Airspace activities in support of environmental tasks

[1,2]Dumitru-Dorin Prunariu, [3,4,5]Ildiko Tulbure

[1] Romanian Space Agency, Bucharest, Romania; [2] Association of Space Explorer, ASE Europe, Illkirch-Graffenstaden, France; [3] University „1 Decembrie 1918", Alba Iulia, Romania; [4] Clausthal University of Technology, Clausthal-Zellerfeld, Germany; [5] Technical University of Cluj-Napoca, Romania. Corresponding author: I. Tulbure, ildiko.tulbure@gmail.com

Abstract. Airspace activities opened new possibilities by air traffic regarding developments in different human activity fields, especially on the human mobility side. Anyway environmental impacts of air traffic may be local or global, temporary or long-lasting. Manufacturing and operating aircraft demand materials, energy and resources. Disposal of old aircraft generates waste that must be recycled or sent to landfill. Emissions created by burning jet fuel cause air pollution and, over decades, climate change. The International Air Transport Association (IATA) has targeted the stabilisation of net carbon emissions because of aviation industry by 2020, with a long-term goal of 50% reduction by 2050 compared to 2005. This is anyway a difficult challenge because of the fact, that passenger traffic will probably increase in the future and connected to this, fuel consumption will increase as well. As a result, it is stringent that initiatives are starting to reduce emissions from commercial aviation with the goal of shaping sustainable aviation. This means that aerospace engineering must bring efficient solutions to improve its environmental performance by making progress in the design and operation of modern aircraft, by implementing the vision of sustainable aviation, approaching this goal by technology assessment as well as by its tool, the Life-Cycle Assessment (LCA). The SESAR 2020 approach of Single European Sky ATM Research Programme is prioritising research for improving Europe's Air Traffic Management (ATM), so that steps for reducing environmental pollution will be made by delivering safer and cleaner air travel.

Key Words: airspace activities, air traffic, environmental tasks, sustainability, life-cycle assessment.

Introduction. Almost all human activities have the final goal to succeed increasing the quality of life of the population. In the field of human mobility different transport activities have to be mentioned. In this regard airspace activities are playing a special role for supporting human mobility and other human activities as well. They are used for supporting data exchange, positioning information, images about the land, meteorological information and researching the atmosphere related to climate change (Jischa 2005).

Airspace activities starting with air traffic are various, being currently used for several scientific, commercial, industrial and governmental applications (Engmann 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 aerospace organizations and programs funded by the governments in order to support such aerospace activities. In this context the Aerospace Industries Association (AIA) in the United States, the Russian Aerospace Defence Forces (ASDFB) can be mentioned to support airspace activities in Russia, also the European Aeronautics Science Network (EASN), in Europe or in Germany the German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt (DLR)), Aerospace Industries Association of Canada (AIAC) in Canada, the Society of Japanese Aerospace Companies in Japan, the China Aerospace Science and Technology Corporation (CASC) in China and many others. In Romania the Association of Romanian Aeronautical Companies (OPIAR), http://www.opiar.ro, is to be mentioned.

Civilian airspace users include scheduled airlines, charter companies, cargo and air freight service providers, the business and leisure aviation sectors and all forms of non-military air travel, from hot air balloons through police helicopters to general aviation pilots. The conceptual framework of airspace has to be first of all clarified, playing an important role in carrying out air traffic and implicitly when considering pollution aspects (Soler 2014; Prunariu 2017).

It is known that there are diverse goals for which airspace technologies can be used, one of these goals being also materialized in mitigating global vulnerability to natural disasters, which 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 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 using existing space and airspace technology for earth observation and meteorological data, communication and navigation satellites can play an important role in supporting disaster management by providing accurate and timely information for decision making (Soler 2014; Prunariu 2017). Experiences made on global level demonstrated that space and airspace systems can provide necessary information, even useful services, in disaster situations. Most relevant applications are represented by detecting, providing and delivering early warnings through earth observations, navigation and communication capabilities. Satellite systems are appropriate for delivering locale-specific disaster warning data and for providing communications in remote rural or under-developed areas. Airspace based observation and communication systems for disaster management have been evolved by using experiences gained through pilot scale studies and operational use of specific space and airspace data. An important step is represented by assessing delivery mechanisms that could effectively provide these services (Prunariu 2017).

Material and Method. First of all the notions of airspace and airspace activities taking place in this area have to be clarified, concluding at the end that for approaching environmental tasks regarding airspace activities, technology assessment has to be carried out by using one of its tools i.e. the Life-Cycle Assessment (LCA) (Tulbure 2013).

Airspace. Airspace, or that space which lies above a nation and comes under its jurisdiction, is the portion of the atmosphere controlled by a country above its territory, including its territorial waters or, more generally, any specific three-dimensional portion of the atmosphere. It is not the same as aerospace, which is the general term for Earth's atmosphere and the outer space in its vicinity (https://en.wikipedia.org/wiki/Airspace). Generally it is considered as being unlimited, but, however, it is a finite resource that can be defined vertically and horizontally, as well as temporaly, when describing its use for aviation purposes. The time dimension is a very important factor in Airspace Management and Air Traffic Control (ATC) (Engmann 2013).

Airspace classes. The International Civil Aviation Organization (ICAO), classifies the airspace in seven classes, from A to G, as presented in Figure 1.

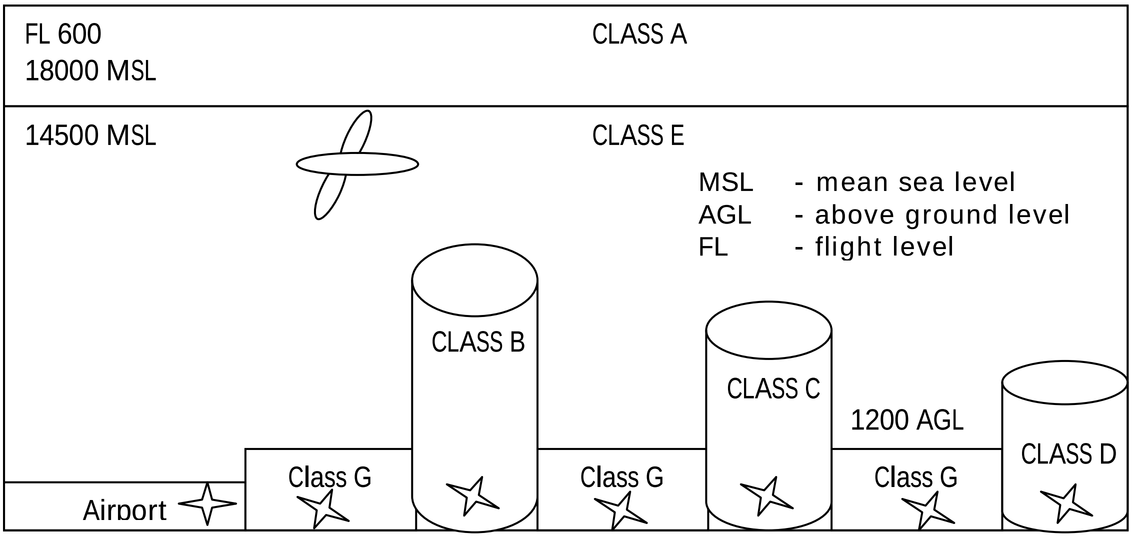

Figure 1. Classification of airspace in Airspace Classes, after ICAO (https://upload.wikimedia.org/wikipedia/commons/thumb/2/2b/Airspace_classes_%28 United_States%29.png/1024px-Airspace_classes_%28 United_States%29.png).

The world's navigable airspace is divided into three-dimensional segments, each of which is assigned to a specific class. Most nations adhere to the classification specified by the ICAO and described below, though they might use only some of the classes defined below, and are maybe significantly modifying the rules and requirements in accordance with certain national requirements.
Controlled airspace is represented by classes A to E, in order of decreasing ATC regulation of flights, as presented below (Engmann 2013):

- class A: all operations must be conducted under IFR (Instrument Flight Rules). All aircraft are subject to ATC clearance, flights are separated from each other by ATC;
- class B: operations may be conducted under IFR, SVFR (Special Visual Flight Rules), or VFR (Visual Flight Rules). Aircraft are subject to ATC clearance;
- class C: operations may be conducted under IFR, SVFR, or VFR. All aircraft are subject to ATC clearance (however, country-specific variations). Aircraft operating under IFR and SVFR are separated from each other and from flights operating under VFR, but VFR flights are not separated from each other. Flights operating under VFR are given traffic information in respect of other VFR flights;
- class D: operations may be conducted under IFR, SVFR, or VFR. All flights are subject to ATC clearance (with country-specific variations). Aircraft operating under IFR and SVFR are separated from each other, and are given traffic information in respect of VFR flights;
- class E: operations may be conducted under IFR, SVFR, or VFR. Aircraft operating under IFR and SVFR are separated from each other, and are subject to ATC clearance. Flights under VFR are not subject to ATC clearance. As far as is practical, traffic information is given to all flights in respect of VFR flights;
- class F: operations may be conducted under IFR or VFR. ATC separation will be provided, so far as practical, to aircraft operating under IFR. Traffic Information may be given as far as is practical in respect of other flights. Class F is not used in the United States. In Canada, class F is the equivalent of U.S. special use airspace including restricted and alert areas, while ICAO defines it as a "hybrid" of class E and class G, in which ATC separation guidance is available but not required for IFR operation (https://en.wikipedia.org/wiki/Airspace_class_(United_States)#Class_F);
- class G: operations may be conducted under IFR or VFR. ATC has no authority but VFR minimums are to be known by pilots. Traffic Information may be given as far as is practical in respect of other flights.

It is to be mentioned that all airspace classes except class G are requiring ATC clearance for IFR operations.

Controlled and uncontrolled airspace. Controlled airspace is airspace of defined dimensions within which ATC services are provided (https://en.wikipedia.org/wiki/Controlled_airspace). The level of control varies with different classes of airspace. Controlled airspace usually imposes higher weather minimums than are applicable in uncontrolled airspace. Controlled airspace is established mainly for following three different reasons, as high-volume air traffic areas, e.g. near airports, existence IFR traffic under ATC guidance, as well as security reasons. Controlled airspace usually exists in the immediate vicinity of busier airports, where aircraft used in commercial air transport flights are climbing out from or making an approach to the airport, or at higher levels where air transport flights would tend to cruise. Some countries also provide controlled airspace almost generally, however in most countries it is common to provide uncontrolled airspace in areas where significant air transport or military activity is not expected.

Uncontrolled airspace is the airspace where an ATC service is not deemed necessary or cannot be provided for practical reasons. According to the mentioned airspace classes, after ICAO, both class F and class G airspace are uncontrolled. It is the opposite of controlled airspace. ATC does not exercise any executive authority in uncontrolled airspace, but may provide basic information services to aircraft in radio contact. Flight in uncontrolled airspace will typically be under VFR. Aircraft operating under IFR should not expect separation from other traffic: however, in certain uncontrolled airspace, this might be provided on a practical advisory basis.

Controlled airspace is classes A to E, in order of decreasing ATC regulation of flights. Flight under IFR is allowed in all controlled airspace (some countries also permit IFR in uncontrolled airspace); flight under VFR is permitted in all airspace except class A.

Single European Sky ATM Research (SESAR). In connection to controlled and uncontrolled airspace, the Single European Sky ATM Research (SESAR) is to be mentioned. SESAR is a collaborative project for completely restoring European airspace and its Air Traffic Management, ATM. The actual programme is managed by the SESAR Joint Undertaking as a public–private partnership (EC 2016). The vision is that by SESAR 2020 the next generation of European Air Traffic Management will be developed, as being a project having as main goal, the best aviation strategy for Europe (EC 2015).

The SESAR project is composed of three phases (EC 2016):

- definition phase (2004-2008), to deliver an ATM master plan defining the content, the development and using plans of next generation of ATM systems;
- development phase (2008-2013), to produce the required new generation of technological systems and components as defined in the definition phase;
- deployment phase (2014-2020), for a large-scale production and implementation of the new ATM infrastructure for air transport activities in Europe.

The military, in the form of the air forces of the EU's Member States, are also users with an interest in SESAR technology developments. Many of these companies and organisations are formally involved in the SESAR work programme (EC 2016).

In the following some examples of SESAR solutions deployed either locally or as part of synchronised plans are given (EC 2016):

- “green” flight arrivals into airports across Europe;
- digitalising Europe’s aviation infrastructure;
- pioneering noise reduction at airports. Within this framework, Frankfurt Airport became the first airport in the world to fully implement GBAS (ground-based augmentation system) precision-landings;
- collaborating across borders to reduce delays;
- lights, runway, increased capacity. In 2016, in Paris by Air France, Europe’s first runway status lights was inaugurated;
- increasing resilience. In 2017 the action has started with Heathrow airport.

Aviation and air quality. Aircraft emissions impact local air quality at ground level, which is in turn a quantifiable risk to human health. It is known that there are representative health effects of air pollutants, such as lung function impairment, lung irritation, increased susceptibility to respiratory infection, and pulmonary inflammation, lung structure damage, premature mortality, aggravation of respiratory and cardiovascular disease. On the other side there are representative environmental effects of air pollutants, such as crop damage, damage to trees and decreased resistance to disease for both crops and other plants, similar health effects on animals as on humans, acid rain, visibility degradation, particle formation, contributions to ozone formation, climate change (Jischa 2005). The International Air Transport Association (IATA) has planned the stabilisation of CO_2 emissions because of aviation industry by 2020, having the goal of 50% reduction by 2050 compared to 2005 (IATA). This challenge is a pretty difficult because the passenger traffic will probably increase in the future, so that the fuel consumption will increase as well. Measures for reducing emissions from commercial aviation with the goal of shaping sustainable aviation are stringent necessary.

As it is to be remarked from Figure 2, the aircraft CO_2 emissions remained pretty stable between 2005 and 2014, and are likely to further increase in the future. In order to succeed considering the whole environmental impact of air traffic, it is necessary to assess the whole life-cycle of airplanes, not only the usage phase of these in form of air traffic (Lopez 2010). The LCA of products is a pretty new but used tool, emphasing the emergence of this tool, as well as its usage in the context of different industrial applications. Concretely it will be mentioned that on a global level there is an ISO standard for using and applying the LCA, that has to be carried out in different stages and for different cycles of a product. The standard family is DIN ISO 14000 for Environmental Management and ISO14040 is referring to LCA (Tulbure 2013). Regarding traffic engineering several transport means can be chosen and the pollutants emissions in their utilisation phase can be assessed and compared. Conclusions regarding the Traffic environmental impacts can be drawn and measures to reduce these impacts can be emphasised (Lopez 2010; Tulbure & Sarb 2016).

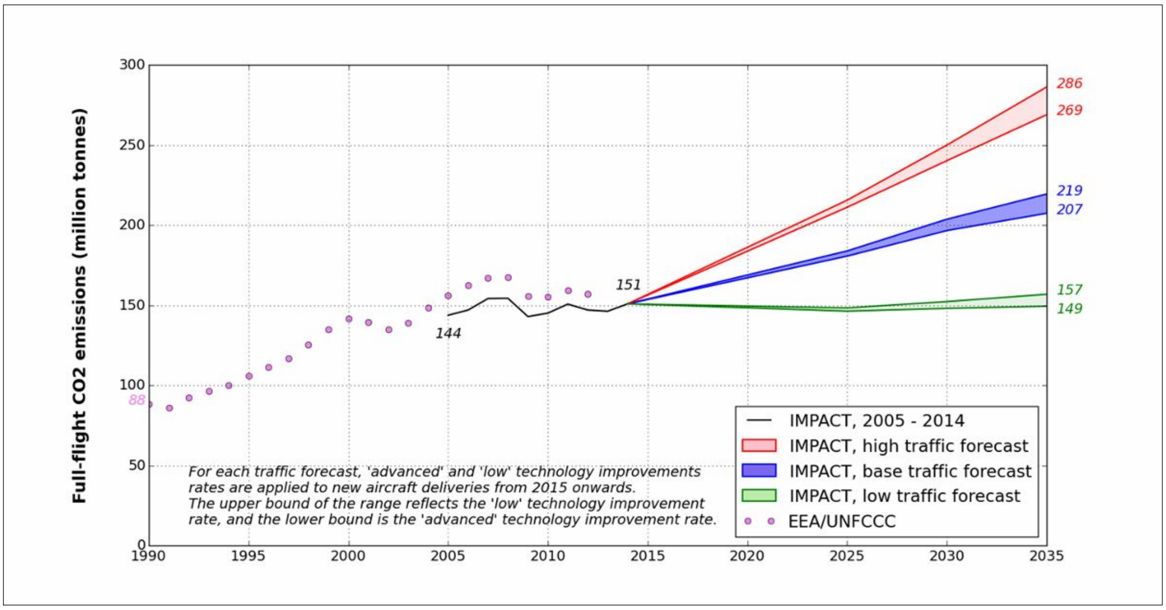

Figure 2. Aircraft CO2 emissions (EASA 2016).

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? With this goal, Technology Assessment brings together almost all scientific disciplines with the common goal of analysing and evaluating environmental impacts of technological applications and of finding the best ways for sustainability operationalisation (Grunwald 2002).

All these evaluation criteria should be considered in sustainability decision-making processes also regarding space and airspace activities (Prunariu & Tulbure 2017). Such activities could support the Aviation Sector by delivering studies of Technology Assessment, as the Californian case study (CEPA 2014). On the other side the sustainability of our society can be sustained by delivering 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, where the main role of space and airspace is becoming obvious (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 (Jischa 2005). Taking into account the technical field connected to the social one, special attention has to be paid to space and airspace activities (Prunariu & Tulbure 2017). This is currently becoming more relevant regarding assuring global sustainability because of the need of cosmical research and clarifications (Soler 2014). A lot of progress has been made in the last years in the field of airspace and 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).

Results and Discussion. Activities of engineers when developing and evaluating technologies can be sustained by the pretty new discipline called Technology Assessment (Grunwald 2002; Jischa 2005; Tulbure 2013), concretely by using specific methods and tools of Technology Assessment depending on the respective evaluation goal.

One of the most applied tools of Technology Assessment is the life-cycle assessment (LCA) (Grunwald 2002; Jischa 2005; Tulbure 2013). LCA is defined on a global level in the standard family DIN ISO 14000, namely in DIN ISO 14040 and on a national level, for instance in Germany, in the Guideline of German Engineers Association, VDI (VDI-Richtlinie 2000). LCA is currently a pretty used tool on processes and products level in order to develop products having 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; Lopes 2010; Tulbure 2013), as presented in Figure 3. It can be observed that besides production and consumption processes also transport processes, stated with ”T”, are taken into account (Tulbure 2013).

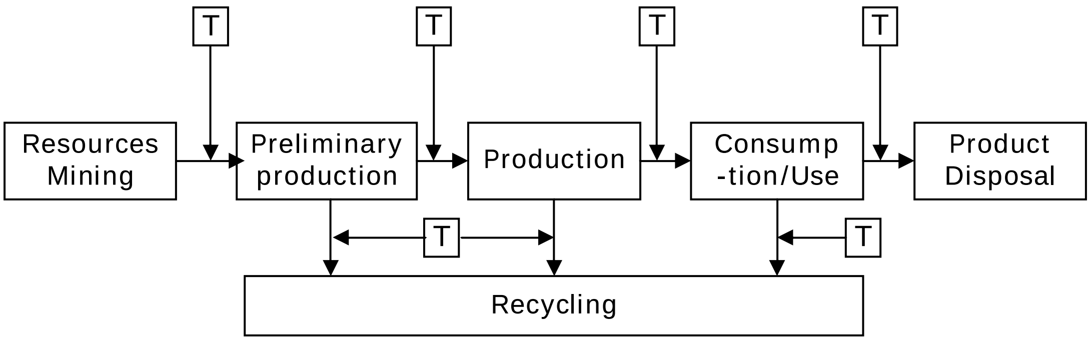

Figure 3. General life-cycle of products.

As a tool of Technology Assessment, LCA is used to improve production lines of products, to compare different products and to ecologically optimise the life-cycle of products. LCA is in fact an ecobalance which can be performed as a singular study or as a comparative study (Grunwald 2002). The ecobalance registers material and energetic flows when producing something, or within a process or a company (Tulbure & Sarb 2016).

With respect to LCA a difficult step is represented by getting on data and information about products and production processes. To compare different life-cycle stations of a product from the point of view of pollutants emissions there is a need to use different environmental indicators. This process is still in development (Tulbure 2013).

The life-cycle of a product takes into account relevant steps in the existence and use of a product, as shown in Figure 3, starting with the extraction of mineral resources used to manufacture the product and ending with the disposal of the product (Grunwald 2002; Lopes 2010; Tulbure & Sarb 2016):

- resources mining: this phase refers to the extraction of mineral resources, that will become the raw material used to manufacture the respective product;
- preliminary production: this phase includes the manufacture of components that will be assembled during production to get the desired final product;
- production: in this phase the components are assembled, resulting the product in its final form;
- consumption/use: after the sale of the product, it enters in the stage of use;
- product disposal: after completing the period of use is reached the last stage in the life-cycle of a product - the disposal, where the used product is directed to the phase of reuse or recycling and waste processing.

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 aircraft or rockets and how sustainable are such activities (Lopes 2010; Soler 2014; Prunariu & Tulbure 2017). For airspace technologies and aircraft should be in the future carried out such LCA, just to optimise environmental tasks with regard to these technologies for shaping the vision of getting sustainable space and airspace activities especially by decreasing their environmental impacts (Lopes 2010; Prunariu 2017).

As an application example of assessing different Traffic Environmental Impacts by using LCA, several transport means have be chosen and the pollutants emissions in their utilisation phase have been assessed and compared (Tulbure & Sarb 2016). The diagrams from Figure 4 are presenting in a concise form the calculation results about the CO_2 emissions for different transport means for the considered distance (Tulbure & Sarb 2016).

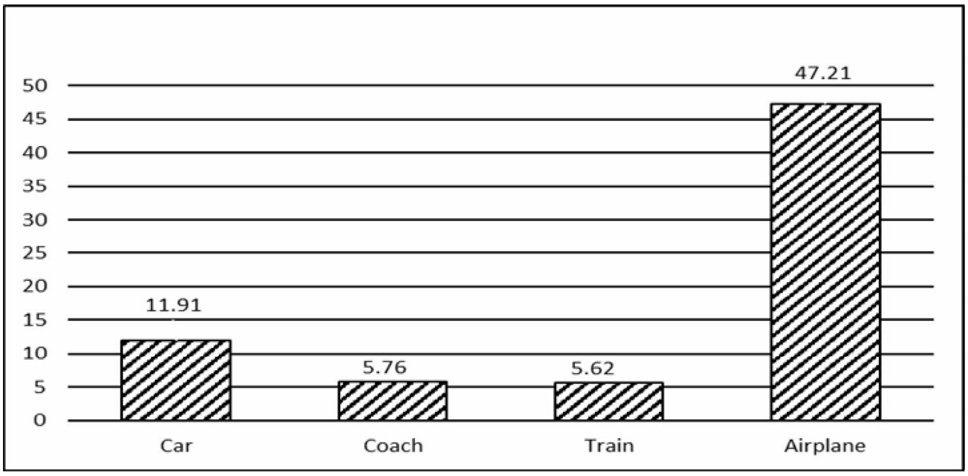

Figure 4. Emissions of CO_2 for different transport means for the same distance between two cities.

The made calculations are emphasising that the operation phase of aircraft accounts for most of the environmental impacts, whilst the train for the smallest, the other two transport means, car and coach, being between the first two ones, as to be remarked from Figure 4. Conclusions regarding the Traffic Environmental Impacts can be drawn and measures of technical and organisational kind to reduce these impacts can follow on different levels, especially regarding air traffic and aircraft.

From the made analysis regarding the potential contribution of airspace activities, especially air traffic for achieving different environmental tasks follows that there are several fields, especially technical and organisational ones, where certain improvements would represent a real progress for assuring the sustainability of our human society. Assessments connected to technological decisions are relevant and far-reaching, yet only rarely applicable to methodical solutions. The assessment problem can be understood as the procedure of organising the analysed possible alternatives considering different evaluation criteria with respect to relevant aims and preferences of the decision makers by considering given restrictions (Prunariu & Tulbure 2017). In this case pollutants emissions have been considered, the whole assessment being especially difficult, if many objectives have to be considered, if different assessment scales emerge or if objectives are differently weighted. The assessment is difficult if information is uncertain, if the considered problem is time-dependent or if many are participating in the decision making process, not being a unique criterion for decision making (Jischa 2005).

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 one is the LCA, where the assessment method based on an emission indicator has been applied for airspace systems. Results emphasise the working way of the presented method, because it is possible to compare environmental impacts of different transport means by calculating CO_2 emissions in the usage phase of each of these. It follows that the operation phase of aircraft accounts for most of the environmental impacts by pollutants emission in the air. There are several measures to reduce these impacts, especially technical ones for reducing fuel consumption, but also organisational ones and ones acting in social field.

Having in mind this result it would be interesting to continue this approach by carrying out a Cross-Impact-Analysis for the human mobility field, just to succeed in assessing different scenarios regarding air traffic when implementing future projects.

Conclusions. It is a recognised reality that demand for air transport is steadily increasing and, if this demand is to be met with all advantages, society must accept the corresponding costs, in terms of noise, pollution, climate change, risk, and resource use. In the long term there are several possibilities to improve aviation's sustainability, as for instance to ensure safety and security, to efficiently optimise available capacity, to collaborate for achieving a shared vision for more sustainable aviation, to make decisions based on optimising the balance between social, economic and environmental aspects, to take every opportunity to modernise appropriate equipment and technology. On the other side is necessary to invest in adequate research, training, education and awareness, as well as to be transparent about both the good and bad aspects of air transport in order to avoid conflicting policy and regulations. Taking into account the presented situation regarding aircraft emissions, by using LCA for assessing environmental tasks, the need for technology improvements follows regarding decreasing environmental pollution because of air traffic by simultaneously optimising fuel consumption. The need to complete such an analysis with a Cross-Impact-Analysis for the human mobility field has become clear for assessing future development strategies in the field of air traffic by simultaneously considering various social aspects.

References

Engmann K., 2013 Technologie des Flugzeuges. Vogel, Würzburg, Germany, p. 22-44.

Grunwald A., 2002 Technikfolgenabschätzung - Eine Einführung (Technology Assessment – An Introduction). Edition Sigma, Berlin, 35 pp.

Jischa M. F., 2005 Herausforderung Zukunft (Challenging the future). Second edition, Elsevier, Spektrum Akademischer Verlag, Heidelberg, Germany, pp. 188-193.

Lopes J. V., 2010 Life-cycle assessment of the Airbus A330-200 aircraft. MSc Thesis, Technical University of Lisbon, Portugal, 118 pp.

Prunariu D., 2017 Space activities in support to climate change mitigation and climate resilience. UFS-DiMTEC Symposium on climate resilience and water. University of the Free State, Bloemfontein, South Africa, 22-23 February 2017.

Prunariu D., Tulbure I., 2017 Space activities and sustainable development. In: Proceedings of the 17th International Multidisciplinary Scientific Geoconference, SGEM2017, "Nano, Bio, Green and Space – Technologies for a Sustainable Future", Section "Space Technologies and Planetary Science", Albena, Bulgaria, 17(62):947-954.

Soler M., 2014 Fundamentals of aerospace engineering: an introductory course to aeronautical engineering. Madrid, ISBN: 978-14-937277-5-9, 404 pp.

Tulbure I., 2013 Technikbewertung – Vorlesungsskript (Technology Assessment - Lecture Notes). Institute for Applied Mechanics, Clausthal University of Technology, Clausthal-Zellerfeld, Germany, pp. 47-63.

Tulbure I., Sarb A., 2016 Analysing and comparing different traffic environmental impacts. In: Proceedings of the International Symposium "The Environment and the Industry", SIMI 2016, INCD ECOIND, Bucharest, 13-14.10.2016, p. 230-236.

VDI-Richtlinie 3780, 2000 Technikbewertung - Begriffe und Grundlagen. New Edition, Berlin.

*** Association of Romanian Aeronautical Companies (OPIAR). Available at: http://www.opiar.ro. Accessed: October, 2017.

*** California Environmental Protection Agency (CEPA), 2014 Technology assessment - aviation sector. California. Available at: https://www.arb.ca.gov/msprog/tech/presentation/aviation.pdf. Accessed: October, 2017.

*** European Aviation Safety Agency (EASA), 2016: European Aviation Environmental Report. Available at: https://ec.europa.eu/transport/sites/transport/ files/european-aviation-environmental-report-2016-72dpi.pdf. Accessed: October, 2017.
*** European Commission (EC), 2015 An aviation strategy for Europe. Available at: https://ec.europa.eu/transport/modes/air/aviation-strategy_en. Accessed: September, 2017.
*** European Commission (EC), 2016 SESAR, 2020 - developing the next generation of European air traffic management. Available at: http://ec.europa.eu/research/press/jti/factsheet_sesar-web.pdf. Accessed: September, 2017.
*** International Air Transport Association (IATA). Available at: http://www.iata.org/Pages/default.aspx. Accessed: September, 2017.
*** International Civil Aviation Organization (ICAO). Available at: https://www.icao.int/Pages/default.aspx. Accessed: October, 2017.
*** Wikipedia, Airspace. Available at: https://en.wikipedia.org/wiki/Airspace. Accessed: June, 2017.
*** https://en.wikipedia.org/wiki/Controlled_airspace. Accessed: September, 2017.
*** https://upload.wikimedia.org/wikipedia/commons/thumb/2/2b/Airspace_classes_%2 United_States%29.png/1024px-Airspace_classes_%28 United_States%29.png. Accessed: July, 2017.
*** https://en.wikipedia.org/wiki/ Airspace_class_(United_States)#Class_F). Accessed: July, 2017.

Received: 03 November 2017. Accepted: 06 December 2017. Published online: 30 December 2017.
Authors:
Dumitru-Dorin Prunariu, Romanian Space Agency, Bucharest, Romania
Ildiko Tulbure, Faculty of Exact and Engineering Sciences, University „1 December 1918“, Unirii-Str., No. 15-17, 510009 Alba Iulia, Romania, e-mail: ildiko.tulbure@gmail.com

How to cite this article:
Prunariu D. D., Tulbure I., 2017 Airspace activities in support of environmental tasks. Ecoterra 14(4):1-9.