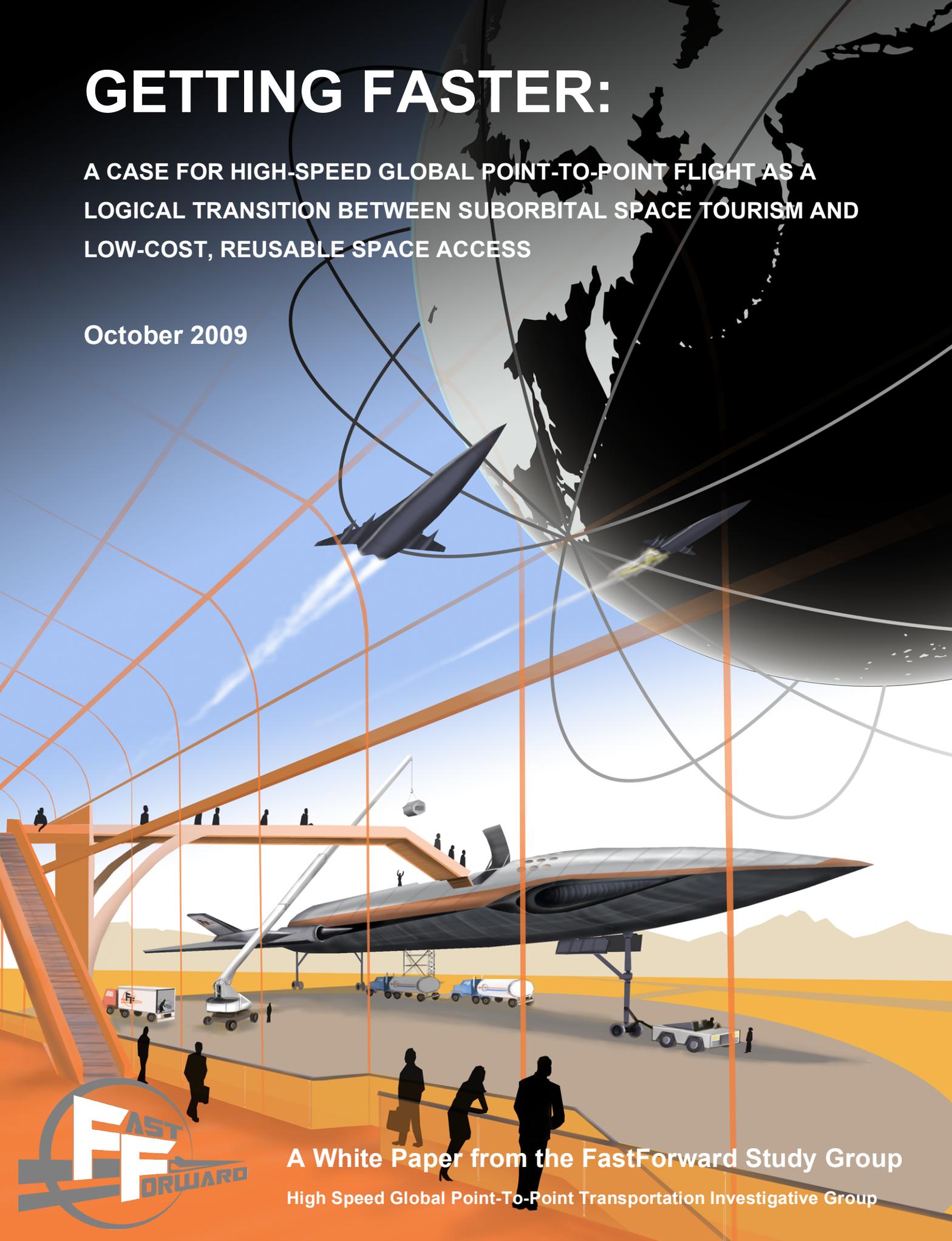


GETTING FASTER:

A CASE FOR HIGH-SPEED GLOBAL POINT-TO-POINT FLIGHT AS A LOGICAL TRANSITION BETWEEN SUBORBITAL SPACE TOURISM AND LOW-COST, REUSABLE SPACE ACCESS

October 2009



A White Paper from the FastForward Study Group
High Speed Global Point-To-Point Transportation Investigative Group

Executive Summary

The FastForward Study Group proposes a new incremental aerospace strategy that recognizes the synergistic role that the emerging market for high-speed global transportation has with the nation's long-term goals for low-cost, reliable space access

As the national leadership in the United States reexamines its strategies, policies, and investments with regard to future space access, the members of the FastForward Study Group suggest a new, incremental approach toward achieving the nation's goals in space. The emerging commercial high-speed global transportation market for passengers and goods offers significant technical and economic synergies with future commercial space access services. Recognizing the key transitional role that this new Point-to-Point (or PTP) transportation service will play between today's single-site suborbital space tourism markets and future low cost, reliable orbital spaceflight, the FastForward Study Group **supports the development of a new coordinated**

national strategy that recognizes the synergistic role that the emerging market for high-speed global transportation has with the nation's long-term goals for low-cost, reliable space access.

The long established goals for orbital space transportation are to provide safe, reliable, and affordable transportation services to low Earth orbit. Many industry leaders believe that commercial reusable space launch vehicles (RLVs) will ultimately provide these advantages. However, several high profile national attempts to develop RLVs in the past have failed to achieve a significant improvement toward reaching these goals. Required government investment has been too high and the development risk has been too great when constrained by present-day technologies. An alternate strategy is needed.

A new incremental strategy is offered in this white paper. Ongoing advancements in high-speed aviation and suborbital space tourism will soon produce extremely long range, reusable aerospace vehicles capable of flying at hypersonic speeds and exo-atmospheric altitudes. For some shippers and business travelers speed is crucial, and these aviation customers would greatly value and utilize air transportation systems that fly much faster than achievable today. Moreover, an emerging rapid point-to-point market would be well suited to serve as an **effective transitional**



Future High-Speed PTP Aerospaceport

This white paper calls for a modest study, to be completed over the next year, to conduct the critical preliminary work necessary to support a new incremental national strategy that will ultimately meet U.S. space transportation needs through the encouragement of synergistic and transitional high speed, global point-to-point flight.

stepping-stone toward future RLVs for space access. Just like future commercial RLVs, global high-speed PTP flight will require technologies, reusable flight vehicles, business strategies, and ground infrastructures that prioritize reliability, safety, and affordability due to market necessity. If encouraged and supported, these commercially driven advancements in aviation will serve as a sustainable foundation for the emergence of future RLVs capable of orbital access. Rather than requiring significant near-term government investment and large technology leaps, **the proposed incremental path will provide a sustainable and logical approach to meeting the nation's long range goals for space transportation by harnessing the commercial aviation industry's existing motivation toward "getting faster."**

However, significant challenges remain to this proposed new strategy. A true public/private partnership will be necessary to develop requisite PTP technologies, develop ground infrastructure, provide a viable regulatory and legal framework, and to provide early markets for these emerging point-to-point services. We urge national leadership to work in partnership with the emerging fast-package delivery and high-speed point-to-point industry to first develop and mature the PTP business model, and then to use that foundation as a stepping-

stone toward achieving safe, reliable, and affordable access to space via commercially developed reusable flight systems.

To gain widespread support, the details of the proposed approach need further definition. Members of the FastForward Study Group have already conducted early research in this area, and we believe it to be promising. However, additional research is needed to produce an actionable set of study products. PTP markets for passengers and priority packages must be better understood and supported with statistically valid analysis. Critical missing technologies must be identified. Aerospaceport needs must be prioritized. Key government roles must be established for various federal and state agencies. Prerequisites for private investment must be identified. As a first step toward better understanding the potential of our proposal, the FastForward Study Group calls for the government to fund a **modest study effort, to be completed in the next year, to conduct critical preliminary work** to better define this proposed new incremental strategy toward meeting national space transportation needs through the encouragement of synergistic and transitional high speed point-to-point flight.

The Future of Space Access

Achieving the Goals of Safety, Reliability, and Affordability

Background

Since the early days of the space age, the federal government has invested heavily in rocket vehicles, rocket engines, and related technologies necessary to launch valuable government payloads into Low Earth Orbit (LEO) and beyond. After decades of development, the U.S. has established an operational fleet of several expendable launch vehicle configurations that are the primary workhorses of America's access to space capability.

Still, many historical space visionaries, including the late Dr. Werner von Braun, have pointed to the potential advantages that could be realized with reusable launch vehicles (RLVs). Reusing space hardware, rather than throwing it away after every flight, is an alternative approach that has been pervasive in the technical literature for over four decades.

U.S. Strategic Goals for Space Access

The United States has long recognized the strategic need for assured access to space. Space launch vehicles are first and foremost required to be **reliable**. The payloads they carry are often critical to national security or represent a significant investment in scientific research and development. In current vehicle configurations, reliability is achieved with a combination of highly reliable parts, strategic use of subsystem redundancy, and stringent quality control¹.

For launches with crewmembers onboard, **safety** is a paramount goal. Reliability is obviously an important influence on safety, but in this context, safety means crew survivability. Launch vehicles are expected to be safe for the

crew, and in the event of a failure they must be able to safely return the crew to Earth.

Additionally, **affordability** is a key goal for future U.S. access to space capabilities². Reductions in launch costs will lead to the expansion of space markets and will eventually create new opportunities to develop and utilize the vast potential of outer space. Robust space exploration campaigns, economic development, and space resource utilization will all be enabled by the availability of low-cost space access.

Commercial Reusable Launch Vehicles

Given the goals of safety, reliability, and affordability, many space experts believe that reusable launch vehicles (RLVs) offer the most promise to make big improvements in these metrics. With RLVs operating at high enough launch rates, recurring launch costs might be decreased by a factor of two or more. Reliability might be improved by an order of magnitude. A mixed fleet of so-called "commercial" RLVs operated by multiple firms in a competition-driven economic environment might underpin a truly robust and sustainable space access market, offering customers multiple choices for launch services.

But how best to achieve these goals? Since the 1980's, the U.S. government has invested in technology programs and even path finding development programs targeted at creating a fully reusable RLV-based space access architecture. However, the high development costs and technological challenges have combined to create a "bridge too far" outcome for these early attempts. A new approach is needed.

The U.S. aviation industry provides a model to emulate with respect to affordability, safety, and reliability. With its current emphasis on “getting faster”, PTP flight could serve as a logical incremental step toward achieving low cost access to space.

Extending Aviation Paradigms to Space

The U.S. aviation industry **provides a model to emulate** with respect to affordability, safety, and reliability. Having decades more time to mature relative to space access, the aviation industry relies on highly reliable, reusable vehicles to deliver safe and affordable transportation to its customers. In addition, priority air cargo customers have come to expect reliable, on-time delivery of goods from various commercial businesses such as DHL, UPS, and FedEx.

It could also be argued that the emerging suborbital space tourism market has its roots more in the aviation industry than in the space industry. Many of the leading companies preparing to offer single-site (point-A to point-A) space tourism experiences are utilizing aviation-like vehicles to accomplish their missions.

Getting Faster

Building on its successful business model for subsonic air travel, many players in the U.S. aviation industry are now focused on “getting faster”. Driven by economic globalization, flight speeds and ranges are being pushed to make global air travel more practical by reducing flight times and eliminating stopovers.

Ongoing technological advancements in high-speed aviation³ and suborbital space tourism will soon produce extremely long range, reusable aerospace vehicles capable of flying

at hypersonic speeds and exo-atmospheric altitudes. For some shippers and business travelers speed is crucial, and these aviation customers would greatly value and utilize air transportation systems that fly much faster than achievable today. Global high-speed PTP flight will require reusable flight vehicles utilizing new propulsion and structures technologies, ground infrastructures, and business strategies that prioritize reliability, safety, and affordability due to market necessity. Environmental impacts such as noise and emissions must be reduced.

Commercial competition remains a key to the success of this next evolutionary step in aviation. Sustainable high-speed PTP services for passengers and cargo will depend on a combination of economic viability for multiple players and supporting advancements in technologies to make high-altitude, long range flight a possibility.

A New Plan

Cognizant of this history and current situation, the FastForward Study Group proposes a logical addition to the United States’ overall strategy to achieve reusable space access⁴. This new approach relies on leveraging ongoing commercially driven advancements in suborbital space tourism and high-speed aviation.

An Incremental Space Development Plan

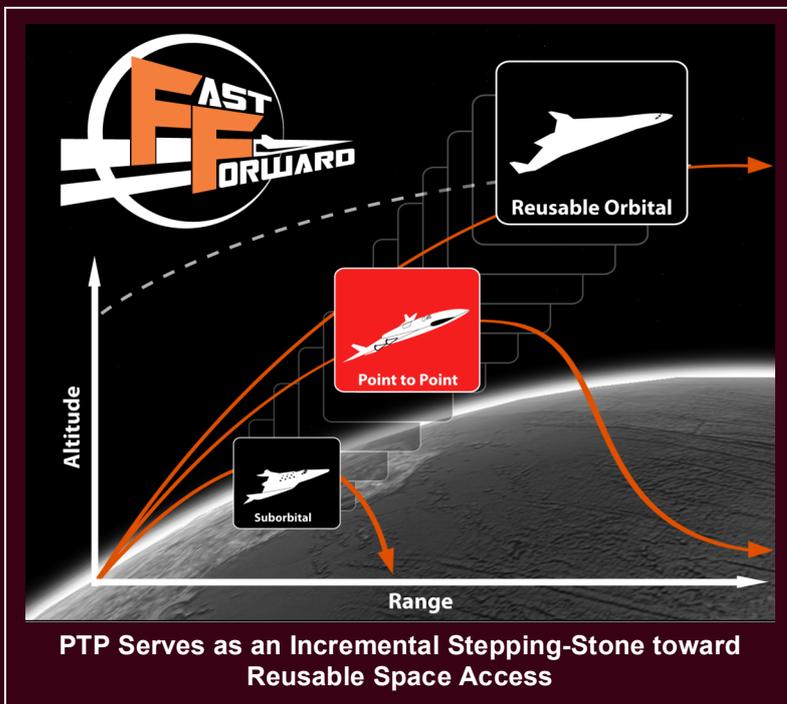
High Speed Global Transport Leads to Reusable Orbital Transport

The FastForward Study Group proposes that a realistic revolution in space access will primarily come from leveraging synergistic advances in high-speed aviation and reusable suborbital transportation (e.g. space tourism concepts) in a deliberate and incremental fashion. If properly managed and encouraged, these two markets could first lead to a sustainable global transportation system for passengers and priority cargos, and then to a safe, reliable space access system. While the timeframe for achieving orbital space access goals might initially be slowed by this incremental approach, we believe that it is overall a fundamentally sound national strategy.

Supported by early government-led research in the 1960's of high-speed reusable flight vehicles such as the X-15, X-24, and HL-10, and more recent R&D efforts in high-speed propulsion such as HyFly and X-51, a technological foundation exists to support higher, faster flight both within the atmosphere and exo-atmospherically. Spurred by private incentives and the opportunity for new markets, progress is being made in applying these capabilities to viable business cases. Several major commercial and business aviation manufacturers in the U.S. are actively interested in developing environmentally friendly vehicle configurations and sustainable business models for long-range supersonic and hypersonic flight.

Following the winning of the \$10M Ansari X-PRIZE by a vehicle built by Burt Rutan's Scaled Composites, multiple private companies have entered the market to provide suborbital space tourism services to high net worth individuals. Many of these same suborbital space tourism companies have publicly stated interest in evolving their business models to include high-speed global point-to-point transportation for priority cargo and passengers using vehicles derived from their current offerings⁵.

If supported by strong public/private partnerships that can overcome the barriers that still exist, these foundational capabilities have the potential to evolve along a series of commercially driven stepping-stones that will lead first to a robust high speed global PTP industry and eventually to safe, reliable, and affordable (i.e. reusable) access to space. A brief description of the proposed plan follows.



Step 1 – Continued Encouragement of Single-Site Reusable Suborbital Transport

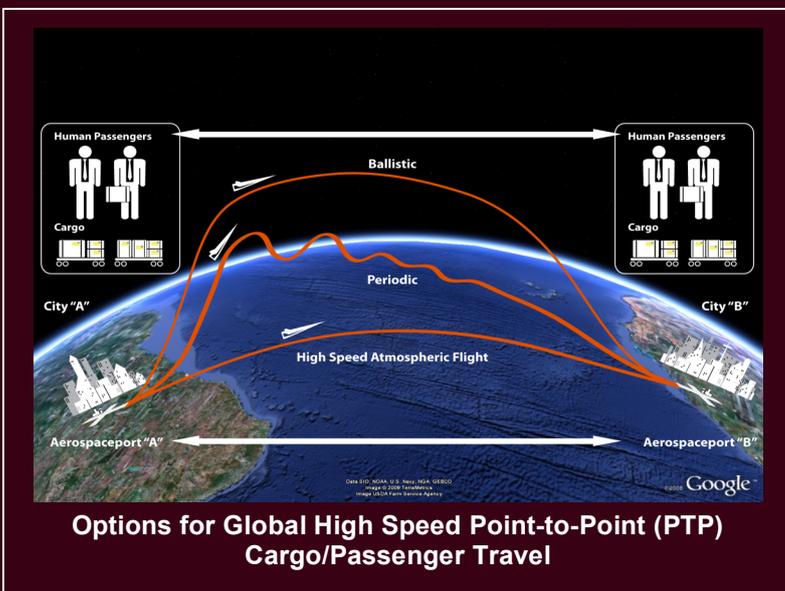
At appropriate prices, commercial markets already exist for suborbital flights that take off and land near the same location on the Earth – both for passengers (so called space tourists) and scientific payloads that must be exposed to brief periods of weightlessness. Many private firms operating in the U.S. have already targeted the emerging single-site market for suborbital personal spaceflight. Key players include Virgin Galactic, Rocketplane Global, XCOR, Sierra Nevada Corporation, and Blue Origin. Preliminary market studies suggest that thousands of high net worth passengers annually would be willing to pay over \$100,000 per ticket for a short ride into suborbital space^{6,7}. A complementary market exists for suborbital cargo delivery, primarily scientific experiments and university payloads. A reusable suborbital flight vehicle would provide researchers with a chance to quickly recover their experiments within minutes of landing rather than the hours it typically takes to recover a payload from a sounding rocket entry vehicle. Suborbital flight vehicles must operate safely, reliably, and affordably in order to sustain and grow their target markets. In response to this implied requirement, leading companies in these fields are proffering flight vehicles that look more like reusable aircraft than expendable rockets.

Through the FAA, the U.S. government has established a regulatory framework that helps guide the development of the new industry without stifling the fledgling organizations operating in this field. Similarly, the Department of Commerce has attempted to develop policies that encourage commercial growth. Participation by the Department of Defense and NASA in the market has been somewhat more indirect. Both agencies have historically funded the technology developments that underpin the reusable flight vehicles that will operate in this market. Admittedly however, the technological challenge of flying vertically up in altitude to the edge of space and back to the launch site is moderate compared to the technological challenges of 1) flying halfway around the globe exo-atmospherically in under two hours or 2) reaching an orbital flight condition. In either latter case, focused technology developments will be needed.

A parallel emphasis of the proposed incremental space development plan must address the requisite ground infrastructure. In reaction to the emerging suborbital space tourism market, new FAA-licensed aerospaceports are springing up in many states across the country (e.g. New Mexico, Florida, Oklahoma, California, and Virginia). Supported by state and local governments, these new aerospaceports will be well positioned to take advantage of the economic benefits derived from the emerging space tourism business. In this initial market, the aerospaceports will operate rather independently. The flight systems they intend to host will both originate and terminate their flights at one location. As such, the current regulatory environment does not adequately address issues such as flight *between* aerospaceports (neither purely domestic nor international flights). Similarly, an international legal framework does not exist to support issues associated with flying passengers or payloads between two points on the globe via a reusable spacecraft.

Step 2 - Global High-speed Point-to-Point

We believe that the next logical step on an incremental space development plan is to extend the current suborbital space tourism market to global high-speed PTP service for



passengers and priority cargo. If achieved, this second-step market could serve as a foundation for a push to future reusable space access vehicles, with their inherent advantages in reliability and affordability.

Building on a successful aviation industry foundation, a future PTP transportation network could serve important commercial centers around the globe with new and enhanced services, specifically better next-day and same day options for fast package deliveries and time-saving flight options for long distance transoceanic passenger routes. For passenger service, key business traveler routes exist between the U.S. and Asia and the U.S. and Europe that support 500 - 1,000 passengers per day each way. For cargo, a future PTP priority cargo service could be an evolution of the current \$100B per year global fast package businesses operated by companies like UPS, FedEx, and DHL. Decreasing door-to-door transportation times in an increment of value to private and military customers will demand significantly faster transportation systems relative to today's subsonic airliners. To be successful, a revolutionary new global PTP service must "get faster" while maintaining economic competitiveness and a track record for safety and reliability.

While this second-step market has a tremendous upside, it currently faces several barriers. The technology challenges are harder. The regulatory and legal frameworks do not exist. The price points and daily volume of the envisioned markets are less well understood. The operational complexities are orders of magnitude more difficult. Challenges remain with respect to customs, emissions, airport noise, and supersonic land overflight. It is likely that private industry cannot make this step alone. Almost certainly, this market will not be realized without NASA and the DoD taking more deliberate steps to ensure its success, either as focused technology developers or anchor customers or both.

Opportunities exist for coordinated supportive efforts across various U.S. government agencies including the FAA, Department of Commerce, NASA, DARPA, and the DoD. With regard to technology advancement in the area

of high-speed PTP flight, the FastForward Study group sees a particular synergy between the U.S. Marine Corps Small Unit Space Transport and Insertion Capability (SUSTAIN) activity and eventual commercial needs for ultra-high speed commercial flight⁹. However, regulatory and policy agencies have not yet started to address the particular needs and challenges for PTP. As part of our call for action, we urge the government to develop a coordinated and supportive position with respect to establishing PTP as a logical transition between suborbital space flight and future reusable space access.

Step 3 - Reusable Orbital Flight

Building on steady and sustainable improvements in aviation technologies and business cases developed for the earlier stepping-stones, the capability will exist to then develop and implement a fleet of aircraft-like reusable space access systems. We believe the goal for more affordable and reliable space access can realistically be achieved via the proposed plan to evolve these new capabilities from high-speed aircraft. The key is to establish a suitable foundation from which to launch an effort to field a reusable launch vehicle, and thus avoid the pitfalls of previous RLV development efforts.

If derived from economically successful PTP flight vehicles, future RLVs might offer reductions in launch costs by a factor of two or more. Reliability and safety metrics would also see significant improvement. The country will have achieved its long-standing goal for safe, reliable, and affordable space access.

Summary

There is today a lack of high-level national focus on long range (supersonic or hypersonic intercontinental Point-A to Point-B) global services that may eventually lead to low cost orbital transportation. The proposed incremental plan highlights this "middle ground" as a key transitional step between suborbital space tourism and space access and implies a need for increased attention to this critical emerging market. The proposed plan is deliberate and incremental, with each step

The proposed incremental space development plan offers several key strategic advantages.

building toward the next and maturing synergies amongst different industries and technological pathways. In the end, the foundation of a strong and commercially sustainable national space program will be created. While this approach might initially seem more indirect and time consuming than just attempting to tackle RLV development challenges directly, it offers a number of advantages.

The key advantages of the FastForward Study Group's proposed incremental space development plan are that it:

- **Evolves** from world-class industries within the U.S., notably: commercial and business aviation, and reusable suborbital transport, with their inherent emphases on reliability, safety, and affordability
- Derives from an immediate **market-driven** need for faster global transportation services that will help sustain the critical transitional step of the plan
- Represents a **true public / private partnership**, with each entity bringing its own unique capabilities to the effort to reduce overall risk
- Is **incremental** by nature, with ample opportunities for commercial competition, synergies with other endeavors, and market development that help reduce peak annual expenses along the stepping stones of its evolution
- **Sustains a strong and flexible domestic aerospace workforce** to support synergistic commercial, civil, and military needs for both rapid global travel and space transportation

In order to implement such a plan at a national level, we urge national leadership to enact coordinated governmental policies, regulatory environments, technology development activities, and infrastructure investments that **work in partnership** with emerging fast-package delivery and high-speed point-to-point developers to achieve the next-step toward safe, reliable, and affordable access to space via reusable flight systems.

A coordinated effort will be required by several government agencies. The U.S. Department of Commerce, NASA, DARPA, the FAA, and the Department of Defense must all play critical roles in establishing policies, regulations, and technology development activities. Innovative partnership solutions will be needed. In some cases, the U.S. government might initially choose to anchor markets for each of the plan's stepping stones much as the Kelly Act of 1925 urged the U.S. government to provide early air mail contracts to budding commercial airlines⁹. Innovative uses of government-sponsored prizes and/or tax policies might also provide a critical jump-start to these emerging markets at all levels.

Industry too, must successfully play its role in the partnership. Market forces will drive innovation in affordability and reliability. Competition will also produce faster services and more efficient modes of operation. If presented with a stable and sustainable market, commercial industry and private investment will drive implementation. The United States aerospace industry enjoys a strong positive balance of trade with the world largely because of the innovation that exists in its commercial sector^{10,11}. We believe it is time to focus this innovation on the problems of high-speed global flight, and ultimately on reusable space access.

Call for Action

A Modest Preliminary Study Effort to Support a Subsequent and Broader Dialog on the Proposed Approach

As a first step, the FastForward Study Group calls for the U.S. Government to fund a modest study effort to conduct critical preliminary work to further define the proposed new **incremental strategy** toward meeting national space transportation needs through the proposed public/private partnership. While many organizations, including the FastForward Study Group, have conducted preliminary research into the potential of this new market¹²⁻¹⁷, **there is still a lack of actionable study products with which to support future investment decisions.** A well-organized study effort is needed to generate these products. The goal of the preliminary study effort should be to provide a firm foundation for a subsequent and broader dialog on the proposed stepping-stone strategy, namely a

key transitional role for point-to-point (PTP) global flight service toward ultimately achieving safe, reliable, and affordable space transportation via reusable flight systems. The FastForward Study Group is prepared to lead this preliminary study or to provide strong participation as needed. This effort should be completed within the next year in order to be relevant to the current national dialog on space access.

As the first step in maturing the proposed plan, the preliminary study effort should focus on the PTP markets and technical solutions, one of the least studied areas in the overall plan in terms of actual technical, economic, and legal implementation. Strategic thinking regarding the overall plan should also be included.



Despite early research on the emerging point-to-point market, there is still a lack of actionable study products with which to support future investment decisions. A modest well-organized study effort is needed.

The preliminary study effort should be a combination of detailed technical analysis and strategic thinking that will:

- Ascertain the possibility of, and establish a credible global market forecast for, future fast-package delivery services for various city pairs
- Ascertain the possibility of, and establish a credible global market forecast for, future high-speed passenger travel for various long range business routes
- Develop a common understanding of the economic relationship between flight speed and PTP market viability (i.e. comparative solutions for supersonic flight vs. hypersonic flight speeds)
- Identify common critical challenges for future aerospaceports
- Identify synergistic government contributions, policies, and partnerships that will help encourage and nurture the growing PTP industry
- Establish potential technical and economic evolutionary paths from suborbital space tourism toward global point-to-point flight and orbital space access
- Develop preliminary comparisons of a future space transportation architecture that evolves from aviation advances against one that is based on the status-quo of expendable rocket vehicles

- Establish a preliminary strategic roadmap for a public/private partnership that will meet national needs in both global transportation and space access

We urge the government to act quickly to commission this critical and necessary step toward meeting the country's future space access needs.

About FastForward

The FastForward Study Group is an ad-hoc industry group focused on future global, high-speed point-to-point transportation

The FastForward Study Group is a diverse, ad-hoc industry study group focused on common issues related to future global, high-speed point-to-point transportation (including passenger travel and fast package delivery). The all-volunteer group is broadly supported across the aerospace industry, with key members from flight system providers (both entrepreneurial and traditional aerospace hardware companies), future operators, government agencies, commercial aerospaceports, academic organizations, and specialist consultants. Members have backgrounds ranging from traditional aviation to space applications.

The FastForward Study Group is focused on examining pre-competitive issues and questions key to understanding the technical and economic viability of future high-speed global transportation services based on either atmospheric or exo-atmospheric flight. These two emerging markets are related, and both share the goal of drastically reducing point-to-point travel times between distance points on the globe to a matter of hours.

Establishing a common understanding of the opportunities and challenges of these markets is critically important for all parties at an early stage. While specific implementation approaches and business strategies vary widely among the study team members, the goal of a safe, reliable, and affordable point-to-point commercial service is universally shared. Key FastForward study activities include market forecasting as a function of price and service class, identification of preferred locations and preferred characteristics of operational sites in the global network, establishment of payload, range, and flight

speed requirements for the flight vehicles, identification of key technology prerequisites, and recognition of common regulatory and policy hurdles. The FastForward Study Group is not a lobbying organization, but the group does informally promote government policies and practices that would be favorable to engendering a strong U.S.-led market-driven business sector in ultra high-speed atmospheric and exo-atmospheric flight.

The FastForward Study Group was organized in 2008 and is managed by SpaceWorks Commercial of Atlanta, GA USA.

FastForward Group Members

John Olds (Executive Director)
Chief Executive Officer
SpaceWorks Engineering, Inc. (SEI)

Dana Andrews
Chief Technology Officer
Andrews Space, Inc.

Michael Beavin
Senior Program Analyst
Office of Space Commercialization
National Oceanic & Atmospheric Administration
U.S. Department of Commerce

Kevin Bowcutt
Senior Technical Fellow
The Boeing Company

A.C. Charania
President
SpaceWorks Commercial

Kelvin Coleman
Program Manager
FAA
Office of Commercial Space Transportation

Dominic DePasquale (Deputy Director)
Director of Washington D.C. Operations
SpaceWorks Commercial

Jack Kennedy
Member
Virginia Commercial Spaceflight Authority

Scott Kennedy
Program Director
Northrop Grumman Corporation

Bill Khourie
Director
OSIDA Oklahoma Spaceport

Amaresh Kollipara
Founder & Managing Partner
Earth2Orbit, LLC

Steve Landeene
Director
Spaceport America

Chuck Lauer
Business Development
Rocketplane Global

Andrew Nelson
Chief Operating Officer
XCOR Aerospace

Allison Odyssey
Aerospace Engineer and Safety Manager
Space Florida

Frank Taylor
Project Manager
Sierra Nevada Corporation

Derek Webber
Washington DC Director
Spaceport Associates

Robert Wetherall
Program Manager
Lockheed Martin Corporation

Stuart Witt
General Manager
Mojave Air and Space Port

Frans von der Dunk
Professor of Space Law
University of Nebraska-Lincoln

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Contact



FastForward Study Group

High Speed Global Point-To-Point Transportation Investigative Group

<http://www.spaceworkscommercial.com/projects/fastforward>



Executive Director

Dr. John R. Olds
Chief Executive Officer (CEO)
SpaceWorks Engineering, Inc. (SEI)
Phone: 1+770-379-8002, Fax: 1+770-379-8001
E-mail: john.olds@sei.aero



Deputy Director

Mr. Dominic DePasquale
Director of Washington D.C. Operations
SpaceWorks Commercial
A Division of SpaceWorks Engineering, Inc. (SEI)
Phone: 1+770-379-8009, Fax: 1+770-379-8001
E-mail: dominic.depasquale@sei.aero

SpaceWorks Engineering, Inc. (SEI)
1200 Ashwood Parkway, Suite 506
Atlanta, GA 30338 U.S.A.