Potential space activities share in achieving global sustainability

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Abstract. The desire of humanity to grow its quality of life was in the past guaranted by the steady technological progress. More recent developments have however pointed out that beside wanted effects of technological progress, negative impacts can also appear. As a possible solution for the recognised complex global problems the concept of Sustainable Development has been defined in 1987 in the Brundtland Report. Taking into account the mobility field, the current vision is to shape *sustainable mobility*. In this regard evaluating technologies is becoming very necessary and for this goal Technology Assessment can be applied. By making assessments of different technologies an answer is actually searched to the question of how do technologies integrate into environment and society? In this regard specific evaluation criteria are considered in sustainability decision-making processes also concerning Space Activities. Applying Space Activities for getting Sustainable Development means among other things setting up Emergency Programs in order to support disaster response operations through the provision of satellite data. In this context the United Nations Platform for Space-based Information for Disaster Management and Emergency Response (UN-SPIDER) is to be mentioned, being implemented in order to support disaster management activities. The vision is to implement this program in the future on a global level, supporting in this way the usage of Space Activities for achieving global sustainability, where systemic thinking is per se required.
Key Words: Space Activities, Global Sustainability, UN-Spider, Emergency Programs, Systemic thinking.

Introduction. With the goal of increasing the quality of life of the population different human activities are currently worldwide carried out as for instance industrial, agricultural, transport, commercial, as well as touristic ones. In the field of human mobility different transport activities have to be mentioned. In this regard *space activities* are playing a special role for supporting different human activities. This is possible by providing safe communications and data exchange, navigation and positioning information, images from space used for different purposes, meteorological information et al. Space activities have to be mentioned also in the context of supporting the development of new technologies, of researching our planet and the outer space (Jischa 2005).

In the context of space activities it is to be clearly stated that correspondingly to some physical explanations the ending of the atmosphere and the beginning of space is unofficially considered at 80-100 km above the ground (Wikipedia). One of these physical explanations is that the air pressure is too low for a lifting body to generate meaningful lift force without exceeding orbital velocity, which is the orbital speed of a body in the gravitational field (Soler 2014). It is to be mentioned that space activities are actually representing a result of human efforts made in science, engineering, business, and even politics, in order to succeed flying outside the Earth atmosphere and using the outer space for a plenty of human related aims.

This short presentation have actually made clear that *space activities* are various, being currently used for several scientific, commercial, industrial and governmental applications (Fortescue et al 2003). Different national aerospace organizations are researching, designing, manufacturing, operating, or maintaining ground and space infrastructure, which is implicitly necessary to put into execution the above mentioned activities. It is to be stated that several countries have space organizations and programs funded by the governments in order to support such aerospace activities. In this context Roscosmos can be mentioned as a state corporation for space activities in Russia, the National Aeronautics and Space Administration in the United States, the European Space Agency in Europe, the Canadian Space Agency in Canada, the Japanese Aeronautics Exploration Agency in Japan, the China National Space Administration in China and many others (Prunariu 2017). In this regard in Romania the Romanian Space Agency, ROSA, can be mentioned (http://www.rosa.ro).

It is known that there are diverse goals for which space technologies can be used, one of these goals being materialized in disaster management and emergency response (Fortescue et al 2003; Bumgarner 2008). On the other side it is to be remarked that global vulnerability to natural disasters has the tendency to increase because the impact of climate change and land degradation processes continues to gain on a global level (Prunariu 2017). Several natural hazards as earthquakes, floods, storms, and others cause serious problems to societies and overload national economic systems. Anyway the losses of life and property could be but avoided if a more efficient risk information system, an improved risk assessment, a more efficient early warning system as well as a better disaster monitoring system would be available (Prunariu 2017). In recognition of these needs UN has already acknowledged that the use of existing space technology, such as earth observation and meteorological satellites, communication and navigation satellites can play an important role in supporting disaster management by providing accurate and timely information for decision making (Bumgarner 2008; Prunariu 2017). It has to be emphasized that space-based information is relevant in all phases of the disaster management cycle from disaster risk reduction to disaster response and recovery. In this regard in 2015 a new global framework for disaster risk reduction for the period 2015 – 2030 has been agreed (SDKP). The final document is referring to the importance of space-based and geospatial information and is emphasizing the importance of developing, periodically updating and disseminating location-based information about disaster risks. This information is including risk maps, which can be used by the decision makers, by the general public and by communities at risk to disaster in an appropriate format by using, if necessary, geospatial information technology for assuring the community sustainability (Prunariu 2017; SDKP; UTC Aerospace Systems).

Material and Method. The United Nations Platform for Space-based Information for Disaster Management and Emergency Response, UN-SPIDER (UN-SPIDER), established in 2007, is representing a platform which is supporting the use of space technologies especially for disaster management and emergency response. It has three offices, one in Vienna, one in Bonn, and one in Beijing (UN-SPIDER Knowledge Portal).

***UN-Spider**.* Among UN-SPIDER activities there are some, that can be mentioned, as being the most relevant ones: knowledge management, outreach activities and technical advisory support (UN-SPIDER Newsletter 2015).

1. Knowledge Management – It is to be mentioned that a knowledge base on space-based information and solutions to support risk and disaster management is available through the UN-SPIDER Knowledge Portal, http://www.un-spider.org/, that started in 2009. This Portal is providing the dissemination tool for specific outputs, what means that it is playing a relevant role for all knowledge management activities carried out within the UN-SPIDER framework. The main tool of it is the Space Application Matrix, a search engine to make available case studies regarding the application of different space-based resources in different phases of the disaster management cycle. The UN-SPIDER's knowledge management activities have especially the goal of raising awareness of interested persons and of promoting change in attitudes for using space-based information. UN-SPIDER is fostering its awareness-raising activities especially through its publications;
2. Outreach Activities – These are targeting the full disaster management cycle and are addressing different agencies from public and private sector, being best managed by a coordinated approach. In order to successfully promote the use of space-based information for supporting the full disaster management cycle, practitioners and experts from the disaster management and space communities are involved in UN-SPIDER activities. Among other activities, UN-SPIDER's outreach activities are especially including the organization of seminars and

workshops. Events are organized in order to demonstrate the opportunities that space-based information is offering for disaster and risk management.

3. Technical Advisory Support (TAS) - It is used for analysing the existing capacity to use space-based information, as well as for approaching the existing institutional framework for supporting disaster management through space based information. TAS has the goal to succeed in overcoming these limitations mainly through networking with regional institutions, international cooperation, and through establishing certain disaster management plans. It covers region-specific aspects such as trans-boundary issues, emergency response, risk assessment, existing GIS-based disaster management systems. UN-SPIDER's TAS has three pilars: Technical Advisory Missions, Capacity Building and Facilitation of Emergency Support/Technical Support (UN-SPIDER Knowledge Portal). This kind of activity is one of the prime activities of the UN-SPIDER programme at a national level.

The needs for space-based information can actually be identified by Technical Advisory Missions, TAMs. Usually these are officially requested by the respective national government and are conducted by experts, which are at the end making recommendations for improving the usage of space-based information at national level (UN-SPIDER Newsletter 2015). Capacity Building is representing a process of relieving the concrete application of individuals and agencies competencies to use space-based information for preventing and effectively responding to the challenges because of natural hazards and related humanitarian crises. UN-SPIDER capacity building efforts are containing mainly four types of activities (UN-SPIDER Newsletter 2015):

- providing policy-relevant advice to institutions regarding the use of space-based information;
- facilitating access to space-based data and services;
- facilitating the training of individuals on access to and use of such data;
- facilitating access to infrastructure, hardware, and software for space-based applications.

UN-SPIDER provides the Emergency Support in case of emergencies and disasters situations by taking the role of a bridge linking the disaster management agencies in charge of response operations with the corresponding space agencies (UN-SPIDER Newsletter 2015). The UN-SPIDER program is striving for becoming a gateway to space information for supporting disaster management, but also for environmental management (Prunariu 2017). UN-SPIDER is implemented as an open network of providers of space-based solutions for supporting diverse activities for environmental and disaster management having the goal of assuring Sustainable Development (SDKP). By taking into consideration this goal it follows that the aim of this mission is to assess national capacities as well as existing policies and activities to use space-based technologies and information for disaster risk reduction as well as for management and emergency response (UN-SPIDER Knowledge Portal).

For really shaping Sustainable Space Activities, different space programs shall contribute to a green design, reduction of natural resources use as well as use of appropriate bio-fuels. Such activities should be implemented in the future, where systemic thinking is per-se required, as requested for shaping global sustainability (Sustainable Development Goals 2015). Just to give an example in this direction it is to be stated that the American Aerospace Systems Company is developing Ecological Integrated Propulsion Systems in order to improve fuel efficiency and reduce noise pollution (UTC Aerospace Systems 2015).

The concept of global sustainability. Several times in different circles it has been emphasized that the technological progress has actually assured to shape the desire of humanity to increase its quality of life. The developments have however emphasized that beside wanted effects of technological progress, undesired effects can appear. After the Conference for Environment in Stockholm in 1972 and the first report to the Club of Rome „The Limits to Growth“ in 1972 (Meadows et al 1972) was finally understood that besides wanted effects of technological progress, undesired negative effects can appear. Nowadays we confront us with a series of global problems, as presented in Figure 1, which can be grouped in three categories: world population growth, growth of energy and natural resources consumption and environmental pollution (Meadows et al 1972).

It is to be emphasized that in order to find solutions for these problems, debates on scientific, social and political levels started some time ago on a global level (Jischa 2005). In the Brundtland Report 1987 the concept of Sustainable Development has been defined and accepted as a possible solution for the global complex ecological, economic and social problems (Hauff 1987):*"Sustainable Development means the ability of humanity to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs."*

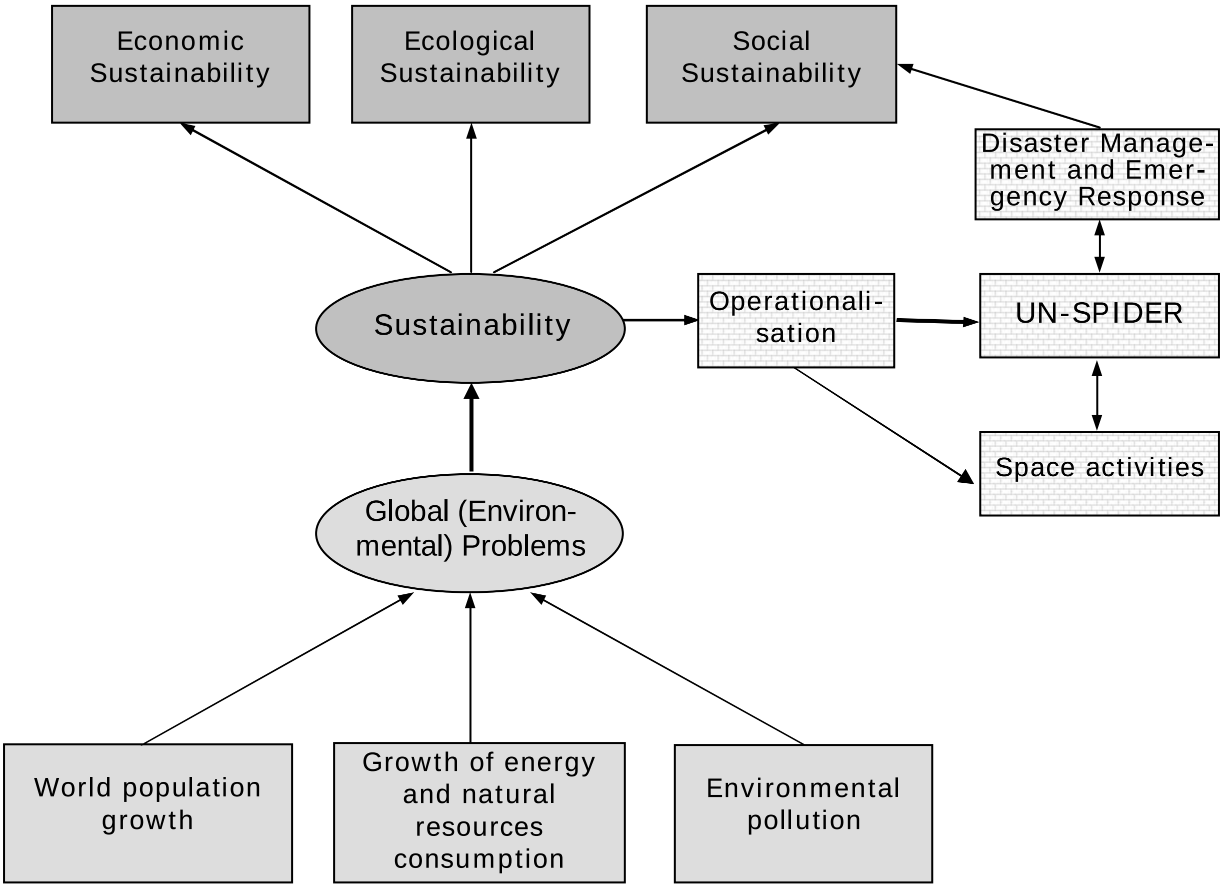

Figure 1. The Sustainability concept and the role of space activities for its operationalisation.

Regarding the mobility field, presently the vision is to develop mobility by respecting the concept of Sustainable Development, i.e. by shaping *sustainable mobility*. With this goal the pretty new discipline *Technology Assessment* has to be used, which is trying to give an answer to the question: Which are the technologies that humanity needs, how do these technologies integrate into environment and society? Technology Assessment brings together almost all scientific disciplines with the common goal of finding the best ways for sustainability operationalisation and actually points out that there are new evaluation criteria for technological applications (Tulbure 2013).

All these evaluation criteria should be considered in sustainability decision-making processes also regarding Space Activities (Prunariu & Tulbure 2017). Such activities could support the Sustainability of our human society by delivering several useful information and by conducting regional and global Emergency Programs. Specific emergency programs are thought in order to support disaster response operations through the usage of maps and additional information derived from satellite imagery (Prunariu 2017).

Related to assuring the sustainability of our human society the technical field is playing an important role, beside the environmental and socio-economic field (Tulbure 2003; Jischa 2005). Taking into account the technical field connected to the social one, special attention has to be paid to *space activities* (Prunariu & Tulbure 2017). This is currently becoming more relevant regarding assuring global sustainability because of the need of cosmical research and clarifications (Fortescue et al 2003). In different scientific circles it is well known that without astrological planetary information the sustainability research would be almost impossible. A lot of progress has been made in the last years in the field of *space activities* because of using new innovative ICT based techniques (Soler 2014). The knowledge about spatial interplanetary relations is a foremost condition for assuring the Sustainable Development on a planetary level (Prunariu & Tulbure 2017).

Sustainability operationalisation. The operationalisation of the concept of Sustainable Development means the transformation or translation of its goals into political measures and controlling instruments. In order to operationalise Sustainable Development a general methodology can be applied and is materialized in the following steps (Tulbure 2003):

- defining the sustainability problem;
- establishing the space and time scales;
- systemic approach of the region by modelling the interactions;
- establishing concrete aims for the studied case;
- developing concepts and measures by establishing priorities;
- developing evaluation and control instruments, indicators;
- verifying possible results, which could be obtained after introducing the proposed measures, comparing different scenarios;
- applying into the practice the developed concept.

From this general methodology follows that the operationalisation is only possible, when for an individual problem-case concrete aims are established and from these aims concepts to achieve them are developed. Sustainability is to be newly defined for each different case. The space and time scales are to be newly defined for each case (Jischa 2005).

Evaluation and control instruments are represented by Sustainable Development Indicators (SDI) (Sustainable Development Goals 2015). These indicators permit to quantitatively formulate the proposed objectives and goals for achieving Sustainable Development (Sustainable Development Goals 2015). After introducing the proposed measures, by calculating the mentioned indicators and by comparing them to the reference values, the current realization degree can be controlled and verified. The possibility to make corrections is assured in this way. As another application of such indicators it can be stated that they can serve as an instrument which helps to better understand the impacts of introducing certain measures and as an instrument to inform the general public (Tulbure 2013).

It is well known that part of what engineers do is represented by theis activities of evaluating developments in technology. Their evaluation has been up to now almost without exception focused on technical and economic aspects following legal and financial boundary conditions. With respect to sustainability more criteria have to be considered like: environmental quality, social and human values, quality of life. From this presentation it became more than clear that the activities of engineers when evaluating technologies can be sustained by the pretty new discipline called Technology Assessment, TA (Grunwald 2002; Jischa 2005; Tulbure 2013).

Technology Assessment means the methodical, systematic, organised process of:

- analysing a technology and its developmental possibilities,
- assessing the direct and indirect technical, economic, health, ecological, human, social and other impacts of this technology and possible alternatives,
- judging these impacts according to defined goals and values, or also demanding further desirable developments,
- deriving possibilities for action and design from this and elaborating these,

so that well-founded decisions are possible and can be made and implemented by suitable institutions if need be (VDI-Richtlinie 2000).

When going through the given methodology for operationalisation of Sustainable Development one can recognize that many steps can also be identified in the phases distinguished in Technology Assessment (Tulbure 2013), as presented above. Often a concrete sustainability problem especially related to a technological issue is to be solved by carrying out a so-called "TA-study" (Grunwald 2002). Or a TA-study has as a goal to research if the effects of a technology application do not conflict with the goals of Sustainable Development (SD Goals 2015). For the operationalisation of Sustainable Development there is a need to use the instruments of Technology Assessment, the most applied one being the Life Cycle Assessment, LCA (Grunwald 2002; Jischa 2005; Tulbure 2013). Technology Assessment tries to give an answer to the question: Which are the technologies that we need, how are these technologies to be developed and how do they integrate into environment and society? From this reason Technology Assessment, TA has to play a central role in the next global technological, environmental and social development in the sustainable direction (Grunwald 2002; Jischa 2005).

Operationalisation of Sustainable Development with Technology Assessment means analysing the stability of complex dynamic environmental, economic and social systems in order to try to discover developments which lead to instabilities. In this context there are several fields where research is needed; after (Jischa 2005) these fields are:

- State description by using Sustainable Development Indicators (SDI);
- Dealing with uncertain, unclear knowledge or non-existent knowledge;
- Improvement of methods and instruments;
- Orientation with values and dealing with value conflicts;
- Developing criteria for evaluation and making judgement;
- Modelling and simulation of dynamic systems.

The concept of Technology Assessment is a pretty interdisciplinary concept and it follows that it brings together almost all scientific disciplines in searching an answer to the question of how sustainability can be operationalised (Tulbure 2013).

When carrying out a study of Technology Assessment several methods and instruments of Technology Assessment can be used (Grunwald 2002). Some of the most used instruments of Technology Assessment are the following (Tulbure 2013):

- Environmental Management Systems;
- Environmental Impact Assessment;
- Life-Cycle-Assessment, LCA;
- Ecobalances;
- Ecoaudit.

Especially the Life-Cycle-Assessment, LCA is currently a pretty used instrument of Technology Assessment on the level of processes or products, in order to try to develop products having the minimum possible environmental impact during their whole life cycle, this means during their production but also during their consumption as well as during recycling or disposal phase (Grunwald 2002; Tulbure 2013).

Each technology should actually be evaluated by carrying out a study of Technology Assessment for it, just to try to recognize the most vulnerable points in the context of the analysed technology and to find possibilities to reduce the corresponding consumptiong of energy, water and other ressources. Especially in the mobility field there are several studies carried out, first of all for road and rail transport (Grunwald 2002). Most recently also the mobility by plane has started to be analysed, pretty young analysis can be found in the field of aerospace activities, use of rockets and how sustainable are such activities (Fortescue et al 2003; Prunariu & Tulbure 2017). Space technologies should be in the future concentrated also on shaping the vision of getting Sustainable Earth Activities by operationalizing Sustainable Development through Technology Assessment on a global level (Prunariu & Tulbure 2017).

Results and Discussion. From the made analysis regarding the potential contribution of space activities for achieving global sustainability follows that there are several fields where the application of space activities would represent a real progress for assuring the sustainability of our human society. Assessments connected to technological decisions are usually important and far-reaching, yet only rarely applicable to methodical solutions. The assessment problem can be understood as the procedure of organising in an optimum way the analysed possible alternatives considering different evaluation criteria with respect to some relevant aims and according preferences of the decision makers by considering in the same time given restrictions (Tulbure 2013). The whole assessment problematique is especially difficult, if many objectives have to be simultaneously considered in the evaluation, if different assessment scales emerge or objectives are weighted differently. The assessment process is extremely difficult if information is uncertain or may be subject to doubt, if the considered problem is time-dependent or many are participating in the decision making process not being a unique criterion for decision making (Jischa 2005). Therefore, often the evaluation process has to deal with a multidimensional assessment problem. Consequently, one usually has to deal with complex and nonlinear systems, where many non-measurable qualities occur and interactions are at least partially uncertain. In order to assess possible effects of human activities, especially industrial and transport processes on environment, several tools, so-called instruments of Technology Assessment can be applied with respect to the question which has to be answered. The most used ones are: environmental management systems, life-cycle-assessment, eco-audit, as well as ecobalances (Tulbure 2013). Technology Assessment studies with the goal of assuring Sustainable Development on a global level can also be carried out for space systems by considering specific methods for multi criteria decision analysis, MCDA, as well as for multi criteria decision making, MCDM (Jischa 2005; Tulbure 2013; Prunariu 2017).

Conclusions. In the present article the potential contribution of space systems and activities to Sustainable Development has been analysed. In order to support global sustainability an adequate use of space systems is actually indispensable. Presently there is a debate on a global level regarding respecting the Sustainable Development goals and how can each technology contribute to it. Space systems can contribute to this attempt especially by the UN-SPIDER platform. On the other side there is a need to take responsibilities for inappropriate usage of space systems, because this issue can really compromise the sustainability of our human society. This means as a general conclusion that the real existing possibilities of using space systems and activities for achieving the sustainability of our society have to be continuously explored. Delivering a kind of agenda regarding the usage possibilities of space systems for getting global sustainability could be one of the aerospace engineering contributions in this regard. For industry and engineers the operationalisation of Sustainable Development could be materialised in leading Technology Assessment studies. The heightened awareness of the importance of space systems has increased the interest in the development of specific methods of Technology Assessment for better comprehending possible impacts of using aerospace systems. The evaluation question has to be seriously analysed and the assessment difficulties of using space systems have to be debated. The got feedback from public authorities and users of space-based technologies underlines the need to further develop existing systems. The issue of insufficient human resources in terms of national experts which could work with space-based information is representing another future challenge. On the other side a lack of awareness has been registered about the potential benefits of space-based information. UN-SPIDER has the goal to close these gaps by using different possibilities. For instance raising awareness and providing support to strengthen local capacities could be part of UN-SPIDER's main activities. The main objective of these activities is to assure that different organizations are using space-based information to efficiently develop sustainability strategies on a national and global level.

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