**Lunar SAR**

**IAASS’ topics of interest and messages**

**Preamble**

Space Safety is the common denominator of Space activities, irrespective of participant’s nationality, affiliation and type of international cooperation. On such grounds, Search and Rescue (SAR) activities in Space, and more specifically on Lunar Soil, can be tackled with the aim of building a sincere cooperation among different key-players at operational level and bridging possible political gaps.

Astronauts’ SAR is mentioned in several diplomatic documents governing space activities, such as the Outer Space Treaty (OST), the Astronauts’ Agreement, and the Moon Agreement. Astronauts’ SAR activities that may be encountered in space, whether in Earth orbit, in Outer Space or on the Moon, will also face challenging new technical and operational aspects in addition to the already existing diplomatic and political ones for Astronauts’ SAR activities on Earth, whether on land, at sea or in the air. SAR activities in Space are practically impossible to carry out unless an appropriate agreement is in place following extensive preparation and comprehensive negotiation between the Parties, encompassing many aspects, inter alia legal, semantic, technical and operational, etc.

Previously debates about SAR in Space carried on in Conferences regularly organized by the Space Explorers, or the professional association of Astronauts from all over the world. This initiative has lost momentum since the days of US – USSR/Russia cooperation in Space activities, because there was not much to discuss. In view of the near-term announced Lunar activities by several actors, who are no longer necessarily in a cooperative attitude, now is the time to resume this discussion at an expert level. Grounded in a genuine dedication to the preservation of human life, and above each political dimension, we have a moral imperative to address the problems and implications in managing the associated risks, ultimately focusing on procedures and operations.

**Background considerations**

The obligation to provide support to astronauts in distress, as defined in the OST, is referred to “States”: at the time of the negotiation and signing of the OST, only two States had Human Spaceflight capabilities and each of them had its own area of influence. With this in mind, it is very reasonable to understand that, even without explicitly mentioning these two States, the OST was intended for the possible ground operations in case the crew launched by a State could have landed outside the borders of this State or of States within its area of influence; even more delicate would have been the case of landing within the borders or area of influence of the other State. With this understanding in mind, this point of the OST aimed for a reciprocity basis.

Today’s situation of Space activities is much different from that of OST’s signing times, especially regarding the foreseeable activities announced for Lunar Exploration, Colonisation and Exploitation. Two government-led, international Consortia are preparing Lunar activities for the near future: the United States-led Consortium organized under the ARTEMIS accords signed by 20 States so far, and the International Lunar Research Station (ILRS), a mega space project jointly proposed by the national space agencies of China and Russia, expected to become operational by 2035. Several private actors have announced their interests, and at least one (iSpace) has already launched and plans to begin commercial operations on the moon soon.

Even taking into account these significant changes in the overall scenario or the case that the OST might become de-facto commonly ignored by the tacit agreement of key-players, the obligation originally defined by the OST remains in effect as long as the OST is not changed or declared obsolete, considering that “pacta servanda sunt”.

The second and significant difference with respect to the context of original OST is that SAR operations on Lunar soil can obviously only be performed by Astronauts, Cosmonauts or Taikonauts which are physically on the Moon and no longer by the traditional State Forces or Civil Service, as it could be the case of SAR operations on Earth’s land, sea or air. It is suggested here to call anyone who operates on the Moon, regardless of the State from which their mission was launched, Moonwalkers or “Selenenauts” – from Selene, the ancient Greek name of Moon. So, if only the Selenenauts physically present on lunar soil could provide support to fellow humans who ended up in difficulty during lunar operations, regardless of their nationality or under the aegis of which State they are carrying out SAR operations, their execution can only be made possible by previous agreements, procedures, and communication standards necessary for compatible interfaces.

It could be argued whether the OST obligation on this point, which is explicitly referred to States Parties to the Treaty, is to be extended to Selenenauts, as they are not States per se. While it could easily be argued that Astronauts, Cosmonauts and Taikonauts acting in the context of a mission led by a State performing Human Spaceflight could be considered formal representatives of that State, it may not be immediately clear whether that status can or should be also extended to Selenenauts acting for a private enterprise, which is not a State per se. In this regard, however, it should be noted that the OST also specifies that the State from which a mission has been launched bears international responsibility for that mission[[1]](#footnote-1). From this point of view, even the Selenenauts participating in a commercial mission launched by a private company should be considered representatives of the State that authorized the mission. In this context, it could be inferred from the above considerations that the OST will still be applicable for the announced Moon activities, even in case they are not managed directly by States.

It might be predictable that Lunar bases, whether belonging to different international programs, such as ARTEMIS or ILRS, or to private, commercial enterprises, would be located relatively close to an area of common interest, such as the South Pole, where large reservoirs of water ice are signposted. If so, they might also be located relatively close to each other, which could ease the logistic of carrying out SAR activities. SAR operations could also be possible, albeit a little more complicated, in case the bases are located far apart, relying on vehicles in cislunar orbit. In either case, any discussion that could be held in the short term about which places on the lunar soil the different actors intend to choose to land and settle should already now include considerations on the lunar SAR activities to be carried out at the time they will be necessary.

**Implementation Challenges**

The foreseeable challenges to implement the obligation defined by the OST for the provision of SAR in case of distress of crew are mainly of two natures: legal and technical/operational. While we will try to address the two categories separately here, in many respects they are intertwined.

***Legal Challenges***

To facilitate the execution of common procedures aimed at providing support, the Parties need a mutual agreement to abdicate to at least part of their sovereignty and establish a shared, but independent, Governance. This aspect encompasses virtually all others. Below is a non-exhaustive list of the main points on which the Parties must agree:

* *Jurisdictional – Mutual Waivers of Responsibility*: that whoever provides assistance may be in the position to manipulate, invade, etc., the sovereignty of persons and/or properties. Clear examples of this point are reciprocal exchange of crew medical data and system technical data, down to the level required to enable the expected SAR intervention.
	+ *Confidentiality*: to disclose and exchange in advance confidential medical information of one’s Space Operators (Selenenauts) in order to put those who provide support in the condition to intervene in a safe and effective way.
	+ *Proprietary Information*: to disclose proprietary information about specific hardware and software items or to converge on commonly agreed standard items, in order to ensure safe operations.
* *System’s Architecture*: to agree on a standard, or at least compatible, system architecture such to enable joint operations.
* *Semantic / Language*: to use pre-defined common language(s) (English, Chinese, Russian, etc.), taxonomy and instruction set, in order to operate safely in case of emergency.
* *Communications*: to rely on common communication protocols and adequate technology tools to ensure clear, reliable and unambiguous communication.
* *Operational Procedures*: to ensure a clear and consolidated modus operandi that can be implemented even in conditions of stress and emergency; a common set of standard procedures must be agreed upon and exercised regularly in shared training.
* *Command Line*: to delegate the necessary autonomy to the local SAR Operators, with full remote support, but without direct interference, from the States to which Operators belong.
* *Prioritized Resource Allocation:* allocate predetermined resources to the commonly established SAR Entity maintain the required level of allocation for the required time and under the required conditions and at the required level of priority to enable operations.

***Technical/operational challenges***

Search and Rescue (SAR) Operations in harsh and hostile environment are inherently life-threatening, face technical and operational challenges, enforce stringent and not negotiable requirements, and must follow standard protocols without deviations and compromises.

This mandates standardized - or fully compatible - sets of hardware, software, operational procedures and management of any related information. A simple, not exhaustive, list of capabilities already developed either for the terrestrial or Low earth Orbit (LEO) environment to be exported on and adapted to the lunar environment, be it lunar surface or cislunar orbits, includes:

* communicate and navigate
	+ *The absence of magnetic field on the Moon imposes use of a Moon Global Navigation Satellite System; experience acquired on Earth could be exported*
* distress tracking and messaging
	+ *Experience out of terrestrial Advanced Next Generation Emergency Locator (ANGEL) beacons, including distress messaging standard format definition, could be exported*
* surface mobility
	+ *In addition to nominal exploration activities, adequate surface mobility is required for the safe transportation of distressed re and first-help provision*
* international surface docking standard
	+ *Evolution of existing international docking standards to enable crew transfer between the Moon Surface and Pressurised Modules*
* EVA standardised access/egress to/from pressurised habitats
	+ *Dust mitigation measures and dust removal protocols*
	+ *Airlock hatch compatible dimensions*
	+ *Life support interface control panels and umbilical interfaces*
	+ *RF communication between EVA crew members, spacecraft and ground*
* Standard EVA-to-EVA suit interfaces
	+ *Interoperability, to provide emergency support between EVA suited crews*

Several of these technologies, although familiar virtually since the beginning of Space activities, have to be redesigned and training activities redefined, in view of future applications on the Moon [[2]](#footnote-2). The time has therefore come to lay the foundation of possible agreements and propose both legal and technical roadmaps to make the implementation of any Lunar SAR activity possible later-on.

**The precedent of the ISS**

The scenario described above is not new in Space activities, as it is already largely implemented for the case of the ISS, which is a co-ownership between the Participant States, in principle on equal terms and regulated by the IGA signed by the Governments of the Participant States. This co-owned status has naturally generated and sustained the need of open communication, standardization, and exchange of sensible information, as well as commonly agreed priorities and cooperation.

A similar level of cooperation and of willingness to both accept and abide by agreed principles and conditions could be expected within each Consortium participating in Lunar activities. However, it is easily foreseeable that the acceptance of these principles by different Consortia is not so easy, in consideration of the naturally competitive nature of commercial activities, and of the competitive and potentially adversarial nature of both geo-political entities involved (the Consortium led by the United States under the ARTEMIS accords, and the ILRS Sino-Russian team).

**Examples of SAR Operations in harsh and hostile environments on Earth working well**

Safety of human life is paramount and remains the overriding principle governing any emergency response anywhere around the world. Search and Rescue cooperation agreements to safeguard human life and conduct SAR operations in harsh and hostile environments on Earth, established by Entities that do not necessarily cooperate outside these specific boundaries, exist and work well. Some are listed below are taken as inspirational examples for Lunar SAR Operations as well.

***ISMERLO***

The International Submarine Escape and Rescue Liaison Office (ISMERLO) is an organization that aims at facilitating an international response for a distress submarine (DISSUB) and at enhancing the ability to respond to a call for assistance through its coordination role. Although established by NATO, ISMERLO supports all nations and pursues the involvement of nations operating submarines globallly. ISMERLO is a military organization operating in an international environment and focused on the humanitarian objective of saving lives at sea.

The 15 members of ISMERLO currently are: Australia, Brazil, China, France, India, Italy, Japan, NSRS (NATO Submarine Rescue System) , Korea (ROK), Russia, Singapore, Spain, Sweden, Türkiye, USA.

***ARCTIC AGREEMENT***

In May 2011, the eight Arctic States signed the Agreement on Cooperation on Aeronautical and Maritime Search and Rescue in the Arctic during the 8th Arctic Council Ministerial in Nuuk, Greenland (Denmark). This is the first legally binding agreement negotiated under the auspices of the Arctic Council, the leading intergovernmental forum formally established in 1996 and promoting cooperation, coordination and interaction among the Arctic States, Arctic Indigenous peoples and other Arctic inhabitants on common Arctic issues, in particular on issues of sustainable development and environmental protection in the Arctic.

***SAR in Antarctic***

The Antarctic region is defined as the Antarctic Treaty area South of 60 degrees latitude South as well as peripheral ocean areas in which ships and aircraft transit between the Antarctic and South Africa, Australia, New Zealand or South America. Besides the traditional exploration and scientific missions, also touristic activities in Antarctic significantly increased in recent times.

The allocation of responsibility for Search and Rescue (SAR) depends on “who” is in distress, irrespective of what may be deployed in the operation: “maritime” SAR when a ship or person at sea is in distress; “aeronautical” SAR when an aircraft is in distress; and “land” SAR in all other cases.

International Search and Rescue systems and procedures for the Antarctic exist and are based, as in the rest of the globe, around the International Maritime Organisation (IMO) and International Civil Aviation Organisation (ICAO) global search and rescue plans, which divide the globe into search and rescue regions (SRRs). Exactly the same obligations and principles that apply in the rest of the world apply to the Antarctic, except that while maritime and aeronautical SAR are covered, land SAR is not, as no nation is responsible by international agreement for coordinating land SAR in the Antarctic.

Besides the difficult climate and geography of the Antarctic region what makes Search and Rescue in the Antarctic notably different and difficult is that most of the region is remote from emergency response assets and facilities. Additionally, ships and aircraft operating in the harsh Antarctic environment need special capabilities to deal with the cold and ice conditions.

***Cospar-Sarsat***

The International Cospar-Sarsat Programme is a satellite-aided search and rescue (SAR) initiative. It is organized as a treaty-based, nonprofit, intergovernmental, humanitarian, cooperative of 45 nations and agencies. It is dedicated to detecting and locating emergency locator radio beacons activated by persons, aircraft or vessels in distress, and forwarding this alert information to authorities that can take action for rescue. Member countries operate a constellation of around 66 satellites orbiting the Earth which carry radio receivers capable of locating an emergency beacon anywhere on Earth transmitting on the Cospas-Sarsat frequency of 406 MHz.

Distress alerts are detected, located and forwarded to over 200 countries and territories at no cost to beacon owners or the receiving government agencies. Cospas-Sarsat was conceived and initiated by Canada, France, the United States, and the former Soviet Union in 1979. The first rescue using the technology of Cospas-Sarsat occurred on 10 September 1982; 40 years ago. The definitive agreement was signed by those four States as the "Parties" to the agreement on 1 July 1988.

The term Cospas-Sarsat derives from COSPAS (КОСПАС), an acronym from the transliterated Russian "Космическая Система Поиска Аварийных Судов" (Latin script: "Cosmicheskaya Sistema Poiska Avariynyh Sudov"), meaning "Space System for the Search of Vessels in Distress", and SARSAT, an acronym for "Search And Rescue Satellite-Aided Tracking".

**Conclusions and recommendations**

IAASS[[3]](#footnote-3) and BIT[[4]](#footnote-4) have jointly organized the 1st Conference on Lunar SAR activities in October 2022.

The main outcome of the Conference is that the implementation of Lunar SAR capabilities requires the development of the following elements:

1. Satellite-based communication and navigation systems
2. Receivers and transmitters of distress radio signals. Processing, localization, and transmission of alert messages
3. Development of international Lunar SAR interoperability standards
4. Performance of dedicated research and development activities
5. Organisation for coordinating and executing rescue operations

It is emphasized that any decision capable of enabling Lunar SAR Operations must be made as soon as possible, both at legal and technical/operational level, as it would be extremely difficult, if not impossible, to retrofit quickly the system when the need for a SAR operation occurs. Therefore, this discussion should become part of the one addressing how the different key players plan to make known the places on the lunar soil they intend to choose for landing and development.

1. As per Article 6 of the OST: “States Parties to the Treaty shall bear international responsibility for national activities in outer space, including the Moon and other celestial bodies …, and for assuring that national activities are carried out in conformity with the provisions set forth in the present Treaty. The activities of non-governmental entities in outer space, including the Moon and other celestial bodies, shall require authorization and continuing supervision by the appropriate State Party to the Treaty.”. [↑](#footnote-ref-1)
2. E.g., t*wo modules approaching to perform the docking maneuver on the Moon surface are within a gravity field and each of them is independently referred to its interface with the underneath soil; therefore, a new system of exchanged forces has to be considered as they are not any longer free floating, as used to be when docking in orbit, and have lost the automatic self-alignment capability.*  [↑](#footnote-ref-2)
3. The International Association for the Advancement of the Space Safety (IAASS) is a non-profit association committed to furthering international cooperation and scientific advancement in space systems safety. Legally established on April 16, 2004 in the Netherlands, IAASS became a member of the International Astronautical Federation (IAF) in October 2004 and in June 2010 IAASS was granted the Observer status at the United Nations COPUOS (Committee on the Peaceful Uses of Outer Space). [↑](#footnote-ref-3)
4. Beijing Institute of Technology (BIT) is a national leading co-educational public university located in Beijing, China. It was established in 1940 in Yan’an, Shaanxi. It is a major research university under the supervision of the Ministry of Industry and Information Technology. [↑](#footnote-ref-4)