

DEVELOPING AND REGULATING THE SPACEWAYS

Dr. William A. Gaubatz
President
SpaceClipper International
Universal Space Lines, Inc.
Newport Beach, CA USA

Abstract

The world soon will enter a new era of space transportation dominated by reusable systems (Spaceplanes), a market dominated by passenger and cargo transportation, and a proliferation of launch sites (Spaceports) located throughout the world at inland as well as at coastal sites. Spaceplanes will connect not only terrestrial Spaceports pairs, but also earth and orbiting spaceport pairs in creating a new transportation infrastructure of Spaceways.

Planning for the Spaceways system must consider an entire space transportation infrastructure that provides services for space industries and the traveling public. Spaceways include elements such as the ground support systems, the control systems, the navigation and weather systems, the collision avoidance systems, the refueling stations and Spaceports. The Spaceways must also have the laws, policies, procedures and protocols to regulate and control them.

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Opening the Spaceways is an infrastructure development problem that must be accomplished as an international undertaking. International planning should begin now during the most formative stages of the Spaceways.

An International Spaceways Forum is proposed to discuss and develop strategies for establishing an International Spaceways Association (ISA). Such a forum would be attended by all space faring nations and might consist of six panels: 1) Policy and Procedures; 2) Safety; 3) Standards; 4) Routes; 5) Regulations/Control; and 6) Spaceways Use and Protocols. This international forum could formulate long term national and international policies which actively support the Spaceways development.

Forward

Space remains as the last great frontier to be opened to the public. It is tantalizingly close to the entire world's population, yet only a very elite group of men and women have traveled there. Opening the Space Frontier to the Public means overcoming transportation infrastructure problems the first major

one being the development of safe, reusable Spaceplanes. The development challenges involved are enormous and full of tough engineering problems. To turn new technologies into practical designs that can be manufactured and maintained for routine, low cost, operations is proving to be a tremendous undertaking. But there are equally tough regulatory processes and procedures to be put into place to govern the developments needed to establish, maintain and regulate an immense and effective new transportation infrastructure for space -- the Spaceways.

The Spaceways will enable the space frontier to reach its potential as a major new economic sector. Overall architectures for the Spaceways must be developed and processes for planning, monitoring and controlling the traffic need to be developed and demonstrated. Such processes must be carried out as international cooperative efforts by governments and industries as part of a broad space-development objective, centered on first developing the Spaceways infrastructure. This development will stimulate the entrepreneurs, fully engage the public, and bring to reality, the benefits of a place called space. Such an economic vision for space can only be realized by first achieving a new transportation vision.

Spaceways and the Space Frontier

Spaceways are much more than vehicles for getting to low earth orbit. The Spaceways must include elements such

as the space traffic control systems, ground support systems, the navigation and weather systems, the collision avoidance systems, the refueling stations and spaceports.

The Spaceways must also have the laws, policies, procedures and protocols to regulate and control them. How will routes be assigned and who can operate them? How are schedules established and who coordinates them? Who is responsible for debris and its clean-up? What are the criteria for owning and operating a spaceport or a spaceline?

We will have Spaceways for travel to and from near Earth orbits. We will have Spaceways for flying through near Earth space for rapid point-to-point terrestrial travel and delivery of cargo. We will have Spaceways for travel within space between Earth orbiting facilities, lunar outposts, the asteroids and the planets. We will book passage on regularly scheduled flights or we will charter fights for special needs. Spaceways must simply become a service for those who need to travel to and from space -- just like we plan for air travel or ground travel to day. The community of "space faring" nations, needs to plan for a Spaceways architecture that can stimulate the opening of the space frontier and then grow to support its expansion.

Spaceways architecture planning must be carried out in the context of a total infrastructure development, providing a continuum of safe, low cost transportation services. Clearly the first step that must be taken is getting from

Earth to near Earth orbit on a routine basis from spaceports, located throughout the world, that support terrestrial as well as in-space markets and with economical, non-debris creating vehicles. How might this development evolve?

Today space users are few and the "Spaceways" that support them are not crowded. Outside of having to deal with the location of space junk and meet local range safety standards and launch licensing, there are few restrictions on space flight. Satellites and occasional exploration missions are flown from a few launch sites or spaceports around the world. This limited infrastructure services a very profitable communications industry, supports a continuously "manned" outpost, MIR, and has enabled spectacular scientific experiments and explorations.

On entering the 21st Century, traffic associated with the International Space Station (ISS) development and operation along with increased military and civilian use of space for communication, navigation and observation will likely force the issues of managing and regulating the Spaceways. A space traffic control system will be established. ISS operations will likely result in the first regularly scheduled flights for the Space Shuttle and expendable launch vehicles for delivery of cargo, equipment and crews for the broad set of science, Earth observation and industrial experiments. Emergency evacuation routes and services for ISS crews will be established. Space navigation and launch control using the Global

Positioning Satellite and telecommunication satellites network will be introduced.

As the world's telephone markets are opened and the "information highway" continues to expand, the development of near Earth orbit telecommunication satellites, will likely double the use of the Spaceways and increase the number of spaceport locations and nations using the Spaceways. A number of satellite constellations are planned involving hundreds of satellites being placed into orbit, serviced, and eventually replaced by newer, higher performance models. Nations participating in and using these new services will also participate in the launching of these satellites from new spaceports and with new launch systems. This new market will enable the commercial introduction of the first reusable Spaceplanes, leading to the opening of space for business.

Developments from the International Space Station will stimulate commercial uses of the space environment. Space-manufacturing and industrial parks facilities will be developed and operated followed by living facilities for the employees and visitors. Development of the in-space infrastructure itself will become a major business, and Spaceways may be dedicated to support this construction work. Expendable launch vehicle routes will be augmented and will have begun to be replaced by reusable space vehicles. Lower costs of transportation brought about by the reusable systems will enable more exploration of the moon, and permanent lunar mappers will be placed in orbit to

monitor the lunar surface. Space adventure travel will be well established.

The Spaceways will continue to expand supporting lunar developments and settlements, planetary explorations, and other orbital operations and businesses. With high reliability demonstrated through many years of safe transport of passengers to and from and through space, hazardous wastes will be carried to in-space facilities for processing, storage and disposal.

The new space economy will develop requirements (and its new revenues will pay) for further science and space exploration and an expansion of the space frontier beyond the Earth and Moon boundaries. There will be a need to establish multiple lunar spaceports to support the development of a lunar infrastructure and we will need a lunar Spaceways traffic control system. The harvesting will begin of the natural resources of space including solar energy as well as the minerals from nearby asteroids, as the space frontier begins to return goods and services and add new sources of wealth to earth.

Planning for the transportation support for this new economy must consider the definition and assignment of the Spaceways routes and control responsibilities. Assignments need to consider factors such as present and future uses, based on space access points, spaceport locations, projected traffic, civil/commercial/military sector uses, and present and projected individual satellites, satellite

constellations, new space stations, industrial parks and power plants.

For example, should Spaceways routes for travel to and from space be the same as, or separated from, rapid terrestrial point-to-point travel? Can nonreusable launch vehicles and reusable Spaceplanes operate in the same routes? Can Spaceways routes intersect satellite orbits and, if so, what are separation distances and who monitors and enforces them? Conversely, can satellite orbits intersect Spaceways routes?

What restrictions need to be placed on de-orbiting satellites or non-reusable launch vehicle parts? How will "one-of-a-kind" space flights, such as planetary exploration, be handled with respect to factors like routes, timing, and control? How will experimental spaceships and satellites be controlled? How will the different types of spaceships be integrated into a common operational architecture, for example, those that have powered landing capability and those that do not, those that have cross-range capability and those that do not, those that take-off and land vertically and those that take-off and land horizontally, those that are dependent on the atmosphere for part of their flight and those that want to escape the atmosphere as quickly as possible?

What are the international standards for fuel and refueling equipment? How will the international Spaceways be integrated with the international Airways? Are these protocols that could be dealt with by the International Civil

Aviation Organization (ICAO). What is the forum for dealing with all of these issues?

Planning for the Spaceways requires a change in thinking about space transportation. A launch to space today is scheduled because there is a specific satellite to place into orbit, a science experiment to carry-out or a planetary probe to send on its way. Today's infrastructure is designed to support this type of travel. The metric for effectiveness is dollars per pound and very large launch systems are built to minimize this metric. Operations require months of planning and are subject to change and delays due to weather. Every launch is a new experience because the same vehicle is never flown more than once. Space development is bounded by this limited transportation capability.

To open space, there must be a transportation infrastructure that supports hundreds then thousands of flights per year to and from and through space. An infrastructure that can help the economic expansion of space and then grow with the new demands of space travel. Effectiveness will be measured by cost per flight and availability - when a flight schedule is posted, the customer wants to fly then - not when it is convenient for the spaceplane to fly or the spaceport to support a flight. The goal must be to service the space frontier, supporting unbounded developments.

Establishing the Spaceways requires an emphasis on high operational safety with low cost. This emphasis leads to reusable vehicles that can be type certified and commercially operated and maintained for years of safe, routine flight. These vehicles will enable operations that will stimulate and support future growth of the space frontier.

Opening the Spaceways

Opening the Spaceways is a multi-faceted infrastructure development problem. Although presently it is being "pursued by individual nations and companies with some international cooperation, Spaceways development must ultimately be accomplished as an international undertaking because the issues are international in scope. Unlike ground, water, and air transportation where it may take hours to arrive at a foreign destination or enter the territorial boundaries of other nations, when you take off for a space trip you are headed for other nation's territories within minutes. As flight through space is used for rapid point-to-point transportation for cargo and finally passengers, international standards and protocols must be in place to govern this traffic and insure the safety of the traveling public.

Planning for the Spaceways

Although individual nations need to put their own policies into place, the

implementations of these policies need to be carried out in an atmosphere of international cooperation. This international planning should begin now during the most formative stages of the Spaceways.

Standards such as being developed by the International Organization for Standardization (ISO) need to be adopted or expanded to cover all aspects of the Spaceways development and operations. Procedures and tests must be agreed to that will validate the designs and satisfy the public's confidence in the safety of these Spaceplanes. This is a necessity to gain the public's vote in allowing Spaceplanes to fly over their cities and towns, and carry passengers.

It is important that the regulatory requirements be developed now, which will support the design and technology and operational requirements needed to preserve the public health and safety, as these new systems begin their development flights and eventually go into routine operation.

International Forum

An International Spaceways Forum is proposed to discuss and develop strategies for establishing an International Spaceways Association (ISA). Such a forum would be attended by all space faring nations and might consist of six panels: Policy and Procedures; Safety; Standards; Routes; Regulations/Control; and Spaceways Use and Protocols. Issues to be dealt with might include the following:

Policy and Procedures - What is the scope of ISA? How is it sanctioned? How can ISA help promote and stimulate the commercial use of space? How can it help "harmonize" standards and regulations among the space faring nations? What types of standards and procedures should it be involved?

Should ISA be a regulating body or only recommend regulations? What is its jurisdiction? How does it deal with issues like space debris, its generation, its cleanup? Is membership in ISA mandatory for operating in space? What are the procedures for taking actions or recommending actions?

Where should national and international boundaries for Spaceways be drawn? How should boundaries between state, national and international licensing and certification be drawn? How should it deal with space exploration? How does it recognize and interface with military use of space?

Safety - Subpanels might include ground, air, space, personnel and equipment dealing with the users, the public, the communities and the operations. Protection of the public-safety and achieving equitable insurance coverage are two key issues.

Standards - Under the ISO Technical Committee for Aircraft and Space Vehicles Space Standardization, Subcommittee 14, Space Systems and Operations, is developing standards which need to be adopted or expanded to cover all aspects of the Spaceways

development and operations. What are the standards by which safety will be measured? What are the standards by which Spaceplanes will be certified? Are there different standards for non-reusable launch vehicles and reusable Spaceplanes? What procedures and tests will validate the designs and satisfy the public's confidence in the safety of these Spaceplanes?

It is important that the regulatory requirements be developed now, which will support the design and technology and operational requirements needed to preserve the public health and safety, as these new systems begin their development flights and eventually go into routine operation. Therefore, it is time to start looking at space transportation in the same way that we look at our present airline transportation systems.

While we must be very careful to put into place those regulations and processes that will assure public safety and convenience, we must also be very careful to introduce the regulations such that the fledgling Spaceways are not delayed or "killed" at "birth."

Routes - How is a Spaceways route defined? How is a Spaceways route assigned? Is a Spaceways route owned? Is there "free space"? Are there different segments to a Spaceways route, for example an atmospheric, an ascent, a reentry, a fly back, an in-space, an intra-space, to name a few? Are there different or restricted routes for different uses, such as cargo, passengers,

emergency vehicles, medical evacuation?

Regulations/Controls - What is the process by which regulations are developed and agreed to? What regulations and processes exist or are being developed by various groups, such as the ISO Commercial Space committee or the Range Commanders Council, that can be adopted and/or modified for use? How are civil, commercial, and defense interests represented and included? What is the regulating body and jurisdiction of the international body vice the national bodies? Whose laws apply and how are they modified during times of international unrest or conflict? What are the methods by which adherence to regulations are monitored and controlled?

Spaceways Use and Protocols - What are the recognized uses of the Spaceways and the process for such recognition? How will manned, manned-tended and autonomous operations be integrated? How does a user enter and leave a Spaceways? How does a Spaceplane approach another Spaceplane or a Space Hotel or a Spaceport? How are emergencies declared, recognized and responded to? What are the medical criteria for operating or using the Spaceways and how are they established? What is the language for Spaceways operations - spoken and software? The ISO Subcommittee 13 on Space Data and Information Transfer Systems is addressing international protocols for space which can be a starting point.

Although there are a large number of potential issues to be dealt with, not all of them have to be resolved for the reusable Spaceplanes development activities to continue and the Spaceways development to expand.

The formation of an international forum to address these issues and lay out a framework for their resolution and eventual regulation would provide: 1) the start of international policies and reference standards for future space transportation and Spaceways developments; 2) a stimulating influence for future space transportation investments by having a known, stable and supportive international environment for developments and operations; and, 3) a greater public awareness of and demand for the development of space and routine travel to and from and through space.

An International Cooperative Effort

An international forum leading to the ISA formation would be the initiating act for formulating long term national and international policies which actively encourage and support the Spaceways development.

The technology is in-hand to achieve the performance and operations goals for the reusable space transportation needed to open the Spaceways. A new focus is required now to assure that the regulatory processes are in place to guide and sustain the development demanded for the commercial success of the Spaceways. The policy development necessary to achieve these goals needs to

be an international cooperative effort among governments and industries.

Such policies would provide a stabilizing environment for accelerating and sustaining the opening and growth of the Spaceways. With the Spaceways in place, space would at last be open to the public who will establish space as a major new economic sector.