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International Certification for Commercial Reusable Space Transportation

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ABSTRACT

That air travel has come to be the safest mode of transportation while supporting a very profitable aircraft and airline industry is the result of a highly cooperative, highly interactive program between government and industry. At the core of this successful cooperation is a well defined process with experienced proven procedures providing governing processes for safety at every step in the design and development, production, operation and maintenance of new and existing air transportation systems. This process sets and updates through operational experience the standard by which the government regulates industry and industry regulates itself. This process has one overarching goal – assurance and protection of public safety and safeguard of property and environment.

For space travel to become generally accessible by the general public a similar process must be put into place. The overarching goal of the Space Transportation regulatory process must be the ensuring of public safety and the safeguarding of property and the environment. Operation of reusable space transportation systems to and from spaceports located in communities throughout the world can only happen if they are designed and operated to meet this goal.

A discussion is presented on the applicability of existing standards and processes followed by the commercial aircraft and airline industry to reusable space transportation. The FAA established certification policy, rule making procedures and certification process are presented as examples to be followed. A certification process for the reusable space

transportation (RST) system that encompasses not only type design and production certification, but also spaceworthiness and commercial operator's licensing for continued revenue operations is recommended.

A proposal is made for the International Institute of Space Law to establish a working group to develop the international governing processes and procedures for certifying and regulating the operation of the reusable space transportation infrastructure for space services and the transport of passengers and cargo to and from and through space.

BACKGROUND

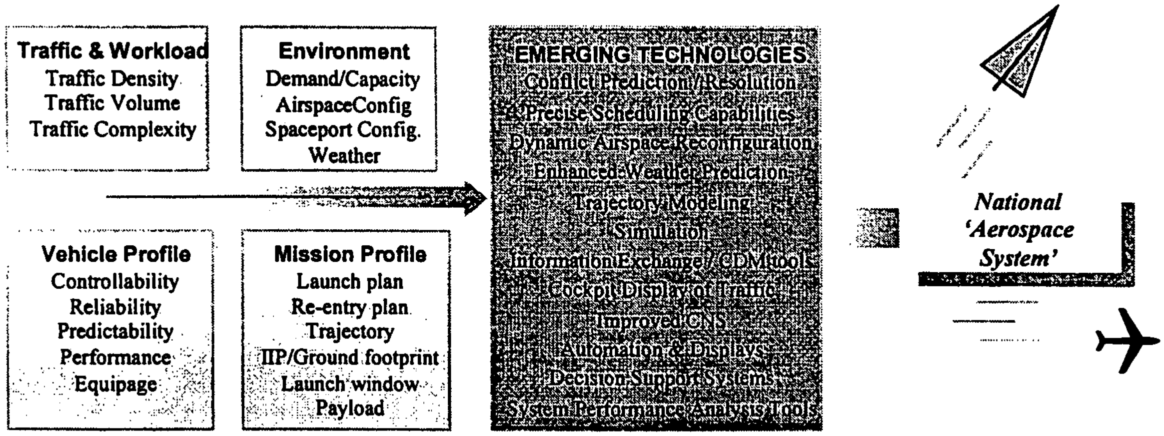
With the opening of the Space Frontier to the public the use of space as a place for business will greatly expand. Ultimately, travel, sports, vacations along with industrial research and manufacturing and hundreds of other activities will become common place as the entrepreneurial public is fully engaged in the development and exploitation of space.

For space to reach this level of development it must be routinely, safely and affordably reachable from spaceports located throughout the world. For this to happen, a new transportation infrastructure, the Spaceways, must be put into place – joining past transportation infrastructures of roadways, waterways, railways and airways that played a vital role in opening and expanding the frontiers here on earth. At the heart of the Spaceways opening will be a robust reusable space transportation business. The development of this business, however, is paced by four key factors — technology, regulations, market and financing, Figure 1.

Figure 1. Key Business Factors

The technology required to develop profitable systems is available, although it needs to be matured. Major growth markets, such as space tourism and rapid transportation, are available to support a profitable business once the Spaceways are opened. A stable regulatory environment together with the technology and market are essential to attract the private and public financing required to capitalize the business.

Private enterprise can effect the market and technology; national and international government actions are required to develop and implement the regulations, procedures and protocols to govern the safe, efficient operations of the Spaceways. Actions are underway within the Office of Commercial Space Transportation of the U.S. Federal Aviation Administration (FAA/AST) to develop the operational architectures for the Spaceways and to establish the standards for their ground and flight systems. This is being done to support the



.Commercial Space Transportation Concept of Operation in the National Aerospace System in 2005, FAA/AST, February 8, 1999

Figure 2. Factors Influencing NAS

development of the 21st Century National Aerospace System (NAS) for the United States, Figure 2. (1)

A key element of this architecture is the sharing of air corridors between airplanes and spaceplanes. Implicit in this sharing is that both types of systems have the same levels of operational safety.

Available and developing technology for reusable space systems can support the development of the performance and operations required for the Spaceways. Achieving this new capability requires an emphasis on low cost, high availability with high operational safety – reusable vehicles that can be operated and maintained for years of safe, routine flight and will not be considered as ultra-hazardous in the context of defining absolute liability. One of the biggest changes that must occur in the present day planning for the future is the need to recognize safety as the main design and operating criteria for future reusable space travel systems. Fundamental design and operational approach ***changes must be made from*** today's probabilistic launch readiness approach ***to*** a deterministic flight safety approach, Figure 3.

Figure 3. New Safety Approach

To realize their cost and service potentials, the reusable space vehicles (RSVs) will have high usage rates, short, minimum-maintenance turnaround times and high reliability components and subsystems to maximize time between overhauls. To meet their safety requirements, the RSVs will have high factors of safety together with selected redundancies and a maintenance plan that assures that these safety features are retained during the operational life of the RSV. The performance capabilities of the RSV must be met within the boundaries of these safety, cost and service requirements. Ultimately, extensive flight testing and operations experience will be required to accumulate and document the time-age-cycle data for the RSV subsystems and components to assess and validate their operational risks and insurability and to demonstrate their commercial viability.

To set the criteria for such designs in absence of years of experience, standards must be established now as the benchmark for safety to govern the technical, business and legal environments of current and future RST systems. Fortunately the aircraft industry already has a well documented, experience proven certification process in place which the RST industry can adopt to set these standards for its near and long term operations and growth.

The following sections provide a discussion of the development of these regulatory standards for aviation and their applicability to space flight.

SETTING THE STANDARDS

The Air Commerce Act of 20 May 1926, was the cornerstone of the government's regulation of civil aviation in the US. This landmark legislation was passed at the urging of the aviation industry, whose leaders believed the airplane could not reach its full commercial potential without Federal action to improve and maintain safety standards. The Act charged the Secretary of Commerce with fostering air commerce, issuing and enforcing air traffic rules, licensing pilots, certifying aircraft, establishing airways, and operating and maintaining aids to air navigation. This act led to the first airworthiness rules to guide the industry.

The Federal Aviation Act of 1958 created the Federal Aviation Administration (FAA), empowering FAA to carryout two key roles as defined in Section 103. Section 103(a) states that the FAA administrator shall regulate air commerce in such a manner as to promote its development and safety. Section 103(b) states that the FAA shall consider the promotion, encouragement, and development of civil aeronautics. The Act empowered FAA to prescribe and revise rules and Federal Aviation Regulations (FARs) relative to operational safety as defined in the Title 14 Code of Federal Regulations (CFR) – Aeronautics and Space. FAA became a part of Department of Transportation (DOT) in the DOT Act of 1966 that established transportation at a cabinet level and retained the responsibility for aviation safety with the FAA administrator.

Service history and empirical data prove that correctness of design decisions affecting safety is exceptionally high. Resulting national and international standards evolved over the past 70 plus years have resulted in aircraft that are designed and operated to meet strict airworthiness and vehicle certification requirements for safety and reliability. The process sets (and updates through operational experience) the standards by which the FAA regulates industry and industry regulates itself. Similar processes have been established and successfully implemented by other countries. The regulatory process has one overarching goal – assurance and protection of public safety and safeguard of property and environment. The result has been to produce the safest and most efficient mode of transportation in existence. In 1998 615 million people flew on approximately 14 million U.S. scheduled carrier flights without a single fatality.

In the US the Commercial Space Launch Act of 1984 is the cornerstone of the government's regulation of space transportation. The Associate Administrator for the Office of Commercial Space Transportation (AST) is empowered through the Act of 1984 to issue commercial Spaceport license and commercial operator's license based on an evaluation of the Operator's ability to ensure public safety and safeguard property and environment.

Applicable FARs for the commercial operator's license are also provided in 14 CFR. The Act of 1998 amends the Commercial Space Launch Act of 1984 to include RST systems and work is underway to evolve a process for the RST industry similar to that used by commercial aviation. The procedures and requirements govern all space activities conducted from US territory or by citizens of the United States and cover five areas that directly impact the potential liability of a RST enterprise. These areas are: (1) site location safety; (2) operating procedures accuracy; (3) personnel qualifications; (4) equipment adequacy; and, (5) system safety and mission reviews. These generally deal with meeting requirements of today's space law with operations from isolated launch ranges. For the Spaceways to expand into and service the international community, vehicle spaceworthiness and certification, as related to product liability and indemnification also must be dealt with.

MEETING THE STANDARDS

First-generation RSVs will set the spaceworthiness standards as they evolve into a 21st century global transportation system, offering daily flights to and from space and 45-minute connecting flights between any two Spaceport pairs on Earth. These RST systems will be expected to function within the boundaries of an international regulatory framework such has been established for the aviation industry by the International Civil Aviation Organization, ICAO. Like aviation the single purpose goal of the RST standards will be to ensure public safety and safeguard property and environment. The type of systems and service needed for commercial operations of the Spaceways can only be achieved by meeting this goal.

To achieve this goal it is essential to recognize the distinction between system safety and reliability. Safety deals with the consequence of failure and reliability deals with the likelihood or frequency of failure. Safety deals with lives and property; reliability deals with cost and replacement times. With the heritage that exists from the expendable launch vehicle operations it is easy to use the two terms interchangeably – the consequence of failure of an ELV subsystem or component is generally thought to be the loss of the system – lives and property are protected through isolation of the operations. ELV experience has been that in every one hundred ELV launches from two to ten vehicles with their payloads are lost.

The safety record and operations constraints achieved by today's commercial launch are not acceptable for RSVs if Spaceways are to support routine, affordable, safe space travel, Figure 4. [2]

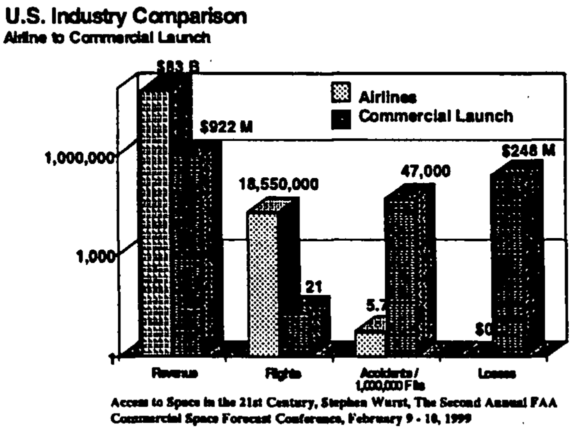


Figure 4. Safety Comparisons

For RSTs to meet their promise, ***loss of the RST vehicle must never be a design or operations option.*** This leads to the fail-safe rule which must govern the design of reusable space transportation systems, just as it has for aircraft, Figure 5.

During any given flight, no single failure or foreseeable combinations shall prevent the continued safe flight and landing of the vehicle. For RSTs to be a business as well as an operational success the emerging RST and space travel industries must have two priorities for design and operations.

<u>First</u>, design and concepts of operation of the system must provide for the safe return and landing of the vehicle together with its crew, passengers and cargo even with anomalous operations events and/or equipment malfunctions or failures, throughout the entire operations envelope. This is the failsafe rule that also effectively eliminates the distinction between flights carrying crew and passengers and flights carrying only cargo.

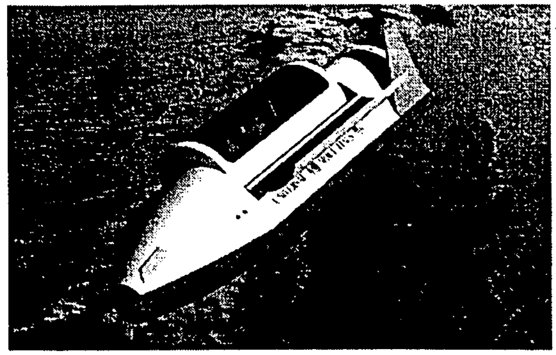
<u>Second</u>, the system design, manufacture and operation must incorporate both a quality and a maintenance plan that assures that the margins associated with achieving the first design and operations priority are sustained throughout the operational life of the system. How well the RST and space travel industries will succeed in meeting these priorities will become a matter of historical record of learning experiences,

Designing for Safety

During any one flight, no single failure or foreseeable combination shall prevent the continued safe flight and landing of the airplane/spaceplane.

Fail-safe Design Methods
- **Design quality and integrity**
- **Margins/factors of safety**
- **Error tolerance**
- **Damage tolerance**
- **Failure containment**
- **Effective redundancy**
- **Isolation and separation**
- **Reliability and maintainability**
- **Failure indication and corrective action**
- **Flight crew procedures**
- **Maintenance program**

Merging the aircraft and rocket "worlds"



Space*Clipper* Passenger Safety

Figure 5. Fail Safe Design Rule

which will enable them to continuously improve and grow.

The RSV industries can not settle for anything less than a perfect safety record. This involves changing fundamental design and operational approaches from today's probabilistic launch readiness approach to a deterministic flight safety approach. This requires two key elements 1) fail-safe designs and 2) maintenance that sustains the safe design. These are at the heart of the success of our aircraft and airline industries.

TYPICAL FARs

The regulations that have been developed to govern the aircraft industry incorporate years of experience, to guide the design and operations. For example, the FAR 25 - Airworthiness Standards: Transport Category Airplanes, shown below, relates to structural loads specifying the factor of safety that must be used and the load limits that must be achieved and verified through test. (3)

Sec. 25.303 Factor of safety. Unless otherwise specified, a factor of safety of 1.5 must be applied to the prescribed limit load which are considered external loads on the structure. When a loading condition is prescribed in terms of ultimate loads, a factor of safety need not be applied unless otherwise specified.

[Amdt. 25-23, 35 FR 5672, Apr. 8, 1970]

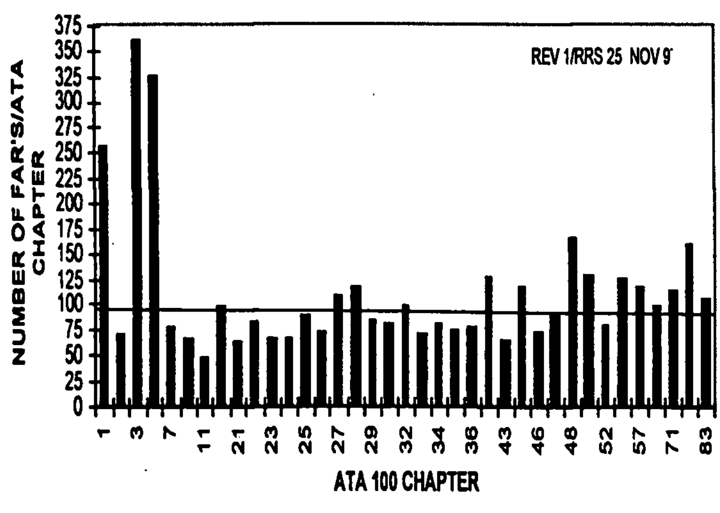
Sec. 25.305 Strength and deformation.

(a) The structure must be able to support limit loads without detrimental permanent deformation. At any load up to limit loads, the deformation ma not interfere with safe operation.

Sec. 25.963 Fuel tanks: general.

(a) Each fuel tank must be able to withstand, without failure, the vibration, inertia, fluid, and structural loads that it may be subjected to in operation.
(b) Flexible fuel tank liners must be approved or must be shown to be suitable for the particular application.
(c) Integral fuel tanks must have facilities for interior inspection and repair.
(d) Fuel tanks within the fuselage contour must be able to resist rupture and to retain fuel, under the inertia forces prescribed for the emergency landing conditions in Sec. 25.561. In addition, these tanks must be in a protected position so that exposure of the tanks to scraping action with the ground is unlikely.

The regulations provide an engineering checklist of what experience has shown must be done and what the FAA will be reviewing for compliance. This is a systems engineering process that considers the individual subsystems and components in context of the total RST system. The design criteria for the RST system starts with the mission and customer set of performance requirements and service characteristics, which are satisfied within a set of certification standards. These standards establish the basis against which the system will be evaluated through design and manufacture verifications, flight-testing and, finally, revenue operations. The FARs are stringent in their insistence on safety but not in how to comply. The designer must decide how best to achieve safe designs



1 - DESIGN ENGINEERING
2 - PRODUCTION
3 - FLIGHT OPERATIONS
5 - MAINTENANCE
7 - PARKING AND TAXIING
10 - LIFTING, HANDLING & TRANSPORTATION
11 - PLACARDS AND MARKINGS
12 - SERVICING
21 - ENVIRONMENTAL CONTROL SYSTEMS
22 - FLIGHT MANAGEMENT SYSTEM
23 - COMMUNICATIONS
24 - ELECTRICAL POWER
25 - EQUIPMENT/FURNISHINGS/PAYLOAD BAY
26 - FIRE PROTECTION
27 - FLIGHT CONTROLS
28 - FUEL
29 - HYDRAULIC POWER
31 - INSTRUMENTATION
32 - LANDING GEAR
33 - LIGHTS
34 - NAVIGATION AND GUIDANCE
35 - FLIGHT CREW SYSTEMS
36 - PNEUMATIC POWER
41 - FLIGHT CREW MODULE
43 - SEPARATION SYSTEM
45 - FLIGHT SOFTWARE
46 - TELEMETRY
47 - ON-BOARD DIAGNOSTICS
48 - REACTION CONTROL SYSTEM (RCS)
49 - AUXILIARY POWER UNIT
52 - DOORS AND PANELS
53 - STRUCTURES
57 - WINGS AND STABILIZERS
58 - THERMAL PROTECTION SYSTEM
71 - PROPULSION ISNTALLATION
72 - MAIN ENGINE
83 - SUPPORT AND TEST EQUIPMENT

Certification basis for type design development based on applicable CFR 14 FAR's and previous operational data.

Figure 6. Existing FARs Applicability

that support safe operations.

A review of the existing FARs for subsonic large transport aircraft, eliminating those not applicable to spaceplanes, has shown their guidance to be applicable to RST systems, Figure 6.

This suggests that the certification requirements for new RST systems can be developed within the existing CFR 14 FARs. However, much work remains to tailor them to the specific requirements for RST operating systems. It has been argued that such a goal is too expensive to achieve; however, not achieving this goal will make reusable space transportation too limited in applications and, therefore, too expensive to operate.

RSV Certification Path

The responsibilities of the FAA/AST from the beginning (1984) have been: to license commercial Spaceport sites and commercial space launches, to protect public health and safety; to safeguard property, national security and foreign policy interests; and, to encourage, facilitate and promote commercial space access by the private sector.

These responsibilities are derived from an era of space transportation dominated by expendable launch vehicle (ELV) systems. Current annual worldwide launches to space are on the order of 100 and return flights (primarily the Space Shuttle) are much fewer. In the 21st Century government and private sectors will be entering a new era of transportation to and from and through space. It will be an era dominated by RSVs, a market dominated by cargo and passenger transportation and a

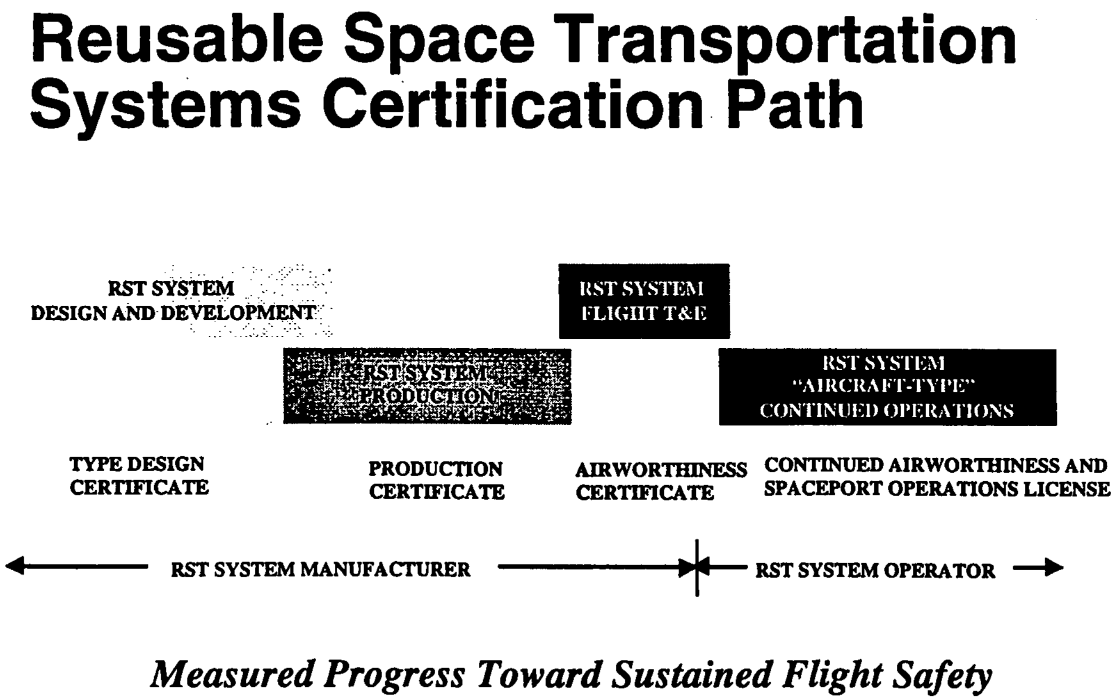


Figure 7. Certification Path

proliferation of commercial spaceports located inland as well as coastal sites.

Unlike existing ELV systems, which take-off and deliver their payloads into space a new RSV system is designed not just to take-off and deliver payloads into space, but also return, land, be serviced and fly again, like an aircraft. The FARs and policies for RST systems should, therefore, be very similar to that of the commercial aircraft and airlines, which follow a certification process that assures flight safety.

Following an aviation-like certification process, FAA/AST could issue a variety of certificates and licenses. The resulting RSV certification process path for the system acquisition phases and spectrum of certificates is presented in Figure 7.

The certification process encompasses activities in the RSV design, development production/manufacturing, Operational Test and Evaluation (OTE), revenue operations phases. The RSV system manufacturer, together with FAA/AST would prepare a Certification Program Plan (CPP) to use as the basis for obtaining an experimental type certification to operate, maintain and support the RSV during the OTE phase.

Flight-testing during OT&E is a key step leading to an initial operators license. It provides flight and ground operations verification of safety compliance and validates the required performance and operational capabilities, including system availability and dependability. It provides demonstrated proof of readiness to operate in today's air and space architecture within today's legal regimes.

Flight-testing of the RSV could be carried out under the guidance of subsections of FAR Part 21.

(a) Research and development. Testing new aircraft design concepts, new aircraft equipment, new aircraft installations, new aircraft operating techniques, or new uses for aircraft.

(b) Showing compliance with regulations. Conducting flight tests and other operations to show compliance for issuance of type and supplemental type certificates, flights to substantiate major design changes, and flights to show compliance with the function and reliability requirements of the regulations...

The RSV could operate under experimental certificates until full compliance with their CPP is proven. The system operator would use the OTE experience and empirical data to obtain a type certificate and commercial operator's license for maintaining continued spaceworthiness during revenue operations. During this phase, the Spaceport would receive their operators license.

FAA CERTIFICATES

Within this process FAA/AST would issue a variety of certificates and licenses.

(b) Type Design Certificate – Issued to RSV manufacturer for approval of a specific type design of RSV flight vehicle, ground systems and operations functions.

c) <u>Production Certificate</u> – Issued to RSV manufacturer (holder of type design certificate) when shown quality control and production methods insures RSV equipment conform to type design certification FARs and are in fit condition for safe operation.

d) <u>Airworthiness Certificate</u> – Issued to manufacturer for a specific RSV type design, flight operations and maintenance that meets approved design and is in fit condition for safe operations and continued airworthiness.

e) <u>Commercial Operator's License</u> – Issued to RSV operator for continued operations at designated commercial Spaceport that has the above certificates. Note that the commercial operator's license is fundamentally different from a launch license. In contrast to a launch license, which authorizes an operator (or licensee) to conduct a launch or series of identical launches, a commercial operator's license authorizes an operator (or licensee) to conduct operations within the certification boundaries on a continuing basis without interruption for an extended period.

f) <u>Spaceport License</u> – Issued to designated Spaceport operating site after evaluation of site safety and environmental requirements.

g) <u>Other Approvals</u> – Issued for components and parts manufacturer approval, Technical Standard Order (TSO), component repair and overhaul shops, vehicle and engine repair and overhaul facilities, flight operations training schools, maintenance training schools, etc.

Thus, the certification process for the RSV system would encompass type design, production, airworthiness and commercial operator's licensing for continued operations, Figure 8.

- **Safety is built into the regulations**
  - **Type certification reflects enforcement of the regulations**
  - **Regulations are constantly being reviewed for adequacy.**
- **Types of regulations**
  - **Airworthiness, continued operations, environmental, airworthiness directives, technical standard orders, special regulations, special condition, waivers and exemptions.**
- **Type design certificates**
  - **FAR's in Part 21 (designation of applicable FAR's, certification basis, type aircraft, location of manufacturing facilities, production, flight test, flight operations, maintenance, airport compatibility, etc.).**
- **Continued airworthiness reviews**
  - **FAR's in Part 25 (design), Part 33 (engine), Part 43 (maintenance), Part 61 (flight ops), Part 65 (maintainers) and Part 121 (operations)**
- **Aviation Act of 1958 provides for Open Hearings on rule making (Part 11).**
  - **Proposed rule making is published in the Federal Register and open participation is invited.**

Figure 8. Type Certificates

The point of departure is the CFR Title 14 FARs for large transport aircraft and the heritage and procedures from NASA Space Shuttle, NASA DC-XA demonstration program, ELV systems, and commercial subsonic and supersonic aircraft. Use of empirical data, based on experience and precedent issues, is the foundation for the development of the certification basis and approval of applicable FARs, regulatory policies and procedures. This approach demands that RLV designs maintain aircraft-like safety standards while achieving the efficiencies of aircraft-like operations. It will establish the regulatory standards for all current and follow-on systems rather than licensing standards, which would be tailored to accommodate the uniqueness of each RSV design, and operating concept. A set of uniform standards and governing processes is essential to establishing an international regulatory environment and the legal regime for supporting future growth.

RULE MAKING

The FAA/AST rule making process is highly interactive with industry and is open to public comment and participation. The process takes into account industry needs and incorporates lessons learned through operations and research and development activities to maintain the regulations current with respect to technology and operational needs. Figure 9 presents an overall roadmap of the rulemaking process.

Given that RSV's are expected to operate in performance envelope which were not envisioned when the current airworthiness standards were defined, type certification and commercial operator's licensing will encounter new issues. To be successful, RSV should be designed with "build-in" safety margins using existing commercial aircraft fail-safe design rule and methods. It must meet environmental requirements for noise, emissions and hazardous materials handling, must provide the same level of safety, reliability, operability and supportability found in commercial aircraft, and must be economically successful.

Certification involves considerations of the total system and operating cycles, Figure 10. The RSV system must be viewed as the totally integrated operational system consisting of three distinct elements: (1) The Flight Vehicle; (2) Ground Systems; and, (3) Operations.

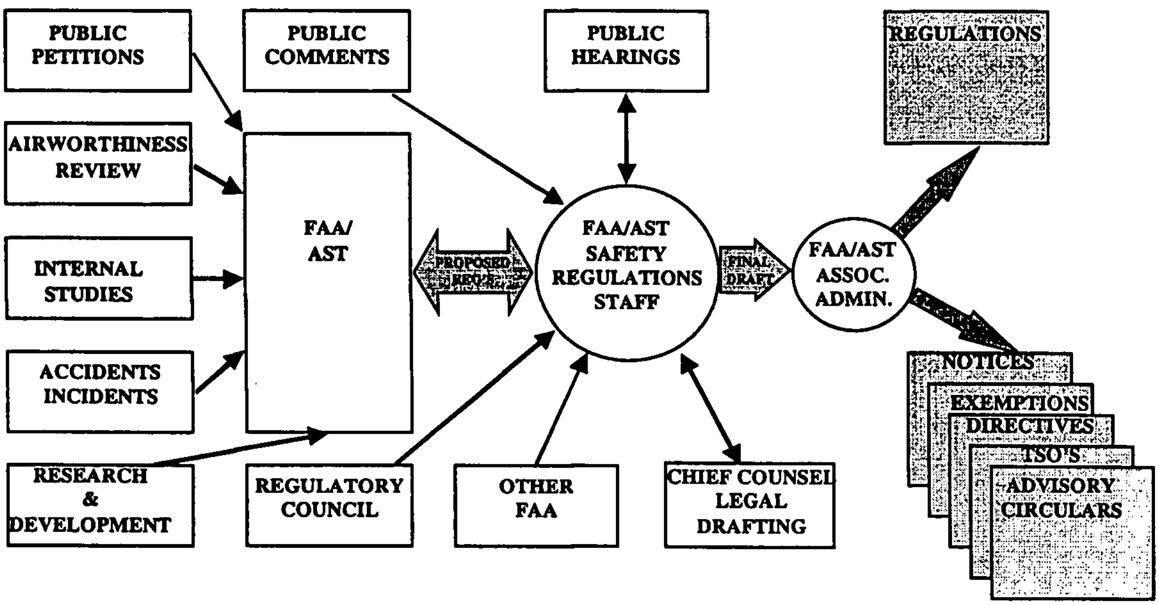


Figure 9. Rule Making Process

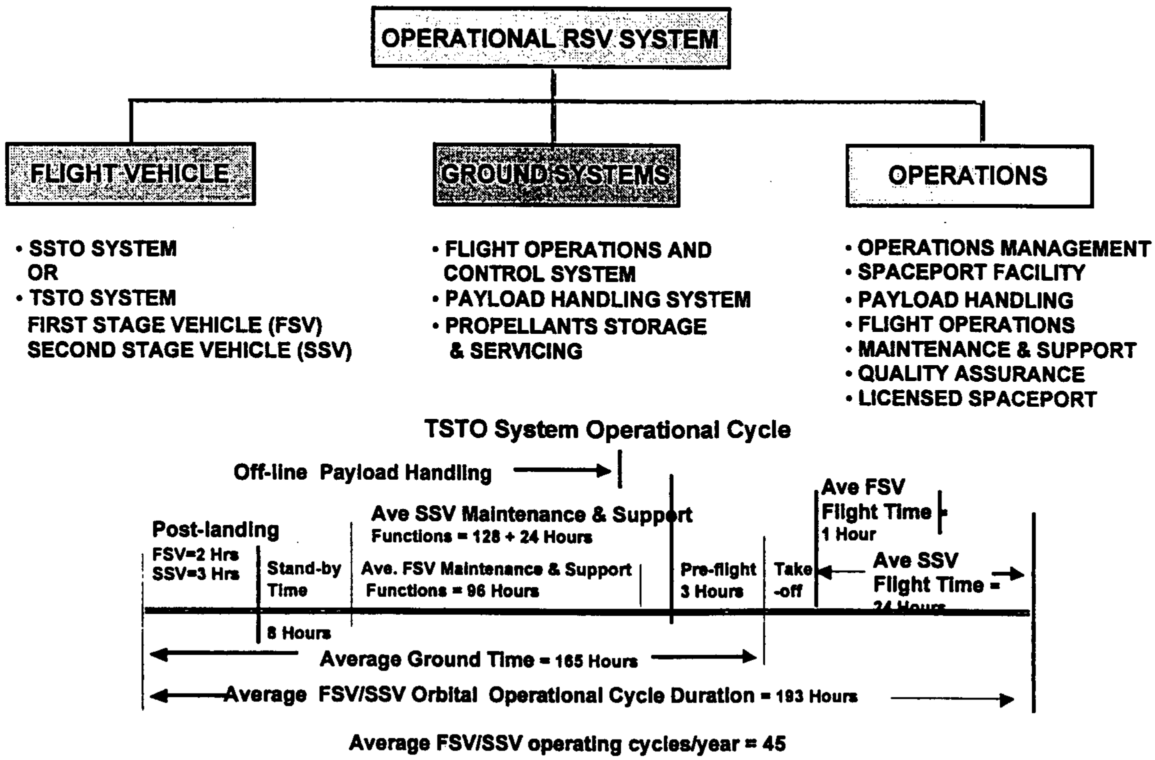
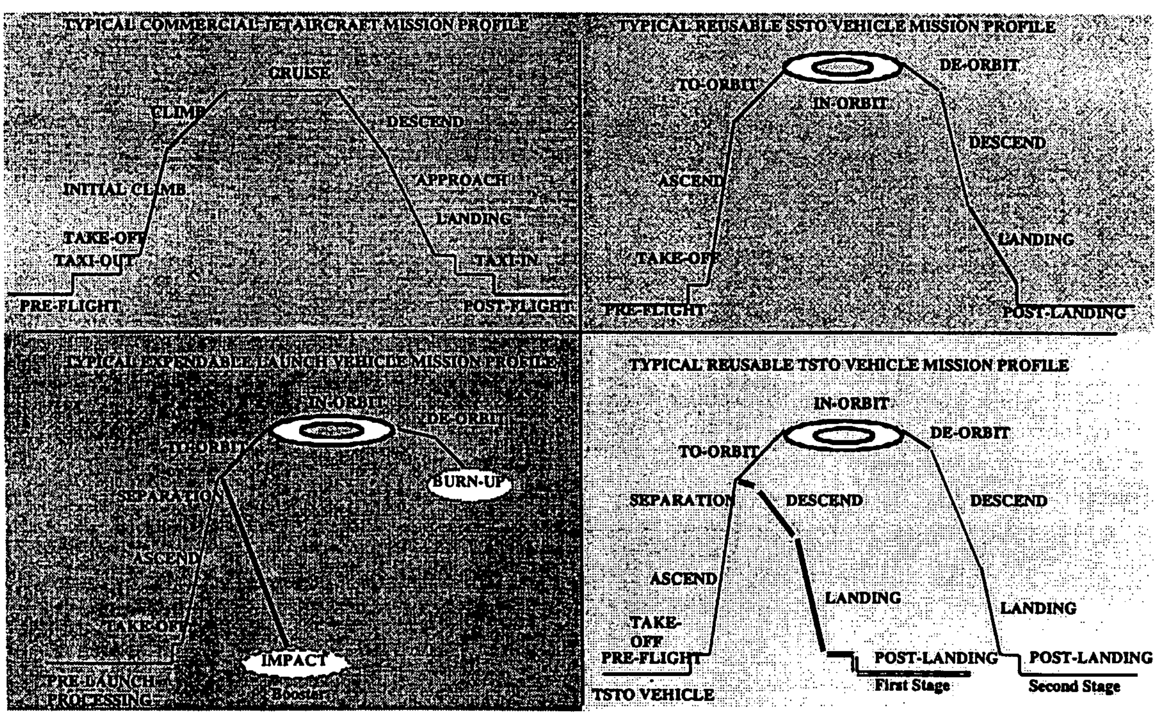


Figure 10. Total System



SSTO - Single Stage to Orbit
TSTO - Two Stage to Orbit

Figure 11. Mission Segments

The certification process considers all elements of the system throughout all aspects of the operating cycle.

Operations must consider all of the mission segments, Figure 11. Just like for aircraft operations, the reusable space transportation systems must consider how safety is achieved throughout all segments of the flight and ground operations, including emergency aborts. Understanding the functional requirements and potential failure modes and safety consequences throughout all flight segments is an essential first-step in the design for certification process.

The certification process would become a living prescription for safety and an integral part of future RST system design, test and space travel operations, Figure 12.

It need not be a "daunting" or expensive process, if it is incorporated from the beginning. It would lead to a safe design and a system whose safety can be maintained throughout its life. It would support a new transportation infrastructure that would be perceived and accepted by the public for safe, routine travel to and from and through space from spaceports located in their communities. The operational goal must be a 100% safety record.

There are well defined processes in place, such as those developed and fine tuned by the FAA, that have been proven for aircraft and airline operations safety. Ongoing studies suggest that these will be equally applicable to governing the development and operation of reusable space transportation systems and producing equally enviable safety records.

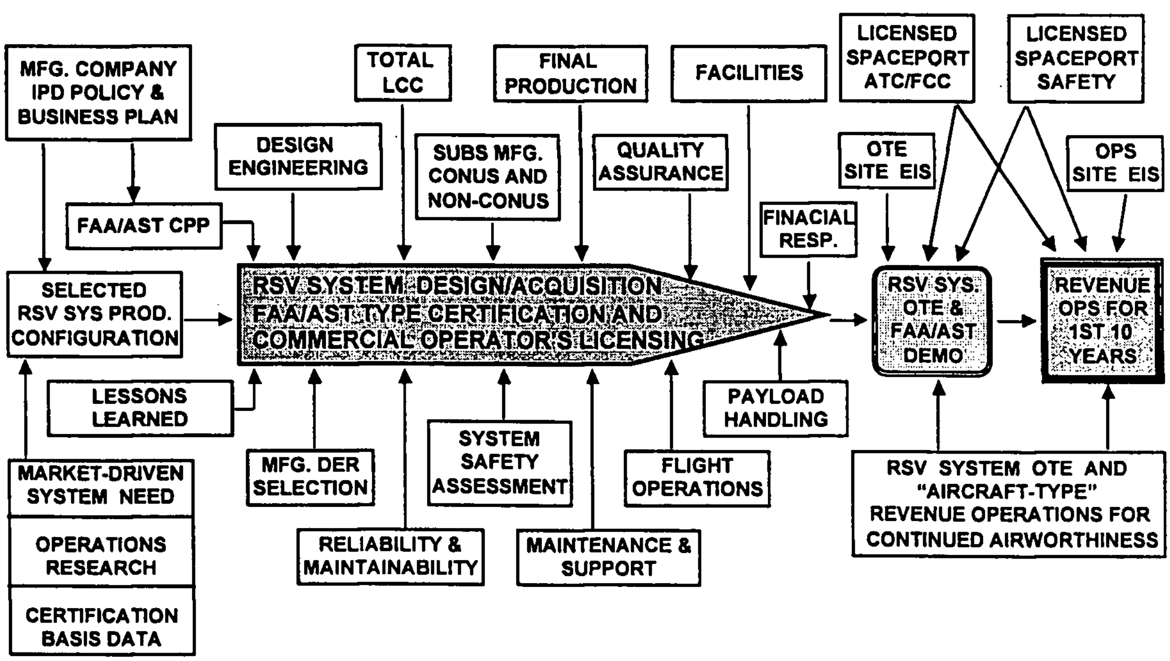


Figure 12. Certification Process

It is time to put these processes in place for reusable space transportation systems. This needs to be an international cooperative effort among governments and industries.

IISL INTERNATIONAL PLANNING

Because space transportation is a fundamental infrastructure for all spacefaring nations, international planning should begin now during the most formative stages of the Spaceways.[5] As launch systems leave the isolation of the ranges, standards need to be adopted or developed covering all aspects of the Spaceways development and operations that will justify the public's confidence in their safety for operations in their communities.

Conventions governing responsibilities and liabilities need to be drawn-up to clearly establish boundaries for the new responsibilities of governments and operating companies. Businesses must have a well defined, stable regulatory environment in which they can plan and grow.

It is proposed that a working group be formed within the International Institute of Space Law to identify issues and prepare a roadmap for the development of the international governing processes and procedures for certifying and regulating the operation of the reusable space transportation infrastructure. This group would identify the impacts on existing treaties and laws and lead to a legal regime for the transport of passengers and

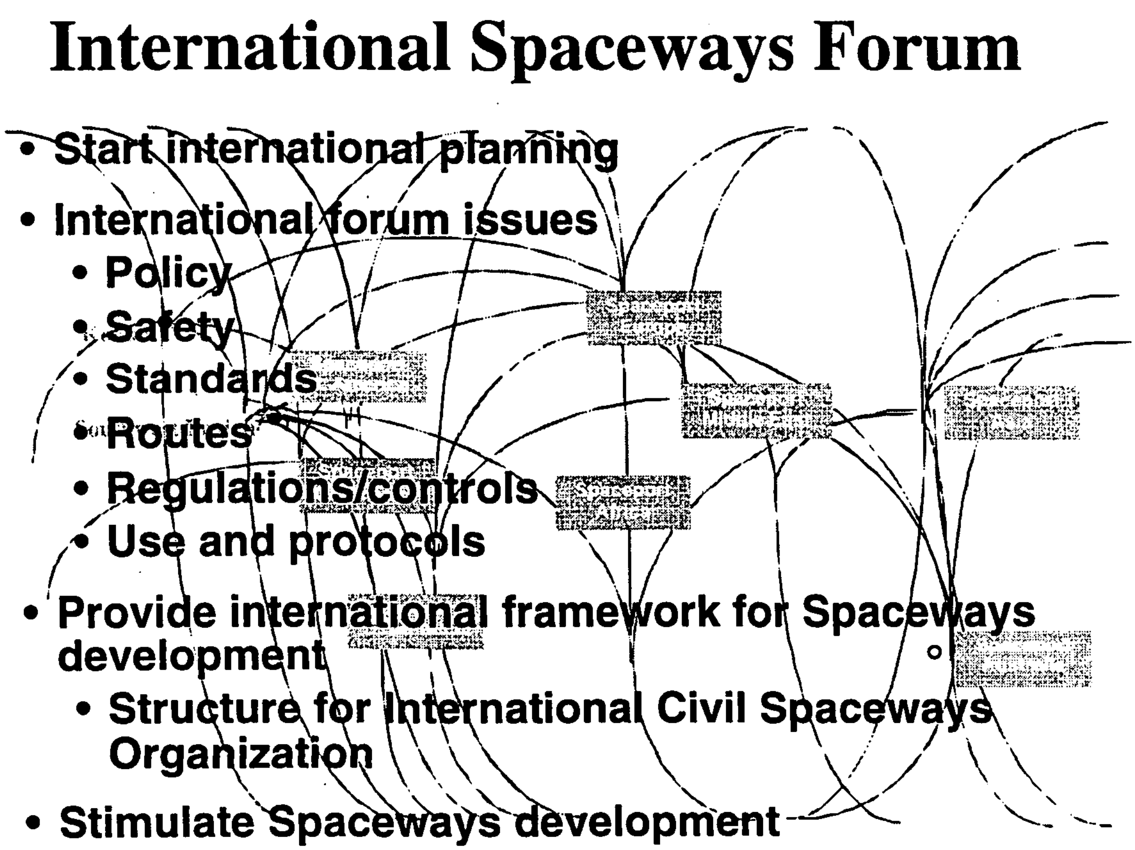


Figure 13. Spaceways Forum

cargo to and from and through space.

The working group could be initiated as an International Spaceways Forum (ISF) covering the following six areas: 1) Policy and Procedures; 2) Safety; 3) Standards; 4) Routes; 5) Regulations/Control; and 6) Spaceways Use and Protocols, Figure 13.

Issues to be dealt with might include the following:

(1) Policy and Procedures- What is the scope of ISF? How are results sanctioned? How can it help "harmonize" standards and regulations among the spacefaring nations? In what types of standards and procedures should it be involved and to what depth? What are the applicability and limitations of existing laws and treaties? How can ISF help promote and stimulate the commercial use of space?

Should ISF lead to an international advisory or regulating body, e.g. International Civil Spaceways Organization (ICSO) or incorporate within an existing body, e.g. ICAO? What would be its jurisdiction? Under what legal regime would it operate and how would it deal with issues like space debris, its generation, and its cleanup? Could/should this be a sanctioning body for operating in space? What are the procedures for taking actions or recommending actions? How will it interface and harmonize with the UN Committee on Peaceful Uses of Outer Space (COPUOS)? 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?

(2) Safety- Topics would 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.

(3) Standards- Standards need to be adopted or developed covering 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 and reusable launch vehicles? What procedures and tests will validate the designs and satisfy the public's confidence in the safety of these spaceplanes, and gain their vote in allowing spaceplanes to fly over cities and towns, and carry passengers?

(4) Routes- How is a Spaceways route defined? How is a Spaceways route assigned? Is a Spaceways route owned and, if so, by whom? Is there "free space" in context of the original outer space treaty of 1967? 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? Are Spaceways differentiated from Airways and if so, how?

(5) 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 vis-a-vis 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? How are operations in the Spaceways and Airways harmonized?

(6) 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? What is the language for Spaceways operations - spoken and software? How are emergencies declared, recognized and responded to? What are the medical criteria for operating or using the Spaceways and how are they established?

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 specific issues and lay out a framework for their resolution would lead to a stable and supportive international environment for developments and operations of the Spaceways and future space transportation systems.

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