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21st Century Space Commerce Taking-off from “Aerospaceports”

presented to

**The 33rd Space Congress
“America’s Space Program - What’s Ahead?”**

at the Technical Paper Session:

Space Business Aspects in a Commercial Market

by

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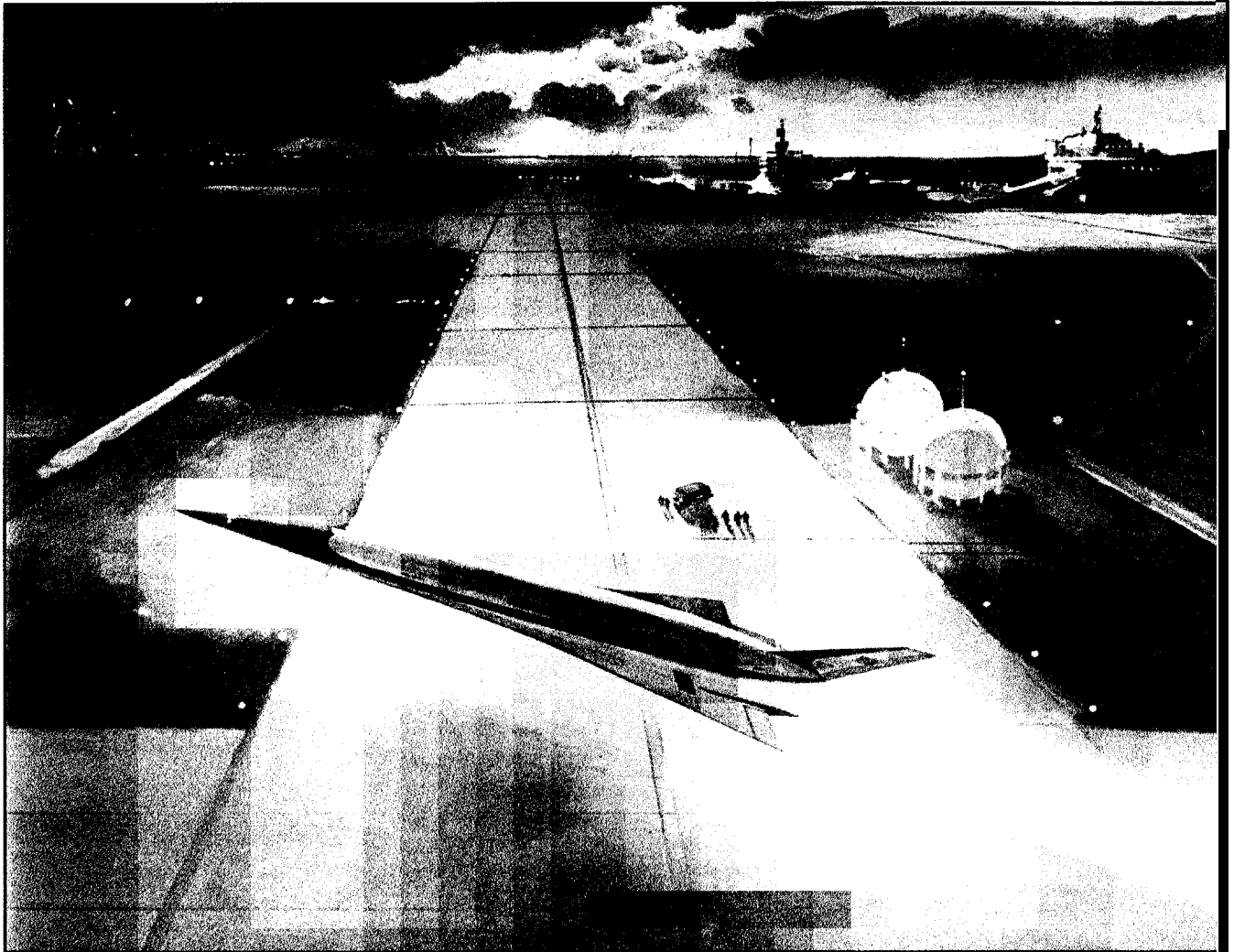
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Abstract

This paper describes how Space commerce may grow to partially overlap Air commerce in the 21st century, resulting in the evolution of some of America’s airports and spaceports into “aerospaceports .” Aerospaceports will play a key role in privatization and commercialization of America’s space program by establishing space transportation and associated support services as routine and accessible. Air and Space are closely related frontiers, one being an extension of the other in terms of the environment, science, engineering, government policies, and commerce. We have seen airplanes modified to fly one step further sampling the space environment; NACA transformed into NASA, a Space Wing established by the U.S. Air Force; rockets launch commercial satellites; and spaceport authorities established by state governments. Moreover, we have just recently seen the U.S. DOT’s Office of Commercial Space Transportation (OCST) merge with the Federal Aviation Administration (FAA). Soon, we may even see an X-34 type vehicle takeoff and land at an airport. Undeniably, the space program’s evolution toward commercial enterprise is underway; however, it is still in its infancy. The development of reusable space launch vehicles capable of operating at America’s airports with airline-type reliability and acceptability is key to the emergence of aerospaceports, in-turn allowing the development of new space-industry markets, including transportation, manufacturing, energy, mining, and even tourism.

INTRODUCTION

This paper explains how space commerce will begin to flourish in the 21st century as it takes off from “Aerospaceports”. Three issues will be addressed: (1) why space commerce will flourish, (2) why it will happen in the 21st century, and (3) why it will takeoff from “aerospaceports”. This paper will also propose and define the term “aerospace ports” and discuss the path to achieving space commercialization.



United States Aerospaceplane Taking-off from an Early 21st Century Aerospaceport (ref 10)

WHY SPACE COMMERCE ?

Question: Why is space commerce going to flourish ?

Answer: Because there is tremendous profit to be made in new markets.

“There is no shortage of capital or capitalists willing to take big risks for big rewards. Money will always flow to the best risk-adjusted rate of return, whether that’s treasury bills, pharmaceuticals, memory chips, or low gravity Disney lands on the Moon,” according to Thomas Dolan, editor of *Baron’s Financial Weekly* (ref 1). In the first quarter of the 21st century space access will become dramatically y more affordable, allowing space entrepreneurs and their investors very attractive risk-adjusted rates of return. Space business has the potential of becoming the greatest money making endeavor of the 21st century because it brings a completely new dimension to traditionally very successful markets such as transportation, manufacturing, energy, mining, and tourism.

Transportation

Since ancient times we have sought to move people and property with the least expenditure of time, effort, and money. Improvements in transportation have allowed progress in commerce and, consequently, our standard of living. Travel that once took years or months, now takes days or even hours, and in the 21st century it should take only minutes. Travel from New York City to San Francisco in 1848 could take four months; in 1920 a fast train made it in 3 days; today a jet airliner makes it in 4 to 5 hours; in the 2020s it should take only a few minutes aboard an aerospaceplane with an express suborbital flight (ref 2, 3). At the turn to the 20th century, most people thought it preposterous that they would travel by air. In 1903 the Wright brothers achieved the first heavier-than-air flight. In 1918 regular airmail service was started. In 1957-58 air travel exceeded rail passenger travel and more than 1 million passengers flew across the Atlantic (ref 2). In 1990 world airlines carried 1.1 billion passengers (ref 2). In the 2020s space transportation should become big business by evolving from today's limited movements of satellites and astronauts into tomorrow's large scale transport of cargo and passengers between distant locations on Earth and to and from Low Earth Orbit (LEO) and beyond.

Suborbital express flights will entail high speed transport of valuable cargo and passengers between the most distant locations on Earth. An aerospaceplane of the 21st century, for example, should enable airliner-type transport between Tokyo and Orlando in less than two hours. High value cargo such as transplant organs, medicines, or any product which is needed or wanted ASAP in our "instant gratification" society could be shipped using "Suborbital Express" within 2-4 hours. Express-mail service providers could eventually find it cost-effective to operate fleets of aerospaceplanes for those customers who need or want the fastest delivery possible. Passenger movement holds even greater business potential for suborbital express transport. Based on the past history of passenger transportation, suborbital aerospaceliners should expect their first customers to be business executives, followed by tourists, and then even by commuters. Moreover, military applications for suborbital express flights are obvious, perhaps filling the initial orders for such aerospaceplanes.

21st century aerospaceplanes will enable affordable ground to LEO transportation. This will open the space frontier to every government, entrepreneur, and tourist; resulting in a high demand for aerospaceplanes and aerospace liner services. Once we can reach LEO with relative ease, LEO will be built up with various government, military, science, industry, and recreation infrastructures requiring transport of people, consumables, materials, and products. LEO platforms (e.g., space stations, hotels, propellant depots, interplanetary ports) will require regular workcrew replacements and customer transport. Resupply of consumables (e.g., water, food, propellant), tools, and experiments to platforms in LEO will be needed. In addition, medical and other emergency services will require quick aerospaceplane transport to and from LEO. Replacement of aging satellites (i.e., communication and navigation satellite constellations) will require retrieval and deployment using aerospaceplanes. Delivery of Geostationary Earth Orbit (GEO) satellites and interplanetary probes to LEO-ports will require aerospace planes and transport services as well. In the 21st century, transportation to and from LEO will no longer be limited to a few astronauts and satellites per year.

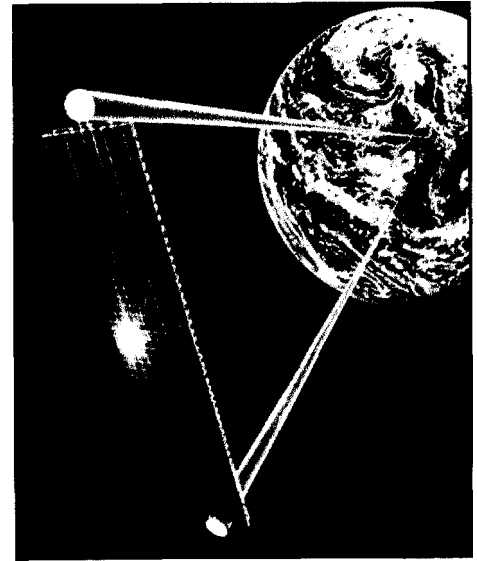
Manufacturing and Construction

The abundant weightlessness and hard vacuum characteristics available in LEO present unique conditions which can be very advantageous for the manufacturing of certain products. Many of these products are yet to be discovered, but some have, and the potential for others is great. Already, aboard the Space Shuttle and other spacecraft, special processing equipment has been used to demonstrate that crystals of materials that serve as key components in electronic and optical devices can be grown larger and more perfect in the microgravity of space (ref 4). Cost effective access and infrastructure will make it economically feasible to manufacture such crystals in space, leading to improved semiconductor chips (for faster computers) and other products. Pharmaceutical companies are keenly interested in the prospects for producing protein

crystals of superior quality in space, leading to new life-saving drugs (ref 4). Other possibilities lie in the processing of unique glasses, new metal alloys, and composites. Over 400 exceptionally strong and light metal alloys have been identified as potential candidates for space manufacture (ref 4). Moreover, the manufacture, construction, or assembly of large space platforms (e.g., space-based ports) and large interplanetary manned spacecraft (e.g., lunar, Mars) would be more practical in the weightlessness of LEO. LEO-based construction promises to be a significant industry as we learn to use LEO as anew launch site for deeper space expansion.

Energy

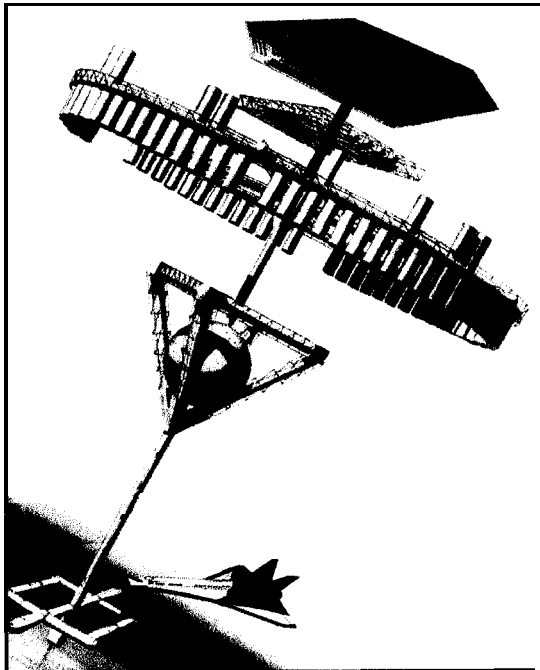
In 1968, Dr. Peter Glaser first proposed the concept of the Satellite Solar Power Station (SSPS) – a photovoltaic power system capable of relaying to the Earth’s surface substantial amounts of captured solar energy using microwaves. At the time, Earth-based energy was abundant and plentiful, and the SSPS concept was shelved for the future. Since, however, the world has seen rising energy costs and periods of energy shortage, making it clear that in the 21st century an SSPS type system coupled with low cost access to LEO would present a substantial commercial energy enterprise. In addition, expansion of commerce into LEO may require a multitude of propellant depots (“gas stations”) in LEO and beyond, representing yet another potential industry.



Power Station Satellite (ref 11)

Mining

Expansion of commerce into space will result in a growing need for life sustaining consumables (e.g., water, oxygen), propellant (e.g., hydrogen and oxygen), and construction materials (e.g., metals). Near-Earth-space already contains these materials, making it more affordable to tap them in space rather than lift them up from the deep gravity well of Earth. For example, the moon is likely to have frozen water left over from cometary impacts on its surface, hidden from sunlight in craters at its polar regions. Such water can be used for drinking or processing into oxygen and hydrogen for life support and propellant. The moon also has a variety of metal ores which can be extracted and formed into construction materials. Helium-3 is another resource which can be extracted from the lunar surface for future power generation (ref 5). Near Earth Asteroids (NEA)s are plentiful, numbering in the hundreds to thousands and constituting additional resources for metals and perhaps even frozen water. Some NEAs are easier to reach (i.e., by AV) from LEO than reaching the Moon. The sources of consumables, propellant, and construction materials already existent in near-Earth-space could draw extensive space-based mining and trade commerce.



Tokyo Orbital International (ref 3)

Tourism

Tourism is perhaps the largest industry on Earth – totaling thousands of billions of dollars every year (ref 6, 7, 8). Throughout our history, with each opened frontier, even Antarctica, tourists followed the explorers and settlers. The tourists follow for curiosity and recreation — to try things they’ve never done before. It is likely that low cost access to space

will eventually bring about a significant space tourism and recreation industry, perhaps including hotels in LEO and on the Moon. Japan's Shimizu Corporation is already pursuing such efforts by developing designs and performing cost-pay-back studies for "Tokyo Orbital International," a LEO hotel (ref 3).

WHY 21st CENTURY ?

Question: Why would Space Commerce be finally realized in the 21st century ?

Answer: Because in the 21st century we will finally gain the technology required to make space commerce profitable — the technology to access LEO affordably.

Progress in transportation technology has not ceased since ancient times, because a nation's political development and economic success, both in peace and war, are directly tied to the transportation technology available to that nation. For early Egypt it was the use of the Nile River, for the Roman Empire it was road building, for the British Empire it was sea power, and for the early American westward movement it was the railroad (ref 2). The quest for more advanced transportation will continue into the 21st century and beyond. Those nations that continue this quest will flourish. The United States and many other nations (e.g., Britain, Germany, Russia, Japan) recognize this and are constantly engaged in advancing transportation technology.

When we examine the rate at which transportation technology has progressed in human history, we see that the rate of technological breakthroughs has dramatically increased with time. Two thousand years ago the Romans created roads. But, in the last two hundred years alone we have seen the steam engine (late 1700s), then the internal combustion engine (late 1800s), then heavier than air flight (early 1900s), then jet engine air flight (mid 1900s), and then rocket space flight (latter 1900s). The outstanding technological progress which we continue to make provides us with a more capable world, which in-turn makes faster technological progress; hence an accelerating progression.

Truly affordable, practical, and reliable access to space requires some new technological breakthroughs which are close at hand. We are already set on a course which could lead us to these breakthroughs in the early part of the 21st century. This course involves progression from our current expendable or partially reusable vertical rocket launch systems, to fully reusable horizontal take-off systems with advanced combinations of airbreathing and rocket propulsion. In the mid 1980s, the U.S. embarked on a major pursuit to develop the first aerospace plane — the X-30 National AeroSpace Plane (NASP). This effort lasted almost a decade and cost a couple billion dollars. The NASP project, along with several similar foreign projects in Europe and Japan, demonstrated that a Single Stage to Orbit (SSTO) vehicle, which is fully reusable and operates efficiently like an airliner rather than like the Space Shuttle, should be achievable early in the 21st century. It's only a matter of time and (especially) money before SSTO technologies are developed, tested, and refined.



NASP / X-30

The full reusability aspects of an SSTO vehicle — tremendously simplifying operations and cutting production and refurbishment costs — will allow the first breakthrough in dramatically reducing the cost of reaching LEO. The second major breakthrough will come later, when an airbreathing engine (e.g., SCRAM) is developed to propel a vehicle to hypersonic speeds above Mach 15. This will reduce significantly the required on-board oxidizer mass, enabling the lifting of additional payload mass instead. A speed of Mach 25 must be attained in order to achieve LEO. It is unlikely, however, that an airbreathing engine will propel a vehicle all the way to this orbital velocity. A supplementary rocket engine mode will likely be needed to

make the final jump into LEO. The low cost access to LEO to be provided by 21st century aerospaceplanes will depend on these two inevitable breakthroughs. The key areas which require work in order for these breakthroughs to be realized are: materials, hypersonic aerodynamics and thermodynamics, and propulsion. In 1994-95, the U.S. government abandoned NASP for another more closely attainable vehicle, the SSTO all-liquid-rocket Reusable Launch Vehicle (RLV). This vehicle promises to achieve the first breakthrough, discussed above, by 2005-2010. However, the X-33/RLV effort should also set us on course to achieve the second critical breakthrough — an airbreathing aerospaceplane — by approximately 2020.

WHY AEROSPACEPORTS ?

Question: What are “aerospaceports” and why will space commerce depend on them ?

Answer: Aerospaceports will be 21st century ground-based ports serving as intermodal transportation gates for efficient flow of commerce across Earth and beyond.

Airports

The modern commercial airport is primarily a facility for handling the arrival and departure of domestic and international commercial aircraft, passengers, and freight. However, it also serves as a major node in the extensive global network of intermodal transportation, directly connecting various sorts of transportation systems such as passenger cars, buses and trains, as well as freight trucks and trains. In recent times, it has also become a convenient center for trade, business meetings, and commerce dealings with practical and luxurious amenities such as free trade zones, conference centers, security, hotels, restaurants, and mall-like shopping (e.g., the Orlando International Airport). Airports are shaped by such requirements as: sufficient space to accommodate long runways, taxiways, hangars, terminals, parking lots, cargo buildings, and various utility facilities necessary for efficient airport operations (i.e., machine shops, fuel depots, fire and rescue); sufficient roads, highways, and rail for public and freight ground transportation access; and sufficient distance from residential areas to reduce the effect of aircraft noise. Commercial airports in the U.S. are usually publicly owned, and operated by municipal, county, or other government agencies. Federal regulations govern their operational methods and set safety standards. For example, port-of-entry infrastructure is provided for admittance of imported goods and collection of custom duties. Global commerce today is dependent on these commercial airports.

Spaceports

Today, launch sites for space vehicles exist throughout the world. However, these “spaceports” are customized to the specific few vehicles using that location. For example, at the U.S. Cape Canaveral Air Station (CCAS), an Atlas rocket uses launch infrastructure designed for Atlas rockets, a Delta has its own unique facilities, as does a Titan. Kennedy Space Center (KSC), adjacent to CCAS, has unique launch facilities for the Space Shuttle fleet. Florida’s spaceport (CCAS / KSC) has multiple airstrips used by the Shuttle and other military and NASA aircraft, and these facilities should be available for future aerospaceplanes. Vandenberg Air Force Base (VAFB) is another major U.S. spaceport. VAFB is ideal for launches into polar orbit since there are no southward land masses which may be affected by expended stages or by debris from aborted or unsuccessful launches. In a similar fashion, CCAS and KSC are ideal for launches into an equatorial orbit since there are no eastward land masses that may be adversely affected. These two major U.S. spaceports are used to test new missiles and launch vehicles, and to launch our existing fleet of space vehicles.

Unfortunately, today’s spaceport-launched vehicles are at best only slightly better than 98% reliable. 1994-95 was troubled by numerous launch vehicle failures, emphasizing how unreliable our current launchers can be when compared to commercial airliners with 99.9+% reliability. Moreover, in contrast to commercial airliner failures, most space launcher failures are explosively destructive. Consequently, U.S. spaceports are not yet integrated into the intermodal commercial transportation system. These launch sites

serve, for the most part, very specialized military, civil, and commercial needs. For commercial missions, the government allows launch contractors to use government infrastructure and services to compete with foreign launch companies for satellite delivery business.

Aerospaceports

Today's spaceports are suitable for today's type of non-reusable (expendable) and partially reusable launch vehicles. However, early in the 21st century (approximately 2010-2020s) a new breed of vehicles should emerge, capable of operating like today's commercial airliners — a breed of SSTO rockets to be followed by airbreathing aerospace planes. These new vehicles will be used to launch full scale space commerce, opening the space frontier to the entrepreneurs. Moreover, aerospaceplanes will not only be used for transport to and from LEO, but also for suborbital express transport achieving travel times of two hours or less between distant locations such as Orlando and Tokyo. The ground port for such aerospaceliners should be an intermodal transportation port — an aerospace port.

Today's spaceports and major airports will have to evolve into aerospaceports or risk becoming obsolete. Aerospaceplanes featuring horizontal take-off and landing will require specialized equipment and facilities that may not be too different from existing airport infrastructure. In addition, aerospaceplane commerce will need the business base which is already in place at major airports. The Orlando International Airport will be an excellent candidate for expansion into the arena of commercial space transportation because of its proximity to the Cape Canaveral spaceport, and its existing infrastructure and support services (i.e., intermodal connectivity and accessibility, port-of-entry, trade zoning, compliance with DOT/DOC regulations, security, facilities, amenities, and financial incentives).



Some Airports will Evolve into Aerospaceports in the 21st Century (ref 12)

It should not be inferred, however, that traditional air and space transportation systems will cease to operate. For large, heavy, specialized space payloads (i.e., interplanetary payloads >50,000 lbs) heavy lift expendable boosters will likely be more practical than SSTO or aerospaceplane vehicles. These will continue to launch from today's standard launch pads. Similarly, 21st century airliners like today's commercial aviation aircraft (i.e., not capable of high-altitude, high velocity flight) will probably be more cost-effective for shorter flights. These may operate side by side with suborbital express or LEO destined aerospace planes at aerospaceports, but may have exclusive use of smaller domestic or regional airports.

THE PATH TO SPACE COMMERCIALIZATION

The path to achievement of self supporting space commerce in the 21st century will require government sponsorship of technology development, government regulation, and some government guarantees to cover industry's initial high risk investments.

Government Sponsorship and Regulation

Governments around the world have recognized the power associated with transportation and, hence, have sponsored its development and advancement. In many places throughout the world, transportation infrastructure is government owned and operated. In the U. S., transportation is primarily privatized, but with significant federal aid for developing and maintaining railroads, highways, waterways, aviation, and other transportation infrastructure (ref 2). The government has also funded weather forecasting and navigation means on which the transportation industry has become dependent for safety and reliability. A recent example is the development and deployment of the NAVSTAR Global Positioning System (GPS) satellite constellation.

With government funding and concern for public safety come government regulation. In 1966 most of the U.S. transportation regulatory agencies (e.g., railroad, highway, air) were combined under the Department of Transportation (DOT). Under the DOT, the Federal Aviation Administration (FAA) regulates all aspects of airplane and airport safety and runs the vast and critical Air-Traffic-Control (ATC) System (ref 2). Recently, the DOT's Office of Commercial Space Transportation (OCST) was merged with the FAA in order to extend the effective architecture achieved with commercial aviation to space transportation (ref 9). For example, in the 21st century the FAA's ATC may likely become the "Aerospace"-Traffic -Control System, governing all major flight traffic up to and including LEO and perhaps beyond. OCST already regulates U.S. commercial space launches.

Development of aviation in the U.S. required a strong partnership between government and private industry. The National Advisory Committee for Aeronautics (NACA) was established by the U.S. government in 1915 to supervise and direct the scientific study of the problems of flight, with a view to their practical solution (ref 10). NACA was a cooperative entity representing the academic community, the military, and industry in the development of aviation technology. In 1958, NACA was transformed into the National Aeronautics and Space Administration (NASA). Since, however, NASA has become an organization primarily concerned with space science, although a vast amount of its annual budget is devoted to operating the Space Shuttle fleet (a.k.a. the "Space Transportation System"). NASA's recent moves to turn Space Station development and Shuttle operations over to single managing contractors are steps toward establishing the agency as a "customer" of industry-provided services, including space transportation. As a user of, and investor in, commercial space transportation, NASA should assume a "catalyst" role similar to NACA'S – encouraging and enabling commercial enterprise in an emerging transportation industry.

At the state government level, states like Florida have foreseen the evolution of the launch industry and have established space transportation authorities to develop infrastructure and provide regulatory and sup-

port services. Florida's spaceport authority has statewide regulatory responsibility for commercial space transportation.

Aerospace Industry

Today, worldwide, about 500 airlines are engaged in passenger and cargo operations (ref 2). The United States operates the largest scheduled airline fleet in the world (numbering more than 4,000 large jet aircraft) which carries the largest number of passengers (about 450 million annually as of the early 1990s) (ref 2). Undoubtedly, in the 21st century the spaceline industry will become an extension of the airline industry, forming an "aerospace" industry. In 1995, Orbital Science Corporation and Rockwell International moved to create the first "space line" company — American Spacelines, in anticipation of transitioning the NASA co-funded X-34 fully reusable launch system from an experimental vehicle to a commercial space transportation enterprise. However, the U.S. airline industry giants (e.g., United, American, Delta) are not likely to adopt space transportation business until manufacturers like Boeing and McDonnell Douglas offer aerospaceplanes for sale alongside their 777s and MD-80s.

There is much to be achieved before aerospaceplanes are available for reliable and profitable commercial operations: development of new technology, incorporating this technology into experimental vehicles, and performing extensive flight testing. For example, Airbus Industrie (a European consortium) developed a state-of-the-art aircraft for the airline industry in the 1970-80s, the A320, which flies "by-wire," using advanced computer driven electronic controls rather than the traditional hydraulic and cable systems. This technologically innovative plane became a best-seller even before its first commercial flight in 1988 (ref 2). However, it had to endure and perform acceptably through nearly 800 flights before its commercial sales began (ref 2). A commercial aerospace plane with its anticipated revolutionary technology and sub-orbital flight trajectories will undoubtedly have to undergo approximately 1000 test flights before it becomes truly viable for widespread commercial use.

CONCLUSION

Today, the U.S. government is trying to press industry into financing the development of new commercial space transportation systems based on the notion that "if you build it, they (the customers) will come." The U.S. industry, however, realizes that with currently available and near-term technologies, the commercial space transportation capability achievable in the next decade may still be too expensive for full scale space commerce to flourish. The only customers likely to afford such transportation services will be governments and very large corporations or consortiums. Without government guarantees to use such transportation (in-turn guaranteeing recovery of industry investments) industry are reluctant to invest billions of dollars at this time. If the U.S. government wishes to attain long term global leadership in space transportation it must: (1) guarantee industry's return on investment by becoming an "anchor tenant" for short-term services, (2) fund the advancement of space transportation technology with primary focus on the achievement of airliner type reliability and affordability to LEO, and (3) sponsor the extension of commercial aviation regulations, infrastructure (i.e., selected spaceports and airports), and support systems to serve commercial space transportation.

A nation's political and economic development, both in peace and war, are tied to the transportation facilities available in that nation (ref 2). If the U.S. does not take the steps identified above, other nations could leave the U.S. and its economic prosperity (as well as military dominance) behind. The key is to significantly lower the cost to LEO. In the long term, the means to significantly lowering the cost of reaching LEO will reside at aerospaceports with commercial airline-type aerospace planes which use the atmosphere for propulsion and lift. To achieve these means we must invest in developing the technology and architecture. This investment will have to be made early in the 21st century.

BIBLIOGRAPHY

- (1) The Cold Hard Realities of Space Business; Alexander Howertan; Ad Astra; March-April 1995
- (2) Grolier Encyclopaedia; Grolier Electronic Publishing; 1993
- (3) Space the Next 100 Years; Nicholas Booth; Orion Books; 1990
- (4) Commercial Use of Space: A New Economic Strength for America; NASA office of Commercial Programs; NP-113
- (5) Changing the Course of History; Madhu Thangavelu; Space News; November 1995
- (6) Space Tourism A Flight of Fantasy or the Next Major Space Product?; Barbara Stone; NASA of Office of Advanced Concepts & Technology; 31st Space Congress; 1994
- (7) Nonreimbursable Space Act Agreement between the Space Transportation Association and NASA to Conduct a Study of Space Tourism; 1995
- (8) Abridged Text of Speaker Newt Gingrich's Comments at NSS Seminar "Space Policy for the 21st Century," 3 march 1995; Ad Astra; May-June 1995
- (9) Interview with Ed O'Conner, Executive Director of Spaceport Florida Authority; by David Tamir; October 1995
- (10) Pioneering the Space Frontier: The Report of the National Commission on Space; Bantam Books; 1986
- (11) Illustrated Encyclopedia of Space Technology; Kenneth Gatland; Orion Books; 1989
- (12) Visions of Space; David Hardy; Dragon's World Publishing; 1989