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Space debris**

Research on space debris, the safety of space objects with nuclear power sources on board and problems relating to their collision with space debris

Note by the Secretariat

Addendum

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* [A/AC.105/C.1/L.412](#).



II. Replies received from Member States

Democratic Republic of the Congo

[Original: French]
[19 October 2023]

The National Centre for Remote Sensing has a monitoring project covering the national territory, but it does not yet have the equipment needed to research space debris or the safety of space objects with nuclear power sources on board. These two topical issues will be the subject of a study this year so that the progress made can be showcased in 2024.

Ecuador

[Original: Spanish]
[18 October 2023]

With regard to this area of research, it is universally known that the space debris population continues to grow. The main cause of concern in relation to space operations is the increased risk to spacecraft owing to potential collisions with objects launched into outer space that remain there for a long time or do not re-enter the Earth's atmosphere at all. Such collisions would prevent the space surrounding the Earth from being used for commercial, research or exploration purposes.

The growing proliferation of space debris is a widely recognized problem. It raises fundamental concerns with regard to space operations because of the increased hazard it poses to spacecraft and satellites launched into outer space. This is because of the risk of collisions with previously launched objects that remain in orbit for long periods of time without breaking up or re-entering the Earth's atmosphere.

This increase in space debris not only jeopardizes the safety of space operations, but also risks reducing access to the space surrounding the Earth for various purposes, including commercial, research and exploration purposes. The presence of space debris in orbit hampers the conduct of scientific research, makes it difficult to explore new space frontiers and poses challenges to the expansion of commercial activities in outer space.

Joint action at the global level is required to address this mounting concern. Standards and technologies are being developed to curtail the generation of new space debris and dispose of existing debris. Responsible management of space debris is essential to ensure that outer space continues to be a safe and sustainable resource for future generations.

Within the framework of its space-related competencies, the Military Geographical Institute of Ecuador is developing a proposal for regulations governing the registration of objects launched into outer space.

The overall objective is to draw up a proposal for national space regulations that would regulate space activities and the activities of objects intended to be launched into outer space, with a view to ensuring compliance with what was agreed in the Convention on International Liability for Damage Caused by Space Objects (as overseen by the Committee on the Peaceful Uses of Outer Space), which has been signed and ratified by Ecuador. In addition, space debris, the safety of space objects with nuclear power sources on board and problems relating to their collision with space debris will be addressed.

The specific goals are to:

- Gather information on the public and private institutions involved in this area, so as to identify actors and their roles

- Analyse the rules for the registration of objects launched into outer space that are in place in other countries of the region in order to learn about relevant aspects
- Establish the minimum content required for the proposed national regulations
- Reach out to the actors identified and channel the proposal through a lead entity

The project is national in scope, because compliance with the proposed regulations would be mandatory for all citizens, even for those carrying out space activities outside the territory of Ecuador.

Conclusions

The Military Geographical Institute is developing a proposal for national regulations governing the registration, in compliance with international agreements, of objects launched into outer space. This requires identifying the actors involved, analysing other countries' regulations, defining what the proposed regulations should cover and conducting outreach on the proposal. The regulations will be mandatory for all citizens, even for those carrying out space activities outside the territory of Ecuador.

Recommendations

- It is recommended to continue fostering the technical participation of Ecuador in activities relating to the peaceful uses of outer space.
- It is recommended that joint work be undertaken by the Foreign Ministry, through the various diplomatic missions and representations to international organizations, and the Military Geographical Institute, as the technical body, with a view to establishing a national position on space-related matters.

Mexico

[Original: Spanish]
[18 October 2023]

With respect to national research on space debris, and in line with debris remediation practices, Mexico has undertaken research on that topic through its public universities.

In that regard, national research on space debris carried out by public universities is reported annually. One of those universities is the National Autonomous University of Mexico (UNAM), which, through its Faculty of Engineering and its High Technology Centre in Juriquilla, Querétaro, has been carrying out work aimed at planning future missions with a focus on sustainability.

With regard to the monitoring of space debris in order to ensure the safety of space infrastructure, the Autonomous University of Sinaloa (UAS), through the use of its telescope, has joined international efforts led by the International Scientific Optical Network (ISON).

In addition, the Centre for Research on Physical and Mathematical Sciences of the Autonomous University of Nuevo León (UANL) is participating in the International Project for Monitoring Space Debris, which comprises a network of 25 observatories in more than 15 countries under the coordination of the Keldysh Institute of the Russian Academy of Sciences.

Mexico took part, together with Germany, Canada and Czechia, in the initiative to create a compendium of space debris mitigation standards, the first-ever document to contain first-hand information from Member States regarding the regulatory measures they have taken to reduce and remove space debris.

Russian Federation

[Original: Russian]
[17 October 2023]

The activities of the Russian Federation to prevent the formation of and remove space debris were carried out using the automated warning system for hazardous situations in near-Earth space. In the system's suite of databases, 30,242 human-made space objects were catalogued as at 31 August 2023, including 2,307 objects yet to be identified. The 27,935 identified space objects include 8,649 operational satellites and 19,286 space debris objects. Most of the space objects catalogued belong to the United States of America, followed by the Russian Federation and China. The number of catalogued space debris objects attributed to the Russian Federation was almost the same as at the end of 2022.

In the Russian Federation, the following work is being carried out to create various systems for removing space debris from protected areas of outer space:

- (a) Research has continued on the use of an ion beam injection system to remove space debris from the geostationary orbit region;
- (b) A proposal has been made to develop a universal module, to be used by different spacecraft, for deorbiting satellites by means of aerodynamic braking effected by a spherical inflatable brake shield made of thin metal-coated polymer sheeting;
- (c) Work has been carried out on the design of an autonomous docking module for the removal of large items of space debris from low orbits.

The Russian model for space debris prediction and analysis has been updated to reflect data gathered from the automated warning system for hazardous situations in near-Earth space and organizations participating in research on human-caused space debris.

The Russian Federation supports international efforts to resolve the problems of space debris and is of the view that the Space Debris Mitigation Guidelines and the Guidelines for the Long-term Sustainability of Outer Space Activities help to increase the safety of space operations.

The space activities of the Russian Federation involving the use of nuclear power sources are carried out in accordance with domestic legislation and the country's international obligations. All relevant requirements were met during the preparation and launch in 2023 of the Luna-25 spacecraft, which carried two radioisotope heat sources and one radioisotope thermoelectric generator.

Saudi Arabia

[Original: Arabic]
[1 November 2023]

The Kingdom of Saudi Arabia focuses on the space sector as part of its Vision 2030, which seeks to stimulate space-related industries through cooperation with counterpart space agencies and international centres and bodies on the transfer of technology, the acquisition of infrastructure and the training of national cadres to work in the space field and space sciences. Paying particular attention to space debris is essential to ensuring the safety of people and public and private property.

During 2023, Saudi Arabia launched its Astronaut Programme for crewed flights to help achieve its ambitions and the goals of its Vision 2030. The Astronaut Programme has strengthened the Kingdom's position in the space and research sector, enabling

Saudi astronauts to conduct 14 scientific experiments aboard the International Space Station, including the following:

- Measurement of changes in blood biomarkers reflecting functional brain tissue on short space missions to determine if such missions are safe for the human brain
- Measurement of the effect of short-term space flight on telomere length
- The use of pupillometry to measure any changes in intracranial pressure to enhance knowledge of the neuro-ocular syndrome associated with space flight
- The use of a portable electroencephalography device to measure and study the effect of the microgravity environment on electrical brain activity
- The use of near-infrared spectroscopy as a non-invasive technique to measure cerebral perfusion and repositioning of the brain in microgravity
- The conduct of a study on the possibility of cloud seeding in a microgravity environment to ascertain whether cloud seeding can be applied to human settlements on the surface of the Moon and of Mars
- The use of an immune cell model to simulate an inflammatory response to varicose vein treatment in microgravity conditions in space to understand changes in inflammatory response in space, especially changes in the lifetime of messenger RNA, an essential molecule for the production of pro-inflammatory proteins

Saudi Arabia, represented by the Saudi Space Agency, established a centre for the monitoring of space objects at the Agency's headquarters in 2021. The centre conducts daily monitoring of space objects that pass over the Kingdom of Saudi Arabia and responds to significant space incidents.

The centre also raises awareness about space debris and regularly tracks satellites to identify potential satellite collisions or out-of-control satellites. This requires determining the locations of satellites and where they may fall in order to adopt safety and prevention measures to protect people and property and to reduce damage as much as possible. The centre's main roles with respect to the various Earth orbits include:

- (a) Tracking, monitoring and ensuring the safety of Saudi satellites;
- (b) Predicting the locations of satellite and space object collisions or uncontrolled re-entries by simulating the movement of satellites and space objects;
- (c) Determining the expected time and place of the entry of space objects into the atmosphere.

A number of Saudi national observatories and research centres in universities have local capabilities to observe space debris. They include the King Abdulaziz City for Science and Technology, which has several optical observatories that can be used to monitor satellites in near-Earth orbit and objects re-entering the atmosphere. The Saudi Space Agency pursues regional and international cooperation to ensure the safety of outer space through the use of new technologies in this field.

A number of awareness-raising initiatives are under way, including research to raise awareness about space debris.

A team from the Saudi Space Agency makes visits to educational institutions and centres and holds workshops with research and academic agencies in the Kingdom. The Agency is also preparing a road map for research, development and innovation in space and space-related fields to identify space debris research objectives that the Kingdom hopes to achieve in the next few years.

The foregoing information about the Saudi space sector, which is based on the National Space Strategy, can be summarized in the following points, taking into account international conventions and treaties:

- The Kingdom launched the Astronaut Programme for crewed flights, which pursues the Kingdom's ambitions and the goals of its Vision 2030.
- The Kingdom possesses national scientific capabilities in research centres and universities and the necessary infrastructure to monitor satellites and space objects in all orbits.
- The Kingdom has future plans regarding space debris and is focusing on raising public awareness by holding educational courses and dialogue sessions.
- The Kingdom is pursuing international cooperation on space and space-related fields with governmental and private entities.
- The Kingdom is preparing a road map for research, development and innovation in space and space-related fields to determine the current situation of the Kingdom in respect of space debris and to address gaps.
- The Kingdom does not have any space objects carrying nuclear fuel sources on board.

Ukraine

[Original: English]
[6 November 2023]

In Ukraine, research on space debris has been carried out by different enterprises and institutions for a long time.

Thus, in 2021 the Institute of Technical Mechanics (ITM) of the National Academy of Sciences of Ukraine (NASU) and the State Space Agency of Ukraine (www.nas.gov.ua) carried out scientific projects on the development of a structural diagram of an artificial magnetic field source for the magnetohydrodynamic braking of a space debris object in the Earth's ionosphere and on the mini-magnetosphere as a means to control the movement of a spacecraft in the Earth's ionosphere by using its own magnetic field and substantiating the effectiveness of the technology for cleaning near-Earth space of space debris (experimental and theoretical studies).

In recent years, ITM, within the framework of NASU departmental research and competitive grants, has carried out work on the problem of ensuring the safety of spacecraft in relation to the danger posed by their collision with fragments of space debris, as well as considered the issue of preventing the growth of clouds of such fragments. A set of tasks related to the deorbiting of spacecraft that have ceased to function from operational orbits is being studied. An electrodynamic space tether system that uses the phenomenon of electrodynamic braking force for the deorbiting of spent rocket and space technology objects is being researched. Calculations and estimations have shown that the implementation of the proposed system can allow the effective cleaning of space debris from low Earth orbit.

The research required to implement the concept of contactless space debris removal, known as the LEOSWEEP project (improving low Earth orbit security with enhanced electric propulsion), was carried out. Simplified analytical models for calculating the impact transmitted to the space debris object by the ion beam of the service spacecraft's electrojet propulsion system (shepherd) were developed. A method for determining the force of an ion beam on an orbiting object on the basis of the known central projection of the object onto the picture plane of the shepherd's video camera was proposed. The control for maintaining the required relative position of the shepherd was synthesized.

Research was carried out and scientific and practical problems were solved to synthesize new design schemes for aerodynamic systems for the deorbiting of

spacecraft from low Earth orbit. In the context of the development of the design scheme and the selection of the parameters of the aerodynamic system for the deorbiting of an upper stage of the Cyclone-4 launch vehicle, the design view was developed and the mechanical parameters of the system were selected. A new design scheme for the aerodynamic deorbit system of the Sich-2-1 spacecraft created by the Pivdenne Design Office was developed. The aerodynamic deorbit system was upgraded for implementation on the upper stage of the Cyclone-1M launch vehicle.

ITM has formulated a concept according to which space debris objects are considered as resources for industrial production in orbit and as one of the types of near-space resources. A new task arises in relation thereto, in connection with the disposal of spacecraft fragments. As a first step, it is necessary to collect all the fragments together into several clusters, each of which will be placed in one of the disposal orbits. Debris in the vicinity of these orbits will not be transported to Earth, which is distant, but to a nearby recycling centre. Thus, it is possible to develop cheaper technologies for collecting spacecraft fragments and to preserve them as a material for future space industrialization. Several dozen or even hundreds of recycling centres will not pose a threat to operating spacecraft. Within the framework of fundamental, competitive (applied) research topics, research is being conducted on the problem of space debris disposal and the implementation of industrial production in orbit.

In the context of international cooperation, Anatolii Alpatov, Corresponding Member of NASU, Doctor of Technical Sciences and Full Professor, and Serhii Khoroshilov, Doctor of Technical Sciences and Full Professor, participate as permanent experts in the work of the Inter-Agency Space Debris Coordination Committee and work in groups specializing in the protection of spacecraft from space debris.

No studies have been carried out on the safety of space objects using nuclear power sources on board or the problems associated with their collision with space debris.

The National Space Facilities Control and Test Centre (<https://spacecenter.gov.ua>) also takes part in activities related to the study of space debris, and the calculation of dangerous approaches of space objects with nuclear power sources on board and problems relating to their collision with space debris.

Representatives of the Centre take part in the work of the Steering Group and Working Group 1 of the Inter-Agency Space Debris Coordination Committee (IADC) as part of the delegation of the State Space Agency of Ukraine. In 2022 and 2023, they participated in two IADC meetings: one in Jeju, Republic of Korea, in October 2022, and one in Darmstadt, Germany, in June 2023.

Under the leadership of the representative of the National Space Facilities Control and Test Centre, the internal task of Working Group 1 of IADC was carried out, as a result of which an IADC document entitled “Recommendation for the optical observations data exchange format” was developed, which was made available on the open part of the IADC website. In the future, this document will be used to provide proposals for making relevant changes to the Consultative Committee for Space Data Systems CCSDS 503.0-B-2 “Tracking Data Message” standard.

An additional analysis of the light curves of space object 18340, which were obtained by IADC participants as part of the campaign of photometric observations of the last stages of launch vehicles in low orbits (AI38.2), was carried out in order to obtain more detailed information about the state of the space object.

In February 2022, in the context of participation in the internal task of Working Group 1 of IADC regarding the observation of the results of the fragmentation of the space object in low Earth orbit (IADC internal task 39.2), test observations of six fragments of the COSMOS1408 spacecraft were carried out by the optical sensors of the National Space Facilities Control and Test Centre. In 2023, a photometric campaign of observations of the main fragment of this space object (number 13552) was organized by the Centre and is currently ongoing.

The Centre conducts daily calculations of dangerous approaches of space objects with nuclear or radioisotope power systems that are in the United States Space Command (USSPACECOM) catalogue of space objects.

On the basis of the results of calculations carried out by the Centre, the number of dangerous approaches (in calculations, a distance between objects of less than 1,500 m is considered a dangerous approach) of space objects with nuclear or radioisotope power systems that are in the USSPACECOM catalogue of space objects was determined. During 2022, there were 425 dangerous approaches. During 2023 (as at 18 October), there were 129 dangerous approaches.

Annex

Mexico: public and private universities in Mexico engaged in activities and research relating to space debris

Public universities

Projects or observatories affiliated to the International Scientific Optical Network (ISON) project:

ISON is an international project currently consisting of 30 telescopes at 20 observatories, located in a number of countries, that are used to detect, monitor and track objects in space. The project has a presence in 50 countries and employs approximately 200 researchers.

<i>University or research centre</i>	<i>Name of institute</i>	<i>Project</i>	<i>Person responsible</i>	<i>Project description</i>	<i>Remarks</i>
Autonomous University of Nuevo León (UANL)	Faculty of Physical and Mathematical Sciences (FCFM)	International Observatory for Space Debris Monitoring – ISON project	Enrique Pérez León	Under the ISON project, with the support of the UANL Observatory, a space observation network is being established for the monitoring of space debris, asteroids and even gamma ray bursts to improve understanding of the initial conditions of the universe	The UANL Observatory was inaugurated on 7 March 2017 and has continued to operate to date The Observatory currently forms part of the master's programme in astrophysics at FCFM, supporting research
				http://vidauniversitaria.uanl.mx/telescopio-de-la-uanl-importante-para-proyecto-ison/ www.milenio.com/cultura/inauguran-observatorio-uanl-monitorear-clima-espacial	
Autonomous University of Sinaloa (UAS)	Astronomy Centre (CA)	UAS Astronomical Observatory – ISON project	Tatiana Nikolaevna Kokina Yurova	Under the ISON project, with the support of the UAS Astronomical Observatory, a space observation network is being established for monitoring near-Earth asteroids and debris generated by space technology, obtaining images and analysing information	The UAS observatory was inaugurated on 3 May 2012 and has continued to operate to date In the case of UAS, monitoring-based research and analysis are conducted in collaboration with the Keldysh Institute of Applied Mathematics of the Russian Academy of Sciences
				http://reserva.uas.edu.mx/index.php?p=2 www.noroeste.com.mx/buen-vivir/detecta-observatorio-de-la-uas-basura-espacial-KANO451478 https://direcciondecomunicacion.unison.mx/presentan-monitoreo-de-basura-espacial-en-aniversario-del-area-de-astronomia-del-difus/	

Projects with other affiliations

<i>University or research centre</i>	<i>Name of institute</i>	<i>Project</i>	<i>Person responsible</i>	<i>Project description</i>	<i>Remarks</i>
National Autonomous University of Mexico (UNAM) and Autonomous University of Nuevo León (UANL)	Institute of Astronomy (IA) and Faculty of Physical and Mathematical Sciences (FCFM)	University Programme for the Development of Astrophysics and Space – San Pedro Mártir National Astronomical Observatory (OAN-SPM)	Eduardo Pérez Tijerina	The Observatory will participate in the State Programme of Scientific Tourism, offering guided astronomical observation activities, and, as part of the project of the University programme on international collaboration, will continue to participate in the monitoring of space debris, gamma ray bursts and space weather	The OAN-SPM Observatory was inaugurated recently, in 2020, at the height of the coronavirus disease (COVID-19) pandemic The Observatory is the laboratory used by students of the bachelor's degree programme in physics who are specializing in astronomy and students of the master's degree programme in planetary astrophysics and related technologies, which meets the standard of excellence of the National Science and Technology Council
<p>https://puntou.uanl.mx/noti-u/abriria-en-julio-observatorio-astronomico-universitario-uanl/ www.astrossp.unam.mx/es/ www.planeacion.unam.mx/Memoria/2014/PDF/7.2-IA.pdf</p>					

Earlier projects

<i>University or research centre</i>	<i>Name of institute</i>	<i>Project</i>	<i>Person responsible</i>	<i>Project description</i>	<i>Remarks</i>
National Autonomous University of Mexico (UNAM)	Advanced Technology Centre (CAT) and Faculty of Engineering (FI), Juriquilla Campus, Querétaro	Strategies for reducing space debris	Saúl Santillán Gutiérrez	Research activities and development of strategies aimed at space debris mitigation, addressing such issues as the detection of space particles, the development of mathematical models of debris generation, measurements and protection plans	The research and strategy development activities began in 2013 and it is not known if those activities are still being carried out The research team included researchers, graduate students and undergraduate students in technology and engineering
<p>www.dgcs.unam.mx/boletin/bdboletin/2013_129.html www.zonacentronoticias.com/2013/02/desarrollan-en-la-unam-estrategias-para-reducir-la-basura-espacial/ www.equilibriummedicinatural.com/a-limpiar-el-espacio-sideral/</p>					

Projects focused on research and outreach (current)

<i>University or research centre</i>	<i>Name of institute</i>	<i>Project</i>	<i>Person responsible</i>	<i>Project description</i>	<i>Remarks</i>
National Polytechnic Institute (IPN)	College of Mechanical and Electrical Engineering (ESIME) and the ESIME Ticomán Aerospace Association (AAET)	General space debris research and outreach	N/A	IPN, through the ESIME Ticomán unit, founded the ESIME Ticomán Aerospace Association, one of the objectives of which is to carry out research on such topics as space debris. These bodies frequently publish articles on that topic, disseminating information within the Institute and among the general public	Since the inauguration of AAET, these bodies have produced and disseminated information on space debris and other topics They do not currently have a project as such in this area, as they are in the process of expansion
				https://www.aetipn.com/single-post/2017/04/11/basura-espacial www.unoosa.org/documents/pdf/copuos/stsc/2020/statements/2020-02-05-PM-Item08-04-MexicoS.pdf www.zaragoza.unam.mx/wp-content/Portal2015/ActividadesCulturales/NocheEstrellas/BasuraEspacial.pdf	
National Autonomous University of Mexico (UNAM)	Institute of Astronomy (IA)	General space debris research and outreach	N/A	The objectives of the Institute of Astronomy are, inter alia, to conduct research on astrophysics and develop astronomical instrumentation. The Institute also conducts outreach activities and disseminates information relating to astronomy and science in general, including the topic of space debris (see links below)	The Institute has carried out research on space since its establishment, contributing to scientific outreach through the UNAM scientific education journal <i>¿Cómo ves? – Revista de Divulgación de la Ciencia</i> Its objective is to provide high-quality training at the bachelor's, master's and doctoral levels
				www.comoves.unam.mx/numeros/articulo/170/basura-espacial www.comoves.unam.mx/numeros/retos/261	

Private universities

<i>University or research centre</i>	<i>Name of institute</i>	<i>Project</i>	<i>Person responsible</i>	<i>Project description</i>	<i>Remarks</i>
Pan-American University (UP)	Faculty of Engineering at the Aguascalientes and Mexico City campuses	Colibri Mission project (Pakal nanosatellite – CubeSat)	Led by the same group of students (see second link for information on the leaders of each area under the project)	The Pakal nanosatellite/CubeSat project is capable of obtaining measurements of atmospheric density in low Earth orbit in order to study atmospheric phenomena and contribute globally to solving the space debris problem	<p>The Colibri Mission project was inaugurated in 2018 and currently remains under development</p> <p>The project is being developed with the involvement of more than 50 Pan-American University students from different areas of study and in collaboration with the Space Propulsion Laboratory of the Massachusetts Institute of Technology, through which it has become part of the programme of international science and technology initiatives (MISTI)</p>
<p>www.sinembargo.mx/04-07-2021/3994408</p> <p>www.colibrimission.com/</p>					