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INTERNATIONAL RULE PLANNING FOR GOVERNING SPACE TRANSPORTATION

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ABSTRACT

Space transportation is a fundamental infrastructure for all spacefaring nations; consequently, international planning for its governance should begin now during the formative stages of the Spaceways. Standards must be devised and adopted covering all aspects of the Spaceways development and operations to assure functional safety, and for the protection of the public they will serve. International agreements defining and designating rights, responsibilities, obligations and liabilities are needed to clearly establish boundaries for the roles of governments and the companies developing and operating the space transportation systems. A well defined, stable regulatory environment will be essential for businesses to plan and grow. This paper identifies and examines the primary areas that will need to be studied for the international rule planning for governing space transportation and the Spaceways. A proposal is made for the creation of an International Spaceways Forum working group as a means to address these specific issues. The results from this group would identify the specific next steps to be taken and recommend an international structure for implementation.

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INTRODUCTION

We are at the beginning of a new era of transportation to, from and through space. It likely will be an era dominated by reusable launch vehicles (RLVs), carrying passengers and cargo from Earth to orbiting facilities, as well as for point-to-point travel between cities with connecting spaceport pairs. The decision to proceed with commercial RLV development can only be made upon consideration of the capability of the space transportation system to be designed within established, governing boundaries of operational safety that protect the public and total system life cycle costs that yield an acceptable return on investment. For this to occur the governing boundaries must be defined, accepted by the public, recognized by the financial community and embraced by the developers and operators of space transportation systems.

In order for new RLVs and other systems to reach their potential of providing routine access to space, a reliable space transportation infrastructure - the Spaceways - must be established. Overall architectures for the Spaceways must be developed, including space traffic control, communications, and operating site protocols. It is timely now to establish an international working group to address the certification and safety issues presented by new RLVs, and define the Spaceways systems requirements for both managing and controlling sustained ground and flight operations at spaceport sites, and for maintaining operational interface and integrating with aircraft and air traffic control.

International Planning

Space transportation is a fundamental infrastructure for all space faring nations. Accordingly, it would be beneficial for international planning to begin at the advent of the formative stages of the Spaceways. As RLVs leave the isolation of today's launch facilities and provide frequent, reliable and economical transportation to and from major population centers on Earth and in orbit, standards need to be developed and adopted, encompassing all aspects of the Spaceways creation and functioning. The public both will demand and deserve nothing less to justify confidence in their safety for operations and for the protection of their environment.[1]

The business community also will demand a well defined, stable regulatory environment in which to plan and grow. Countries and communities must have a well-understood and accepted international regulatory environment within which they can frame their laws, confidently plan future growth, and anticipate the cost of participation. Therefore, international agreements governing obligations and liabilities will need to be drafted to clearly establish boundaries for the new responsibilities of governments and the companies developing and conducting the space transportation systems.

Initial Operations Research and Analysis

The potential for commercial RLV and Spaceways development, acquisition, certification and operations must be considered in the context of the projected future market growth and market-driven needs. The establishment of the objectives can provide the foundation to develop specific design-to requirements and a clear definition of the scope of the safety issues to be addressed and controlled.[2]

Operational effectiveness for existing launch systems is dominated by marginal safety, low availability and utilization, marginal responsiveness to market demand, and high cost. Lessons learned data supply a starting point for an operations research and analysis to establish an historical database for use in projecting new RLVs development, and provide guidance for the establishment of certification processes. This research database includes information collected from actual experience of Shuttle and Soyuz vehicles, Ballistic Missile Defense Organization (BMDO) DC-X, NASA RLV technology demonstration programs (DC-XA, X-33, X-34, X-37, X-40, and X-38/CRV, ISAS VTOL-RLV ("Dango-San"), data from the High Speed Civil Transport (HSCT) aircraft design, production and operations concept studies, and data from the commercial aircraft industry.[3]

The empirical data provide a baseline on system performance, factors of safety, operating cost, and system reliability. They also provide information on operational hazards to determine what, when, why and how critical failures have occurred, consequences of critical failures, and issues related to ground and flight activities. The use of empirical data, based on experience and precedent issues, is the foundation for the development of the certification basis and approval of applicable regulatory policies and procedures as is currently conducted by the United States in the civil aviation industry.

MAJOR ISSUES TO BE ADDRESSED

Developing governing policies for the new Spaceways space transportation infrastructure requires multidisciplinary efforts incorporating technical, legal and economic considerations. Six major categories of issues can be identified which will be involved in establishing and governing a major space transportation infrastructure: 1) Policy and Procedures; 2) Safety; 3) Standards; 4) Routes; 5) Regulations/Control; and 6) Spaceways Use and Protocols.[4]

(1) *Policy and Procedures*

The international community has established certain policies to govern mankind's activities in outer space, as expressed in the existing treaties and international instruments. The application of such policies to the Spaceways will present novel questions of interpretation as well as challenges for changes. Among these policy issues are matters relating to:

- whether the assignment of an orbital route is violative of the non-appropriation principle of the Outer Space Treaty;[5]

- whether the terms "astronaut" and "envoy of mankind" include fare-paying passengers;[6]

- whether space vehicles, and space objects have a right to be protected against interference,[7] whether such interference is deliberate, by means of debris, or by collision with another object,[8] or through electromagnetic signal or radiation whether or not accompanied by criminal intent;[9]

- the implications of Spaceways regulation on liability, registration and identification of launch vehicles and space objects,[10] and the long-debated issue of delimitation.[11]

The policies and procedures to be considered also include matters of structure and process, that is, the form and jurisdiction of the entity which will have authority to promulgate appropriate regulations, provide a mechanism for the resolution of disputes,[12] and establish a means for enforcement. The governing body necessarily must harmonize and coordinate its functions with national and other international regulatory structures, including the International Civil Aviation Organization,[13] the United Nations Committee on Peaceful Uses of Outer Space, and the International Telecommunications Union.[14]

The extent and limitations on jurisdiction carefully must be considered and articulated, including questions concerning national and international boundaries for Spaceways, clear jurisdictional divisions between state, national and international licensing and certification, and any permissible military use of space (such as surveillance satellites). In addition, the applicability and limitations of existing laws and treaties must be examined, and recommendations for specific amendments thereto made where necessary and desirable. Thus, a comprehensive review of existing policies and procedures regulating today's commercial transportation systems, together with an identification of the organizations and their authorities for implementing these policies, can provide important guidance in structuring a path to the regulation and governance of space transportation. Results from this policy review also would be used as points of references for each of the major groups of issues.

(2) *Safety*

The pre-eminent concerns for the establishment of the Spaceways must be the safety of passengers and crew and people, homes and businesses located at and surrounding the spaceports, and the environment. A key issue will be providing for RLV certifications relative to design, manufacturing and sustained functioning, such that safety is assured by the inherent design of the vehicle and its operations.[15] This range of safety must extend to other vehicles that may conduct activities in proximity to the Spaceways and related infrastructure, whether on the ground, the oceans, in the airspace, or in outer space. Public safety for current expendable as well as reusable launch vehicles is achieved through separation and isolation of the launch site and flight path from public access and areas of public utilization. However, existing regulations, so successfully used by the commercial airline and aircraft industries, can provide a more appropriate model for the Spaceways than can expendable launch vehicles.[16] The objective of the certification process is to find the launch vehicles and Spaceways design to be in compliance with operational safety and continued airworthiness standards, based on a defined set of guidelines and procedures, now and for the foreseeable future.[17]

The success of the design certification system in the aviation industry has been dependent upon the close cooperation between the drafters of the regulations and aircraft manufacturers and operators. Adoption of this highly interactive process for Spaceways will provide guidelines and safety criteria at every step of RLV type designs, production, flight test and operations with predictable costs. Moreover, it would provide commercial RLV developers with a clear set of guidelines and criteria to govern future technology development as well as a process to benefit from operational experience. Without uniform standards of safety an integrated air-space traffic control system cannot be implemented. Also, as space traffic increases along with the number of spaceports throughout the world, uniform standards of safety will be demanded for ground facilities as a condition for landings and departures as well as processing of passengers and payloads, flight operations maintenance and servicing. Appropriate provisions, however, will need to be made to ensure confidentiality of proprietary or competition sensitive system engineering data.[18]

(3) *Standards*

RLVs are unlike existing expendable launch vehicles, which take-off, deliver their payloads into space and either become debris or re-enter the atmosphere and ablate. Each ELV flight is a first flight. New RLVs are designed not just to take-off and deliver payloads into space, but also return to their spaceports and be used over and over again. The RLVs will carry crew and passengers, have designed-in flight abort capability, and factors of safety margins equal to or greater than today's commercial aircraft. Regulations, standards and policies for new RLVs likely will be very similar to that of the commercial aircraft - system type design and production, flight operations, maintenance and continued airworthiness certification as well as existing spaceport Range Safety expected casualty criteria.

A comparison of commercial aircraft and RLVs at a functional system (hardware and software) level shows the significant relevance and, hence, a strong rationale for using the aircraft experiences to develop approaches for safe designs and operations for RLVs. FAA type design certificate, commercial operator's license regulations and operating site expected casualty criteria provide useful models for managing and controlling a reliable and cost-efficient Spaceways systems.[19]

The Commercial Space Launch Act of 1984[20] and U.S. Federal Aviation Regulations[21] empower the Federal Aviation Administration's Administrator of Space Transportation (AST) to issue commercial launch site and commercial operator's licenses. The license allows operators to launch the expendable launch vehicles after it is demonstrated that the ELV is in compliance with operational safety. Safety is defined in terms of expected casualty criteria, meaning protection of public safety and safeguard of environment and property on ground, and secure financial and insurance requirements.

The U.S. Commercial Space Act of 1997[22] amended the 1984 Act to include reusable space transportation systems and operating sites for licensing authority. The Commercial Space Act of 1997 also authorizes potential RLV operators to maintain the operating site and conduct activities on a continuing basis without interruption for an extended period.

To date, there is no comprehensive certification process for RLVs, and the current regulations of the AST govern primarily unmanned commercial vehicles and objects.[23] Nevertheless, AST is studying the operational architectures for a space transportation system, which ultimately will encompass procedures necessary for type design certification, commercial operator's licenses, and Spaceways systems regulations, including ground infrastructure and spaceports.[24]

(4) *Routes*

In anticipating and planning for the growth of space transportation, consideration will need to be given to the definition and control of the routes that RLVs will fly to, from and through space. Unlike transit through the airways and seaways that have both spatial and temporal variability, Spaceways are governed to a large extent by the rigors of orbital mechanics. Once started on a Spaceways route, it is difficult and economically disadvantageous for a RLV to change its course. In addition, RLV routes must be harmonized with satellites transiting or orbiting in the Spaceways.[25]

Spaceways routes can be categorized by a number of criteria defined by their uses and the type of equipment that might be operated within the Earth-Moon Frontier. These routes would serve many operators and could be assigned according to their use. The assignment of routes will need to be made in consideration of factors such as present and future uses based on space access points, spaceport locations, proximity to population centers, projected traffic, civil/commercial/military sector uses, and present and projected satellites, stations, industrial parks and power plants.[26]

The types of RLVs being operated, the cargo they might carry, and emergency or exigent circumstances all could be used to differentiate and prioritize routes. For example, rocket powered RLVs may require different trajectories than combined "air-breathing-rocket powered" RLVs. In addition, RLVs using nuclear propulsion or carrying hazardous materials might be restricted to routes isolated from passenger-carrying RLVs or routes over major population centers. Routes would need to be established for trips and shipments of goods to other countries and continents through connecting spaceport pairs. Thus, routine terrestrial travel routes for people and cargo will need to be established, shrinking the world for international commerce and travel. Nevertheless, the regulations must be sufficiently flexible to make appropriate allowance for new technologies that may be developed.[27]

(5) *Regulations and Controls*

Issues concerning regulation and controls include the coordination of safety requirements and the establishment of appropriate standards as well as operational processes. This will include an examination of the national regulatory structures together with international and other groups that are concerned with traffic to, from and/or within space. Examples include ISO Technical Committee (TC20) for Aircraft and Space Vehicles, ISO Subcommittee (TC20/SC14) for Space Systems and Operations, ISO Subcommittee (TC20/SC13) for Space Data and Transfer Systems, and the Range Commanders Council.[28]

A second major area would deal with issues of liability and indemnification. A major step forward in promoting the aviation industry was the Warsaw Convention[29] which assigned absolute liability to international carriers and at the same time set reasonable limits on compensation for damages. There is no counterpart to the Warsaw Convention in extant space law.

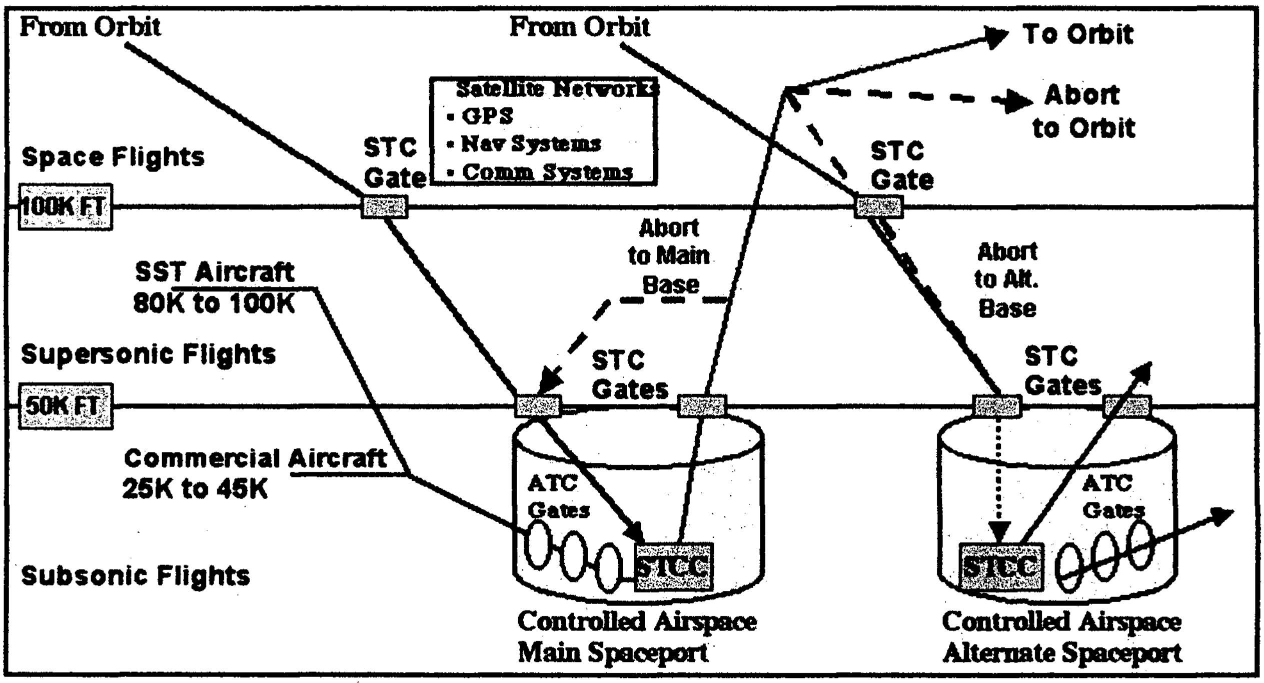
The Liability Convention holds states internationally liable for damages caused by space objects under certain circumstances, but does not set any ceiling on the amount that can be claimed or recovered. In addition, the licensing statutes require that all parties to a licensed launch activity execute a reciprocal waiver of claims on behalf of themselves, their contractors, sub-contractors, customers, and the contractors and sub-contractors of the customer, pursuant to which each entity agrees to be responsible for property damage and personal injuries it sustains resulting from an activity carried out under the license.[30] The waiver by the U.S. government, however, is limited to the amount of a claim in excess of the required insurance coverage.[31] A procedure has been established for the payment of such claims, subject to a maximum of $1,500,000,000.[32]

(6) *Spaceways Use and Protocols*

In the current space market, the use of the launch vehicles is limited and relatively easy to control. With 100 or so flights per year, vehicles and their cargo are qualified for each flight and "routes" are easy to de-conflict. However, frequent and regular passenger and cargo space transportation will require a comprehensive approach to space traffic control, including the recognized uses of the Spaceways and the process for such recognition. Perek has identified the following categories of issues pertaining to control of space traffic: coordination of communications; collision avoidance, traffic separation, removal of inactive vehicles, reducing debris and pollution prevention, restricting human error and technical malfunction, and identification of space objects.[33]

Space traffic control is an emerging concept that will be required to place transportation traffic to, from and through space in the same regulatory environment as air traffic is today. Space traffic must be a routine activity that can be controlled efficiently and effectively, and provide enough flexibility to support a wide range of cargo and crewed RLVs and scheduling variations to support the demands of the marketplace. An integrated air and space traffic control system will replace today's expensive test-range tracking infrastructure with ground and on-board position reporting capability via transponder, global positioning system (GPS) fixes, inertial navigation system (INS) instrument landing systems (ILS) solutions, and potential other technologies yet to be developed. Up-link and downlink telemetry initially will be enabled by low cost commercial ground stations, and ultimately, by space based communications constellations. A potential architecture for integrating air and space traffic is shown in Figure 1.

Detailed operational protocols will need to be developed for all aspects of planned mission objectives, as well as all foreseeable risk scenarios. A robust and responsive control for the Spaceways will be essential to all future commercial RLV flight activities in order to fully exploit the operational safety, functionality, supportability and market responsiveness being designed into RLVs.



ATC= Air Traffic Control / STC= Space Transition Corridor / STCC= Space Transition Corridor Control

Figure 1

THE ISF PROPOSAL

The foregoing discussion demonstrates that the development of a space transportation infrastructure for the frequent, regular and routine carriage of passengers and cargo presents a variety of issues that will require extensive studies and analyses. It is proposed that the subject of "Regulating the Spaceways" be considered for a dedicated session of a future Colloquium of the IISL. The membership of the Institute is uniquely qualified to examine and identify issues and prepare a roadmap for the development of the international governing processes and procedures. These processes and procedures would cover but not be limited to certifying new RLVs and Spaceways systems and regulating the operation of the reusable space transportation infrastructure. This dedicated session could become the foundation for further study of the Spaceways establishment, such as by means of an independent International Spaceways Forum (ISF). The ISF could be coordinated with the IAA Committee on Space Policies, Economics and Law, with invitations to participate extended to appropriate government agencies and industry organizations in all interested countries, as well as national and international organizations such as the ISO, ABA, ASIL, ILA, IBA, COSPAR, and the AAS, to name but a few examples.[34]

The ISF would be chartered to carry out the following four specific tasks:

(1) Identify and characterize the issues associated with governing the Spaceways.
(2) Identify and assess the applicability of existing or planned regulations and standards.
(3) Prepare roadmaps for the development of the governing processes and procedures.
(4) Identify the applicability of and impacts on existing national laws and treaties.

Although there are a large number of potential issues to be considered, not all of them need to be resolved for the RLV development activities to continue and the Spaceways to be initiated. The formation of the ISF to address these specific issues will provide an evolutionary process for the identification and resolution of issues, and lead to a stable and supportive international environment for the development and operation of the Spaceways and future space transportation systems.[35]

The ultimate goal of the activities of the ISF would be to:

Provide for developing the uniform governance of space transportation and its supporting infrastructure to assure the safety of the traveling public and protection of lives and properties and to foster a commercially profitable operating environment.

CONCLUDING REMARKS

A dedicated session of the IISL Colloquium leading to the ISF formation could be the initiating act for formulating long term national and international policies that actively encourage and support the Spaceways development. Such policies could provide a stabilizing environment for accelerating and sustaining the opening and growth of the Spaceways. With the Spaceways in place, space would be open for business and pleasure and space business could become a self-sustaining and expanding new economic sector. National and international leadership is needed to take such visions to action, and to make opening the space frontier a reality.

Notes:

1. *See* Gaubatz, *International Certification for Commercial Reusable Space Transportation*, in PROCEEDINGS OF THE 42ND COLLOQUIUM ON THE LAW OF OUTER SPACE 246, 251 (2000) [hereinafter referred to as "Gaubatz, International Certification"].

2. *See* Gaubatz and Smiljanic, *Designing Reusable Space Vehicles for High Operability*, IAF Paper No. IAF-97-V.5.01 (October 1997).

3. See Data Compilation on file in the offices of Smiljanic Consultants, Inc.

4. *See* Gaubatz, *Developing and Regulating the Spaceways*, in PROCEEDINGS OF THE 41ST COLLOQUIUM ON THE LAW OF OUTER SPACE 50, 55-7 (1999) [hereinafter referred to as "Gaubatz, Regulating the Spaceways"].

5. Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, *opened for signature* January 27, 1967, article II, 18 U.S.T. 2410, T.I.A.S. No. 6347, 610 U.N.T.S. 205, *text reproduced in* UNITED NATIONS TREATIES AND PRINCIPLES ON OUTER SPACE 3 (1999); *see* Collins, *Legal Considerations for Traffic Systems in Near-Earth Space*, in PROCEEDINGS OF THE 32ND COLLOQUIUM ON THE LAW OF OUTER SPACE 296, 298 (1990).

6. *See* Agreement on the Rescue of Astronauts, the Return of Astronauts, and the Return of Objects Launched Into Outer Space, *opened for signature* April 22, 1968, 19 U.S.T. 7570, T.I.A.S. No. 6599, 672 U.N.T.S. 119, *text reproduced in* UNITED NATIONS TREATIES AND PRINCIPLES ON OUTER SPACE 8 (1999); *see also* Outer Space Treaty *supra* note 5, at art. V; Scott, *Policy/Legal Framework for Space Tourism Regulation*, 28 J. SPACE L. 1, 3 (2000).

7. *See* Collins, *supra* note 5, at 297.

8. *See generally* Perek, *Traffic Rules for Outer Space*, in PROCEEDINGS OF THE 25TH COLLOQUIUM ON THE LAW OF OUTER SPACE 37 (1983); Collins & Williams, *Toward Traffic Systems for Near-Earth Space*, in PROCEEDINGS OF THE 29TH COLLOQUIUM ON THE LAW OF OUTER SPACE 161 (1987).

9. *See* Diederiks-Verschoor, *Protection of Security of Space Traffic*, in PROCEEDINGS OF THE 28TH COLLOQUIUM ON THE LAW OF OUTER SPACE 220 (1986).

10. *See* Convention on International Liability for Damages Caused by Space Objects, *opened for signature* March 29, 1972, 24 U.S.T. 2389, T.I.A.S. No. 7762, 961 U.N.T.S. 187, *text reproduced in* UNITED NATIONS TREATIES AND PRINCIPLES ON OUTER SPACE 11 (1999); *see also* Outer Space Treaty, *supra* note 5, at art. VI.

11. *See* Convention on Registration of Objects Launched Into Outer Space, *opened for signature* January 14, 1975, 28 U.S.T. 695, T.I.A.S. No. 8480, 1023 U.N.T.S. 15, *text reproduced in* UNITED NATIONS TREATIES AND PRINCIPLES ON OUTER SPACE 18 (1999); *see also* Perek, *supra* note 8, at 41; Gorove, *An International Space Flight Organization Envisioned by the United States to Become Conceivably Operational Around 2005 May Put to Rest Much of the Long-Standing and Vexatious Issues of Delimitation of Airspace and Outer Space*, 28 J. SPACE L. 53 (2000).

12. *See* Diederiks-Verschoor, *supra* note 9, at 221.

13. *See* Convention on International Civil Aviation, December 7, 1944, 61 Stat. 1180, T.I.A.S. No. 1591, 15 U.N.T.S. 292, ICAO Doc. 7300/5.

14. *See* Collins and Williams, *supra* note 8, at 169, (noting that the ITU considers all functioning satellites to be "telecommunication systems" within its jurisdiction, and that insurance underwriters will have a role in determining risks of collision and responses thereto).

15. *See* Gaubatz, Smith and Smiljanic, *Translating SSTO System Operability and*

Supportability Requirements Into Measures of System Effectiveness, AIAA Paper No. AIAA-96-4247 (September 1996).

16. *See* Gaubatz, International Certification, *supra* note 1 at 253.

17. *See* Gaubatz and Smiljanic, *supra* note 2.

18. *Cf.* 14 C.F.R. § 413.7 (confidentiality).

19. *See* Collins, *supra* note 5, at 299.

20. P.L. 98-575 (October 30, 1984), 49 U.S.C. §§ 2601 *et seq.*

21. 14 CFR Part 400 *et seq.*

22. P.L. 105-103 (October 28, 1998).

23. *See* 14 C.F.R, FAR §§ 400 *et seq.*; *id.* at § 1214; *see also* Scott, *supra* note 6, at 4.

24. *See* FAA/AST, *Commercial Space Transportation Concept of Operation in the National Aerospace System in 2005* (February 9, 1999).

25. *See* Perek, *supra* note 8, at 38-9; Collins & Williams, *supra* note 8, at 162-63; Collins, *supra* note 5, at 297.

26. *See* Gaubatz, Regulating the Spaceways, *supra* note 4, at 53.

27. *See* Perek, *supra* note 8, at 39.

28. *See* Gaubatz, Regulating the Spaceways, *supra* note 4, at 55-6.

29. *See* Convention for the Unification of Certain Rules Relating to International Carriage by Air, October 12, 1929, 49 Stat. 3000, T.S. 876, 137 L.N.T.S. 11.

30. 49 U.S.C. § 70112 (b)(1). For a discussion of the application of the reciprocal waivers, *see Martin Marietta Corporation v. Intelsat*, 978 F.2d 140 (4th Cir. 1992), *as amended* 991 F.2d 94 (1993); *see also* Bostwick, *Liability of Aerospace Manufacturers: McPherson v. Buick Sputters into the Space Age*, 22 J. SPACE L. 75 (1994); Meredith, *Spacecraft Failure-Related Litigation in the United States: Many Failures, but Few Suits*, in PROCEEDINGS OF THE 38TH COLLOQUIUM ON THE LAW OF OUTER SPACE 22 (1996).

31. *See* 49 U.S.C. § 70112 (b)(2). Licensees granted authority by the AST must carry insurance, which is limited by statute to a maximum of the greater of $500,000,000 or the largest amount available at reasonable cost in the global marketplace for third party liability claims, and $100,000,000 for property damage claims in favor of the U.S. government. 49 U.S.C. § 70112 (a)(3).

32. 49 U.S.C. § 70113 (a)(1) (expressed in 1989 dollars).

33. *See* Perek, *supra* note 8, at 38-41.

34. *See* Gaubatz, Regulating the Spaceways, *supra* note 4, at 55; Gaubatz, International Certification, *supra* note 1, at 260-62.

35. *See* Collins, *supra* note 5, at 302; Perek, *supra* note 8, at 42.