Chapter V

Space – A Real but Invisible Property

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The commercialization of space has taken place in such a manner that space is being treated as a commodity or a property. Man's hunger to become richer and richer is not confined to owning property on the earth, but has travelled beyond the earth's frontiers into space. The old saying that *the world is a global village* is rapidly losing its shine and a new phrase is knocking on the door, i.e. *the universe is a metro city*. Since space is being treated as a commodity or property, all rights on other moveable or immovable property are going to be exercised on space too. The days are not far when the existing statutes like Transfer of Property Act, Contract Act, Sale of Goods Act, laws related to Intellectual Property Rights, etc. will have to be amended to incorporate space and outer space activities. Though the amendments in other Acts may wait for sometime, the issue related to intellectual property rights over space and outer space has already heated up.

5.1 Property Rights and Disputes in Outer Space

'Space – The Final Frontier' : Thus goes the famous tag line of the immensely popular Star Trek series. History has witnessed that almost everything that is possible to imagine in the human mind, gets concrete shape sooner or later, and human imagination has no limits. So whether space really is the final frontier or not for human beings will only become apparent in the future, but it certainly seems to be the final frontier for lawyers. Space buffs are dreaming about vast land developments on the moon, planets and asteroids – and wherever

people start making land claims, lawyers can't be far behind. In 2005, the U.S. Court of Appeals for the Ninth Circuit in San Francisco dismissed a lawsuit by a Nevada man who claims he owns Asteroid 433, a mountainous celestial rock also known as Eros. After NASA landed a robotic spaceship on Eros in 2001, online entrepreneur and space enthusiast Gregory W. Nemitz of Carson City, hoping to set a legal precedent for future cosmic exploration, informed the space agency that he owned Eros. He had previously filed his claim to ownership of the asteroid at an online registry for celestial land claims, which a professor of Seton Hall University School of Law started in the 1990s to stir discussion of space-related legal issues.

After NASA landed its probe on Eros, Nemitz asked NASA to pay a "parking/storage fee" of $20 for one century, plus late-payment fees. The agency refused to pay. NASA general counsel Edward Frankle informed Nemitz that his property claim "of a celestial body ... appears to have no foundation in law". In response, Nemitz sued NASA and the U.S. State Department.

In April 2004, the U.S. District Court in Reno tossed out Nemitz's suit "for lack of a recognizable legal theory" behind his claims. On 10th February, the San Francisco-based Ninth Circuit issued a terse ruling, without explanation, that upheld the District Court decision.

Disillusioned by the decision, Nemitz, a non-lawyer who argued the case himself without the aid of an attorney, plans no further legal action. But he is quite upset about what he regards as a federal transgression of his rights.

Though it sounds strange, the case of Nemitz v. United States is just one of the more peculiar sideshows in an emerging circus known as "space law". Space is new legal territory, just as the air was in the early days of aviation and as the seas were in the dawn of ocean voyaging. For space buffs, the stickiest legal issue is property rights in space, the question of whether a private person can lay claim to property where there is no constituted government. And it involves not only land, but also the airless void of space. Entrepreneurship is the driving force.

Space enthusiasts look forward to an age of space commercialization on a grand scale, ranging from orbital hotels with zero-gravity swimming pools that float in the middle of a room to lunar factories that mine nuclear fuel for terrestrial fusion reactors. They are afraid that such dreams might be stillborn if the legal details, especially property rights, are not worked out in advance.

The legal status of property claims in space remains uncertain partly because of the ambivalent wording of the U.N. Outer Space Treaty of 1967, which called space "the province of all mankind". A subsequent U.N. document, the Moon Treaty of 1979, was less ambiguous, as it implied that space resources should be commonly owned by all nations. The United States signed the first treaty but not the second one. Most space fans vehemently opposed the Moon Treaty, believing that its assertion that the moon could not become "the property of any state, international, intergovernmental or nongovernmental organization" was socialistic and would force space entrepreneurs to share their profits with all nations.

In a potentially groundbreaking article on space property rights, space law expert Rosanna Sattler argued that an overhaul of current treaties and laws is needed to "stimulate commercial enterprise on the moon, asteroids and Mars."

A major corporation "is not going to invest millions and millions of dollars for a communications system on the moon if there's no law up there to protect their assets," said Sattler, whose article, titled "Transporting a Legal System for Property Rights: From the Earth to the Stars," appeared in the summer issue of the University of Chicago Law School's Chicago Journal of International Law.

Another lawyer trying to rewrite space law, UC Davis-educated Wayne White of Boulder, Colorado, advocates revising space law via a legal theory that he calls "property rights without territorial sovereignty".

White, who served on the U.S. State Department's legal subcommittee at a United Nations Conference on Space Exploration in 2003, proposes that the United States pass a domestic law that recognizes the right of individuals to own and operate space industries, as long as they obey a "use it or lose it" provision: If they abandon the industry, they give up rights to it. In this way, he says, the United States could awaken other countries to the necessity for revised space laws and encourage them to negotiate a new international treaty that, he hopes, would clarify the legal status of property rights in space.

"Space development and settlement will not happen if it's internationally taxed and controlled," White said. "I think space settlement is a social 'release valve' that we desperately need. ... It's only going to get more crowded here on Earth."

At some point in the future, private entities will begin to appropriate resources and inhabit outer space. Initially, such activities will be risky and expensive. Existing international law provides limited legal protection and little incentive for investment in outer space. Hence a regime of real property rights which would provide an element of legal certainty and incentive for private ventures is needed. The concept of real property rights is intimately tied to the sovereignty which nation states exercise over territory. The 1967 Outer Space Treaty prohibits states from establishing territorial sovereignty, but authorizes and, in some cases even requires, that states exercise jurisdiction over space objects and personnel. Therefore, some form of property rights which would not require states to establish territorial sovereignty, while remaining within the jurisdictional limitations set forth in the Outer Space Treaty, can be established.

5.2 Need for Real Property Rights

The 1967 Outer Space Treaty does not provide a positive regime for the governance of space development. The 1979 Moon Treaty provides a regime for development, but that regime prohibits real property rights. For that and other reasons, most nations have not signed or ratified the Moon Treaty.

A development regime which provides some form of property rights will become increasingly necessary as space develops. Professionals foresee an integrated system of solar power generation, lunar and asteroidal mining, orbital industrialization, and habitation in outer space. In the midst of this complexity, the right to maintain a facility in a given location relative to another space object may create conflict. Such conflicts may arise sooner than we expect, if private companies begin building subsidiary facilities around space stations. Eventually large public facilities will become the hub of private space development, and owners will want to protect the proximity value of their facility location.

It also seems likely that at some point national governments and/or private companies will clash over the right to exploit a given mineral deposit. Finally, the geosynchronous orbit is already crowded with satellites, and other orbits with unique characteristics may become scarce in the future.

The institution of real property is the most efficient method of allocating the scarce resource of location value. Space habitats, for example, will be very expensive and will probably require financing from private as well as public sources. Selling property rights for living or business space on the habitat would be one way of obtaining private financing. Private law condominiums would seem to be a particularly apt financing model – inhabitants could hold title to their living space and pay a monthly fee for life-support services and maintenance of common areas.

Even those countries which do not have launch capability would benefit from a property regime. Private entities from the developing nations could obtain property rights by purchasing obsolete facilities from foreign entities that are more technologically advanced.

A regime of real property rights would provide legal and political certainty. Investors and settlers could predict the outcome of a conflict with greater certainty by analogizing to terrestrial property law. Settlers and developers would also be reassured, knowing that other nations would respect their right to remain at a given location.

Under a regime of functional property rights, title would arise on the basis of a principle entirely different from traditional property rights. Bestowal of title would not depend upon a government's control over a specific area, but rather upon its control over the space objects and personnel at that location. Once bestowed, these rights would, nevertheless, be almost identical to terrestrial property rights.

On Earth the exclusion of others from the use and enjoyment of a given area is the principal right associated with real property ownership. In space, first-come, first-served occupation, and the prohibition against harmful interference with other states' activities provides states with a similar, although less clearly defined, right of exclusion. Property rights legislation would extend this right to a state's citizens. Functional property rights would be subject to the limitations of Article VIII jurisdiction. These rights would terminate if activity were halted, as for example, if a space object was abandoned or returned to Earth. Finally, rights would be limited to the area occupied by the space object, and to a reasonable safety area around the facility. Hence, orbital property rights would extend only to the moving "envelope" occupied by a facility, and not to its entire orbital path.

5.3 Real Property Rights Regime

Article II of the 1967 Outer Space Treaty prohibits national appropriation of outer space, it does not prohibit private appropriation. Hence, private entities may appropriate area in outer space or on a celestial body, although states may not. Because the relationship between property and territorial sovereignty differs under common law and civil law systems, it is not immediately clear whether Article II would permit national governments to confer property rights upon private entities under their jurisdiction. The common law theory of title has its roots in feudal law. Under this theory the Crown holds the ultimate title to all lands, and the proprietary rights of the subject are explained in terms of vassalage. Thus, common law nations which are parties to the Outer Space Treaty cannot confer real property rights on private entities because Article II would prohibit them from claiming territorial sovereignty. Civil law, on the other hand, is derived from Roman law, which distinguishes between property and sovereignty. Under this theory it is possible for property to exist in the absence of territorial sovereignty.

Article VIII of the Outer Space Treaty requires parties to the treaty to "retain jurisdiction and control over . . . space objects on their registry . . . and over any personnel thereof, while in outer space or on a celestial body." Article VIII confers "quasi-territorial" jurisdiction. It applies to the space facility, to a reasonable area around the facility (for safety purposes), and to all personnel in or near the facility, irrespective of nationality. Space objects occupy locations on a first-come, first-served basis, and personnel have the right to conduct their activities without the harmful interference of other states. In addition, although entities may not claim ownership of mineral resources "in place", once they have been removed (i.e. mined) then they are subject to ownership.

Article VIII jurisdiction also permits the state of registry to subject its space objects and personnel to any national laws which are not in conflict with international law. However, this jurisdiction in limited in terms of time. It ceases to exist when activity is halted as, for example, when a space object is abandoned or returned to Earth.

Taken together, the rights conferred upon private entities under the Outer Space Treaty amount to a limited form of property rights. And, because Article VIII permits states to pass laws and regulate the activities of private entities under their jurisdiction, it is possible for states to unilaterally implement a system of limited property rights which would not constitute a violation of the provisions of the Outer Space Treaty. Because this form of limited property rights would be based upon Article VIII jurisdiction, and not territorial sovereignty, it would not violate Article II of the Outer Space Treaty, even if the state in question were a common law country.

Some of the legal, political, military, economic and social consequences of implementing such limited real property rights, in the absence of territorial sovereignty, are discussed here.

Legal Implications

Because this proposal for limited property rights is consistent with the Outer Space Treaty and other international law, it would be easy for states to implement. Both common law and civil law countries are free to unilaterally enact this form of limited property rights, without any changes in the Outer Space Treaty or other international law.

Implementing this real property regime would provide greater legal certainty to investors and entities participating in the development and settlement of outer space. Those entities will be able to look to terrestrial property law for legal precedents. National judicial systems would experience similar benefits, as judges could decide cases on the basis of established legal principles.

However, the field of space law is so sufficiently specialized that it will eventually be necessary to create specialized courts to adjudicate space disputes. In locations like Mars, it will probably be necessary to set up local courts once substantial development and settlement occurs, because delays in communicating with Earth would otherwise make judicial proceedings unacceptably cumbersome and time consuming.

Another benefit of this form of limited property rights will be competition between national legal systems and a resulting cross-fertilization of legal ideas. To a certain extent, this process is already occurring with advances in communications and the globalization of business interests on Earth; such limited property rights would accelerate this trend. Because the proposed property regime does not rely on territorial sovereignty, and because the safety zone jurisdiction outside facilities would be strictly limited, entities would not be claiming large areas. This means that different facilities and their safety zones could each be under the jurisdiction of a different state, and yet still be in close proximity to each other. Assuming that entities residing in and operating these facilities have frequent interaction, differences in national laws would be immediately obvious and would have a real-life impact on the entities involved. The expected result would be a demand for the most economically efficient and least restrictive laws, with the laws of other space-faring nations serving as examples.

Political Implications

There are four principal reasons why the United States and the Soviet Union (and later other countries) chose to prohibit territorial sovereignty in Article II of the Outer Space Treaty: (1) to prevent conflict; (2) to ensure free access to all areas of outer space; (3) because it would be difficult for states to delineate boundaries in outer space; and (4) to enhance national pride, prestige and influence.

The entire history of the Earth is one long tale of military conflict over disputed territory, or even outright seizure of territory by governments with no lawful claim to the territory in question. Permitting national claims of territorial sovereignty in Outer Space would only perpetuate that history of conflict. The modern standard for establishing territorial sovereignty is the continuous and peaceful display of state authority. Despite the word "peaceful", this standard, as a practical matter, generally means establishing and maintaining military control over territory.

Here the question of being able to afford the expense of defending territorial claims with military force arises. When there is a choice between spending our precious resources on military defence of territory in outer space, and spending our resources on research, development, and settlement, most sane people would prefer the latter.

The second reason for prohibiting territorial sovereignty was to ensure free access to outer space. If nations begin claiming large areas of outer space or on celestial bodies, it will prevent entities from other nations from having free access to both claimed and unclaimed areas of outer space. Because the extent of safety zone jurisdiction is very limited, free access would not be as much of an issue with limited property rights as it would with territorial sovereignty, where the areas claimed are typically much larger.

The third reason for prohibiting territorial sovereignty was because it would be difficult for states to delineate boundaries in outer space. That reasoning still applies today. While it would be difficult for nations to delineate the boundaries of territory in open space, it would be far easier to delineate the boundaries of real property claims, because the area claimed will be far smaller, and because safety zones in many cases will extend a uniform distance from a facility, in all directions.

The final reason for prohibiting territorial sovereignty was to enhance national pride, prestige and influence. The major powers were vying for the allegiance of the many new African and Asian nations at the time when they negotiated the language of Article II. These former colonies that had recently become independent were extremely wary of "superpower imperialism". Consequently, both the Soviet Union and the United States could expect to gain political influence and prestige should they reject territorial sovereignty and its overtones of colonialism.

Today those political views are still present in some, and perhaps many non space-faring nations. Consequently, the space-faring nations will encounter far less political opposition to a real property regime which does not include national claims of territorial sovereignty.

Non space-faring nations fear that the space-faring nations will appropriate most or all of the best resources before they have the ability to participate in space development and settlement. In the view of most of the space-faring nations, this fear is unfounded, because the resources of outer space are virtually unlimited when compared with the limited resources of Earth. Nevertheless, these attitudes prevail in the non space-faring nations, and they must be considered when evaluating a property rights regime.

Fortunately, the proposed regime of limited property rights should defuse most of the possible political opposition from the non space-faring nations. Because the Article II prohibition of territorial sovereignty remains in place, the non space-faring nations can rest assured that large areas of outer space will remain unclaimed for the foreseeable future. Furthermore, because private entities could sell outmoded or financially unsuccessful facilities, including the associated property rights, other nations would have the opportunity to purchase those facilities and property rights, even though they might not have developed space-faring technology. The limited property rights regime therefore addresses the concerns of the non space-faring nations, and even provides them with the opportunity to share in space development and settlement, while still achieving the objectives of private entities. Finally, the proposed regime should be politically acceptable to the governments of space-faring nations, because: (1) they will have the independence to enact and fine tune property legislation without seeking the approval of other nations, including non space-faring nations that have far different political views, (2) their citizens can develop and settle in space without transferring any of the income from those activities to the non space-faring nations, and (3) governmental entities will have the same jurisdictional rights over facilities and safety zones that private entities do.

Military and Security Implications

The military implications of the proposed real property regime are fairly obvious in the light of the preceding discussion regarding prevention of conflict in outer space. If the Article II prohibition of territorial sovereignty remains in place, nations will not have to exert military control over large areas in order to perfect territorial claims. And, wars over conflicting territorial claims will not occur as they did when European nations settled and developed the North and South American continents.

However, the military and possibly other security forces will have a role. Once mining and industrial development takes place, it may be necessary for the military to be available to prevent others from stealing mining claims, sabotaging competitors' facilities, etc. In the early stages of development and settlement, entities are likely to cluster their facilities in close proximity for safety and economic reasons. The military would therefore have a fairly easy time defending those facilities, in a manner similar to Army forts which defended nearby settlements while the American West was being settled. Once local governments are established and have defensive capability, the need for Earth's military forces will diminish.

Another concern is international security. Unfortunately, the threat of terrorist activity is always a possibility. To prevent such activity, states which implement the limited property regime will undoubtedly want to provide in any legislation that the government has the right to prohibit sales of facilities and property rights to nations which present any sort of significant security risk.

Economic Implications

The institution of real property rights is the most efficient manner of administering the territory occupied by private entities. The proposed real property regime will allow a free market to develop in property rights. Commercial entities that want to buy more technologically advanced facilities can sell their facility and buy a new one. Commercial entities that engage in an unsuccessful venture will still have some residual value remaining in their facility and property rights. Such entities could then sell their facility and property rights to recoup some of their investment.

Because the proposed regime will permit judges, lawyers and legislators to look to terrestrial property law for precedents, private entities will enter into space ventures with greater certainty about their legal rights, and the outcome of any potential legal disputes. Real property rights will thereby encourage private space development and settlement, at very little cost to the taxpayers.

Finally, the regime will help ease the transition to self governance in outer space. Once a space community becomes self governing, it will be a simple process to convert limited property rights to full-fledged property rights. Earth governments should allow and encourage space communities to become self governing as soon as they are economically self-supporting and willing to govern themselves. The proposed property regime will help to facilitate that goal.

However, though some lawyers believe that space laws need to be revamped, there are some who think that the present legal situation in space does not warrant immediate overhaul of the existing laws or treaties, at least not right away, in order for space entrepreneurs to plan for commercial exploitation of the heavens.

Still, the enterprising will grab every opportunity that comes their way. There are online sites that sell low-budget "deeds" to terrain in space, say, a few acres at a specified latitude and longitude on the moon. A space lawyers' professional organization, the International Institute of Space Law, has issued a statement cautioning that "the deeds they sell have no legal value or significance, and convey no recognized rights whatsoever".

Thus, it is increasingly apparent that space law promises to be a mushrooming enterprise for future lawyers in the coming years. This is in severe contrast to the recent past when there was only one paragraph in one book that mentioned space law.

5.4 Space Debris

Space debris or orbital debris, also called space junk and space waste, are the objects in orbit around Earth created by humans, and that no longer serve any useful purpose. It generally refers to material that is in orbit as the result of space missions, but is no longer serving any function. They consist of everything from entire spent rocket stages and defunct satellites to explosion fragments, paint flakes, dust, and slag from solid rocket motors, coolant released by nuclear powered satellites, deliberate insertion of small needles, and other small particles. Clouds of very small particles may cause erosive damage, like sandblasting. There are many sources of debris. One source is discarded hardware. For example, many launch vehicle upper stages have been left in orbit after they are spent. Many satellites are also abandoned at the end of their useful life. Another source of debris is spacecraft and mission operations, such as deployments and separations. These have typically involved the release of items such as separation bolts, lens caps, momentum flywheels, nuclear reactor cores, clamp bands, auxiliary motors, launch vehicle fairings, and adapter shrouds.

Material degradation due to atomic oxygen, solar heating, and solar radiation has resulted in the production of particulates such as paint flakes and bits of multilayer insulation. Solid rocket motors used to boost satellite orbits have produced various debris items, including motor casings, aluminium oxide exhaust particles, nozzle slag, motor-liner residuals, solid-fuel fragments, and exhaust cone bits resulting from erosion during the burn.

A major contributor to the orbital debris background has been object break-up. More than 124 break-ups have been verified, and more are believed to have occurred. Break-ups generally are caused by explosions and collisions with other objects in space, but the majority of break-ups have been caused due to explosions. Explosions can occur when propellant and oxidizer inadvertently mix, residual propellant becomes over-pressurized due to heating, or batteries become over-pressurized. Some satellites have been deliberately detonated. Explosions can also be indirectly triggered by collisions with debris.

The first major space debris collision was on 10th February, 2009. The deactivated Kosmos-2251 and an operational Iridium 33 collided 789 kilometres (490 m) over northern Siberia[1]. Both satellites were destroyed. The collision scattered considerable debris, which poses an elevated risk to spacecraft. Three such collisions are known to have occurred since the beginning of the space age. In addition, the debris research community has concluded that at least one additional break-up was caused by collision. The cause of approximately 22% of observed break-ups is unknown.

Approximately 70,000 objects estimated to be 2 cm in size have been observed in the 850-1,000 km altitude band. NASA has hypothesized that these objects are frozen bits of nuclear reactor coolant that are leaking from a number of Russian RORSATs. At altitudes of 2,000 km and lower, it is generally accepted that the debris population dominates the natural meteoroid population for object sizes 1 mm and larger.[2]

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[1] *Marks, Paul, 'New Scientist, Satellite collision 'more powerful than China's ASAT test, 13 Feb. 2009*

[2] *"Debris Danger", Aviation Week & Space Technology, Vol. 169, 15 Sept. 2008, p.18*

In 1958, the United States launched a satellite named Vanguard I. It was the fourth man-made satellite to be put in geocentric orbit. It has become one of the longest surviving pieces of space junk and as of June 2009 remains the oldest piece still in orbit.[3]

Several objects have been lost in space and have become debris. These objects have included a glove lost by astronaut Edward Higgins White on the first American space-walk; a camera Michael Collins lost near the spacecraft Gemini 10; garbage bags jettisoned by the Soviet Mir cosmonauts throughout the space station's 15-year life; and a wrench and toothbrush. Sunita Williams of STS-116 mission also lost a camera during one of her space walks. During a space walk to reinforce a torn solar panel during mission STS-120, a pair of pliers was lost and most recently, during STS-126, Heidemarie Stefanyshyn-Piper lost a briefcase-sized tool bag in one of the mission's walks[4]. Most of those everyday objects have re-entered the Earth's atmosphere within weeks due to the orbits where they were released. Items like these are not major contributors to the space debris environment. On the other hand, explosion events are a major contribution to the space debris problem. About 100 tons of fragments generated during approximately 200 such events are still in orbit.[5] Thus space debris is most concentrated in low Earth orbit, though some extends out past geosynchronous orbit.

5.5 Mitigation of Orbital Debris

Space "junk" has become a growing concern in recent years, since collisions at orbital velocities can be highly damaging to functional

[3] *"Debris Danger", Aviation Week & Space Technology, Vol. 169, 15 Sept. 2008, p.19*
[4] *Tufte, Edward, 'Envisioning Information'*
[5] *"Debris Danger", Aviation Week & Space Technology, Vol. 169, 15 Sept. 2008, p.18*

satellites and can also produce even more space debris in the process. This is called the Kessler Syndrome. Some spacecraft, like the International Space Station, are now armoured to mitigate damage with this hazard. Astronauts on space-walks are also vulnerable.

Both radar and optical detectors, such as lasers, are the main tools used for tracking space debris. Tracking objects smaller than 10 cm is difficult due to their small cross-section and reduced orbital stability, though debris as small as 1 cm can be tracked.

ISRO is a member of Interagency Space Debris Coordination Committee (IADC) participated by major space agencies, and has been contributing to the international efforts in this area. India has undertaken a series of mitigation measures, meeting with broad consensus of space faring nations and members of UNCOPUOS. Space debris mitigation measures are voluntarily adopted and information and techniques related to mitigation measures are shared with other space faring countries in the framework of IADC. The design of Indian launch vehicle systems such as PSLV and GSLV incorporates measures to minimize operational debris. The communications spacecraft have provisions in the design for re-orbiting into higher orbit at the end of their operational life.

For a proper assessment of the dangers caused by satellite debris, there are some facts to be borne in mind –

- Satellites in a very low orbit will come down and burn up in the process

- Satellites placed in a very high orbit present fewer problems because they will last more than a thousand years

- Satellites operating in the intermediate range are more exposed to accidents and risks than the others. The category most likely to get involved in an accident is that of satellites launched into a geostationary orbit.

In order to mitigate the generation of additional space debris, a number of measures have been proposed. The passivation of spent upper stages by the release of residual fuels is aimed at reducing the risk of on-orbit explosions that could generate thousands of additional debris objects.

Taking satellites out of orbit at the end of their operational life would also be an effective mitigation measure. This could be facilitated with a "terminator tether", an electro-dynamic tether that is rolled out, and slows down the spacecraft. In cases when a direct and controlled de-orbit would require too much fuel, a satellite can also be brought to an orbit where atmospheric drag would cause it to de-orbit after some years. Such a manoeuvre was successfully performed with the French Spot-1 satellite, bringing its time to atmospheric re-entry down from a projected 200 years to about 15 years by lowering its perigee from 830 km to about 550 km.[6]

Because of budgetary constraints, satellites are rarely de-orbited. In orbital altitudes where it would not be economically feasible to de-orbit a satellite, such as in the geostationary ring, aging satellites are brought to a graveyard orbit where no operational satellites are

[6] *Portree, David and Loftus, Joseph, ' Orbital Debris', (1999), p.13*

present. This process would be suitable for unmanned satellites. As of 2002, all geostationary satellites are required to commit to moving to a graveyard orbit at the end of their operational life prior to launch. Manned satellites should be required to keep their waste matter on board and should be banned from jettisoning it in space.

Proposals have been made for ways to "sweep" space debris back into the Earth's atmosphere, including automated tugs, laser brooms to vaporize or nudge particles into rapidly-decaying orbits, or huge aero-gel blobs to absorb impacting junk and eventually fall out of orbit with them trapped inside.

Other ideas to decay "junk orbits", such as using ice bullets that evaporate/sublimate after impact, have political complications because they can be considered weapons in space. Unless there are very specific international agreements, de-orbiting junk using violence is unlikely. In theory, any technique that can de-orbit space junk could also de-orbit a functioning satellite, and thus might be considered a weapon. This is why most current efforts are being devoted to prevention of collisions by keeping track of the larger debris, and prevention of more debris.

There is no international treaty that requires or authorizes certain behaviour that would minimize space debris, but the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS) did publish voluntary guidelines in 2007. As of 2008, the committee is discussing international "rules of the road" to prevent collisions between satellites. NASA has implemented its own procedures for limiting debris production as have some other space agencies.

The most effective procedure for removing satellites and other space vehicles could be to bring them down through controlled re-entry after they have fulfilled their function. Controlled landings have been achieved with both manned and unmanned missions. In the case of satellites with limited capability for manoeuvring, and because of the uncertainty of the exact time of the decay and of the site of impact on the earth's surface, a destructive re-entry over a safe area such as the ocean, perhaps with total burn up in the atmosphere, is the most effective way of reducing space debris. Most debris, however, is inert and cannot be removed from orbit without some external means. In such cases recovery could be made by a remote manipulator arm or other space garbage collector.

5.6 Space Traffic Control

The orbit of the Earth is cluttered with human-made hazards from numerous nations in the form of on-duty satellites, deserted spacecraft, leftover fragments of exploded rocket upper stages, even chunks of solid rocket motor propellant down to tiny flecks of paint shedding from space hardware.

But that is not all that is there in space. Add to these fast-moving separation bolts, lens caps, momentum flywheels, nuclear reactor cores, clamp bands, auxiliary motors, launch vehicle fairings and adapter shrouds. At one point, there was even a toothbrush reportedly zipping through the global space commons. In the majority, discarded wreckage populates space.

Some space trash tumbles into the Earth's atmosphere, or is purposely nudged out of orbit to crash into remote stretches of ocean.

But there is a problem with this process. Portions of spacecraft and other space hardware, sometimes significant pieces, may survive re-entry and pose a hazard to people and property on the ground.

The point to note here is that after almost fifty years of satellite launchings, low Earth orbit is no longer the wide-open spaces of days gone by. The orbital space around the Earth has become a busy thoroughfare of satellites operated by several nations. The region is also littered with dead and dying satellites, plus bits of debris ranging from large and dangerous chunks to potentially deadly nuts and bolts and even hazardous chips of paint. Just as airlines work under an air traffic control system, it is time for a space traffic management system.

Now experts have begun to discuss a surveillance and collision avoidance service – a strategy or a scheme like traffic police to regulate outer space in a better way.

Today there are over 10,000 objects larger than 4 inches (10 cm.) that are tracked by U.S. ground surveillance equipment. Of that total, roughly 700 are operating satellites. There are some 4,000 rocket bodies and satellites, dead or alive, orbiting the Earth. In addition, more than 6,000 other large, observable and tracked bits of debris float around up there. More than 200,000 smaller bits bigger than 1 centimetre – still potentially dangerous but not tracked – are thought to be in orbit. Much of this material moves at 17,500 mph.

A Chinese anti-satellite test that was conducted last year created an enormous new cloud of debris that experts called the most prolific and severe fragmentation in space ever. There are also millions of tiny bits of material, including droplets of radioactive coolant that leaked out of poorly plumbed Soviet nuclear-powered spacecraft.

Satellites and debris in low-Earth orbit can pose a threat to other satellites, space shuttles, and the International Space Station.

Here are some worrisome factoids:

- Throughout its flying years, the space shuttle has moved more than eight times to avoid an oncoming object[7];

- The International Space Station had dodged a large tracked object six times since it has been in orbit[8];

- Operators of a German satellite had to fire onboard thrusters to avoid debris;

- Ground controllers of a satellite were surprised to find they were sharing the same Geosynchronous Earth Orbiting slot with another operator and that the two satellites at times passed unacceptably close.

A major collision of two orbiting objects is predictable. Furthermore, it is inevitable that communications will be disrupted unintentionally, but nonetheless harmfully, by radio frequency interference between satellites.

The only reported collision of two tracked objects took place on July 24, 1996. The French Cerise satellite was hit by a chunk of Ariane H-

[7] *Portree, David and Loftus, Joseph, 'Orbital Debris', (1999), p.15*
[8] *Ibid*

10 rocket stage[9]. A boom on the spacecraft was clipped off during the incident, although the craft was later able to continue its mission.

The total mass of the debris population is increasing and approaching 5,000 tons. The most significant and worrisome problem is that large debris would break up into small pieces in course of time, thus increasing the population of dangerous fragments. It is a question if all that mass can be left in orbit without jeopardizing future space activities.

No doubt, future collisions will result in fast-talking lawyers, insurance companies, and government specialists. Rules of the space road and procedures to minimize collisions are likely to be mandated.

There is need to link aspects of securing safe operations in space, primarily debris mitigation, improved space surveillance and notification policies among operators that can ensure against collisions.

An "Incidents in Space" agreement, based on the Incidents at Sea and Prevention of Dangerous Military Activities agreements signed by the Soviet Union and the United States during the Cold War, can be developed. Doing so might further constrain dangerous activities in space. Such agreements, on a bilateral or multilateral basis, could help bolster a space traffic control regime by pledging militaries to abide by the rules and avoid provocative actions in space.

The first priority of a space traffic control system should be to minimize the number of objects requiring traffic control. Of the

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[9] *Portree, David and Loftus, 'Joseph Orbital Debris', (1999)*

10,000 objects currently catalogued by the U.S. Space Surveillance Network, only a few hundred are functioning, operational spacecraft, with the remainder being discarded rocket bodies, abandoned spacecraft, and fragments of both. An additional 100,000 objects in Earth orbit are not being maintained in a catalogue, but are large enough to significantly damage most spacecraft if a collision should occur[10].

It has been the goal of the NASA Orbital Debris Program Office to come up with cost-effective ways to minimize the growth in orbital debris. At the international level that task is coordinated by the Inter-Agency Space Debris Coordination Committee (IADC). NASA's recommended policy is that spacecraft should not remain in low-Earth orbit for more than 25 years after their operational life, and operational procedures should be required to minimize the possibility of accidental explosions in space.

However, we are not likely to eliminate all orbital debris and, as spacecraft become larger and more numerous, the only option may be some sort of traffic control system.

There are many challenges ahead to put in place space traffic management concepts and practices. Perhaps the greatest challenge is reaching a consensus on the definition of space traffic management and its objectives. In the simplest terms, space traffic management should promote physical and electromagnetic non-interference among the multitude of operational space systems.

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[10] *Thoma, K.; Wicklein, M.; Schneider, E. (2005-08). "New Protection Concepts for Meteoroid / Debris Shields"*

Most space faring nations do not yet exert control over the selection of orbital parameters for new space systems within their own countries, much less in an international context. The prospects for such intrusive space traffic management in the foreseeable future are not bright. There is need, however, to keep building a strong technical foundation on space debris issues. Without doing this, discussions on space traffic management would most probably prove to be ineffective.

5.7 Intellectual Property Aspects

The Law of Intellectual Property relates to protection for creations of the human mind. Intellectual property laws typically grant to the author of the intellectual creation a set of exclusive rights for exploiting and benefiting from the creation, which are limited in scope, duration and geographical extent.

The policy behind protecting Intellectual Property Rights (IPRs) has at least two aspects. Firstly, intellectual property protection is intended to encourage the creativity of the human mind for the benefit of the public, by ensuring that the advantages derived from the exploitation of the creation will, if possible, inure to the creator himself, in order to encourage the creative activity and also to afford the investors in research and development a fair return on their investments.

The second policy consideration is to encourage the publication, distribution and disclosure of the creation to the public, rather than keeping it secret. It also encourages commercial enterprises to seek out creative works for profitable exploitation.

The constant evolution of high technology and the ever-changing geopolitical situation underlines the need for the universal harmonization of industrial and intellectual property laws. The analysis of the specific problems relating to intellectual property rights arising from the utilization of the future International Space Station and from satellite remote sensing are examples which illustrate this need.

Issues related to IPRs in outer space have, at this moment, still a somewhat 'exotic' character. This is because microgravity activities, which take place in the near-zero gravity of outer space, have not developed as quickly and did not yet mature and create a commercial dimension as other space applications, such as, for instance, satellite remote sensing and satellite telecommunications. Furthermore, the private sector's entities active in the field of space activities are not necessarily very interested in microgravity research at this stage. Although pharmaceutical and biotechnical industries may have a potential interest in microgravity activities, this is a far cry from a market of commercial production in outer space. Apart from the technical and financial barriers for microgravity research, a clear legal structure is also needed in order to encourage private sector participation.

The issue of IPRs in outer space currently concerns mainly telecommunication and remote sensing activities. Here the discussions of legal solutions to the specific problems which arise from those activities are in a much more advanced stage than with respect to IPR issues.

With regard to satellite broadcasting, it is the European Union which plays an important role by creating an environment in which transfrontier broadcasts will not be hampered by legal obstacles. The legal protection of remote sensing data is a subject that was initially taken up by a study commissioned by the European Centre for Space Law (ECSL) in 1989 and later was followed up by a joint ECSL/ESA/European Commission study. Here the main issue was whether remote sensing data could be protected under existing copyrights in the European States. This question was important according to ESA in order to allow the controlled flow of the data gathered by its ERS satellite and at the same time to stimulate private investments in remote sensing activities. The results of the study indicated clearly that existing copyright laws did not offer adequate protection and that additional actions were needed. Currently, an attempt is made to enhance the protection by considering remote sensing data as falling under the proposed directive for the legal protection of databases, which is still under discussion in the EU Council.

Protection of remote sensing data is indeed something that should be clearly defined in legal terms and stems from the successful operation of the first ESA's ERS-1 and the proposed amendment of the Eumetsat Convention in which Eumetsat attempts to clarify the legal qualification of its data.

Before going into the problems arising from IPRs and space activities, a brief panorama on the existing regulation in this field is useful to better understand the harmonisation of IPRs since the last century.

Meaning of intellectual property

It is important to understand what is generally meant by industrial and intellectual property. According to Article 1.2 of the Paris

Convention (Stockholm text), the protection of industrial property has as its objects patents, utility models, industrial designs, trademarks, service marks, trade names, indication of source or appellations of origin, and the repression of unfair competition.

Intellectual property covers, according to the Bern Convention for the Protection of Literary and Artistic Work, every production in the literary, scientific and artistic domain, whatever the mode or form of its expression. This includes databases and computer programmes of all kinds.

Industrial property and intellectual property can be characterised by a dual nature, i.e. being at the same time national and international. Patents, in particular, and copyright protection are governed by national laws and rules of a given country. At the same time, international conventions ensure minimum rights and provide certain measures for enforcement of rights by the Contracting States.

Intellectual property has attracted a significant amount of interest on an international scale since the end of the previous century. In the first instance, the desire to protect and commercialise industrial inventions, trade marks, drawings and copyright beyond the territorial boundaries of the country where they were made, led to the creation of the Paris Union System in 1883. The treaty creating this system, which has been amended on a number of occasions, deals with intellectual property in general and obliges or invites States participating in the system to enact legislation on certain intellectual property matters like assimilation to national treatment for foreign inventions, temporary protection of inventions at exhibitions, priority rights and infringement.

The Bern Convention, signed in 1886 and revised several times since, is the other international instrument playing a role in the delicate process of harmonisation. Dedicated to the protection of literary and artistic works, it is the main source where the fundamental principles underlying national copyright laws can be found. Indeed, it has stimulated the adoption, improvement and standardisation of national legislations, facilitated by the scale of its worldwide acceptance.

An additional milestone in the history of international industrial property was the signature of the Patent Cooperation Treaty (PCT) on 19th June, 1970 in Washington. This Treaty establishes a centralised 'international applications' procedure for the granting of various patents at the national or regional level. This is done through a single operation which calls for the designation of various States. The PCT also creates an 'international search' system which is used to establish a report on the novelty value and incentive element of the invention.

With the adoption of the European Patent Convention (EPC), which was signed in Munich on 5th October, 1975, the European States established a centralised system for the application for national patents and their granting. Later on, the States of the European Economic Community (EEC) drafted a unitary patent process which applied to the overall territory of the EEC Member States [Community Patent Convention (CPC) or Luxembourg Convention].

The adoption of those two European Conventions has led interested States to adapt their respective national legislations to bring them in line with the principles contained in the Conventions. Thus, the Conventions have already played a major role in the process of harmonising patent laws in Europe.

At the European level, acknowledgement has to be made of the significant amount of work done by the European Union (EU). In the area of intellectual property rights, the EU efforts contribute to the convergence of national legislations required for the proper functioning of the common market (Article 3h of the EEC Treaty). This issue has been the subject of a number of Council directives (on harmonising trademark standards, protecting computer software programmes, harmonising copyright provisions, etc.) These directives, while aiming at bringing European legislations in line with the provisions of international Conventions, seek to standardise existing national regulations in order to provide an adequate level of legal protection.

However, the coexistence of numerous intellectual property regulatory systems, both at the national and international levels, is creating significant coordination problems. An important role in this respect will be played by the Agreement on the Trade-Related Aspects of Intellectual Property (TRIPS) which is a part of the Agreement establishing the World Trade Organisation, resulting from the GATT Uruguay Round negotiations, which was concluded in April 1994. As a result, those provisions will be binding on countries that are members of the WTO but are not party to the Paris Convention. In addition, the TRIPS Agreement set out additional standards for patents and other forms of intellectual property.

The issues involving IPRs in respect of inventions made or used in outer space which might require harmonized international norms for their solution, can be briefly summarized as follows:

Patentability of inventions made in outer space

The question arises as to who has the right to patent protection, who has the control over the rights which are granted with the patent. Here the differences between the two main patent systems existing in the world, i.e. the first-to-file and the first-to-invent patent systems, underline the need for harmonization. In fact, all the criteria to determine to whom the invention belongs, the relevance of the place where the invention has been made, the evaluation of the prior art and novelty, are different.

Infringement of existing patents by the use of technology in outer space

This is another pertinent question that needs to be addressed. Here the activity performed in space will infringe a patent where the activities can be considered as occurring in the territory of the country (e.g. Article 21 Inter-Governmental Agreement) in which the patent has effect. A prior identification of which patent may potentially be infringed and the granting of a license is a solution which, however, is not always easy to enforce.

These problems have been the object of various colloquia and debates, one of which was organized in December 1994 in Paris by ESA and ECSL. The workshop focused on the global aspects of IPRs and space activities and aimed at identifying the requirements of the various players in the space area, with respect to intellectual property protection, which could range from the harmonization of the existing specific regulations, to the identification and/or elaboration of common practice.

The differences between the approach of national space agencies in this field, the coexistence of a multitude of actors, of a public and private nature, the political constraints on the activities, showed how space activities traditionally have been isolated from the general debates which always characterised intellectual property protection.

The participation of the major European and International organisations (EU, EPO and WIPO) in the field of intellectual property, at this workshop, raised the possibility of further elaborated research and analysis of the problems which characterise intellectual property protection and space activities.

Patent protection and microgravity activities

The main legal issues are:

a) Which European patent laws protect the research process conducted in space and the results of such research achieved in space? Can an infringement occurring in outer space give rise to liability under patent laws?

b) What would be the legal consequences of an invention being developed in space?

When trying to answer question (a), one has to bear in mind that European national regulations dealing with industrial property are not concerned with the actual location of the invention's conception. It is therefore irrelevant under this regulation where the invention was made and one may apply for a patent with regard to inventions made in outer space under any national or European system. The location could, on the other hand, prove to be relevant where the patent law of a given country provides that for certain types of inventions, i.e. those relating to technologies having a direct bearing on national security, the first application for a patent must be filed in the country where the invention was made. This provision has the purpose of allowing security clearance for the invention before it is published or filed in a foreign country.

As regards the use of a nationally protected invention in outer space, or the infringement that may result from that use, the situation is different. An authorised or non-authorised use will not bear the legal consequences in those European States that have not recognised the object located in outer space, where the use is made, as being an extension of their territory.

In principle, national patents are enforceable only within the territorial boundaries of a given country. The same principle applies within the framework of the European Patent Convention (Art.64), which allows for the acquisition of a 'bundle' of national patents of the countries party to the Convention, indicated in the application; the patent therefore has the effect of a national patent in each of the countries mentioned in the application.

Outer space, similar to the high seas and Antarctica, is not subject to national appropriation and does not fall under any national sovereignty. This implies that outer space cannot be appropriated by use or claim or any other means (Art. II of the Outer Space Treaty). However, a State retains jurisdiction and control over objects it sends into outer space (Art. VIII of the Outer Space Treaty). With regard to the applicability of national patent regulations, problems occur when an invention is used or infringed in outer space, because these regulations are only applicable in the territory of the specified State which, by definition, excludes the extra-territorial areas of outer space.

This situation led to the amendment of the patent law in the United States. The legislators made this law also applicable to inventions in outer space when such inventions take place onboard space objects coming under the jurisdiction or control of the United States. Any invention or component made, used or sold in outer space on a space object under the jurisdiction or control of the United States shall be considered to have been made, used or sold in the United States. The same approach inspired the German ratification of the Space Station Inter-Governmental Agreement (IGA).

Turning to question (b), no provision contained in European legislation or regulations would retain the location of the conception of an invention as a criterion for granting a patent application. However, a distinction is made in US patent law between foreign inventive activity and domestic inventive activity. In contrast to the patent laws of most countries, where the patent is awarded to the first person to file a patent application on the product or process, a patent will be issued under US law to the first person to invent the product or process he claims in his patent. The first to invent is said to have 'priority' over others claiming the same invention. Priority is determined by reference to certain key events such as conception, reduction to practice, and diligence.

Another important characteristic of US patent law concerns activities considered to be 'prior art'. Patent law distinguishes between domestic and foreign activity for the purpose of determining what falls under the category of prior art. For instance, patents and printed publications, no matter where they originate, are prior art, but items previously known, used or invented are considered to be prior art only if they occur within the United States.

Finally, the definition of infringement contained in the US patent law as being the unauthorised conception, use or sale of an invention within the United States, creates the same problems of applicability of patent law as in other countries.

The International Space Station

The Inter-Governmental Agreement (IGA) on the International Space Station, signed on 29th September 1988 by countries representing four partners - the USA, Japan, Canada and ten ESA Member States - is probably the most complex and interesting example of a long-term international cooperative endeavour in space.

The intrinsic characteristics of the exploitation and utilisation of the International Space Station generate corresponding legal implications.

Such characteristics include the following:

- the Station will be 'permanently inhabited' by a multinational crew
- the Station will be located in outer space
- the multi-purpose scientific and commercial utilisation of this facility as a research laboratory, as a factory for manufacturing materials, and as a service station for supplying or repairing satellites.

The agreement between the Partners, described in the IGA, is based on a system that is complex to manage and which has been the subject of lengthy discussions. These discussions touched upon, inter alia, the registration, jurisdiction and control of flight elements considered as space objects under Article VIII of the Outer Space Treaty.

These discussions focussed especially on the necessity of complying with one of the fundamental principles of outer space law, which is stated in Article II of the Outer Space Treaty, under which outer space is not subject to national appropriation in whole or in part.

The solution that has been accepted by the signatories of the IGA is that each 'Partner' will register each element it provides as a space object, thereby establishing its jurisdiction and control over such elements, i.e. the ability to issue regulations and have them enforced. The same principle applies to persons onboard the Space Station, who are nationals of the Partner States.

This why Article 1 of the IGA, which defines the scope of the Agreement and its purpose – to establish 'a long-term international cooperative framework ... for the development ... and utilisation of a ... Space Station for peaceful purposes' - should be read in conjunction with Article III of the Outer Space Treaty, which stipulates that the exploration and use of outer space shall continue in the interests of maintaining peace and promoting scientific cooperation at the international level. Similarly, the possibility of exercising jurisdiction and control over Space Station elements (Article 5 of the IGA) does not infringe upon Article II of the Outer Space Treaty, which bars any claim of sovereignty over outer space.

The IGA and IPRs: Specific issues for the European Partner

Article 21 of the IGA aims at resolving issues relating to IPRs developed or used onboard the Space Station, on the basis of the principles explained above. The two main questions dealt with in the IGA are the acquisition of IPRs over results obtained from activities carried out onboard the Space Station, and the protection against infringement of IPRs (granted on Earth) that may occur onboard the Space Station. The fundamental principle laid down in the IGA is that the part of the Space Station complex in which the invention was made is deemed to be an extension of the territory of the State that registered that element.

The approach adopted by the Space Station Partners raises a general question about the applicability of the jurisdiction and control criteria to solve the problem of the territorial application of patent laws and a number of questions relating to the European Partner States.

Firstly, Article 21.2 of the IGA establishes a legal fiction regarding the ten European Partner States: these States are deemed to be located on a single territory which is subject to one set of regulations. It goes without saying that the ten European Partner States that are signatories of the IGA are not located on a single and unique 'territory'. A consequence of the legal fiction is therefore that, in order to implement the IGA, the European Partner States will have to establish IPR provisions at the national level which are not only compatible with those established in the other European Partner States, but also appropriate for responding to the needs expressed in the IGA, a process that could be described as a standardisation of legal texts.

The process of legal harmonisation called for by the IGA imposes a certain burden on the signatory States. As a first step, the States concerned will have to proceed with the identification of possible obstacles to be surmounted if harmonisation is to be achieved and, as a second step, they must assess the results of the harmonisation process already underway in Europe in the field of IPRs in order to determine whether such a process can influence or respond to the need for the protection of IPRs designed or used onboard the Space Station.

The procedures applicable to the ratification of treaties differ from State to State and one has to bear this simple fact in mind when considering the implementation of IGA provisions. The ratification procedure can involve transforming provisions provided by the IGA into national law (by legislative process) or incorporating these provisions without recourse to any procedure whatsoever - in which case the IGA enters into force, bypassing the legislative process of the State.

The Space Station IGA has, to date, been ratified by six European States: Germany, The Netherlands, Norway, Denmark, Spain and Italy. Germany exercised the right laid down in Article 21.2 of the IGA by enacting legislation on 13th July, 1991 for the purpose of ratifying the IGA. Article 2 of this legislation stipulates that for the purposes of German copyright and industrial patent legislation, an activity occurring in or on an ESA-registered element is deemed to occur within the German territory. The remaining provisions of Article 21 of the IGA are considered to be self-executing, and for this reason Germany has not felt it necessary to enact further legislation.

The other European States, having ratified the IGA, did not consider it appropriate to enact legislation and have given immediate and direct validity to the provisions of the IGA. The United Kingdom, for its part, has informed ESA that it intends to enact legislation in line with the provisions of Article 21 of the IGA and is currently studying the scope of changes to be made to its national law in order to ratify the IGA.

The IGA entered into force on 30th January, 1992, the conditions prescribed in its Article 25(a) having been fulfilled with the ratification by Japan and the acceptance by the USA.

The necessary harmonisation process referred to above is obviously not made easier by the procedural aspects, i.e. the numerous procedures which need to be carefully monitored and guided in order to transform the legal fiction of the IGA into reality.

The lack of coordination regarding solutions adopted or to be adopted by the ten European States could significantly affect the development of a legal system that is uniformly applicable to the design and utilisation of IPRs onboard the Space Station. For this reason, to provide an adequate framework for the protection of rights provided for in the IGA, ratification of the IGA by all the European States through the same procedure as followed by Germany would be a worthwhile development.

Thus it is obvious that the role of Intellectual Property in space activities in general, and in those of ESA in particular, is important in order to protect and promote the results of R&D and to encourage industry to select creative works for exploitation.

The policy developed by ESA in this field is in line with the main characteristics of Intellectual Property, i.e. it encourages publication, distribution and disclosure of the innovation to the public, in order to stimulate the improvement of scientific knowledge.

The example of the International Space Station shows that new actions have to be undertaken in order to arrive at a coordinated and harmonised legal framework for the IPRs of the ESA Member States.

5.8 Protection of Space Systems

The problem of protecting space systems including the satellite, its associated ground equipment, and the communications links between the two, from either natural or man-made phenomena has troubled space experts for a long time. A variety of different technical approaches have been examined over time. In his classic and widely quoted work on the subject, Robert Giffen describes these as including: "hardening" or shielding systems against physical effects; enhancing the capability to manoeuvre out of harm's way; proliferating the number of systems in existence; hiding or disguising the purpose of a particular system; increasing a satellite's ability to operate autonomously from ground stations; and establishing the means to quickly replace or "reconstitute" a given system.

However, as Giffen and others point out, each approach entails real as well as opportunity costs. For example, weight is a major factor in the design, operational longevity, and total cost (including launch) of a satellite. Every kilogram devoted to hardening is a kilogram that could conceivably be used for more operational equipment or for additional fuel to maintain a satellite in the desired orbit. Likewise, satellites and rockets are big-ticket items, a fact that militates against building and launching more than are absolutely required to perform a particular mission. Thus, despite a general acknowledgment that more could and perhaps should be done to physically protect space systems, the costs involved have had an inhibiting effect, particularly in the absence of an immediate threat. As one senior military official recently lamented, military and civilian satellites as a rule do not even have on-board systems to signal if and when they have been deliberately attacked: "We have ways of telling something happened to the satellite, but why did it quit? Did it quit because of fatigue, or an electromagnetic pulse from deep space, or because somebody lased it? We can only make an educated guess".

An altogether different approach to the protection of space systems is suggested by arms control. As some proponents have argued, the international legal regime could be strengthened to afford greater protection to satellites beyond that already provided by existing treaties. Since it potentially has the most to lose in an environment in which satellites were considered legitimate targets, the United States, they contend, should strongly favour measures to either restrict systems that have an anti-satellite role or restrict activities that directly threaten satellites. This line of reasoning admittedly has some appeal as well as a respectable pedigree. After all, the Eisenhower administration refrained from developing ASATs (anti-satellites) in part to avoid lending any legitimacy to potential attacks on American reconnaissance satellites. That said, the prospect of addressing vulnerability of satellites through arms control measures has never generated much enthusiasm. During the late 1980s, several significant articles analyzed various approaches to space arms control that could be characterized as either banning things or banning actions.

However, as previously mentioned, the preliminary discussions on space arms control with the Soviet Union during the Reagan administration made little headway. More recently, Clinton administration officials have emphatically stated that arms control discussions to ban anti-satellite testing or systems are neither "underway, envisioned, nor under consideration".

In fact, upon closer examination, formal arms control agreements would not appear to hold much promise as an approach to protecting U.S. military and commercial satellites in the emerging space environment. The basic problem with limiting capabilities is determining just what capabilities to limit. During the Cold War, the major arms control initiatives dealt almost exclusively with fielded military capabilities and relatively mature technologies. Even so, there was considerable room for debate over the "units of account" – that is, what things should or could reasonably be subject to limits. For example, in the first strategic arms control talks, negotiators could not agree on ways to constrain intercontinental ballistic missiles directly, so they settled upon limiting their launchers, or silos. The problem is compounded in the case of anti-satellite weapons. In the absence of an existing threat, an agreement aimed at weapons that could pose a threat to satellites can only speculate as to the types of systems, capabilities, or activities that should be subject to restriction. Space technology is developing so rapidly that entirely unforeseen threats could emerge within the life of a formal arms control treaty. Thus, limiting a particular kind of capability, such as the rocket-mounted satellite interceptors developed by the United States and the Soviet Union during the Cold War, would provide little protection against systems based on entirely new or different technology and could engender a false sense of security.

Additionally, some of the systems that might be used to attack satellites, which would therefore be subject to limitation, might also have other, entirely legitimate civilian or military purposes. Reductio ad adsurdum, any satellite that can be manoeuvred in such a way as to collide with another satellite could theoretically be used for "anti-satellite" purposes. While one might counter that the functions of individual satellites are generally widely known, not everyone will agree. The Soviet Union, for example, objected to the U.S. space shuttle as a potential anti-satellite platform since it had the capability to "snatch" satellites in orbit.

Even those future systems that have been popularly identified as having a possible anti-satellite role, such as space-based lasers or a military space plane, could also perform a variety of other missions. The former has in fact been most closely identified with defence against ballistic missile warheads. The latter could be used to perform routine but cost-effective logistical tasks, such as repair, refuelling, or replacement of satellites in orbit. Thus, unless a system is unmistakably identified as an anti-satellite weapon, either by declaration or unequivocal action, it may be exceedingly difficult to apply an ASAT label to it. Limiting a system simply because it possesses a potential anti-satellite capability would be unduly restrictive and could deny the nation capabilities that might prove militarily or economically important. Finally, attempting to place limits on multiple-use systems only if they were equipped for an ASAT role would pose obvious verification and enforcement problems or, conversely, opportunities for cheating by one or more parties.

Likewise, restricting certain activities that ostensibly constitute deliberate interference or attacks on satellites would also add little value. The international legal regime already contains provisions for non-interference. As noted earlier, the 1967 Outer Space Treaty endorses the principle of non-interference in the peaceful exploration or use of space. Similarly, the 1973 International Telecommunications Convention states that all space objects must be operated in such a way as to avoid harmful interference to the radio services or communications of others. Additionally, military radio installations must observe statutory provisions relative to . . . the measures to be taken to prevent harmful interference.

Finally, the strategic arms treaties between the United States and the successor states to the Soviet Union prohibit interference with national technical means of verifying the treaty, which include some space systems. Thus, in peacetime at least, deliberate interference with the satellites and their signals is already restricted by international agreement.

Actual hostilities are a different matter. The provisions of the Outer Space Treaty about non-interference may not apply in this instance since the treaty also acknowledges that nations will conduct their activities in space in accordance with the U.N. Charter, which explicitly recognizes every nation's inherent right to individual or collective self-defence. Only rarely has international law specifically prohibited the use of particular weapons or specific activities in warfare, and then usually in cases where the treatment of non-combatants is at issue or considerable opprobrium is attached to the weapon or activity in question – such as poison gas.

While attacks on satellites might have profound military or economic consequences, they would hardly generate the same kind of moral outrage. Thus, it stretches the imagination to believe that any nation would ever consent to an arms agreement that would categorically foreclose the option of attacks on space systems in wartime or would actually refrain from attacking a satellite if it concluded that significant military advantage could be gained from doing so. For all these reasons, a categorical ban on attacks on satellites would seem to hold little promise.

While legally banning anti-satellite systems or activities associated with their use would not appear to add much value at the moment, it may be possible for nations to mutually refrain from activities that might be construed as threatening to the satellites of others. Such undertakings are not without precedent. When it has been within their general interests, nations have held back from employing certain weapons and engaging in certain activities during wartime, even in the absence of specific agreements. For the most part, the major powers avoided the use of chemical weapons during the Second World War. None of the nuclear states have employed their nuclear arsenals in military conflicts since the attacks on Hiroshima and Nagasaki in August 1945. Given the cost of developing weapons in space and the ramifications of attacking a satellite and thereby inviting some sort of retaliation (either against one's own space systems or elsewhere), nations might conclude that the long-term costs are not worth the potential gains. As long as such mutual restraint is exercised, it may be possible for the space powers to uphold the principle of unfettered access to space without the need to actually employ anti-satellite weapons either to deter or defend against their use by others.

There may also be several useful opportunities for the United States to engage the other space powers in discussions on the rules of the road in space to enhance understanding and confidence in their respective space activities.

Existing international agreements call upon nations to register the space objects they launch with the secretary general of the United Nations. The information required is minimal, including only the name of the launch state, registration number or other designator, date and territory of the launch, basic orbital parameters, and general function of the space object. This approach could be extended to provide for greater transparency concerning satellite payloads in order to reduce uncertainties about possible threats posed by a particular space object and to foster a climate of greater openness. The growing use of space and the problem of orbital debris suggest another area in which greater international cooperation would be beneficial.

The standards and practices that govern air traffic worldwide might be applied to space, perhaps in the form of a "Space Federal Aviation Administration". These examples are suggestive and by no means exhaustive. The main point is that there are significant opportunities for greater cooperation and collaboration in defining proper activities in space that have immediate importance and are more likely to sustain peaceful operations in space than a narrowly drawn arms control agreement that attempts to ban anti-satellite weapons or activities.

As noted earlier, a central dilemma in fashioning future space policy is balancing the need to protect one's own capability to use space and, at the same time, to deny that same capability to an adversary. Even if it were possible to devise an effective arms control regime to protect satellites from interference or attack during hostilities, it might not be worth the price if it prevented us from taking actions necessary to stop an enemy from using space to its advantage or, conversely, to our disadvantage. Armed conflict has historically entailed efforts to confuse or disrupt the opponent's gathering of timely intelligence, communicating with and controlling its forces, and navigating across the battlefield.

The rapid tempo and lethality of modern warfare place an even higher premium on maintaining an information edge over the opponent. Because such information is increasingly derived from or transmitted through space systems, success in future conflicts could very well depend upon the ability to shut off (perhaps only temporarily) an adversary's ability to obtain and use space products and services. The possible means of accomplishing this particular task are quite varied. The overall mission of protecting satellites and denying their use to adversaries, commonly referred to as space control, actually entails several interrelated activities and objectives. These include, inter alia, assuring access to space and the ability to operate there; surveillance of objects in space; protecting space systems from attack; preventing unauthorized access to or use of friendly space systems; and negating space systems that pose a risk to national and allied interests.

5.9 Environmental Concerns

The benefits of using outer space in areas like remote sensing, telecommunications, exploration and tourism among several others have been adequately pointed out by various media. But every major scientific breakthrough is accompanied by side effects which may not always be highlighted. It is become increasingly clear in recent times that the environment of outer space has been adversely affected by the rush of human activities in space. Hence environment protection in space should be given a high priority whenever any activity or project related to space is taken up.

Soon after the launch of Sputnik I the International Council of Scientific Unions identified several problems of pollution. Therefore, a special body for further investigation was commissioned, called the Committee on Contamination by Extra-terrestrial Exploration. Then, in 1964, the David Davies Memorial Institute of International Studies formulated some draft rules concerning changes in the environment of the earth. In the draft rules, the term 'changes in the space around the earth' was interpreted as 'changes in the space around the earth by means of the introduction of novel elements or the disturbance of the physical equilibrium, or processes which cause reactions upon, or in the vicinity of, the earth'.

Different types of damage may be caused to the space environment which can be classified as follows –

i) Damage caused by debris circulating in space
ii) Damage cause by harmful contamination and harmful interference
iii) Damage caused by nuclear and radioactive space activities
iv) Damage to the ozone layer
v) Damage caused by space stations
vi) Damage caused by solar satellites

i) *Damage caused by debris circulating in space*

The damage caused by debris may be in several forms. It may be caused by debris falling down on the earth from space. It could also be debris colliding in outer space with other space objects, and by interfering with telecommunications and remote sensing. Space debris can endanger both human life and active payloads. Some examples of damage caused on the surface of the earth are the Skylab which fell down over Australia in July 1979, and the Cosmos 954 satellite which disintegrated over Canada in 1978[11]. A collision occurred when the space shuttle challenger was hit by a tiny piece of paint that had originally come from a delta rocket and measured just 0.2 mm in diameter. The main cause of damage is the velocity of the debris.

ii) *Damage caused by harmful contamination and harmful interference*

The term harmful contamination of outer space has not been defined. But there is a distinction between forward contamination and back contamination[12]. Forward contamination is caused by the introduction of harmful matter into outer space. Back contamination is caused by the introduction of extraterrestrial matter into the earth and the atmosphere by space action. Regarding harmful interference, the common term used is pollution which can be defined as a modification of the environment through human agency by the introduction of undesirable elements or by the undesirable use of elements.

iii) *Damage caused by nuclear and radioactive space activities*

Contamination can be caused by parts of a satellite that comes down carrying a nuclear charge. In April 1970, parts of the Apollo 13, which included a nuclear reactor, fortunately fell somewhere into the Pacific Ocean. But with the increasingly frequent use of satellites, there is the possibility of dangerous accidents occurring in the future, if such parts of satellites fall on inhabited areas of land.

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[11] *Prof. Dr. I.H. Ph. Diederiks-Verschoor & Prof. Dr. V. Kopal, "An Introduction to Space Law", p.127*
[12] *S. Gorove, 'Studies in Space Law; Its Challenges and Prospects', 1977, p.153*

iv) *Damage to the ozone layer*

The ozone layer is in the stratosphere, which starts between 8 km and 16 km above sea level and continues to approximately 50 km. Ozone is formed when oxygen molecules are dissociated by the sun's ultraviolet radiation. The ozone molecules then absorb this same radiation. If the ozone layer is depleted, more ultraviolet radiation will reach the surface of the earth. This will cause an increase in skin cancers and eye cataracts in human beings amongst other things. Despite concerns about ozone change, its measurement has not yet become routine and global. Continuity of measurement and global coverage from a set of long-life satellites carrying accurately standardized instruments is needed.

v) *Damage caused by space stations*

The number of operational space stations is not yet large, but their permanent character and the increasingly intensive use of these complex satellites in future could eventually cause damage to the environment in which they are placed.

vi) *Damage caused by solar satellites*

Solar energy can be transmitted from outer space to the earth by three methods, i.e. transmission by microwaves, laser beams and reflected light. Environment and human health can be seriously and adversely affected by sustained power transmission from outer space. This can happen if they are exposed to risks by the terrestrial activities surrounding solar power satellites operations.

The importance of protecting the environment of outer space and celestial bodies needs to be realised along with the effects of space activities on the terrestrial environment. Legal safeguards must be achieved by way of regional and international co-operation, and all states must be sincere in their determination to explore and use outer space for the benefit and in the interest of all countries.