THE NASA SPACE SHUTTLE AND OTHER AEROSPACE VEHICLES: A PRIMER FOR LAWYERS ON LEGAL CHARACTERIZATION

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In February 1974 a fascinating book was published in the United States. Entitled *The Spaceships of Ezekiel,*[1] it ostensibly indicated that this was merely one of a growing number of popular books addressing the possibility that planet Earth was visited in ancient times by alien beings from outer space. Closer examination of this book, however, reveals that the author, unlike the authors of similar books, was a technically competent person, that is, he was a qualified scientist or engineer. In fact, Josef F. Blumrich was Chief of the Systems Layout Branch of the National Aeronautics and Space Administration (NASA), and had helped to develop the Skylab and Saturn V rocket. Using the large body of aerospace knowledge which exists today, as well as his own engineering experience, which began in 1934, Blumrich read passages from the *Book of Ezekiel* in the *Old Testament* verbatim and concluded that a highly complicated spaceship, at least two decades advanced of the earth's current technology, could have visited this planet on at least several occasions over 2,500 years ago. This spaceship was designed to function in both the earth's atmosphere and in outer space and served as a shuttle between the earth's surface and another spacecraft acting as a "mothership" which remained in orbit around the earth.[2]

Since the late 1960's, NASA has been developing and perfecting plans for a reusable space vehicle that can function in both the atmospheric and earth orbital environments and serve as a shuttle between the earth's surface and earth orbit. This vehicle has been

1. J. BLUMRICH, THE SPACESHIPS OF EZEKIEL (1974).
2. *Id.* at 43-45.

named the Space Shuttle and will be a part of a planned Space Transportation System for the 1980's and beyond.

The Space Shuttle will be launched vertically in the manner of a "traditional" rocket-propelled launch vehicle, achieve orbit and conduct orbital maneuvers like a manned spacecraft, and, after entering the earth's atmosphere, maneuver and land in somewhat the same manner as a "conventional" aircraft. The Shuttle completed its atmospheric Approach and Landing Tests (ALT) in 1977 and is now being prepared for its first Orbital Test Flights (OTF) in 1979. It will provide a manned capability in earth orbit heretofore unprecedented in human experience. Moreover, it is likely that another and more advanced reusable spacecraft with the ability to function in the atmosphere will be developed before the new millennium arrives.[3]

Since the first man-made satellite was orbited in 1957, the international legal community has produced a plethora of articles, books, reports, conferences and symposia addressing the legal problems generated by space activities. Numerous articles pertaining to space law, or, more correctly, the law relating to the activities and interactions of humans in space, have appeared in legal periodicals. The majority of articles appeared after Sputnik I, but some perspicacious writers published articles in 1957, which was prior to Sputnik's launch,[4] and some even earlier.[5]

Few space law writers, however, have given more than perfunctory consideration to the potential legal problems which could attach to the operation of those spacecraft having the ability to function in the earth's atmospheric environment. This is due perhaps to the fact that such vehicles, discussed in part I *infra*, have not been in existence, with the exception of the limited-maneuverability manned and unmanned entry vehicles used since 1957 and certain high altitude experimental vehicles, such as the X-15 and some of the lifting-body vehicles discussed in part II *infra*. The advent of the Space Shuttle will compel a more thorough examination

3. This article will not address any aspect of the political controversy that has been and, to an extent, continues to be attached to the Shuttle project. Suffice it to say that a reusable vehicle to carry people and objects between the earth's surface and earth orbit is the next logical step in manned spaceflight. This step is even more logical once the premise that manned spaceflight has a permanent place in the spectrum of space exploration is accepted.

4. *See, e.g.,* McDougal, *Artificial Satellites: A Modest Proposal*, 51 AM. J. INT'L L. 74 (1957); Cheng, *International Law and High Altitude Flights: Balloons, Rockets and Man-Made Satellites*, 6 INT'L & COMP. L.Q. 487 (1957).

5. *See, e.g.,* Cooper, *High Altitude Flight and National Sovereignty*, 4 INT'L L.Q. 411 (1951); Jacobini, *Problems of High Altitude or Space Jurisdiction*, 6 W. POL. Q. 680 (1953).

and analysis of the legal aspects of vehicular instrumentalities of flight capable of functioning to varying degrees in both outer space and the earth's atmosphere. The purpose of this article is to assist in preparing the way toward a better understanding not only of the legal aspects of the Space Shuttle program, but of all types of aerospace vehicles. Specifically, this article will discuss the place of aerospace vehicles within the general classification of vehicular flight instrumentalities, the historical background of the aerospace vehicle concept, the technological facts of the Space Shuttle and its operation, and the legal characterization of aerospace vehicles, particularly that of the Space Shuttle.

Characterization involves the study of various types of definitions, technological and legal, which could apply to the Space Shuttle under varying circumstances. This is of primary importance because it is the basis for all other areas of inquiry into the legal aspects of the Space Shuttle. Prior to considering the legal aspects of the Space Shuttle, it is essential to have a general understanding of certain basic scientific and technological facts. Such facts include a brief profile of the historical development of the aerospace vehicle concept. This profile should include those technologically significant vehicles that were never built, as well as those that were. Moreover, a description of the Space Shuttle itself and its general operation is essential. These facts allow an understanding of the Space Shuttle's technological characterization which, in turn, leads to an understanding of the legal characterization. Because the Space Shuttle is the most complicated space vehicle yet to be built, the following discussion pertaining to the technological characterization is more lengthy than the discussion focusing on a legal analysis. This technology-to-law ratio is justified because this article is intended to be a primer for lawyers who know the basics of law but do not necessarily know the basics of aerospace science and technology. Finally, this article shall not attempt to address all possible legal aspects of the Space Shuttle, but shall be concerned with characterization, the primary focus being on the Space Shuttle Orbiter.

I. THE CLASSIFICATION OF VEHICULAR FLIGHT INSTRUMENTALITIES

The number of specific types of flight vehicles built, although not necessarily put into operational use, such as general or private aviation, commercial air transport, military and other non-experimental governmental use, for the purpose of carrying humans and objects above the earth's surface, is impressively large. If a system of nomenclature is utilized, based upon the particular environment, either atmospheric or outer space, in which a given vehicle is designed to function successfully, there appears to be three basic types of flight vehicles: 1) those designed to function *only within* the earth's atmosphere—*pure air vehicles*; 2) those designed to function *only beyond* the earth's atmosphere—*pure space vehicles*; and 3) those designed to function *both in and beyond* the earth's atmosphere—*aerospace vehicles*.

This classification scheme is intended to provide merely a basic and general orientation toward understanding the nature of aerospace vehicles. It uses the criterion of the particular environment in which a given vehicle is designed to function. In no way does the system take into account the various legal classifications of flight vehicles that have developed among the nation states of the planet. The use of the term atmosphere creates a problem because it is central to the scheme of nomenclature and must be defined. For purposes of this article, the term atmosphere will refer to the region that exists between the earth's surface and orbital space. Orbital space refers to that region in which objects will circle the earth *at least once* if given the proper velocity.[6] The more familiar but less precise term is outer space, which is used here in a scientific sense. Below the region of orbital or outer space exists a region in which objects cannot orbit due to the fact that the density of such gas molecules as nitrogen and oxygen, which are collectively referred to as air, increases as the altitude decreases.

Several points should be emphasized at this juncture. First, it must be remembered that the previous explanation is intended so that nontechnically competent people can understand the basic differences among the various regions or regimes of flight and, consequently, the nature and characteristics of the different vehicles which operate within such regimes. Actually, the gases which comprise the earth's atmosphere can be found in varying degrees above the altitude at which objects can orbit the earth at least once.

The focus of this discussion is on the phenomenon of orbital flight. For purposes of this article, the point at which orbital flight begins signals the termination of the atmosphere. The atmosphere, however, can be defined *for other purposes* as extending above the altitude at which objects can orbit the earth at least once. The at-

6. This figure is sometimes given as about 17,500 miles per hour.

mosphere that extends beyond the regime of orbital flight is of such a rarefied nature that it presents no problem to orbiting objects, except perhaps to objects of large volume and low density, such as the Echo balloon satellite.[7]

Below the regime of orbital flight the atmosphere becomes too dense for vehicles to orbit, necessitating the use of other techniques to keep a given object aloft. Basically, there are three known methods by which an object may be kept above the earth's surface without being materially connected to the surface. First, design an object which is lighter than the air it displaces. Such an object will utilize the principle of buoyancy and will float in the atmosphere in the same manner that a ship floats on water. In both cases, the object is supported by the upward force of the fluid, such as gas or liquid, in which it is immersed or floating. Second, design an object which is heavier than the air it displaces, but which can create the aerodynamic lift necessary to keep it supported in the air.[8] Third, design an object heavier than the air it displaces, but which can create sufficient downward thrust toward the center of the earth to counteract the force of gravity and, consequently, raise itself upward away from the center of the earth.[9] An examination of the above three methods of supporting an object in the atmosphere in relation to the various types of flight vehicles follows. Each type shall be placed within the classification scheme.

A. Pure Air Vehicles

This type of flight vehicle is the most familiar and constitutes the largest number of flight vehicles. Until the widespread use of rocket propulsion following World War II, pure air vehicles relied on buoyancy or aerodynamic lift for support. Traditionally and collectively, the former were referred to as aerostats, while the latter were referred to as aerodynes. Both aerostats and aerodynes were

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7. The use of the term atmosphere corresponds closely to what has otherwise been referred to as the sensible atmosphere. *See* text accompanying notes 28 and 29 *infra*. For purposes of simplicity, and at the risk of oversimplification, the term atmosphere will be used.

8. *See* F.A.A. FLIGHT STANDARDS SERVICE, U.S. DEP'T OF TRANSPORTATION, PILOT'S HANDBOOK OF AERONAUTICAL KNOWLEDGE (1971); TRE TRYCKARE, THE LORE OF FLIGHT 283-89, 341-42 (J. Taylor ed. 1970) [hereinafter cited as Taylor].

9. This is based upon one of Newton's laws of motion. *Every acting force is always opposed by an equal and opposite reacting force*. This method of supporting an object in the air can be referred to as the simple action-reaction or simple downward thrust method.

included in the term aircraft.[10] Subclassifications of aerostat include the balloon, blimp, and dirigible; the last two sometimes are referred to as airships. Subclassifications of aerodyne include the glider, airplane, and rotorcraft.[11]

The term aircraft is the broadest term used in relation to pure air vehicles. Putting aside legal definitions for now, the most authoritative technical definition of the term aircraft can be found in the NASA dictionaries of 1959 and 1965. Both contain the same definition of the term:

> [A]ircraft: Any structure, machine, or contrivance, esp. a vehicle, designed to be supported by the air, being borne up either by the dynamic action of the air upon the surfaces of the structure or object, or by its own buoyancy; such structures, machines, or vehicles collectively, as, fifty *aircraft*.
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> Aircraft, in its broadest meaning, includes fixed-wing airplanes, helicopters, gliders, airships, free and captive balloons, ornithopters, flying model aircraft, kites, etc., but since the term carries a strong vehicular suggestion, it is more often applied, or recognized to apply, only to such of these craft as are designed to support or convey a burden in or through the air.[12]

The term aircraft, therefore, was quite appropriate up to World War II as a synonym for pure air vehicles.

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10. The NASA Aeronautical Dictionary defined the terms aerostat and aerodyne as follows:

> *Aerostat*: An aircraft that obtains all or most of its lift by virtue of contained air or gas lighter than the surrounding air, i.e., a balloon or airship.
> *Aerodyne*: Any aircraft that derives all of its lift from aerodynamic forces.

NASA AERONAUTICAL DICTIONARY 5, 6 (F. Adams ed. 1959) [hereinafter cited as 1959 NASA DICTIONARY]. The 1965 NASA edition, however, omitted both terms. *See* DICTIONARY OF TECHNICAL TERMS FOR AEROSPACE USE (W. Allen ed. 1965) [hereinafter cited as 1965 NASA DICTIONARY].

11. Aerostat has been used to describe a larger, much improved version of the World War II tethered barrage balloon designed for use in civilian communications services and military reconnaissance. *See* AVIATION WEEK AND SPACE TECHNOLOGY, Jan. 8, 1973, at 36; Jan. 15, 1973, at 60; Apr. 29, 1974, at 52 [hereinafter cited as AW&ST]. The various subclassifications of aerostat and aerodyne are used more today than the terms themselves, particularly the term airplane. Although the 1959 NASA Dictionary contained an elaborate description of the term airplane, the 1965 NASA Dictionary omitted the term completely. A rotorcraft is

> [a]n aircraft which derives, for all or part of its flight, the whole or a substantial part of its lift from a rotor system, comprising a set of external wings or blades arranged to rotate about a substantially vertical axis. Rotorcraft are divided into helicopters, autogyros, convertiplanes and vertoplanes.

K. MUNSON, HELICOPTERS AND OTHER ROTORCRAFT SINCE 1907 15 (1968).

12. 1959 NASA DICTIONARY, *supra* note 10, at 8; 1965 NASA DICTIONARY, *supra* note 10, at 8.

Although rocket propulsion was known centuries ago,[13] the advent of its extensive use was primarily for weaponry and scientific research. The period between World War II and the launching of the first successful artificial earth satellite in 1957 rendered the term aircraft inadequate to cover all pure air vehicles. Prior to the war, such vehicles were kept aloft by either aerostatic or aerodynamic lifting techniques. Rocket-propelled vehicles prior to World War II were of such a small size and of such a highly experimental nature that they were effectively disqualified as contenders for the title of aircraft.[14] The German V-2, which was the first successful large rocket-propelled vehicle, sparked a succession of flying machines that did not depend upon either aerostatic or aerodynamic lift techniques to carry human-sized payloads up and away from the earth's surface. Rather, the vehicles relied upon the downward thrust of their propulsion systems, which had to be greater than the gravitational attraction of the total mass of the rocket-propelled vehicle. These vehicles were never regarded as aircraft, at least not in the same manner as aerostats and aerodynes.

With rocket propulsion came jet propulsion and another group of vehicles vied with the more traditional types of pure air vehicles for the title of aircraft.[15] These vehicles were more successful in this

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13. Rocket-propelled vehicles utilizing solid chemical propellants were used by the Chinese around 1200 A.D., and perhaps even earlier. The first successful rocket-propelled vehicle using liquid chemical propellants did not appear until 1926 and was built by Dr. Robert H. Goddard.

14. Attention should be directed toward the term rocket, which has been avoided without the use of accompanying descriptive terms, usually related to propulsion. The term rocket often has caused confusion in writings on aerospace law. NASA has continued to use the same basic definition of the term.

> Rocket: 1. A projectile, pyrotechnic device, or flying vehicle propelled by a rocket engine. 2. A rocket engine; any one of the *combustion chambers* or tubes of a multichambered rocket engine.

1965 NASA DICTIONARY, *supra* note 10, at 239. *See also* 1959 NASA DICTIONARY, *supra* note 10, at 143. This article will utilize the second conception of the term, namely, that the rocket is a specific type of propulsion mechanism. This article also will express the conception of rocket in the vehicular sense by using more specific terms, such as rocket-propelled vehicle, or rocket airplane. It should be understood that the terms rocket engine and rocket motor will be regarded as being synonymous.

15. Jet propulsion is propulsion produced by the discharge, opposite to the desired direction of movement, of a high-speed stream of fluid through a nozzle or an orifice. Rocket propulsion is actually one type of jet propulsion. The difference between rocket-type jet propulsion and the other types of jet propulsion found aboard various flight vehicles is that a rocket engine carries its oxygen supply for combustion along with its fuel, and is able, therefore, to function independent of the surrounding air. Jet engines carry only their fuel with them and must utilize the ambient air for combustion. For this reason, the latter types of jet engines are often referred to as airbreathing engines and cannot function in the vacuum environment of outer space.

regard because they were aerodynes of the airplane type with the addition of jet propulsion systems. The first of these vehicles to be put into operation was the German V-1, sometimes referred to as the flying bomb or buzz bomb. The winged, airbreathing, jet-propelled V-1 had no pilot and, like other winged, unmanned vehicles appearing since, such as the United States Snark, the Bomarc vehicles, and the current advanced Cruise missiles, was often referred to as a missile rather than an aircraft.[16] However, there is no mistake that such vehicles are aircraft because they fit the traditional definition of aerodynes.[17] This is verified by the remainder of the definition of aircraft contained in the NASA dictionaries of 1959 and 1965:

> Guided missiles, flying bombs, etc., that are supported by the air, such as the German V-1 of World War II, are aircraft, while guided missiles, flying vehicles, or projectiles that are not supported by the air, such as the Viking rocket, are rarely, if ever, considered aircraft. However, in the absence of any widely accepted general term to embrace all kinds of flying vehicles, air-

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This article will use the terms jet or jet engine in relation to the airbreathing type. However, the terms gas-jet thruster or gas-jet controls do not refer to airbreathing jet engines, but to small rocket motors utilized on pure space vehicles and aerospace vehicles to control attitude while in orbital space or in the upper portions of the atmosphere. At these altitudes, aerodynamic control surfaces, such as ailerons, elevators, and rudders, are ineffective.

16. The term missile has caused some confusion. Basically, a missile is "[a]ny object thrown, dropped, fired, launched, or otherwise projected with the purpose of striking a target." 1959 NASA DICTIONARY, *supra* note 10, at 113. The 1965 NASA Dictionary contains this same definition of missile but adds: "Short for *ballistic missile, guided missile. Missile* should not be used loosely as a synonym for *rocket* or *spacecraft*." 1965 NASA DICTIONARY, *supra* note 10, at 178.

A guided missile is one that receives thrust and guidance from its propulsion and guidance system throughout most, if not all, of its flight. Unmanned surface-to-air (*SA*) and air-to-air (*AA*) missiles used for defense against aircraft invariably are guided missiles because the targets move and may attempt evasive action.

A ballistic missile is

> [a] missile designed to operate primarily in accordance with the laws of ballistics. A ballistic missile is guided during a portion of its flight, usually the upward portion, and is under no thrust from its propelling system during the latter portion of its flight; it describes a trajectory similar to that of an artillery shell. The German V-2 of World War II is an early example of this kind of missile.

1965 NASA DICTIONARY, *supra* note 10, at 32. *See also* 1959 NASA DICTIONARY, *supra* note 10, at 25.

The ballistic missile derives its name from the Greek (*ballein*, to throw) and Latin (*mittere*, to send) languages, and it is, in fact, a device that is sent by being thrown. The throwing implies the action of gravity and air at most. Trajectories are determined, on the one hand, by the speed and angle of throwing and, on the other, by the action of gravity and the atmosphere. J. MARTIN, ATMOSPHERIC REENTRY: AN INTRODUCTION TO ITS SCIENCE AND ENGINEERING 1 (1966).

17. *See* note 10 *supra*.

craft is sometimes employed *generically* in this sense; but this usage is uncertain and is not sanctioned by common acceptance.[18]

In summary, it is possible to state that any vehicle with airbreathing jet engines and wings, whether manner or unmanned, can be classified technically as aircraft.[19] Rocket-propelled vehicles that do not have wings generally are not classifiable as aircraft in a technical sense, although certain municipal statutory or administrative definitions of aircraft can include such vehicles. Rocket-propelled vehicles with wings or special aerodynamic shapes that take the place of wings will be discussed under the heading *Aerospace Vehicles, infra*. Nonpowered orbital and suborbital entry vehicles shall also be discussed *infra*, although some of these vehicles can be defined technically as aircraft.

B. Pure Space Vehicles

This type of flight vehicle constitutes the second largest of the three main classifications and includes the different types of unmanned satellites launched into earth orbit and beyond. Objects far enough away from the earth's surface and having a velocity of about 18,000 miles per hour will orbit the earth indefinitely apart from any resistance or drag from the air and other gas molecules that exist to some degree in orbital space. The gravitational attraction between the earth and the satellite-object is balanced by the forward motion of the satellite. Then described as being in free fall, the satellite follows a circular or, more usually, an elliptical path around the earth. In technical terms, the centripetal force impelling the satellite downward or inward toward the celestial body in question is balanced by the centrifugal force impelling the satellite upward or outward away from the body.

Past attempts to delineate the subcategories of pure space vehicles brought confusion.[20] It is sufficient to divide pure space vehi-

18. *See* note 12 *supra*. The rocket-propelled launch vehicles that are used to place various types of satellites in orbit by rising vertically off their launch pads solely by means of their own thrust, therefore, are not aircraft in the commonly accepted meaning of the term. Although, as the definition states, they might be considered aircraft under a broad, generic meaning of the term. Since these launch vehicles function, at least in part, in both the atmospheric and outer space environments, they can be classified as aerospace vehicles. *See* note 34 *infra*.

19. Most vehicles utilizing some form of airbreathing jet propulsion have either wings or some type of aerodynamically shaped structure to generate aerodynamic lift for support of the vehicle while in flight in the atmosphere.

20. Early attempts to classify vehicles designed for use in outer space were confused at

cles into two subcategories: 1) those designed to function only in the space between celestial bodies, either by orbiting those bodies or by being put on flyby trajectories (the vehicle passes close to the body but does not actually go into orbit around the body); and 2) those designed to function on the surfaces of celestial bodies that have surfaces.[21]

Pure space vehicles are not designed to function to any degree in any atmospheric environment. They are launched from within earth's atmospheric environment, but are protected from the adverse effects of the atmosphere by various shields or shrouds. If a pure space vehicle enters a planetary atmosphere such as earth's, it will begin to generate heat from the friction caused by the reaction of the air molecules with the vehicle's outer surfaces. Eventually, as it plunges deeper into the atmosphere, it will either burn up entirely or partially. In the latter case, the remainder of the vehicle will fall to the surface of the planet. If the planet does not have a surface in the ordinary meaning of the term, the vehicle will fall into the planet's interior.[22] The various types of unmanned pure space vehicles that have been orbited are too numerous to mention. Yet, there have been only three types of manned pure space vehicles. They are the Lunar Module, used for the Apollo lunar landing missions, the earth-orbiting Salyut and Skylab space stations.[23] These vehicles

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times about the proper criteria to use. *See, e.g.*, Verplaetse, *On the Definition and Legal Status of Spacecraft*, 29 J. AIR L. & COM. 131, 132-34 (1963), for an elaborate discussion of rocket vehicles, rocket engines, and a long list of factors considered in the definition of spacecraft. Verplaetse also differentiates between rocket vehicles, moon probes, artificial satellites, moonships, and spaceships, all of which can be placed in one of the three major categories. *Id.* at 137 n.27.

Another classification attempt based upon inadequate knowledge of outer space can be found in M. VASQUEZ, COSMIC INTERNATIONAL LAW 93-95 (E. Malley trans. 1965) where a dichotomy between satellites and free vehicles fails to take into consideration the fact that a satellite orbit is determined by the presence of gravitational attraction between the space vehicle in question and some celestial entity capable of such attraction. However, since gravity is a universal force from which it is impossible to ever completely escape, a space vehicle will always be in orbit around something at any given time in its mission. For this reason, a space vehicle actually never stops orbiting, but only changes from one type of orbit to another. In effect, it is never free of gravity, although it may leave the orbit of any given celestial body by creating enough thrust, through its propulsion system, to achieve escape velocity and, therefore, proceed away from the body it was orbiting on an escape trajectory. Escape velocity from earth orbit is about 24,000 miles per hour.

21. Note that the latter subcategory of pure space vehicle could include vehicles designed to enter and, to varying degrees, function in the atmospheres of certain celestial bodies.

22. The large outer planets of the solar system, Jupiter, Saturn, Uranus, and Neptune, are thought to be planets without surfaces in the usual meaning of the term.

23. Since the term pure space vehicles was defined to include vehicles designed to func-

could not survive entry into the earth's atmosphere, and if any people were aboard they would be killed during the process. All of the other manned space vehicles were designed so that they could, either in whole or in part, deorbit and enter the earth's atmosphere. They were designed to withstand the tremendous heat generated during entry and, in some cases, by maneuvering to a limited degree, finally land safely on the earth's surface to discharge their human occupants.[24] Because of these special, though limited, abilities to function in the earth's atmosphere, these manned vehicles qualify for inclusion in the classification of aerospace vehicles.

It is possible to consider all pure space vehicles as spacecraft. The 1965 NASA dictionary defines spacecraft as "[d]evices, manned and unmanned, which are designed to be placed into an orbit around the earth or into a trajectory to another celestial body."[25] While this definition may include all vehicles that could be classified as pure space vehicles, the reverse is not true. Many of the aerospace vehicles discussed *infra* also can be classfied as spacecraft. The term spacecraft, therefore, includes all pure space vehicles and most aerospace vehicles. This distinction will be important when discussing the legal significance of the term spacecraft.

C. *Aerospace Vehicles*

The existence of aerospace vehicles is based upon the obvious fact that an object traveling from the earth's surface to outer space and back must pass through the earth's atmosphere. This cannot be avoided, at least as far as current scientific knowledge can determine.[26] The 1965 NASA dictionary defines aerospace vehicle as "[a] vehicle capable of flight within and outside the sensible atmosphere."[27] The sensible atmosphere is defined as "[t]hat part of the

tion on the surfaces of planetary bodies, it would be possible to include the four-wheeled, self-propelled Lunar Rover used by the lunar landing crews of Apollos 15, 16, and 17 to explore the lunar surface as a pure space vehicle. Also included would be the eight-wheeled, robot devices, called Lunokhod, used by the Soviet Union in several unmanned lunar landing missions.

24. In the case of certain earlier Soviet vehicles, the cosmonauts ejected from the vehicle at a particular altitude to land independently of the vehicle.

25. 1965 NASA DICTIONARY, *supra* note 10, at 258. The 1959 NASA Dictionary does not contain the term.

26. This statement is rooted in the conception of physical reality as consisting of only the three dimensions perceptible to humans. It is possible to theorize of the existence of more dimensions, but this is so far into the frontier of scientific theory as to be indeterminable.

27. 1965 NASA DICTIONARY, *supra* note 10, at 8.

atmosphere that offers resistance to a body passing through it."[28] The latter definition corresponds to the conception of the atmosphere offered earlier, namely, the region between the earth's surface and orbital space in which the density of the air is so great that spacecraft cannot orbit.[29] The former definition corresponds to the definition of aerospace vehicle offered earlier.[30]

Therefore, as its name implies, the aerospace vehicle has a dual nature.[31] It must be capable of functioning both as a pure air vehicle and a pure space vehicle, although it is not entirely either.[32] No aerospace vehicle has been built or even conceived to function as an aerostat in the atmospheric part of its mission. Thus, the aircraft role of an aerospace vehicle usually will be performed in the manner of an aerodyne[33] and, more particularly, as a glider or air-

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28. *Id.* at 249. Neither this term nor the one in note 27 *supra* is contained in the 1959 NASA Dictionary.

29. It should be pointed out that the 1965 NASA Dictionary definition of sensible atmosphere does not necessarily preclude spacecraft from orbiting in it; it only precludes spacecraft from orbiting *indefinitely* in it. In other words, although a spacecraft may orbit in the sensible atmosphere, it will not do so for long because the resitance of the air will cause the spacecraft/satellite to come closer to the earth with each revolution or orbit. Eventually encountering so much resistance that it cannot complete another orbit, the spacecraft begins falling to the earth's surface and burns up either entirely or partially in the increasingly dense atmosphere. This is referred to as the process of orbital decay. In order for a spacecraft to orbit in the sensible atmosphere for any appreciable period of time, it must have an onboard rocket engine (or engines) which periodically fire or burn so as to boost the vehicle to a higher orbit. Since most satellite orbits are elliptical, a satellite could be in the sensible atmosphere for only part of its orbit, that part coming closest to earth, referred to as the perigee.

30. *See* note 27 *supra*. Although the NASA definition used the term flight instead of function, the two terms will be regarded as essentially synonymous, because it is obvious that a functioning flight instrumentality is one capable of flight in the environment for which it was designed.

31. The term is derived from aeronautics and space.

> Aerospace: 1. Of or pertaining to both the earth's atmosphere and space, as in *aerospace industries*. 2. Earth's envelope of air and space above it; the two considered as a single realm for activity in the flight of air vehicles and in the launching, guidance, and control of ballistic missiles, earth satellites, dirigible space vehicles, and the like.
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> *Aerospace* in sense 2 is used primarily by the U.S. Air Force.
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> The term *aerospace* first appeared in print in the *Interim Glossary: Aero-Space Terms* (edited by Woodford Agee Heflin) published in February 1958 at the Air University, Maxwell Air Force Base, Alabama.

1965 NASA DICTIONARY, *supra* note 10, at 7. This term did not appear in the 1959 NASA Dictionary.

32. Wayne Koons, an engineer at the Manned Spacecraft Center in Houston, describes the NASA Space Shuttle by stating: "[t]he shuttle is neither an airplane nor a spacecraft; it's some of both and not all of either." AW&ST, *supra* note 11, Sept. 11, 1972, at 100.

33. The 1965 NASA Dictionary, though omitting the terms aerostat and aerodyne, did contain a replacement term more oriented to the Space Age.

> Aerodynamic vehicle: A device, such as an airplane, glider, etc., capable of flight

plane.[34]

A complication occurs because not all flight vehicles that are capable of being classified as aerospace vehicles have utilized aerodynamic techniques while in the atmospheric entry portion of their mission. In fact, all of the manned space flights which have occurred so far, with the exception of the X-15 suborbital flights, have involved ballistic entries into the atmosphere rather than aerodynamic entries. The use of ballistic manned entry vehicles in all manned orbital flights to date is due to the fact that they were more simple to design and operate and less costly than the aerodynamically designed aerospace vehicles at the times in question.[35]

> only within a sensible atmosphere and relying on aerodynamic forces to maintain flight. The term is used when the context calls for discrimination from *space vehicle*.

1965 NASA DICTIONARY, *supra* note 10, at 7.

34. NASA tested, in the form of a small scale, radio controlled model, at least one aerospace vehicle design that utilized a rotary wing mechanism during the final portion of its entry and landing operation. *See* Smith, Space Shuttle in Perspective—History in the Making, at 6 (AIAA Paper 75-336, presented at the 11th Annual Meeting and Technical Display of the American Institute of Aeronautics and Astronautics, Washington, D.C., Feb. 24-26, 1975) [hereinafter cited as Smith] (copy on file with CALIF. W. INT'L L.J.).

At this point, note the use of the entry and return portion of a space mission as the criterion by which to subclassify aerospace vehicles through the technique, ballistic or aerodynamic, utilized by the particular aerospace vehicle to return to earth. Here a wrinkle appears in the scheme of nomenclature, for rocket-propelled launch vehicles or booster-rockets are designed to function in both the earth's atmosphere and outer space. Therefore, they can be classified as aerospace vehicles. To date, these vehicles have been expendable, functioning solely for a single mission, and only during the ascent or launch phase. All have been composed of one or more stages which do not accompany the payload into orbit and, instead, separate from the main launch vehicle configuration and return to the earth's surface, being destroyed in the process. The booster stages which do accompany the payload into orbit are not designed to survive atmospheric entry should their orbits eventually decay. Because of these characteristics, booster rockets do not warrant the same consideration as do the manned and unmanned entry vehicles. Both types of vehicles, however, can be classified as aerospace vehicles.

The Saturn V lunar launch vehicle serves as an example: the first stage (S-IC) separates at an altitude of about 36 miles and thereupon falls back to earth; the second stage (S-II) at about 108 miles, thereupon falling back to earth; and the third stage (S-IVB) places the Apollo spacecraft in an initial parking orbit around the earth and later on a lunar trajectory.

35. Although the concept of winged and lifting-body aerospace vehicles was well known in the early 1960's when the first manned flights began, the emphasis in manned spaceflight focused on the ballistic vehicle's use for the proposed manned missions for two reasons: 1) the ballistic vehicles were not as heavy and were the only ones that could be launched and boosted to orbital velocities with existing booster rockets; and 2) more was known about the characteristics of ballistic vehicles during launch and entry activities than about the winged or lifting-body vehicles. *See* Flickinger, *Man in Space—Its Challenges and Opportunities*, in PEACETIME USES OF OUTER SPACE 241, 246 (S. Ramo ed. 1961). A brief explanation of the principle of ballistic flight is given in note 16 *supra*. The 1965 NASA Dictionary defines ballistic reentry simply as "[n]onlifting reentry." 1965 NASA DICTIONARY, *supra* note 10, at 32. No definition is given for lifting reentry.

1. *Ballistic Aerospace Vehicles.* The ballistic vehicles used in all manned space missions to date, with the exception of certain X-15 missions, have been launched by a booster rocket on either suborbital, as in the first two Mercury missions, or orbital trajectories. In the latter case, the crew members either remain inside the vehicle or dock with and transfer to a pure space vehicle that was either brought with them, as in the Apollo Lunar Module, or launched earlier and in orbit waiting for them, as in the Salyut and Skylab space stations. Upon completion of the orbital phase of the mission, the crew members transfer back to their vehicle, undock from the pure space vehicle, and begin the process of deorbit and entry.

At this point several differences appear. Although the Mercury spacecraft returned in total to the earth's surface, all of the other manned spacecraft returned only that part designed as the entry vehicle. In the case of Apollo, Vostok, Voskhod, and Soyuz, the entry vehicle was much smaller than the remainder of the spacecraft.[36] While the entry vehicle was equipped with a heat shield to withstand the effects of entry and deployed a parachute at the proper altitude to slow down its descent to earth, the remainder of the spacecraft remained in orbit or burned upon entering the atmosphere.[37] Obviously, the entry vehicle qualifies as being an aerospace vehicle, and a limited one in terms of maneuverability, while the remainder of this spacecraft is a pure space vehicle.[38]

2. *Aerodynamic Aerospace Vehicles.* The manned entry capsules used in the United States Gemini and Apollo programs were designed to be able to generate some aerodynamic lift; yet, they were basically ballistic vehicles.[39] The Space Shuttle, as well as the other aerodynamic aerospace vehicles that led to the design of the Space Shuttle, will function basically as a glider during its entry and return to earth in the sensible atmosphere.[40] Most of the earlier concepts for aerospace vehicles never got past the drawing board;

36. *See generally* K. GATLAND, MANNED SPACECRAFT (1967).

37. It should be noted that while the Soviet entry vehicles were, for the most part, spherical in shape, operating on purely ballistic trajectories, the United States vehicles were more conical in shape. The Gemini and Apollo spacecraft were designed to generate a degree of lift, thereby giving the crew some aerodynamic control for a more precise entry. *See* Smith, *supra* note 34, at 4-5.

38. Similarly, unmanned ballistic entry vehicles can qualify as aerospace vehicles. Some examples are the nose cones of sounding rockets, ballistic missile warheads, the film-return capsules of certain types of reconnaissance satellites, and the portion of the Soviet Luna 16 lunar landing vehicle which returned to earth with a sample of lunar soil.

39. *See* note 37 *supra*.

40. *See* text accompanying note 28 *supra*.

and those that did and were actually built and flight-tested were used merely as research vehicles. The Space Shuttle will be the first fully aerodynamically designed aerospace vehicle to be put into operation.

II. THE HISTORICAL BACKGROUND OF THE AEROSPACE VEHICLE CONCEPT

Essential to an examination of the legal aspects of the Space Shuttle and other aerospace vehicles is an understanding of their nature and operation. Insight can be derived from a brief look at the history of the theory and practice of the aerospace vehicle concept, focusing on the aerodynamic-type aerospace vehicle. Due to their greater maneuverability upon entry into the earth's atmosphere and their greater flexibility and versatility *vis-à-vis* mission planning, aerodynamic-type aerospace vehicles probably will be utilized more in the future than the ballistic-type aerospace vehicle.[41]

The design and operation of the aerodynamic-type aerospace vehicle has now entered the real world of the engineer and the test pilot, while remaining subject to the influence of the politician, economist, and military strategist. Some basic facts underlying the design and operation of aerospace vehicles were known to science fiction writers of the last century. One fact was that the rocket engine was the only propulsion system known to be capable of functioning in outer space.[42]Another fact was that pure space vehicles would not be able to function in an atmospheric environment.[43] Present day science fiction has only refined the technology involved.[44]

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41. Large, reusable ballistic-type aerospace vehicles have been considered in the past and currently are being considered for future use to carry payloads that the present Space Shuttle cannot carry. *See* P. BONO & K. GATLAND, FRONTIERS OF SPACE (1969) [hereinafter cited as BONO & GATLAND]; 19 SPACEFLIGHT 82, 87-89, 172-73 (1977).

42. Jules Verne, in his novel *From The Earth To The Moon* (1865), equipped his fictitious spacecraft, a large projectile fired from a large gun, with rockets for steering in much the same manner that present day spacecraft do for orbital maneuvering and attitude control. A. CLARKE, THE PROMISE OF SPACE 7 (1968).

43. In 1897, a German professor of mathematics named Kurd Lasswitz published AUF ZWEI PLANETEN (ON TWO PLANETS), in which Martian beings traveled to earth from mars in spacecraft constructed along mathematical principles. Instead of simply crashing to the earth's surface, as the Martians in H.G. Wells' *War Of The Worlds* (1898) did, Lasswitz's Martians first landed on a space station outside of the earth's atmosphere and thereupon transferred to shuttlecraft to descend to the earth's surface. W. LEY, EVENTS IN SPACE 5-6 (1969).

44. An example was the motion picture made by Stanley Kubrick entitled 2001: A

Early in this century, these facts led to the idea of a rocket propelled aircraft or airplane, often referred to as the rocket airplane or rocket plane.[45] Early attempts at transforming the aerospace vehicle from the imagination to the drawing board and to the flight test and operational stages can be traced back to the year 1928. The idea of adding a rocket motor to an aircraft to create a manned flight vehicle able to function propulsionwise, in both the earth's atmosphere and outer space, was proposed by Max Valier, an Austrian writer on the subjects of science and science fiction.[46] Although there were a number of actual experiments adding rocket motors to airplanes or gliders,[47] the first significant work on the design and operation of aerospace vehicles was done by the Austrian engineer, Dr. Eugene Sanger.[48]

A. The Sanger-Bredt Antipodal Bomber

The concept of a rocket aircraft that could be launched from the earth's surface by a reusable booster, reach high speeds and altitudes, and thereby be capable of extended range, was proposed in 1933 by Dr. Sanger in his book, *The Technique of Rocket Flight*.[49] Later, extensive research was conducted by Dr. Sanger, Dr. Irene Bredt, and a research team at Trauen, Germany.[50] The planned vehicle would have been launched to a peak altitude of 162 miles into outer space.[51] Thereafter, by using a skipping technique of dropping to low points, usually about twenty-five miles altitude,

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SPACE ODYSSEY (Metro-Goldwyn-Mayer 1968), in which millions of moviegoers watched an advanced aerospace vehicle rendezvous and dock with a large orbiting space station of advanced design.

45. The 1959 NASA Dictionary defines rocket airplane as "[a]n airplane using a rocket or rockets for its chief or only propulsion." 1959 NASA DICTIONARY, *supra* note 10, at 143. The 1965 NASA Dictionary contains the same definition, but adds the term rocket plane, defined as "[a]n airplane powered by rocket engines." 1965 NASA DICTIONARY, *supra* note 10, at 239-40.

46. W. LEY, ROCKETS, MISSILES, AND MEN IN SPACE 419 (1968).

47. *Id.* at 419-25. The spectacularly unsuccessful nature of these early experiments all but assured that the rocket airplane concept would be regarded generally as only an aberration of the human mind. *See* text accompanying note 14 *supra*.

48. W. LEY, *supra* note 46, at 425. Note, however, that the concept of the aerospace vehicle was present to one degree or another in the writings of some of the early pioneers of rocketry, such as Tsiolkovsky, Esnault-Pelterie, Goddard, and Oberth. AMERICAN INSTITUTE OF AERONAUTICS AND ASTRONAUTICS, AD HOC COMMITTEE ON THE ASSESSMENT OF NEW SPACE TRANSPORTATION SYSTEMS, NEW SPACE TRANSPORTATION SYSTEMS—AN AIAA ASSESSMENT 14 (J. Layton & J. Grey eds. 1973) [hereinafter cited as *The Green Book*].

49. BONO & GATLAND, *supra* note 41, at 131.

50. *Id.* at 131-32.

51. W. LEY, *supra* note 46, at 444-48.

and then being bounced by the denser air to decreasingly higher points from fifty-one to seventy-eight miles altitude for decreasing distances, much in the manner of a flat stone being skipped or bounced off of the surface of a pond, the vehicle would have been able to extend its range to 14,600 miles, or halfway around the earth.[52] The pilot would then have been able to land at any large, politically friendly airport.[53] The mission of the one man vehicle would have been to deliver a bomb load to a designated target area.[54]

The Sanger-Bredt Antipodal Bomber was intended to reach altitudes now considered orbital or outer space. Although the vehicle could have extended the skip technique to actually circle the earth and return to its original launch area,[55] it was not designed to be an orbiting spacecraft. The vehicle's maximum velocity of 13,428 miles per hour[56] was less than the 18,000 miles per hour required to achieve low orbit of the earth. Nevertheless, the general conclusions of Dr. Sanger and his associates dominated aerospace technology for a generation.[57]

B. Post-World War II Projects

After the Second World War, the scene for aerospace vehicle development shifted to the United States. Germany, however, experimented before and during the war with a number of different rocket propelled aircraft unrelated to Dr. Sanger's research on the Antipodal Bomber. These rocket airplanes, such as the Heinkel He-112, which utilized a regular propeller driven engine on some flights; the Heinkel He-176, the first aircraft to be equipped solely with liquid rocket propulsion; the Messerschmitt Me-163 Komet,

52. The name Antipodal Bomber is derived from the fact that the vehicle would have traveled between the earth's antipodes, those points on opposite sides of the earth. Other names applied to the Sanger vehicle are Glide Bomber, Boost Glide Bomber, and Skip Glide Bomber. J. SPARKS, WINGED ROCKETRY 74-75 (1968).

53. W. LEY, *supra* note 46, at 447.

54. Although the Sanger vehicle was originally designed during World War II to carry conventional bombs, it was of questionable value militarily because it carried only a small bomb load in comparision to the large piston engine propeller-driven aircraft in regular use. The subsequent development of the atomic bomb made the Sanger concept much more important to both United States and Soviet military planners after the War. *See* W. LEY, *supra* note 46, at 447; N. DANILOFF, THE KREMLIN AND THE COSMOS 46-52, 221 (1968).

55. W. LEY, *supra* note 46, at 447.

56. *Id.* at 446.

57. BONO & GATLAND, *supra* note 41, at 132. The United States Dyna-Soar project, discussed *infra*, at 423-24, was based to a large extent on Dr. Sanger's work. W. LEY, *supra* note 46, at 448.

the first rocket-propelled aircraft to be put into operational use in combat; and the vertically launched Natter, a last-ditch attempt at halting the allied bombing penetrations of Germany toward the end of the War, were all pure air vehicles designed for either traditional combat missions or experimentation.[58] Their use for purposes of space exploration was not considered.[59] Dr. Sanger's Antipodal Bomber, therefore, was the most important concept coming from that period before and during World War II for purposes of post-war experimentation with the aerodynamic type of aerospace vehicle.[60]

United States interest in rocket-powered aircraft increased toward the end of the war.[61] Discussion began in 1944 of building a manned aircraft capable of reaching supersonic speeds. This vehicle, the Bell XS (Experimental Supersonic) 1, later called the X-1,[62] was not intended to be an aerospace vehicle because it would not reach an altitude in or near orbital space. It was rocket-propelled and had the mission of exploring the characteristics of transonic and supersonic flight.[63] These two reasons account for its note in

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58. *Id.* at 427-32; J. SPARKS, *supra* note 52, at 16-62. Dr. Sanger had nothing to do with the development of these vehicles.

59. The same can be said of the Japanese "Ohka" which is sometimes referred to as the "Baka" by the Allied forces. It is a specially designed Kamikaze aircraft piloted by one man and powered by a solid-propellant rocket motor. *See* J. SPARKS, *supra* note 52, at 88-98.

Various rocket airplane experiments were conducted by the Soviet Union prior to and during the first part of World War II, particularly with the RP-318-1, the first manned rocket airplane to be flown in the Soviet Union, and the BI-1, the first rocket airplane designed specifically for combat missions to be flown under full power. *See* Shchetinkov, *Development of Winged Rockets in the USSR, 1930-39,* FIRST STEPS TOWARD SPACE—SMITHSONIAN ANNALS OF FLIGHT (No. 10) 247 (F. Durant III & G. James eds. 1974); E. RIABCHIKOV, RUSSIANS IN SPACE 126-35 (1971).

60. W. LEY, *supra* note 46, at 218; J. SPARKS, *supra* note 52, at 65-70. Plans were made by Germany to add wings to the body of the standard V-2, more properly the A-4, ballistic missile. This would increase the range of the A-4, giving it the capability of making a gliding entry upon returning to the sensible atmosphere from outer space. Only a few prototypes of this winged A-4, referred to as the A-9, apparently were built. More elaborate plans, such as converting it into a manned vehicle, or giving it a large rocket-propelled booster stage (the A-10) to increase its range even more, never got off the drawing board. The Germans also designed another type of winged A-4, called the A-4b, basically an A-4 with two short wings attached. Apparently, they built and test fired two of them, but with only partial success. *See* Smith, *supra* note 34, at 1-2.

61. *See* J. SPARKS, *supra* note 52, at 99-104.

62. W. LEY, *supra* note 46, at 436.

63. *Id.* at 434-35. The use of a rocket engine was not even an original requirement for the X-1. The designers were given the choice of any means of propulsion that would give the vehicle the required speed and performance. *Id.* at 436. Rocket propulsion, however, was finally decided upon. The speed of an aircraft is often designated by the Mach number, which is the ratio of the speed of the aircraft to the speed of sound in the surrounding atmos-

any genealogy of aerospace vehicles. After completion of the X-1 flights, experimentation with rocket airplanes continued to explore aspects of supersonic flight.[64] The next significant and one of the most successful phases of the entire United States effort to develop aerospace vehicles was the X-15 program.

C. The North American X-15

The North American X-15 is probably the most familiar aerodynamic-type of aerospace vehicle among those conceived, built, and flown. Alternately adopting the appearance of an aircraft and spacecraft, the X-15 became the first manned aerodynamic-type aerospace vehicle to enter the lower regions of outer space. Propulsion was provided by a single rocket engine, and the crew, as in the Sanger-Bredt concept, consisted of the pilot alone. The greatest speed the X-15 reached was 4,520 miles per hour, and the highest altitude was sixty seven miles on August 22, 1963, when it attained an altitude above 99.999% of the earth's atmosphere.[65] On October 24, 1968, the final flight of the X-15 program was completed:

> In the ten years of its active life, it [X-15] proved the feasibility of manned space flight, extended the borders of manned flight into the edge of space and the hypersonic speed range, and carried research experiments to sustained heights and speeds that had never before been attained by manned aircraft.[66]

The spacecraft nature of the X-15 was apparent by the fact that the pilots wore a new type of full pressure suit leading to the improved suits worn by Mercury and Gemini astronauts.[67] Moreover, gas-jet thrusters, which are, in effect, small rocket motors, were used to control the X-15's attitude at altitudes where the air was too thin for normal aerodynamic surfaces to act. Experience with the X-15 led to the design of attitude thrusters for Mercury space-

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phere; differing conditions will cause variations in the speed of sound. Aircraft flying at subsonic speeds have a Mach number of 0.8 or less; those flying at transonic speeds have a number of from 0.85 to 1.3; and those flying at supersonic speeds have a number above 1.3 but no higher than 3.0. Any speeds above Mach 3.0 are designated as hypersonic. *Id.* at 434.

64. Examples are the Douglas Skyrocket (designated the D-558-2 and also provided with a jet engine), the Bell X-1A, and the X-2, all of which had varying degrees of success. *Id.* at 440-43. *See also* Vosburgh, *Flying in the "Blowtorch" Era*, 98 NATIONAL GEOGRAPHIC 287 (1950), for an illustrated account of some of the early United States experiments with rocket-propelled and other types of aircraft.

65. *See* D. ANDERTON, AERONAUTICS 7 (NASA EP-61, 1970) (copy on file with CALIF. W. INT'L L.J.).

66. *Id.* at 5.

67. K. GATLAND, *supra* note 36, at 204.

craft,[68] as well as to the development of ablative coatings for thermal protection of later research vehicles.[69] Although the X-15 was not designed to be an orbital vehicle, it could have been so made with the proper modifications; there were, in fact, such plans at one time.[70] Finally, five air force pilots qualified for astronauts' wings by flying the X-15 to an altitude above fifty miles.[71]

D. The Boeing X-20 "Dyna-Soar"

The first attempt to actually build an aerodynamic-type aerospace vehicle based upon the conclusions reached by Dr. Sanger and his associates was made by the Boeing Company under a contract with the Air Force and with NASA support.[72] Research into problems of hypersonic flight had begun in 1953 and, after thousands of hours of study and experimentation, the researchers began to realize that wingless vehicles with a minimum of aerodynamic surfaces, using both aerodynamic and gas-jet controls for lift and maneuverability, could be steered in the earth's atmosphere merely by being banked.[73] In orbital space the vehicle would be maneuvered by gas-jet thrusters, similar to those used by spacecraft today. The result of this research was the X-20. It was conceived to fill the gap between hypersonic, suborbital, winged vehicles, such as the X-15, and the earth orbiting spacecraft that began to appear in 1957.[74] The name Dyna-Soar is an abbreviated form of the words dynamic and soaring, indicating that the X-20 could maneuver in the earth's atmosphere as well as in orbital space.[75]

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68. *Id.* at 203.

69. BONO & GATLAND, *supra* note 41, at 147. Ablative coatings are those that provide a heat shield for spacecraft entering the atmosphere by scouring off or vaporizing as they burn, thus removing the heat. Another type of heat shield is the heat-sink type which is composed of materials that soak up heat as a sponge does water. It should be noted that aerodynamically designed aerospace vehicles, whether of the winged or the lifting-body kind, can control their rate of descent somewhat and, thus, control frictional heating during entry. H. GOODWIN, SPACE: FRONTIER UNLIMITED 28 (1962).

70. J. SPARKS, *supra* note 52, at 142.

71. D. ANDERTON, *supra* note 65, at 5.

72. BONO & GATLAND, *supra* note 41, at 134; D. ANDERTON, *supra* note 65, at 14.

73. BONO & GATLAND, *supra* note 41, at 134.

74. D. ANDERTON, *supra* note 65, at 14.

75. BONO & GATLAND, *supra* note 41, at 134. At first the Dyna-Soar was expected to utilize the atmospheric skip or bounce technique to circle the earth without actually going into orbit, as in the manner originally planned for the Sanger-Bredt Antipodal Bomber because, at the time, there were no launch vehicles capable of placing it into orbit. By the late 1950's, with the emergence of the United States Titan III-C program, the plans to use the Sanger technique were abandoned in favor of true orbital flight. J. SPARKS, *supra* note 52, at 145.

Finalized plans indicated that the Dyna-Soar was to be launched by a Titan III-C booster rocket, with the Dyna-Soar placed atop of the nose of the booster. The booster was not reusable and consisted of a liquid propellant center core with two shorter solid propellant rockets attached to opposite sides of the core rocket. This entire assembly was to be capable of generating more than 2.5 million pounds of thrust.[76] After achieving a certain altitude, the Dyna-Soar was to separate from the booster and continue into orbit. Upon completion of its orbital tasks, the Dyna-Soar would deorbit and enter the atmosphere through the use of a retro-rocket motor located in its tail section. Once in the sensible atmosphere, it would simply glide back to the earth's surface. Aerodynamic controls would allow the pilot to select various landing sites by utilizing the proper series of banking maneuvers. This is basically the same deorbit and entry procedure that will be utilized by the Space Shuttle Orbiter, which is also a space glider.

Glide tests with a full-scale Dyna-Soar were being planned by Boeing, NASA, and the Air Force in 1963-64. Due to growing complexity, cost, and engineering problems, the project was cancelled before they could begin in 1963.[77] Even though the Dyna-Soar became extinct, experimentation on aerospace vehicle design and operation continued. The research accomplished under the X-20 project was utilized in other projects.

E. The Lifting-Body Research Vehicles

Clearly the development of a reusable and economic aerospace vehicle capable of achieving orbit to rendezvous and dock with pure space vehicles, such as space stations, and of performing other orbital tasks before entering the atmosphere and making a controlled descent to land at an airbase, was desirable. This led to the idea of lifting body vehicles. Originated in 1957 by Dr. Alfred J. Eggers, Jr., the concept of the lifting body depends upon the vehicle attaining aerodynamic stability and lift from a specifically shaped

76. *Id.*

77. BONO & GATLAND, *supra* note 41, at 136. Another aerospace vehicle concept of the early 1960's was the United States Air Force's Aerospace Plane, also designated ASP or Space Plane. Never getting past the drawing board stage, the Aerospace Plane concept involved a manned, winged aerospace vehicle powered by both airbreathing and rocket engines. A single-stage-to-orbit (SSTO) vehicle, the Aerospace Plane was much more complicated conceptually than was the X-20 Dyna-Soar. *See* Salkeld, *Orbital Rocket Airplanes—A Fresh Perspective*, 14 ASTRONAUTICS & AERONAUTICS (No. 4) 50 (1976).

body and without the use of wings.[78] Such vehicles utilize the energy they have at orbital altitudes and convert part of it into aerodynamic lift during descent to the earth to perform hypersonic inflight maneuvers. Also, they must be capable of landing on a runway following a glide approach at speeds comparable to jet fighter aircraft.[79] These vehicles can be described generically as having half-conical bodies with blunted noses to reduce heating during atmospheric entry, and tail fins to provide stability and control for maneuvering in the atmosphere. The elimination of wings from the vehicles reduces structural and heating problems.[80]

Although the X-20 Dyna-Soar had a lifting-body design, the first lifting-body research vehicle actually to fly was the Northrop M2-F1, a glider towed aloft by a C-47 propeller driven transport airplane and released for a glide landing. Thereafter, in the mid-1960's, two more lifting-body designs were built. They were the Northrop M2-F2 and the Northrop HL-10.[81] Both vehicles were launched by air and were dropped from a parent B-52 jet bomber, as was the X-15.[82] The M2-F2 was damaged subsequently in a landing accident, rebuilt, and renamed the M2-F3.[83]

Another lifting-body design, but one with more sophisticated controls, was the Martin X-24A. It was used by NASA and the Air Force in research similar to NASA's own efforts with the M2-F2/3 and the HL-10. As with the other lifting-body designs, it was air launched from a parent B-52.[84]

Upon completion of the X-24A program, the vehicle was dismantled to its structural skeleton and rebuilt into a new type of lifting-body and was designated as the X-24B. It had a longer and more streamlined nose than the X-24A and the wings had a double

78. K. GATLAND, *supra* note 36, at 238.

79. *Id.*

80. *Id.* at 238-39, 243-44.

81. *Id.* at 239; D. ANDERTON, *supra* note 65, at 20.

82. K. GATLAND, *supra* note 36, at 96.

83. The pinpoint accuracy possible with a lifting-body vehicle was demonstrated at Edwards Air Force Base in California when the M2-F3 landed within 71 feet of a predetermined point after a flight from an altitude of 40,000 feet. AW&ST, *supra* note 11, Jan. 24, 1972, at 9.

84. K. GATLAND, *supra* note 36, at 241. The X-24A was originally named the SV-5P. Another lifting-body in the SV-5 series, the SV-5J, was powered by an airbreathing turbojet engine and was able to take off under its own power. It was used to train pilots in the low speed handling of lifting-body vehicles. Experiments also were conducted with smaller, unmanned lifting-body entry vehicles to test various designs, systems, and ablative coatings. Unlike the manned lifting-bodies, these vehicles, such as the SV-5D, were launched to orbital altitudes. *Id.* at 241-43.

delta shape that resulted in more maneuverability than the X-24A.[85] The X-24B continued the joint research conducted by NASA and the Air Force into aerospace vehicle design. It specifically investigated the supersonic, transonic, and subsonic flight and landing characteristics of a hypersonic flight vehicle.[86] Although the X-24B was not expected to be flown much higher than 60,000 feet nor faster than Mach 1.5, its configuration was designed to represent hypersonic vehicles capable of speeds from Mach 4 to orbital velocities, particularly in the Mach 8 to 12 regime.[87]

F. The Space Shuttle

Technically competent proposals and plans for an operational aerodynamic-type aerospace vehicle have existed since before World War II, although such plans usually were known only to the scientific and technical community.[88] Between 1954 and 1969, thousands of scientists and engineers explored the aerospace vehicle concept with increasing emphasis placed upon the utilization of such a reusable vehicle as part of a total space transportation system.[89] Finally, on September 15, 1969, the Space Task Group, which had been formed by the President and chaired by the Vice President to study the scope and pace of the United States space program for the decade of 1970, submitted a report with supporting documentation from NASA, the Department of Defense, and the President's Science Advisory Committee. The report recommended

85. AW&ST, *supra* note 11, Sept. 4, 1972, at 77-78. Although the lifting-body research vehicles do not technically have wings, the winglike extensions of their bodies are, nevertheless, sometimes referred to as such. The term double-delta in relation to the wing configuration simply means that the wing on each side of the body consists of two leading edges and each edge is at a different angle to the body. The Space Shuttle also has a double-delta wing.

86. As with earlier lifting-body designs, the X-24B was air-dropped from a parent B-52 at altitudes of usually 40,000 to 45,000 feet, after which it either glided to earth on unpowered flights or fired its rocket propulsion system to reach a peak altitude or velocity. Then it glided back for a deadstick or unpowered landing.

87. AW&ST, *supra* note 11, Sept. 4, 1972, at 77-78.

88. Certain plans were publicized in periodicals and newspapers oriented toward the general public. An early example is the article appearing in the *Sacramento Bee*, Feb. 13, 1947, at 4, entitled *A Trip to the Moon and Back*, the first of six articles describing a concept for a recoverable space transportation system of two stages, one of which is a rocket plane type of aerospace vehicle. *The Green Book, supra* note 48, at 14-15. Other articles, co-authored by Wernher von Braun, appeared in *Colliers magazine* in 1954. *Id.* at 14. *See also* ACROSS THE SPACE FRONTIER (C. Ryan ed. 1952), a popular, early book on space travel featuring, *inter alia*, Wernher von Braun's concept for a three-stage rocket ship that utilized an aerodynamic-type aerospace vehicle for the third stage orbital and entry vehicle in much the same manner that the Space Shuttle Orbiter will be utilized.

89. *The Green Book, supra* note 48, at 14-17. *See also* Smith, *supra* note 34, at 7-9.

that a space transportation system could obtain cost effectiveness by incorporating the three factors of *reusability* of space vehicles and equipment, *commonality*, and *integration* of manned and unmanned flight operations.[90] Two vehicle systems were recommended for the utilization of space: 1) an earth-to-orbit shuttle system used to place payloads in low earth orbit; and 2) an orbit-to-orbit shuttle system placed in low earth orbit by the first shuttle system, and used to transfer payloads from low to higher orbits, including synchronous and escape trajectory orbits.[91] The former shuttle system is now referred to as the Space Shuttle. The latter system, now including several Space Shuttle upper stages, differs because of the fact that it includes pure space vehicles and no aerospace vehicles. Both systems, the Space Shuttle and its upper stages, are referred to as the Space Transportation System.

III. The Current Space Shuttle Concept: Vehicles and Operations

The original NASA concept for the Space Shuttle called for the concurrent development of two vehicles, an orbiter and a booster. Each was to be manned, fully reusable, long-lived, and capable of flying back to its base after completion of its mission, much in the same manner as a conventional fixed-wing aircraft.[92] Then, a phased approach was studied in which the orbiter would have been developed first and flown atop a conventional unmanned and expendable booster rocket three years before a reusable booster would have been brought into operational use.[93] Subsequently, various studies by NASA and the aerospace industry set forth a number of different Space Shuttle configurations. Although the or-

90. *See* Gregory, *Shuttle Design Starts in Outer Orbit*, 9 ASTRONAUTICS & AERONAUTICS (No. 8) 46 (1971); PRESIDENT'S SCIENCE ADVISORY COMMITTEE, THE NEXT DECADE IN SPACE—A REPORT OF THE SPACE SCIENCE AND TECHNOLOGY PANEL OF THE PRESIDENT'S SCIENCE ADVISORY COMMITTEE (1970) [hereinafter cited as SUMMARY REPORT]. Specifically, the Summary Report provides in part:

> The national program for the next decade in space should focus on utilizing space capabilities for the welfare, security, and enlightenment of all people.

Id. at *i*. It recommended as a goal for the 1970's a study

> with a view to early development, [of] a reusable space transportation system with an early goal of replacing all existing launch vehicles larger than [the] Scout with a system permitting satellite recovery and orbital assembly and ultimately a radical reduction in unit cost of space transportation.

Id.

91. *Id.* at 42. Pure space vehicles for the exploration of space beyond earth orbit also were discussed.

92. AW&ST, *supra* note 11, June 7, 1971, at 55.

93. AW&ST, *supra* note 11, June 21, 1971, at 19.

biter's design was agreed upon generally regarding its basic characteristics, there was no agreement regarding the boosters. A number of proposals were advanced supporting manned versus unmanned, reusable versus expendable and flyback versus ballistic water recoverable.[94] In March 1972, a decision was reached regarding the present general configuration of the Space Shuttle.[95] Since then, however, reductions have been made in both the size and weight of the Space Shuttle.[96]

A. The Vehicle Components

As it sits on the launch pad, the complete Space Shuttle configuration will have a height of 184 feet, which is about half that of the Saturn 5/Apollo lunar mission vehicle,[97] and will have a gross liftoff weight (GLOW) of 4,500,000 pounds. The configuration will consist of three main elements: 1) the Orbiter; 2) the External Tank (ET); and 3) the twin Solid Rocket Booster (SRB) motors. While the Orbiter and SRB's will be reusable, the ET will not.[98]

1. *The Orbiter*. The Orbiter will appear very much like a conventional airplane, with nose, cockpit, cabin area, fuselage, wings, elevons, tailfin/vertical stabilizer, rudder, and, when extended for landing, tricycle nose-wheel type landing gear. As a

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94. For a detailed discussion of the development of the Shuttle configuration, *see* AW&ST, *supra* note 11, July 12, 1971, at 36; Aug. 2, 1971, at 40; Sept. 13, 1971, at 15; Sept. 20, 1971, at 16; Oct. 25, 1971, at 12; Jan. 10, 1972, at 15, 46; Jan. 24, 1972, at 36, 40; Feb. 14, 1972, at 24. *See also* Smith, *supra* note 34, at 10.

95. AW&ST, *supra* note 11, Mar. 20, 1972, at 14. The present configuration was adopted for the reason that it coexisted best with the extremely severe fiscal constraints under which NASA was compelled to work, while at the same time meeting the necessary technological standards *vis-à-vis* design, operation, and maintenance of the Shuttle system.

96. AW&ST, *supra* note 11, Apr. 16, 1973, at 18.

97. *See* Malkin, *Space Shuttle—The New Baseline*, 12 ASTRONAUTICS & AERONAUTICS (No. 1) 62 (1974). The description of the Space Shuttle and its operations will contain facts and figures current to the time of writing. There may be subsequent changes regarding dimensions, operational procedures, and the like, but these subsequent changes should not affect the discussion and analysis of the legal characterization of the Space Shuttle. Such technological changes in the baseline design which have ramifications *vis-à-vis* the law, will be discussed in a subsequent article. *See also* LYNDON B. JOHNSON SPACE CENTER, U.S. NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, SCIENTIFIC AND TECHNICAL INFORMATION OFFICE, SPACE SHUTTLE (NASA SP 407, 1976) [hereinafter cited as SPACE SHUTTLE] (copy on file with CALIF. W. INT'L L.J.); SPACEFLIGHT, Nov. 1974, at 419; Ulsamer, *A New Era of Economical Spaceflight*, AIR FORCE MAGAZINE, Oct. 1974, at 34; Fink, *Space Shuttle Flight Plan Written*, AW&ST, *supra* note 11, June 3, 1974, at 12; Watts, *American Prospects in Space*, SKY AND TELESCOPE, May 1974, at 308.

98. The term Space Shuttle will be used in the remainder of this article to refer to the entire configuration of Orbiter, ET, and SRB's. The Orbiter itself will be referred to by its specific name.

spacecraft it will differ from the often cluttered-looking spacecraft of today, such as the Skylab, Salyut, and Apollo Lunar Module. Rather, it will resemble the sleek, cleanlined space vehicles of the Buck Rogers era.[99]

The Orbiter will be comparable in size to a medium sized transport aircraft, such as the DC-9. Its operational weight, less fuel, will be approximately 150,000 pounds; its length, 122 feet; and its wingspan, 78 feet. A double-delta configuration was chosen for the wings to improve the Orbiter's hypersonic flight characteristics, while maintaining a favorable lift over drag (L/D) ratio of about 4.5 for approach and landing.[100] The Orbiter will have a cargo bay measuring 15 feet in diameter and 60 feet in length, larger than a standard railroad boxcar.[101] The cargo bay will extend from 26.3% to 82.2% of the reference body length of the Orbiter.

Part of the Orbiter's overall appearance will differ from the appearance of a conventional aircraft. There will be no airbreathing engines on the Orbiter.[102] Instead, there will be three Space Shuttle Main Engines (SSME), which, along with the SRB motors attached to the ET, will provide the primary propulsion for the Space Shuttle, lifting the Orbiter from the earth's surface into earth suborbit. The SSME's will be located in the Orbiter's aft fuselage. Also, a number of smaller rocket engines to provide propulsion and altitude control while in orbit and during certain phases of entry will appear at various locations on the Orbiter.

99. *See Spaceship Earth: A New Perspective*, 11 ASTRONAUTICS & AERONAUTICS (No. 11) 62 (1973).

100. AW&ST, *supra* note 11, Oct. 10, 1977, at 27. The L/D ratio represents the horizontal distance a gliding vehicle will cover for each unit of altitude lost; thus, the Orbiter will be able to glide about 4.5 miles for each mile it descends. On final approach and landing the Orbiter's glideslope will be 20-22 degrees. *Id.*

101. AW&ST, *supra* note 11, Aug. 21, 1972, at 11.

102. Malkin, *supra* note 97, at 72. Originally, it was believed that the Orbiter might be equipped with airbreathing jet engines for maneuvering in the atmosphere during entry following orbital flights. This plan was abandoned after extensive testing proved that such engines, which would have added to the Orbiter's cost and complexity, were unnecessary for a safe return. This left the use of airbreathing jet engines to horizontal flight tests and cross-country ferry flights in the atmosphere. For this role, NASA then chose the Pratt & Whitney TF 33 turbofan jet engine. This is the advanced military version of the JT 3D turbofan that powers later models of the Boeing 707 and DC-8 commercial transports. AW&ST, *supra* note 11, July 9, 1973, at 45. Finally, after studies indicated that the provisions which would have been made in the Orbiter's design for attachment of the jet engines also would have increased its cost, complexity, and weight, it was decided not to use jet engines, but to mount the Orbiter piggyback-fashion atop a Boeing 747 jet transport to ferry it. Horizontal flight tests would be conducted by releasing the Orbiter in midair. AW&ST, *supra* note 11, Jan. 21, 1974, at 45; June 24, 1974, at 21; July 8, 1974, at 35. These tests have now been completed.

2. *The External Tank and Solid Rocket Boosters.* The ET will be attached to the bottom side of the Orbiter and will contain both the liquid-hydrogen fuel and the liquid-oxygen oxidizer for the SSME's. Since the ET will be jettisoned prior to attaining actual orbital flight, it will carry no rocket motors or associated systems; its sole purpose will be to carry all of the fuel and oxidizer for the SSME's.

The two SRB's will be placed on either side of the ET prior to liftoff and will be attached only to the ET and not to the Orbiter. Although the sole purpose of the SRB's will be to fire in parallel with the SSME's in lifting the Orbiter off the launch pad and sending it on its way toward earth orbit, they will function separately because each SRB is both a fuel tank and a rocket motor. Unlike the ET and like the Orbiter, the SRB's will be recovered after completing each mission, refurbished, and used again for another mission. For this reason, the SRB's will contain such equipment as small rocket motors for separation from the ET and a parachute recovery system.

B. Overall View of a Space Shuttle Mission

The Space Shuttle will be based at and launched from the two major launch sites in the United States. Approximately two-thirds of the Space Shuttle missions will be launched at the NASA Kennedy Space Center (KSC) at Cape Canaveral, Florida, while the remaining missions will originate at Vandenberg Air Force Base (VAFB) in California. The KSC missions will involve low-inclination orbits, including synchronous equatorial orbits, while the VAFB missions will involve high-inclination orbits, including polar and retrograde orbits.[103] The two launch sites will provide the Space Shuttle with access to all orbital inclinations required for anticipated missions.[104] Each Space Shuttle mission will consist of

103. Malkin, *supra* note 97, at 72. The inclination of a satellite orbit is its angle to the equator.

104. *Id.* at 73. The practical launch inclination limits at KSC will be from about 28.5 to 56 degrees, while those at VAFB will be from 56 to 104 degrees. It is a matter of conjecture at this time whether the Space Shuttle ever will be launched from other sites. Prior to the selection of KSC and VAFB there were at least four other sites in contention as Space Shuttle launch facilities. *See generally* NATIONAL JOURNAL, Apr. 24, 1971, at 869. There are, however, three sites in addition to KSC and VAFB which the Orbiter can utilize for contingency landing purposes. They are the Edwards Air Force Base in California, and specific airfields on Guam and Hawaii. AW&ST, *supra* note 11, June 30, 1975, at 33. The Orbiter would then be ferried by NASA's 747 from any of those sites to KSC or VAFB for launch. *See* note 102 *supra*.

three basic phases: the ascent phase, the orbital phase, and the descent phase.

1. *The Ascent Phase.* After installing the payload into the cargo bay of the Orbiter, the familiar rollout to the launch pad, and the final checkout on the launch pad, the ignition sequence of the Space Shuttle will commence. At the proper moment, the three SSME's, fueled by the ET, and the twin SRB's will ignite, these five rocket motors burning in parallel and creating a thrust of about 6,780,000 pounds. Thereupon, the entire Space Shuttle configuration, the Orbiter, the ET, and the SRB's, a total of four component vehicles attached together, will begin to lift vertically off the launch pad. Upon clearing the launch tower, the Space Shuttle will pitch over from the vertical to its predesignated flight-path angle, continuing to rise in the atmosphere in this manner until about two minutes after liftoff, at which time, at an altitude of approximately 24 nautical miles (45 km.), the twin SRB's will be jettisoned after having exhausted their solid propellants. The SRB's will fall back separately to the earth's surface, deploying first drogue and then main parachutes to slow their descent. Finally, the SRB's will land in the ocean at a predicted impact point of approximately 150 nautical miles (278 km.) from the launch site. Impact areas will be in the Atlantic off the coast of Florida for KSC missions, and in the Pacific off the coast of California for VAFB missions. At these points, ships and aircraft will be waiting to locate and recover the SRB's through the use of signals from built-in homing devices. The SRB's will be taken back to the Space Shuttle base where they will be examined, repaired if necessary, and refurbished for use on another flight.

Meanwhile, the Orbiter and the ET, which now comprise the entire Space Shuttle, will continue to ascend until about eight minutes after liftoff. At this point, at a velocity of approximately 50-100 feet per second less than orbital velocity, the SSME's will shut down and the ET will be jettisoned. The ET will begin to descend toward the earth's surface, partially to burn up due to atmospheric heating and partially to impact in pieces in a preselected remote ocean area.[105]

105. Malkin, *supra* note 97, at 71. The first operational baseline of the current Space Shuttle concept had the ET inserting into orbit attached to the Orbiter. The ET then would have been separated from the Orbiter and deorbited by firing retrorockets in the ET, while the Orbiter continued to orbit. This change from retrorocket deorbit of the ET to suborbital, unpowered jettison was made to simplify the Space Shuttle operating procedures, to improve

After the jettison of the ET, the Orbiter will become the entire Space Shuttle. The SRB's and ET will be gone and, although still an integral part of the Orbiter, the three SSME's will be nonfunctional for the duration of the mission because without the ET there will be no fuel for them. The Orbiter, however, will have two separate rocket systems for orbital propulsion and attitude control. The first system, the Orbital Maneuvering Subsystem (OMS), will consist of two hypergolic rocket engines, each capable of approximately a 6000 pound thrust, mounted in pods on the aft fuselage at the base of the Orbiter's vertical stabilizer.[106] After the ET is jettisoned, these engines will ignite and provide the Orbiter with orbital velocity. With orbital insertion completed, the ascent phase of the Space Shuttle mission will terminate, and the orbital portion will begin. The entire ascent phase lasts about ten minutes.

2. *The Orbital Phase.* After the Orbiter has been inserted into an initial orbit of about 50 by 100 nautical miles (90 by 185 km.) by the OMS engines, the engines will fire again one-half an earth revolution later. At this point, the Orbiter will be at apogee (100 nautical miles, 185 km.) and will be inserted into a new and usually more circular orbit required for whatever mission it has undertaken.[107] The mission may last from a few hours to thirty days. During this time the OMS will be utilized for major control of the Orbiter, including orbital transfer, rendezvous, and, at the end of the orbital phase of the mission, deorbit.

The second rocket system utilized after the jettison of the ET will be the Reaction Control Subsystem (RCS). It consists of one module in the nose of the Orbiter and two modules included as integral parts of the OMS pods, one in each pod. The total RCS will include thirty-eight 870 pound thrusters and six 25 pound thrust vernier motors. The RCS utilizes the same hypergolic fuel mixture as the OMS and will provide attitude control during orbital maneuvers and certain portions of the descent phase. While the RCS modules will perform smaller attitude changes in orbit, major control will be provided by thrust vectoring the OMS. This can be

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reliability, and to reduce the Space Shuttle crew's workload. It also allowed the weight of the ET to be reduced. In either case, the ET would impact in a pre-selected remote ocean area.

106. *Id.* at 69. Hypergolic rocket engines utilize fuels that ignite on contact with each other and without the need of an ignition system. In the case of the OMS, the fuels are nitrogen tetroxide (N_2O_4) and monomethylhydrazine (MMH).

107. This maneuver following the preliminary orbital insertion usually is referred to as circularization and will be accomplished by the OMS.

accomplished by moving the engines that are on special swivels and thereby varying the direction of thrust.

The missions the Orbiter and its crew can accomplish in orbit may range from the deployment of unmanned satellites to extensive scientific studies conducted in Spacelab, a payload of the Shuttle. When the mission has been completed, the Orbiter crew will set the systems for deorbit and fire the OMS engines to decelerate the Orbiter for atmospheric entry and eventual landing.

3. *The Descent Phase.* The descent phase is of great importance to the legal characterization of the Space Shuttle, because it is during the descent phase that the Orbiter acquires some of the technological characteristics of an aircraft, without losing any of the legal characteristics of a spacecraft.[108]

After the OMS engines have made their deorbit burn, the Orbiter will enter the atmosphere at an angle of attack, the angle between the wing chord line and the flight path, of about thirty degrees. This means that the nose of the Orbiter will be raised about thirty degrees to the direction in which the Orbiter is moving. Atmospheric heating will occur on the underside of the Orbiter, and temperatures up to 3000 degrees Fahrenheit will be reached on some parts of the Orbiter's nose and leading edges.[109] The Orbiter's attitude will be controlled by the RCS during the initial part of the descent phase. As the atmospheric density increases, the Orbiter's aerodynamic control surfaces will become effective, and, during a transition period of several minutes, the Orbiter will be jointly controlled by the RCS and the aerodynamic surfaces. When the aerodynamic surfaces become fully effective for control,[110] the RCS will

108. Note that the SRB's and the ET each went through its own descent phase. The SRB's was during the ascent phase of the Orbiter and ET, and the ET's was at the end of the ascent phase and the beginning of the orbital phase of the Orbiter.

109. Malkin, *supra* note 97, at 63. Temperatures up to 600 degrees Fahrenheit will be reached on the Orbiter's lee side which is the side opposite the Orbiter's direction of descent, namely, the top or dorsal side of the vehicle. Special materials developed during earlier experimental aerospace vehicle programs will be used to protect the Orbiter's surface. *Id.*

110. The aerodynamic surfaces of the Orbiter include the wings and attached elevons (combination elevators and ailerons used on vehicles which have delta-shaped wings, but no horizontal stabilizer), the vertical stabilizer and attached rudder/speed brake, and the body flap (a horizontal control surface attached to the aft fuselage below the SSME's and functioning during ascent as a heat shield for the Orbiter's SSME rocket nozzles) used in conjunction with the elevons for pitch control. The aerodynamic surfaces control the Orbiter at speeds less than Mach 5. SPACE SHUTTLE, *supra* note 97, at 32. Full aerodynamic control of all three axis (pitch, roll, yaw) will not be acquired until the Orbiter has descended to about 80,000 feet (24 km.). U.S. NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, DRAFT ENVIRONMENTAL IMPACT STATEMENT—SPACE SHUTTLE PROGRAM 28 (July 1977) (copy on file

be shut down and the Orbiter will become a totally aerodynamically controlled vehicle similar to a conventional heavier-than-air aircraft, but, more specifically, it will be a glider. It would be incorrect to consider the Orbiter simply as a conventional aircraft, due to its very limited flight capabilities.

The Orbiter crew will then take the vehicle through a series of successive trajectory target points to an altitude of about 130,000 feet (39 km.), utilizing the Orbiter's guidance and navigational system, as well as ground navigational aids, to update their position.[111] At 70,000 feet (20 km.) altitude, and about 30 miles (50 km.) from the landing field, terminal area energy management (TAEM) will commence. At 10,000 feet (3 km.) final approach and landing will begin, controlled by an autoland system.[112] The touchdown speed of the Orbiter will be about 190 knots (350 km/hr), and the Orbiter will be able to land on a 300 foot-wide, 15,000 foot-long runway.[113] The time from deorbit to landing lasts approximately thirty minutes.

Upon landing, the Orbiter will begin the process of ground turnaround, during which it will be readied for the next flight into space. It will be taken to the proper facility for inspection, maintenance, limited servicing, repair, if necessary, and checkout for the next mission. Installation of the payload into the cargo bay, attachment of the refurbished SRB's, and a new ET will begin the prelaunch process once again. As currently envisioned, the turnaround process will take fourteen days from the landing of the Orbiter to liftoff of the total Space Shuttle configuration, on a two-shift-day,

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with CALIF. W. INT'L L.J.). Note that during liftoff, the Orbiter's aerodynamic controls will be locked and directional control will be provided by thrust vectoring of the three SSME's and the two SRB's.

111. Malkin, *supra* note 97, at 75. During the atmospheric heating at the beginning of the descent phase, all communications with the ground will be blacked out. By the time the Orbiter is functioning as a totally aerodynamically controlled vehicle, the blackout will have ended. *Id.*

112. *Id.* TAEM refers to the process in which the crew will put the Orbiter in a number of energy management S-turns or circles, if necessary, in order to utilize atmospheric drag in dissipating the energy the vehicle has developed due to its high velocity. This will decrease the Orbiter's velocity so that it can make a final approach and a safe landing. AW&ST, *supra* note 11, June 10, 1974, at 47.

113. Although the Orbiter, in some ways, will be functioning like an aircraft during the latter part of the descent phase of each mission, the landing sequence will not be conventional because the Orbiter will have no propulsion capability and will not be able to abort a landing, pull up, and go around again for another landing attempt. The landing usually will be fully automatic, the crew's function being to supervise, monitor, and back up the autoland system. Further details of the landing sequence can be found in Pogust, *Landing the Shuttle*, 12 ASTRONAUTICS & AERONAUTICS (No. 12) 52 (1974).

five-day week.[114]

IV. LEGAL CHARACTERIZATION

To date there has been a paucity of discussion regarding the legal aspects of the Space Shuttle. The subject, however, has been addressed at several recent Colloquia on the Law of Outer Space sponsored by the International Institute of Space Law of the International Astronautical Federation,[115] as well as having been noted in certain other forums.[116] At this juncture of the analysis, it is necessary and important to discuss the legal characterization of the Space Shuttle in a manner which will assist understanding of the interplay of scientific, technological, and legal factors within the international community. For this reason, a lengthy discussion devoted to placing the Space Shuttle, as well as the aerospace vehicle concept in general, in both historical and technological perspective has preceded the legal analysis. Such perspective is a condition precedent to understanding the legal aspects of the Space Shuttle and any future aerospace vehicles.

A. *Theoretical Legal Characterization of the Space Shuttle*

The foregoing discussion indicates that the Space Shuttle is an aerospace vehicle able to function in both atmospheric and earth orbital environments. This is a technological characterization that involves the Space Shuttle's ability to function jointly as an aircraft and a spacecraft without being subject to the characterization either as a pure air vehicle or a pure space vehicle. As one approaches a

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114. Malkin, *supra* note 97, at 75. In an emergency, such as an orbital rescue mission, the Space Shuttle can be launched from standby status within two hours after notification and held in standby status for 24 hours. Standby status is defined as ready for launch except for main propellant fill, crew ingress, and final systems verification. *The Green Book, supra* note 48, at 35.

115. *See, e.g.*, Tamm, *Advent of the Space Shuttle in Earth Resources Investigations*, PROC. FIFTEENTH COLLOQUIUM OF THE LAW OF OUTER SPACE 45 (M. Schwartz ed. 1973); Tamm, *Further Reflections Upon the Legal Aspects of Sky Lab and the Space Shuttle*, PROC. SIXTEENTH COLLOQUIUM OF THE LAW OF OUTER SPACE 242 (M. Schwartz ed. 1974); *Roundtable of the Scientific Liaison Committee of the International Academy of Astronautics and the International Institute of Space Law*, PROC. SEVENTEENTH COLLOQUIUM OF THE LAW OF OUTER SPACE 297-401 (M. Schwartz ed. 1975); Sloup, *The Relationship of Air Law and Space Law—A View from the Space Shuttle, Including Its Internal and External Environments*, PROC. NINETEENTH COLLOQUIUM ON THE LAW OF OUTER SPACE 202 (M. Schwartz ed. 1977).

116. *See, e.g.*, Menter, *Jurisdiction Over Man-Made Orbital Satellites*, 2 J. SPACE L.19, 21 (1974); Tamm, *The Space Shuttle: Investigation of Earth Resources by Manned Observations*, 1 J. SPACE L. 64 (1973).

legal characterization of the Space Shuttle, a problem arises; namely, that the term aerospace vehicle has not acquired any legal significance in aerospace law, either on the municipal or international level.[117] At least one solution to the problem has been advocated.[118] The legal terms generally utilized for flight vehicles are aircraft and several variations of the term spacecraft.

1. *The Space Shuttle As an "Aircraft."* The term aircraft is used widely in both municipal and international law, although several types of definitions are in use. The following names are tentatively suggested for the various definitions of the generic legal term aircraft: 1) the broad definition; 2) the savings clause provision; 3) the international definition; 4) the carriage definition; and 5) the enumerative definition.

One formulation of the broad definition of the term aircraft in the United States is illustrated by section 101(5) of the Federal Aviation Act of 1958.[119] This definition has been used in United States federal legislation on aviation matters since the Air Commerce Act of 1926.[120] The potentially broad scope of this definition began to

117. This statement must be qualified in regard to municipal law, for it is based upon an examination of the 1965 publication AIR LAWS AND TREATIES OF THE WORLD, note 124 *infra*. It is possible that the term aerospace vehicle has been adopted in the municipal laws of one or more states since 1965, and by 1965 certain states had adopted rather forward looking definitions for flight vehicles of special capability.

118. The David Davies Memorial Institute of International Studies, in its *Draft Code of Rules on the Exploration and Uses of Outer Space*, 29 J. AIR L. & COM. 141 (1963), contained the following provisions in article 4.1:

> No spacecraft launched from the territory of any State may at any stage of its flight enter the airspace of another State without the consent of that State: provided that . . . . b. any craft capable of operating both as a spacecraft and as an aircraft shall for the purposes of its use of the airspace be deemed to be an aircraft . . . ;

Id. at 148. The key terms used in article 4.1 are aircraft, spacecraft, and airspace. Article 1 provides:

> *Aircraft* means any craft which depends, as means of flight upon the consumption of air, or upon aerodynamic lift, or both;
> *Spacecraft* means any craft, capable of orbital movement or manoeuvre in outer space and includes any craft which is being operated as a space station;
> *Airspace* means the volume of space between the surface of the earth at sea level and an altitude of 80,000 metres above it;
> *Outer space* means space outside the airspace . . . ;

Id. at 143. Under this definition, the Orbiter could be considered both an aircraft and a spacecraft, although the aircraft label could apply only during the descent phase.

119. Pub. L. No. 85-726, 72 Stat. 731 (codified in 49 U.S.C. §§ 1301 *et seq.* (1970)). Aircraft means any contrivance now known or hereafter invented, used, or designed for navigation of or flight in the air. *Id.* at § 1301(5).

120. The original definition in section 9(c) added the following phrase after the word air: "except a parachute or other contrivance designed for such navigation but used primarily as safety equipment." H. HOTCHKISS, A TREATISE ON AVIATION LAW 197 (1928). This phrase was maintained in the Air Commerce Act of 1926, as amended, until 1938. The Civil Aero-

become apparent to United States lawmakers during the hearings on the passage of the Federal Aviation Act of 1958, within nine months of the orbiting of Sputnik I:

> The [Senate Interstate and Foreign Commerce] Committee specifically considered the desirability of amending the definition of the word "aircraft," as it appeared in the Civil Aeronautics Act of 1938. It was the view of the committee that in order for the Administrator of the new [Federal Aviation] Agency to properly discharge his responsibilities under the new act, particularly those in connection with the allocation of airspace, that his jurisdiction should extend not only to vehicles commonly considered as aircraft, but also during their flight through airspace, other vehicles such as rockets, missiles and other airborne objects. After due deliberation, the committee concluded that no change in the definition of the term "aircraft" was necessary in order to achieve this objective, since all vehicles, rockets, and missiles, as well as aircraft, are in fact used at least in part for navigation of the airspace. Accordingly, no change in the definition to achieve this purpose of the committee was necessary, and none was made.[121]

The broad definition can include, unless it is stated otherwise in the particular international or municipal law in question by treaty or statute, or is so ordered by executive, administrative, or judicial mandate, those flight vehicles that traditionally have been regarded as aircraft and those vehicles that rely for support simply upon the downward thrust or simple action-reaction method of support in the atmosphere.[122] Thus, any aerospace vehicle, including the Space Shuttle, could be defined as an aircraft during the descent and ascent phases of the mission. This is so whether the descent be a ballistic or an aerodynamic type of entry and, if the latter, whether by airplane, glider, or rotorcraft techniques.[123]

In 1965, the broad definition seemed to be employed by at least forty-one nations in addition to the United States, although

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nautics Act of 1938 repealed the 1926 Act, and left the definition of aircraft as it now appears in the 1958 Act. *See* H. HOTCHKISS, A TREATISE ON AVIATION LAW 183, 199 (2d ed. 1938).

121. V THE ECONOMIC REGULATION OF BUSINESS AND INDUSTRY 3333, 3353 (B. Schwartz ed. 1973). *See also Hearings on S. 3880 Before the Subcomm. on Aviation of the Senate Comm. on Interstate and Foreign Commerce*, 85th Cong., 2d Sess. 262-63 (1958).

122. *See* note 9 *supra*.

123. Hang-gliders, such as the Rogallo wing, named for NASA engineer Francis M. Rogallo, also could be considered aircraft under the broad definition, as could the exotic Skycycle X-2 that daredevil Evel Knievel utilized in his attempt to fly over the Snake River Canyon on September 8, 1974. *See* The Christian Science Monitor, Sept. 6, 1974, at 2, col. 1; *id.* Sept. 10, 1974, at 13, col. 1.

several different formulations of terminology appeared to be in use.[124] For example:

> Canada: 'Aircraft' means any machine used or designed for navigation of the air;[125]
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> . . . .
>
> Chad: In the application of this Code, an aircraft shall be deemed to be any contrivance which can maintain itself, and move in the air;[126]
>
> . . . .
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> Costa Rica: Aircraft or Airship: devices known or which may be invented in the future, lighter or heavier than air, used in navigation or intended for flight in the atmosphere;[127]
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> . . . .
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> Dominican Republic: Aircraft. Any vehicle capable of supporting itself in the air;[128]
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> . . . .
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> Egypt: The word aircraft shall mean all balloons, whether captive or free, dirgibles, airplanes, kites and gliders as well as all other contrivances capable of rising or circulating in the air;[129]
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> . . . .
>
> France: Aircraft in the meaning of this law shall be any contrivance capable of rising and circulating in the air;[130]
>
> . . . .
>
> Ireland: The word 'aircraft' includes all balloons, whether fixed or free, kites, gliders, airships and flying machines;[131]
>
> . . . .
>
> Lebanon: For the purpose of this Law, every machine capable of taking off and flying shall be deemed an aircraft. This definition includes airships and balloons of all kinds;[132]
>
> . . . .
>
> Taiwan (Formosa): 'Aircraft' shall mean an airplane, airship, balloon, and any other craft used for flight and navigation

124. SENATE COMM. ON COMMERCE, 89TH CONG., 1ST SESS., AIR LAWS AND TREATIES OF THE WORLD (Comm. Print 1965) [hereinafter cited as 1, 2, or 3 AIR LAWS]. Although over ten years old, this document continues to be the only publicly available, comprehensive collection of foreign municipal laws on aviation and space matters; there do not seem to be any plans to update it at the present time.

125. 1 AIR LAWS, *supra* note 124, at 332.

126. *Id.* at 396.

127. *Id.* at 502.

128. *Id.* at 605.

129. *Id.* at 631.

130. *Id.* at 701.

131. *Id.* at 1171.

132. 2 AIR LAWS, *supra* note 124, at 1639.

in the air;[133]

. . . .

Yugoslavia: Any contrivance, used or intended for flying or air navigation shall be considered as an aircraft.[134]

The above examples illustrate the variant terminology found in the broad definition of aircraft.[135] It certainly is possible that various types of flight vehicles might not be included within specific definitions. This may depend upon how certain the terms are defined. These legal definitions, however, seem to focus upon the ability of the machine, contrivance, device, vehicle, or craft to function in an unspecified manner above the earth's surface without being attached to it. They seem to be concerned with the machine's ability to navigate, maintain itself, move, fly, rise, or circulate.[136] The absence of limitations placed upon these broad definitions, even though such limitations are key elements in other definitions, is the reason for including these definitions under the broad category.[137]

Regarding the Space Shuttle, it has been stated that the United States formulation of the broad definition could include not only the Orbiter during the descent phase of any particular mission, but also the entire Space Shuttle vehicle configuration during the ascent phase. Other formulations of the broad definition might disagree with this conclusion.[138] There are good reasons why the Space

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133. *Id.* at 2397.

134. *Id.* at 3071.

135. The United States itself employs a slightly different formulation in its Federal Aviation Regulations: "Aircraft means a device that is used or intended to be used for flight in the air." 14 C.F.R. § 1.1 (1977).

136. This is the technological criterion upon which the great majority of aircraft definitions are based. Some definitions introduce into what otherwise would be a regular broad definition a political/governmental criterion, namely, whether the aircraft is civilian or military.

> [CHINESE PEOPLES' REPUBLIC] The civil airplanes denoted in this law include all non-military airplanes, airships, balloons or any other conveyance that can fly in the air.

1 AIR LAWS, *supra* note 124, at 435.

> [UNION OF SOVIET SOCIALIST REPUBLICS] All flying devices (both lighter and heavier than air), with the exception of flying devices of the Armed Forces, shall be considered civil aircraft.

2 AIR LAWS, *supra* note 124, at 2546. Most states introduce the civil/military factor in another provision of the code, statute, or decree in question. *See, e.g.*, 49 U.S.C. §§ 1301(14), 1301(15) & 1301(32) (1970).

137. Regarding such definitions as Ireland's, which simply contain a list of different types of aircraft, it may be assumed reasonable that the inclusion of the term flying machines allows the definition to cover practically all types of flight vehicles.

138. The Soviet definition of civil aircraft would include "spacecraft, missiles, rockets, etc. . . . , as long as they are not operated by the military establishment." J. COOPER, AIR

Shuttle should not be defined as an aircraft, and, by decision of the Federal Aviation Administration, has not been defined as such under United States law.

A provision referred to here as a savings clause may be inserted into the aviation statute, code, or decree under consideration; such a clause will allow the administrative or executive authority of the state in question to regulate flight vehicles which might not be classified as aircraft under the state's regular definition of aircraft. Denmark's aviation law contains such a savings clause:

> For the safety of aviation or in the general interests of the public the Minister of Public Works may issue exceptions from the provisions of this law or issue special regulations referring to aircraft with no pilot aboard, or which are operated without engine or aircraft which are of an extraordinary type; these exceptions and regulations shall not amend any provisions which according to their content are provisions of civil or criminal statutes.
>
> The Minister may issue regulations on inventions which are designed to operate in the air, but are not aircraft.[139]

The aviation law of several other nations utilizes savings clause provisions.[140] Whatever the exact formulation, all savings clause

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CODE OF THE U.S.S.R. 11 (1966). The broad definition used by West Germany is more specific:

> Aircraft shall be deemed airplanes, rotary blade aircraft, dirigibles, glider planes, free and captive balloons, kites, flight models, and other instrumentalities intended for the use of the airspace, in particular spacecraft, rockets and similar flight instrumentalities.

1 AIR LAWS, *supra* note 124, at 754, 777. *See also* Bockstiegel, *Transport to Outer Space by Private Enterprises*, GERMAN J. AIR & SPACE L. (ZEITSCHRIFT FUR LUFT-UND WELTRAUMRECHT) 304, 310-312 (1976). In regard to the United Kingdom's Civil Aviation Act, 1949, (12, 13 & 14 Geo. 6, c. 67):

> Section 40 speaks of "aircraft," but no express definition of this term is to be found in the Act. The Air Navigation Order, 1960 (First Schedule), contains a table of general classification of aircraft which comprises balloons (free and captive); airships; gliders; kites; aeroplanes (landplanes, seaplanes, and amphibian); gyroplanes and helicopters. In most circumstances this table would provide a satisfactory definition of "aircraft" for the purpose of section 40, but it is submitted that it should not be adopted as an exhaustive definition. For example, a spacecraft in flight to or from its proper medium in outer space might well be classified as an "aircraft" for the purposes of section 40, but the same object would be difficult to place in the table set out in the Air Navigation Order.

A. MCNAIR, THE LAW OF THE AIR 116-17 (3d ed. 1964).

139. 1 AIR LAWS, *supra* note 124, at 603.

140. Iceland, Norway, and Sweden have basically the same type of provision as Denmark. *Id.* at 952; 2 AIR LAWS, *supra* note 124, at 1957, 2356-57. Japan and Korea tie their savings clause provisions to the carriage type of definition; Korea, however, also inserts a civil criterion.

> [JAPAN] In this Law, 'aircraft' shall mean any airplane, rotorcraft, glider and

provisions have the same effect. They allow the nation in question the same scope of competence to prescribe and enforce rules of conduct regarding any and all types of flight vehicles similar to nations relying upon the broad type of definition.[141] It may be assumed that the Space Shuttle, both the Orbiter in the descent phase and the entire Space Shuttle configuration during the ascent phase, could be within the scope of the savings clauses of all of these nations, regardless of whether the Space Shuttle vehicles would be defined as aircraft.[142]

The international type definition is important because it has been adopted in reference to two of the most important multilateral aviation conventions, the Paris Convention of 1919,[143] and its suc-

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> airship which can be used for air navigation with a person on board and any contrivance usable for air navigation which may be designated by cabinet order.

Id. at 1440.

> [KOREA] In this Law, 'aircraft' shall mean any airplane, airship, glider or rotorcraft which can be used for civil air navigation with a person on board, or any contrivance usable for air navigation which may be so designated by a State Council decree.

Id. at 1517. Netherlands attaches its savings clause to the international type of definition.

> [NETHERLANDS] Aircraft: machines that can derive support in the atmosphere from the reactions of the air, including or excepting machines to be designated by Order in Council.

Id. at 1809. Netherlands also has the following provisions:

> Further regulations can be made by or in virtue of an Order in Council . . . (f) concerning the use of helicopters, rockets, parachutes and model aircraft . . . ;

Id. at 1827. Poland has the most elaborate savings clause provision of all.

> [POLAND] 1. An aircraft shall be deemed a device designed for the transportation of persons or goods in the air space, capable of flight in this space as a result of the reactions of the air.
> 2. The Council of Ministers is authorised to subject the following aircraft to all or to some provisions of the air law:
> 1) Aircraft capable of flight in the air space as a result of the reaction of the air but not designed for the transportation of persons and goods,
> 2) Aircraft capable of flight in the air space irrespective of the reaction of the air, whether or not designed for the transportation of persons and goods.

Id. at 2110.

141. Iceland includes a broad definition in its aviation law.

> Any machine and substantial parts thereof, capable of rising in the air or remaining aloft or moving in the air, is deemed an aircraft for purposes of this law.

1 AIR LAWS, *supra* note 124, at 923.

142. It is interesting to note that all of these savings clause provisions date from the early 1960's when they were adopted or became effective. The Netherlands' law, however, became effective in 1959. It was during that time period that aerospace vehicles, such as the X-15 and X-20, were receiving much public attention, the former being test-flown and the latter being in the process of design. It is reasonable to speculate that the drafters of the various savings clauses were concerned about this new type of vehicle that might not fit the more traditional or conventional concept of aircraft.

143. Convention Relating to the Regulation of Aerial Navigation, *done* Oct. 13, 1919, Additional Protocol, *signed* May 1, 1920, 11 L.N.T.S. 174 (1922) [hereinafter cited as Paris Convention].

cessor, the Chicago Convention of 1944.[144] The Paris Convention did not define the term aircraft in its own provisions, but a definition was provided in Annex A to the Convention where it stated that "[t]he word 'Aircraft' shall comprise all machines which can derive support in the atmosphere from reactions of the air."[145] The United States signed the Paris Convention but did not ratify it. Those nations of the Western Hemisphere that did not become bound by the Paris Convention signed and ratified the Habana Convention of 1928.[146] The Habana Convention did not include annexes as did the Paris Convention,[147] but it did provide that:

> The contracting states shall procure as far as possible uniformity of laws and regulations governing aerial navigation. The Pan American Union shall cooperate with the governments of the contracting states to attain the desired uniformity of laws and regulations for aerial navigation in the states parties to the convention.[148]

Whether the parties to the Habana Convention would have adopted either a definition of aircraft like the one adopted by Annex A of the Paris Convention, or a broad type of definition as adopted by the United States in the Air Commerce Act of 1926,[149] is moot because both Treaties were later replaced by the Chicago Convention of 1944.[150] Like the Paris Convention, the Chicago Convention did not have a definition of the term aircraft included within its provisions. A subcommittee at the Chicago Convention proposed a definition stating that "[a]ircraft shall comprise all apparatus or contrivances which can derive support in the atmosphere from reactions of the air."[151]

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144. Convention on International Civil Aviation, *opened for signature* Dec. 7, 1944, 61 Stat. 1180, T.I.A.S. No. 1591, 15 U.N.T.S. 295 [hereinafter cited as Chicago Convention].

145. Paris Convention, Annex A, *supra* note 143, *as cited in* Cooper, *Contiguous Zones in Aerospace—Preventive and Protective Jurisdiction*, 7 A.F. JAG L. REV. (No. 5) 15, 16 (1965).

146. Convention on Commercial Aviation, *done* Feb. 28, 1928, 47 Stat. 1901, T.S. No. 840, 129 L.N.T.S. 225 [hereinafter cited as Habana Convention]. States which ratified the Habana Convention were Mexico, Nicaragua, Panama, Guatemala, Costa Rica, Honduras, Dominican Republic, Haiti, Chile, the United States, and Ecuador. *See* 5 J. AIR L. & COM. 653-54 (1934); 7 J. AIR L. & COM. 616 (1936).

147. Latchford, *Habana Convention on Commercial Aviation*, 2 J. AIR L. & COM. 207, 209 (1931).

148. Habana Convention, *supra* note 146, art. XXXII.

149. *See* text accompanying note 120 *supra*.

150. Article 80 provides, in substance, that states parties to either the Paris or Habana Conventions shall denounce those Conventions upon joining the Chicago Convention.

151. Proceedings of the Civil Aviation Conference, Chicago, Ill. (Nov. 1-Dec. 7, 1944), vol. II, *as cited in* Cooper, *supra* note 145, at 16.

Although the Chicago Convention did not enact the final texts of the several annexes to the Convention, the International Civil Aviation Organization (ICAO), which was created by the Convention and given the power under article 37 to adopt international standards and procedures relating to matters concerned with the safety, regularity, and efficiency of air navigation, did adopt them. In Annex 7, the term aircraft was defined as "[a]ny machine that can derive support in the atmosphere from the reactions of the air."[152] Several other multilateral air navigation treaties do not define the term aircraft in their provisions.[153] The Chicago Convention Annex should be considered as the most logical source to consult for an international definition of the term, because the Chicago Convention remains the basic general convention on international aviation matters.[154]

In 1965, there were approximately twenty-eight states that had adopted the international definition in their municipal aviation laws.[155] The distinctive feature of this definition is that it requires that the vehicle in question "derive support in the atmosphere from the reactions of the air,"[156] which, in effect, limits the international definition of aircraft to those vehicles whose support in the atmos-

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152. *Id.*

153. *See, e.g.*, Warsaw Convention for the Unification of Certain Rules Relating to International Carriage by Air, *opened for signature* Oct. 12, 1929, 49 Stat. 3000, T.S. No. 876, 137 L.N.T.S. 11; Rome Convention on Damage Caused by Foreign Aircraft to Third Parties on the Surface, *done* Oct. 7, 1952, 310 U.N.T.S. 181; Tokyo Convention on Offenses and Certain Other Acts Committed on Board Aircraft, *done* Sept. 14, 1963, 20 U.S.T. 2941, T.I.A.S. No. 6768, 704 U.N.T.S. 219; Hague Convention for the Suppression of Unlawful Seizure of Aircraft, *done* Dec. 16, 1970, 22 U.S.T. 1641, T.I.A.S. No. 7192; Montreal Convention for the Suppression of Unlawful Acts Against the Safety of Civil Aviation, *done* Sept. 23, 1971, 24 U.S.T. 564, T.I.A.S. No. 7570. The Geneva Convention on the International Recognition of Rights in Aircraft, *opened for signature* June 19, 1948, 4 U.S.T. 1830, T.I.A.S. No. 2847, 310 U.N.T.S. 151 does provide that the term aircraft for purposes of the convention "shall include the airframe, engines, propellers, radio apparatus, and all other articles intended for use in the aircraft whether installed therein or temporarily separated therefrom." *Id.*, art. XVI. This, however, does not define the term aircraft, but only states that whatever an aircraft is, it shall include the aforementioned things.

The Agreement Between the Government of the United States of America and the Government of the Union of Soviet Socialist Republics on the Prevention of Incidents On and Over the High Seas, May 25, 1972, 23 U.S.T. 1168, T.I.A.S. No. 7379, on the other hand, defines aircraft as "all military manned heavier-than-air and lighter-than-air craft, excluding space craft." *Id.* art. I(2).

154. As of January 1, 1977, 136 states were parties to the Chicago Convention. TIF 270 (1977).

155. *See* note 124 *supra*.

156. Unlike the broad and savings clause types of definitions, there is little variation in terminology among the states that utilize the international definition; the standard being the Chicago Convention Annex 7 formulation. Exceptions are Greece and Nepal:

phere relies on either the principle of buoyancy or aerodynamic lift. In other words, aircraft in the international definition are those flight vehicles that fit the classical or traditional subclassifications of aerostat or aerodyne. Vehicles that derive support solely from the technique of creating sufficient downward thrust to counteract the force of gravity do not appear to be included in this definition.[157]

The above conclusion implies that aerospace vehicles ascending from the earth's surface solely by means of rocket engines, from the V-2's of the 1940's to the Space Shuttles of the 1980's, could not be aircraft according to the international definition, if only the ascent phase of their missions was considered.[158] During the descent phase of its mission, the Space Shuttle Orbiter, functioning as a glider, could fit the international definition because it would be deriving support from the aerodynamic lift created by its wings once it reached an altitude low enough for such force to become possible.[159] Aerospace vehicles returning to the earth's surface through purely ballistic techniques, such as the V-2 rocket vehicles, could not be defined as aircraft under the international definition.[160] Ve-

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> [GREECE] Aircraft: any device capable of supporting itself in the airspace by static or dynamic action exercised on it by the air.

1 AIR LAWS, *supra* note 124, at 823.

> [NEPAL] *Airplane* shall mean every type of machine capable of flying in the air by means of atmospheric reaction and shall include balloons, airplanes, kites, gliders and flying machines, attached or free flying.

2 AIR LAWS, *supra* note 124, at 1802. Note that Nepal's definition used the term airplane rather than aircraft. The first word in the definition should probably be translated as aircraft because airplane is included in the definition along with balloons, kites, gliders and flying machines. If airplane is the proper translation, however, this is the only definition using airplane as the main term; the other definitions define airplane, if at all, as a subclassification of aircraft. Since the word aircraft does appear in other parts of the Nepal law, there is probably a mistake in translation.

157. *See* note 9 *supra*.

158. A rocket engine does not utilize oxygen from the atmosphere for combustion; instead, it carries its own supply with it. This is why a rocket engine is the only known propulsion system capable of functioning in the nearly perfect vacuum of outer space. In addition, a rocket engine will not function as efficiently in the earth's atmosphere as it will in outer space. This is because a rocket creates thrust by pushing only against the expanding products of its own combustion and nothing else, and the presence of an atmosphere hinders the expansion of these combustion products, thereby reducing the rocket's thrust. The surrounding atmosphere or air, therefore, not only does not help to support a rocket-propelled launch vehicle during its launch or ascent phase, but actually reduces such support. The Space Shuttle Main Engines (SSME), each producing at liftoff 375,000 pounds of thrust at sea-level, would produce 470,000 pounds of thrust if no atmosphere were present at liftoff. They will, in fact, produce 512,300 pounds of thrust in outer space at full power.

159. *See* note 110 *supra*.

160. *See* Cooper, *supra* note 145, at 17. Winged aerospace vehicles such as the A-4b and

hicles deriving support solely by means of downward thrust from airbreathing jet engines, but using no aerodynamic lift techniques, might be able to fit within the international definition. Their use of oxygen from the surrounding atmosphere possibly could be construed as "deriving support in the atmosphere from the reactions of the air," because the oxygen is mixed with the onboard fuel and ignited inside the jet engines.[161]

As this brief analysis indicates, the international definition does not include as many types of flight vehicles as the broad and savings clause definitions do. The differentiating factor is the nonapplicability of the international definition to vehicles deriving support above the earth's surface solely from the simple action-reaction or downward thrust technique, particularly if a rocket engine is used. It should be appreciated, however, that it is in the interest of every state to regulate the presence of any type of flight vehicle within its airspace. For this reason, the last word on the interpretation of the word aircraft must come from the proper authorities of the state in question, notwithstanding the great latitude available in interpreting the various key terms used in the definitions.[162]

A-9 versions of the V-2 (A-4), could qualify as aircraft under the international definition, as could lifting-body vehicles. *See* note 60 *supra*. Also, aerospace vehicles utilizing a mixture of simple downward thrust and aerodynamic techniques to descend to the earth's surface or to move from place to place could qualify as aircraft. Aerospace vehicles using only downward thrust to descend, such as the hypothetical passenger or cargo-carrying intercontinental ballistic rockets, could not qualify as aircraft under the international definition. *See* note 41 *supra*.

Note that aerospace vehicles, such as the manned entry capsules used today by the United States and the Soviet Union, might possibly qualify as aircraft under the international definition during their final landing phase. This is because during that time they have deployed parachutes to slow their descent and are "deriving support in the atmosphere from the reactions of the air."

161. There have been very few manned vehicles utilizing downward thrust from airbreathing jet engines as their only means of support in the atmosphere, and all have been experimental. One example was the Thrust Measuring Rig (TMR), or Flying Bedstead, built by Rolls-Royce and first tested in 1954. *See* Taylor, *supra* note 8, at 177.

162. The easiest methods through which states utilizing the international definition can insure that any flight vehicle entering their airspace will come within the scope of their aviation laws, are to either add a savings clause to the international definition or simply to change to the broad definition.

Some states, such as Egypt and Nigeria, seem to employ both the broad and international definitions. *See* 1 AIR LAWS, *supra* note 124, at 631, 634; 2 AIR LAWS, *supra* note 124, at 1909. The Nigerian international definition, however, speaks of an aircraft as "any type of air-supported vehicle, whether mechanically propelled or not, and includes all types of aerodynes and aerostats." *Id.* at 1916-17. If air-supported vehicle is interpreted as a vehicle simply supported in the air by whatever means, rather than a vehicle supported by reactions of the air, then this too is a broad definition.

The remaining types of definitions are used by relatively few states and, in some cases, may be interpreted in such a way that they simply become variations of the broad definition. One group of definitions, referred to as the carriage type, imposes the limitation that the vehicle be capable of conveyance or transportation, usually of persons or goods. Examples are:

> [ITALY] An aircraft shall be deemed any machine suitable for transportation of persons or goods by air from one place to another;[163]
>
> . . . .
>
> [PARAGUAY] An aircraft shall be any machine intended for carriage of persons or things by air;[164]
>
> . . . .
>
> [ROMANIA] All flying craft (heavier or lighter than air) used for the transportation of passengers or goods, with the exception of those aircraft held and used by the Air Force, shall be considered civil aircraft.[165]

If the term *goods* is given a liberal meaning, then this type of definition can be considered synonymous with the broad definition; even kites, small balloons, model rockets, and airplanes can carry some types of objects. Although the Space Shuttle Orbiter, with its large cargo bay, might appear to qualify as an aircraft under this definition,[166] it must be remembered that the Space Shuttle will be engaged in space transportation from earth to orbit rather than air transportation from one earth location to another.

Another definition might be referred to as the enumerative type because it simply lists those types of flight vehicles that are included under the generic term aircraft.[167] If certain key terms are

163. 1 AIR LAWS, *supra* note 124, at 1330.

164. 2 AIR LAWS, *supra* note 124, at 2015.

165. *Id.* at 2151.

166. *See* text accompanying note 101 *supra.*

167. *E.g.*:

> [BOLIVIA] Overflight, taking off, and landing on land or water anywhere on the territory of the Republic and its territorial waters by aircraft (Airplanes, hydroplanes, dirigibles, balloons, etc.) shall be subject to the provisions of this decree.

1 AIR LAWS, *supra* note 124, at 261.

> [JORDAN] (Aircraft) means all balloons, airplanes, dirigibles, or gliders.

2 AIR LAWS, *supra* note 124, at 1499.

> [KUWAIT] In these Regulations unless the context otherwise requires: . . .
> 'Aeroplane' means a flying machine supported in flight by fixed wings; . . .
> 'Flying Machine' means an aircraft heavier than air and having means of mechanical propulsion . . . ;
> 'Glider' means an aircraft heavier than air not fixed to the ground and having no means of mechanical propulsion, but having means of directional control.

given a liberal interpretation, the definitions could be considered simply as variations of the broad definition and possibly could pertain to the Space Shuttle Orbiter during its descent and ascent phases.[168]

It is evident from the preceding discussion that almost any state could define the Space Shuttle Orbiter as an aircraft during those portions of the descent phase when the Orbiter is at a low enough altitude to be functioning as a glider. Moreover, many states could define the entire Space Shuttle configuration as an aircraft during the ascent phase and the initial portions of the descent phase even though aerodynamic lift forces would not be operative at such times. These conclusions must be viewed in light of the fact that during any given mission the United States Space Shuttle will not enter the airspace of any state other than its flag state under its normal, operational mode, and at all other times it will be in the international regimes of either high seas airspace or outer space.

2. *The Space Shuttle As a "Spacecraft."* An examination of the legal terminology developed relating to spacecraft, unlike the previous examination of aircraft legal terminology, can be conducted almost entirely in the international sphere, because by 1965 very few states had incorporated the term spacecraft into their municipal aviation laws.[169]

The 1967 Outer Space Treaty,[170] while being the principal convention relating to the establishment of general rules for the activities of humans *vis-à-vis* outer space, does not provide a

Id. at 1573, 1575.

168. It should be recalled that the Space Shuttle Orbiter can always technologically be considered a glider, and it seems that it could be so defined legally by Jordan and Kuwait. Bolivia does not mention the term glider in its definition, but it does use the word *etc.* and, therefore, might interpret the definition to cover gliders.

169. *See* notes 138 and 140 *supra*. The National Aeronautics and Space Act of 1958, Pub. L. No. 85-568, 72 Stat. 426 (codified at 42 U.S.C. §§ 2451 *et seq.* (1970)) defines aeronautical and space vehicles as "aircraft, missiles, satellites, and other space vehicles, manned and unmanned, together with related equipment, devices, components, and parts." *Id.* at § 2452(2).

The other main United States statute relating to space activities, the Communications Satellite Act of 1962, Pub. L. No. 87-624, 76 Stat. 419 (codified at 47 U.S.C. §§ 701 *et seq.* (1970)) defines communications satellite as "an earth satellite which is intentionally used to relay telecommunication information." *Id.* at § 702(3).

170. Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, *done* Jan. 27, 1967, 18 U.S.T. 2410, T.I.A.S. No. 6347, 610 U.N.T.S. 205 [hereinafter cited as 1967 Outer Space Treaty].

definition for the term spacecraft.[171] All of the applicable treaty provisions, with the exception of article XII, could apply to the Orbiter during all phases of any given mission into earth orbit.

The 1968 Astronaut Agreement[172] similarly does not provide a definition of spacecraft, although it does refer to "objects launched into outer space" in the title.[173] It should be apparent that the Orbiter could be included within the terminology of the applicable Treaty provisions, because the Orbiter is designed to be placed into earth orbit on any given mission.

The Radio Regulations of 1959[174] did not define the term spacecraft, but were revised in 1963 at the Extraordinary Administrative Radio Conference[175] to define spacecraft as"[a]ny type of space vehicle, including an earth satellite or a deep-space probe, whether manned or unmanned."[176] In 1971, at the World Administrative Radio Conference for Space Telecommunications,[177] the definition was further modified to state that a spacecraft was "[a] man-made vehicle which is intended to go beyond the major portion of the earth's atmosphere."[178] Either definition could include the Orbiter if a situation in which the Orbiter would be engaging in

171. The treaty does, however, use the following terminology. Article V, on the rendering of assistance to astronauts, refers to the state of registry of the astronauts' "space vehicle"; article VII, on liability, refers to the "launching of an object into outer space"; article VIII, on the retention of jurisdiction, refers to "an object launched into outer space"; article X gives states rights "to observe the flight of space objects launched by those [other] States"; article XII, on visits of facilities, refers to "[a]11 stations, installations, equipment and space vehicles on the moon and other celestial bodies . . . ." *Id.* art. V, VII, VIII, X & XII.

172. Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space, *done* Apr. 22, 1968, 19 U.S.T. 7570, T.I.A.S. No. 6599 [hereinafter cited as 1968 Astronaut Agreement].

173. Articles 1 through 4, while addressing the rescue and return of personnel of a "spacecraft," do not define the term. Article 5 is directed to the return of a "space object or its component parts" in paragraphs 1, 2, 4 and 5, but uses "objects launched into outer space or their component parts" in paragraph 3. *Id.* art. 1, 2, 3, 4 & 5, para. 1, 2, 3, 4, & 5.

174. Radio Regulations, *done* Dec. 21, 1959, 12 U.S.T. 2377, T.I.A.S. No. 4893. The term Space Station was defined as "[a] station in the earth—space service or the space service located on an object which is beyond, or intended to go beyond, the major portion of the earth's atmosphere and which is not intended for flight between points on the earth's surface." *Id.* Reg. 72.

175. Partial Revision of Radio Regulations, Geneva, 1959, and Additional Protocol, *done* Nov. 8, 1963, 15 U.S.T. 887, T.I.A.S. No. 5603.

176. *Id.* at 920 (Reg. 84BH). Other, more specific definitions relating to various types of communications spacecraft can be found in Annex 1: Revision of Article 1 of the Radio Regulations. *Id.* at 916-20. *See also* W. JENKS, SPACE LAW 189 (1965).

177. Partial Revision of Radio Regulations, Geneva, 1971, and Final Protocol: Space Telecommunications, *done* July 17, 1971, 23 U.S.T. 1527, T.I.A.S. No. 7435.

178. *Id.* at 1577 (Reg. 84BAA).

activities covered by the Radio Regulations should ever arise.[179]

The 1972 Liability Convention,[180] one of the four most important multilateral treaties on space activites currently in force, states that "[t]he term 'space object' includes component parts of a space object as well as its launch vehicle and parts thereof."[181] Obviously, this Treaty covers the Orbiter, the SRB's, and the ET.

Under article I(b) of the Convention on Registration of Objects Launched Into Outer Space,[182] there is no actual definition of space object; there is, however, a statement that the term "includes component parts of a space object as well as its launch vehicle and parts thereof."[183] This provision, which is identical to the 1972 Liability Convention provision, should apply to the Orbiter *vis-à-vis* the Registration Convention in the same manner that it does *vis-à-vis* the 1972 Liability Convention. The SRB's and the ET, however, will not have to be registered because these components separate from the Orbiter prior to its attaining orbit.

The Soviet Union's Draft Treaty Relating to the Moon[184] refers to space objects, spacecraft, and similar terms in various articles; yet, it provides no actual definition of these terms.[185] Although the Space Shuttle Orbiter might be covered by these terms, as could the SRB's and ET, the issue is purely academic because no part of the entire Space Shuttle vehicle configuration is envisaged as ever being within the vicinity of the moon.[186]

The International Conference of States on the Distribution of Programme-Carrying Signals Transmitted by Satellite, also referred to as the Brussels Conference,[187] defines satellite as "any de-

179. The Orbiter probably would be in orbit while conducting such activities relating to telecommunications. Therefore, without the SRB's and ET, it is of no practical significance to consider whether the SRB's and ET would qualify as spacecraft under the definition used in the Radio Regulations.

180. Convention on International Liability for Damage Caused by Space Objects, *done* Mar. 29, 1972, 24 U.S.T. 2389, T.I.A.S. No. 7762 [hereinafter cited as 1972 Liability Convention].

181. *Id.* art. I(d).

182. 29 U.N. GAOR, Supp. (No. 20) Annex (Agenda Item 32), U.N. Doc. A/RES/3235 (1974), *reprinted in* 14 INT'L LEGAL MATS. 43 (1975) [hereinafter cited as Registration Convention].

183. *Id.* at 45.

184. U.N. Doc. A/AC. 105/115, Apr. 27, 1973, *reprinted in* 1 J. SPACE L. 170-79 (1973).

185. The term vehicle(s) also is used in certain articles. *See* arts. VII, VIII, IX, X, XI, and note 23 *supra*.

186. The furthest the Orbiter will ever be from earth is about 600 nautical miles (1100 km.).

187. HOUSE COMM. ON SCIENCE AND ASTRONAUTICS, 93D CONG., 2D SESS. (Comm. Print 1974).

vice in extraterrestrial space capable of transmitting signals."[188] This could cover the Orbiter since, all things being equal, it will have this capability.

In conclusion, it is apparent that in order to determine whether a pure space vehicle, an aerospace vehicle, or any component parts of such vehicles, including payloads or cargoes, are covered by the provisions of given international or municipal law, it is necessary to study the terminology of the particular treaty or statute in question. Although the terms *space object, object launched into outer space*, or *spacecraft* will probably be used frequently in the future,[189] the first two terms will probably be used most often and usually in conjunction with the terms *component parts* and *launch vehicle* and *component parts thereof*. Regarding the Space Shuttle, the Orbiter could be covered by practically any terminology, such as *space object, object launched into outer space*, and *spacecraft*. Yet, the application of such terms to the SRB's and the ET is conditioned upon whether the terms apply to suborbital vehicles.

B. United States Practice

This article has not attempted to address all the possible legal aspects of NASA's Space Shuttle, but only its legal characterization with particular emphasis upon the Orbiter. John R. Tamm posed the question of whether the Orbiter is "a legal chameleon that assimilates with the environment in which it functions."[190] It appears that, theoretically, the question might be answered in the affirmative.

However, a few statements should be made about the aircraft nature of the Orbiter. The Orbiter was characterized initially as a winged, aerodynamic-type aerospace vehicle. This technological characterization was elaborated upon in the discussions relating to the historical background of the aerospace vehicle concept and the current Space Shuttle concept. It was pointed out that certain technological facts concerning the Orbiter vehicle and its operations do

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188. *Id.* art. 1(iii).

189. *See* note 153 *supra* in relation to the use of the undefined term spacecraft in the United States-Soviet Union Agreement on the Prevention of Incidents On and Over the High Seas. *See also* note 118 *supra* regarding the David Davies Draft Code definition of spacecraft, which would apply to the Orbiter. Both of these documents also contain definitions of aircraft which could apply to the Orbiter, although the United States-Soviet Union Agreement would seem to exclude the Orbiter as an aircraft because it is also a spacecraft. Regarding the David Davies definitions, the Orbiter would seem to fit either aircraft or spacecraft. Again, the dual nature of the Orbiter as an aerospace vehicle is clearly illustrated.

190. Tamm, *supra* note 115, at 45; Tamm, *supra* note 116, at 65.

give the Orbiter an aircraft nature during the descent phase. Further, it was pointed out that the Orbiter should not be considered as "just another aircraft," due to the fact that the Orbiter's landing will be unpowered, quite unlike that of conventional jet transports.[191] Additionally, while the Space Shuttle operations will be more like aircraft operations than any previously manned spacecraft operations, the nature of these operations will still be more spacecraft than aircraft.[192] Technical personnel with the Space Shuttle program have pointed out that while the Orbiter during the descent phase can be referred to as an airplane in the technological sense, this label should not be applied indiscriminately.[193]

When addressing the matter of United States municipal law, namely, the 1958 Federal Aviation Act[194] and Federal Aviation Regulations, the fact that an object can fall within the literal definition of aircraft as used by the Act does not mean that such object will or actually should be regulated as an aircraft. This is true for any law of municipal or international orgin.[195] The Federal Aviation Administration has decided that the Space Shuttle is *not* an aircraft under the Federal Aviation Act of 1958 or the accompany-

191. *See* note 113 *supra*.

192. *See* Tindall, A Cursory Look at Shuttle Flight Operations (AIAA Paper 73-36, presented at the 9th Annual Meeting and Technical Display of the American Institute of Aeronautics and Astronautics in Washington, D.C., Jan. 8-10, 1973)(copy on file with CALIF. W. INT'L L.J.).

Robert F. Thompson, Space Shuttle Program Manager at NASA's Johnson Space Center, in discussing a decision to reduce the Orbiter free flight approach and landing tests to five from the original number of eight, stated:

> The shuttle is an orbital vehicle, not a landing research vehicle. We want only enough time spent in the approach and landing tests to give us confidence that we are not overlooking anything there and then go back to the central theme of the program, space flight.

AW&ST, *supra* note 11, July 25, 1977, at 23.

193. Myron Malkin, NASA Space Shuttle Program Director, speaking of the Orbiter at the 26th International Astronautical Federation Congress in Lisbon stated, "It's not a gleaming airplane . . . . It's more like a brick airplane and it flies like a brick too." *See* Harford, *IAF Balances the "Now" of Application Satellites and the "Tomorrow" of Space Power and the Shuttle*, 13 ASTRONAUTICS & AERONAUTICS , (No. 12) 54, 58 (1975). The Orbiter's L/D ratio is less than 5. This value applies during subsonic flight in a clean configuration with landing gear retracted, speed brake closed, and all aerodynamic control surfaces trimmed for maximum efficiency. *See* AIR FORCE MAGAZINE, Apr. 1977, at 49. Comparatively, the L/D of a clean DC-9 is about 16, while certain high performance sailplanes have L/D ratios of 30 or more. Although the NASA astronauts who flew the Orbiter *Enterprise* during the approach and landing tests conducted in 1977 at Edwards Air Force Base on occasion did refer to it as an airplane or aircraft, they did so purely in a technological sense and not a legal sense. AW&ST, *supra* note 11, Sept. 19, 1977, at 22-23; Oct. 3, 1977, at 25.

194. Federal Aviation Act of 1958, 49 U.S.C. §§ 1301 *et seq.* (1970).

195. *See* Bockstiegel, *supra* note 138, at 310-11.

ing Federal Aviation Regulations. Rather, it is a space vehicle under the National Aeronautics and Space Act of 1958.[196] This appears to be a wise course of action, for it insures that the Space Shuttle will not be subjected to a regulatory regime designed for pure air vehicles and the activities in which they engage, such as aviation and air transport.[197] Regarding the matter of safety in navigable airspace, the Federal Aviation Administration has the authority to fulfill its statutory duties by prescribing rules and regulations, *inter alia*, "for the prevention of collision between aircraft . . . and airborne objects."[198] This will insure that Space Shuttle operations, like previous United States space operations, will be coordinated properly with other uses of navigable airspace.[199]

V. CONCLUSION

Aerospace vehicles, such as the NASA Space Shuttle, provide the means to utilize more effectively and efficiently the outer space environment. Due to the physical reality of the earth's atmosphere, and the obvious necessity of transiting it when going to and coming from outer space, aerospace vehicles, such as the Space Shuttle, must face the legal and political reality of airspace and its attendant aviation regulatory regime. Subjecting aerospace vehicles to the aviation regulatory regime without full and careful consideration of the consequences, however, would hinder these vehicles from realizing their full potential. Not only the vehicle's state of nationality, but the international community in general, will benefit from the increased utilization of outer space.

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196. *See Space Transportation System: Hearings (Including Report) Before the Subcomm. on Space Science and Applications of the House Comm. on Science and Technology*, 95th Cong., 1st Sess. 609, 626-27 (1977).

197. *See* Sloup, *supra* note 115, at 204-05.

198. Federal Aviation Act of 1958, 49 U.S.C. § 1348(c) (1970).

199. The FAA has never defined space vehicles as aircraft, even though the definition of aircraft contained in the Federal Aviation Act is broad enough to encompass such vehicles as the Saturn V or other expendable launch vehicles, such as Saturn IB, Titan, Atlas, Delta, or Scout. The FAA has the authority to insure the safe and efficient use of navigable airspace during space launch and landing operations without defining space vehicles as aircraft. FAA and NASA officials have already met to determine what restricted airspace and other operational conditions are necessary to insure that Space Shuttle operations are conducted with due regard for the safe and efficient use of navigable airspace. 42 Fed. Reg. 17139-40 (1977). Final rules based on proposed FAA rules for the alteration and establishment of several restricted air space areas under 14 C.F.R. Parts 71 & 73 for Space Shuttle operations from Kennedy Space Center in Florida are published at 42 Fed. Reg. 29475 (1977).

The Space Shuttle's very limited atmospheric flight capabilities emphasize its spacecraft nature over its admitted technological aircraft nature. The decision of the Federal Aviation Administration not to define the Space Shuttle as an aircraft under the Federal Aviation Act of 1958, recognizes these facts and insures that the Space Shuttle will not be subjected to regulations that are unnecessary and incompatible with the Space Shuttle's spacecraft nature and mission.

Any regulation must be approached with the Space Shuttle's true nature, characteristics, and potential benefits in mind. Successor vehicles to the current Space Shuttle may have increased operating capabilities in the atmosphere and will require additional consideration of their legal aspects. Any regulatory regime for aerospace vehicles should be designed in light of outer space activites; this is true for both municipal and international law.