental Law and Policy Review, 40(1) p.305, 307.

Lary, D et al., 2018, Machine Learning Applications for Earth Observation, Earth Observations Open Science and Innovation. [online] Available at: <https://link.springer.com/chapter/10.1007/978-3-319-65633-5_8> [Accessed 06 February 2019].

Laurenson, X., 2018. Bringing into use and suspension. [online] Available at: <https://www.itu.int/en/ITU-R/space/WRS18space/WRS18-BringingIntoUse-07122018.pdf> [Accessed 6 February 2019].

Lockney, D., 2008. NASA Technologies Benefit Our Lives. [online] Available at: <https://spinoff.nasa.gov/Spinoff2008/tech_benefits.html> [Accessed 10 February 2019].

Lockridge, R., 2012. Me trying to fix everyone’s poor referencing skills. [online] Available at: <https://knowyourmeme.com/memes/best-cry-ever> [Accessed 11 February 2019].

Lucas, R. and Milne, T., 2018. Remote Sensing of Wetland Types: Semiarid Wetlands of Southern Hemisphere. The Wetland Book. [online] pp.1665-1671. Available at: <https://link.springer.com/referenceworkentry/10.1007%2F978-90-481-9659-3_308> [Accessed 6 February 2019].

Lyall, F. and Larsen P.B., 2009. Space Law A Treatise. UK and USA: Ashgate Publishing Limited.

Maniewicz, M., 2016. ITU and ITU-R Basics and Facts. [pdf] Geneva: International Telecommunications Union. Available at: <https://www.itu.int/dms_pub/itu-r/md/15/wrs16/sp/R15-WRS16-SP-0001!!PDF-E.pdf> [Accessed 6 February 2019].

Muñoz-Patchen, C., 2018. Regulating the Space Commons: Treating Space Debris as Abandoned Property in Violation of the Outer Space Treaty. 19(1) p.245, 247–52, 250, 255, 247.

Nanosats, 2019. Database of nanosatellites. [image online] Available at <https://www.nanosats.eu/> [Accessed 7 February 2019].

NASA, 2017. Women in Space. Available at: https://history.nasa.gov/women.html [Accessed 7 February 2019].

NASA, 2018. NASA Earth Science Division Operating Missions. [image online] Available at: <https://eospso.nasa.gov/> [Accessed 07 February 2019].

NASA. 2019. Workforce Information Cubes for NASA. Available at: https://wicn.nssc.nasa.gov/wicn_cubes.html [Accessed 7 February 2019].

Nikkei Asian Review, 2018. Southeast Asian tech hubs race to become the next Silicon Valley [online] Available at: <https://asia.nikkei.com/Spotlight/Cover-Story/Southeast-Asian-tech-hubs-race-to-become-the-next-Silicon-Valley> Accessed [10 February 2019].

OCDE, n.d. The OECD Environmental Outlook to 2030. [pdf] Available at: <http://www.oecd.org/centrodemexico/medios/42172885.pdf>[Access 07 February 2019].

Oliver, C., and Oliver, F. 2018. Climates. In Global Resources and the Environment. [online] Cambridge University Press, Available at: <https://static.cambridge.org/resource/id/urn:cambridge.org:id:binary:20180704072116139-0826:9781316779484:17293fig7_1.png?pub-status=live> [Accessed 07 February 2019].

Pacific Telecommunications Council (PTC), 2018. Pacific Islands Road Map Towards WRC-19. [pdf] Honolulu: Pacific Telecommunications Council ’18. Available at : <http://www.ctu.int/wp-content/uploads/2018/Events/January/WorkshopAndMeetingOfTheSMTF/Presentations/PITA-WRC-19-Road-Map.pdf> [Accessed 7 February 2019].

Paganini, M.and Petiteville, I., 2019. Satellite Earth Observations in support of the sustainable development goals. [pdf] Available at ,< https://eospso.gsfc.nasa.gov/sites/default/files/publications/OCO-2MissionBrochure_final_508_0.pdf> [Accessed 6 February 2019].

Pandey, G., 2016. The women scientists who took India into space. [online] BBC News. Available at: <https://www.bbc.com/news/world-asia-india-38253471> [Accessed 7 February 2019].

Planet Labs Inc., 2018. Home. [online] Planet. Available at: <https://www.planet.com/> [Accessed 11 Feb. 2019].

Popular Science China - Science Principles China, 2017. Profile: Peru's engineer-turned-president Martin Vizcarra - Xinhua [online] Available at: <http://www.xinhuanet.com/science/2017-09/14/c_136609544.htm> [Accessed 7 Feb. 2019].

QB50, 2018. CubeSats Participating in the QB50 Project. [online] Available at: <https://www.qb50.eu/index.php/community.html> [Accessed 10 February 2019].

QB50, 2018. QB50 Mission Objectives. [online] Available at: <https://www.qb50.eu/index.php/project-description-obj/mission-objectives.html> [Accessed 10 February 2019].

Rodriguez-Alvarez, N. et. al. 2009. Soil Moisture Retrieval Using GNSS-R Techniques: Experimental Results Over a Bare Soil Field. IEEE Transactions on Geoscience and Remote Sensing, Vol. 47, No. 11.

Rubel, F. and Kottek, M., 2010. Observed and projected climate shifts 1901-2100 depicted by world maps of the Köppen-Geiger climate classification. Meteorologische Zeitschrift, [online] 19(2), pp.135-141. Available at: http://koeppen-geiger.vu-wien.ac.at/shifts.htm [Accessed 6 Feb. 2019].

Ryan, B., 2017. Big Data Challenges in Building a Global Earth Observation System of Systems. [online] Available at: <https://www.slideshare.net/BigData_Europe/sc7-workshop-3-big-data-challenges-in-building-a-global-earth-observation-system-of-systems-geoss> [Accessed 06 February 2019].

SERVIVR GLOBAL, 2018. About SERVIR. [online] <https://www.servirglobal.net/> [Accessed 11 February 2019].

Space Generation Advisory Council, 2018. Space Generation Advisory Council. [online] Available at: <https://spacegeneration.org> [Accessed 8 February 2019].

Strahilevitz, L.J., 2010. The Right to Abandon. University of Pennsylvania Law Review, 158(355) pp.363.

Sweeting, M., 2018. Modern Small Satellites-Changing the Economics of Space. Proceedings of the IEEE, [online] 106(3), pp.343-361. Available at: https://ieeexplore.ieee.org/document/8303876/figures#figures [Accessed 6 February 2019].

Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, 610 UNTS 205, opened for signature 27 January 1967, entered into force 10 October 1967.

Trimble Agriculture, 2018, What is Precision Agriculture, Available at <https://agriculture.trimble.com/blog/what-is-precision-ag/> [10 February 2019]

Tuttle, B., 2018. Here's How Much It Costs for Elon Musk to Launch a SpaceX Rocket. [online] MONEY.com. Available at: <http://money.com/money/5135565/elon-musk-falcon-heavy-rocket-launch-cost/> [Accessed 7 February 2019].

UN Women, 2017. SDG 5: Achieve gender equality and empower all women and girls. [online] Available at: http://www.unwomen.org/en/news/in-focus/women-and-the-sdgs/sdg-5-gender-equality [Accessed 7 February 2019].

UN, 1999. The Space Millennium: Vienna Declaration on Space and Human Development. The Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE III). [pdf] Available at: http://www.unoosa.org/pdf/reports/unispace/viennadeclE.pdf [Accessed 27 November 2018].

UN, 2015. Transforming our world: the 2030 Agenda for Sustainable Development. [online] Available at: <undocs.org/A/RES/70/1> [Accessed 7 February 2019].

UN, 2015. About the Sustainable Development Goals. [online] Available at: <https://www.un.org/sustainabledevelopment/sustainable-development-goals/> [Accessed 06 February 2019].

UN, 2018. Sustainable Development Goals [online] Available at <https://www.un.org/sustainabledevelopment/> [Access 5 February 2019].

UN, 2018, European Global Navigation Satellite Systems and Copernicus: Supporting the Development Goals, building blocks towards the 2030 Agenda [pdf]. Available at: <www.unoosa.org/res/oosadoc/data/documents/2018/stspace/stspace71_0_html/st_space_71E.pdf> [Accessed 5 February 2019].

UN, 2018. The "Space2030" agenda and the global governance of outer space activities. [online] Available at: <http://www.unoosa.org/oosa/oosadoc/data/documents/2018/aac.105/aac.1051166_0.html> [Accessed 6 February 2019].

UN, 2018. Thematic priority 7: Capacity-building for the twenty-first century. [online] Available at: <http://www.unoosa.org/oosa/oosadoc/data/documents/2018/aac.105/aac.1051174_0.html> [Accessed 8 February 2019].

UN, 2019. Annual Report Momentum for Change 2017. [online] Available at: <https://unfccc.int/resource/mfc2017/> [Accessed 11 February 2019].

UN, 2019. Benefits of Space: Education. [online] Available at: <http://www.unoosa.org/oosa/en/benefits-of-space/education.html> [Accessed 5 February 2019].

UN, 2019. Planetary Health. Available at: <https://unfccc.int/climate-action/momentum-for-change/planetary-health> [Accessed 11 February 2019].

Union Concerned Scientist, 2019. Who has satellites? [image online] Available at: <https://www.ucsusa.org/nuclear-weapons/space-

weapons/satellite-database> [Accessed 06 February 2019].

UniSA, 2018. Venture Catalyst Space. [online] Available at: <http://icc.unisa.edu.au/venturecatalystspace/> Accessed [10 February 2019]

UNISDR, et al., 2018. Economic losses, poverty & disasters: 1998-2017. [pdf] Available at: <www.unisdr.org/we/inform/publications/61119> [Accessed 5 February 2019].

UNOOSA, 2010. Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space. [online] United Nations Office for Outer Space Affairs. Available at: <http://www.unoosa.org/pdf/publications/st_space_49E.pdf> [Accessed 6 February 2019].

UNOOSA, 2018. Compendium: Space Debris Mitigation Standards Adopted by States and International Organizations. [online] United Nations Office for Outer Space Affairs. Available at: <http://www.unoosa.org/documents/pdf/spacelaw/sd/Space_Debris_Compendium_COPUOS_28_Dec_2018.pdf> [Accessed 05 February 2019].

UNOOSA, 2018. Proposal by the Bureau of the Working Group on the “Space2030” Agenda on a draft structure of a “Space2030” agenda [pdf] Available at: <http://www.unoosa.org/res/oosadoc/data/documents/2019/aac_105c_1l/aac_105c_1l_372_0_html/V1808639.pdf> [Accessed 8 February 2019]

UNOOSA, 2018. Report on the United Nations/Germany High-level Forum: The way forward after UNISPACE+50 and on “Space2030”. Available at: http://www.unoosa.org/oosa/oosadoc/data/documents/2019/aac.105/aac.1051204_0.html [Accessed 7 February 2019].

UNOOSA, 2018. United Nations/Austria Symposium on Space for the Sustainable Development Goals. [online] Available at: <http://www.unoosa.org/oosa/en/ourwork/psa/schedule/2018/SDGs-un-austria-Symposium.html> [Accessed 5 February 2019].

UNOOSA, 2018. Working Groups of the Committee and its Subcommittees. [online] Available at: <http://www.unoosa.org/oosa/en/ourwork/copuos/working-groups.html> [Accessed 6 February 2019].

UNOOSA, 2018c. Briefing for Permanent Missions at the United Nations Office in Vienna. [online] Available at: <http://www.unoosa.org/oosa/en/aboutus/director/director-statements/2018/director-speech-2018-permanent-missions-briefing.html> [Accessed 10 February].

UNOOSA, 2019a. Fifty years since the first United Nations Conference on the Exploration and Peaceful Uses of Outer Space (1968 - 2018): UNISPACE+50. [online] Available at: <http://www.unoosa.org/oosa/en/ourwork/unispaceplus50/index.html> [Accessed 5 February 2019].

UN-SPIDER, 2018. UN-SPIDER facilitates use of space-based information for disaster risk reduction. [online] Available at: <https://reliefweb.int/report/world/un-spider-facilitates-use-space-based-information-disaster-risk-reduction>, [Accessed 5 February 2019].

Vallet, A., 2018. Orbit-Spectrum International Regulatory Framework, [online] Available at: <https://www.itu.int/dms_pub/itu-r/md/15/wrs18/sp/R15-WRS18-SP-0016!!PDF-E.pdf> [Accessed 6 February 2019].

Wall, M., 2011. The Fallen Heroes of Human Spaceflight, [online] Space.com. Available at: <https://www.space.com/11353-human-spaceflight-deaths-50-years-space-missions.html> [Accessed 6 Feb. 2019].

Wanzala, J., 2018. Science Vital to Achieving Global Development GoalsSpace. [online] Available at: <https://www.indepthnews.net/index.php/sustainability/poverty/2093-space-science-vital-to-achieving-global-development-goals> [Accessed 8th February 2019].

Way, T., 2018, The Space Gap, Access to Technology, and the Perpetuation of Poverty. [online] Available at <https://scholarworks.bgsu.edu/irj/vol5/iss1/7> [Access 5 February 2019].

Wekerle, T., et al., 2017. Status and Trends of Smallsats and their Launch Vehicles — An Up-to-date Review. [pdf] Available at: <http://www.scielo.br/pdf/jatm/v9n3/2175-9146-jatm-09-03-0269.pdf> [Accessed 6 Feb. 2019].

Wisner, B. and Adams, J., 2002. Environmental health in emergencies and disasters: A practical guide. [online] Available at: <https://www.who.int/water_sanitation_health/hygiene/emergencies/em2002intro.pdf?ua=1> [Accessed 5 February 2019].

Wolfram, C., Shelef, O., Gertler, P., 2012. How Will Energy Demand Develop in the Developing World. [online] Available at: <https://pubs.aeaweb.org/doi/pdf/10.1257/jep.26.1.119> [Accessed 7 February 2019].

Wood, D., 2018. Space Technology Contributes to the Sustainable Development Goals. [online] Available at: <https://unctad.org/meetings/en/Presentation/enc162018p02_Wood_en.pdf> [Accessed 5 February 2019].

World Economic Forum, 2019. Mapping Global Transformations. [online] Available at: <https://toplink.weforum.org/knowledge/insight/a1Gb0000000pTDUEA2/explore/dimension/a1Gb00000

02KWrHEAW/summary> [Accessed 6 February 2019].

World Food Programme, 2017. Introduction to Hunger Map. [online] Available at: <https://www.wfp.org/content/2017-hunger-map?_ga=2.252341130.2007546102.1549580521-1271314476.1549580521> [Accessed 08 February 2019].

World Mapping LLC, 2018. Pricing Information for High Resolution Satellite Imagery. [online] Available at: <http://www.landinfo.com/satellite-imagery-pricing.html> [Accessed 06 February 2019].

World Meteorological Organization, 2015. Status of the Global Observing System for Climate. [online] Available at: <https://library.wmo.int/pmb_ged/gcos_195_en.pdf > [Accessed 7 February].

Xinhua, 2017. More than 2,000 aerospace technologies have been converted to civilian use in China. Available at: <http://taikongmedia.com/Item/Show.asp?m=1&d=24124> [Accessed 6 February 2019].

Xue, X. (2018). No BAT in space. [online] Available at: <http://www.vccoo.com/v/4xc7x4> [Accessed 6 Feb. 2019].

Yokope, P., 2014. The Criticality of C-band for Satellite Communications. [doc] Brisbane: Asia Pacific Telecommunity Conference Preparatory Group. Available at: <https://www.apt.int/sites/default/files/2014/05/APG15-3-INP-1_The_Criticality_Of_C-Band.docx> [Accessed 7 February 2019].

Yuen, K. et al, 2014. Orbiting Carbon Observatory-2 (OCO-2). [online] Available at < https://eospso.gsfc.nasa.gov/sites/default/files/publications/OCO-2MissionBrochure_final_508_0.pdf> [Accessed 6 February 2019].

Zubrin, R., 2012. How Much Is an Astronaut's Life Worth?. [online] Available at: <https://reason.com/archives/2012/01/26/how-much-is-an-astronauts-life-worth> [Accessed 6 February 2019]. Reference to a website:

[5] E. Mack, Could Virgin Galactic's Spaceport America be put up for sale? 23 February 2015, http://www.gizmag.com/spaceport-america-hits-nags/36200/, (accessed 30.04.16).