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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

I. Introduction

1. At its sixty-fifth session, the Committee on the Peaceful Uses of Outer Space agreed that Member States and international organizations having permanent observer status with the Committee should continue to be invited to provide reports on research on space debris, the safety of space objects with nuclear power sources on board, problems relating to the collision of such space objects with space debris and the ways in which debris mitigation guidelines were being implemented (A/77/20, para. 102). Accordingly, a communication dated 19 August 2022 was sent to Member States and international organizations having permanent observer status, inviting them to provide their reports by 28 October 2022 so that the information contained in them could be made available to the Scientific and Technical Subcommittee at its sixtieth session.

2. The present document has been prepared by the Secretariat on the basis of information received from 10 Member States, namely, Algeria, Austria, Bolivia (Plurinational State of), Germany, India, Italy, Japan, Mexico, Myanmar and Slovakia. Further information provided by Japan, including figures related to space debris, will be made available as a conference room paper at the sixtieth session of the Subcommittee.

* A/AC.105/C.1/L.405.

II. Replies received from Member States

Algeria

[Original: French]
[11 October 2022]

These concerns are of particular importance to Algeria because of the size of its territory, the density of its population and the growing number of space objects in orbit over its territory.

However, the country has not yet undertaken research on space debris or put in place a national mechanism for space debris mitigation, owing to the recency of its space activities and the small number of Algerian satellites in orbit.

Algeria welcomes the work of the Office for Outer Space Affairs to promote international collaboration and foster progress in this area and reiterates its support for the efforts of the international community to mitigate space debris and protect the orbital and suborbital environments.

With regard to the safety of space objects with nuclear power sources on board, Algeria, which participates actively in the work of the Committee on the Peaceful Uses of Outer Space and its two subsidiary bodies and endorses the principles related thereto, is concerned about the possible consequences of the use of such power sources in outer space, which would undermine any form of long-term sustainability of outer space activities and the preservation of outer space as the common heritage of humankind for future generations.

For that reason, it recalls the provisions of article IV of the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, which stipulates that States parties to the Treaty undertake not to place in orbit around the Earth any objects carrying nuclear weapons or any other kinds of weapons of mass destruction, install such weapons on celestial bodies, or station such weapons in outer space in any other manner.

Algeria considers it essential that States pay greater attention to the potential consequences of the use of nuclear power sources and supports all initiatives involving the transfer of expertise in that area in order to enable all States that wish to make use of power sources in space to do so safely.

Austria

[Original: English]
[25 October 2022]

Besides performing routine range measurements of active satellites equipped with corner cube retroreflectors, the satellite laser ranging station of the Space Research Institute of the Austrian Academy of Sciences is currently involved in several activities related to space safety.[1] The design and assembly of backup retroreflectors for use in future satellite missions will play a crucial role in attitude determination and future removal missions. The Space Research Institute is developing a tool to simulate satellite laser ranging residuals while varying orbit, tumbling or corner cube retroreflector configuration. In addition, determination of tumbling and attitude motion is made by analysing single photon light curves, which display the reflected sunlight from satellites or space debris objects. A large database was built that characterizes and measures more than 20 different space debris objects. The combination of different techniques (for example, light curves, satellite laser ranging, space debris laser ranging and imaging radar) is also investigated and is

[1] Further information on the satellite laser ranging station is available at www.oeaw.ac.at/en/iwf/institute/infrastructure/slr-station.

referred to as “data fusion”. The Space Research Institute is also involved in the design, simulation and development of laser and detection packages for the upgrading of existing satellite laser ranging stations or for newly emerging space debris laser ranging stations.

Bolivia (Plurinational State of)

[Original: Spanish]
[24 October 2022]

According to the functions of the Bolivian Space Agency as set out in Supreme Decree No. 423 of 10 February 2010, the role of the Agency concerns the provision of services relating to satellite communications and the analysis of satellite images. Consequently, the Agency is not conducting research on the topics referred to by the Office for Outer Space Affairs of the Secretariat.

Germany

[Original: English]
[27 October 2022]

Research activities on issues related to space debris are conducted in Germany in all relevant fields. This includes space debris environment modelling, observation of space debris, technology development for observations, studies of the effects of hypervelocity impact on spacecraft, protection of space systems from the impact of micrometeoroids and space debris, as well as design for demise technologies. German experts actively participate in relevant international forums in the field of space debris research and space safety, inter alia, the Inter-Agency Space Debris Coordination Committee and the International Academy of Astronautics, in international standardization activities in the field of space debris, and in aspects of space traffic coordination. German industry and academia are also involved in technology developments to serve the long-term sustainable use of outer space and the protection of the Earth.

The German Space Agency at the German Aerospace Center (DLR) has further improved space debris mitigation in DLR-supported small-satellite projects at universities and research institutes. Internal process changes at the German Space Agency ensure that DLR space debris mitigation requirements are implemented as mandatory requirements in research grants for space missions. Furthermore, a continuous dialogue has been established with the small-satellite initiative of German universities. The aim of that dialogue is to maintain a high level of sustainability for the fast-growing space activities at universities and to support the sharing of knowledge and best practices within the university landscape. The German Space Agency provides support to ongoing projects, has offered online expert workshops related to space debris mitigation topics and has conducted a survey on space mission operations at universities in Germany. A report on the results from the survey was issued in March 2022.

Measurements

The development of capabilities for generating and utilizing sensor data is needed to establish a national space surveillance competence, for instance, to generate a space object catalogue and to perform orbit determination. Such an object catalogue is the backbone of space situational awareness operations. Therefore, the German Space Agency, through its national programme with funding from the German Federal Ministry for Economic Affairs and Climate Action, initiated the development of the German Experimental Space Surveillance and Tracking Radar (GESTRA). The system was developed by the Fraunhofer Institute for High Frequency Physics and Radar Techniques. It is an experimental system to survey and determine the orbital information of resident space objects in low Earth orbit. In 2020, the two radar

shelters were transported to and commissioned at their operational site, and further integration and test and verification activities have been performed there since then. The system can be operated fully remotely by the German Space Situational Awareness Centre (GSSAC). GESTRA is also intended to serve as an experimental platform for bi- and multi-static radar operations and to provide data to research institutions in Germany to conduct further studies in that area.

A database has been developed and has been hosted and operated by GSSAC since 2019 for the collection and sharing of measurements from the European Union Space Surveillance and Tracking (EU SST) consortium, serving as the main data-sharing platform for EU SST. As a second step, the development of a European precursor catalogue based on that database has been initiated.

Multiple options have been identified to increase the performance of ground-based surveillance radar measurements of space debris. A promising option is the use of multiple surveillance radars at separate sites working in bi- and multi-static configurations. Such a network of radars is expected not only to increase the size of a surveillance area, but also to result in better measurements of single objects. A study to further analyse such operation modes is currently being conducted through a collaboration between two Fraunhofer institutes. A simulation framework has been developed that enables the modelling of various configurations of multi-static surveillance radar systems.

An international network of optical telescopes called the Small-Aperture Robotic Telescope Network (SMARTnet) currently consists of four telescope stations with a total of nine telescopes. Those stations are located in Switzerland, Spain, South Africa and Australia, with DLR operating the ones in South Africa and Australia. A third DLR station is planned to be deployed in South America in 2023. The network is organized by DLR in close cooperation with the Astronomical Institute of the University of Bern, Switzerland, and is open to the public. The telescope stations consist of several telescopes with apertures ranging from 20 cm to 80 cm. The network monitors the geostationary region and related orbits to support research on collision avoidance and other scientific topics, encompassing data for objects larger than approximately 30 cm in geosynchronous orbits. Objects fainter than a magnitude of 18.5 have already been detected, their positions measured and their orbits calculated. A significant improvement in the accuracy of derived orbit information in geosynchronous Earth orbit was proved. Clustered satellites have also been resolved unambiguously.

DLR is also developing an information system with the Backbone Catalogue of Relational Debris Information, an orbital database for objects in Earth orbit, which is central to this project. Key functionalities, such as object correlation using observations from different sensors (e.g. SMARTnet), providing the first observational data to be processed by the system, orbit determination and orbit propagation, are currently fully operational. A graph clustering algorithm is applied for detecting new resident space objects. The system can process different measurement types, including radar, optical and satellite laser ranging (SLR). The different input data can also be fused and combined for objects to result in a better orbit determination solution. Furthermore, a complete screening algorithm to detect close approaches between objects is in development. All algorithms are programmed such that observation data for up to 100,000 objects can be processed in real time. Currently ongoing research topics include manoeuvre detection and deriving optimum planning from the database for sensors to keep all objects within a specified accuracy. Furthermore, a user interface has been developed which allows for the exporting of data from the database to be used by other software programs or by other entities.

A large Ritchey-Chrétien telescope with a diameter of 1.75 m for the observation and analysis of small space debris objects a few centimetres in size has been installed by DLR in southern Germany, at the Johannes Kepler Observatory. The telescope is equipped with four Nasmyth foci and a Coudé path. In addition, it can be used as a laser transmitter or photon receiver participating in bistatic laser ranging campaigns,

using transportable containerized laser transmitters. In general, the telescope serves as a research platform for developing new and innovative laser optical technologies for space safety applications for all Earth orbits, including the very low Earth orbit altitude range. The focus of the laser technology implemented will be in the near infrared spectral range, including, in particular, the eye-safe laser wavelength range. In addition to the implementation of active laser optical technologies, the passive optical spectral analysis of orbital objects will be addressed.

A very compact, automatically operated satellite laser ranging system (miniSLR) has been developed by DLR. The system provides laser ranging precision down to a few centimetres in the positional data, from satellites in low Earth orbits and medium Earth orbits that are equipped with retroreflectors. Such data have numerous applications in geodesy, Earth observation, satellite operation and the monitoring of decommissioned satellites. A corresponding in-orbit component based on an athermal ceramic retroreflector design has been developed and can be utilized by satellite operators as a solution for laser-based space traffic monitoring. In addition, the use of new passive polarimetric distinguishable retroreflectors allows for the tagging of satellites, which is useful, for example, in the case of cluster launches of small satellites and within satellite constellations. The miniSLR laser optical ground station is adapted as a specific laser transmitter for the polarimetric retroreflector payload components.

Modelling and on-orbit and on-ground risk assessment

The main objective of a new project at the Technical University of Braunschweig is to develop various metrics to assess sustainability criteria for the use of, in particular, the low Earth orbit with reference to the increasing collision probabilities in this region. Such investigations are of particular importance at present, since the existing mitigation policies are not specifically designed to manage the extraordinarily high number of objects expected as a result of the introduction of megaconstellations. Thus, objective criteria to assess the overall “health status” of the orbital space debris environment that are similar in concept to, for example, those of the Ocean Health Index could provide tools to not only measure the global state of that environment but also to define objective criteria for achieving its sustainability.

Germany also significantly contributes to research on the effects of on-orbit collisions and space debris impacts through the Fraunhofer Institute for High-Speed Dynamics, Ernst Mach Institute. Experimental simulation of hypervelocity impact is performed using light-gas accelerators and high-speed diagnostics at the current limits of ground testing. Spacecraft components, such as carbon fibre reinforced plastic structures, transparent materials, pressure vessels and de-orbit motor propellants, have been tested not only for evaluating damage effects and quantitative design limits but also for deriving models to assess the consequences of space debris impacts at the system level. Impact experiments, mainly performed under a European Space Agency contract, are complemented by numerical simulations for extending the parameter range of collision conditions and performing numerical experiments at the spacecraft level. Specialized hydrocodes and discrete element methods are developed and applied for complex simulations of hypervelocity collisions at the Fraunhofer Ernst Mach Institute. An example of the latter is the recently concluded DEM-O project, supported by the German Space Agency. The project demonstrates the suitability of using a discrete element method for simulating hypervelocity impact. Using particle-based models, it is possible to accurately simulate hypervelocity impact scenarios, in particular the fragmentation that results from such impacts. The discrete nature of this method puts it at a distinct advantage for modelling in-orbit satellite fragmentation and break-up when compared to traditional hydrocodes. In the last phase of the project, focus has been placed on improving the modelling of secondary impacts that occur within a satellite immediately following a hypervelocity impact event.

The concern about the on-ground risk caused by spacecraft fragments surviving atmospheric re-entry has grown significantly during the past decade, resulting in

numerous activities of the space community, such as re-entry simulation tool development, improvement and validation, as well as research on design for demise. The purpose of the first group of activities is to increase confidence in numerical re-entry risk predictions, while the aim of the second kind of activities is to develop new spacecraft design techniques which are likely to improve demise behaviour significantly.

The German Space Operations Center (GSOC) started to develop and operate a software system for conjunction assessment of spacecraft operated by GSOC in 2009 and ever since has continued to further develop, maintain and operate the system. Besides conjunction assessment, the GSOC collision avoidance system (COLA) also features collision avoidance manoeuvre planning and generation of collision avoidance products. GSOC supports other entities in conjunction assessment and collision avoidance. It shares satellite ephemeris data with conjunction service providers such as EU SST, the Space Data Association and the 18th Space Defense Squadron of the United States Space Force and actively contacts other satellite operators in order to harmonize collision avoidance measures where needed.

India

[Original: English]
[28 October 2021]

India is in the process of formally adopting a national policy on space activities which addresses, inter alia, the space debris mitigation requirements for ensuring the safety and sustainability of outer space activities.

The Indian Space Research Organization (ISRO) has initiated several research activities in the areas related to space debris, including modelling of the space debris environment, re-entry analysis, fragmentation analysis and active debris removal.

The ISRO System for Safe and Sustainable Operations (IS4OM) has been established for the coordinated management of all space situational awareness activities and the establishment of observational facilities for space object tracking. The establishment of observational facilities for the dedicated tracking and monitoring of space objects in low Earth orbit and geosynchronous Earth orbit, including the tracking and monitoring of space debris under the Network for Space Object Tracking and Analysis, are already under way. Plans to set up additional optical telescopes are also on the anvil.

A control centre has been established under the scope of IS4OM for the processing of observations from various observational facilities with a view to building a national catalogue of space debris, among other activities related to space situational awareness.

ISRO has been carrying out research to improve the atmospheric re-entry prediction of space objects and on re-entry fragmentation modelling and analysis. ISRO actively participates in the annual re-entry prediction campaigns of the Inter-Agency Space Debris Coordination Committee (IADC). Efforts towards further enhancements of the existing methodologies for the avoidance of collisions of space assets with space debris, namely, space object proximity analysis and launch collision avoidance analysis, are under way.

As a member of IADC, the Space Debris Committee of the International Academy of Astronautics, the Space Traffic Management Technical Committee of the International Astronautical Federation, Working Group 7 of the International Standards Organization and the Working Group on Long-term Sustainability of Outer Space Activities of the Committee on the Peaceful Uses of Outer Space, ISRO actively contributes to various international activities and studies related to space debris.

ISRO does not presently have any nuclear-powered space objects that can pose a threat to safety in outer space. If such an object is planned for any future mission,

ISRO will address the relevant safety issues in line with internationally accepted guidelines.

Italy

[Original: English]
[2 November 2022]

The synergies that exist in studying the hazards posed by natural and artificial space objects have emerged as stronger than ever in 2022. The Italian scientific and technological communities have long-standing expertise with regard to both types of hazards, as witnessed by their active participation in certain major national and international initiatives, which have resulted in:

(a) Advances in the realization and deployment of the so-called "Flyeye" telescopes, which are devoted to surveying the near-Earth object and space debris populations;

(b) Participation in the European Union Space Surveillance and Tracking (EU SST) consortium and the signing of the related partnership agreement, with the aim of reaching a high level of autonomy in monitoring the space debris population;

(c) Coordination of research and development initiatives at the national and international levels;

(d) The successful completion of the LICIAcube (Light Italian Cubesat for Imaging of Asteroids) mission to the binary asteroid Didymos.

The Flyeye telescope is a wide-field, high-sensitivity sensor with an unprecedentedly large field of view, jointly conceived by research institutions and industry in Italy. A network of Flyeye telescopes is able to observe the whole visible sky every night, thus it can be extremely effective in the timely detection of "imminent impactors" (that is, 50-metre-class asteroids on a collision course with our planet), as well as in surveying the medium Earth orbit region, where navigation constellations reside, and the region above 1,500 km of altitude. The first Flyeye telescope has been realized in collaboration with the European Space Agency for planetary defence purposes and is to be deployed soon at the Italian Space Agency (ASI) Centre for Space Geodesy, located in Matera, Italy, for a commissioning and science verification phase. A parallel initiative was undertaken by ASI in 2022 for the procurement of four Flyeye telescopes for use in space debris observation.

Within the framework of the EU SST consortium, Italy is in charge of providing re-entry and fragmentation services. In 2022, that operational activity resulted in close monitoring of the most significant uncontrolled re-entry events (in coordination with the Italian Department for Civil Protection), as well as in-orbit fragmentation events.

Italy is deeply involved in two research and development projects of the European Union.

The Near-Earth Object Rapid Observation, Characterization and Key Simulations (NEOROCKS) project, led by the Italian National Institute for Astrophysics, aims to address the physical characterization of near-Earth objects, the knowledge of which plays a decisive role in evaluating the severity of an asteroid impact. Extended observation campaigns accessing large-aperture telescopes have been carried out, a refined database of near-Earth object physical properties has been implemented and a "rapid response experiment" that follows the whole sequence, from discovery to astrometric follow-up and physical characterization of a newly discovered object, has been successfully performed.

In November 2022, the Space Debris and Asteroid Research Network (Stardust) project organized the second International Stardust Conference in order to share methods and results generated by the project and to expose the participants, in

particular early-stage researchers, to the research being actively conducted around the world in the fields of space debris and asteroids.

The problems of near-Earth objects and space debris share the need to use the advanced methods of the field of celestial mechanics. In this respect, the Italian celestial mechanics community has been involved at the highest level in many meetings organized throughout the year to address a great variety of issues, from purely theoretical aspects to space applications. It is worthwhile to mention the Eighth International Meeting on Celestial Mechanics, organized by the University of Rome Tor Vergata, the International Workshop on Co-orbital Motion (COOMOT) held at the Institute for Applied Mathematics and Information Technologies "Enrico Magenes" of the National Research Council of Italy in Milan, Italy, and the Celestial Mechanics Theory and Applications (CELTA)-Cortina Summer School No. 14, hosted by the University of the Highlands and Islands, Scotland, United Kingdom of Great Britain and Northern Ireland. The enthusiastic participation of a new generation of skilled students and young researchers has been recorded in all cases.

Finally, an outstanding result has been obtained thanks to the close collaboration between the Italian scientific and industrial communities, coordinated by ASI. On 11 September 2022, the LICIAcube satellite separated from the Double Asteroid Redirection Test (DART) spacecraft of the National Aeronautics and Space Administration of the United States of America, which was aimed to impact Dimorphos, the 140-m satellite of the asteroid Didymos, in order to perform the first-ever asteroid deflection experiment. All LICIAcube subsystems functioned nominally and on 26 September 2022 the Italian probe successfully imaged the plume generated by the impact of the DART spacecraft, thus providing unique data for both improving our knowledge of the asteroid's composition and internal structure and modelling the dynamics of impacting a small celestial body.

Japan

[Original: English]
[20 October 2022]

Overview

The present report covers debris-related activities mainly conducted by the Japan Aerospace Exploration Agency (JAXA), as requested by the Office for Outer Space Affairs of the Secretariat.

The following debris-related research and development activities are being conducted as of October 2022:

(a) Active debris removal;

(b) Status of debris avoidance manoeuvres and research on core technology for space situational awareness;

(c) Research on technology to observe objects in low Earth orbit and geostationary orbit (geosynchronous Earth orbit) and determine their orbits;

(d) In situ microdebris measurement system;

(e) Development of a composite propellant tank;

(f) Space debris observation using satellite laser ranging, and the development of a general-purpose satellite laser ranging reflector.

Further information is provided in the sections below.

Status

Active debris removal

JAXA has organized and structured a research programme that is aimed at realizing low-cost active debris removal missions. The research and development of key technology for active debris removal has three major themes: non-cooperative rendezvous, capture technology for non-cooperative targets and de-orbiting technology to remove massive intact space debris. JAXA is cooperating with Japanese private companies to realize low-cost active debris removal on a commercial basis and working to provide these essential key technologies for that purpose.

JAXA is also leading the Commercial Removal of Debris Demonstration (CRD2) programme. The programme comprises two phases and is aimed at conducting active debris removal in partnership with private enterprises. During the first phase of the programme, the demonstration of key technologies such as non-cooperative rendezvous and proximity operation, and the inspection of the H-IIA second stage are planned for Japanese fiscal year 2022. During the second phase, the demonstration of active debris removal and re-entry of the H-IIA second stage is planned for after Japanese fiscal year 2025. Astroscale Japan Inc. was selected through an open competition in February 2020 as a partner company for the first phase.

Status of debris avoidance manoeuvres and research on core technology for space situational awareness

JAXA regularly receives conjunction notifications from the Combined Space Operations Center (CSpOC). In 2021, JAXA executed two debris avoidance manoeuvres for spacecraft in low Earth orbit. As a satellite operator, JAXA has recognized that the conjunction risk posed by space debris remains high, as the space environment deteriorates year after year.

Core technology for space situational awareness

JAXA has developed a new space situational awareness system, which is currently in trial operation to check its performance before it goes into full operation in April 2023. The system includes:

(a) Radar: JAXA has developed a new radar for low Earth orbit, which can observe 10-cm-class objects at an altitude of 650 km;

(b) Telescope: JAXA has refurbished its 1-m-class and 50-cm-class telescopes to increase their capability to observe space debris in high orbit, including the geostationary orbit;

(c) Analysis system: JAXA has developed a new system to analyse observation data from the radar and telescope facilities, which is then used to conduct risk assessments and make collision avoidance plans in cases where space debris is approaching JAXA satellites.

JAXA has also developed a tool to support planning for debris avoidance manoeuvres upon receiving a conjunction data message from CSpOC and has made it available free of charge to all satellite operators on the JAXA website since March 2021.

The tool is expected to simplify the procedure for debris avoidance manoeuvres and reduce the related workload. JAXA will continue this activity.

Research on technology to observe objects in low Earth orbit and geostationary orbit (geosynchronous Earth orbit) and determine their orbits

Generally, the observation of objects in low Earth orbit is conducted mainly by radar system, but JAXA has been working to develop an optical system to reduce the cost of both construction and operation. A large complementary metal-oxide

semiconductor (CMOS) sensor for low Earth orbit observation has been developed. Analysing the data from the CMOS sensor with field programmable gate array-based image-processing technologies enables the detection of objects in low Earth orbit measuring 10 cm or less. In order to increase the observation opportunities in relation to objects in low Earth and geosynchronous Earth orbits, two remote observation sites have been established in Australia, one at the Zadko Observatory in Western Australia and another one with an installation comprising four 18-cm telescopes at the Siding Spring Observatory in New South Wales, in addition to the Mount Nyukasa Observatory in Japan. These observation sites will make it possible to carry out precise orbital determinations and altitude estimation of objects in low Earth orbit using the data from both sites in Australia.

In situ microdebris measurement system

The space debris monitor is an in situ microdebris sensor focusing on micro- to milli-sized debris in orbit. The latest flight experiment was conducted by H-II Transfer Vehicle Kounotori-5 (HTV-5). Information based on actual measurements of those small debris objects is essential to properly understand the vast amount of small debris orbiting near the Earth, especially since such debris is becoming a dominant risk factor in orbit.

The unique properties of the space debris monitor are its simple detection system, which does not need any special calibration before flight, and the potential to collaborate easily with other sensors. The space debris monitor consists of a debris detection area and circuit areas. The debris detection area is made of very thin polyimide film and there are thousands of 50-µm-wide conductive grid lines capable of detecting the diameter of collided debris measuring from 100 µm to millimetres.

JAXA is jointly collaborating with the Orbital Debris Program Office of the National Aeronautics and Space Administration (NASA) of the United States of America to develop a new in situ microdebris measurement system in order to understand the number of small debris objects orbiting at an altitude of less than 1,000 km. In a collaboration between NASA and JAXA, a series of hypervelocity impact tests are under way using a breadboard model.

Development of a composite propellant tank

A propellant tank is usually made of titanium alloy, which is superior because of its light weight and good chemical compatibility with the propellant. However, its melting point is so high that such a propellant tank would not demise during re-entry and would pose a risk to people on the ground.

For several years, JAXA conducted research to develop an aluminium-lined, carbon composite-overwrapped tank with a lower melting temperature. As a feasibility study, JAXA conducted fundamental tests, including a liner material aluminium compatibility test with hydrazine propellant and an arc heating test.

After the manufacture and testing of a shorter engineering model EM-1 tank, JAXA manufactured a full-sized EM-2 tank. The shape of the EM-2 tank is identical to that of the nominal tank, which includes a propellant management device. Using the EM-2 tank, a proof pressure test, a vibration test (for wet and dry conditions), an external leak test, a pressure cycle test and a burst pressure test were conducted, and all of them showed good results. Subsequently, the critical design review was completed.

The composite propellant tank has a shorter delivery period and lower cost than a titanium propellant tank. Experimental and analytical evaluation of demisability during re-entry is ongoing.

Space debris observation using satellite laser ranging, and the development of a general-purpose satellite laser ranging reflector

JAXA is focusing on satellite laser ranging as the third space debris observation method after radar and telescope observation.

The Tsukuba satellite laser ranging station is scheduled to enter into operation in April 2023.

In recent years, it has become increasingly important to improve the visibility of orbiting objects. JAXA has developed an affordable and compact satellite laser ranging reflector (named Mt.FUJI) that can be universally used in low Earth orbit. JAXA will promote its application internationally to improve the trackability of on-orbit objects, thereby contributing to the sustainable use of outer space.

Mexico

[Original: Spanish]
[28 October 2022]

The amount of space debris in orbit continues to grow as a result of new launches and the fragmentation of existing objects, and most of the potentially harmful orbital debris is not regularly monitored. Although compliance with existing space debris mitigation guidelines has improved to some extent, current compliance rates (between 40 and 60 per cent, depending on the orbital regime) are far from those needed to prevent the steady increase in debris collisions.

The growing number of small satellites, the decreasing lifetime of satellites and the possibility of creating large commercial constellations of thousands of satellites are posing new challenges. At the same time, the increase in commercial options for space situational awareness, on-orbit servicing of satellites and active debris removal could bring some benefits, although these activities present their own political and legal challenges.

Mexico supported the initiative of Canada, Germany and Czechia to create a compendium of actions to mitigate such debris, which was submitted for consideration by the Legal Subcommittee of the Committee on the Peaceful Uses of Outer Space at its fifty-third session and was 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.[2]

Space debris has already fallen to Earth in Mexico, so far without causing harm to people but nonetheless posing a major risk, which the Mexican Space Agency (AEM) has begun working to address. The most recent incident of this type occurred on 25 April 2016, when space debris from the Russian Federation spacecraft Soyuz-2-1A fell in Mahahual, Quintana Roo State, Mexico. In the same year and in the same place, fragments of the European spacecraft Ariane 5 were found. The necessary measures were made possible by the Quintana Roo State Civil Protection Unit and local residents.[3]

Falling space debris is a reality not only in Mexico but also worldwide. A solution must therefore be sought in order to address the situation before serious consequences occur.

Accordingly, and given the importance of the issue, Mexico, through the Mexican Space Agency, has taken steps to become a member of the Inter-Agency Space Debris Coordination Committee and has also begun to coordinate, at the national level, activities relating to the problems of space debris.

[2] www.unoosa.org/oosa/en/ourwork/topics/space-debris/compendium.html.

[3] Further information on the incident is available at https://elquintanaroo.mx/cae-basura-espacial-en-mahahual (in Spanish).

With a view to coordinating the experience of Mexico at the national level, public and private universities have likewise undertaken the task of developing models for the identification of debris and the monitoring of space debris and satellite damage through observatories to ensure the safety of space infrastructure, as well as activities, research and methods that have proved effective in reducing the generation of space debris.

One such activity is the recent Colibri Mission, which is a university project aimed at helping to mitigate space debris by means of a cube satellite capable of locating, with exact coordinates, the position of space debris, to be complemented by a series of models based on gravity, atmosphere, velocity and many other variables.[4]

The Colibri Mission satellite will remain in orbit for one year. It is currently in the design phase, during which the mission has been technically defined, and the implementation process is now under way.

Lastly, an indicative table showing the main activities and research being carried out by public and private universities in Mexico in relation to space debris is included in the annex to the present document.

Myanmar

[Original: English]
[20 October 2022]

As one of the States attending the UNISPACE+50 high-level segment held on 20 and 21 June 2018, Myanmar was congratulated and noted for participating in the historic anniversary of the first United Nations Conference on the Exploration and Peaceful Uses of Outer Space, supported by the Office for Outer Space Affairs. Myanmar will remain a member of the international space community with the aim of strengthening the uses of space in achieving the Sustainable Development Goals.

As a developing country, the Government of the Republic of the Union of Myanmar has already formulated a space programme aimed at fulfilling the space aspirations of launching a national satellite and gaining control over strategic national communications and broadcasting. While operating its satellite system, Myanmar will emphasize space science, technology, law and policy for the benefit of the regional and multiregional community and also contribute to the achievement of global initiatives such as the 2030 Agenda for Sustainable Development.

As the national satellite project is at the planning stage, Myanmar has not faced the issues of space debris, nuclear power sources and related problems. Although Myanmar has not yet considered the research on those issues, it will focus on cooperation with the international community and organizations to develop and implement space debris mitigation, as it is important to ensure a secure and peaceful space environment while its own satellite system is in progress.

Slovakia

[Original: English]
[28 October 2022]

Slovak optical sensor observations of objects that are potential targets for active debris removal missions and to monitor conditions prior to re-entry

The Department of Astronomy and Astrophysics, part of the Faculty of Mathematics, Physics and Informatics of Comenius University in Bratislava, observes, on a regular basis, with its 0.7-m Newtonian telescope (AGO70), objects in low Earth orbit that are potential candidates for active debris removal missions,

[4] Further information on the Colibri Mission is available at https://colibrimission.com.

including targets such as the European Space Agency Vespa adapter. Additionally, extensive campaigns have been conducted to monitor the dynamic and rotational properties of objects months and weeks before their re-entry in order to more accurately predict their demise.

Application of the Slovak all-sky meteor network for re-entry events monitoring

The Faculty of Mathematics, Physics and Informatics of Comenius University is investigating the possibility of using its Automatic Meteor Orbit System (AMOS) camera system for space debris re-entry measurements. AMOS is used for automatic meteor detection, orbit determination and spectrum extraction. Comenius University developed and is now operating a total of 23 AMOS cameras worldwide, including spectral cameras, with 7 situated in the Slovak Republic, 3 in the Canary Islands (Spain), 4 in Chile, 3 in Hawaii (United States of America), 6 in Australia and 4 recently deployed in South Africa. The AMOS network detects re-entry events, which allows the Faculty to model the trajectories of created fragments in the atmosphere and to analyse their spectral properties. The analysis should lead to an improvement of survivability predictions for fragments and on-ground population risk estimates.

Space debris characterization through photometry and spectroscopy

The Faculty of Mathematics, Physics and Informatics of Comenius University is conducting several studies dedicated to the classification and characterization of space debris objects in order to better understand the origins and creation mechanisms of space debris. The AGO70 telescope is used to acquire light curves of space debris. Those data are used to identify the objects' reflectance properties and their size and shape. The Faculty is investigating the application of machine learning methods to distinguish objects according to their brightness properties and to classify space objects according to their shape and surface reflectance properties. By using different spectral-type photometric filters, the Faculty is investigating the surface reflectance properties of space objects as a function of wavelength, which is directly related to material properties. AMOS spectral cameras are used to acquire specular glints and their spectra from objects in low Earth orbit. The acquired spectra provide high-resolution information about surface properties as a function of wavelength.

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.

University or research centre	*Name of institute*	*Project*	*Person responsible*	*Project description*	*Remarks*
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
	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

University or research centre	*Name of institute*	*Project*	*Person responsible*	*Project description*	*Remarks*
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
	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				

Earlier projects

University or research centre	*Name of institute*	*Project*	*Person responsible*	*Project description*	*Remarks*
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
	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.equilibriummedicinanatural.com/a-limpiar-el-espacio-sideral/				

Projects focused on research and outreach (current)

University or research centre	*Name of institute*	*Project*	*Person responsible*	*Project description*	*Remarks*
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
	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 on the topic of space debris (see the links below)	The Institute has carried out research on space since its establishment, contributing to scientific outreach through the UNAM scientific education journal *¿Cómo ves? – Revista de Divulgación de la Ciencia*. 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

University or research centre	*Name of institute*	*Project*	*Person responsible*	*Project description*	*Remarks*
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 mentioned in the remarks (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	The Colibri Mission project was inaugurated in 2018 and currently remains under development. 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)
	www.sinembargo.mx/04-07-2021/3994408 www.colibrimission.com/				