ASTROREGS – THE'RULES OF THE ROAD' IN OUTER SPACE

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Abstract

Space travel has evolved greatly over the past five decades. From Sputnik to the Space Shuttle, from lunar landings to Mars, man's entry into space has come so far, and yet, in many respects, our use of space has just begun. One thing has proved constant - objects in space are becoming more numerous. As space travel comes of age, accident-free transportation will require the creation of common deconfliction measures. Will spacefarers of the future look to their Astronomical Collision Avoidance Regulations (ASTROREGS), for guidance?

This paper will provide a context for the creation of space navigation rules and will advance proposals for 'Rules of the Road' that deal specifically with anticipated encounters in space. Based on the precedents of transportation history, specifically road, maritime, and aviation modes, the existing norms and regulations have been expanded to accommodate the unique properties of outer space and the speed necessary for efficient inter-planetary travel.

Concurrently, in the fields of admiralty or insurance law, the existence of agreed-to navigational rules, and the deviation from those rules, have been used to determine fault. It stands to reason that with an increase in space transportation, the establishment of a standard method of determining fault will be a necessity for future space travelers as well.

Space's Unique Properties And The Dangers Of Collision

The unique properties of outer space and the speed necessary for efficient inter-planetary travel dramatically increase both the probability of, and the catastrophic consequences of, collisions.

Non-spacefarers frequently think of acceleration in terms of 'forward' or 'backward.' Acceleration along a single plane, without any outside forces, is regarded as one-dimensional travel. However, even one-dimensional travel has two-dimensional factors. The second dimension of travel, perpendicular to the first dimension, would be 'up' and 'down.' On Earth, this is normally associated with a force we take for granted, because it is, literally, right beneath our feet – gravity. We take gravity for granted because on the road and on the sea, gravity is relatively constant, keeping us at surface level. In collision avoidance on the land or sea, our most frequent concerns are with a third dimension of travel: direction. Thus, seafarers frequently avoid collisions by speeding up or slowing down, and by turning left or right. Similarly, in the air, a more true three-dimensional collision avoidance model, collisions are frequently avoided by increasing/decreasing altitude or turning left/right. (These maneuvers are preferred to speeding up/slowing down for reasons of aerodynamic stability.)

The three dimensions of travel described above are transformed in the context of space travel. To begin with, there is no absolute scientific line between the end of the Earth's atmosphere and the beginning of true space. Second, in true space there is virtually no friction – no air or water with which to react. Third, the further one travels from a given planet, the lower the immediate gravitational pull of that planet.

Gravity or, more correctly, *gravities* found in space take on a new significance. For example, at launch, the Space Shuttle will accelerate from 0-17,500 miles per hour in order to break free of the Earth's atmosphere.[1] Once in space, a craft may use a planet's gravity to further increase its own speed. The spacecraft Galileo first used the Earth as a 'slingshot' to reach a velocity of 20,250 mph. As Galileo encountered the gravitational pull of Io, one of Jupiter's moons, it was traveling at a velocity of 54,225 mph. Jupiter's enormous gravity force accelerated Galileo to its high speed.

It should be noted, however, that even at these incredibly hazardous speeds, interplanetary voyages currently take years to accomplish.[2] Current space flight operations, both manned and unmanned, often include trajectory changes or orbit maneuvers[3] to avoid the 2613 satellites, 90 space probes and 6079 debris objects currently estimated to be in orbit around Earth.[4]

The conduct of ordinary space transit must include procedures or 'Rules of the Road,' in order to avoid collisions with other spacecraft in transit, wherever such encounters may occur. Given the high speeds involved in interstellar travel, the expansion of commercial, scientific and military operations in space, and the acknowledged tendency for high-density traffic to clog certain space highways, the available distance and time within which a spacefarer may be able to react to a potential collision is significantly diminished. Standard evasion procedures are already needed to assist modern day spacefarers, and they will be increasingly necessary to avoid collisions in the coming years.

Current international law "provides no 'Rules of the Road' for outer space and does not determine which spacecraft has the right of way."[5] Furthermore, "because there are no rules as to who has the right of way, collisions may result in both parties 'being in the right.'"[6] "To create order in space activity, states must know what rules apply to them and where those rules apply ... In the future, more numerous and larger missions may affect each other and space planners must know what rules apply to them in order to avoid collisions and other possible harmful effects on the missions of other countries."[7]

Today the only traffic rules in space are those that govern the situating of satellites in geo-stationary orbit. These orbital "slots" are created and agreed to at the International Telecommunications Union.[8] There exist no specific international air traffic regulations especially tailored to space transportation systems. "In order to safeguard the re-entry of space transportation systems to Earth, air traffic lawyers and space lawyers will have to eliminate incompatibilities between their two regimes. Such efforts must take into account the legitimate rights and interests of States affected by any compromise, particularly as they pertain to security interests of international aviation."[9]

"The legal regimes used in regulating collisions of ships at sea and aircraft in flight provide the most relevant model allocating liability between spacecraft in flight. Differing degrees of conformity to an elaborate system of safety rules and regulations largely determine liability ... When rules of space navigation and traffic control are established through custom or explicit agreement, failure to comply with any such rules if such failure has caused or contributed to collision, will presumably be regarded as constituting actionable 'fault.'"[10]

The Law of the Sea

On the sea, frictional forces are different than those found on land. It takes longer to stop and greater force to change direction. Additionally, commercial sea-going craft tend to be more massive and thus even at slower speeds can create greater damage. A punctured hull and gradual loss of buoyancy can send even the most massive craft to the bottom of the sea. Thus, the dangers of collision at sea are catastrophic when compared to those on land.

Recognizing this, as early as 1910, the Convention for the Unification of Certain Rules of Law with respect to Collisions between Vessels was held in Brussels. By 1972, the nations of the world, recognizing the unique dangers of sea travel, signed the International Regulations for Prevention of Collisions at Sea (COLREGS). The COLREGS provide binding comprehensive regulations for the prevention of collisions on the water.[11]

Entered into force in 1977, the regulations were intended to standardize actions taken to avoid collision that had previously been established by custom and treaties:

Risk of Collision

(a) Every vessel shall use all available means appropriate to the prevailing circumstances and conditions to determine if risk of collision exists. If there is any doubt such risk shall be deemed to exist.

(b) Proper use shall be made of radar equipment if fitted and operational, including long-range scanning to obtain early warning of risk of collision and radar plotting or equivalent systematic observation of detected objects.

(c) Assumptions shall not be made on the basis of scanty information, especially scanty radar information.

(d) In determining if risk of collision exists the following considerations shall be among those taken into account:

- *(i) Such risk shall be deemed to exist if the compass bearing of an approaching vessel does not appreciably change;*
- *(ii) Such risk may sometimes exist even when an appreciable bearing change is evident, particularly when approaching a very large vessel or a tow or when approaching a vessel at close range.*

Action to Avoid Collision

(a)Any action taken to avoid collision shall, if the circumstances of the case admit, be positive, made in ample time and with due regard to the observance of good seamanship.

(b) Any alteration of course and/or speed to avoid collision shall, if the circumstances of the case admit be large enough to be readily apparent to another vessel observing visually or by radar;

a succession of small alterations of course and/or speed shall be avoided.

(c) If there is sufficient sea room, alteration of course alone may be the most effective action to avoid a close-quarters situation provided that it is made in good time, is substantial and does not result in another close-quarters situation.

(d) Action taken to avoid collision with another vessel shall be such as to result in passing at a safe distance. The effectiveness of the action shall be carefully checked until the other vessel is finally past and clear.

(e) If necessary to avoid collision or allow more time to assess the situation, a vessel may slacken her speed or take all way off by stopping or reversing her means of propulsion.

(f)

- *(i) A vessel which, by any of these rules, is required not to impede the passage or safe passage of another vessel shall when required by the circumstances of the case, take early action to allow sufficient sea room for the safe passage of the other vessel*
- *(ii) A vessel required not to impede the passage or safe passage of another vessel is not relieved of this obligation if approaching the other vessel so as to involve risk of collision and shall, when taking action, have full regard to the action which may be required by the rules of this part.*
- *(iii) A vessel the passage of which is not to be impeded remains fully obliged to comply with the rules of this part when the two vessels are approaching one another so as to involve risk of collision.*

Overtaking

(a) Notwithstanding anything contained in the Rules of Part B, Sections I and II, any vessel overtaking any other shall keep out of the way of the vessel being overtaken.

(b) A vessel shall be deemed to be overtaking when coming up with a another vessel from a direction more than 22.5 degrees abaft her beam, that is, in such a position with reference to the vessel she is overtaking, that at night she would be able to see only the stern light of that vessel but neither of her sidelights.

(c) When a vessel is in any doubt as to whether she is overtaking another, she shall assume that this is the case and act accordingly.

(d) Any subsequent alteration of the bearing between the two vessels shall not make the overtaking vessel a crossing vessel within the meaning of these Rules or relieve her of the duty of keeping clear of the overtaken vessel until she is finally past and clear.

Head-on Situation

(a) When two power-driven vessels are meeting on reciprocal or nearly reciprocal courses so as to involve risk of collision each shall alter her course to starboard so that each shall pass on the port side of the other.

(b) Such a situation shall be deemed to exist when a vessel sees the other ahead or nearly ahead and by night she could see the masthead lights in line or nearly in line and/or both sidelights and by day she observes the corresponding aspect of the other vessel.

(c) When a vessel is in any doubt as to whether such a situation exists she shall assume that it does exist and act accordingly.

Crossing Situation

When two power-driven vessels are crossing so as to involve risk of collision, the vessel which has the other on her own starboard side shall keep out of the way and shall, if the circumstances of the case admit, avoid crossing ahead of the other vessel.

Action by Give-way Vessel

Every vessel which is directed to keep out of the way of another vessel shall, so far as possible, take early and substantial action to keep well clear.

Action by Stand-on Vessel

(a)

- *(i) Where one of two vessels is to keep out of the way of the other shall keep her course and speed.*
- *(ii) The latter vessel may however take action to avoid collision by her maneuver alone, as soon as it becomes apparent to her that the vessel required to keep out of the way is not taking appropriate action in accordance with these Rules.*

(b) When, from any cause, the vessel required to keep her course and speed finds herself so close that collision cannot be avoided by the action of the give-way vessel alone, she shall take such action as will best aid to avoid collision.

(c) A power-driven vessel which takes action in a crossing situation in accordance with subparagraph (a)(ii) of this Rule to avoid collision with another power-driven vessel shall, if the circumstances of the case admit, not alter course to port for a vessel on her own port side.

(d) This Rule does not relieve the give-way vessel of her obligation to keep out of the way.[12]

The Law of the Air

The dangers of collision in the Earth's atmosphere are even more likely to result in fatality and complete destruction of the craft involved than those at sea. Aircraft are constructed of lighter and frequently more vulnerable materials than surface craft. This makes most aircraft very susceptible to damage. Additionally, because gravity is such a constant threat, an aircraft must always maintain the integrity of its lifting and control surfaces for aerodynamic purposes. Even the slightest damage can cause a loss of aerodynamic control.

"In 1943, the US initiated studies of ... civil aviation problems which, once more, confirmed the belief that they either were to be tackled on an international scale or it would not be possible to use [aviation] as one of the principal elements in the economic development of the world."[13] By 1944, a new organization, conceived in Chicago, had emerged. The International Civil Aviation Organization (ICAO)'s stated purpose is to develop the principles and techniques of international air navigation, and foster the planning and development of international air transport, to ensure the safe and orderly growth of international civil aviation throughout the world, to encourage the development of airways, airports, and air navigation facilities for international civil aviation, and to promote safety of flight in international air navigation.[14]

The ICAO has recognized that in order to ensure safety, regularity and efficiency of international civil aviation operations, international standardization is essential in all matters affecting them, that is, all matters in the operation of aircraft, aircraft airworthiness and the numerous facilities and services required in their support such as aerodromes, telecommunications, navigation aids, meteorology, air traffic services, search and rescue, aeronautical information services and aeronautical charts. A common understanding between the countries of the world on these matters is absolutely necessary.[15]

The ICAO Rules, also known as the "Chicago rules," appear below:

Operating near other aircraft

(a) No person may operate an aircraft so close to another aircraft as to create a collision hazard.

(b) No person may operate an aircraft in formation flight except by arrangement with the pilot in command of each aircraft in the formation.

(c) No person may operate an aircraft, carrying passengers for hire, in formation flight.

Right-of-way rules (Except water operations)

(a) Inapplicability. This section does not apply to the operation of an aircraft on water.

(b) General. When weather conditions permit, regardless of whether an operation is conducted under instrument flight rules or visual flight rules, vigilance shall be maintained by each person operating an aircraft so as to see and avoid other aircraft. When a rule of this section gives another aircraft the right-of-way, the pilot shall give way to that aircraft and may not pass over, under, or ahead of it unless well clear.

(c) In distress. An aircraft in distress has the right-of-way over all other air traffic.

(d) Converging. When aircraft of the same category are converging at approximately the same altitude (except head-on, or nearly so), the aircraft to the other's right has the right-of-way. If the aircraft are of different categories --

(1) A balloon has the right-of-way over any other category of aircraft;

(2) A glider has the right-of-way over an airship, airplane, or rotorcraft; and

(3) An airship has the right-of-way over an airplane or rotorcraft.

However, an aircraft towing or refueling other aircraft has the right-of-way over all other engine-driven aircraft.

(e) Approaching head-on. When aircraft are approaching each other head-on, or nearly so, each pilot of each aircraft shall alter course to the right.

(f) Overtaking. Each aircraft that is being overtaken has the right-of-way and each pilot of an overtaking aircraft shall alter course to the right to pass well clear.

(g) Landing. Aircraft, while on final approach to land or while landing, have the right-of-way over other aircraft in flight or operating on the surface, except that they shall not take advantage of this rule to force an aircraft off the runway surface which has already landed and is attempting to make way for an aircraft on final approach. When two or more aircraft are approaching an airport for the purpose of landing, the aircraft at the lower altitude has the right-of-way, but it shall not take advantage of this rule to cut in front of another which is on final approach to land or to overtake that aircraft.

In addition, altitude is the preferred method of separation, since aircraft maintaining different altitudes cannot collide no matter what their routes may be. The usual minimum is 1000 feet of vertical separation, though this is increased to as much as 5000 feet at very high altitudes.[16]

The Law of Space

With a legacy of codified collision avoidance regulations on the sea and in the air, it could be presumed that at the outset of the space age, a similar approach to standardized procedures should naturally follow. And yet, the progress of multinational agreement on space issues does not appear to have kept pace with the progress made in outer space.

It was not until 1967, a decade after the launch of Sputnik, that the United Nations Outer Space Committee announced the first agreement on a treaty governing Exploration And Use Of Outer Space, The Moon And Other Celestial Bodies.[17] The 1967 Space Treaty was followed in 1968 with an agreement on the rescue of astronauts in space, and in 1972, with a Convention on International Liability for Damage Caused by Space Objects.[18]

According to the 1972 Convention, a launching State is deemed liable for damage due to its faults in space. No means however, were provided to determine fault for an event occurring in space, (i.e., other than at the surface of the Earth or to aircraft in flight).[19]

The 1972 Convention states, in pertinent part:

Taking into consideration that, notwithstanding the precautionary measures to be taken by States and intergovernmental organizations involved in the launching of space objects, damage may on occasion be caused by such objects...

Recognizing the need to elaborate effective international rules and procedures concerning liability for damage caused by space objects and to ensure, in particular, the prompt payment under the terms of this Convention of a full and equitable measure of compensation to victims of such damage...

Have agreed on the following:

Article I

The term "damage" means loss of life, personal injury, or other impairment of health; or loss of or damage to property of States or of persons, natural or juridical, or property of international intergovernmental organizations.

Article II

A launching state shall be absolutely liable to pay compensation for damage caused by its space object on the surface of the Earth or to aircraft in flight.

Article III

In the event of damage being caused elsewhere than on the surface of the Earth to a space object of one launching State or to persons or property on board such a space object by a space object of another launching state, the latter shall be liable only if such damage is due to its fault or the fault of persons for whom it is responsible.

Article IV

1. *In the event of damage being caused elsewhere than on the surface of the Earth to a space object of one launching State or to persons or property on board such a space object by a space object of another launching state, and of damage thereby being caused to a third State or to its natural or juridical persons, the first two states shall be jointly and severably liable to the third State, to the extent indicated by the following:*
2. *... the burden of compensation for the damage shall be apportioned between the first two States in accordance with the extent to which they were at fault.*

Article VI

2. *No exoneration whatever shall be granted in cases where the damage has resulted from the activities conducted by a launching State which are not in conformity with international law including, in particular, the Charter of the United Nations and the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies.*

Article IX

A claim for compensation for damage may be presented to a launching State not later than one year following the date of the occurrence of the damage or the identification of the launching State which is liable

Article X

2. *If however, a State does not know of the occurrence of the damage or has not been able to identify the launching State which is liable, it may present a claim within one year following the date on which it learned of the aforementioned facts; however, this period shall in no event exceed one year following the date on which the State could reasonably be expected to have learned of the facts through the exercise of due diligence.*

Article XI

2. *Nothing in this Convention shall prevent a state, or natural or juridical persons it might represent, from pursuing a claim in the courts or administrative tribunals or agencies of a launching state.*[20]

No subsequent multinational agreements have promulgated rules that would lead to determinations of fault for a collision in space.

"The legal regimes used in regulating collisions of ships at sea and aircraft in flight provide the most relevant model allocating liability between spacecraft in flight. Differing degrees of conformity to an elaborate system of safety rules and regulations largely determine liability ... When rules of space navigation and traffic control are established through custom or explicit agreement, failure to comply with any such rules if such failure has caused or contributed to collision, will presumably be regarded as constituting actionable 'fault.'"[21]

Through regulations, spacefarers can expect to have a reasonable degree of predictability in avoiding other spacecraft, and grounds for legal recourse should damage occur. Spacefarers should also have confidence that their own preventive decisions are in conformity with those of their fellow spacefarers, that there is a common understanding of the situation, and that they do not actually increase the danger or complicate situations further.

Dr. Lubos Perek, in his paper Early Concepts for Space Traffic, has discussed some of these ideals with regard to establishing rules for avoidance of collisions: "Knowledge of traffic rules enables drivers, helmsmen, or pilots to anticipate the actions of their counterparts and to choose the optimal action. Many rules exist in the 'Rules of the Road,' such as rules on right of way, priority at crossings, etc."[22]

As an initial proposition, "A State owes at all times a duty to protect other States against injurious acts by individuals from within its jurisdiction"[23] When one considers that launching states already have the duty to register and license spacecraft, it is only natural that a launching state should have a reasonable expectation of what capabilities and norms its spacecraft must have to avoid other states' craft. Thus, the U.S. Code delineates domestic responsibility to "regulate commercial space transportation industry, only to the extent to ensure compliance with international obligations of the United States and to protect the public and safety, safety of property."[24]

A New Dimension Of Collision Avoidance Thinking

Some "space traffic" rules are already in force, and what's more, are followed by all space users. The International Telecommunication Union has been applying traffic rules to geostationary satellites for a long time, almost since the beginning of the use of the orbital belt.[25] Limited avoidance maneuvers have been developed for use in particular in geostationary orbit. [26]

Collisions in space are unlike those at sea or within the Earth's atmosphere. They involve movement and positioning that is not oriented exclusively to the Earth. Thus, for example, it is recognized that due to the differences between the legal regimes of air and space law and the differences between the activities conducted in air and space, "the wholesale adoption of aviation law to the space environment is not a viable alternative."[27] However, modeling space traffic laws as closely as possible to existing ICAO regulations would make the transition to space travel easier in its formative years.

Looking at the COLREGS and ICAO as a foundation, we can propose a reasonable set of ASTROREGS, incorporating the special considerations of space travel. The "Chicago Rules," to a certain extent, resemble the COLREGS, and since both have been effective in regulating transportation, they set a strong precedent (just as the Antarctica Treaty concerning state claims of ownership was used to draft the Outer Space Treaty).[28] "Marine traffic is regulated by special International Regulations for Preventing Collisions at Sea. For the prevention of collisions in the air, sophisticated practices and technical elements have been introduced."[29] Space is the next venue for regulation.

Space law, however, must take into account an added 'dimension,' of travel that is unique to space itself. Currently all of our dimensional analysis is based on a common reference of "up"– that opposite the Earth's gravitational pull. We drive our cars sitting upright. We sail our ships standing with our feet towards the sea. Even in flight, we base our direction in reference to the Earth's horizon – presumed to be parallel, if not close to parallel, to our own perpendicular stance tangential to Earth.

Space is technically a 3-dimensional environment. But, while all of the current 'Rules of the Road' are based on gravity (perpendicular to the tangent of the Earth), in space there is either no gravity or multiple gravities, so that there exists no easy common reference for which dimension is which. In outer space, the lack of gravity or multiple forces of gravity will require a variation of these rules to establish commonality. This fourth-dimension - orientation - will be the principle change in adapting ICAO and COLREGS to ASTROREGS.

If a spacecraft is not facing the Earth it will turn 'right' the same way that a spacecraft facing the Earth will turn to its 'right.' Without a common gravity orientation, each may turn towards the other, even if intending to turn away. Additionally, some spacecraft may purposefully rotate by design (such as those using centripetal forces to simulate gravity or those who seek to avoid uneven radiation by a solar body), and thus 'right' is an ever-changing proposition with regards to other craft.

We currently orient our third dimension in terms of North and South, East and West. Earth's magnetic poles enabled early navigational tools based on magnetism to shape the nature of its common orientation. As primitive as these tools seem in the age of space travel, it is proposed that the concept of polar orientation can still serve a very significant purpose, as follows:

All planets rotate in one direction - using primitive terms: 'clockwise' or 'counter-clockwise.' Whichever way a planet is spinning, motion cannot be in more than one direction simultaneously. We can use this rotation as a basis to establish each planet's 'North' regardless of any intrinsic magnetic properties. Using Earth as the model, all planets will be judged to rotate counter clockwise. Based on a counter clockwise rotation, the top pole shall be north, and the bottom pole shall be south. This will be termed "polar orientation."

Concepts of "Meeting," "Crossing" and "Overtaking" have been refined to meet the added dimensions of space travel as well. Overtaking is currently defined by maritime regulations as being 22.5 degrees abaft of the beam. Since the beam of a craft in space would encompass 365 degrees in a plane perpendicular to the forward motion of travel, and because a space craft's direction of travel may not always be the same as its thrust orientation, the most logical determination of "Overtaking" would be the equivalent of 22.5 degrees abaft of that beam. In simpler terms, this would be a cone measuring 67 degrees opening opposite the direction of travel of the craft.

<u>Some Additional Adaptations from Air and Sea Laws:</u>

In addition to the 'Rules of the Road' proposals found at the end of this paper, it is submitted that additional matters found in air and sea regulations should be included in special rules complementing the ASTROGREGS:

1. <u>Jurisdiction</u>. Both the COLREGS and ICAO regulations define their jurisdiction. Although there is no current consensus, custom, or explicit agreement on where the border lies between atmosphere and space, proposed regulations delineate that a local space 'authority' be charged with defining such matters. The same local space authority, should also be charged with the governance of areas with increased traffic such as planetary, moon, space station, or spaceports. Since the local authority would most likely be in the best position to determine prevailing conditions of weather, density of traffic, gravitational forces, magnetic forces, and radiation influences, the local authority should also be charged with charting, defining, and maintaining navigational references, special transit lanes, and orbital separation schemes.

An example of such a local authority for our Earth and surrounding satellites might be an outcrop of the current United Nations organization. Outside the space-atmosphere border, the U.N. authority would promulgate the rules and regulations for near-Earth space travel. Inside the atmosphere, where travel requires different craft properties than used in space, the individual nations and spaceport authorities would promulgate their own regulations. Both inner and exo-atmospheric authorities would be expected to conform their rules as closely as possible to the ASTROREGS while fine-tuning the regulations to meet the circumstances of their varying areas.

2. Navigational Data Transmission. "More than any other environment, states that send objects into space require timely knowledge of positions and movements of other space objects ... Aircraft all over the world use relatively inexpensive equipment to serve the function of collision avoidance and traffic control. Given the advanced state of technology of space objects, the regime for outer space should also make use of electronic devices for these purposes."[30] Continuous automatic transmission of such positional and direction of travel data should be required. Authorities should promulgate reference points for effective interstellar transit. Additionally, prioritization of reference points within a set of special rules would assist computers in relaying their positions to other craft by automatic and continuous transmission.

3. Orbits Defined. On Earth, designated orbits are already in existence by virtue of efficiency and the peculiar gravitational forces of this planet. Geostationary satellites currently occupy a ring approximately 35,786 kilometers (19,323 nautical miles or 22,241 statute miles) above the Earth's surface.[31] To stay over the same spot on Earth, a geostationary satellite also has to be nearly directly above the equator. Other proposed orbits to be defined might be those of a Disposal Orbit – for space debris near a planet or a 'Space Anchorage,' where vessels too large to reenter a planet's atmosphere would position themselves while shuttlecraft carry goods or passengers to the surface.[32]

4. Pollution. Finally, with or without preemptive destruction, pollution abatement must be addressed.[33] In fulfilling its role of fostering all aspects of international civil aeronautics, the [ICAO] Organization is giving special attention to the impact that civil aviation has on the environment, with the aim of ensuring maximum compatibility between safe and orderly development of civil aviation and the preservation and enhancement of a wholesome human environment.[34] The Environmental Protection Agency regulates discharge of waste at sea. So, too, should a local space authority regulate the creation and disposal of space debris.

ASTROREGS
Astronomical Collision Avoidance Regulations

I. General

A. These rules shall apply to all craft in space and transiting atmospheres bordered by space.

B. Nothing in these rules shall interfere with the operation of special rules made by appropriate Galaxial, Planetary, and Satellite authorities for spaceports and space harbors. Such special rules shall conform as closely as possible to these rules.

C. Local authorities shall promulgate special rules to include, but not limited to:

(i) Explicit delineation of distance from a planet's surface at which the atmosphere/space border exists.
(ii) Charting, defining, and maintaining large objects, naturally occurring satellites, planets, and other navigational references.
(iii) Pollution abatement measures.

D. Traffic separation schemes may be adopted by the authority for the purposes of these rules.

E. Orbital separation schemes may be adopted by the authority for the purposes of these rules.

II. Responsibility

A. Nothing in these rules shall exonerate any craft, or the owner, master, crew or state of origin thereof, from the consequences of any neglect to comply with these rules or to the neglect of any precaution which may be required by the ordinary practice of space farers, or by the special circumstances of the case.

B. In construing and complying with these rules, due regard shall be had to all dangers of navigation and collision and to any special circumstances, including the limitations of the craft involved which may make a departure from these rules necessary to avoid immediate danger.

III. General Definitions

For the purposes of these rules, except where the context otherwise requires:

A. The term "Space" means not on the surface of a planet or traveling in the atmosphere of a planet.

B. The term "Craft" includes both those with propulsion and not under command. The term "Craft" encompasses all manned vessels, satellites, stations or transport. The term "Craft" also means all unmanned man-made vessels, satellites, stations or transport in active use.

C. The term "Propulsion-driven" means any craft propelled by machine, chemical, pulse, sonic, anti-gravity, or magnetic device.

D. The term "Solar-driven" means any craft propelled solely by solar power, solar sail or other means dependent on the radiation of a star.

E. The term "Not under command" means a craft which through some exceptional circumstance is unable to maneuver as required by these rules and is therefore unable to keep out of the way of another craft.

F. The term "Restricted in ability to maneuver" means a craft which from the nature of its employment is restricted in ability to maneuver as required by these rules and is therefore unable to keep out of the way of another craft.
G. The term "Restricted detection ability" means any condition in which the detection of other craft or objects is restricted or hampered by forces not normally encountered, to include, but not limited to visual, magnetic, and solar radiation interference.
H. The term "Meeting" means approaching head-on or nearly head-on angles.
I. The term "Crossing" means approaching at any angle other than head-on or from 0-67 degrees in any direction opposite from the direction of travel of another craft.
J. The term "Overtaking" means approaching from 0-67 degrees in any direction opposite from the direction of travel of another craft.
K. The term "Object" encompasses all naturally occurring debris, meteors, and asteroids.
The term "Object" also means all unmanned man-made debris or satellites not in active use.
L. The term "Orbit" means circumnavigating a planet in space.
M. The term "Pole" means the axis on which a planet rotates. Rotation in a counter-clockwise direction indicates a Northern aspect. Rotation in a clockwise direction indicates a Southern aspect.

IV. Situational Awareness
Every craft shall at all times maintain geographic awareness of their own positions and the positions and directions of travel of other craft and objects by all navigational means available, to include, but not limited to visual, computerized radar/sonar/laser and beacon oriented means.

V. Safe Speed
Every craft shall at all times proceed at a safe speed so that it can take proper and effective action to avoid collision within a distance appropriate to the prevailing circumstances and conditions. In determining a safe speed the following factors should be among those taken into account:
(i) The current capability of detection
(ii) Traffic density including concentrations of not under command craft and space objects
(iii) The maneuverability of the craft with regard to stopping distance and turning ability in the prevailing conditions
(iv) The presence of background conditions that might obfuscate navigational awareness and ability; and
(v) The possibility that detection capability may not be adequate to detect small objects at an adequate range.

VI. Risk of Collision
A. Every craft shall use all available means appropriate to the prevailing circumstances and conditions to determine if risk of collision exists.
B. Assumptions shall not be made on the basis of scanty information.
C. If there is any doubt, risk of collision shall be deemed to exist.

VII. Action to Avoid Collision
A. Any action taken to avoid collision shall, if the circumstances of the case admit, be positive, made in ample time and with due regard to the observance of good seamanship
B. Any alteration of course and/or sped to avoid collision shall, if the circumstances of the case admit, be large enough to be readily apparent to another craft observing visually or by other means of detection. A succession of small alterations of course and/or speed should be avoided.
C. Action taken to avoid collision with another craft shall be such as to result in passing at a safe distance. The effectiveness of the action shall be carefully checked until the other craft is passed and clear.
D. If there is sufficient distance and time, craft may communicate intentions to alter course or speed via radio, light or any other means available to other craft, provided that the receiving craft receives, understands, and agrees to those intentions. The sending craft must receive confirmation of agreement from the receiving craft.
E. A 'give-way' craft which, by these rules is required not to impede the passage of another craft shall, when required by the circumstances of the case, take early action to allow sufficient room for the safe passage of the other craft.
F. A 'give-way' craft, shall not be relieved of its obligation if approaching the other craft so as to involve risk of collision, and shall when taking action, have full regard to the action which may be required by the rules of this part.
G. A 'stand-on' craft which, by these rules is not to be impeded, remains fully obliged to comply with the rules of this part when two craft are approaching one another so as to involve risk of collision.

VIII. Traffic Separation Schemes
A. This rule applies to traffic separation schemes adopted by the organization and does not relieve any craft of its obligation under any other rule.
B. A craft utilizing a traffic separation scheme shall:
(i) Proceed in the appropriate traffic lane in the general direction of traffic flow for that lane.
(ii) So far as practicable keep clear of the traffic separation line or separation zone
(iii) Normally join or leave a traffic lane at the termination of the lane, but when joining or leaving from either side, shall do so at as small of an angle to the general direction of traffic flow as practicable.
C. A craft shall, so far as practicable, avoid crossing traffic lane, but if obliged to do so shall cross on a heading as nearly as practicable at right angles to the general direction of traffic flow.
D. A craft other than crossing or joining shall not normally enter a separation zone or separation line except n cases of emergency to avoid immediate danger
E. A craft not using traffic separation scheme shall avoid it by as wide a margin as is practicable.

F. A craft restricted in ability to maneuver when engaged in an operation for the maintenance of safety of navigation in a traffic separation scheme is exempted from complying with this rule to the extent necessary to carry out the operation.

IX. Conduct Of Craft In Awareness Of One Another
All craft cognizant of other craft and objects shall determine whether they are:
A. Meeting: typically referred to as 'head-on.'
B. Crossing: at any angle other than from 0-67 degrees in any direction opposite from the direction of travel of another craft.
C. Overtaking: 0-67 degrees in any direction opposite from the direction of travel of another craft.

X. Meeting Head-on Situation
A. When two craft are meeting on reciprocal or nearly reciprocal courses so as to involve risk of collision, the craft closest to the North Pole of the closest planet shall turn towards the North Pole of such planet. The craft furthest from the North Pole shall turn away from the North Pole. If both craft are equidistant from the North Pole, the craft closest the South Pole shall turn towards the South Pole and the craft furthest from the South Pole shall turn away from the South Pole. If both craft are equidistant from both the South Pole and the North Pole, the craft traveling in the direction of the planet's rotation has the right of way. If both craft are traveling in the direction of the planet's rotation, an overtaking situation will be presumed to exist despite craft orientation vis-à-vis each other. In any event craft shall pass clear of each other.
B. Such a situation shall be deemed to exist when a craft observes the corresponding course of the other craft. When a craft is in any doubt as to whether such a situation exists it shall assume that it does exist and act accordingly.

XI. Crossing Situation
When two propulsion-driven craft are crossing so as to involve risk of collision, the craft closest to the North Pole of the closest planet shall turn towards the North Pole of such planet. The craft furthest from the North Pole shall turn away from the North Pole. If both craft are equidistant from the North Pole, the craft closest the South Pole shall turn towards the South Pole and the craft furthest from the South Pole shall turn away from the South Pole. If both craft are equidistant from both the South Pole and the North Pole, the craft traveling in the direction of the planet's rotation has the right of way. If both craft are traveling in the direction of the planet's rotation, an overtaking situation will be presumed to exist despite craft orientation vis-à-vis each other. In any event, craft shall pass clear of each other and shall, if circumstances of the case admit, avoid crossing ahead of the other vessel.

XII. Overtaking
A. Notwithstanding anything contained in the Rules, any craft overtaking any other shall keep out of the way of the craft being overtaken.
B. A craft shall be deemed to be overtaking when coming up with another craft from a direction more than 67 degrees opposite the direction in which the stand-on vessel is traveling.
C. When a craft is in doubt as to whether it is overtaking another, it shall assume that this is the case and act accordingly.
D. Any subsequent alteration of the bearing between the two craft shall not make the overtaking craft a crossing craft within the meaning of these rules or relieve her of the duty of keeping clear of the overtaken craft until it is finally past and clear.

XIII. Action By Give-Way Craft
Every craft which by the function of these rules is to keep out of the way of another vessel shall, so far as possible, take early and substantial action to keep well clear.

XIV. Action By Stand-on Craft
A. Where one craft is to keep out of the way of another, the latter stand-on craft shall keep its course and speed. The stand-on craft may take action to avoid collision by its maneuver alone, as soon as it becomes apparent that the craft required to keep out of the way is not taking appropriate action in compliance with these rules.
B. When, from any cause, the stand-on craft required to keep its course and speed finds itself so close that collision cannot be avoided by the action of the give-way craft alone, the stand-on craft shall take such action as will best aid to avoid collision.
C. This rule does not relieve the give-way craft of its obligation to keep out of the way.

XV. Responsibilities Between Different Classes Of Craft
A. A propulsion-driven craft shall keep out of the way of:
(i) A craft not under command
(ii) A craft restricted in its ability to maneuver
(iii) A solar-driven craft
B. A solar-driven craft shall keep out of the way of:
(i) A craft not under command
(ii) A craft restricted in its ability to maneuver
C. A craft restricted in its ability to maneuver
Shall keep out of the way of a craft not under command

XVI. Navigational Transponders And Lights
Computerized navigation shall be utilized to feed into constantly transmitting transponders, which will relay the charted position and direction of travel of the craft vis-à-vis the closest planet and other reference planets/sun/galaxy.

XVII. Navigational Beacons
A. Flashing White & Red – Outbound Traffic Separation Scheme
B. Flashing White & Green – Inbound Traffic Separation Scheme
C. Red – All Craft (direction opposite travel)
D. Yellow – Spinning Object/Craft
E. Green – Propulsion-driven craft

F. Blue/Flashing White & Blue– Craft not under command/Restricted in ability to maneuver

XVIII. Communications
May be made via Radio/Pulse/Light or any other means appropriate to a vessel's speed.

1 http://seds.lpl.arizona.edu/ssa/docs/Space.Shuttle/general.shtml#four
2 http://quest.arc.nasa.gov/galileo/Galileo-QA/Speed/Speed_of_the_spacecraft.1
3 http://faculty.erau.edu/ericksol/courses/sp215/ch3/ch3_debris.htm
4 Id.
5 F. Kenneth Schwetje, Space Law: Considerations for Space Planners, reprinted in 12 Rutgers Computer and Technology Law Journal 245 (1987).
6 Id.
7 Lubos Perek, Delimitation of Air Space and Outer Space: Is It Necessary?, in Earth Oriented Space Activities & Their Legal Implications 275 (1981) in F. Kenneth Schwetje, Space Law: Considerations for Space Planners, reprinted in 12 Rutgers Computer and Technology Law Journal 245 (1987).
8 http://www.spacefuture.com/habitat/law.shtml
9 Germany's response to a U.N. Questionnaire at http://www.oosa.unvienna.org/aero/question04.html
10 M.S. Mc Dougal, H.D. Lasswell & L.A. Vlasic, Law and Public Order in Space 569 (1963) in F. Kenneth Schwetje, Space Law: Considerations for Space Planners, reprinted in 12 Rutgers Computer and Technology Law Journal 245 (1987).
11 http://www.csc.noaa.gov/opis/html/summary/irpcs.htm
12 International Navigational Rules Act of 1977, October, 20, 1972, U.S.-U.K., T.I.A.S. No. 8587
13 http://www.icao.int/cgi/goto.pl?icao/en/history.htm
14 http://www.icao.int/cgi/goto.pl?icao/en/pub/memo.htm
15 http://www.icao.int/cgi/goto.pl?icao/en/pub/memo.htm
16 http://www.downport.com/bard/bard/gail/gail0005.html
17 Codified by the United States in 18 U.S.T. 2410, T.I.A.S. 6347
18 Codified by the United States in 24 U.S.T. 2389, T.I.A.S. 7762
19 F. Kenneth Schwetje, Space Law: Considerations for Space Planners, reprinted in 12 Rutgers Computer and Technology Law Journal 245 (1987)
20 Convention on International Liability for Damage Caused by Space Objects, Oct 9, 1973, United States-Great Britain-USSR, 24 U.S.T. 2389, T.I.A.S. No. 7762
21 M.S. Mc Dougal, H.D. Lasswell & L.A. Vlasic, Law and Public Order in Space 569 (1963) in F. Kenneth Schwetje, Space Law: Considerations for Space Planners, reprinted in 12 Rutgers Computer and Technology Law Journal 245 (1987).
22 Lubos Perek, Early Concepts for Space Traffic, IISL/ECSL Symposium on Prospects for Space Traffic Management (Apr. 2, 2002) reprinted in E-mail from Lubos Perek, Professor Emeritus, Astronomical Institute, Academy of Sciences, Prague, Czech Republic (Oct. 30, 2002, 13:33:21 –0500).
23 Trail Smelter Case (United States v. Canada), III U.N.Rep. Int'l Arb. Awards 1905, 1907 (1949).
24 49 USC § 70101 (1998).
25 Lubos Perek, Early Concepts for Space Traffic, IISL/ECSL Symposium on Prospects for Space Traffic Management (Apr. 2, 2002) reprinted in E-mail from Lubos Perek, Professor Emeritus, Astronomical Institute, Academy of Sciences, Prague, Czech Republic (Oct. 30, 2002, 13:33:21 –0500).
26 Id.
27 F. Kenneth Schwetje, Space Law: Considerations for Space Planners, reprinted in 12 Rutgers Computer and Technology Law Journal 245 (1987).
28 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, Jan 27 1967, 1967 ATS No 24; 610 UNTS 205 [1967 Space Treaty]
29 Lubos Perek, Early Concepts for Space Traffic, IISL/ECSL Symposium on Prospects for Space Traffic Management (Apr. 2, 2002) reprinted in E-mail from Lubos Perek, Professor Emeritus, Astronomical Institute, Academy of Sciences, Prague, Czech Republic (Oct. 30, 2002, 13:33:21 –0500).
30 Lubos Perek, Traffic Rules for Outer Space, Proc. 25th Colloq. On the L. Outer Space 37, 41 (1982) in F. Kenneth Schwetje, Space Law: Considerations for Space Planners, reprinted in 12 Rutgers Computer and Technology Law Journal 245 (1987).
31 http://liftoff.msfc.nasa.gov/academy/rocket_sci/satellites/geo-high.html
32 Lubos Perek, Early Concepts for Space Traffic, IISL/ECSL Symposium on Prospects for Space Traffic Management (Apr. 2, 2002) reprinted in E-mail from Lubos Perek, Professor Emeritus, Astronomical Institute, Academy of Sciences, Prague, Czech Republic (Oct. 30, 2002, 13:33:21 –0500).
33 "States shall avoid harmful contamination of space and celestial bodies" reprinted in the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space including the Moon and Other Celestial Bodies, Oct 10, 1967, United States-Great Britain-USSR, 18 U.S.T. 2410, T.I.A.S. No. 6347
34 http://www.icao.int/cgi/goto.pl?icao/en/pub/memo.htm